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Inventorisation and integrated management of soil water resources

J. Indian Soc. Coastal agric. Res., 24(1), 1-5, 2006 **Invited Paper**

Arsenic Contamination in Agriculture : A Threat to Water-Soil-Crop-Animal-Human Continuum in 21st Century

S. K. SANYAL

Bidhan Chandra Krishi Viswavidyalaya, Kalyani - 741 235, Nadia, West Bengal

The widespread arsenic (As) contamination in ground water in parts of West Bengal (India) and Bangladesh is well documented. In West Bengal alone, 85 blocks, located primarily in 9 districts, covering an area of about 39000 sq km on the eastern bank of the river Bhagirathi, are affected with 9 to 10 million population reportedly drinking ground water laden with various degrees with arsenic contamination. Such contamination has been reported to be of both geogenic and anthropogenic in origin. In India, however, arsenic contamination has been mainly of geogenic origin in which widely practised wetland summer (*boro*) paddy cultivation, using large quantum of ground water, is believed to play a role. The ground water As concentration (50–1600 $\mu g\ L^{-1}$), reported from the affected areas of West Bengal, are several orders of magnitude higher than the stipulated Indian standard for the permissible limit in drinking water (50 $\mu g\ L^{-1}$, which is also the maximum acceptable concentration, MAC, for drinking water in Bangladesh, India and several other countries), as well as the WHO guideline value (10 $\mu g\ L^{-1}$).

The main focus of attention, until recently, has been exclusively on arsenic contamination in ground water derived drinking water. However, of the total ground water used in the affected belt, less than 10% accounts for drinking purpose, leaving more than 90% of it in the agricultural sector, leading to its entry in the food chain. Interestingly, the surface water bodies, located in the affected belt, have remained largely free of arsenic.

Arsenic held by solid phases within the sediments, especially iron oxides, organic matter and sulphides may constitute the primary arsenic sources in ground water under conditions conducive to arsenic release from these solid phases. These include abiotic reactions (oxidation/reduction, ion exchange, chemical transformations) and biotic reactions (microbial methylation). Arsenic in ground water is generally present as dissolved, deprotonated/protonated oxyanions, namely arsenites ($As^{III}O_3^{3-}$; $H_nAs^{III}O_3^{(3-n)-}$, with n = 1,2) or arsenate ($As^{V}O_4^{3-}$, $H_nAs^{V}O_4^{(3-n)-}$, with n = 1,2), or both, besides the organic forms which have different levels of toxicity following the order: arsine >organo-arsine compounds >arsenites and oxides >arsenates >arsonium metals>native arsenic metal. Different crop plants raised in one of our crop cafeteria experiments exhibited varying tendencies to accumulate arsenic. Such accumulation in different plant parts also tended to fall off in the following sequence: root > stem > leaf > economic produce. A large number of other significant findings have ensued from the extensive research studies performed at Bidhan Chandra Krishi Viswavidyalaya and elsewhere. The retention of As by the soil organic fraction in the affected sites of study has been amply demonstrated, so also the release potential of As from the resulting organo-As complexes by the competing oxyanions such as phosphate and nitrate. The application of FYM and phosphate was found to have opposing effect on release of native and applied As in the contaminated soils, with FYM reducing such release, thereby tending to moderate the toxic effect of As in soil–plant system. A number of other manures, namely compost, poultry manure, neem cake, etc. have also been examined as ameliorants, not only for rice, but for other crops as well (e.g., potato, elephant footyam), with encouraging results. Alternative and promising cropping sequences with market demand, but of less irrigational requirement, were examined as substitute for the dominant rice-rice-fallow sequence in the affected areas to minimize the arsenic uptake by food crops. This apart, inclusion of pulses /other legumes /green manure crops in the cropping sequence, coupled with organic manure addition, was found helpful in moderating arsenic build-up in soil and plant parts.

Furthermore, pond stored contaminated ground water was also found to get partially decontaminated over time by sedimentation-cum-dilution due to rainfall, and conjunctive irrigation using such water bodies reduced the dependence on ground water irrigation. Our current research thrust covers, among others, arsenic speciation in different food crops for ascertaining the net toxicity, and the corresponding risk assessment due to the food intake.

(***Key words :*** *Arsenic in soil & water, Ground & surface water contamination, Geogenic origin, Complexes in soil, Permissible limit for drinking, Uptake in food chain, Cropping system, Amelioration method*)

Arsenic (As), which is placed in Group V and Period 4 of the Periodic Table, is a naturally occurring element that has both metallic and non-metallic properties. One of the earliest references to the use of arsenic (around 3000 BC) was found in bronze alloys (Partington, 1935). Arsenic also found use in medicines well before 400 BC. In agriculture, arsenic compounds were used as insecticides such as *sandarach* (realgar, AsS), which was effective for protection of grapes, and reports of use of arsenic as insecticide by the Chinese workers was found in the 10th century (Sanyal, 1999). Widespread use of arsenic in agriculture may possibly be traced as an insecticide to control potato beetle. This was followed by London Purple (a mixture of calcium arsenate and arsenite with some organic matter) as an insecticide (Sanyal, 1999). Presently high toxicity and increased appearance of arsenic in the biosphere has triggered public and political concern. Arsenic contamination in ground water, and the influence thereof on soil-plant-animal-human continuum, have been reported from various parts of the globe at different points of time (Chowdhury *et al.*, 2001, Mukhopadhyay and Sanyal, 2004, Sanyal, 2005). Such contamination has been reported to be of both geogenic and anthropogenic in origin. In India, however, arsenic contamination has been mainly of geogenic in origin (Sanyal, 2005).

Arsenic contamination in ground water has been reported at different times from West Bengal, India and countries like U.S.A., Argentina, Chile, Mexico, Taiwan, Hungary, Finland, Nepal and Bangladesh (Sanyal, 1999). Out of 20 countries in different parts of the world, where ground water arsenic contamination and human suffering therefrom have been reported so far, the magnitude is considered to be the highest in Bangladesh, followed by West Bengal, India (Sanyal, 2005). The scale of the problem is grave and unprecedented, covering a geographic area of 0.173 million square kilometer, while exposing 36 million people in the Bengal delta basin to risk (Ghosh *et al.*, 2004, Sanyal and Dhillon, 2005). The widespread arsenic contamination in ground water in different parts of West Bengal, distributed over 85 blocks, located primarily in five districts (namely, Malda, Murshidabad, Nadia, North and South 24 Parganas) adjoining the river Bhagirathi, as well as the contiguous districts in Bangladesh, is of great concern (Sanyal, 2005). Recently, several agencies like UNICEF; Central Ground Water Board, Government of India; School of Environmental Studies, Jadavpur University, Jadavpur and others also reported that many parts of the ground water of the entire Ganga basin is contaminated with arsenic (appeared in *Anandabazar Patrika*, Kolkata, March 24, 2004).

Dissolved arsenic concentrations in natural waters (except ground water) are generally low, except in areas characterized by geothermal water and/or mining activities. The sedimentary rocks generally have higher arsenic content than do igneous and metamorphic rocks, while suspended and bottom sediments in most aquatic systems contain more arsenic than most natural waters (Sanyal, 2005). The capacity to retain arsenic is primarily governed by the sediment grain size and the presence of surface coating composed of clays, clay-sized iron, manganese oxides and organic matter.

Arsenic held by solid phases within the sediments, especially iron oxides, organic matter and sulphides, may constitute the primary arsenic sources in ground water under conditions conducive to arsenic release from these solid phases. These include abiotic reactions (oxidation/reduction, ion exchange, chemical transformations) and biotic reactions (microbial methylation) (Sanyal, 2005).

The ground water As concentration (50 - 1600 μgL^{-1}), noted in the affected areas of West Bengal, are several orders of magnitude higher than the stipulated Indian standard for the permissible limit in drinking water (50 μgL^{-1}, which is also the maximum acceptable concentration, MAC, for drinking water in Bangladesh, India and several other countries), as well as the WHO guideline value (10 μgL^{-1}) (WHO, 1993, Ghosh *et al.*, 2004). However, such guidelines for soil, plant and animal systems are not available (Ghosh *et al.*, 2004).

The effect of ingestion of inorganic arsenic in drinking water and the health effects in adults has been well established (Guha Mazumdar *et al.*, 1998). As small as 0.1 g of arsenic trioxide can prove lethal to humans (Jarup, 1992). Toxicity of arsenic to human depends on the concentration and the length of exposure. Arsenical toxicity develops insidiously after six months to two years or more depending on the amount of intake of arsenic laden ground water (in case of contaminated ground water serving as the drinking water source as in West Bengal and Bangladesh) and arsenic concentration in it. Early symptoms of arsenic poisoning include skin disorders, weakness, languor, anorexia, nausea and vomiting with diarrhoea or constipation. With the progress of poisoning, the symptoms attain more characteristic features, which include acute diarrhoea, oedema (especially of the eyelids and ankles), skin pigmentation, arsenical melanosis and hyperkeratosis, enlargement of liver, respiratory diseases and skin cancer. In severe cases, gangrene in the limbs and malignant neoplasm are also observed (Mandal *et al.*, 1996). "Bell Ville Disease" (typical arsenic induced cutaneous manifestations among the people of Bell Ville) in Argentina, "Black

Foot Disease" in Taiwan and "Kai Dam" disease in Thailand are well established as health disorders due to arsenic poisoning (Sanyal and Dhillon, 2005). As a matter of fact, the hair, nail, skin scale and urine samples of a large number of people, residing in the affected belt of West Bengal (India) and Bangladesh, have been analyzed by several workers. Many of these samples had arsenic loading more than the corresponding toxic levels [Normal levels of arsenic in hair range from 80 to 250 ug kg^{-1}, while 1000 ug kg^{-1} is the indication level of toxicity; normal levels of arsenic in nail range from 430 to 1080 ug kg^{-1}; normal levels of arsenic in urine range from 5 to 40 ug in 1.5 L (per day)] (Chowdhury *et al.*, 2001).

The concerned scientific community, planners and executing agencies have, so far, focused attention mainly on arsenic in drinking water. That arsenic contaminated irrigation water used in agriculture can inject the heavy metal into food web, and thereby into man, was largely ignored. Actually more than 90% of the total ground water used in the affected belt of West Bengal finds application in the agricultural sector to meet the crop irrigational requirements (Sanyal and Dhillon, 2005). Indeed, uptake by crop plants grown in soils contaminated with high concentration of arsenic and irrigated with such arsenic contaminated ground water has been noted by several workers (Ghosh *et al.*, 2004). Such findings call for an immediate attention since what remains essentially a *point* and fixed source of arsenic contamination as for drinking water (e.g., a tubewell discharging contaminated water), may well become a *diffuse* and uncertain source of contamination when arsenic finds its way into the food web, accompanied with possible biomagnification up in the food chain. This assumes added significance in view of the reported finding of higher (than permissible) level of arsenic in the urine samples of some people having no history of consuming arsenic contaminated drinking water (Sanyal, 2005). Besides, arsenic contamination alone can limit, or even negate, the productivity and quality of the agricultural produce. The outflow of contaminated products to local, national and international markets may also be further restricted by sanitary and phytosanitary measures. Thus, the complexities of arsenic problem in management system, as emphasized above, warrants sustained research work to characterize the entire gamut of the intricacies of arsenic toxicity in ground water-soil-crop continuum, and come up with the effective remedial measures to contain the toxic effect of arsenic thereon.

Arsenic in ground water is generally present as dissolved, deprotonated/protonated oxyanions, namely arsenites ($As^{III}O_3^{3-}$; $H_n As^{III}O_3^{(3-n)-}$, with n = 1,2) or arsenate ($As^VO_4^{3-}$, $H_nAs^VO_4^{(3-n)-}$, with n = 1,2), or both, besides the organic forms. The toxicity of arsenic compounds in ground water/soil environment depends largely on its oxidation state, and hence on redox status and pH, as well as, whether arsenic is present in organic combinations. The toxicity follows the order: arsine [AsH_3; valence state of arsenic (As): -3]>organo-arsine compounds >arsenites (As^{3+}form) and oxides (As^{3+} form)>arsenates (As^{5+} form)>arsonium metals (+1)>native arsenic metal (0). The arsenites are much more soluble, mobile, and toxic than arsenates in aquatic and soil environments. At pH 6-8, in most aquatic systems, both $H_2As^VO_4^-$ and $HAs^VO_4^{2-}$ ions (pentavalent arsenic forms) occur in considerable proportions in an oxidized environment (redox potential, E_h=0.2-0.5V), while the arsenous acid, $H_3As^{III}O_3$ is the predominant species (trivalent arsenic form) under reduced conditions (E_h=0-0.1V) (Sanyal, 1999).

The arsenic loading of the ground water which is used as irrigation source varied from 0.06 to 0.53 mgL^{-1} in Nonaghata *mouza* of the Haringhata block of Nadia district in West Bengal (Ghosh *et al.*, 2004). A high degree of such contamination was also found in different parts of the affected belt, to name a few, Gotera and Ghentugachi *mouzas* of Chakadaha block of Nadia district (ranging from trace to 0.89 mgL^{-1}); Ambikanagar, Chakla, Iajpur and Chyangdana villages under Deganga block of North 24- Parganas district of West Bengal (varying from 0.05 to 0.50 mgL^{-1}), etc. by a group of researchers at Bidhan Chandra Krishi Viswavidyalaya (Sanyal, 2005).

Some of our research studies, conducted at the selected affected areas, revealed that the total and Olsen extractable (i.e., 0.5M $NaHCO_3$, pH 8.5 – extractable As which constitutes the soil As pool amenable to plant uptake) arsenic varied from 8.4 mg kg^{-1} to 24.3 mg kg^{-1} and from 2.90 mg kg^{-1} to 15.8 mg kg^{-1}, respectively, in the given affected soils of West Bengal (Sanyal, 2005). The soil arsenic contents of these areas were generally higher than those reported for the soils of several other countries like Argentina, China, Italy, Mexico, France, Australia, etc.

As mentioned earlier, several crops (such as elephant footyam, green gram, cowpea, sesame, groundnut, etc.) tended to show a build-up of arsenic in substantial quantities in different plant parts. A number of other vegetables, namely cauliflower, tomato, bittergourd were also noted to accumulate arsenic in their economic produce (Ghosh *et al.*, 2004). The arsenic content of the leaves, stem and potato tuber at harvest were 5.51, 9.34 and 10.2 mg kg^{-1}, respectively, when potato was grown with irrigation water having an arsenic loading of 0.22 mg AsL^{-1} (Adak *et al.*, 2002). Thus, the distribution of arsenic content in plant parts generally followed the order: root > stem>leaf > economic produce.

Reduction of arsenate to more toxic arsenite is facilitated by lowering of redox potential (E_h) which is encountered under anoxic soil conditions, with arsenite being more soluble and mobile than arsenate. Thus, rice plant is rather susceptible to arsenic toxicity since it is grown under submerged soil conditions (low E_h) (Sanyal, 1999). Indeed, the total arsenic loading of rice crop was to the tune of 10 mg kg^{-1} and even more at 14% moisture level in the selected districts of Bangladesh (Duxbery *et al.*, 2003). Application of graded doses of arsenic in a pot culture experiment, conducted at Bidhan Chandra Krishi Viswavidyalaya, West Bengal, led to visual symptoms of arsenic poisoning in the leaves of rice plants (Ghosh, 2005). The symptoms were reddening of leaf tip followed by lateral expansion towards the leaf blade. Such reddening of leaves proceeded from the margin of the leaves to their midribs. In general, the symptom of the affected leaves became visible in the pots treated with 40 mg kg^{-1} arsenic and beyond although no visual symptom was found in the pots treated with upto 20 mg kg^{-1} arsenic rate (Ghosh, 2005). Further, the processing of rice (i.e., parboiling and milling, etc.) was found to increase the arsenic loading in rice for both the traditional and the high yielding cultivars (Ghosh *et al.*, 2004).

The concentrations of arsenic in flowering plants were found to be 0.114, 0.203, 0.214, 0.235 and 0.293 mg kg^{-1} when the levels of soil arsenic were 0, <20, 20-30, 40-50 and >50 mg kg^{-1}, respectively (Zhou, 1986). Tuberose and marigold, two important flowers of the country, were also found to accumulate arsenic in their floral body with such arsenic content in the flower samples ranging from 1.8 to 3.6 mg kg^{-1} (Ghosh, 2005). The toxicity of arsenic species in plant body is reported to follow the order: Arsine (AsH_3) > As^{3+} > As^{5+}> MMA (Monomethyl arsenic acid)> DMMA (dimethyl arsenic acid) (NRC, 1978).

Several weed species, namely *Ludwigia parviflora*, *Filmbristylis sp.*, *Ageratum conyzoides*, *Eleusine indica*, etc. showed promise of accumulating substantial amounts of arsenic (e.g., 50 times or even more of their biomass) in their plant biomass when present in the arsenic affected areas, in comparison with the situation where such weeds grew in arsenic free areas under observation. Thus, the latter could be of importance in regard to cost effective phytoremediation options for the given arsenic contamination problem (Ghosh, 2005). However, speciation of the different forms of arsenic revealed that the *net* toxicity of the arsenic increased when arsenic entered into the food chain from the contaminated ground water irrigation source *via* soil (Ghosh, 2005).

It is thus apparent that arsenic uptake by crops, irrigated with arsenic contaminated ground water, caused entry of arsenic in the food chain, which could be of importance in regard to the health hazards to humans as well as the animals of the affected areas. On the other hand, arsenic contamination in agroecosystem, which acts as a conduit for the passage of the toxicant to human population *via* food web, came under serious consideration only recently. The present communication demonstrates that equal, if not greater, attention is necessary for understanding the complex aspects of accumulation of arsenic in the food web *vis-à-vis* drinking water alone, and its ultimate passage to the human populations. Notwithstanding what is discussed above, much more and sustained research work remains to be done to characterize the entire gamut of intricacies of arsenic contamination spectrum in soil-plant-animal-human system. This covers evolving the effective remedial measures [e.g., incorporation of organic manures (namely, FYM, poultry manure, neem cake, oil cake, etc.), cultivation of low water requiring cropping sequences, identification of bioremediating species, conjunctive use of surface and ground water, exploration of the genetic make-up of several important plant species, including the varieties of such cultivars commonly used in the arsenic belt, *vis-à-vis* arsenic accumulation and tolerance by these species worth undertaking for identifying the relevant DNA markers and enzyme systems from to contain the toxin in the said system. Immediate needs, among others, are improvement of field and laboratory protocols for large scale measurement of arsenic, and that for different forms/ species of arsenic in ground water-soil-plant-animal-human continuum, strengthening of inter-institutional and inter-disciplinary action programme, on-demand testing of arsenic presence in abiotic and biotic systems, long term technical alternatives to reduce dependence on arsenic contaminated resources, awareness and involvement of the affected populations for the confinement through mass movements, gradually leading to the zeroing of arsenic related problem, and promotion of international networking in support of arsenic mitigation options (Sanyal and Nasar, 2002, Sanyal, 2005).

REFERENCES

Adak, S.K., Mandal, B.K. and Sanyal, S.K. (2002). Yield of potato as influenced by arsenic contaminated irrigation water. In *Potato, Global Research & Development*, Vol. **2**, pp. 926-928. Indian Potato Research Association, Central Potato Research Institute, Shimla.

Chowdhury, U.K., Rahaman, M.M., Mondal, B.K., Paul, K., Lodh, D., Biswas, B.K., Basu, G.K., Chanda, C.R., Saha, K.C., Mukherjee, S.C., Roy, S., Das, R., Kaies, I., Barua, A.K., Palit, S.K., Quamruzzaman, Q. and Chakraborti, D. (2001). Groundwater contamination and human suffering in West Bengal, India and Bangladesh. *Environmental Science* **8**: 393-415.

Duxbery, J.M., Mayer, A.B., Lauren, J.G. and Hassan, N. (2003). Food chain aspects of arsenic contamination in Bengladesh effects on quality and productivity of rice. *J. Environ. Sci. Health Port A Tox. Hazard Subst. Environ. Eng.* **38**: 9-61.

Ghosh, K. (2005). A study on arsenic dynamics in soil-crop system in selected arsenic affected soils of West Bengal along with potential mitigation options. *Ph. D. Thesis*, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal.

Ghosh, K., Das, I., Saha, S., Banik, G.C., Ghosh, S., Maji, N.C. and Sanyal, S. K. (2004). Arsenic chemistry in groundwater in the Bengal-delta plain: Implications in agricultural system. *Journal of Indian Chemical Society* **81**: 1063-1072.

Guha Mazumdar, D.N., Haque, R., Ghosh, N., De, B. K., Santra, A., Chakraborti, D. and Smith, A. H. (1998). Arsenic levels in drinking water and the prevalence of skin lesions in West Bengal, India. *International Journal of Epidemiology* **27:** 871-877.

Jarup, L. (1992). *Dose-response Relation for Occupational Exposure to Arsenic and Cadmium.* National Institute for Occupational Health, Sweden.

Mandal, B.K., Chowdhury, T.R., Samanta, G., Basu, G.K., Chowdhury, P.P., Chanda, C.R., Lodh, D., Naran, N.K., Dhara, R.K., Tamili, D.K., Das, D., Saha, K.C. and Chakraborti, D. (1996). Arsenic in groundwater in seven districts of West Bengal, India – the biggest arsenic calamity in the world. *Current Science* **70**: 976-986.

Mukhopadhyay, D. and Sanyal, S.K. (2004). Complexation and release isotherm of arsenic in arsenic-humic/fulvic equilibrium study. *Australian Journal of Soil Research* **42**: 815-824.

NRC (1978). *National Research Council of Canada*, No. **15391**, Ottawa, Canada.

Partington, J.R. (1935). *Origins and Development of Applied Chemistry.* Longman, London, U.K.

Sanyal, S.K. (1999). Chemodynamics of geogenic contaminants in the soil environment-arsenic. Proceedings Second International Conference *Contaminants in the Soil Environment in the Australasia-Pacific Region*, held at New Delhi, 12-17 Dec, 1999. Extended Abstracts, pp. 389-390. Indian Network for Soil Contamination Research, New Delhi, India and Soil Contamination Research in Asia and the Pacific, Adelaide, Australia.

Sanyal, S.K. (2005). Arsenic contamination in agriculture: A threat to water-soil-crop-animal-human continuum. Presidential Address, Agriculture & Forestry Sciences, 92nd Session *Indian Science Congress Association (ISCA)*, held at Ahmedabad, 3-7 Jan, 2005. The Indian Science Congress Association, Kolkata.

Sanyal, S.K. and Dhillon, K.S. (2005). Arsenic and selenium dynamics in water- soil -plant system: A threat to environmental quality. Invited Lead Lecture, Proceedings International Conference *Soil, Water and Environmental Quality: Issues and Strategies*, held at New Delhi, 28 Jan to 1 Feb, 2005 (in press).

Sanyal, S.K. and Nasar, S.K.T. (2002). Arsenic contamination of groundwater in West Bengal (India): Build-up in soil-crop systems. In *Analysis and Practice in Water Resource Engineering for Disaster Mitigation*, pp. 216-222. New Age International (P) Publishers, New Delhi.

WHO (1993). *Guidelines for Drinking-water Quality*, 2nd Edn, Vol. **1**.

Zhou, D. (1986). Adsorption and release of arsenic in soil. *Huanjing Huaxyu* **5**: 77-83.

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Invited Paper

Modeling for Water Management in Coastal Ecosystems

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The entire coastal region in India except north Gujarat receives a normal annual rainfall of more than 100 cm. Availability of freshwater is a major problem in the coastal region. Since the major source of water in coastal areas is rainfall and ground water, inefficient rainwater management and over-exploitation of ground water for irrigation in the west and south coastline have caused acute shortage of water. While, the major part of the east coast suffers from severe waterlogging problem due to flat topography and low hydraulic conductivity. All along the coastline, ground water quality is being threatened due to the surface or subsurface seawater intrusion. Major issues related to water management in coastal areas are waterlogging and salinity, rainwater management and seawater intrusion. Water management policies in coastal areas must focus on providing adequate drainage facility, appropriate rainwater harvesting structures and developing appropriate ground water pumping rate and pumping schedule combinations. This requires location specific studies to investigate the surface and subsurface hydrologic behaviour. Field investigation of hydrologic behaviour is a time consuming and costly affair. This investigation can easily and conveniently be carried out through modeling of processes governing the hydrology of coastal ecosystem. There are several models available, which can be used for design of drainage system and rainwater harvesting structure and simulate the seawater intrusion. The most appropriate model can be calibrated and validated for the use in local conditions. This paper covers the various aspects of water management and the utility of modeling for water management in coastal ecosystem.

***(Key words:** Modeling, Coastal ecosystems, Seawater intrusion, Hydrologic behaviour, Water management).*

Coastal ecosystem is a zone where sea influences the life of all living beings including the human population residing there. It includes the coastal land and the part of river basin adjoining the sea. This ecosystem also supports a broad diversity of terrestrial and marine habitats. The Indian coastline is more than 8000 km long bounded by the Arabian Sea in west, the Bay of Bengal in the east, and the Indian Ocean in the south. The topography of coastal region in India varies from lowlying to high hills. The deltaic region of river Ganges, land between eastern *Ghats* and Bay of Bengal in the eastern coast, between western *Ghats* and the Arabian Sea in the western coast, the coast of Kerala and the coast of Valsad and Surat districts in Gujarat are nearly level to lowlying. Deltas of eastern coast with marshy lands of Sundarbans in the north and with natural depression lakes like Chilka, Killeru and Pulikhat along the eastern coast are generally lowlying. The coastal area of Lakshadweep group of Islands exhibits flat topography while the Andaman and Nicobar group of Islands fall under lowlying to high hills.

The major Indian shore lines are:

- Deltaic (deltas of Ganga, Mahanadi, Godavari, Krishna and Cauvery)
- Shoreline of emergence between Ganga and Godavari, and Krishna delta and Kanyakumari
- Compound shoreline of Kerala and Karnataka
- Submergent shoreline of Maharashtra
- Estuarine shoreline of Gulf of Cambay
- Submergent shoreline of Gulf of Kutch
- Natural shoreline of Lakshadweep
- Compound shorelines of Adamans and Nicobars

The Indian coastline offers an excellent opportunity for agricultural growth particularly on east coast, which has vast stretch of fertile alluvial land. Agriculture in the coastal ecosystem is mostly rainfed or irrigated by ground water. Though the availability of both the rainfall and ground water is in abundance in most of the coastal region of India, scarcity of water is felt particularly in post-monsoon period due to the seasonal characteristic of the rainfall and the seawater intrusion in coastal aquifer. Entire coastal region except north Gujarat receives a normal annual rainfall of more than 100 cm. In the west coast, it is as high as 250 cm. However, more than 80% of the annual rainfall is received during rainy season except coastal Tamilnadu, which receives maximum rainfall during October and November. The major source of water in coastal areas is rainfall and ground water.

Inefficient rainwater management and over-exploitation of ground water for irrigation in the west and south coastline has caused acute shortage of water. On the other hand, the major part of the east coast suffers from severe waterlogging problems due to flat topography and low hydraulic conductivity. All along the coastline, ground water quality is being threatened due to the surface or subsurface seawater intrusion.

The coastal ecosystems are vulnerable to a variety of natural hazards including erosion, salt water intrusions, subsidence, *tsunami* and floods. Exposure to such natural hazards is expected to increase due both to increase in population density in lowlying coastal areas and the effects of global climate change (e.g. sea level rise and possible increases in the frequency of extreme weather such as tropical cyclones) (IGOS, 2004)

Major issues related to water management in coastal areas

The major issues related to water management in coastal areas are waterlogging and salinity, rainwater management, and seawater intrusion. Due to heavy and concentrated rainfall, flat topography and low hydraulic conductivity of soils, the coastal soils are subjected to intense waterlogging. Excess rain during monsoon and poor water management practices result in excessive surface runoff and soil loss. Water balance analysis of coastal areas for June to September and October to December (Table 1) shows substantial surplus water in monsoon period in all the coastal regions except Andhra Pradesh and Saurashtra (Rao and Dhruvanarayan, 1979). It indicates that there are ample opportunities for rainwater harvesting for supplemental irrigation and ground water recharge. Seawater intrusion is another serious problem in coastal region. Due to excessive pumping of coastal aquifer, the natural balance between freshwater and seawater is disturbed, as a result, fresh water flow to coastal waters is reduced and seawater moves towards fresh water aquifers (Fig. 1). Lowering of the water table by drainage canals also lead to salt water intrusion. Seawater intrusion is the movement of seawater into fresh water aquifers due to natural processes or human activities. Seawater intrusion is caused by decrease in ground water levels or by increases in seawater levels. Intrusion can affect the quality of water not only at the pumping well sites, but also at other well sites and at undeveloped portions of the aquifer

People leaving in coastal areas have evolved effective indigenous methods for water harvesting. Indigenous techniques are playing effective role in several parts of the coastal region in India. *Virdas* in Banni grasslands of Great Rann of Kutch built by the nomadic Maldharis for rainwater harvesting helped the Maldharis to separate potable freshwater from non-potable salt water. In Kasaragod district of the northern Malabar region of Kerala, people depend on *Surangam* for water. *Surangam* is a horizontal well mostly excavated in hard laterite rock formations to construct a tunnel like structure. Water which seeps out of the hard rock and flows out of the tunnel, is usually collected in an open pit constructed outside the *surangam* for use. *Eris* (tanks) are very common for water harvesting in coastal region of Tamilnadu. *Eris* plays important roles in maintaining ecological harmony as flood control systems, preventing soil erosion and wastage of runoff during periods of heavy rainfall, and

Table 1. *Water balance analysis of coastal areas for June to September and October to December*

State	Rainfall (mm)	Potential ET (mm)	Water surplus ordeficit (mm)	Rainfall (mm)	Potential ET (mm)	Water surplus or deficit (mm)
West Bengal	1,325	519	806	177	310	-123
Orissa	1,140	477	663	180	280	-100
Andhra Pradesh	570	590	-20	330	337	-7
Tamil Nadu	340	640	-300	480	357	-123
Karnataka	2850	375	2,475	250	345	-85
Kerala	2010	395	1614	550	335	-215
Maharashtra	2700	475	2225	130	344	-214
Gujarat	930	556	365	30	357	-327
Saurashtra and Kutch	450	714	-264	20	413	-393

(Rao and Dhruvanarayan, 1979)

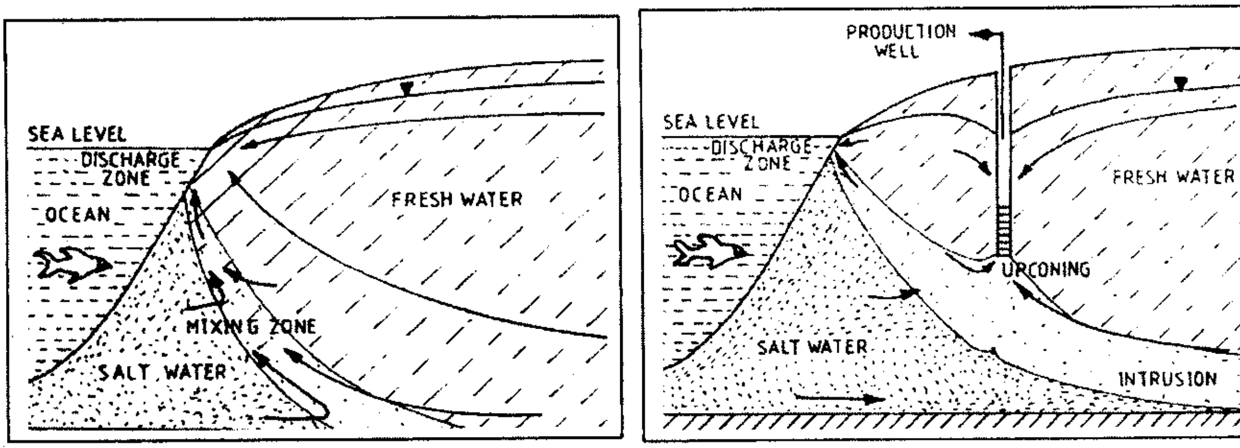

Fig. 1. Schematic representation of salt water intrusion in coastal aquifers.

recharging the ground water in the surrounding areas. It is an important source of irrigation for the farmers of Tamilnadu. A series of jackwells, connected by split bamboos to collect the overflows, are a common practice to harvest throughfalls (rainfall) from the leaves and are being used by the tribals of Great Nicobar Island. One jackwell leads to another, ultimately leading to the biggest jackwell, with an approximate diameter of 6 m and depth of 7 m. There is need to promote the indigenous water harvesting techniques with scientific input. Simulation models can be used to develop and improve the design of indigenous technologies to suit the local needs.

Water management policies in coastal areas

Water management policies in coastal areas must focus on providing adequate drainage facility, appropriate rainwater harvesting structures with developing appropriate ground water pumping rate and pumping schedule combinations. Some important measures to control the salt water intrusion are reduction of the rates of ground water pumping to keep it within the sustainable yield (van Dam, 1999), relocation of abstraction works to reduce the losses of fresh ground water by outflow, increase of natural recharge, artificial recharge, abstraction of saline ground water to increase the volume of fresh ground water and reduce the losses of fresh ground water by outflow.

Modeling for water resources development and management

Development of water management policies requires location specific studies to investigate the surface and subsurface hydrologic behaviour. Field investigations of hydrologic behaviour are a time consuming and costly affair and such investigations can be easily and conveniently carried out through modeling of processes governing the hydrology of coastal ecosystems. There are several models available, which can be used for design of drainage system and rainwater harvesting structures as well as for simulation of seawater intrusion. The most appropriate model can be calibrated and validated for its application at specific locations. Efforts are going on to validate or develop models for water management in coastal regions. An attempt has been made here to review the modeling efforts and discuss on important models which can be used for water management in coastal areas.

Ferreira *et al.* (2005) used GALDIT method for assessing the vulnerability to seawater intrusion in Portuguese aquifer of Monte Gordo. According to them, the most important factors controlling seawater intrusion were Ground water occurrence (aquifer type; unconfined, confined and leaky confined); Aquifer hydraulic conductivity; Depth to ground water Level above the sea; Distance from the shore (distance inland perpendicular from shoreline); Impact of existing status of seawater intrusion in the area; and Thickness of the aquifer, which is being mapped. The acronym GALDIT was formed from the highlighted letters of the parameters for ease of reference. These factors were determined to include the basic requirements needed to assess the general seawater intrusion potential of each hydrogeologic setting. GALDIT factors represent measurable parameters for which data were generally available from a variety of sources without the need for a detailed investigation. A numerical ranking system to assess seawater intrusion potential in hydrogeologic settings was devised by them using GALDIT factors.

Bhosale and Kumar (2002) simulated seawater intrusion in a section of Ernakulam coast through Saturated-Unsaturated TRAnsport (SUTRA) model and examined the impact of increased pumping scenarios on extent of seawater intrusion. They reported that the sensitive zone (salinity more than 500 mg l^{-1}) in this area was between 400 m to 2000 m from the high tide line and the ground water in this zone was already contaminated due to saline water (total dissolved solid concentration above the standard limit). They concluded that any ground water development activity in the region needs to be carefully planned with remedial measures in order to contain further intrusion of seawater.

Chachadi *et al.* (2003) used GALDIT model to assess the impact of sea level rise on salt water intrusion in the coastal area of North Goa. They concluded that the rise of 0.5 m sea level would cause maximum surface inundation in the estuaries/creeks compared to the main coast. This was because of the fact that the main coast had rocky and steeply elevated ground surface at many places. On the other hand, the estuaries/creeks have very flat topography and very low elevations above the sea level. They also concluded that the seawater intrusion in the area along the creeks was widespread and has an increased level of ingress after 0.5 m sea level rise as seen from the GALDIT score contour map.

Seawater intrusion in coastal aquifers is generally three dimensional (3-D) in nature but there are very few reported results on 3-D simulations. Das and Datta (2001) conducted 3-D simulations to study the response of coastal aquifers and demonstrated that a series of pumps near the ocean-face boundary induced a hydraulic head distribution which can be effectively used for controlling seawater intrusion.

Some important models for water management in coastal aquifers

SEAWAT-2000 :

SEAWAT-2000 is a computer program for the simulation of three-dimensional, variable density, transient ground water flow in porous media (Langevin *et al.*, 2005). It combines MODFLOW-2000 and MT3DMS into a single computer program and contains all of the processes simulated by MODFLOW-2000.

SEAWAT requires a set of initial conditions, hydraulic properties, and stresses to be specified for every model cell in the finite difference grid. Primary output is head and concentration, which can be written to the listing file or to separate binary files. Other output includes the complete listing of all input data, drawdown, flow budget, and transport budget data. Flow budget data are printed as a summary in the listing file, and detailed budget data for all model cells can be written into a separate file.

SUTRA Version 2D3D.1: USGS: This is a model for 2D or 3D saturated-unsaturated, variable density ground water flow with solute or energy transport (Voss and Provost, 2002)

SUTRA-MS Version 2004.1: SUTRA-MS is a modification of SUTRA Version 2D3D.1. It can simulate variably saturated to fully saturated flow, advection, and production and the transport of multiple species, and allow for dependence of density and viscosity on any of the simulated species (Hughes and Sanford, 2004).

FEFLOW : FEFLOW (Diersch, 1998) is a complete ground water model combined with powerful graphical features, sophisticated analysis tools and robust numerical algorithms for:

- Density-dependent flow (salt water intrusion)
- Transient or steady state flow
- Saturated and unsaturated flow
- Multiple free surfaces (perched water table)
- Mass and heat transport

FEFLOW can be used to determine the spatial and temporal distribution of ground water heads and contaminants, estimate the duration and travel times of a pollutant in aquifers, evaluate the impact of seawater intrusion due to ground water pumping and/or mining activities along coastal regions, simulate the combined effects of geothermal gradients and saline ground water flow for deep well injection of nuclear wastes, design and optimize pumping well locations and pumping rates, determine the influence of dewatering activities on local and regional ground water supplies, evaluate remediation alternatives, plan remediation strategies, optimize ground water remediation system designs, analyze moisture dynamics and seepage through the dam, predict the rates of infiltration/aquifer recharge due to precipitation, storm water retention ponds or artificial aquifer recharge schemes.

Seawater intrusion (SWI) package for MODFLOW-USGS: The Seawater intrusion (SWI) is a package for the modeling of regional seawater

Table 2. *Some important hydrologic simulation models*

Model	Type	Scale of application	Source	Time step
WATFLOOD	Hydrologic budget of watershed	Large basins (>10000 km^2)	Department of Civil Engineering, University of Waterloo, Canada	Daily
PRMS	Precipitation runoff model	Small and medium (may be tried for large) basins	USGS	Daily
SWIM	~~Soil water infiltration~~ and movement	~~Small basins~~	Scien~~tific Software~~ Group,, Washington	Daily
SWAT	Soil and water assessment tool	Small and medium (could be tried for large) basins	R Srinivasan, Blackland Research Centre, Temple, TX	Daily
TOPMODEL	Topography based hydrologic modeling	Small (could be tried for medium and large) basins	Institute of Environmental Sciences, University of Lancaster, UK	Daily
NAVMO2	Precipitation-runoff-evapotranspiration model	Large (2x2 km grid sizes)	K Jasper, University of Bundeswehr, Water Resources Institute, Neubiburg, Germany	Daily

Source: Narula *et al.* (2002)

intrusion with MODFLOW (Bakker and Schaars, 2005). The SWI package simulates the evolution of the three-dimensional density distribution through time and can model each aquifer with a single layer of cells. An existing MODFLOW model of a coastal aquifer can be modified to simulate seawater intrusion through the addition of one input file. The SWI package can simulate interface flow, stratified flow, and continuously varying density flow.

Some of the other popularly used hydrologic simulation models have been listed in Table 2.

CONCLUSION

Water management in coastal region is a complex issue. Salt water intrusion, severe runoff and soil erosion, backwater flows and waterlogging and salinity are major challenges before water management scientists. Though the problems are complex, they can be solved if appropriate strategies are developed. Studies presented in this paper demonstrate that these problems can be minimized. However, there is an urgent need to develop guidelines for pumping of coastal aquifers. Indigenous techniques of water harvesting should be promoted with proper scientific designs. Simulation models can be used to analyze the different water resources development and management scenarios to select the most optimum one. There are a number of models available which can be calibrated and validated for local conditions to generate the water management scenarios. Some of the important models presented in this paper are widely used and can be tried out for Indian coastal regions.

REFERENCES

Bakker Mark and Schaars Frans (2005). Theory, user manual, and examples. In *The Sea Water Intrusion (SWI)Package Manual*, Part I, Version **1.2.** http://www.engr.uga.edu/documents/mbakker/swimanpart2.pdf

Bhosale Dipanjali, D. and Kumar, C. P. (2002). Simulation of seawater intrusion in Ernakulam Coast. In Proceedings International Conference *Hydrology and Watershed Management*, Vol **II**, pp. 390-399, held at Hyderabad.

Chachadi, A. G., Ferreira João Paulo C. Lobo, Ligia Noronha and Choudri, B. S. (2003). Assessing the impact of sea-level rise on salt water intrusion in coastal aquifers using GALDIT model APRH/CEAS. In Proceedings Seminário *Sobre Águas Subterrâneas*, Lisboa.

Das, A. and Datta Bithin (2001). Simulation of seawater intrusion in coastal aquifers: Some typical responses. *Sadhana* **26** (4): 317-352.

Diersch, H.J.G. (1998). FEFLOW user's manual Interactive. In *Graphics-based Finite Element Simulation System FEFLOW for Modeling Ground Water Flow, Contaminant Mass and Heat Transport Process*. WASY GmbH, Berlin.

Ferreira João Paulo Lobo, Chachadi, A. G. and Catarina (2005). Application to the Portuguese aquifer of Monte Gordo: Assessing aquifer vulnerability to seawater intrusion sing GALDIT method. In Proceedings The Fourth Inter-Celtic Colloquium *Hydrology and Management of Water Resources*, Part **I**, held at Guimaraos, Pourtugal.

Hughes, J.D. and Sanford, W.E. (2004). SUTRA-MS: A version of SUTRA modified to simulate heat and multiple-solute transport, *U.S. Geological Survey Open-File Report* **2004-1207.** 141p. http://water.usgs.gov/nrp/gwsoftware/sutra.html

IGOS (2004). In *Coastal Theme Report*, Version 6, IGOS Partnership Doc No. 5.1 11-bis Meeting, Beijing, P.R. China.

Langevin Christian, D.W., Shoemaker Barclay and Guo Weixing (2005). *SEAWAT 2000*, U.S. Geological Survey, Fort Lauderdale, Florida, CDM & Missimer, Fort Myers, Florida. http://water.usgs.gov/ogw/seawat/summary2k. html

Narula, K. K., Bansal, N. K. and Gosain, A. K. (2002). Hydrological sciences and recent advances: a review. *TERI Information Digest on Energy and Environment* **1**(1): 71-93.

Rao, K.V.G.K. and Dhruvanarayan, V.V. (1979). Hydrology and drainage conditions of coastal saline soils. In Proceedings Conference *Problems and Management of Coastal Saline Soils*, pp. 29-52, held at CSSRI Regional Station, Canning Town, West Bengal.

van Dam, J.C. (1999). Exploitation, restoration and management. In *Seawater Intrusion in Coastal Aquifers - Concepts, Methods and Practices*, Bear, Jacob and others (eds.), pp. 73-125, Kluwer Academic Publishers, Dordrecht, The Netherlands.

Voss, C. I. and Provost, A.M. (2002). *SUTRA, A Model for Saturated-Unsaturated Variable-Density Ground-Water Flow with Solute or Energy Transport.* Investigations Report 02-4231, U.S. Geological Survey Water-Resources. 250p. http://water.usgs.gov/nrp/gwsoftware/sutra.html

J. Indian Soc. Coastal agric. Res., 24(1), 12-22, 2006 **Invited Paper**

Soils, Soil Nutrient Status and Nutrient Management Strategies for Enhancing Productivity of Rice-based Cropping Systems in the Coastal Ecosystem

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Soils in coastal India are acidic (red and lateritic soils), saline and deltaic alluvial. These soils are low in bases, available N, P, and K and high in Fe. The major problems in these soils are acidity, nutrient deficiencies, strong P fixation and Fe toxicity, and in some cases, toxicity due to Mn and Al as well. Increasing intensity of cropping to feed the ever-growing population of coastal areas has led to persistent nutrient mining from the soil, which has an adverse effect on soil health. The rice growing soils of coastal India are either underfed with plant available nutrients (like eastern India) or overfed in areas like Krishna and Godavari deltas of Andhra Pradesh and Cauvery delta of Tamil Nadu. In recent years the nutrient management strategies have gained importance in crops and cropping systems for maintaining soil available nutrient status without nutrient mining for sustainable higher productivity under long term basis.

Long term experiments have shown that neither organic sources nor mineral fertilizers alone can achieve sustainability in the crop production. Continuous use of FYM is effective in stabilizing rice productivity under low to medium cropping intensity where the nutrient demand is relatively small. Nonetheless, integrated use of organic and mineral fertilizers has been found to be more effective in maintaining higher productivity and stability through correction of deficiencies of secondary and micronutrients in the course of mineralization, on one hand, and favourable physical and soil ecological conditions, on the other. Organic manuring improved the physical and microbial conditions of soil and also enhances fertilizer use efficiency when applied in conjunction with mineral fertilizers. Thus, all the major sources of plant nutrients, such as soil, mineral, organic and biological should be utilized in an efficient and judicious manner for sustainable higher crop production in rice-based cropping system.

***(Key words** : Rice-based cropping systems, Nutritional constraints, Balanced fertilization, Integrated nutrient management)*

Among the food grains, rice is the principal cereal crop and is cultivated in 44 m ha land area of India with production of 93 m tonnes. The coastal areas of India contribute significantly with an area of 18.2 m ha and 5.5% of the total geographical area of the country with food grain production of 37 million tonnes. The ecosystem is characterized by tropical and subtropical conditions with hot summers and mild winters. Yet the productivity of the principal cereal crop is quite low as compared to the rest of the country. It is primarily due to the soil and edaphic factors (acid, saline and sandy nature with deficiencies of major and micronutrients in soils), climate, and the poor cultural management practices followed. There is still ample opportunity to increase the productivity of rice in these areas through suitable nutrient management practices, which may be the most important factor of crop production. This paper examines the existing nutrient status of soils in these areas and the nutrient management options to boost the productivity of rice based cropping systems in a sustainable manner.

Climate and soils under coastal agroecosystems: The National Bureau of Soil Survey and Land use Planning prepared an agroecological region map consisting of 21 regions based on physiography, soils, bioclimatic, natural vegetation, and length of growing period (Sehgal *et al.*, 1992). Coastal agroecosystem falls under the agroecoregions no. 19, 20 and 21.

Plant nutritional constraints to crop production in coastal ecosystem

Coastal salt affected soils constitute 2.1 m ha area out of the total 7 m ha salt affected soils in India. The coastal saline soils, earlier estimated to cover 2.1 m ha are now believed to cover 2.5 – 3.0 m ha (Bandyopadhyay and Sinha, 1985). About 90% of the coastal saline soils are in the three states of Gujurat (34%), Orissa (19%) and West Bengal (38%) (Yadav *et al.*, 1979). These soils are having pH of less than 8.2, SAR less than 15 and chloride and sulphates of Ca and Mg as predominant salts.

Acid soils in India are mostly distributed in coastal regions of India. They extend over 49 m ha, out of which 47% have a pH of 5.6-6.5 and in 50% of them the pH is less than 5.5 (Panda, 1987). Coastal acid red and lateritic soils are found mostly in the Konkan-Malabar west coast, West Bengal and Orissa. Moderately acid soils under flooded rice are not considered as problem soils since submergence can raise their pH towards neutrality. These acid soils are low in cation exchange capacity, bases, available NPK, but high in Fe. The major problems in these soils are acidity, nutrient deficiencies, strong P fixation, and toxicities of Fe and, in some cases, Mn and Al as well (Mahapatra and Patanaik, 1982, Patnaik and Bhadrachalam, 1985).

The soils of coastal Andhra Pradesh are coarse textured, porous, alluvial, deltaic alluvial and coastal sandy, and are deficient in N and P. Deficiency of Zn is also wide spread. Leaching losses of nutrient is a great concern in these areas. The coastal soils of Tamil Nadu are alluvial in nature and are medium to high in available P. Zn deficiency is predominant in these regions. The coastal alluvial soils of Karnataka representing high rainfall areas are acidic. The soils formed under high rainfall areas representing mostly the lateritic and coastal alluvium are acidic in nature in Kerala. Problem soils, particularly the acid sulphate soils, require special treatment and management practice. The acid sulphate and related problem soils occupy nearly 108000 ha in western Kerala and 280000 ha in southern part of West Bengal (Van Breeman and Pons, 1978). These occur in the areas, which remain submerged in most part of the year and are situated 1-1.5 m below the mean sea level. It is reported that almost 0.5 m ha of coastal soils of Sundarbans, which are saline and acidic, may be called potentially acid sulphate soils (Bandyopadhyaya and Sarkar, 1987).

Due to intensive cultivation practices, secondary and micronutrient deficiencies are emerging, especially due to the use of high analysis fertilizers such as urea, DAP and high grade complexes. Sulphur is now considered as the fourth major nutrient in crop production especially in irrigated paddy and positive response to S in paddy has been reported in Andhra Pradesh and Tamil Nadu.

Fertilizer use in cropping systems depends on the characteristics of the previous crop, and the quantity and kind of fertilizer applied. Since the last one and half decade, systems approach to plant nutrition involving integrated use of all sources of plant nutrients has been attempted. This is because single nutrient approach has often caused reduced fertilizer use-efficiency and consequent problems of multi-nutrient deficiencies in the exhaustive cereal-based cropping systems. Therefore, balanced fertilization is considered necessary for increasing crop productivity and maintaining soil fertility. Integrated Plant Nutrient Supply (IPNS) envisaging conjunctive use of inorganic and organic sources of nutrients and biofertilizers is a novel system of plant nutrient use for sustaining soil health and crop productivity. It has been amply demonstrated by All India Coordinated Long Term Fertilizer Experiments Project of ICAR that integrated use of optimal dose of NPK and FYM ensures better and sustainable yields, while correcting some of the micro- and secondary nutrient deficiencies. The integrated nutrient management and increasing nutrient use efficiency, would lower the cost of production. This will also help in maintaining soil health and productivity and minimize contamination of ground waters with nitrates.

Nutrient management under rice-based cropping system

Rainfed situations

Under rainfed conditions the grain yield and response of rice to fertilizers are lower than under irrigated condition. An application of 30-60 kg N ha^{-1} preferably in split doses in light textured soils is considered optimum under upland conditions (Acharya *et al.*, 2003). Upland rice is also mixed sown with various legumes like groundnut, pigeon pea, green gram and black gram in eastern India. These legumes benefit the associating cereal crop to the extent of 25-40 kg N ha^{-1} through biological N fixation.

Balanced fertilization with N, P and K: Under rainfed lowlands, the grain yield of rice decreases with increase in water depth and the yield stabilization occurs at a progressively lower level of N (Sharma, 1994). The response to N was found to be significant up to 80 kg N ha^{-1} in shallow lowland (0-30 cm water depth), up to 60 kg N ha^{-1} in intermediate lowland (30-50 cm) and up to 40 kg N ha^{-1} under semideep (50-100 cm) to deepwater (> 100 cm) conditions. Root zone placement of N as urea supergranules or single basal application of sulphur coated urea, urea gypsum and Mussoorie phos-coated urea was promising under lowland conditions (Sharma, 1994). Application of phosphorus along with N has been found essential particularly under the deficient soil and flash flood conditions (Reddy *et al.*, 1991). Under intermediate deepwater, there was response to different levels of

P in the first year but in the second year when the crop was grown in the same layout as of the previous year, a progressive increase in rice yield up to 60 kg P_2O_5 ha^{-1} was observed. This was possibly due to the residual effect suggesting application of moderate dose of P for better submergence tolerance and higher productivity. Response to K application has been found to be significant, particularly in the high rainfall regions and in light textured soils of the coastal regions under continuous rice cropping.

Sequence crops after the harvest of rice are normally grown without fertilizer or with meager dose of N. It is well known that nitrogen applied to *kharif* rice has little carry over effect to the succeeding crops and therefore it is necessary to apply required doses of N to these crops. It does not matter much if N is not applied to *rabi* pulses or not but oilseeds like groundnut, mustard, sunflower and safflower show good response to moderate dose of fertilizers. On the other hand, *kharif* rice can make better use of residual P because of its increased availability due to higher temperature and submergence of the soil. In rice-groundnut and rice-green gram cropping system under rainfed conditions, application of acidulated rock phosphate or a mixture of rock phosphate and superphosphate in 25:75 or 50:50 proportions has also been found to be a better source of P compared with superphosphate in acid soils of eastern India. In acid lateritic soils of coastal regions, application of 60-80 kg N and 40-60 kg P_2O_5 ha^{-1} is generally recommended. Rice workers agreed that direct application of powdered rock phosphate is superior to water soluble sources of P from agronomic point of view. Rock phosphates are considered useful in adding Ca and Mg in addition to P and also for reducing rate of P fixation. In the upland acid soils of Orissa, a combined use of water soluble P with rock phosphate is also suggested.

IPNS system: Experiments in acid lateritic soils of West Bengal have shown that virtually many available organic resources (paddy straw, farmyard manure, water hycinth compost, green manure, Azolla) along with fertilizer promoted the growth and yield of rice (Sharma and Mittra, 1990). It was advantageous to apply straw 4 weeks ahead of planting time. Under shallow lowlands in West Bengal, the yield potential of high yielding rice varieties under rainfed conditions was realized when organic manuring was carried out with the locally available organic materials for supplementing fertilizer N up to 50% of the total crop requirement (75-90 kg N ha^{-1}) (Sharma and Mittra, 1991). However, under the intermediate lowlands situation where the requirement for N was relatively lower (60 kg N ha^{-1}), about 75-100% of the crop needs could be met by applications of 10 t FYM ha^{-1} or *in situ* green manuring with *dhaincha* (Sharma, 1994, Sharma and Das, 1994). Such integrated nutrient supply system ensured continued availability of N to rice throughout its growth period and thus eliminated the use of N through top dressing of urea fertilizer, which is often infeasible under deeper depths of floodwater.

Irrigated situations

Balanced fertilization with N, P and K: Cropping systems involving rice throughout the year are practised in eastern and southern states. Since these cereal-based cropping systems require large quantities of nutrients for sustained productivity it is generally not possible to reduce the fertilizer dose for the succeeding crop without appreciable yield reduction.

The slow release N carriers like sulphur-coated urea and Mussoorie phos-coated urea have shown a significant residual effect on the succeeding crop of rice in rice-rice cropping system, but this alone was not sufficient to realize the yield potential of the *rabi* crop. Similarly, in the rice-wheat system in Kharagpur the result also showed some indication of residual effect of N applied in the form of slow release fertilizer like urea supergranules, and sulphur-coated urea to *kharif* rice (Kolhe and Mittra, 1987) but for sustained high level of productivity the recommended level of N was needed to be applied for wheat as well. In an experiment conducted in Krishna district of Andhra Pradesh on coarse textured soil it was suggested that appropriate integrated nutrient management strategies (Reddy, 1990) would include growing of green manure crops in off season, using coated urea, placing N in the root zone, use of soil application and foliar spraying in case of Zn for immediate productivity and long range of soil fertility maintenance (Table 1). In highly acidic saline soils (low in available P) in coastal West Bengal, studies indicated that liming of soil up to ½ SM (Shoemaker's) level and application of high doses of P fertilizers could improve rice yield. The beneficial effect of rock phosphates was not immediately reflected but its effect was observed after a few initial croppings. It was also observed that soil pH improved due to liming and application of rock phosphate but decreased subsequently due to discontinuation of liming which indicated that liming was necessary after a few years. They also indicated that liming of

Table 1. *Efficiency of various nutrient management methods (average of three years)*

Method of nutrient management	Grain yield (kg ha^{-1})	Cost (Rs. ha^{-1})*	B:C ratio
Soil incorporation of green gram	5031 (4742)	250	2.31
Soil incorporation of sunnhemp	4961 (4724)	250	1.89
Neem coated urea in rice (50:50:0) @100 kg N ha^{-1}	5193 (4720)	150	6.30
Urea + soil (1:5) in 25:50:25 split @ 100 kg N ha^{-1}	5228 (5023)	30	13.66
Root zone application of urea solution @ 100 kg N ha^{-1}	5790 (5185)	80	15.12
Zinc sulphate in moderate deficient soils @ 50 kg ha^{-1} **	5177 (4035)	183	12.41
Zinc sulphate in saline-alkali soils @ 100 kg ha^{-1} **	4590 (1805)	367	15.17
Three sprays of zinc sulphate @ 1 kg ha^{-1} per application at 15-30 DAT	5240 (4615)	230	9.61
Gypsum @ 500 kg ha^{-1} at pegging stage in *rabi* groundnut	1644 (1397)	200	9.88

* Additional cost of technology (values in parentheses are mean check yield)

** Average of three years

acid soils of Sundarbans may not render much benefit to rice cultivation, rather it may cause deficiency of several micronutrients especially Zn. At Kharagpur there was only a marginal response to direct application of P on rice (3-6 kg grain per kg P_2O_5) and the residual effect on the succeeding wheat or gram was also not appreciable to realize their high yields. Evaluation of rock phosphate as a source of P in rice-rice or rice-wheat system indicates that there is a tremendous potential to go in for direct application of ground rock phosphate in most neutral to acid soils (Randhawa, 1992). Since critical soil test values of P differ greatly for rice and wheat, these should be determined and advocated separately while making fertilizer recommendations in such cropping system.

There are indications of depletion of native soil reserve K in soils of Barrackpore and Bhubaneswar despite the continuous application of inorganic fertilizers. Studies carried out in Bhubaneswar showed that higher doses of K are extremely important for sustaining rice-rice productivity. The need for sulphur application has been established by LTFE experiment at Barrackpore and Bhubaneswar due the continuous use of sulphur free NPK for obtaining sustained high yields for dominant cropping systems of the agro-ecological regions represented by these centers (LTFE, 2000).

Iron toxicity is a major problem in coastal lateritic acid soils of India. Ferrous Fe concentration above (300-500 ppm) has been measured in the solution of several soils. It occurs in Karnataka, Kerala, Orissa and West Bengal. An example of manmade Fe toxicity was found in Goa where negligent iron ore mining has resulted in fertile soils overlain by ore waste through erosion and deposition. Iron toxicity by itself is rather a complex problem and is often related to insufficient supply of P, K, Zn and some times Ca and Mg rather than just a high level of active iron. Several corrective measures have been suggested to overcome iron toxicity in rice. These include liming, application of MnO_2, P and K (Patra and Mohanty, 1989). In Orissa, 60 kg of K_2O ha^{-1} was reported to correct Fe toxicity (Panda and Nanda, 1985). Survey conducted on fertility status of coastal sandy soils growing groundnut in Andhra Pradesh revealed that these soils were predominantly low in available N, P, K and Ca. The deficiencies of S and Zn are also emerging at alarming rate (Jamuna *et al.*, *1984*).

At Monokompu, Kerala, 90 kg N per ha through urea applied in splits (50% basal + 25% each at 30 DAT and PI stage or 50% at DAT + 25% each at 30 DAT and PI stage) gave the highest yield of 4 t ha^{-1} (Ittyavirah *et al.*, 1979). Application of 60-80 kg P_2O_5 ha^{-1} is also needed. Availability of Zn in acid sulphate soils is low because of inherent low Zn content or as a result of liming. To correct the Zn deficiency, either soil or spray application is needed. Ammonium acetate extractable iron in these soils has been reported to be in the range of 184-562 ppm (Ghosh *et al.*, 1976). The adverse effect of high concentration of ferrous Fe in the root zone can be taken care of by liming, P and K application, and drainage. Low to moderate toxicity in the early stages can be corrected by spraying 0.2-0.5% $MnSO_4$ solutions.

IPNS system: Nutrient use efficiency was found to increase considerably with combined use of organic and inorganic sources in red and lateritic soils under rice-rice sequences of coastal Orissa

(Panda and Sahu, 1989). Results of long term experiments under different crop sequences in alluvial, red and lateritic soils of coastal eastern India revealed that NPK + FYM was superior to 150% NPK in sustaining high crop yields (Table 2). The availability of soil nutrients also showed a build-up in soils receiving organics and inorganics compared to those receiving inorganic fertilizers alone (Table 3) (LTFE, 2000). At Navasari, in coastal Gujarat under rice-wheat system, the highest grain yield of rice (3.7 t ha^{-1}) was recorded under 50% NPK + 50% N as FYM followed by 75% NPK + 25% N as FYM which were however at par. In wheat, the highest grain yield (2.5 t ha^{-1}) was recorded under 75% NPK + 25% N as green organic matter.

A study conducted by CSSRI at Canning Town West Bengal on integrated nutrient management strategies for rice-based cropping system in salt affected soils suggested that application of chemical fertilizers supplemented through organic manure produced significantly higher rice yield than chemical fertilizers alone. Grain yield of rice through application of city compost (1.53% N) plus urea, applied in ratio of 3:1 in terms of N equivalence, was the highest (4.26 t ha^{-1}) among all treatments producing nearly 50% higher yield over control (farmer's practice, 20 kg N ha^{-1}) (Bandyopadhyay and Maji, 2001-2002). In another study in coastal saline soils of Sundarbans, the role of organic materials (*Glyricida* sp, *Exoecaria* sp and mixture of locally available tree leaves) supplementing N requirement in wetland rice was evaluated. It was observed that the organic materials were beneficial in reducing 50% of urea needed to rice crop without reduction in crop yield (Babu and Rao, 1996-97). Under AICRP Cropping System study at Bhubaneswar, during *kharif* rice, maximum yield (5.56 t ha^{-1}) was recorded under 75% NPK + 25% N as green organic matter followed by 50% NPK + 50% N as green organic matter. However 50% NPK + 50% N as FYM was statistically at par with recommended NPK. Yield recorded under 50% NPK + 25% N as green organic matter were at par with 50% NPK + 50% FYM in rice-rice system. Crop yield data under integrated nutrient management are shown in Table 4. From similar study at Karjat, coastal Gujarat, it was reported that full dose of NPK recorded the highest yield (6.26 t ha^{-1}) followed by 50% and 75% N substitution of recommended NPK in the form of FYM. The yield reduction under these treatments was 21.1% and 22%, respectively during *kharif*. During *rabi*, yield under recommended NPK and 75% NPK + 25% N as FYM were at par, whereas 0.8% yield reduction was noticed for 50% NPK + 50% N as crop residue over recommended NPK. At Karmana

Table 2. *Long term effect of organics and inorganic manuring on grain yield (t ha^{-1}) of crops*

Location	Crop	100% NPK	150% NPK	100% NPK + FYM
Barrackpore (Alluvial)(1972-98)	Rice	3.9	4.3	4.1
	Wheat	2.4	2.9	2.5
	Jute	2.2	2.3	2.2
Bhubaneswar (1973-1994)	Rice	2.8	3.0	3.5
	Rice	3.0	3.3	3.7

Table 3. *Fertilizer use and changes in nutrient availability of soils of eastern India (LTFE, 1972-1994)*

Location/fertilizer treatment	Changes (±) in the available nutrient status of soil (kg ha^{-1}) compared to the initial value		
	N	P	K
Barrackpore (Alluvial)			
NPK + FYM	+105	+8	+55
NPK	+101	+5	+52
NP	+100	+15	-9
N	+85	-18	-47
Bhubaneswar (Lateritic)			
NPK + FYM	-	+98	+22
NPK	-	+47	+26
NP	-	+63	+6
N	-	-24	-10

Table 4. *Crop yields (t ha^{-1}) in farmers' fields with integrated use of manures and fertilizers in the eastern coastal regions of India*

Location	Nutrients added through	1994-95		1995-96	
		Rice (K)	Rice (R)	Rice (K)	Rice (R)
West Bengal (Midnapur)	Fertilizer (NPK)	1.8	4.6	2.8	5.1
	Fert.+Green manure (GM)*	2.3	5.1	3.2	6.1
	Increase/decrease (±) over NPK	(+0.5)	(+0.5)	(+0.4)	(+1.0)
Orissa (Puri)	NPK	4.0	1.6	3.1	4.2
	NPK+GM	5.4	2.0	3.5	4.5
	Increase/decrease (±) over NPK	(+1.4)	(+0.4)	(+0.4)	(+0.3)
		Rice	Groundnut	Rice	Groundnut
	NPK	3.1	2.4	3.1	3.2
	NPK+GM	3.4	3.3	4.0	2.8
	Increase/decrease (±) over NPK	(+0.3)	(+0.9)	(+0.9)	(-0.4)

K = *Kharif*, R = *Rabi*; * Dhaincha (*Sesbania aculeata*) grown and ploughed 45 days before *kharif* rice

in coastal Kerala, under rice-rice system, it was observed that the highest yield (5.6 t ha^{-1}) was recorded under 50% NPK + 50% as green organic matter during *kharif*. Integrated nutrient sources recorded increase in yield over recommended NPK to the tune of 9%, 7.4% and 2.39% under 50% NPK + 50% N as crop residues, 75% NPK + 25% N as crop residues, and 50% NPK + 50% N as green manuring, respectively. In *rabi*, 50% NPK+ 50% crop residues recorded the highest yield (4.25 t ha^{-1}) and 9% increase in yield over recommended NPK.

Several crops and plant species have been used as green manures in rice-based cropping systems. Some common leguminous green manure crops are: Sunnhemp (*Crotolaria juncea*), Dhaincha (*Sesbania aculeata*), Mung bean, Cowpea. Berseem, etc. These when incorporated six to seven weeks prior to rice transplanting benefits crops in terms of yield, nutrient use efficiency and building up of soil health. Results from various studies clearly indicated the benefits (Table 4) of integrated use of green manures and fertilizers (Sarkar, 1998).

Lime and fertilizer applications are required to obtain good yield in acid suphate soils. Flushing the soil wherever possible can also reduce the concentration of toxic salts. Field experiment with green manures conducted at Mannuthy, Kerala in a highly acidic soils (pH 4.9) to study the effect of *in situ* incorporation of *dhaincha* in presence and absence of inorganic fertilizers on rice production. Results indicated that the highest grain yield of rice (29.6% increase over *dhaincha* application alone) was recorded with treatment combination containing half of the recommended fertilizer dose (35, 17.5, 17.5 kg ha^{-1}, N, P_2O_5 and K_2O, respectively) supplemented with *dhaincha in situ* incorporation (Table 5).

Table 5. *Grain yield of rice as influenced by dhaincha incorporation with and without fertilizers*

Treatment	Grain yield (kg ha^{-1})	% Increase
Dhaincha alone	3246	-
NPK (70-35-35n kg ha^{-1})	4129	27.2
Dhaincha + 70-35-35n kg ha^{-1})	4208	29.6
CD (p=0.05)	490	

In trials under rice-based cropping system conducted at ICAR Research Complex Goa, it was observed that rotating groundnut with rice increased the grain yield of subsequent rice crop markedly. Also rice grown under recycled paddy straw with mushroom substrate in 2:1 ratio consistently registered higher productivity (4.5 t ha^{-1}) (Samra, 2004). Among the different cropping systems tried, rice-brinjal system produced the best productivity level particularly under recycled FYM. It was observed that rice-cowpea system was the best under residual moisture condition.

Yield levels with nutrient uptake and balance

Balanced fertilization with N, P and K: Production potential of rice-based cropping systems depends on the availability of assured irrigation and other essential inputs like fertilizers. The average productivity of the dominant rice-rice cropping system in southern India has been reported to vary from 7.4-9.4 t ha^{-1}, whereas that of rice-wheat system in northwestern India ranged from 7.5-11.2 t ha^{-1}. Nutrient uptake data provide a reliable estimate of nutrient requirement of a crop which thus helps in formulating fertilizer recommendation schedules in multiple cropping systems. At

Bhubaneswar under rice-rice cropping it was revealed that during *kharif*, the effect of NPK levels was highly significant at 80 kg ha^{-1}, 40 kg ha^{-1} and 40 kg ha^{-1}, respectively. During *rabi*, NPK levels effect was significant at 120, 80 and 40 kg ha^{-1}, respectively. Similar study by AICRP-CS at Karmana, Kerala showed that highest grain yield of *kharif* rice was attained with application of 80 kg ha^{-1} of N and 80 kg of P_2O_5. The effect of K_2O was non-significant. However, during *rabi*, 80 kg ha^{-1} of P_2O_5 was at par with 40 kg ha^{-1} of P_2O_5.

Cropping systems involving cereals remove large quantities of nutrients from soil and thereby may lead to impoverishment of fertile soils under situation of imbalanced and improper use of fertilizers. Nutrient balance in different rice-based cropping system indicate that removal of N and P almost equals the amount added at 50% recommended level of NPK but at higher levels (100-150% NPK), there is an increasingly positive balance (Prasad, 1994). The coastal saline soils of Sundarbans (soils rich in available P and K) generally did not respond to the application of P and K fertilizers. But the long term study suggested slow but gradual decline in available P status of the soil due to continuous omission of P fertilizers. Application or omission of N fertilizer also didn't show any effect on the available N content of the soil. The result suggested that application of P@ 11 kg ha^{-1} for each crop of rice and 5 kg ha^{-1} for each crop of maize was necessary for maintaining P fertility status of coastal soils. Application of N for each crop was, however, essential for higher yield. Application of K may be omitted without affecting the yield of crops and K fertility status of soil (Bandyopadhyay and Burman, 2004-05). At Navasari, Gujarat experiment was conducted by AICRP-CS to determine the frequency of P application for judicious use of P fertilizer under rice-rice system. Results revealed the highest grain yield (4.29 t ha^{-1}) of rice under P application in alternate years during *kharif* followed by P application in alternate years in *rabi* only as compared to P application during both *kharif* and *rabi*. The percentage yield increase for the above treatment was the highest at 8.74% as compared to P application during both *kharif* and *rabi*.

IPNS system : Organic manuring with FYM improved the status of organic carbon and total N, but in the un-manured plots, these were stable around the original level (Sharma and Sharma, 1993). Therefore, a positive nutrient balance and gradual build-up of soil fertility through judicious application of chemical fertilizers along with available sources organic matter and inclusion of legume in a rice-based cropping systems would help in sustaining productivity at a higher level.

Pattanayak *et al.* (2001) reported that in a medium land sandy acidic soil under rice *dhaincha* and azolla were better green manure crops than sunnhemp. Further the P sources like single superphosphate (SSP) and Udaipur rock phosphate (URP) mixture in the ratio 1:1 was more efficient than the lone source of URP and as good as lone application of SSP in influencing their biomass production, N addition, and recycling of nutrients like P, K, Ca and Mg which benefited the subsequent rice crop with increased yield and N economy (Table 6). In rice-rice experiment at Bhubanswar, highest yield of rice during both *kharif* and *rabi* was recorded to the tune of 4.9 t ha^{-1} and 5 t ha^{-1} under recommended dose of NPK + cellulolytic microorganisms, followed by the recommended dose of N + FYM 5 t ha^{-1} applied during *kharif* and the recommended dose of N + 20 kg extra N through incorporation of crop residue during *rabi*. Both recommended dose of N + FYM @ 5 t ha^{-1} and application of N + 20 kg extra N were at par statistically in terms of system yield (Anon., 2003-04).

Table 6. *Yield of rice as affected by various green manure crops fertilized with different P source*

Source of P	Grain yield (q ha^{-1})				
	No GM	Dhaincha	Sunnhemp	Azolla	Mean
SSP	29.5	35.7	32.2	36.0	33.4
URP	27.3	34.6	31.8	33.8	31.9
SSP+URP	30.0	36.2	31.8	35.8	33.9
Mean	29.0	34.5	31.8	35.2	-
CD (p=0.05)	P-Sources	GM	P-sources x GM		
	1.37	1.58	2.73		

SSP: Single super phosphate; URP: Udaipur rock phosphate

Continuous rice cropping and soil fertility

It is commonly believed that continuous cropping with rice using heavy doses of chemical fertilizers over a prolonged period results in soil fertility deterioration and exceedingly low crop yields. This has been found to be associated with poor soil physical conditions and imbalance in micro- and secondary nutrients and build-up of soil acidity. Application of N alone failed to achieve productivity level even equal to the control plots (no N) after 12 years in rice- rice and rice-wheat cropping systems (LTFE, 2000). In a long term experiment in Bhubaneswar in lateritic soils it was observed that integrated use of FYM @ 10 t ha^{-1} and chemical fertilizer in *kharif* did not result in higher yield, although produced more stable production. Response to P appeared only after the 8th cropping cycle when Olsen P level decreased to 15 kg ha^{-1}. There was a greater response to P in *rabi* season and K came up as the most limiting factor in crop production (Sahoo *et al.*, 1998). Application of lime @ 11 t ha^{-1} in alternate years arrested the slow building of soil acidity, alleviated Fe toxicity and improved productivity significantly. The integrated use of lime, organic manure and chemical fertilizers with emphasis on K and S in *kharif* and P and B in *rabi* resulted in sustained productivity of rice-rice system in coastal Orissa.

In rice-based cropping system productivity of crops improved gradually by the use of organic manures. Incorporation of FYM at 10-15 t ha^{-1} along with 100% NPK dose produced an additional yield of 0.3-0.6 t ha^{-1} over 150% NPK dose in, rice-wheat and rice-rice cropping systems (Nambiar, 1985). Further, results showed that yield of rice increased initially for a few years with NPK application, but subsequently the productivity started decreasing particularly when no fertilizer or only N was applied. On the other hand, there was a progressive increase in yield with application of FYM along with recommended doses of NPK fertilizers (Prasad and Power, 1994). Therefore, to stabilize crop yields at a high level without deterioration of soil health, application of NPK fertilizers at optimal rates accompanied with FYM is recommended. Build-up of available P and K is often noticed in those rice-based cropping systems, which included potato as one of the component crops (LTFE, 2000). Applications of industrial wastes, viz. paper factory sludge (PFS), fly ash (FA) and rice husk (RH) along with farmyard manure (FYM) and mineral fertilizers (MF) in an acid lateritic soil improved growth, yield attributes, yield and nutrient uptake of both crops, rice (wet season) and groundnut (dry season) in a two-crop system (Karmakar *et al.*, 2003). The study also indicated that such integrated nutrient management system improved soil health with respect to bulk density, pH, organic carbon and available nutrient content of soil

IPNS packages for nutrient needs of dominant rice-based cropping systems in coastal ecosystem

The IPNS system reduces the production cost by saving of costly chemical fertilizers, ensures soil health and minimizes environmental pollution. Sharma and Biswas (2004) reported IPNS package for various rice-based cropping systems under various agroclimatic zones. Here, we presented some of the pertinent packages based on rice-based cropping under coastal ecosystems (Table 7).

CONCLUSION

Under conditions of fertilizer scarcity and higher cost, economic use of fertilizers and their efficient management is of greater significance. Extensive use of moderate to low doses of fertilizers with an assured return is preferable to high inputs with comparatively lower and/or risky monetary returns. Some guiding principles for efficient fertilizer use in rice-based cropping systems are as follows:

1. Nutrients applied once in a cropping system should be given to most responsive crop having high requirement for that nutrient e.g. N should be applied to both the crops in rice- cereal system, P to *rabi*/summer legumes, and P and K to potato. Further, organic manures should be applied to *kharif* rice because of their better decomposition and assimilation.
2. While fertilizer use is a must for higher crop production, imbalanced use should be avoided based on soil test in order to get better results.
3. Soil fertility and productivity can be maintained and improved through the conjunctive use of available renewable sources of plant nutrients and chemical fertilizers. A reduction in the use of chemical fertilizers through such combination should be made for enhancing nutrient-use efficiency, besides for being cost effective and rational in using farm resources.
4. In the exhaustive rice-cereal system, legumes should be suitably fitted to augment productivity and maintain soil fertility. Legume residues should be returned to the soil after harvest or a green manure crop can be raised before *kharif* rice, wherever feasible.

Table 7. *Recommended IPNS package for coastal ecosystems*

Cropping system	Fertilizer recommendation	IPNS package
Lower Gangetic plains (mainly plains of Bengal; alluvial and red and lateritic soils)		
Rice-Rice	Rice: 80 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}	Rice: 60 kg N + 40 kg P_2O_5 + 30 kg K_2O + FYM GM @ 10 t ha^{-1} + 20 kg $ZnSO_4$ ha^{-1}
	Rice (HYV): 120 kg N + 80 kg P_2O_5 + 60 kg K_2O ha^{-1}	Rice: 90 kg N + 80 kg P_2O_5 + 60 kg K_2O + Azolla @ 10 t ha^{-1}
Rice-wheat	Rice: 80 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}	Rice: 40 kg N + 45 kg P_2O_5 + 30 kg K_2O + FYM/ GM @ 10 t ha^{-1} + azolla @ 10 t ha^{-1}/BGA @ 10 kg ha^{-1} + 20 kg $ZnSO_4$ ha^{-1}
	Wheat: 120 kg N + 60 kg P_2O_5 + 60 kg K_2O ha^{-1}	Wheat: 90 kg N + 45 kg P_2O_5 + 45 kg K_2O ha^{-1}
Jute-Rice-Potato	Jute: 40 kg N + 20 kg P_2O_5 + 40 kg K_2O ha^{-1}	Jute: 30 kg N + FYM @ 5 t ha^{-1}
	Rice: 60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	Rice: 30 kg N + 30 kg P_2O_5 + 30 kg K_2O + azolla @ 10 t ha^{-1}/BGA @ 10 kg ha^{-1} + 20 kg $ZnSO_4$ ha^{-1}
	Potato: 180 kg N + 80 kg P_2O_5 + 120 kg K_2O ha^{-1}	Potato: 150 kg N + 40 kg P_2O_5 + 100 kg K_2O + FYM @ 5 t ha^{-1} + seed treatment with azotobacter and PSB
East Coast Plains and *Ghats* and West Coast Plains Regions (Red and Lateritic and alluvial soils)*		
Rice-Rice	Rice: 100 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	Rice: 75 kg N + 15 kg P_2O_5 + 15 kg K_2O + FYM Green manure @ 5 t ha^{-1}
	Rice: 120 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}	Rice: 90 kg N + 60 kg P_2O_5 + 40 kg K_2O + azolla @ 10 t ha^{-1} / BGA @ 10 kg ha^{-1} + 20 kg $ZnSO_4$ ha^{-1}
Rice-Pulses	Rice: 100 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	Rice: 25 kg N + 15 kg K_2O ha^{-1} + pulse crop residue incorporation + azolla @ 10 t ha^{-1} / BGA @ 10 kg ha^{-1}
	Pulses: 20 kg N + 40 kg P_2O_5 + 20 kg K_2O ha^{-1} + rhizobium	Pulses: 10 kg N + 20 kg P_2O_5 + 10 kg K_2O ha^{-1} + rhizobium + 2.5 t FYM ha^{-1} + 500 g PSB ha^{-1}

* Liming @ 3-4 q ha^{-1} in furrows at the time of sowing for soils having pH $\leq$ 5.5

5. Deterioration of soil health can be checked by efficient use of fertilizers/manures (farmyard manure), appropriate cultural practices, and selection of suitable fertility building crops in rice-based cropping system in coastal India.
6. Acid sulphate soils can be managed by split application of N fertilizer in rice, foliar application of Zn and possible drainage to flush out the excess salts.
7. Integrated use of nutrient management schedule should be followed to avoid any possible deficiencies of major, secondary and micronutrients. Green manuring should be followed to reduce P fixation and Fe toxicity in coastal acid soils.

Future research work

IPNS strategies for adoption in coastal regions of India for rice based cropping systems :

1. Liming or farmyard manure use along with NPK fertilizers
2. Use of crop wastes with organic manures with NPK fertilizers in rainfed areas
3. Use of B, Mo and lime and organic manures with NPK fertilizers in vegetable crops
4. Green manuring/organic manuring with rock phosphate application in rice along with N and K fertilizers
5. Use of lime, P and Mo and *Rhizobium* culture in pulses besides N and K fertilizers
6. Development of appropriate cultivars and formulation of their nutrient management schedules under rainfed and problem soil conditions
7. Development of more efficient and economic integrated plant nutrient management system

using locally available organic sources in conjunction with chemical fertilizers for realizing high productivity simultaneously enahncing soil quality

8. Application of micronutrients and secondary nutrients whose deficiencies are gradually becoming more wide spread in the intensive cropping systems
9. Constant monitoring of soil available nutrient along with micronutrients and their balance sheet should be worked out under different soils and climatic conditions
10. The positive gains from the organic manures should be worked out with respect to the soil physical condition
11. Use of modern scientific tools such as biotechnology and genetic engineering to develop new plant types which are efficient user of nutrients both from soil and atmosphere side-by-side resulting in higher grain yield
12. Soil quality assessment through development of suitable soil quality indices under rice-based cropping systems in coastal eco-systems for sustainable crop production

REFERENCES

Acharya, C.L., Subba Rao, A., Biswas, A.K., Sammi Reddy, K., Yadav, R.L., Dwivesdi, B.S., Shukla, A.K., Singh, V.K. and Sharma, S.K. (2003). *Methodologies and Package of Practices on Improved Fertilizer Use Efficiency under Various Agro-climatic Regions for Different Crops/ Cropping Systems and Soil Conditions*, Bulletin, Indian Institute of Soil Science, Bhopal. 74p.

Anon. (2003-04). In *Annual Report*, Project Directorate Cropping Systems Research, Modipuram, Meerut.

Babu Ravindra and Rao Gururaja, G. (1996-97). Evaluations of breeding of arable crops for salt affected black soils of Bhatt region. In *Annual Report*, pp. 77-78, Central Soil Salinity Research Institute, Karnal, India.

Bandyopadhyaya, A.K. and Sinha, T. S. (1985). Rice cultivation in coastal saline soils. *Better Farming in Salt Affected Soils Series*, No. **10**, CSSRI, Karnal. 11p.

Bandyopadhyaya, A.K. and Sarkar, D. (1987). Occurrence of acid-saline soils in coastal area in Sundarban area of West Bengal. *Journal of Indian Society of Soil Science* **35**: 542-544.

Bandyopadhyay, B.K. and Maji, B. (2001-02). Long-term experiment to study the effect of mixing P and K treatment on yield of crops. In *Annual Report*, pp. 88, Central Soil Salinity Research Institute, Karnal, India.

Bandyopadhyay, B.K. and Burman, D. (2004-05). Long-term experiment to study the effect of mixing P and K treatment on yield of crop. In *Annual Report*, pp. 86, Central Soil Salinity Research Institute, Karnal, India.

Ghosh, S.K., Das, D.K. and Deb, D.L. (1976). In *Physical, Chemical and Mineralogical Characteristics of Acid Sulphate Soils of Kerala*, Bulletin No. **11**, pp. 117-130, Indian Society of Soil Science.

Ittyavirah, P.J., Nair, S.S., Pillai, K.S. and Verghese, T. (1979). Feasibility of moderate nitrogen technology for rice in acid sulphate soils of Kuttanad in Kerala. *Fertilizer News* **24**: 43-44.

Jamuna, P., Parvathamma, N., Subramanyam, K., Subba Rao, A. and Pillai, R.N. (1984). Fertility status of coastal sands growing groundnut in Guntur and Prakasam districts of Andhra Pradesh. *The Andhra Agricultural Journal* **31**(4): 344-356.

Karmakar, S., Mittra, B.N. and Ghosh, B.C. (2003). Integrated nutrient management in rice-groundnut cropping system utilizing industrial wastes. *Fertilizer News* **48**(3): 31-34 & 37-40.

Kolhe, S.S. and Mittra B.N. (1987). Direct and residual effect of slow release urea fertilizers in rice-wheat cropping system. *Journal of Agronomy and Crop Science* **158**(3): 199-194.

LTFE (2000). *Three Decades of AICRP on Long-term Fertility Experiment to Study the Changes in Soil Quality, Crop Productivity and Sustainability*, A. Swarup (ed.), Bulletin, Indian Institute of Soil Science, Bhopal, India. 59p.

Maohapatra, I.C. and Patnaik, S. (1982). Management of upland rice soils. In Transaction *12th International Congress Soil Science*, Symposium Papers **II**, pp. 212-228.

Nambiar, K.K.M. (1985). All India Co-coordinated Research Project on long term fertilizer experiments and its research achievements. *Fertilizer News* **10**(4): 56-66.

Panda, N. and Nanda, S.S.K. (1985). Soils of Orissa and their management. In *Soils of India and their Management*, pp. 177-207. Fertilizer Association of India, New Delhi.

Panda, N. (1987). Acid soils of eastern India–their chemistry and management. *Journal of Indian Society of Soil Science* **35**: 568-581.

Panda, N. and Sahu, D. (1989). Long-term effects of manures and fertilizers in rice-based cropping systems in subhumid lateritic soils. *Fertilizer News* **34**(4): 39-44.

Patnaik, S. and Bhadrachalam, A. (1985). Amelioration and management of low productive and problem soils for optimizing rice yield. In *Rice Research in India*, pp. 280-308, ICAR, New Delhi.

Patra, B.N. and Mohanty, S.K. (1989). Effects of amendments on transformation of Fe and Mn in iron toxic rice soils under submergence. *Journal of Indian Society of Soil Science* **37**: 276-283.

Pattanayak, S.K., Misra, K.N., Jena, M.K. and Nayak, R.K. (2001). Evaluation of green manure crops fertilized with various sources and their effect on subsequent rice crop. *Journal of Indian Society of Soil Science* **49**(2): 285-291.

Prasad, B. (1994). Integrated Nutrient Management (INM) for sustainable agriculture. *Fertilizer News* **39**(9): 19-25.

Prasad, R. and Power, J.F. (1994). In Proceedings FAI Seminar *Challenges of Liberalization in the Fertilizer and Agriculture Sectors*, C **III/4**, pp. 1-12. Fertilizer Association of India, New Delhi.

Randhawa, N.S. (1992). In Proceeding National Symposium *Resource Management for Sustained Crop Production*, pp. 17-30, Indian Society of Agronomy, RAU, Bikaner.

Reddy, M.D., Sharma, A.R. and Panda, M.M. (1991). Flood tolerance of rice grown under intermediate deep water conditions (15-50 cm) as affected by phosphorus fertilizers. *Journal of Agricultural Sciences* (Cambridge) **117**: 319-324.

Reddy, M.N. (1990). Integrated nutrient management for rice based cropping systems. In Proceedings International Symposium *Rice Research Frontiers*, K. Murlidharan, K.V. Rao, K. Satyanaraya, G.S.V. Prasad & E.A.Siddque (eds.), pp. 301-302, held at Directorate of Rice Research, Hyderabad, 15-18 Nov, 1990.

Sahoo, D., Rout, K.K. and Misra, V. (1998). Effect of twenty-five years of fertilizer application on productivity of rice-rice system. In *Long-term Fertility Management through Integrated Plant Nutrient Supply*, A. Swarup, D.D. Reddy & R.N. Prasad (eds.), pp. 206-214, Indian Institute of Soil Science, Bhopal.

Samra, J.S. (2004). Resource management options in multi enterprise Agriculture. In *Multi Enterprise System for Viable Agriculture*, Proceedings *6th Agricultural Science Congress*, C.L. Acharya, R.K. Gupta, D.L.N. Rao & A.S. Rao (eds.), pp. 19-39, Indian Institute of Soil Science, Bhopal.

Sarkar, A.K. (1998). Integrated nutrient management strategies for sustainable crop production in eastern region. In *Long-term Fertility Management through Integrated Plant Nutrient Supply*, A. Swarup, D.D. Reddy & R.N. Prasad (eds.), pp. 112-124, Indian Institute of Soil Science, Bhopal.

Sehgal, J., Mandal, D.K., Mandal, C. and Vadivelu, S. (1992). *Agro-ecological Sub-region of India*, NBSS Publication No. **24**, NBSS & LUP, Nagpur. 75p.

Sharma, A.R. and Mittra, B.N. (1991). Bio-and mineral fertilizers in rice based cropping systems for yield maximization of rice-wheat cropping system complementary effect of organic. *Fertilizer News* **35**(2): 43-51.

Sharma, A.R. (1994). Fertilizer Management in rainfed low land rice under excess water conditions. *Fertilizer News* **39**(5): 35-44.

Sharma, A.R. and Das, K.C. (1994). Effect of green manuring rice under intermediate deep water conditions (0-50 cm). *Journal of Agricultural Sciences* (Cambridge) **122**: 359-364.

Sharma, G.D. and Sharma, H.L. (1993). Fertility management for yield maximization of rice-wheat cropping systems. *Fertilizer News* **38**(11): 19-23.

Sharma, P.D. and Biswas, P.P. (2004). IPNS packages for dominant cropping systems in different agro-climatic regions of the country. *Fertilizer News* **44**(10): 43-47.

Van Breeman and Pons, L.J. (1978). Acid sulphate soils and rice. In *Soils and Rice*, pp. 739-761, IRRI, Philippines.

Yadav, J.S.P., Bandyopadhyaya, A.K., Rao, K.V.G.K., Sinha, T.S. and Biswas, C.R. (1979). *Coastal Saline Soils of India*, Bulletin No. **5**, CSSRI, Karnal. 34p.

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Integrated Water Management Strategies for Coastal Ecosystem

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Management of rainwater is central and crucial that forms the basis for improvement in the coastal region of the country. Integrated natural resource management appears to be a correct approach for watershed management. However, looking to the small land holdings in coastal ecosystem, farming system approach, in particular, seems to be more appropriate. It is an integrated approach for rainwater management dealing with on-farm storage of excess rainwater during monsoon season and recycling the same for irrigation of crops during deficit periods in dry season with the objective to introduce multicropping and multiple use of water in the otherwise predominantly monocropped rice areas. The application of a user-friendly computer software (RAINSIM), developed for this purpose based on study at Central Soil Salinity Research Institute, Regional Station, Canning Town, West Bengal, is illustrated for assessing the extent of waterlogging/drought periods, optimal design of on-farm reservoir, simulation of surface drainage improvement, estimation of supplemental irrigation, crop planning and optimal allocation of land and water. In another study at IIT, Delhi, application of modern tools such as remote sensing and geographical information system was found to be helpful in mapping lowlying lands, wetland vegetation and forest cover, crop yield estimation, and in assessing performance of the irrigation/drainage systems. As an overall strategy, it is important to evolve location specific farming system components through systems engineering for maximizing net returns to the farmers.

*(**Key words :** Integrated water management, Farming system approach, Water productivity, Software on water harvesting & recycling, Crop calendar, Drainage assessment, Use of satellite data, Estimation of crop yield and water logged / salt affected land)*

The agriculture in the coastal ecosystem is predominantly rainfed in nature, characterized by excess water during the rainy season followed by acute water scarcity in the post-monsoon period. This poses severe threat to improved agricultural production as well as productivity. On the other hand, coastal regions are seen as the potential areas for bridging the expected shortages in the national food production in future due to high rainfall which provides scope to increased agricultural productivity which is low at present (Table 1). Management of rainwater is, therefore, central and crucial particularly with regard to the small holdings generally occurring in the coastal ecosystem. This calls for development of strategic technological packages based on integrated natural resource management suiting to different coastal subsystems.

Integrated natural resource management, watershed management or farming system approach are the terms often used synonymously though their dimension of area vary from basin to farm scale. Integrated natural resource management may be a correct approach for watershed management. However, looking to the small land holdings in coastal ecosystem, farming system approach, in particular, seems to be more appropriate. It is an integrated approach for rainwater management dealing with on-farm storage of excess rainwater during monsoon season and recycling the same for irrigation of crops during deficit periods in dry season with the objective to introduce multicropping and multiple use of water in the otherwise predominantly monocropped rice areas. Since rice is the main cropping system in the entire coastal region, focus needs to be reoriented towards an integrated planning for rice-based crop planning which may be compatible with the available land and water resources for improved and sustainable productivity. The strategy for management of natural resources consists of construction of drainage embankments, reduction in surface waterlogging, rainwater conservation, provision of supplemental irrigation, precision farming, farming system approach, optimal land and water allocation. The application of user-friendly computer software, RAINSIM, developed for this purpose, is illustrated in the Sundarbans delta, West Bengal for assessing the extent of waterlogging/drought periods, optimal design of on-farm reservoir, simulation of surface drainage improvement, estimation of supplemental irrigation, crop planning and optimal allocation of land and water.

Table 1. *Rice productivity in coastal India*

Region/crops	Average land productivity# (kg/m^2)	Experimental productivity		Reference for water productivity
		Land (kg/m^2)	Water (kg/m^3)	
West Bengal	0.25	0.50	0.36	Ambast *et al.* (1998)
Orissa	0.16	0.56	0.21	Kar *et al.* (2004)
Andhra Pradesh	0.30	0.59	-	-
Tamil Nadu	0.33	0.53	-	-
Kerala	0.22	0.57	-	-
Karnataka	0.22	0.53	0.61	-
Maharashtra	0.18	0.45	-	Manjunatha *et al.* (2004)
Gujarat	0.15	0.56	-	-
All India	0.28	0.58	-	-

Crop water productivity (kg/m^3) = Yield (kg/ha)/Water consumed in ET+Losses (m^3/ha)

Based on Statistical Abstract of India, 2003

Application of modern tools such as remote sensing and geographical information system may be helpful in lowlying lands, wetland vegetation and forest cover mapping, crop yield estimation, and in assessing the performance of the drainage systems. Further, micro-zoning should be the basis for effective implementation of the integrated natural resource management in improving the coastal agricultural productivity.

Coastal ecosystem

The National Bureau of Soil Survey & Land Use Planning of India (Sehgal *et al.*, 1992) has brought out a 21 zone agro-ecological regional map of the country, essentially based on physiography, soils, bioclimatic types, and growing period, which influences the supply of water for plant growth. The zones coming under coastal ecosystems are:

(a) *Eastern Coastal Plain*: Hot subhumid ecoregion with alluvium, derived soils. It covers the estern coastal plain extending from Cauvery Delta to Gangetic Delta and occupies 2.5% of the land area. It has hot summers and mild winters, with an annual rainfall of 1200 to 1600 mm. The growing period ranges from 150-210 days. The soils are mainly clayey with slight acidity. Rainfed and irrigated rice farming are practised. Imperfect drainage and salinity are the major constraints.

(b) *Western* Ghats *and Coastal Plains*: Hot humid-perhumid ecoregion with red, laterite and alluvium-derived soils. It constitutes Western coastal plains of Maharashtra, Karnataka, and Kerala States covering 3% of the land area. It has hot summers, with rainfall exceeding 2000 mm. The growing period is more than 270 days. It has red, lateritic and alluvial soils. Waterlogging and severe erosion are the major problems. It has high potential for export oriented plantation crops.

Climate and soils

The climate of most of the coastal subregions in India falls under the hot and humid or subhumid condition with limited variations (except the north Gujarat coast which is semi-arid). Almost the entire coastal area in the country, excluding the north Gujarat coast, receives a normal annual rainfall in excess of 1000 mm with the west cost receiving more than 2500 mm per year and 80% of it occurring during June to September in Gujarat, Maharashtra and Karnataka. In West Bengal and Orissa some amount of rainfall is also received during May and October as well. Tamil Nadu receives about 70% of rainfall during October and November. Thus, most of the coastal areas have surplus rainfall either during June-September or October-December. In the coastal areas, very heavy rainfall events of 200 to 400 mm in 24 hours are frequent thereby causing surface waterlogging, flash floods and damage to crops and property.

The average maximum temperatures are in the range of 25 to 30°C, whereas the average minimum temperatures seldom fall below 20°C during the winter months of December to February. The annual evaporation ranges from 1350 to 2150 mm in West Bengal and in Gujarat, respectively. The high evaporation causes salinization of surface soil especially in dry seasons in the presence of high and poor quality groundwater.

Soils in coastal areas are in general deep to very deep, imperfectly to poorly drained, sand to fine loamy to fine in texture. The sandy shores are covered partly with water during high tides and stormy periods. The soils are calcareous, slightly to moderately saline, and alkaline. Heavy exploitation of groundwater in many coastal areas has resulted in seawater intrusion and development of high soil salinity.

Production system constraints

The agriculture in the coastal ecosystem is predominantly rainfed in nature and is characterized by excess water during the rainy season followed by acute water scarcity in the post-monsoon period, and this poses a severe threat to improved agricultural production as well as productivity of the regions. Management of rainwater is, therefore, crucial particularly with regard to the small holdings in the coastal ecosystem. Apart from erratic rainfall pattern, the poor and inefficient water management practices result in about 70% loss of the rainwater, mostly as surface runoff, to the sea, thereby reducing the per capita availability of fresh water to the coastal people. Kerala State presents a typical example, where despite more than 3000 mm annual rainfall, the per capita effective rainwater availability is less than even some dry parts of Rajasthan mainly due to heavy surface runoff loss because of steeply sloping topography, excessive deforestation and road construction. Moreover, the growing competitive demand for good quality water from industry, power and household sectors is further compounding the water crisis. The excess runoff results in eroding the top fertile soils of the region and also leads to poor ground water recharge due to lesser ponding time. The indiscriminate and excessive withdrawal of ground water causes lowering of water table and also ingress of seawater, which in turn, leads to acute salinization of land and water. The poor drainage is another key factor limiting the agricultural production in the coastal region. The excess rainwater available during the monsoon period needs to be conserved through reduced runoff and storage in ponds so as to reuse it as life saving irrigations to the crops during the lean periods. However, it is important to optimize the land and water allocation for maximizing the net profits. The problems related to productivity in coastal soils may be summarized as:

1. Inundation of agricultural lands by tidal water and seawater ingress in aquifers
2. High soil salinity due to shallow saline groundwater in winter/summer months
3. High rainfall in monsoon months and cyclonic weather
4. Impeded surface and subsurface drainage conditions
5. Uneven distribution of rainfall causing lack of good quality irrigation water for second crops during dry periods
6. Lack of irrigation infrastructure

Improving productivity through natural resource management

Integrated natural resource management, watershed management or farming system approach are the terms often used synonymously though their dimensions of area vary from basin to farm scale (Fig. 1). The integrated natural resource management may be good for planning strategy, watershed management may be good for program implementation, while farming system approach should be more suiting to the beneficiaries with small land holdings. In all these approaches, rainwater management forms the basis of improvement. However, looking to the small land holdings in coastal ecosystem, farming system approach seems to be more appropriate. It is an integrated approach on rainwater management dealing with on-farm storage of excess rainwater during monsoon season and recycling the same for irrigation of crops during deficit periods in dry season with the objective to introduce multicropping in the otherwise predominantly monocropped areas.

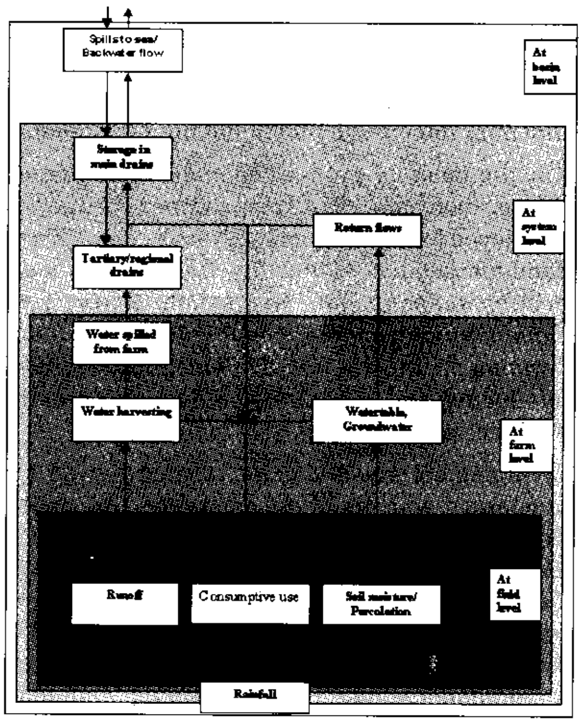

Fig.1. A comprehensive framework of hydrological processes at different scales

Rainwater management

Almost entire coastal area in the country receives normal annual rainfall of about 1500 mm. Of that, 80% of the rainfall is occurring in four monsoon months during June to October, except in Tamil Nadu, and there is very little water in the remaining period. Therefore, the prospect of crop and water productivity improvement in the entire coastal ecosystem is largely dependent and centered around the rainfall. This calls for development of strategic technological packages based on integrated natural resource management suiting to different subsystems.

.A comprehensive work on rainwater management, based on a study conducted at Central Soil Salinity Research Institute, Regional Station, Canning Town, West Bengal (Sundarbans delta), was presented by Ambast *et al.* (1998). They analyzed historical annual, monthly and weekly rainfall and evaporation data and fitted to different probabilistic distributions for various planning. Following significant achievements emerged out of the study:

(i) The statistical analysis of rainfall and evaporation data indicated that the region has an average annual rainfall of 1768 mm (82% is received during June-October) and evaporation of 1581 mm. July and August being the most wet months indicated the probability of severe crop damage due to waterlogging. Monthly water balance analysis indicated considerable scope of excess rainwater storage in on-farm reservoir (OFR). It was indicated that on an average about 5-week drought (with 3-week continuous drought during ripening stage) might occur during *kharif* season.

(ii) On the basis of probability analysis of rainfall-evaporation data, rice transplanting schedule was developed for reducing climatic hazard in different land toposequences. Further, using summer and winter seasons planting schedule and crop suitability in the region, a crop calendar of optimal farming operations was developed for stabilizing production and minimizing production losses due to uncertain weather.

(iii) Hydrological modelling for rainfed humid rice lowlands was used to estimate the excess rainwater availability for optimal design of OFR. It was recommended to convert 20% of the farm/watershed area into OFR to harvest excess rainwater. The suggested procedure should be used for optimal design of OFR in different agroecological conditions.

(iv) Simulation of surface drainage improvement by rainwater harvesting in OFR in lowlying rice areas of the East Mograhat Drainage Basin was conducted. The water depth hydrographs with and without OFR indicated surface drainage improvement up to 75%. It provides scope for cultivation of high yielding rice varieties in rainfed humid rice lowlands.

(v) Requirement of supplemental irrigation in *kharif* season may help in stabilizing rice production against weather uncertainty. It was estimated that 1 supplemental irrigation might be required at the grain formation stage in two out of ten years.

(vi) Linear programming model was used for optimal land and water allocation in dry season for various constraints of land and water for maximizing profits. Optimal allocation indicated benefit-cost ratio of 2:1 (excluding income from fishery and horticulture), and thus justified the investment in OFR.

Further, user-friendly computer software RAINSIM for Rainwater Simulation Modelling was developed (Ambast *et al.*, 2002a). It would be useful in scientific/developmental work using probability analyses of weather data, crop planning, optimal design of OFR, simulation of surface waterlogging with and without rainwater storage in OFR, supplemental irrigation requirement and optimal land and water allocation for maximizing net profit to the farmers (Fig. 2).

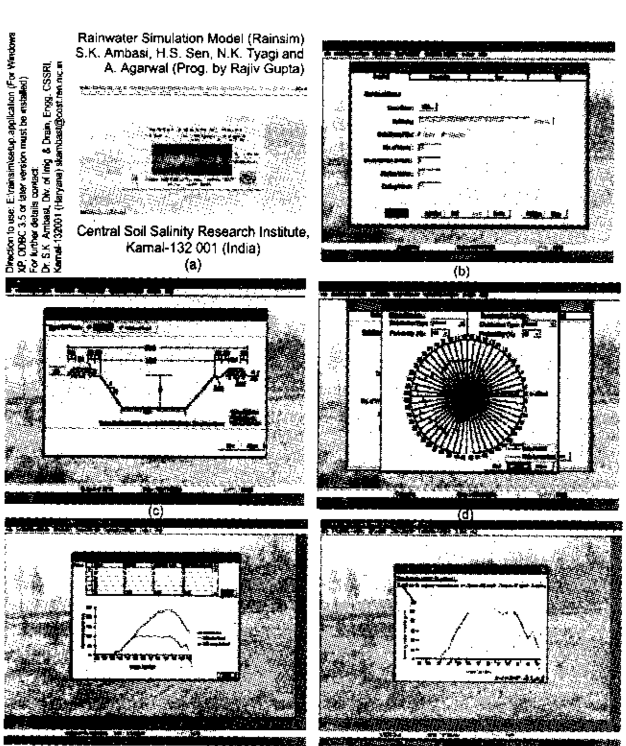

Fig. 2. Important features of RAINSIM software (a) about software (b) input file management (c) Design of OFR (d) development weather based crop calendar (e) simulation of surface drainge improvement (f) simulation of supplemental irrigation requirement

Drainage improvement

Most of the coastal lowlying areas are frequently inundated due to ingress of seawater through tidal estuaries. These estuaries are slowly silting up due to high silt load carried along with the river flows causing congested drainage system and flooding of agricultural fields. It has been suggested that earthen embankments, preferable brick pitched, having side slope of 3:1 on the river side and 2:1 on the country side, with 1 m free board above the high tidal level, are appropriate for protection against flooding (Rao, 1981). To effect drainage from such embanked areas, one-way sluice gates should be provided in the embankments. It has been observed that the density of field drainage is not sufficient to drain excess water from agricultural lands. For improving the field drainage system, it was suggested to construct peripheral *bunds* to clearly demarcate the catchment and also the various fields, so that inflow of excess water from outside the area into the catchment and the flow from one to another zone could be regulated. It is important that the planned drainage basins be monitored frequently for their drainage system performance.

Precision farming and improved irrigation methods

Precision farming or site specific farming is an emerging technology that allows farmers to have most efficient use of inputs and agronomic practices. It has the potential not only towards reduced cost of cultivation through more efficient and effective application of crop inputs but it also protects the fragile environment. A careful water balance analysis of annual precipitation and potential evapotranspiration is essential to determine the water surplus/deficit periods beforehand, so that all the agricultural operations can be adjusted accordingly. This will help to save the crops from water stress (excess/deficit) during its critical growth stages and also help the farmers in the decision making regarding crop choice as well as its acreage depending upon the water availability. The concept of harvesting excess rainwater in OFR may be effectively utilized for growing pulses, oilseeds, tuber crops, vegetables, spices, etc. after *kharif* rice.

Water conserved in limited quantity should be judiciously used for irrigation. Limited information are available on irrigation methods for the coastal ecosystems, where, in general, the soils are to a large extent saline and medium to heavy texture in nature. Microirrigation, especially in the form of drip, should be a potential irrigation method for coastal environment. Drip irrigation system can prove beneficial for the coastal region particularly to irrigate the high value crops, such as plantation crops of coconut, arecanut, oil palm, cashew, cocoa, and spices, viz. black peeper, cardamom, ginger, turmeric, coriander, cumin, etc. The controlled use of water and fertilizer directly in the root zone through drip irrigation not only increases the input use efficiencies but also reduces possible negative interactions in the soil profile. Besides, this system provides scope of using poor quality water in conjunction with fresh water for irrigation. Another improved technology to utilize the surface water is lifesaving irrigation by digging *doruvus* which is a conical pit dug to collect seeped-in water. In this method, suitable particularly for sandy loam soil, with fresh water floating over saline ground water, may be skimmed horizontally through tile drains at the rate of 18 lps, which would be sufficient for operating 6 sprinklers continuously. The technology has been tested in Andhra Pradesh.

Application of space technology for management of natural resources

Space programmes, all over the world, have unique dimension to use space technology for sustainable development of natural resources. The Indian Remote Sensing (IRS) satellites have been intended to cater the needs of critical information to the agricultural sector, whereas INSAT series of satellites are providing weather related information. Although the applications of remote sensing in agriculture begin with inventory of soil and surface water resources, today its applications witnessed a phase transition from resource mapping to decision making due to its enormously improved capability to monitor agricultural and hydrological conditions of the land surface. Ambast *et al.* (2002) in a study conducted at IIT, Delhi comprehensively reviewed potential and limitation of remote sensing applications in the field of water resources management. Remote sensing inputs are being used for number of applications, such as monitoring cropping intensity, identification of waterlogged/salt affected areas, evaluation of irrigation/land drainage schemes, and groundwater prospect mapping.

Monitoring land drainage schemes: A number of surface drainage projects are in operation in coastal areas to ease the surface waterlogging. The performance monitoring of these large drainage projects through field observations and construction of water level hydrographs is quite difficult. Moreover, very limited attempts have been made to develop the criteria to evaluate the surface drainage systems (Ambast, 1996). Satellite remote sensing provides the opportunity to capture the information of a large area at frequent intervals. The capability of remote sensing to monitor agricultural and hydrological conditions of the land surface has undergone major improvements in the last decade.

Absence of total vegetation on severely waterlogged or salt affected soil surface makes it possible to detect waterlogged and saline surfaces directly from the remote sensing data, whereas it is difficult to identify otherwise slightly or moderately affected waterlogged and salt affected cropped land directly. But such waterlogged and saline cropped land have very distinct reflectance characteristics due to patchy crop growth, which can be identified indirectly with low albedo-low NDVI and high albedo-low NDVI, respectively (Ambast and Tyagi, 2002, Fig. 3a). The procedure was applied on the satellite image of Bhalaut Canal command defining seven crop classes, i.e. slightly, moderately and severely waterlogged crops, slightly, moderately and severely salt affected crops, and normal crops (Fig. 3b).

The economic analysis indicated an average loss of 18% of the potential due to waterlogging and soil salinity in the command. Similar technique may be employed in coastal saline lands to monitor waterlogged and saline lands.

Estimation of crop yield: The ultimate aim of efficient drainage system is to enhance the crop and water productivity uniformly in the drainage basin. Since remote sensing cannot provide crop yield information directly, normalized difference vegetation index (NDVI) was used for assessing the crop biomass. Field observed regression model between NDVI and crop yields was extrapolated for crop yield estimation of large areas using spatial technique. One such study was conducted in Sone Low Level Canal system for wheat crop ($Y_{(wheat)}$ = 91.1*NDVI* - 23.8) and applied on remotely sensed data (Ambast *et al.*, 2002b). The estimated crop yield is shown in Fig. 4(a,b). Similar technique may be employed in coastal drainage basins to estimate crops yields to monitor performance of drainage systems.

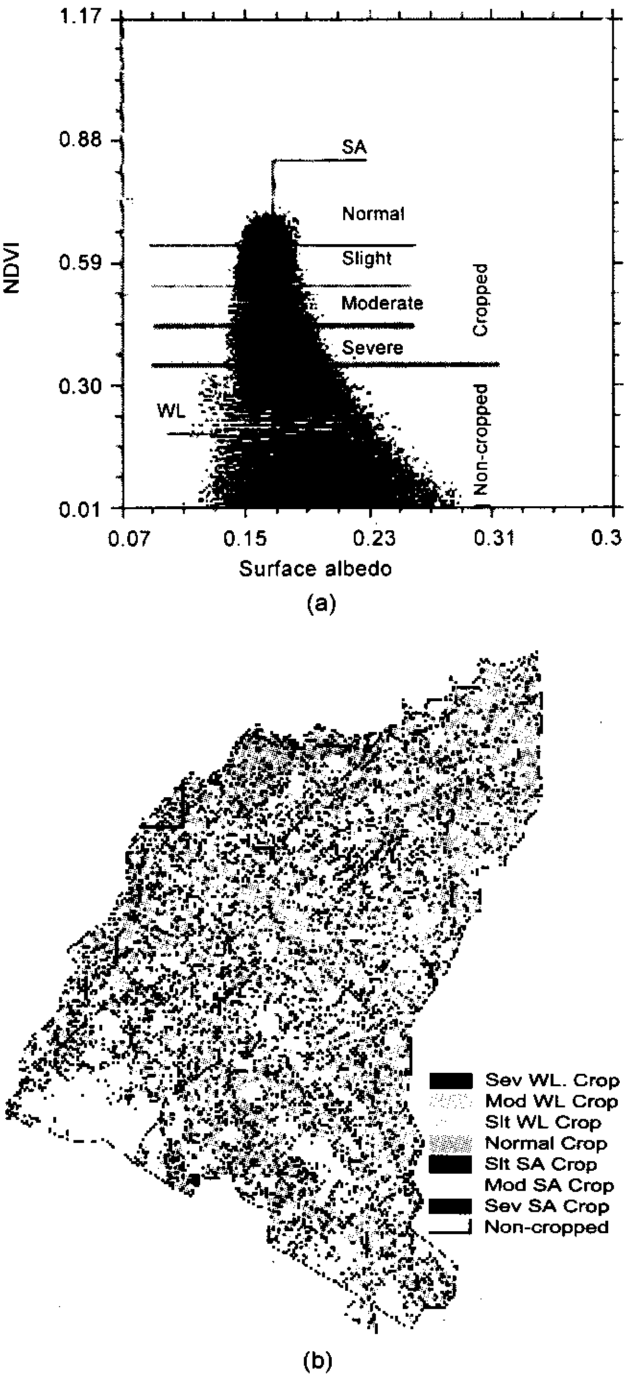

Fig. 3. Waterlogged and salt-affected land in the Bhalaut branch canal command (WYC)

Improving land and water productivity in coastal region - Some issues

The climate change, global warming and competition among various uses of water is leading to reduced water availability to agriculture sector. In rainfed areas of coastal region uncertainty of weather is another factor for non-stabilized agricultural productivity. Following are the water related issues, which require more focus in future research:

1. Information on crop/farm/system water productivity is important to cross check and compare the performance, particularly when water scarcity increases. There is a need to generate database on water productivity from field level to system level in coastal ecosystem.

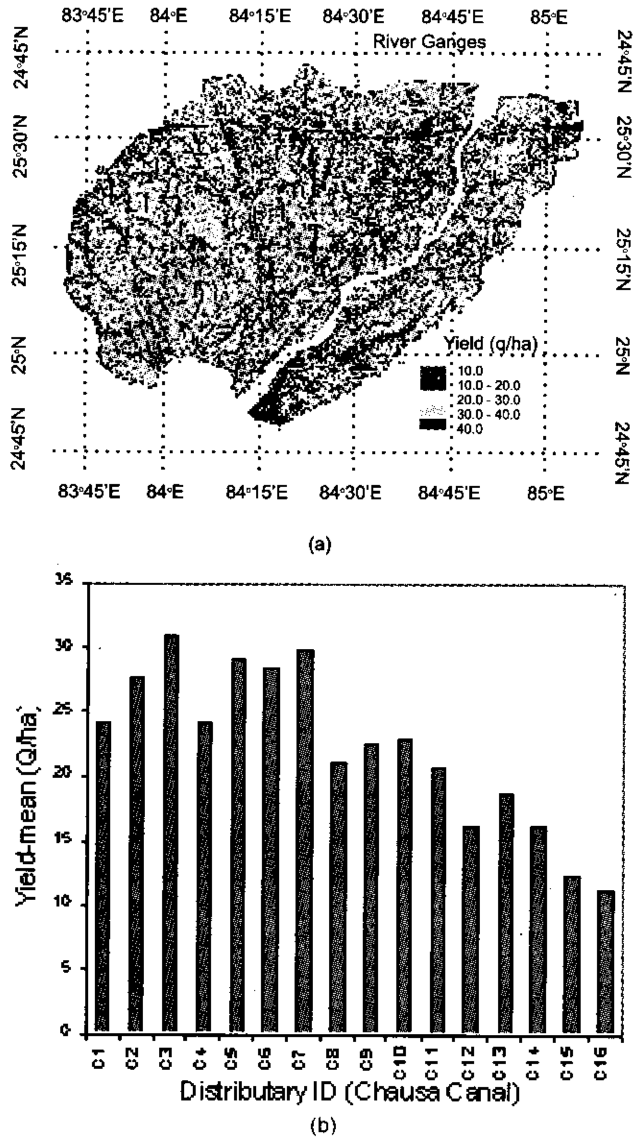

Fig.4. (a) Yield (wheat) image and (b) mean crop yield in the SLLC command

2. Different farming system options, available in each coastal subregion, may also be evaluated for water productivity apart from land productivity and their economics.
3. Monitoring of planned surface drainage improvement schemes would help in identifying the reasons of their poor performance and suggestive measures for their improvement.
4. Application of modern techniques such as remote sensing and geographical information system may be used in future coastal agricultural research. However, application of microwave remote sensing may be explored in combination of optical remote sensing due to continuous cloud cover in the coastal regions.

REFERENCES

Ambast, S.K. (1996). Evaluation criteria for monitoring surface drainage system. *Journal of the Indian Society of Coastal Agricultural Research* **14**(1&2): 93-102.

Ambast, S.K., Sen, H.S. and Tyagi, N.K. (1998). *Rainwater Management for Multiple Cropping in Sundarbans Delta (W.B.)*, Bulletin No **2/98**, Regional Research Station, Central Soil Salinity Research Institute, Canning Town, India. 69p.

Ambast, S.K., Keshari, A.K. and Gosain, A.K. (2002). Satellite remote sensing to support management of irrigation system: Concepts and approaches. *Irrigation and Drainage* **51**(1): 25-39.

Ambast, S.K., Sen, H.S., Tyagi, N.K. and Agrawal, A. (2002). *RAINSIM: on Rainwater Simulation Modelling: A Computer Software*, CSSRI, Karnal.

Ambast, S.K. and Tyagi, N.K. (2002). In *Monitoring and Evaluation of Irrigation System Performance in Saline Irrigated Command, Bhalaut Distributary, Haryana (CSSRI) - A Methodology for Identification of Waterlogging and Soil-Salinity Conditions Using Remote Sensing*, pp. 35-42, CSSRI, Karnal & Alterra, ILRI, Wageningen.

Kar, G., Singh, R. and Verma, H.N. (2004). Alternative crop strategies for assured and efficient crop production in upland rainfed rice area of eastern India based on rainfall analysis. *Agricultural Water Management* **67**: 47-62.

Manjunatha, M.V. Oosterbaan, R.J., Gupta, S.K., Rajkumar, H. and Jansen, H. (2004). Performance of sub-surface drains for reclaiming waterlogged saline lands under rolling topography in Tungbhadra irrigation project in India. *Agricultural Water Management* **69**: 69-82.

Rao, K.V.G.K. (1981). On-farm water management in coastal saline lands. *Journal of the Indian Society of Coastal Agricultural Research* **9**(1&2): 347-357.

Sehgal, J., Mandal, D.K., Mandal, C. and Vadivelu, C. (1992). *Agro-ecological Regions of India*, 2nd Edn, National Bureau of Soil Survey and Land use Planning, Nagpur, Publication No **24**. 130p.

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Contamination by Fertilizer Residues in Wetland Rice Ecosystems of Kuttanad, Kerala

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An investigation was carried out to evaluate the extent of contamination by fertilisers in rice fields and surrounding ecosystems in Kuttanad, Kerala. The extent of contamination was not negligible. The application of N fertilizer either as basal or at top dressing has increased the NH_4-N content of the soil during additional crop season (June-Sep). During *punja* season also, it followed the same trend, but the quantity of NH_4-N was much reduced. Application of fertilizers has considerably increased the NH_4-N content of field water, which showed an increase from 6.9 to 12.0 mg L^{-1}. Compared to additional crop, NH_4-N content of water was lower during *punja* season. The NO_2 + NO_3–N also followed the same trend as that of NH_4-N, though the quantity was very low. During *punja* their contents increased further which indicates the higher extent of contamination in that season. The study area was generally deficient in available P due to high P fixation capacity of soil. The study area recorded comparatively higher values for available K. Basal application of K fertilizer had increased it from 177 to 191 mg kg^{-1}. In canal water, the concentration of contaminants showed a decrease from June to October followed by a gradual increase recording the maximum value during April.

(***Key words***: *Soil & water contamination, Fertiliser residue, Wetland rice*)

Kuttanad, the rice bowl of Kerala is a unique agricultural tract lying 0.6 to 2.2 m below mean sea level on the western coast of Kerala. The area is subjected to periodical flooding during monsoon and salinity intrusion during summer. Rice is cultivated here in contiguous fields (polders) surrounded by waterways/canals protected by ring *bunds* in about 55,000 ha during *punja* (Oct-Feb, March) and 22,000 ha during additional crop (June-Sep) season. Crop failures are common during *punja* season due to salinity intrusion and by flooding during additional crop season. In order to protect rice from salinity intrusion, a regulator was constructed and kept it closed during December to April resulting in water stagnation in Kuttanad with fertilizer and pesticide residues. Rice cultivation in Kuttanad is characterized by profuse and indiscriminate use of fertilizers and pesticides leading to pollution of waterways and canals with their residues. The peculiar water management practice of "alternate letting in of water from surrounding canals to polders and draining out of water to canals" at frequent intervals makes the situation worse since the contaminated water is used again and again. This contamination had played a significant role in the eco-degradation of Kuttanad, which is an alarming issue at present. The extent of contamination by fertilizer residues in Kuttanad ecosystem is presented below.

MATERIALS AND METHODS

Surface soil samples were collected from 27 polders before fertilizer application, i.e. before draining away the water from the field, and 5-7 days after fertilizer application. Water samples were collected from the field before letting out the water prior to fertilizer application and draining out the water after fertilizer application. Water from the surrounding canals was drawn at monthly intervals. Fertilizer recommendation for short duration variety of rice is 70:35:35 kg ha^{-1} of N, P and K as per recommendation of Kerala Agricultural University. But the quantity of fertilizers applied by the farmers varied from 75 percent of recommended dose to 150 percent. The estimations of different chemical parameters of soil and water were done as described by Page (1982) and plant nutrient by the methods of Piper (1966).

RESULTS AND DISCUSSION

The soils of the area are extremely acidic with a pH range of 3.5-4.6, mildly saline and high in organic carbon. The data on soil available nutrients are presented in Table 1. The NH_4-N content of the soil increased owing to basal and top dressing of fertilizer. NH_4-N content of the soil however decreased by the time of top dressing, evidently due to crop uptake and other types of loss. The NH_4-N content of soil and its increase due to top dressing

Table 1. *Nutrient content of rice soils (mg kg^{-1}) in Kuttanad before and after fertilizer application*

	NH_4-N				NO_2+NO_3-N				Available P		Available K			
	Basal		Top dressing		Basal		Top dressing		Basal		Basal		Top dressing	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
Additional crop	133	136	120	121	17.4	18.0	12.8	13.7	3.5	7.8	177	191	138	149
CD at p=0.05	0.57		1.12		0.233		0.196		0.520		3.57		3.04	
Punja	78	81	69	72	15.4	16.2	13.2	13.9	2.9	6.2	169	182	141	153
CD at p=0.05	0.63		2.46		0.125		0.125		0.568		2.13		2.28	

T1 = Prior to fertilizer application, T2 = After fertiliser application

Table 2. *Nutrient concentration (mg L^{-1}) in standing water of rice fields in Kuttanad*

	NH_4-N				NO_2+NO_3-N				P		K			
	Basal		Top dressing		Basal		Top dressing		Basal		Basal		Top dressing	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
Additional crop	6.90	12.0	3.8	6.3	5.7	9.1	2.7	3.8	0.02	0.04	4.0	7.3	2.4	4.5
CD at p=0.05	0.967		0.235		0.290		0.156		NS		0.359		0.218	
Punja	5.7	9.1	3.4	5.3	5.9	9.4	3.3	5.7	0.03	0.04	4.1	7.8	2.4	4.7
CD at p=0.05	0.276		0.234		0.291		0.175		NS		0.328		0.319	

T1 = Prior to fertilizer application, T2 = After fertiliser application

was lower, compared to basal application. The nutrient uptake is at its maximum during top dressing stage. The same trend was followed during *punja*, but the quantity has been reduced much. Application of fertilizers has considerably increased the NH_4-N content of field water, which showed an increase from 6.9 to 12.0 mg L^{-1}. This has to be looked into very seriously since it indicates the intensity of contamination by NH_4-N in the waterways and canals of Kuttanad. By the time of top dressing the content has decreased as in the case of soil. Compared to additional crop, NH_4-N content of water was lower during *punja* season, evidently due to better oxidation and accumulation as nitrate in water (Table 2). Though the average level of ammoniacal and nitrate nitrogen did not exceed the permissible maximum of 20 and 16 mg L^{-1}, respectively (OECD, 1986), some of the sampling sites exceeded the limit.

The NO_2 + NO_3-N also followed the same trend as that of NH_4-N, though the quantity was very low. Since the soils were always in a submerged condition the major form of N was in ammoniacal form. The increase in NO_2 + NO_3-N content due to fertilizer application was very marginal. The magnitude of decrease for NO_2+NO_3-N content during *punja* was not as conspicuous as in the case of NH_4-N. But the quantity of NO_2+ NO_3-N present in field water was not so low. The field water before fertilizer application contained 5.7 mg of NO_2+NO_3-N per liter of water and the same increased to 9.1 after fertilizer application during additional crop season. During *punja* their contents increased further, indicating that the extent of contamination was more during *punja* season. The quantum of N held in standing water was considerably greater at this period, major part of which was likely to be lost through the drainage water.

The study area was generally deficient in available P due to high P fixation capacity of soil. The available P content also showed an increase from 3.5 to 7.8 mg kg^{-1} due to fertilizer application during additional crop season and during *punja* season the values were much lower. The P content of the field water was only in traces. The very low mobility and very high P fixation capacity of soils are responsible for the absence of P in water.

The study area recorded comparatively higher values of available K. Application of K fertilizer had increased it from 177 to 191 mg kg^{-1} which

Table 3. *Chemical properties and concentration of nutrients of canal water*

	Additional crop season					*Punja*							Summer			
	June	July	Aug	Sept	Mean	Oct	Nov	Dec	Jan	Feb	Mean		Mar	April	May	Mean
NH_4-N (mg L^{-1})	2.0	1.7	1.2	1.3	1.6	1.4	1.8	1.8	1.9	2.1	1.4		3.4	3.6	2.5	3.1
NO_2+NO_3N (mg L^{-1})	2.0	1.5	1.2	1.4	1.5	1.6	1.8	2.1	2.8	3.4	2.3		3.8	3.9	2.6	3.4
K(mg L^{-1})	5.0	3.1	2.0	2.1	3.1	2.1	2.2	2.8	2.8	3.4	2.7		4.8	5.8	5.6	6.5
Sulphate (mg L^{-1})	22.0	20.0	17.1	13.2	18.1	16.7	20.1	20.2	22.5	28.9	22.8		35.4	42.1	40.5	39.3
Chloride (mg L^{-1})	160	100	75	83	105	99	110	130	143	151	127		168	220	240	209
pH	7.1	7.1	7.2	7.2	7.2	7.0	7.0	6.9	6.8	6.5	6.8		6.3	6.1	7.0	6.4
EC (dS m^{-1})	0.6	0.3	0.3	0.3	0.4	0.3	0.2	0.3	0.33	0.48	0.38		0.54	0.70	1.2	0.81

decreased to 138 mg kg^{-1} at the time of top dressing. During *punja* season, the values were higher at the time of top dressing compared to additional crop season. K content of field water has increased from 4.0 to 7.3 mg L^{-1} after fertilizer application during additional crop season. By the time of top dressing the K content has decreased further. The behaviour of K was similar during *punja* season also, but the concentration was more. From the study it was clear that considerable portion of applied fertilizer was lost through drainage water.

In canal water, the NH_4-N content was lower during *punja* and the maximum was recorded during summer, while for nitrates the concentration was greater during *punja* and summer seasons (Table 3). For K, the content showed a decrease from June to October followed by a gradual increase recording the maximum value during April. Sulphates and chlorides also behaved in more or less similar manner. The acidity of water was higher during *punja* and summer season. The data revealed that the extent of contamination was more during *punja* and summer season. The drainage water from the rice fields and lowering of ground water table coupled with lesser quantity of water present in the ecosystem contributed towards this increase.

REFERENCES

OECD (1986). *Water Pollution by Fertilizers and Pesticides*. Organisation for Economic Co-operation and Development, Paris.

Page, A.L. (1982). *Methods of Soil Analysis*, Part **2**, 2nd Edn. American Society of Agronomy, Madison, Wisconsin, USA.

Piper, C. S. (1966). *Soil and Plant Analysis*. Hans Publishers, Bombay.

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Resource Potential and their Utilization for Agricultural Development - A Comparative Analysis of Coastal and Non-Coastal Districts in Orissa

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The direct and indirect work forces constituting around 64% of total state workforce are engaged in agriculture in Orissa. The differential resource endowment and their utilization for agricultural development in the state are reflected in differential development level in coastal and non-coastal districts. There is differential trend in the productivity and production of food and non-food grains in coastal and non-coastal districts of the state. The infrastructural developments for agriculture as well as resource endowments also differ considerably among the coastal and inland districts. The differential resource utilization pattern and economic development level could be traced to differential resource endowments in districts of coastal and inland districts. The coastline, which stretches over 408 km, has also enough potential for marine fisheries development. The contribution of coastal districts to total food grain availability was more than 45% as against the total population of around 31% with total geographical area of 21% of the state. The irrigation availability in coastal districts is more than 50% of the net sown area. Accordingly, cropping intensity and cropping pattern also differ in coastal and non-coastal areas.

(***Key words:*** *Resource management, Demography, Land use & cropping pattern, Agricultural productivity, Water resources, Infrastructure, Input use, Livestock & fishery, Forest, Coastal & non-coastal)*

Orissa continues to be primarily an agrarian economy with more than 65% of workforce engaged in agriculture and the contribution of agriculture to state NSDP was about 28.68% during the year 1997-98. The per capita availability of cultivated land was 0.29 hectares in 1950-51 that decreased to 0.18 hectares in 1998-99. The state has 31.54 lakh small and marginal farmers accounting to 19.88% of the total operational holdings (Anon., 1999-2000). The skewed distribution of resources and their utilization have resulted in uneven growth of coastal and inland districts of Orissa. The differential resource utilization pattern and economic development level could be traced to differential resource endowments in districts of coastal and inland districts. It is pertinent to examine differential resource endowment pattern for any policy decision with regard to regional development of the state and more so when it comes to agriculture.

General characteristics

The coastline of Orissa stretches over 408 km in the east coast covering an area of 410 sq km. The total population of the coastal districts is about 31.46% of state total (as per 2001 census). The coastal region of Orissa has been categorized under northeastern coastal plains and East and Southeastern Coastal Plains. The total coastal tract covers 21% of total geographical area under nine divided districts. The non-coastal areas are grouped under Northwestern Plateau, Western Undulating lands, Southeastern Ghats, Mid Central Table lands, etc.

Soil properties and land resources

The coastal alluvial soils with high total soluble salts (EC 4 ds m^{-1}) are predominant in this region. These soils occur along the coastal belt of the state in a narrow strip extending 5-25 km inward. The salinity occurs due to littoral deposits or estuarial ingress of brackish tidal water from sea through creeks. Nearly 0.254 m ha^{-1} of saline soils are distributed in the district of Balasore, Bhadrak, Jajpur, Jagatsinghpur, Kendrapara, Puri, Khurda and Ganjam. During monsoon, a build-up of subsoil salinity occurs due to high ground water table under lowlying situations. These soils are mostly clay to clay loam in texture and columnar in structure. The pH of the soils varies between 6.0 to 8.0 with a conductivity of 10.40 ds m^{-1} at 25°C in the summer. The exchangeable sodium percentage varies between 18 to 27. The soils are rich in nitrogen and potassium, and low to medium in phosphorus.

Demographic characteristics

The analysis of demographic characteristics of coastal and non-coastal areas (2001 census) reflects that the coastal regions constitute more literate people in both the categories of sex, i.e. male and female in comparison to non-coastal region. Both the urban and rural literacy figures are higher in coastal district than non-coastal districts. Coastal belt is thickly populated (536 per sq km) in comparison to non-coastal belt (168 per sq km). Coastal belt has registered lower females per thousand of males (964) than non-coastal district (982). The population dependent on agriculture is higher in both coastal as well as non-coastal areas. However, in comparison to non-coastal regions, the dependency on agriculture is higher in coastal region. This may be due to spread of industrial locations in non-coastal areas in comparison to coastal areas.

Land utilization pattern

The analysis of land use statistics for the year 1997-98 portrays that a relatively higher level of cropping intensity is recorded for coastal areas (159%) in comparison to non-coastal areas (137%). In coastal districts, areas under barren and non-agricultural use are larger in comparison to non-coastal districts. Area under permanent pasture is more in coastal areas than in non-coastal areas. Among the coastal districts, Bhadrak has maximum area under barren land, whereas Balasore has minimum barren land. Ganjam district has maximum area under the category of net sown area and Jagatsinghpur has the least area under the same category. The geographical size of the district, irrigation potential and distribution of landform (high, medium or low) are influencing factors on net sown area. With respect to distribution of forestland, Jagatsinghpur district has lowest area under forest, whereas Ganjam district has highest area under forest category in the coastal districts. Culturable waste is minimum in Ganjam and maximum in Puri district. Bhadrak district has maximum pastureland. Jagatsinghpur has the minimum area under pastureland. In terms of distribution of land resources under different types of use, net cropped area along with cropping intensity is higher in coastal areas. The culturable wastelands are more in non-coastal districts than in coastal district. No specific trend is found in current and other fallow category for both the regions. Non-coastal districts have more area in comparison to coastal districts with respect to miscellaneous tree and groves category.

Cropping pattern

There is distinct difference in cropping pattern between coastal and non-coastal districts. In coastal district the pattern is mostly paddy-paddy sequence with HYV paddy predominance. More than 70% of area is covered under paddy in the state and in coastal area, it is more than 80%. In *kharif*, both in coastal and non-coastal areas, paddy occupies more than 90% of cultivated area. In *rabi* HYV paddy is taken up in irrigated tracts of both coastal and non-coastal areas and *jhola* or *beda* lands in non-coastal and non-irrigated areas. In *kharif*, non-coastal non-irrigated areas have more area under local paddy varieties whereas in coastal areas it is mostly HYV paddy.

Paddy is the major cereal crop in coastal as well as in non-coastal areas. Major area comes under cereals crops (77.6%) followed by pulses (11.8% area) and oilseeds (6.4%). The area under fibre crops accounted for only 1.2% and other cash crops, which include sugarcane, potato, chilly, ginger, onion, and tobacco, etc constitute only 3% of total gross cropped area. The cropping intensity for coastal district varied between 137 to 172% among the districts. Highest cropping intensity was observed in Puri district (172%) and minimum in Bhadrak district (137%) in coastal areas during the year 1997-98. As compared to non-coastal aggregate, the cropping intensity for coastal areas (159%) was much higher than non-coastal areas (144 %).

Agricultural productivity

Agricultural productivity in general is higher in coastal district than the non-coastal tracts. However, in irrigated tracts of coastal region productivity of major crops varies considerably. The yield of HYV paddy in coastal districts was higher in Cuttack (30 q ha^{-1}) (Table 1), though fertilizer consumption is less as stated earlier. This may be due to alluvium tract in Cuttack district which is otherwise highly fertile due to sediment deposition. Jagatsinghpur (29 q ha^{-1}) comes second in the productivity of HYV paddy in coastal districts followed by Ganjam (26 q ha^{-1}). The average yield rate for Orissa is 23.52 q ha^{-1}. The productivity of major cereals, pulses and oilseeds also vary considerably. The yield of paddy as a whole was highest in Ganjam (17.45 q ha^{-1}) during 1998-99 and in Bhadrak it was 14.30 q ha^{-1}. For Cuttack the yield of paddy was 9.36 q ha^{-1}.

For maize, Kendrapara records highest yield (15.33 q ha^{-1}), followed by Bhadrak (15.00 q ha^{-1}) and Jagatsinghpur (12.87 q ha^{-1}) among coastal districts. In cereals Bhadrak records highest yield 17.51 q ha^{-1} followed by Cuttack (14.97 q ha^{-1}) and Kendrapara (11.87 q ha^{-1}).

Table 1. *Area and yield under HYV paddy coastal districts*

District	Area in '000	Yield (q/ha)
Balasore	92.72	19.78
Bhadrak	97.61	28.99
Cuttuck	61.64	30.1
Jagatsingpur	49.71	28.96
Khurda	60.8	30.25
Puri	94.57	24.1
Kendrapara	51.74	27.88
Ganjam	261.31	26.45
Jajpur	53.1	27.37
Orissa	2160.64	23.52

Source: Directorate of Economics and Statistics, Orissa, BBSR.

Water resources and their utilization

Irrigation plays a vital role in the agrarian economy of Orissa and so far approximately 37% of net cultivated area have been brought under different sources of irrigation and rest 63% of net sown area is rainfed. The state has 65.59 lakh hectare of cultivable land of which 59.00 lakh hectare can be brought under assured irrigation. So far irrigation potential has been created up to 39.73% of the estimated irrigated land covering area of 23.49 lakh hectare. There are two distinctly major irrigation schemes under Mahanadi delta irrigation system (coastal) and Hirakud irrigation system (non-coastal). Coastal irrigation system comes under Mahanadi delta stage-I, stage-II, Risikulya and Salandi major irrigation systems. Inference from Table 2 shows the sourcewise irrigation development and utilization in coastal and non-coastal areas. Canals are the major source of irrigation in both coastal and non-coastal districts and contribute more than 60% of total irrigation potential created from all sources. In coastal districts, Ganjam has more than 50% of arable land getting irrigation followed by Puri, Kendrapada, and Jagatsinghpur (Table 2). Balasore districts have maximum concentration of tubewell irrigation in the state where more than 50% of total ground water potential has been harvested. A comparison of net irrigated area as a percentage of net sown area in coastal and non-coastal districts of the state reflects that (Table 2) in the coastal districts more than 50% of net sown area has been provided with irrigation facilities as compared to 26% in non-coastal area. This has gone a long way in stabilizing agricultural economy of coastal districts in comparison to perpetual droughts in non-coastal districts. However, irregular monsoon and natural calamities have contributed to miseries in coastal Orissa. The coastal areas suffer maximum in the event of floods and cyclone, whereas inland districts suffer maximum in the event of drought.

The coastal tracts have enough potentials for development of dugwells, shallow and deep tubewells as only 14% of total ground water potentials has been harvested so far. Major constraints for development of ground water potential in these tracts have been triangulated holdings, traditional cropping pattern, low economic conditions of the people, and poor electric supply in rural areas. Non-standard pump sets and its poor after sales services also have been identified as major constraints to ground water development. Irrigation tanks are rare in coastal areas, however in Orissa the tank has not been used as a source of irrigation in most of the areas and only confined to some western districts of the state.

Other Infrastructure endowment

Infrastructurally coastal areas are well developed in comparison to non-coastal district. The rural road infrastructure, bank regulated markets, cold storage, schools and colleges at present are more in number in coastal areas than in non-coastal areas. Among the coastal districts, Puri, Jagatsinghpur and Cuttack are well ahead in comparison to other coastal districts, in terms of infrastructural developments, which are vital for sustainable agriculture. The analyses of major infrastructal facilities available districtwise reflect that in terms of village electrification, credit-deposit ratio of banks, etc., coastal districts are much more advanced than non-coastal districts.

Agricultural input use

Inputs like HYV seeds, fertilizer and pesticide application are critical factors for boosting agricultural production. In general, Orissa has been lagging behind other states with respect to fertiliser application and other input use. Average fertiliser application in Orissa was 34 kg ha^{-1} in 1997-98. The districtwise analysis of fertiliser application indicates that coastal districts consume more fertilizer than non-coastal irrigated areas. Among the coastal districts, highest consumption of fertilizers to the extent of 84 kg ha^{-1} was marked in Bhadrak, and minimum was marked for Cuttack (48 kg ha^{-1}) in *kharif*. Balasore district ranks second in term of fertiliser use (74 kg ha^{-1}) followed by Ganjam. In terms of total (N+P+K) Balasore district ranks

Table 2. *Agroeconomic indicators in coastal and non-coastal districts of Orissa (area in '000 ha)*

District	Normal rainfall (mm)	Geographical area	Cultivated area	Net area sown	Per ha fertilizer cons. in kg	Gross Cropped area	Cropping Intensity (%)	Net irrigated area	Gross irrigated area
Coastal									
Balasore	1568.3	371	270	256	73	345	135	66.91	113.6
Bhadrak	1568.3	279	186	176	83	241	137	89.55	125.89
Cuttack	1501.3	392	194	187	38	334	179	88.92	132.12
Jagatsinghpur	1501.3	174	125	114	45	194	170	35	43.89
Jajpur	1501.3	289	185	182	44	293	161	41.47	69.03
Kendrapara	1501.3	257	175	150	38	226	151	189.21	74.24
Ganjam	1295.6	870	398	396	46	638	161	87.89	220.74
Puri	1449.1	306	192	167	45	287	172	53.89	129.78
Khurdha	1449.1	289	137	136	36	227	167	41.19	74.1
Total coastal	1481.73	3227	1862	1764	49.77	2785	159.2	694.03	983.39
Non-coastal									
Bolangir	1443.5	655	338	330	19	449	136	41.75	75.95
Sonepur	1443.5	229	112	107	36	165	155	69.34	106.61
Dhenkanal	1421.1	460	227	199	15	293	147	35.75	50.22
Anugul	1421.1	635	226	219	22	303	138	38.11	53.47
Gajapati	1295.6	381	80	79	39	100	126	23.89	29.27
Kalahandi	1378.2	820	371	362	18	515	142	78.15	101.71
Nawapara	1378.2	341	178	176	11	233	133	25.62	33.91
Keonjhar	1534.5	830	302	298	20	400	134	11.99	28.08
Koraput	1521.8	838	302	292	13	388	133	71.85	101.23
Malkangiri	1521.8	612	141	130	15	190	147	98.81	34.61
Nawarangpur	1521.8	519	215	186	30	275	148	18.03	29.85
Rayagada	1521.8	759	203	165	22	230	140	34.01	42.11
Mayurbhanj	1648.2	1042	441	430	23	514	120	71.91	105.69
Phulbani	1597.1	760	167	155	4	180	116	14.6	17.66
Boudh	1597.1	344	89	82	17	119	145	32.49	36.79
Nayagarh	1449.1	396	133	127	24	226	178	33.38	46.16
Sambalpur	1527	671	194	193	78	255	132	62.24	101.74
Baragarh	1527	583	345	342	83	438	128	135.34	212.8
Deogarh	1527	278	72	69	27	92	134	14.18	24.49
Jharsuguda	1527	220	85	81	57	96	118	9.45	20.48
Sundargarh	1647.6	971	337	336	19	398	118	62.72	81.94
Total non-coastal	1497.619048	12344	4558	4358	28.19	5859	136.5714	983.61	1334.77
Total Orissa	1502.6	15571	6420	6122	38.98		141	1598.64	22318.15

highest with 29.53 thousand metric ton followed by Ganjam and Bhadrak with 28.81 and 19.49 thousand metric tones, respectively during 1997-98. With respect to HYV seed use, Ganjam ranks highest in coastal district in terms of total area under HYV paddy (261.31 thousand ha) followed by Bhadrak and Balasore with 97.61 thousand ha and 92.72 thousand ha, respectively.

Livestock and fishery resources

Among the coastal districts, Ganjam records highest number of livestock as per 1995 census followed by Khurdha and Balasore. Jagatsinghpur district has lowest of livestock resources followed by Cuttack. As regards to fish catch, Balasore district ranks highest with Rs. 12591 lakhs followed by Jagatsinghpur with Rs. 11644 lakhs and

Kendrapara with Rs. 7503 lakhs. The total value of fish production of the state was Rs 810 crores during 1998-99.

Forest resources

During 1997, the total forest area of the state was 58135.47 sq km, which was 37.3% of total geographical area. The forest survey of India records that only 30% of the area is under forest area. The forest area of the state is unevenly distributed. The coastal districts where population density is significantly high have a comparatively smaller area under forest. The districtwise break-up of forest cover for coastal districts reflects that Ganjam district has the maximum area under forest cover (around 50% of total geographical area) followed by Cuttack (around 25%) of area. Bhadrak district however has minimum area under forest cover (only 1%).

REFERENCES

Anon. (1999-2000). *Economic Survey, 1999-2000.* Directorate of Economics and Statistics, Govt. of Orissa.

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Assessment of Soil Biodiversity under Different Land Uses in Coastal Plains of West Bengal- A Case Study

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Coastal soils of West Bengal were assessed under different land uses in respect of physical, chemical and biological behaviour of the soils. Soil biodiversity under different land uses was observed and it was related to the soil physical and chemical conditions. Available P and K content of these soils did not reflect any beneficial effect to the microbial population. However, high salinity and low exchangeable Ca^{2+} were related to the microbial population.

(***Key words*** : *Soil biodiversity, Coastal soils, Land uses)*

The coastal plains of West Bengal are formed by the deltaic deposits from the Ganga - Brahmaputra river and the tidal deposits from the Bay of Bengal in the basement of the Bengal basin. They are characterized by low flat alluvial plains with variable soil physical and chemical properties. The biological properties of the soils are influenced by many factors including climate, vegetation and the physical and chemical characteristics of the soils. The organisms present in a soil influence soil formation and are in turn affected by the edaphic properties that govern water, air and nutrient supply. Thus, a continual feedback relationship is established between the land use and microorganisms and physical and chemical characteristics of the soils. Land use changes are the major driver affecting soil biodiversity. Therefore, the present study was undertaken for assessment of soil biodiversity under different land uses in the coastal plains of West Bengal.

MATERIALS AND METHODS

Surface (0-25 cm) and subsurface (25-50 cm) soil samples were taken from five representative sites like Canning, Sagar, Harinbari, Lothian and Prentice of the coastal areas of West Bengal and analyzed for physicochemical properties and available nutrients (Jackson, 1973, Black, 1965, Subbiah and Asija, 1956). The microbial population of total bacteria, fungi and actinomycetes in the soils were determined by dilution technique and plate counting, respectively in Thronton's modified agar medium (Martin, 1950 and Jensen, 1950). Dominancy of biotope was studied using the quadrates of 10 x 10 m^2 method (Chapman, 1976). Climatic data were collected from IMD Pune and deviation of rainfall from the mean was analyzed.

RESULTS AND DISCUSSION

Year wise deviation of rainfall characteristics (Fig.1) in Sagar indicated that there were few chances of dry spells occurring in the area and chances of floods in the area occurred only twice during the past 21 years. The data also revealed that in general the area received rainfall within the normal range with minimum deviation from the normal.

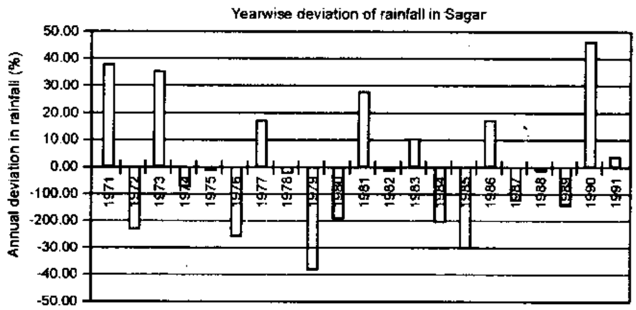

Fig. 1. Rainfall deviation in Sagar, W.B.

Physicochemical properties (Table 1) revealed that there was a wide variation in the soil texture ranging from sandy clay loam to silty clay in different sites of the coastal areas. The percent of sand varied from 3.2 to 48.0 in the surface soil and 3.6 to 44.2 percent in the subsurface soil. The percent of silt and clay ranged from 31.6 to 64.7 and 15.6 to 45.6 percent, respectively. It was observed that the clay percent in the subsurface soils remained higher than in the surface soils. The soils of Canning were acidic (pH 4.5 to 4.6) whereas neutral to alkaline (pH 7.0

Table 1. *Soil attributes and land use in coastal areas of West Bengal*

Location	Soil Depth (cm)	Sand %	Silt %	Clay %	pH	EC dSm^{-1}	CEC	Ex. Ca^{+2}	BS (%)	Land Use
							$cmol(p^+)kg^{-1}$			
Canning	0-25	3.2	64.7	32.1	4.6	10.7	17.4	2.5	66	*Oryza sativa*
	25-50	3.6	56.8	39.6	4.5	11.7	17.9	4.2	78	
Sagar	0-25	48.0	36.1	15.9	7.5	1.4	9.0	6.7	81	*Phoenix*
	25-50	44.2	31.6	24.2	7.0	1.6	10.1	6.5	82	*paludosa*
Harinbari	0-25	24.2	45.8	30.0	8.5	2.2	20.0	10.9	86	*Excoecaria*
	25-50	19.9	41.7	38.4	7.9	1.9	21.5	11.4	77	*agallocha*
Lothian	0-25	19.8	40.3	39.9	7.4	10.8	23.1	12.1	85	*Avicennia*
	25-50	9.6	44.8	45.6	7.2	11.4	21.0	9.8	84	*alba*
Prentice	0-25	8.1	61.8	30.1	7.5	4.6	22.6	10.8	87	*Avicennia*
	25-50	4.9	63.8	31.3	7.3	4.9	19.6	9.7	88	*marina*

Table 2. *Nutrient status and microbial population in coastal area*

Location	Soil depth (cm)	O.C. %	Av-N ppm	Av-P ppm	Av-K ppm	Bacteria x 10^5/g soil	Fungi x10^3/g soil	Actinomycetes x 10^3/g soil
Canning	0-25	1.19	202	11	286	27.9	25.9	1.8
	25-50	0.47	152	22	330	19.6	20.7	0.7
Sagar	0-25	0.47	58	25	106	75.3	25.6	34.0
	25-50	0.45	64	30	225	68.4	24.2	31.7
Harinbari	0-25	0.56	50	31	681	65.0	25.6	33.6
	25-50	0.37	46	31	625	61.1	21.4	32.4
Lothian	0-25	1.17	116	32	630	4.3	2.4	2.3
	25-50	1.21	101	30	618	4.1	1.6	2.1
Prentice	0-25	0.52	122	48	562	7.8	2.1	3.3
	25-50	0.69	109	22	518	6.1	1.5	2.8

to 8.5) reaction was observed in the soils of Sagar, Harinbari, Lothian and Prentice. The salt content varied from 1.4 to 11.7 dSm^{-1}. Soils of Canning and Lothian showed higher salt content ranging from 10.7 to 11.7 dSm^{-1}. The cation exchange capacity ranged from 9.0 to 23.1 cmol (p^+) kg^{-1}. CEC of the soils were at moderate level except for the soils of Sagar. The base saturation varied from 66 to 88 percent. The land use data revealed that *Phoenix paludosa* and *Excoecaria agallocha* were dominant with low salinity soils, whereas *Avicennia alba* and *Avicennia marina* were dominant in the soils having high salinity. Reclaimed mangrove soils of Canning were utilized for rice cultivation.

Nutrient status and microbial population are presented in Table 2. The organic carbon content in the soils ranged from 0.33 to 1.21 percent. The soils of Canning and Lothian had high organic carbon, whereas low to medium level (0.37 to 0.69%) of organic carbon were reported in the soils of Sagar, Harinbari and Prentice. Available N, P and K were found to be lower in the soils of Sagar and Harinbari than in the soils of Lothian and Prentice. Bacteria were the dominant microorganism varying from 1.7 to 75.3 x 10^5 cells g^{-1} of soil followed by actinomycetes varying from 0.7 to 34.0 x 10^3 cells g^{-1}, and fungi (1.5 to 25.9 x 10^3 cell g^{-1}). In all the cases, subsurface soil accounts lower microbial population in comparison to the surface soil. Microbial population was high in the soils of Sagar and Harinbari under *Phoenix paludosa* and *Excoecaria agallocha* in comparison to the soils of Prentice and Lothian soils under the flora of *Avicennia alba* and *Avicennia marina*. Harinbari and Sagar soils had higher microbial activity than that of Prentice and Lothian soils which might be due to anaerobic condition prevailing in the latter group of soils. Further, Lothian soils showed least microbial population, whereas Sagar soils showed higher microbial population, which might be due to the variation in salinity level. Similar results were obtained by Gupta and Bajpai (1974) while working with salt affected soils. The available P and K contents of these soils are however high. Inspite of aerobic condition, the population of bacteria was found lower in the soils of Canning than the soils of Sagar and Harinbari which might be due to high salinity and low exchangeable Ca^{2+} in case of the former. It was revealed that the land use controls and manipulates the organism responsible for nutrient cycling through its effects on soil physical, chemical and biological habitats. The low biological activity in saline soils might be due to osmotic and ionic stress induced by salts.

Variation of physical and chemical properties of soils in the coastal area with different land uses provided variable microenvironment to the organisms for its activity and growth. Depending upon the microbial populations, the biochemical oxidation and reduction reactions showed significant implication in plant nutrition as well as environmental quality. Microenvironment of the soils played a major role in the land use and its sustainability.

REFERENCES

Black, C. A. (1965). *Methods of Soil Analysis*, Part **II**. American Society of Agronomy, Wisconsin, U.S.A.

Chapman, V. J. (1976). Mangrove bio-geography. In *West Coastal Ecosystem*, V.J.Chapman, (ed.), pp. 1-29. Elsevier Scientific Publishing Company, Amsterdam.

Gupta, B.R. and Bajpai, P.D. (1974) Some microbioligical studies in salt affected soils. I. Pattern of soil microbial population as affected by salinity and alkalinity. *Journal of Indian Society of Soil Science* **22**: 176-180.

Jackson, M. L. (1973). *Soil Chemical Analysis*. Prentice Hall of India Private Ltd., New Delhi. 498p.

Jenson, H.L. (1950). In *Experiments in Soil Microbiology*. John Wiley & Sons Inc., New York & London.

Martin, J.P. (1950). In *Experiments in Soil Microbiology*. John Wiley & Sons Inc., New York & London.

Subbiah, B. V. and Asija, G. L. (1956). A rapid procedure for the estimatation of available nitrogen in soil. *Current Science* **25**(8): 259-260.

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Assessment of Changes in Kolleru Lake in Andhra Pradesh due to the Development of Aquaculture Using Satellite Data

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Kolleru lake is ensconced between the two major river basins of the rivers Godavari and Krishna and functions as a natural flood balancing reservoir between the two deltas. Aquaculture and agriculture encroachments into Kolleru lake have caused serious drainage problems. Images taken by Indian Remote Sensing satellite IRS-1D have indicated that there is very drastic reduction in the area of the lake over the past three decades and it has lost its identity as lake. The satellite picture clearly indicated the encroachment of lake and about 43 percent of the 245 sq km area of the lake was encroached for aquaculture. The discharge water from the aquaculture was directly led into the lake. The very high level of nutrients recorded in the lake water may affect the human food chain in the long run.

(Key words: *GIS, Satellite data, Aquaculture, Kolleru lake)*

It is estimated that in less than 25 years two-thirds of the world's people will be living in water-stressed countries, water use is expected to increase by 40 percent, and 17 percent more water will be required for food production to meet the needs of the growing population (World Water Council, 2000). The major factors causing increasing water demand over the past century are population growth, industrial development and pollution, and the expansion of irrigated agriculture.

Kolleru Lake is a large freshwater lake in Andhra Pradesh state. Kolleru is ensconced between the two major river rivers Godavari and Krishna deltas and it is the largest freshwater lake in our country. This lake has been designated as a Ramsar Site in November 2002 considering that the lake functions as a flood balancing reservoir between the Krishna and Godavari deltas and that it supports vulnerable species like grey pelican as well as water fowl including a variety of resident and migratory birds. However the reality appears different. Due to lack of awareness of the importance of this type of coastal wetland environments, the lake has been subjected to severe degradation during the recent decades.

The entire area of the lake comprises vast plains interspersed with pools of water with a few tree species, such as *Borassus flabellifer*, *Acacia nilotica* and *Azadirachta indica*, etc. The shrubs and herbs are typical coastal vegetation. The entire vegetation of this area can be classified into aquatic and terrestrial vegetation. The lake is covered by littoral vegetation, predominantly the hydrophytes. Although the lake is about 35 km inland from the present coast, it was the coastal lagoon in the geological past, believed to have been formed around 6000 years BP, when the shoreline was far inland along the southern margin of the lake, as evident from the presence of series of relict sandy beach dune ridges right up to the southern margin of the lake near Kaikalur and Akividu towns (Sadakata and Rao, 1997).

Apparently, this lagoon has progressively fallen inland with the advancement of the Krishna and Godavari deltas on both sides of it. A number of rivulets, such as Tamileru, Budimeru and several other smaller ones draining a total catchment of about 5400 km^2 decanting their water into it (Hema Malini *et al.*, 1999). Lack of regulation of the seaward flow of the Kolleru waters during monsoon is progressively increasing the high flood line, causing major food problems in the surrounding cities of Eluru and Gudivada, besides submerging second crop, paddy lands and fish tanks. The water spread varies from 135 sq km at +3 m above MSL to 901 sq km at +10 m above MSL. The average depth of the lake, which varies from 0.5 m to 2 m, is gradually being reduced due to siltation. The fast rate of development of fishponds in Kolleru lake has become a major environmental issue and the study was taken up to assess the changes in the land use pattern using satellite data.

execution, otherwise this once pristine natural water body will disappear and the opportunity to protect most precious natural assets may be lost forever.

Table 2. *Pollutant standards for inland surface water*

Parameters	Standards
BOD_5 at 20°C	30 mg/l
pH	5.5 - 9.0
Total suspended solids	100 ppm
Dissolved phosphate	0.2 ppm
Total residual chlorine	1.0 mg/l
Insecticides	nil
Fluorides (as F)	2.0mg/l
Sulphides (as S)	2.0mg/l
Cyanides (as CN)	0.2 mg/l

(IS:2490-1963)

REFERENCES

Hema Malini, B., Murali Krishna, G. and Nagswara Rao, K. (1999). Degradation of wetlands and microclimatic change - A study on Kolleru lake environment. *Indian Journal of Landscience System & Ecolological Studies* **22**: 127-132.

Sadakata, N. and Rao Nagswara, K., (1997) Radio carbon age of the subsurface sediments in the Krishna delta and their geomorphological implication. *Quarterly Journal of Geography* **49**: 163-170.

World Water Council (2000). *World Water Vision Commission Report: A Water Secure World, Vision for Water, Life and the Environment*, World Water Council.

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Monitoring Nutrient Status of a Pilot Site in Coastal Agroecosystem of Karnataka Using GIS Technique

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Monitoring of available nutrient status in a pilot site (Mirjan village) under coastal agroecosystem of Karnataka was carried out over seasons. Soil samples at random were collected under different land uses in the study area twice in the year (May and October) for five seasons. The exact sample locations were recorded using a GPS. The soils were acidic and non-saline with low water soluble salts. Organic carbon content of the surface soil was higher than that of subsurface soils with decreasing trend over the season. The available nitrogen content of the soils was generally low to medium. Majority of the study area (55.36%) was having low P status. The majority of the area was low in available K. Water soluble cations followed decreasing trend over a period.

(***Key words***: *Available nutrients, GPS*)

Karnataka has a coastline of 310 km on the Arabian Sea. Three major groups of soils namely laterites, red and alluvial soils are met with in this area. Many of the soils in this ecosystem are fragile and mis-management may rapidly lose whatever capability they have for sustained productivity. An attempt has been made to monitor nutrient status over seasons in a pilot site (Mirjan village) under coastal agroecosystem of Karnataka.

MATERIALS AND METHODS

Soil samples at random were collected under different land uses in the study area twice in the year (May and October) for five seasons. The exact sample location was recorded using a GPS. Soil samples were drawn from two depths, 0-30 cm and 30-60 cm. The information on crops was also noted. Processed soil samples were analysed for nutrient availability by following standard analytical techniques (Jackson, 1967).

RESULTS AND DISCUSSION

Soil pH and salt content

The data on soil pH over seasons indicate (Table 1) that the soils under study were acidic with the pH ranging from 3.92 to 6.95. The soils were acidic and non-saline. This can be attributed to the acidic parent material, *viz.* granite or granite gneiss, which are low in base minerals. Mean soil pH over seasons indicate that there was decrease in soil pH with time as the soils were subjected to high degree of leaching due to high rainfall (3500mm per year) received in about 4 months. High rainfall causes leaching of bases, which contribute to acidity, as observed by many workers (Patil and Ananthanarayana, 1990). Soluble salt content of the samples was very low and decreased over seasons (Table 1).

Organic carbon

Organic carbon content of the surface soil was higher than that of subsurface soils. Mean OC content of surface and subsurface samples ranged from 1.16 to 1.35% and 0.81 to 0.91%, respectively with decreasing trend over the seasons (Table 1). In most of the samples organic carbon content was high at the surface than in the subsurface. This can be attributed to luxuriant vegetative growth and consequent addition of organic matter to soil in this heavy rainfall area (Powar and Mehta, 1999).

Available nitrogen

The available nitrogen content of the soils was generally low to medium and ranged from 100.35 to 780.40 kg per ha with a mean of 437.62 kg per ha. The available nitrogen content of surface samples was higher than that of subsurface soils (Powar and Patil, 1995). Nitrogen content ranged from low to high in available status with decreasing trend over the seasons (Table 2). Exceptionally high N content at some sites is due to indiscriminate use of fertilizers by the farmers. Even with high organic carbon status of these soils, low to medium N status

Table 1. *pH, EC and organic carbon content of soil samples*

	pH (1:2.5 water)		EC (1:2.5 water) dSm^{-1}		Org-C %	
	Surface	Subsurface	Surface	Subsurface	Surface	Subsurface
I Season (May, 2002)						
Range	4.38-6.95	4.49-6.98	0.01-0.74	0.01-0.89	0.06-3.75	0.03-3.33
Mean	5.35	5.48	0.14	0.12	1.35	0.91
SD	0.51	0.43	0.12	0.14	0.89	0.63
II Season (October, 2002)						
Range	4.04-6.06	4.3-6.78	0.01-0.51	0.01-0.64	0.05-3.52	0.03-3.01
Mean	5.14	5.30	0.12	0.10	1.20	0.85
SD	0.44	0.39	0.09	0.11	0.79	0.55
III Season (May, 2003)						
Range	3.96-5.96	4.05-5.72	0.01-0.54	0.01-0.26	0.05-3.52	0.03-2.74
Mean	4.77	4.91	0.07	0.07	1.27	0.86
SD	0.47	0.43	0.07	0.05	0.83	0.56
IV Season (October, 2003)						
Range	4.03-6.03	4.27-6.74	0.01-0.45	0.01-0.61	0.04-3.38	0.03-2.68
Mean	5.09	5.25	0.12	0.09	1.16	0.81
SD	0.43	0.40	0.08	0.10	0.77	0.53
V Season (May, 2004)						
Range	3.92-5.91	4.01-5.75	0.011-0.520	0.010-0.258	0.05-3.50	0.03-2.73
Mean	4.70	4.82	0.071	0.063	1.22	0.83
SD	0.43	0.42	0.068	0.050	0.79	0.54

Surface, 0-30 cm; Subsurface, 30-60 cm

may be due to the fact that the soil could retain only a limited quantity of mineralized N and significant amount of N lost through leaching and denitrification in the soils (Usha and Jose, 1983).

Ammoniacal and nitrate nitrogen

Measured changes in field ammoniacal and nitrate nitrogen are the net result of a variety of N processes acting simultaneously, including mineralization of organic nitrogen, nitrification of ammonia originating from both native and fertilizer sources, denitrification, immobilization, defixation of ammoniacal N and leaching.

Readily available form of nitrogen (NH_4-N and NO_3-N) followed the trend of available nitrogen in soil. Level of ammoniacal nitrogen was always low in comparison with nitrate nitrogen indicating high rates of nitrification. Largest amount of ammonium and nitrate occurred in surface horizons and decreased with depth in these soils. Similar observation was made by Small and Misztal (1996).

Available phosphorus

Available P content was in the range of 1.99 - 70.1 kg ha^{-1}. Available phosphorus content of the surface samples was higher than that of subsurface samples. Similar observation was made by Dongale (1993) in laterite soils of coastal region. It was low to high in available status and decreased over the seasons (Table 3). Majority of the study area (55.36%) was having low P status. Since the soils are rich in hydrated as well as amorphous oxides of Fe and Al, the potent source of P immobilization, P content is very low in these soils (Badrinath *et al.*, 1986). Available P content was medium at some sites in the study area where pH was near neutral. The near neutral pH has a significant role in enhancing the P availability (Wahid, 1985).

Available potassium

Available potassium content of surface and subsurface samples was low to high and decreased over the seasons (Table 3). Ranganathan and Satyanarayana (1980) observed low content of K in these soils due to low pH. Available K content was

Table 2. *Available N, NH_4-N and NO_3-N content of soil samples*

	Avail. N (kg/ha)		NH_4-N (kg/ha)		NO_3-N (kg/ha)	
	Surface	Subsurface	Surface	Subsurface	Surface	Subsurface
I Season (May, 2002)						
Range	100.35-780.40	94.08-592.70	25.68-99.02	15.23-98.02	25.37-150.53	21.95-134.85
Mean	420.34	347.34	53.03	48.72	70.94	62.88
SD	144.87	121.58	17.49	17.49	23.47	23.09
II Season (October, 2002)						
Range	125.70-740.80	74.04-579.92	20.34-94.08	12.24-94.08	24.29-125.44	21.29-110.22
Mean	380.26	316.72	50.33	44.49	65.44	56.99
SD	133.89	111.32	17.14	17.25	19.35	19.75
III Season (May, 2003)						
Range	104-522	144-498	19.6-70.0	10.0-72.8	32.0-110.0	20.0-93.0
Mean	325	276	36.5	31.9	53.2	44.8
SD	92	77	11.0	9.6	12.3	13.4
IV Season (October, 2003)						
Range	220-630	73-572	20.0-92.1	12.1-92.1	23.3-123.4	20.3-109.2
Mean	422.16	334.10	48.5	42.8	63.5	55.2
SD	115.67	122.01	16.4	16.5	18.8	19.1
V Season (May, 2004)						
Range	211-518	160-465	19.2-69.0	9.6-71.3	31.6-108.0	20.0-92.1
Mean	343	293	36.0	31.7	52.6	44.3
SD	78	73	10.8	9.6	12.0	13.3

Surface, 0-30 cm; Subsurface, 30-60 cm

Table 3. *Available phosphorus and potassium content of soil sample*

	Avail. P (kg/ha)		Avail. K (kg/ha)	
	Surface	Subsurface	Surface	Subsurface
I Season (May, 2002)				
Range	1.99-70.11	2.02-51.28	15.00-463.20	9.00-385.40
Mean	9.78	7.37	92.30	70.38
SD	11.87	7.46	76.50	62.89
II Season (October, 2002)				
Range	1.12-53.76	1.09-25.62	19.00-413.63	10.00-381.80
Mean	7.07	5.84	84.55	63.18
SD	6.72	5.05	73.72	60.36
III Season (May, 2003)				
Range	1.0-49.0	1.0-19.5	49-343	49-392
Mean	7.1	5.6	124	118
SD	7.4	4.5	61	61
IV Season (October, 2003)				
Range	1.0-51.8	1.0-23.6	19-403	9-376
Mean	6.6	5.4	82.6	62.7
SD	6.3	4.6	73	62
V Season (May, 2004)				
Range	1.0-47.2	1.0-17.8	46.0-340	47.0-385.0
Mean	6.8	5.4	120.7	115.7
SD	7.0	4.2	59.7	56.7

Surface, 0-30 cm; Subsurface, 30-60 cm

more at the surface than at the lower depth. The majority of the area (65.59%) was low in available K, 27.21% area was medium and 7.26% area was high in K status. Coarse textured and gravelly soils with deeper solum are particularly low in available potassium due to faster and deeper leaching. In highly weathered soils like laterites where strong weathering had reduced the K content of the entire profile to a low level, the surface soil had a higher K content than the subsoil (Sekhon and Bansal, 1982). The action of plants in transporting K to the surface probably is responsible for this.

REFERENCES

Badrinath, Krishnappa, A.N., Patil, B.N., Kenchaiah, K. and Balakrishnarao, K. (1986). Fertility status of some typical soils of coastal Karnataka. *Journal of Indian Society of Soil Science* **34**: 436-438.

Dongale, J. H. (1993). Depth distribution of different forms of phosphorus lateritic soils of coastal region. *Journal of Indian Society of Soil Science* **41**(1): 62-66.

Jackson, M. L. (1967). *Soil Chemical Analysis*. Prentice Hall of India Private Limited, New Delhi.

Patil, P.L. and Ananthanarayana, R. (1990). Determination of lime requirement of some acid soils of Uttara Kannada district, Karnataka. *Karnataka Journal of Agricultural Sciences* **3**: 161-170.

Powar, S. L. and Mehta, V. B. (1999). Characterization of soils of the Konkan coast. *Journal of Indian Society of Soil Science* **47**(2): 334-337.

Powar, S. L. and Patil, V. S. (1995). Characterization of the coastal coconut growing soils of the Konkan in relation to soil fertility. *Journal of Indian Society of Coastal Agricultural Research* **13**(1): 11-17.

Ranganathan, A. and Satyanarayana, T. (1980). Studies on potassium status of soils of Karnataka. *Journal of the Indian Society of Soil Science* **28**(2): 148-153.

Sekhon, G. S. and Bansal, D. K. (1982). Potassium transformation and losses in various soil – plant systems – A review. *Fertilizer News* **27**(6): 15-22.

Small, H. and Misztal, M. (1996). Ammonium and nitrate content in solutions of arable and forest soils. In *Nitrates in Agricultural System*, pp. 367-374. Institute of Soil Science and Environmental Management, Agricultural University, 20-069, Lubin, Poland.

Usha, P. B. and Jose, A. I. (1983). Carbon-Nitrogen relationship in laterite soils of Kerala. *Agricultural Research Journal of Kerala* **21**(2): 15-22.

Wahid, P. A. (1985). Evaluation of available P to coconut palms in coastal sandy soils. *Indian Coconut Journal* **16**(1): 3-6.

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Fertility Status of Salt Affected Soils of Northwest Agroclimatic Zones of Gujarat

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Fertility status of salt affected soils of northwest agroclimatic zones of Gujarat were evaluated by analyzing 440 soil samples. It was observed that these soils, in general, are low in organic carbon and DTPA extractable Zn, medium in available P_2O_5, and high in K_2O, Fe, Mn and Cu status. It was emphasized that the use of fertilizers in such soils needs to be made only after soil testing.

***(Key words**: Fertility status, Northwest agroclimatic zone, Nutrient index)*

Soil testing for macro and micronutrients is necessary for making fertilizer recommendations to increase crop production. Indiscriminate use of fertilizers, however, may add to salinity besides extra expenditure to the farmers. The northwest agroclimatic arid zone has severe salinity/sodicity problem (0.575 million ha) which restricts agricultural production. The saline and alkali soils are usually low in nitrogen, medium to high in phosphorus, and high in potassium (Joshi and Kadarekar, 1987). However, precise information on the fertility status of the salt affected soils of northwest agroclimatic zone of Gujarat is lacking and hence the present investigation was undertaken.

MATERIALS AND METHODS

Twenty surface (0-30 cm) soil samples from each of 22 *talukas* of 6 districts of this zone having salinity/sodicity problems were collected from the cultivated fields. In all, 440 soil samples were collected which were air dried and ground to pass through 2 mm sieve. The $EC_{2.5}$ (dSm^{-1}), $pH_{2.5}$ and ESP values of northwest agroclimatic zone ranged from 0.19 to 8.20, 7.0 to 9.0 and 29.6 to 33.9 with mean value of 1.29, 8.03 and 11.70, respectively. The soil samples were analyzed for O.C., available P_2O_5 and K_2O by standard methods (Jackson, 1973). DTPA extractable micronutrients were determined by Atomic Absorption Spectrophotometer as per the method outlined by Lindsay and Norvell (1978). Nutrient index was calculated utilizing the following formula.

$$\text{Nutrient index} = [(Nl \times 1) + (Nm \times 2) + (Nh \times 3)]/Nt$$

where, Nl, Nm and Nh are the number of soil samples falling in low, medium and high categories for nutrient status and are given weightage of 1, 2 and 3, respectively. Nt is the total number of soil samples.

RESULTS AND DISCUSSION

The data presented in Table 1 indicate that overall organic carbon was found low and it ranged from 0.53 to 9.55 with a mean value of 3.2 g kg^{-1}. The lowest (0.53 g kg^{-1}) and highest (9.55 g kg^{-1}) O.C. status was found in soils of Bhachau and Anjar *taluka* of Kachchh district, respectively. The available P_2O_5 and K_2O status were medium and high and ranged from 5.12 to 122.9 and 104.8 to 1048.4 with mean value of 40.0 and 464.4 kg ha^{-1}, respectively. These results are in direct line with Joshi and Kadrekar (1987). The DTPA extractable Fe, Mn, Zn and Cu varied from 4.44 to 26.40, 2.73 to 30.08, 0.049 to 1.880 and 0.165 to 2.970 with their corresponding mean values of 11.45, 13.04, 0.467 and 1.327 kg ha^{-1}, respectively.

The nutrient index value (Table 2) were found low for organic carbon and DTPA extractable Zn, medium for available P_2O_5, and high for K_2O and Fe, Mn and Cu in the salt affected soils of Northwest agroclimatic zone of Gujarat.

Table 1. Fertility status of salt affected soils of northwest agroclimatic zone of Gujarat

District	O.C. (g kg^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	Available micronutrients (mg kg^{-1})			
				Fe	Mn	Zn	Cu
Kachchh (180)	0.53-9.55 (3.7)	5.12-122.9 (37.1)	104.8-884.8 (416.9)	45.54-26.40 (11.68)	2.73-30.08 (11.32)	0.049-1.880 (0.644)	0.165-2.970 (1.121)
Rajkot (20)	1.52-6.32 (3.6)	10.2-58.9 (30.6)	419.3-1048.4 (682.4)	7.50-16.11 (10.34)	6.96-20.01 (12.37)	0.049-0.643 (0.267)	0.990-2.795 (1.904)
Surendranagar (60)	1.05-6.87 (2.4)	5.12-79.3 (33.8)	104.8-1015.9 (422.4)	4.44-20.27 (10.37)	6.09-26.22 (12.27)	0.049-1.633 (0.373)	0.330-2.475 (1.43)
Amdavad (20)	1.14-6.68 (2.9)	10.2-105.4 (43.8)	175.0-949.8 (511.8)	6.94-22.22 (12.79)	4.47-26.84 (13.54)	0.049-1.086 (0.383)	1.155-2.805 (1.732)
Mehsana (40)	1.33-5.53 (2.9)	7.68-117.8 (40.6)	314.5-1048.4 (608.8)	4.72-19.44 (11.26)	4.48-26.07 (13.61)	0.049-0.792 (0.357)	0.825-2.640 (1.58)
Banaskantha (120)	0.58-7.44 (2.3)	10.2-103.4 (48.0)	104.8-949.4 (431.2)	4.72-25.27 (11.36)	6.16-28.20 (15.86)	0.049-0.940 (0.332)	0.495-2.970 (1.335)
Overall zone (440)	0.53-9.55 (3.2)	5.12-122.9 (40.0)	104.8-1048.4 (464.4)	4.44-26.40 (11.45)	2.73-30.08 (13.04)	0.049-1.880 (0.467)	0.165-2.970 (1.327)

Parenthesis under district indicates number of samples, and parenthesis under fertility data indicates mean

***Table 2.** Nutrient index for the available nutrients present in the salt affected soils*

District	Major nutrients			Micronutrients			
	O.C.	P_2O_5	K_2O	Fe	Mn	Zn	Cu
Kachchh	1.34	1.78	2.66	2.72	2.54	1.75	2.84
Rajkot	1.30	1.70	3.00	2.45	2.75	1.15	3.00
Surendranagar	1.13	1.68	2.90	2.46	2.68	1.28	2.98
Amadavad	1.15	2.00	2.90	2.75	2.70	1.3	3.00
Mehsana	1.03	1.83	2.48	2.48	2.72	1.33	3.00
Banaskantha	1.03	2.08	2.49	2.52	2.84	1.20	2.97
Overall zone	1.18	1.85	2.60	2.60	2.68	1.45	2.93

REFERENCES

Jackson, M.L. (1973). *Soil Chemical Analysis.* Prentice Hall of India Pvt. Ltd., New Delhi.

Joshi, R.G. and Kadrekar, S.B. (1987). Fertility status of coastal salt affected soils of Maharashtra. *Journal of the Indian Society of Coastal Agricultural Research* **5**(1): 111-116.

Lindsay, W.L. and Norvell, W.A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* **42**: 421-428.

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Fertility Status of Irrigated Soils of Coastal Amreli District of Gujarat

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Chemical analysis of 220 surface soil samples of Amreli district indicates that soils were deficient with respect to available N and S, whereas medium in available P_2O_5 and K_2O status. Among the DTPA extractable micronutrients, Mn and Cu were found sufficient, whereas the soils were medium in Fe and Zn. The nutrient index values were low for available N (1.02) and S(1.27), medium for available P_2O_5 (1.83), K_2O (2.11), DTPA extractable Fe (2.04) and Zn (1.65), and high for Mn (2.68) and Cu (3.0) in the soils of Amreli district.

(**Key words**: *Available macronutrients, DTPA extractable micronutrient, Nutrient index*)

Optimum use of fertilizers is a major factor in any programme designed to bring about an economic increase in agricultural production. It has been seen that the amount of fertilizers required for the same crop varies from soil to soil and even from field to field of the same soil. Maintenance of fertility of the soils is of immense concern to obtain higher yields from it, because plant growth removes nutrients continually from the soils and thereby creating deficiencies of some nutrients. Therefore, an attempt has been made to study the fertility status of irrigated soils of coastal Amreli district of Gujarat.

MATERIALS AND METHODS

Twenty surface soil samples (0 – 15 cm) were collected from each of eleven *talukas* of Amreli district, viz. Amreli, Bagasra, Kunkavav, Babra, Lathi, Liliya, Savarkundla, Dhari, Rajula, Khambha and Jafrabad during May, 2003. Soil samples were air dried, ground and passed through 2 mm sieve. The available N, P_2O_5, K_2O and S were determined as per the methods described by Jackson (1973), while DTPA extractable micronutrients were determined by Atomic Absorption Spectrophotometer as per the method outlined by Lindsay and Norvell (1978). The nutrient index (NI) values for available nutrients present in the soils were calculated utilizing the formula suggested by Parker *et al.* (1951) and classified this index as low (<1.5), medium (1.5 to 2.5) and high (>2.5):

$$NI = [(Nl \times 1) + (Nm \times 2) + (Nh \times 3)]/Nt,$$

where, Nl, Nm and Nh are the number of soil samples falling in low, medium and high categories for nutrient status and are given weightage of 1, 2 and 3, respectively. Nt is the total number of samples.

RESULTS AND DISCUSSION

The data on available macro and micronutrients are presented in Table 1. In general, the soils of Amreli district were low in available nitrogen. It ranged from 117 to 277 with a mean value of 186.5 kg ha^{-1}. The available P_2O_5 and K_2O status was found to be medium and ranged from 3.2 to 116.0 and 67 to 1601 with an average value of 38.44 and 245 kg ha^{-1}, respectively. The medium to high status of available P_2O_5 and K_2O may be due to the fact that farmers are applying FYM to the field. The soils of Amreli district were high in available Mn and Cu and medium in Fe and Zn. The DTPA extractable Fe, Mn, Cu and Zn varied from 1.10 to 16.34, 0.54 to 23.02, 0.98 to 6.99 and 0.20 to 2.94 with their corresponding mean values of 7.84, 12.63, 3.90 and 0.64 mg kg^{-1}, respectively. These results are in conformity with those of Timbadia and Maliwal (2000) and Srivastava and Srivastava (1992).

The nutrient index values (Table 2) were low for available N (1.02) and S (1.27), medium for available P_2O_5 (1.83), K_2O (2.11), DTPA extractable Fe (2.04) and Zn (1.65), and high for Mn (2.68) and Cu (3.0) in the soils of Amreli district.

Table 1. Taluka-*wise range and mean values for available nutrient status in irrigated surface soils of coastal Amreli district*

Name of *talukas*	Available macronutrients				DTPA extractable micronutrients (mg kg^{-1})			
	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	S (mg kg^{-1})	Fe	Mn	Cu	Zn
Amreli	167-266 (213)	19.0-57.2 (39.2)	67-593 (252)	1.13-18.11 (8.56)	2.95-11.31 (7.69)	6.32-23.16 (14.80)	1.66-3.86 (2.38)	0.34-1.11 (0.53)
Savarkundla	133-244 (189)	6.3-60.4 (25.7)	100-571 (246)	1.38-18.11 (7.24)	3.21-16.34 (8.20)	6.29-22.17 (13.15)	1.66-4.98 (2.66)	0.44-1.19 (0.57)
Rajula	152-261 (206)	3.2-65.2 (23.3)	134-481 (303)	1.13-12.0 (4.53)	2.18-11.18 (7.63)	8.23-23.02 (16.15)	2.67-5.02 (3.86)	0.36-2.94 (0.61)
Jafrabad	117-236 (199)	17.5-81.1 (38.3)	67-425 (234)	1.38-17.0 (8.00)	3.83-14.98 (8.97)	7.54-22.52 (16.19)	2.22-6.09 (4.12)	0.40-1.64 (0.57)
Khambha	123-238 (172)	12.7-90.6 (39.0)	78-470 (191)	1.74-21.43 (6.00)	1.10-16.23 (8.11)	0.54-20.16 (11.53)	2.0-5.99 (4.12)	0.25-2.10 (0.75)
Dhari	120-277 (183)	11.1-82.7 (38.0)	112-380 (204)	1.38-10.1 (3.50)	5.45-14.49 (8.90)	10.0-18.0 (13.66)	3.47-6.99 (4.46)	0.31-2.43 (0.70)
Babra	131-229 (181)	8.0-82.7 (43.1)	134-537 (245)	1.13-12.48 (4.37)	1.98-11.05 (7.19)	7.10-19.95 (11.15)	3.90-5.51 (4.81)	0.37-2.47 (0.68)
Kunkavav	120-241 (179)	9.5-116.0 (46.7)	156-459 (238)	2.15-16.5 (6.13)	4.10-9.62 (7.10)	5.98-20.05 (9.56)	3.86-5.42 (4.65)	0.34-2.36 (0.66)
Bagasra	125-216 (171)	11.1-63.6 (36.7)	134-302 (206)	1.64-18.87 (7.08)	2.52-11.52 (6.83)	0.86-15.64 (9.42)	4.34-5.36 (4.96)	0.35-2.40 (0.80)
Liliya	138-229 (176)	9.5-66.8 (45.0)	168-660 (268)	2.15-27.83 (7.39)	3.04-13.49 (7.78)	9.46-17.93 (13.0)	4.58-6.18 (5.26)	0.20-1.61 (0.64)
Lathi	135-230 (183)	15.9-66.8 (47.9)	145-1601 (306)	2.25-27.83 (6.51)	3.15-13.89 (7.89)	6.64-14.40 (10.36)	0.98-2.62 (1.90)	0.30-1.10 (0.57)
Overall	117-277 (186.5)	3.2-116.0 (38.44)	67-1601 (245)	1.13-27.83 (6.30)	1.10-16.34 (7.84)	0.54-23.02 (12.63)	0.98-6.99 (3.90)	0.20-2.94 (0.64)

Values in parentheses indicate the mean values

Table 2. *Nutrient index of available nutrients for irrigated soils of coastal Amreli district*

Name of *talukas*	Macronutrients				Micronutrients			
	N	P_2O_5	K_2O	S	Fe	Mn	Zn	Cu
Amreli	1.15	1.75	2.05	1.35	2.00	2.85	1.55	3.0
Savarkundla	1.0	1.40	2.05	1.25	2.00	2.80	1.95	3.0
Rajula	1.05	1.35	2.50	1.15	2.05	2.90	1.40	3.0
Jafrabad	1.0	1.85	2.05	1.45	2.20	2.95	1.65	3.0
Khambha	1.0	1.85	1.80	1.40	2.15	2.55	1.70	3.0
Dhari	1.1	1.85	2.00	1.05	2.30	2.95	1.65	3.0
Babra	1.0	2.00	2.10	1.15	1.85	2.50	1.75	3.0
Kunkavav	1.0	2.05	2.15	1.25	1.85	2.35	1.65	3.0
Bagasra	1.0	1.80	2.05	1.30	1.90	2.35	1.85	3.0
Liliya	1.0	2.10	2.30	1.35	2.05	2.90	1.70	3.0
Lathi	1.0	2.15	2.20	1.30	2.10	2.40	1.70	3.0
Overall	1.02	1.83	2.11	1.27	2.04	2.68	1.65	3.0

REFERENCES

Jackson, M.L.(1973) *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.

Lindsay, W.L. and Norvell, W.A. (1978) Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* **42**: 421-428.

Parker, F.W., Nelson, W.L., Winter Eric and Miles, I.E.(1951). The broad interpretation and application of soil test information. *Agronomy Journal* **43**(3): 105-112.

Srivastava, A.K. and Srivastva, O.P. (1992). Zinc fractions and availability of applied zinc in salt affected soil amended with gypsum and pyrites. *Journal of Indian Society of Soil Science* **40**: 890-892.

Timbadia, N.K. and Maliwal, G.L. (2000). Nutrient status of coastal salt affected soils and their relationships with soil properties. *Journal of the Indian Society of Coastal Agricultural Research* **18**(1): 58-60.

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Salt Affected Soils of Northwest Agroclimatic Zone of Gujarat: Their Characterization and Categorization

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investigation on the extent of chemical degradation affecting the soils of northwest zone of Gujarat revealed that nearly half (49.7 %) of the cultivated soils of this zone suffered from salinity, followed by salinity-sodicity (31.2 %) and sodicity (19.1 %). The soils of the zone are poor in organic carbon (range 0.053 to 0.86, mean 0.312 percent), alkaline in reaction (pH mean 8.03), and calcareous in nature ($CaCO_3$ range 0.3 to 25 percent).

***(Key words** : Soil characterization, Salt affected soils, North west zone of Gujarat)*

An estimated area of 0.575 m ha in the northwest agroclimatic arid zone has severe salinity/sodicity problem which is restricting agricultural production to a significant extent. In order to evolve effective management strategies to sustain productivity of these salt affected yet potential areas, there is a need to characterize the soils and subsequently map them at proper scale, so that researchers, planners and policy makers have a ready reference at hand for needful action. The present study has been taken up with this primary objective in mind.

MATERIALS AND METHODS

Twenty surface (0-0.30m) soil samples from each of the 22 *talukas* of this zone having salinity/ sodicity problems were collected from the farmers' fields. In all 440 samples were collected and subjected to laboratory characterization. The pH, EC and water soluble ions were estimated using 1:2.5 soil:water ratio (Jackson, 1973). For predicting ECe from $EC_{2.5}$ extract, 75 soil samples representing a wide range of EC, textural class and different geographical locations in the zone, were used to develop a pedo-transfer function, which can be used to predict ECe for other soils of the zone. These soil samples were analysed for C and pH of the saturation extract, 1:2.5 and 1:5 soil:water ratio extracts. Soils were also analyzed for exchangeable cations using standard methods (Richards, 1954). The soil organic carbon content, $CaCO_3$ content and sulphate content were determined by standard methods (Jackson, 1973).

RESULTS AND DISCUSSION

The clay content of the soils ranged from 1.80 to 46.25 percent with a mean value of 13.5 percent for the entire zone indicating that the soils are sandy to sandy loam in texture (Table 1). The free lime content varied from 0.3 to 25 percent with a mean value of 7.0 percent indicating the calcareous nature of the soils. In most of the *talukas*, the average value was above 5 percent and only in few *talukas* it was between 3 to 5 percent. This might be due to impregnation of lime in the transported material and accumulation of shells in the marine alluvial soils. Kanzaria *et al.* (1982) observed high content of $CaCO_3$ in salt affected soils of coastal area. The soils of this zone are poor in organic carbon status with the overall value below 0.5 percent. The overall range of organic carbon content was 0.053 to 0.859 percent with a mean value of 0.312 percent. The findings are in tune with those reported by Kanzaria *et al.* (1982).

The pH value of the soils varied from 7.0 to 9.0 with a mean value of 8.03 for the entire zone indicating that the soil of this zone are neutral to alkaline in reaction (Table 1). Kanzaria *et al.* (1982) reported similar pH range in saline and alkali soils of Saurashtra region of Gujarat. The distribution of soil samples into different pH classes (<8.4, 8.4-8.8 and 8.9- 9.4) as suggested by CSSRI, Karnal (Anon., 1974) show that 79.8 percent of the soil samples had pH less than 8.4.

The values of $EC_{2.5}$ varied widely between 0.19 to 8.20 dS m^{-1} with mean value of 1.29 dS m^{-1} (Table 1). The wide variation in $EC_{2.5}$ could be attributed to the nature of soluble cations and anions present in the soils as well as to the quality of water used for irrigation. Among the various soil properties, EC at 1:2.5 soil:water ratio gave the highest correlation at 1 percent level of significance ($Y = -0.723 + 5.495 X^{**}$) with EC in saturation paste extract, and therefore this equation can be used to compute

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Table 1. Taluka-*wise range and mean values of some chemical parameters of the soils*

Sr. 1	District and *Taluka* 2	$pH_{2.5}$ 3	$EC_{2.5}$ (dSm^{-1}) 4	ESP 5	$CaCO_3$ (%) 6	Organic C (%) 7	Textural Class 8
	Kachchh						
1	Bhuj	7.45-8.45 (7.89)	0.36-4.70 (1.61)	3.69-17.2 (10.40)	0.40-15.50 (3.88)	0.157-0.897 (0.45)	S
2	Nakhtrana	7.00-8.40 (7.71)	0.46-8.10 (2.36)	3.37-30.6 (10.70)	0.30-22.8 (3.76)	0.114-0.903 (0.52)	LS
3	Lakhpat	7.00-8.20 (7.71)	0.23-5.60 (1.28)	4.10-13.2 (8.20)	0.30-25.0 (6.93)	0.080-0.691 (0.35)	S
4	Abdasa	7.20-8.63 (7.89)	0.19-3.10 (0.91)	3.73-28.2 (11.30)	2.00-15.5 (7.22)	0.058-0.592 (0.30)	SL
5	Mandvi	7.00-8.65 (8.04)	0.25-7.20 (1.65)	4.48-33.9 (15.70)	1.70-12.3 (5.44)	0.133-0.802 (0.40)	LS
6	Mundra	7.43-8.60 (8.14)	0.35-2.33 (0.99)	5.92-21.3 (12.20)	3.75-18.7 (9.46)	0.133-0.591 (0.38)	SL
7	Anjar	7.65-8.80 (8.10)	0.28-3.20 (1.23)	4.62-25.1 (12.40)	1.35-22.3 (9.24)	0.115-0.955 (0.46)	LS
8	Bhachau	7.20-8.70 (8.05)	0.26-7.50 (1.37)	3.58-19.1 (9.60)	1.60-24.5 (6.90)	0.053-0.663 (0.26)	SCL
9	Rapar	7.30-8.60 (8.00)	0.20-5.70 (2.08)	3.7-22.8 (10.80)	1.85-12.2 (4.16)	0.076-0.592 (0.23)	LS
	District average	7.00-8.80 (7.95)	0.19-8.10 (1.50)	3.37-33.9 (11.30)	0.30-25.0 (6.33)	0.058-0.859 (0.37)	—
10	Malia (Raj.)	7.92-8.70 (8.46)	0.25-2.55 (0.51)	7.15-17.8 (11.00)	4.60-18.0 (10.10)	0.152-0.632 (0.36)	C
	Surendranagar						
11	Halwad	7.70-8.80 (8.25)	0.28-4.20 (1.20)	7.20-20.9 (13.90)	3.80-20.9 (6.50)	0.105-0.592 (0.34)	SCL
12	Dhrangadhra	7.65-9.00 (8.27)	0.26-3.00 (1.17)	4.96-25.9 (12.90)	3.10-24.2 (10.63)	0.118-0.687 (0.37)	SCL
13	Dasada	8.00-8.75 (8.43)	0.25-1.55 (0.58)	7.19-18.2 (12.20)	3.50-20.8 (13.30)	0.114-0.420 (0.24)	LS
	District average	7.65-9.00 (8.32)	0.25-4.20 (0.98)	4.96-25.9 (13.00)	3.10-24.2 (10.20)	0.105-0.687 (0.32)	—
14	Viramgam (Ahm.)	7.10-8.65 (8.10)	0.30-8.20 (1.95)	8.90-23.1 (15.00)	1.65-17.0 (9.14)	0.114-0.668 (0.29)	SCL
	Mehsana						
15	Sami	8.10-8.66 (8.35)	0.23-0.78 (0.42)	2.96-18.7 (9.50)	1.40-19.8 (9.49)	0.133-0.480 (0.25)	SCL
16	Harij	7.20-8.40 (7.88)	0.25-4.70 (1.46)	4.83-22.2 (11.70)	1.35-11.5 (4.30)	0.133-0.553 (0.32)	SCL
	District average	7.20-8.66 (8.12)	0.23-4.70 (0.94)	2.96-22.2 (10.60)	1.35-19.9 (6.89)	0.133-0.553 (0.29)	—
	Banaskantha						
17	Tharad	7.35-8.30 (7.86)	0.25-2.55 (1.01)	5.30-25.2 (11.00)	1.75-5.2 (3.50)	0.076-0.286 (0.17)	S
18	Vav	7.15-8.35 (7.87)	0.25-3.90 (0.88)	3.26-17.8 (9.60)	1.10-18.7 (4.22)	0.058-0.404 (0.19)	S

Contd.

Sr. 1	District and *Taluka* 2	$pH_{2.5}$ 3	$EC_{2.5}$ (dSm^{-1}) 4	ESP 5	$CaCO_3$ (%) 6	Organic C (%) 7	Textural Class 8
19	Santalpur	7.55-8.40 (8.02)	0.30-2.00 (1.03)	4.22-21.4 (11.20)	3.50-11.6 (8.70)	0.076-0.325 (0.20)	SL
20	Radhanpur	7.00-8.45 (7.96)	0.30-6.50 (1.55)	5.45-18.8 (10.30)	3.25-16.4 (8.50)	0.133-0.744 (0.31)	SCL
21	Deodar	7.30-8.48 (7.75)	0.25-2.65 (1.55)	5.85-29.3 (15.70)	0.35-7.5 (3.38)	0.114-0.544 (0.24)	LS
22	Kankrej	7.35-8.60 (7.92)	0.30-6.10 (1.67)	3.33-30.8 (12.40)	0.50-9.5 (5.00)	0.114-0.496 (0.26)	SCL
	District average	7.15-8.60 (7.90)	0.25-6.50 (1.28)	3.26-30.8 (11.70)	0.35-18.7 (5.53)	0.058-0.744 (0.23)	—
	Overall Zone	7.00-9.00 (8.03)	0.19-8.20 (1.29)	2.96-33.9 (11.70)	0.30-25.0 (7.00)	0.053-0.993 (0.32)	—

Value in parenthesis shows mean

dependable estimates of ECe. Based on this equation, ECe of all the other samples was estimated and the soils were then grouped into 5 classes of salinity proposed by Richards (1954). The results show that 27 percent of the soils had ECe of less than 2.0 dS m^{-1} and were placed in non-saline class, 23 percent had ECe between 2.0 to 4.0 dS m^{-1} and were placed in low salinity class, while the rest of the 50 percent of the soils were placed in moderately saline to very highly saline class.

The highest ESP (Table 1) value of 33.9 was registered in Mandvi *taluka* while the lowest value of 2.98 was obtained in Sami *taluka*. The overall ESP ranged from 2.96 to 33.9 with a mean value of 11.7. The distribution of soil samples into different ESP classes as suggested by CSSRI, Karnal (Anon., 1974) revealed that 44 percent samples were categorized in non-sodic group (<10 ESP) and 47 percent into moderate group (ESP 10 to 20).

Using the criteria proposed by Richards (1954), out of the 440 samples, 49.7 percent samples were grouped as saline soils followed by 31.2 percent as saline-sodic and 19.1 percent as sodic soil group (Fig. 1). This clearly showed that saline soils are dominant in the zone followed by saline-sodic and sodic soils. *Taluka*-wise distribution of the three

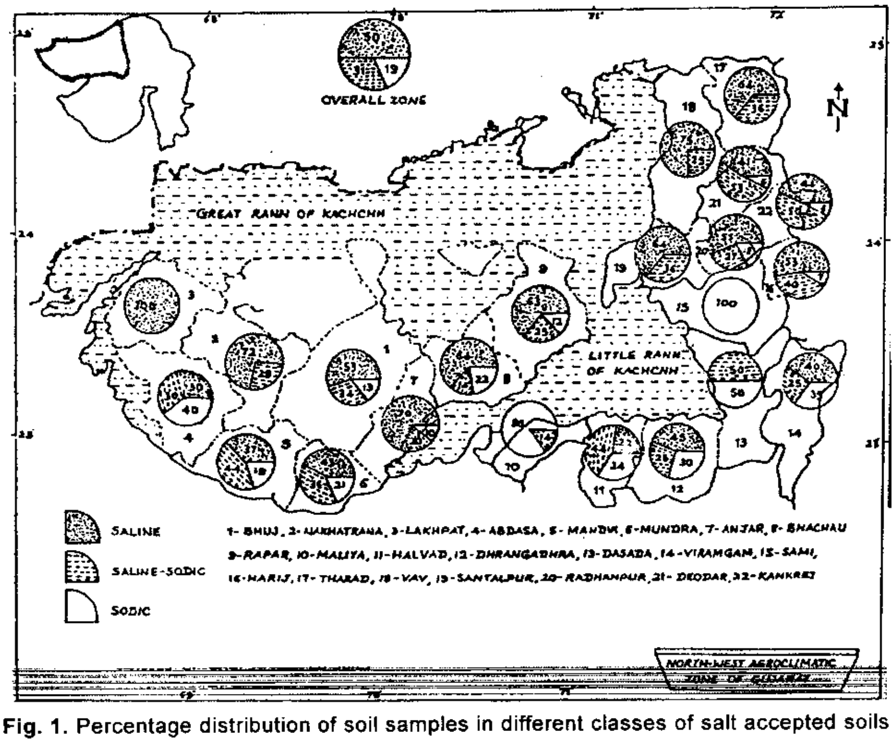

Fig. 1. Percentage distribution of soil samples in different classes of salt accepted soils

groups of salt affected soils showed that within Kachchh district the three *talukas* on the coast of Arabian sea, viz. Abdasa, Mandvi and Mundra had salinity spread in less than 50 percent of the soils. The other six *talukas* of the district lying relatively on the northern and interior side had more than 50 percent of the soils affected by salinity. In Lakhpat *taluka* all the soils fell in saline group. The cause of salinity in soils can be attributed to the arid climate, proximity to sea and shallow ground water of poor quality (Dubey *et al.*, 1986).

Of the remaining cluster of 13 *talukas* adjoining to the Rann of Kachchh, 7 *talukas* on the northern side (Tharad, Vav, Santalpur, Radhanpur, Deodar, Kankrej and Harij) fell under saline group in each *taluka*. This might be due to aridity of the climate, poor quality of ground water and high water table. More than 50 percent of the soils in Deodar, Dasada and Kankrej *talukas* were predominantly saline-sodic in nature. Dubey *et al.* (1984) attributed topography and aridity as the major causes for the formation of the salt affected soil in this region. In the six *talukas* of the southern side (Malia, Halwad, Dhrangadhra, Dasada, Viramgam and Sami), 30 to 100 percent of the samples of each *taluka* were under sodic group. The relatively heavier texture of the soils, soil erosion, lowlying area with poor drainage could be attributed as probable reasons for the higher ESP observed in these soils.

REFERENCES

Anon. (1974). Proceeding Meeting *Review of the Existing Standards for Salt Affected Soils*, held at Central Salt Salinity Research Institute, Karnal, Haryana, 22-23 Feb, 1974.

Dubey, D.D., Banger, S.K. and Sharma, O.P. (1986). Characteristics and classification of some salt affected soils. *Journal of the Indian Society of Soil Science* **34**: 889-892.

Dubey, D.D., Sharma, O.P. and Shila, P.K. (1984). Formation and taxonomy of salt affected Aridisols. *Journal of the Indian Society of Soil Science* **32**: 146-149.

Jackson, M.L. (1973). *Soil Chemical Analysis*. Prentice Hall of India, Private, New Delhi.

Kanzaria, M.V., Patel, M.S., Gundalia, J.D. and Patel, C.L. (1982). Physico-chemical characteristics of salt affected soils of coastal belt of Saurashtra, Kachchh and Gujarat. Proceeding Seminar *Management of Saline-Alkali Soils of Gujarat*, pp.1-27, held at Gujarat Agricultural University, Junagadh, 22-23 April, 1982.

Richards, L.A. (1954). *Diagnosis and Improvement of Saline and Alkali Soils*, Hand book No. **60**. Oxford and IBH Publication Company, Calcutta.

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Salinity Appraisal for Soils of Northwest Agroclimatic Zone of Gujarat Using Chloride Content

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Seventy-five surface (0-30 cm) soil samples were collected from the cultivated salt affected field and analysed for different physical and chemical properties. The results showed highly significant correlations in various dilute aqueous extracts for chloride (r = 0.906 to 928) and sulphate (r = 0.643 to 683) contents of soils with ECe. High correlation coefficient (r) and regression coefficient (b), high percentage of variance (R^2) in case of $Cl_{2.5}$ and Cl_5 were observed and thus, their limits can be utilized for salinity appraisal.

(***Key words***: *Salinity appraisal, Soil water extract*)

High degree of correlation has been obtained for different soils between ECe and chloride content of soils (Gupta *et al.*, 1971 and Patel and Patel, 1989). However, such relationship has not been established for soils of northwest agroclimatic zone of Gujarat. Hence, the feasibility of using chloride and sulphate content, based on dilute soil water extracts, for appraising salinity in soil was studied.

MATERIALS AND METHODS

Seventy-five soil samples (0-30 cm) were collected from the cultivated salt affected soils of northwest agroclimatic zone of Gujarat. Most of the soils have sandy to sandy loam texture. The electrical conductivity, saturation percentage, clay, O.C., $CaCO_3$, pH, CEC, ESP, chloride, sulphate, carbonate and bicarbonate (Table 1) were determined using standard methods (Richards, 1954). The soil samples were categorized into three salinity groups, viz. low (ECe <2.0 dS m^{-1}), medium (ECe 2-8 dS m^{-1}) and high (ECe >8 dS m^{-1}).

RESULTS AND DISCUSSION

The results revealed that the chloride content {cmol(p^+)/kg} in different soil:water extracts was not much affected, whereas sulphate as well as carbonate plus bicarbonate contents {cmol(p^+)/kg} increased on dilution (Table 2). It was observed that correlations between ECe and chloride content increased with increase in salinity.

Highly significant correlations were observed between ECe and chloride (r = 0.906 to 0.928) and between ECe and sulphate (r = 0.643 to 0.683) contents of the soils in different soil:water extracts, while very poor and negative correlations were observed between ECe and carbonate plus bicarbonate contents (Table 3). Very high correlation of chloride as compared to sulphate with EC clearly indicate that these soils can be evaluated by determining chloride content in the soils. Patel and Patel (1989) and Patel *et al.* (2000) obtained very high correlations between ECe with chloride and sulphate content of saturation extract as well as in different soil:water extracts.

For calculating ECe from chloride content of the soil, regression equations were worked out for

Table 1. *Physicochemical properties of salt affected soils*

Particulars	Range	Mean
Saturation percentage	21.9 - 58.6	34.7
Clay %	1.8 - 46.3	16.0
Organic carbon g/kg	11.2 - 92.6	67.0
$CaCO_3$ g/kg	3.0 - 224.0	64.3
pHs	7.03 - 8.60	7.90
ECe dS/m	1.05 - 17.40	7.10
ESP	4.1 - 29.6	14.0
Exch.Ca+Mg [cmol(p^+)/kg]	3.1 - 43.2	20.36
CEC [cmol(p^+)/kg]	3.0 - 41.5	15.8

Table 2. *Average values of different anions (cmol(p^+)/kg) in different soil : water extracts*

Ions	Soil : water extracts		
	Sat. extract	1:2.5	1:5
Chloride	2.20	2.60	2.58
Sulphate	0.429	0.561	0.710
Cabonate + bicaronate	'0.214	0.796	1.018

Table 3. *Average EC & chloride content and correlation coefficients*

Soil:water ratio	Salinity group	Av. ECe (dS/m)	Av. Cl^- (me/l)	Correlation coefficient		
				Cl^-	SO_4^{2-}	$CO_3^{2-}+HCO_3^-$
Saturation extract	Low(7)	1.54	8.31	0.6107	0.7342	0.0025
	Medium(39)	4.84	37.86	0.7785++	0.3690+	-0.1998
	High(29)	11.42	106.00	0.8316++	0.4650++	-1469
	Overall(75)	7.08	61.47	0.9282++	0.6831++	-0.0697
1:2.5	Low(7)	0.53	2.22	0.2776	0.0626	0.2330
	Medium(39)	1.03	3.79	0.6254++	0.2707+	-0.1293
	High(29)	2.16	17.17	0.8123++	0.3582++	-0.2783
	Overall(75)	1.42	10.69	0.9239++	0.6509++	-0.3728++
1:5	Low(7)	0.26	0.84	0.3820	0.0071	-0.4668
	Medium(39)	0.56	3.38	0.5760++	0.2689	0.1196
	High(29)	1.18	7.93	0.7785++	0.4478++	-0.2172
	Overall(75)	0.78	4.91	0.9059++	0.6434++	-0.3665

Figures in parentheses indicate the number of samples.
Low, medium and high salinity denotes ECe <2, 2-8 and >8 dS/m, respectively
+, ++ : Significant at 5 and 1 percent, respectively

Table 4. *Regression equation between ECe & chloride content and their statistical tests of significance*

Soil:water ratio	Regression equation (Y = a + bx)	Percentage of variance (R^2)	Standard error of estimate (sy.x)
Saturation extract	ECe = 1.8060+2.3998++Cle	86.15	1.544
1:2.5	ECe = 0.8586+2.327++$Cl_{2.5}$	85.35	1.688
1:5	EcE = 1.5826+2.2685++Cl_5	78.48	1.920

++ Regression coefficient and correlation coefficient significant at 1 percent

Table 5. *Classification of soils of northwest arid agroclimatic zone of Gujarat based on chloride content [cmol(p^+/kg)]*

Designation particulars	***Very low salinity (ECe <2 dS/m)**	**Low salinity** (2-4dS/m)	Moderately saline (4-8 dS/M)	Saline (8-16 dS/m)	Highly saline (>16 dS/m)
Saturation extract					
Limits of Cl content	<0.15	0.15-1.00	1.00-2.50	2.50-6.00	>6.00
Distribution of samples (%)	2.66	30.66	24.00	42.67	0.00
1:2.5 soil:water extract					
Limit of Cl content	<0.50	0.50-1.40	1.40-3.00	3.00-6.50	>6.50
Distribution of samples (%)	5.33	26.67	25.33	42.67	0.00
1:5 soil:water extract					
Limit of Cl content	<0.25	0.25-1.00	1.00-3.00	3.00-6.50	>6.50
Distribution of samples (%)	2.67	26.67	26.67	44.00	0.00

*Salinity classes are based on Schofield scale

different dilute aqueous extracts (Table 4). Maximum and highly significant values of regression coefficient (b) and percentage of variance (R^2) and minimum standard error of estimate (Sy.x) in 1:2.5 soil:water extracts suggest that the regression equations may be preferred to predict ECe (2.0 to 25.0 dS m^{-1}) from chloride content of the soils. Hogg and Henary (1984) and Patel and Patel (1989) also reported similar regression equation between ECe and chloride content of 1:1, 1:2 and 1:5 soil: water extracts.

The critical limits of chloride content in soils for saturation and various soil:water extracts corresponding to ECe in Schofield scale were calculated using regression equation for overall soils. According to ECe values suggested in Schofield scale (Table 5), 2.66, 30.66, 24.00, 42.67 and 0.00 percent of the samples fall in very low saline, low saline, moderately saline, saline, and highly saline classes, respectively. More or less the same distribution of samples was observed in 1:2.5 and 1:5 soil:water extracts. Thus, the chloride content of soil can serve as an useful index to evaluate the salinity of northwest zone soils.

REFERENCES

Gupta, I.C., Rao, J.S. and Abichandani, C.T. (1971). Some more relationship between certain indices of saline water irrigated soils of Western Rajasthan. *Indian Journal of Agricultural Research* **5**: 195-198.

Hogg, T.J. and Henary, J.L. (1984). Comparison of 1:1 and 1:2 suspension and extract with the saturation extract in estimating salinity in Saskatchewan soils. *Canadian Journal of Soil Science* **64**: 699-704.

Patel, J.C., Patel Jotindra, C. and Patel, K.P. (2000). Salinity-sodicity appraisal and nutrient status of soils from Mahi Right Bank Canal Command Area. *Journal of the Gujarat Society of Agronomy and Soil Science* **1-2**: 18-23.

Patel, Z.N. and Patel, J.C. (1989). Rapid appraisal of salinity for 'Bhal-Nal' soils of Gujarat using chloride content. *Current Agriculture* **13**: 67-71.

Richards, L.A. (1954). *Diagnosis and Improvement of Saline and Sodic Soils*. USDA Hanbook No. **60**. Oxford and IBH Publication Co., Culcutta.

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Rapid Appraisal of Salinity for Soils of Coastal Amreli District of Gujarat

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Two hundred and twenty surface (0-15 cm) soil samples were collected from the cultivated soils of coastal Amreli district and were analyzed for EC and pH from saturation extract and 1:2.5 soil water ratio. The results revealed highly significant correlations to exist between ECe and $EC_{2.5}$ and between pHs and $pH_{2.5}$. High correlation coefficient (r) and regression coefficient (b), high percentage of variance (R^2) in case of $EC_{2.5}$ and $pH_{2.5}$ were observed and hence, prediction of ECe from $EC_{2.5}$ and pHs from $pH_{2.5}$ with greater precision was possible by using the regression equation for the soil of Amreli district as the sample size was high and χ^2 test for observed and expected values were non-significant.

*(**Key words**: Salinity appraisal, Saturation extract, ECe and pHs)*

Soil salinity can be categorized by determining electrical conductivity (dSm^{-1}) of saturation extract of the soil, which is a time consuming, laborious and expensive process. Contrary to this, determination of EC from various dilute soil water extract is rapid and inexpensive. High degree of correlation has, however, been obtained between ECe and EC of dilute solutions of the salt affected soils (Polara *et al.*, 2004), which needs to be validated for the soils of coastal Amreli district of Gujarat. With a view to rapidly appraise the salinity using EC of 1:2.5 soil water aqueous extracts of coastal soils of Amreli district, the present investigation was undertaken.

MATERIALS AND METHODS

Twenty surface (0-15 cm) soil samples from each of 11 *talukas* of coastal Amreli district were collected from the cultivated fields during May 2003. In all, 220 soil samples were collected which were subsequently analyzed for EC and pH from saturation extract (ECe and pHs) of soil and from 1:2.5 soil water extract using standard methods (Richards, 1954). The regression equation for ECe and pHs was calculated from the analyzed values of 18 samples from each of 11 *talukas* (198 samples) of Amreli district. In order to test validity of the developed equation, the values of EC and pH from saturation extract and from 1:2.5 soil water extract of rest of the two samples of each of 11 *talukas* (22 samples) were evaluated using χ^2 test.

RESULTS AND DISCUSSION

The data presented in Table 1 indicate highly significant correlation coefficient between ECe and EC of 1:2.5 soil water extracts. It was revealed that the regression coefficient (b value) between the ECe and EC of 1:2.5 soil water extracts was highly significant. Similar results were also observed between pHs and pH of 1:2.5 soil water extract. These results are in direct line with those reported by Patel and Patel (1992) for the Bhal-Nal soils and Polara *et al.* (2004) for the soils of northwest agroclimatic zone of Gujarat.

The χ^2 test of twenty-two dataset of observed and expected values of ECe and pHs were non-significant (Table 2) suggesting the goodness of fit of regression equation. Similar results were also observed for pHs. The expected values derived from

Table 1. *Regression equation and correlation coefficient between $EC_{2.5}$ and $pH_{2.5}$ with ECe and pHs and their statistical test of significance*

Regression equation (Y= a + bx)	Correlation coefficient (r)	Coefficient of determination (%)	Standard error of estimate (Sy.x)
ECe= 0.5663 + 2.6585**$EC_{2.5}$	0.9812	97.24	0.5926
pHs= 0.7426 + 0.8936**$pH_{2.5}$	0.9596	89.92	0.1306

Table 2. *Observed and expected values of ECe (dS/m) and pHs along with $EC_{2.5}$ and $pH_{2.5}$ and χ^2 test value*

Sample No.	ECe		$EC_{2.5}$	χ^2	pHs		$pH_{2.5}$	χ^2
	Observed	Expected			Observed	Expected		
1	4.3	4.70	1.6	0.034	7.62	7.62	7.70	0.000
2	2.5	2.69	0.8	0.013	7.65	7.71	7.80	0.001
3	8.2	6.68	2.3	0.346	8.10	8.38	8.55	0.009
4	1.9	2.16	0.6	0.031	7.60	7.62	7.70	0.000
5	2.1	2.39	0.9	0.037	8.10	8.20	8.35	0.001
6	3.8	3.22	1.0	0.104	8.00	7.78	8.10	0.006
7	1.1	1.36	0.3	0.049	8.15	8.25	8.40	0.001
8	1.5	1.90	0.5	0.084	7.60	7.67	7.75	0.001
9	1.5	1.90	0.5	0.084	7.40	7.47	7.53	0.001
10	1.8	1.90	0.5	0.005	7.55	7.58	7.65	0.000
11	4.6	4.02	1.3	0.840	7.77	7.85	7.95	0.001
12	2.6	2.43	0.7	0.012	7.60	7.62	7.70	0.000
13	4.8	5.09	1.7	0.017	7.95	7.94	8.05	0.000
14	1.4	2.16	0.6	0.267	7.80	7.86	7.96	0.000
15	3.1	2.69	0.8	0.062	7.65	7.62	7.70	0.000
16	1.3	1.90	0.5	0.189	7.85	7.89	8.00	0.000
17	2.9	2.39	0.9	0.100	8.30	8.29	8.45	0.000
18	4.2	3.76	1.2	0.051	8.50	8.65	8.85	0.003
19	8.4	6.42	2.2	0.611	8.80	8.79	9.00	0.000
20	7.9	8.28	2.9	0.017	8.90	9.01	9.25	0.001
21	2.1	2.16	0.6	0.002	8.00	8.07	8.20	0.001
22	0.8	1.10	0.2	0.820	7.70	7.71	7.80	0.000
Total				**3.784**				**0.025**

the equation were same as observed values. From the above results it can be concluded that the prediction of ECe from $EC_{2.5}$ and pHs from $pH_{2.5}$ with accepted precision is possible by using the regression equation for the soils of Amreli district as the sample size was high and χ^2 values were non-significant.

REFERENCES

Patel, Z.N. and Patel, J.C. (1992). Evaluation of diagnostic techniques for appraising salinity of Bhal-Nal soils of Gujarat using various dilute aqueous extracts. *Gujarat Agricultural University Research Journal* **17**(2): 26-30.

Polara, K.B., Polara, J.V. and Patel, M.S. (2004). Rapid appraisal of salinity for soils of North West agro-climatic zone of Gujarat using various dilute aqueous extracts. *Journal of the Indian Society of Coastal Agricultural Research* **22**(1&2): 46-48.

Richards, L.A. (1954). *Diagnosis and Improvement of Saline and Alkali Soils.* Handbook No. **60**. Oxford and IBH Pub. Co., New Delhi.

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Characterization and Classification of Cultivated Soils of Coastal Amreli District of Gujarat

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Twenty surface (0-15 cm) soil samples from each of the eleven *talukas* of coastal Amreli district were collected from the cultivated soils and were analyzed for different chemical properties. The results revealed that Na^+ and Cl^- were dominant among the water soluble ions, whereas Ca^{++} and Mg^{++} were dominant among the exchangeable cations. More than half (61.4 %) of the cultivated soils of coastal Amreli district were normal in nature, followed by saline (13.6 %), saline-sodic (12.7 %) and sodic (12.3 %).

(***Key words:*** *Characterization of soils, Water soluble and exchangeable ions, Saline soils*)

It is estimated that about 8.087 M ha of land in India are affected by the problems of salinity and sodicity (Yadav *et al.*, 1983). In Gujarat, about 1.649 M ha of land is lost to agriculture because of salinity and sodicity and are extensively distributed both on the coastal and inland areas. The characterization of these soils has not been done earlier, which are reported in this paper.

MATERIALS AND METHODS

Twenty surface (0-15 cm) soil samples from each of the 11 *talukas* of coastal Amreli district were collected from the cultivated fields of the farmers during May, 2003 and were prepared for chemical analysis. The soil pHs and ECe were determined from the saturation extract of soils, whereas water soluble ions were estimated from 1:2.5 soil water extract and exchangeable cations (Ca^{++}, Mg^{++}, Na^+ and K^+) by neutral normal ammonium acetate as per the standard methods outlined by Richards (1954). The analyzed soil samples were then categorized into salinity/sodicity classes as per the criteria suggested by Richards (1954).

RESULTS AND DISCUSSION

The range and mean values (Table 1) of water soluble cations showed higher proportion of Na^+, which was followed by Ca^{++}, Mg^{++} and K^+. In the case of anions, the highest overall mean value of 5.57 meL^{-1} was noted in Cl^- and it was followed by HCO_3^-, SO_4^{--} and the least in $CO_3^=$. These results are in conformity with an earlier report of Polara *et al.* (2004) for the soils of Kachchh region of Gujarat. The exchangeable Ca^{++}, Mg^{++}, Na^+ and K^+ ranged from 5.08 to 33.04, 2.5 to 20.9, 0.5 to 21.6 and 0.01 to 1.23 with their corresponding mean values of 20.6, 11.66, 4.67 and 0.13 $cmol(p^+)\ kg^{-1}$, respectively. The Ca^{++} content was found highest (26.01 $cmol\ (p^+)\ kg^{-1}$) in the soils of Khambha *taluka* as compared to that noted in the soils of other *talukas*. The soils of Liliya *taluka* registered the highest value of Na^+.

The overall ECe, pHs and ESP values (Table 2) ranged from 0.6 to 38.8, 7.0 to 8.9 and 1.1 to 62.1 with mean value of 3.0, 7.90 and 12.80, respectively. The ECe was found highest (4.4 dSm^{-1}) in the soils of Amreli *taluka* as compared to that noted in the soils of other *talukas*, whereas pHs and ESP was registered highest (8.4 and 26.2, respectively) in the soils of Liliya *taluka*. Overall, 13.6, 12.7, 12.3 and 61.4 percent soils of coastal Amreli district were classified into saline, saline-sodic, sodic and normal soil, respectively.

This information can be useful in developing management practices for the cultivated soils of coastal Amreli district.

Table 1. Taluka-*wise range and mean values of water soluble and exchangeable ions in soils*

Name of *taluka*	Water soluble ions (meL^{-1})								Exchangeable cations (cmol (p^+) kg^{-1})			
	Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
Amreli	2.0-7.7 (4.8)*	0.6-6.0 (2.7)	1.5-33.6 (7.8)	0.1-0.8 (0.4)	0.0-0.9 (0.1)	1.1-13.9 (3.3)	3.2-30.5 (10.4)	0.7-2.9 (1.25)	10.15-25.05 (18.29)	6.85-18.95 (14.61)	2.25-19.50 (5.58)	0.0-0.42 (0.15)
Savarkundla	1.3-5.6 (3.2)	0.6-3.6 (1.6)	1.6-19.1 (5.9)	0.2-1.1 (0.4)	0.0-1.0 (0.1)	0.5-9.9 (3.0)	1.4-20.1 (5.6)	0.7-2.3 (1.2)	13.28-25.11 (19.11)	4.94-17.90 (13.34)	1.75-17.50 (6.09)	0.05-0.27 (0.13)
Rajula	0.8-6.1 (3.7)	0.6-4.1 (1.3)	1.1-13.3 (4.9)	0.2-1.0 (0.5)	0.0-1.0 (0.1)	0.5-10.5 (2.8)	0.8-11.4 (5.4)	0.5-1.9 (1.13)	13.11-24.23 (20.35)	10.90-18.88 (15.15)	1.25-15.0 (5.36)	0.08-0.27 (0.15)
Jafrabad	1.4-30.1 (4.2)	0.5-3.1 (1.1)	1.3-120.1 (9.6)	0.2-0.9 (0.4)	0.0-4.2 (0.3)	0.4-35.3 (3.1)	1.0-100.0 (8.8)	0.1-2.3 (1.1)	13.17-25.33 (20.67)	6.83-20.90 (15.18)	2.0-21.40 (5.0)	0.01-0.30 (0.12)
Khambha	1.0-5.1 (2.5)	0.5-1.7 (1.0)	1.1-6.6 (2.8)	0.1-1.0 (0.4)	0.0-0.0 (0.0)	0.3-2.1 (0.9)	0.5-9.3 (3.5)	0.6-1.3 (0.8)	22.06-33.04 (26.01)	3.75-15.98 (9.34)	0.50-4.14 (2.24)	0.04-0.20 (0.09)
Dhari	1.1-5.6 (2.6)	0.6-2.7 (1.2)	1.0-10.2 (3.0)	0.2-0.6 (0.3)	0.0-1.0 (0.1)	0.3-6.1 (1.2)	0.5-11.8 (3.7)	0.6-2.2 (1.15)	16.16-28.13 (23.50)	2.94-18.86 (11.60)	0.8-12.0 (2.94)	0.04-0.26 (0.11)
Babra	1.0-6.2 (3.2)	0.5-3.1 (1.4)	0.7-12.7 (3.9)	0.1-1.0 (0.5)	0.0-0.0 (0.0)	0.2-6.3 (2.3)	0.4-15.6 (4.5)	0.5-3.4 (1.0)	18.08-29.13 (24.10)	2.50-14.69 (8.40)	1.0-4.14 (2.53)	0.05-0.33 (0.12)
Kunkavav	1.0-3.6 (2.0)	0.5-1.7 (0.9)	0.9-4.7 (1.7)	0.2-1.0 (0.4)	0.0-0.0 (0.0)	0.3-2.1 (0.9)	0.8-7.2 (2.6)	0.6-1.5 (0.8)	14.06-30.13 (22.16)	4.77-15.94 (10.74)	1.25-9.41 (3.31)	0.04-0.33 (0.13)
Bagasra	1.9-10.0 (3.7)	0.6-6.2 (1.5)	1.3-25.1 (5.3)	0.1-0.7 (0.3)	0.0-1.0 (0.2)	0.5-5.3 (1.8)	1.6-30.1 (6.6)	0.6-2.2 (1.12)	11.11-25.08 (20.33)	4.83-15.94 (10.97)	1.75-10.21 (4.67)	0.08-0.17 (0.12)
Liliya	1.1-10.2 (3.8)	0.5-3.0 (1.6)	1.3-20.0 (6.7)	0.2-1.5 (0.4)	0.0-3.0 (0.4)	0.3-12.0 (4.2)	1.5-18.5 (5.7)	0.6-2.1 (1.02)	5.08-24.06 (14.05)	3.94-15.94 (9.40)	2.25-21.60 (8.62)	0.09-0.26 (0.16)
Lathi	1.1-5.9 (2.9)	0.5-3.0 (1.4)	1.3-15.9 (5.0)	0.1-1.2 (0.4)	0.0-1.0 (0.1)	0.5-9.2 (3.0)	1.0-13.6 (4.5)	0.6-1.7 (1.07)	13.06-22.25 (17.95)	4.78-14.94 (9.55)	2.50-11.48 (5.08)	0.08-1.23 (0.20)
Overall	0.8-30.1 (3.31)	0.5-6.2 (1.42)	0.7-120.1 (5.14)	0.1-1.5 (0.4)	0.0-4.2 (0.12)	0.2-35.3 (2.43)	0.4-100.0 (5.57)	0.1-3.4 (1.06)	5.08-33.04 (20.60)	2.50-20.90 (11.66)	0.50-21.60 (4.67)	0.01-1.23 (0.13)

Values in the parentheses indicate mean values.

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RESULTS AND DISCUSSION

The range and mean values (Table 1) of water soluble cations showed higher proportion of Na^+, which was followed by Ca^{++}, Mg^{++} and K^+. In the case of anions, the highest overall mean value of 5.57 meL^{-1} was noted in Cl^- and it was followed by HCO_3^-, SO_4^{--} and the least in CO_3^-. These results are in conformity with an earlier report of Polara *et al.* (2004) for the soils of Kachchh region of Gujarat. The exchangeable Ca^{++}, Mg^{++}, Na^+ and K^+ ranged from 5.08 to 33.04, 2.5 to 20.9, 0.5 to 21.6 and 0.01 to 1.23 with their corresponding mean values of 20.6, 11.66, 4.67 and 0.13 cmol(p^+) kg^{-1}, respectively. The Ca^{++} content was found highest {26.01 cmol (p^+) kg^{-1}} in the soils of Khambha *taluka* as compared to that noted in the soils of other *talukas*. The soils of Liliya *taluka* registered the highest value of Na^+.

The overall ECe, pHs and ESP values (Table 2) ranged from 0.6 to 38.8, 7.0 to 8.9 and 1.1 to 62.1 with mean value of 3.0, 7.90 and 12.80, respectively. The ECe was found highest (4.4 dSm^{-1}) in the soils of Amreli *taluka* as compared to that noted in the soils of other *talukas*, whereas pHs and ESP was registered highest (8.4 and 26.2, respectively) in the soils of Liliya *taluka*. Overall, 13.6, 12.7, 12.3 and 61.4 percent soils of coastal Amreli district were classified into saline, saline-sodic, sodic and normal soil, respectively.

This information can be useful in developing management practices for the cultivated soils of coastal Amreli district.

Table 2. Taluka-*wise range and mean values of salinity/ sodicity indices of soils and their classification*

Name of *taluka*	ECe (dSm^{-1})	pHs	ESP	Percentage distribution			
				Saline	Saline-sodic	Sodic	Normal
Amreli	1.5-12.1 (4.4)	7.2-8.8 (7.9)	5.9-52.8 (14.6)	30 (6)	15 (3)	15 (3)	40 (8)
Savarkundla	1.0-8.4 (3.1)	7.2-8.6 (7.9)	5.2-37.5 (15.5)	5 (1)	20 (4)	20 (4)	55 (11)
Rajula	1.0-8.1 (3.2)	7.2-8.8 (7.9)	3.4-34.0 (13.1)	10 (2)	30 (3)	10 (2)	50 (10)
Jafrabad	1.1-38.8 (4.2)	7.6-8.9 (8.0)	4.2-44.1 (12.4)	15 (3)	15 (3)	5 (1)	65 (13)
Khambha	0.8-4.8 (2.0)	7.1-7.9 (7.6)	1.1-10.0 (6.4)	15 (3)	0 (0)	0 (0)	85 (17)
Dhari	0.8-8.0 (2.3)	7.2-8.6 (7.8)	1.7-30.7 (7.6)	15 (3)	5 (1)	5 (1)	75 (15)
Babra	0.6-7.9 (2.7)	7.3-8.0 (7.7)	2.9-12.4 (7.2)	25 (5)	0 (0)	0 (0)	75 (15)
Kunkavav	0.7-3.4 (1.6)	7.5-8.0 (7.7)	3.4-25.1 (9.2)	0 (0)	0 (0)	5 (1)	95 (19)
Bagasra	1.0-9.6 (3.0)	7.5-8.6 (8.1)	5.5-28.9 (12.9)	10 (2)	10 (2)	10 (2)	70 (14)
Liliya	1.0-9.5 (3.8)	7.8-8.9 (8.4)	9.4-62.1 (26.7)	10 (2)	35 (7)	35 (7)	20 (4)
Lathi	0.8-6.3 (2.6)	7.0-8.5 (8.0)	7.9-36.2 (15.7)	15 (3)	10 (2)	30 (6)	45 (9)
Overall	0.6-38.8 (3.0)	7.0-8.9 (7.90)	1.1-62.1 (12.80)	13.6 (30)	12.7 (28)	12.3 (27)	61.4 (135)
	Classification of salt affected soils			35.3 (30)	33.0 (28)	31.7 (27)	

Values in the parentheses under ECe, pHs and ESP indicate the mean and those under Percentage distribution indicate number of samples

REFERENCES

Polara, K.B., Polara, J.V. and Patel, M.S. (2004). Characterization and classification of coastal salt affected soils of Kachchh region of Gujarat. *Journal of the Indian Society of Coastal Agricultural Research* **22**(1&2): 65-68.

Richards, L.A.(1954). *Diagnosis and Improvement of Saline and Alkali Soils*. Handbook No. **60**. Oxford and IBH Pub. Co., Calcutta.

Yadav, J.S.P., Bandyopadhyay, A.K. and Bandyopadhyay, B.K.(1983) Extent of coastal saline soils of India. *Journal of the Indian Society of Coastal Agricultural Research* **1**: 1-6.

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Soils of Coastal Region of Orissa and their Suitability for Various Crops

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Six representative pedons occurring on various landforms of Utkal plain and Mahanadi delta under coastal region of Orissa were studied to characterize, classify and evaluate their suitability for crop production. The soils of Utkal plain were very deep, imperfect to poorly drained, fine loamy, neutral to slightly acidic in reaction, medium in CEC with low content of organic carbon, and subjected to moderate to severe flooding hazards and slight to strong salinity hazards. The soils were classified as Aeric Endoaquepts, Vertic Endoaquepts and Typic Endoaquents. The soils of Mahanadi delta were very deep, well to poorly drained, variable in texture (sandy to very fine), neutral to moderately acidic in reaction, very low to very high in CEC with low to medium content of organic carbon, and subjected to moderate flooding hazards and slight to moderate salinity hazards. They were classified as Aeric Fluvaquents, Vertic Endoaquepts and Typic Ustipsamments. The major soils were moderate to marginally suitable for *bunded* rice, irrigated rice, sunflower and watermelon.

*(**Key words** : Soil-site suitability, Land use)*

The coastal tract of Orissa occupies an area of 7900 sq km (Sen *et al.*, 2000) and it is developed by the deltas of the Mahanadi river and the lower river courses of the Brahmani, the Baitarni, the Subarnarekha and the Rushikulya. More than 5 m contour separates the region from the peninsular upland with wide variations in width. It has a straight shoreline with well defined beaches of sand. Lagoons were formed with coastal uplift adjoining the line of sand dunes. The Chilka, the largest lake, is shallow in the northeast due to silting by the matter brought by the Deya and the Bhargavi rivers. The brackishwater of the sea has given rise to some swamps in Orissa. The coastal area of Orissa was mapped under two physigraphic zones, viz. Utkal plain and Mahanadi delta (Sarkar *et al.*, 1998). Utkal plain, a region of the eastern coast comprises Balasore, part of Puri and Ganjam districts of Orissa State. The area representing Mahanadi delta includes Cuttack, Puri and parts of Balasore and Khurda districts of Orissa. The Mahanadi is subject to heavy flooding causing immense damage as 95 percent of the monsoon rain of the entire catchment basin are discharged through the Mahanadi delta. In the present investigation attempts have been made to characterize and classify the coastal soils of Orissa and evaluation of their suitability for various crops based on problems and potentials of the soils.

MATERIALS AND METHODS

Coastal soils of Orissa were identified, characterized, classified and mapped on 1 : 250,000 scale during SRM work of Orissa using a 3-tier approach, i.e., image interpretation, field surveys and laboratory analysis, and cartography and printing. The region consists of mainly the recent and tertiary alluvium. The area under Utkal plain experiences subtropical, hot and humid climate (AESR 18.4) with length of growing period of 180 to 240 days. The mean summer and winter temperatures are 39°C and 11.5°C, respectively. The average rainfall is 1340 mm. Mahanadi delta exhibits a hot tropical climate (AESR 18.5) characterized by oppressive summer, low daily range of temperature, high humidity and moderate annual rainfall. The mean maximum temperature and mean minimum temperature are 35°C and 22°C, respectively with annual rainfall of 1482 mm. The soil moisture and temperature regimes of the area are ustic and hyperthermic, respectively (Sarkar *et al.*, 2001).

Based on the reconnaissance soil survey (1 : 250,000 scale), six representative pedons occurring in various landforms of Utkal plain and Mahanadi delta were characterized, classified and assessed for various crop suitability using standard procedures (Jackson, 1976, Soil Survey Staff, 1992, Sys *et al.*, 1993).

RESULTS AND DISCUSSION

Three major landforms, i.e. inland plain, coastal plain and mangrove swamp are identified in the Utkal plain. The soils on different landforms vary widely in their characteristics (Tables 1 and 2). The soils occurring on very gently sloping inland plain are very deep, poorly drained and fine loamy (clay 30.2 to 37.2 %) in texture. The conductivity of the saturation extract (ECe) varies from 2.4 to 5.1 dSm^{-1}. They are neutral (pH 6.7 to 7.4) in reaction with very low content of organic carbon (0.10 to 0.22 %). CEC of the soils ranges from 12.8 to 13.4 $cmol(p+)kg^{-1}$. These soils are slightly eroded and subjected to moderate flooding. They have been classified as Aeric Endoaquepts. The soils developed on lowlying coastal plain are dominantly very deep, imperfectly to poorly drained, fine loamy (clay 28.3 to 37.8 %) and classified as Vertic Endoaquepts. The soils are slightly acidic (pH 5.8 to 6.4) in reaction. The conductivity of the saturation extract (ECe) ranges from 5.8 to 13.9 dSm^{-1}. They are subjected to moderate flooding. The soils occurring on nearly level mangrove swamp are very deep, poorly drained and moderately eroded, and subjected to severe flooding. The soils are fine loamy in texture, neutral (pH 6.8 to 7.2) with very low content of organic carbon (0.06 to 0.21%), and classified as Typic Endoaquents. They are subjected to strong salinity (ECe 12.3 to 20.1 dSm^{-1}) due to inundation of high tidal water.

The soils developed on very gently to gently sloping coastal plain of Mahanadi delta are very deep, imperfectly drained, moderately eroded and classified as Aeric Fluvaquents (Tables 1 and 2). They are fine (clay 31.7 to 63.2 %), neutral to slightly acidic (pH 6.3 to 6.6) and have medium to high AWC. The conductivity of the saturation extract (ECe) varies from 3.1 to 6.3 dSm^{-1}. The cation exchange capacity of these soils is medium to high {18.9 to 42.9$cmol(p+)kg^{-1}$} with moderate base status. The soils occurring on lower delta are very deep, poorly drained and subjected to moderate flooding. They are very fine (clay 68.1 to 90.1 %) and classified as Vertic Endoaquepts. These soils are slight to moderately acidic (pH 4.5 to 6.3) with high CEC {33.8 to 55.5$cmol(p+)kg^{-1}$}. ECe value ranges from 5.2 to 7.3 dSm^{-1}. The soils developed on very gently sloping sand dunes are very deep, well to somewhat excessively drained and sandy in texture. They are neutral (pH 6.6 to 7.0) in reaction with very low CEC {2.2 to 2.4 $cmol(p+)kg^{-1}$}. These soils are affected by severe wind erosion and are classified as Typic Ustipsamments.

Based on limitations of soils, soil-site suitability for major crops is evaluated (Table 3). Study reveals that soils of inland and coastal plains of Utkal plain and lower delta and coastal plain of Mahanadi delta are moderate (S2) to marginally suitable (S3) for *bunded* rice, irrigated rice and sunflower. Soils of

Table 1. *Soil-site characteristics of pedons*

Physiography	Sub-physiography	Pedon	Location Village, Dist	Slope (%)	Drainage	Flooding	Erosion	Land use
Utkal Plain	Inland plain	P1	Hidigaon; Balasore	1-3	Poor	Moderate	Slight	Rice
	Coastal plain	P2	Daiapalli; Ganjam	1-3	Imperfect	Moderate	Slight	Rice
	Mangrove swamp	P3	Kharasharpura, Balasore	0-1	Poor	Severe	Moderate	Mangrove
Mahanadi Delta	Coastal plain	P4	Pratapnagar, Khurda	1-3	Imperfect	Moderate	Moderate	Rice
	Lower delta	P5	Nalibasant, Puri	0-1	Poor	Moderate	Slight	Rice
	Sand dunes	P6	Prilakhand, Puri	1-3	Well	Moderate	Severe	Barren

Table 2. *Physical and chemical properties of soils (on the basis of weighted average of 0 to 50 cm depth)*

Pedon	Sand (%)	Silt (%)	clay (%)	pH (1:2.5)	ECe (dSm^{-1})	OC (%)	CEC [cmol ($p^+)kg^{-1}$]	BS (%)	Soil Taxonomy
P1	22.7	45.8	31.5	6.9	3.1	0.18	12.9	79	Fine loamy, Aeric Endoaquepts
P2	51.5	16.3	32.2	6.0	6.3	0.34	12.7	74	Fine-loamy,Vertic Endoaquepts
P3	26.9	45.4	27.7	7.1	14.2	0.18	13.1	83	Fine-loamy,Typic Endoaquents
P4	18.4	42.5	39.1	6.5	3.6	0.38	24.1	69	Fine, Aeric Fluvaquents
P5	3.1	22.2	74.7	5.0	5.9	0.14	38.9	54	Very fine, Vertic Endoaqepts
P6	81.6	12.2	6.2	6.9	1.6	0.06	2.3	75	Typic Ustipsamments

Table 3. *Soil-site suitability for various crops*

Pedons	*Bunded* rice	Irrigated rice	Wheat	Groundnut	Sugarcane	Sun-flower	Water melon	Oil plam	Coconut	Cashew
P1	S2f*	S2f	S3wf	N1w	N1w	S2w	S3wf	S3w	N1w	N1w
P2	S2f	N1n	S3fn	S3wfn	N1w	S2w	S3wfn	N1n	S3w	S3w
P3	N2wn	N2n	N2n	N2wn	N2wn	N2w	N2n	N2n	N2w	N2wn
P4	S2f	S2f	S3wfn	S3w	S2f	S2f	S3f	S3n	S3w	S3w
P5	S3f	S3fn	N1f	N1wf	N1w	S3f	N1fs	N1n	N1w	N1w
P6	N2ws	N2ws	N2ws	N2ws	N2ws	N2ws	S3wf	S3ws	S2wf	S3w

*S2- moderately suitable, S3-marginally suitable, N1- actually unsuitable and potentially suitable, N2- unsuitable, and w, s, f, n denote limitations to wetness, soil physical characteristics, soil fertility and salinity, respectively

mangrove swamp of Utkal plain are unsuitable for most of the crops due to severe flooding and strong salinity. However soils of sand dunes of Mahanadi delta are moderately suitable (S2) for coconut and marginally suitable (S3) for watermelon, oil palm and cashew. The integrated management of soil resources through proper land use plan is essential for overall development of the coastal region of Orissa.

REFERENCES

Jackson, M. L. (1976). *Soil Chemical Analysis.* Prentice Hall of India Private Limited, New Delhi.

Sarkar Dipak, Sahoo, A. K., Sah, K. D. and Gajbhiye, K. S. (2001). Coastal soils of Eastern India-their characteristics, potentials and limitations towards alternate land use plan. *Journal of Indian Society Coastal Agricultural Research* **19**(1&2): 80-83.

Sarkar Dipak, Thampi, C. J., Sehgal, J. and Velayutham, M. (1998). Soils of Orissa: their kinds, distribution, characterization and interpretation for optimizing land use. *NBSS Publ. No.* **49b**, NBSS&LUP, Nagpur 440 010, Maharashtra.

Sen, H. S., Bandyopadhyay, B.K., Maji, B., Bal, A. R. and Yadav, J. S. P. (2000). Management of coastal agro-ecosystem. In *Natural Resource Management for Agricultural Production in India,* J.S.P Yadav & G. B. Singh (eds.), pp. 925-1022. Proceedings International Conference *Managing Natural Resources for Sustainable Agricultural Production in the 21st Century.* Indian Society of Soil Science, IARI, New Delhi - 110 012.

Soil Survey Staff (1992). *Keys to Soil Taxonomy,* 5th Edn. SMSS Tech. Monograph **19**, Blacksburg, Virginia, U.S.A.

Sys, C., Van Ranst, E., Debaveye, J. and Beernaert, F. (1993). *Land Evaluation,* Part **III**. Agricultural Publ. No. **7**., General Administration for Development Cooperation, Place du Champ de Mars 5 bte 57-1050, Brussels, Belgium.

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Retention Pattern of Cadmium and Nickel in Soils of Kerala

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Heavy metals in soils can adversely affect our environment. To assess the retention pattern of cadmium and nickel under experimental conditions, the proportion of topically applied Cd and Ni held in different depths in undisturbed columns of sandy, red and laterite soils was investigated. Downward movement of Cd and Ni in soils was slow and 55 to 85 percent of that applied was retained in the upper 30 cm of the soil columns. Addition of farmyard manure to the soil resulted in lesser downward movement and greater retention in the top soil. Ni was more mobile in soils than Cd.

(***Key words***: *Retention in soil, Cadmium, Nickel*)

Heavy metals form an important group of contaminants in agricultural lands. Environmental problems associated with heavy metal pollution have increased in the recent past. Since the soil is a key element in controlling the fate of heavy metals in the environment, it is important to understand the transport behaviour of heavy metals in soils. The objective of the study reported here was to quantify the retention of topically applied cadmium and nickel in different depths in columns of three major upland soils of Kerala having different physicochemical properties and to determine if farmyard manure in soil binds or releases them.

MATERIALS AND METHODS

The pattern of retention of Cd and Ni in three soil types in the uplands of Kerala was studied by taking core samples and equilibrating with known amount of Cd and Ni for thirty days. The influence of farmyard manure in modifying the pattern was also studied by including it in one set of soil column.

Two core samples each were collected from three locations representing three soil types (Table 1) in May 1997. PVC tubes of 10 cm diameter and 60 cm length were placed on the soil surface covered with a wooden plank and driven into the soil with a hammer to a depth of 50 cm. The tubes were carefully withdrawn and both ends were closed with PVC caps, and transported to laboratory. Soil samples were separately collected from each 10 cm segment to a depth of 50 cm from where the soil columns were taken. The basic physicochemical properties of soils relevant to the study were determined by standard analytical procedures as outlined by Jackson (1973) and are given in Table 1.

Uniformly dried and powdered farmyard manure to represent a level of 10 t ha^{-1} was mixed with surface 15 cm of soil in one column of each soil type. Solutions of $CdCl_2.2H_2O$ and $NiCl_2.6H_2O$ to supply 10 and 100 mg of Cd and Ni per kg of soil were poured on the surface and mixed in the upper 15 cm of soil in all columns. The moisture status of the soil in the columns was maintained at field capacity by pouring desired quantity of distilled water. After 30 days, each soil column was cut into 5 segments of 10 cm length with a hacksaw blade and soil from each segment was transferred to labelled plastic containers. These soils were then air dried, powdered with wooden mallet, passed through 2 mm plastic sieve and analysed for total and extractable Cd and Ni by standard methods (AOAC, 1980)

RESULTS AND DISCUSSION

The pattern of retention of applied Cd and Ni with and without farmyard manure in undisturbed soil columns of selected upland soil types of Kerala are presented in Tables 2 and 3.

Cadmium

Retention of applied Cd in soil layers during downward movement in upland soils showed a regular gradation with depth, a greater proportion being retained in the upper layers and it was invariably higher in soils treated with farmyard manure. It may be seen from Table 2 that the retention of applied Cd in the presence of farmyard manure in sandy *Onattukara* soils was 27.8 and 6.2 percent in the 10 cm layer at top and bottom of the soil column, respectively. In the same soil, the retention of applied Cd in the soil column without farmyard manure was only 17.8 percent in the top layer.

Table 1. *Basic physicochemical properties of the soils used in column study*

Soil properties	Soil type and location		
	Sandy Onattukara (Oxyaquic quartzipsament) Kayamkulam	Laterite soil (Typic plinthustult) Kottarakkara	Red soil (Rhodic haplustox) Vellayani
pH	6.2	5.7	5.2
Organic matter(%)	0.5	1.7	1.4
Clay (%)	6.2	30.4	39.5
CEC {cmol (p^+) kg^{-1}}	5.2	6.9	7.5
Cadmium (mg kg^{-1})			
i. Total	5.3	6.8	2.8
ii. Extractable	0.10	0.18	0.12
Nickel (mg kg^{-1})			
i. Total	23.3	43.6	16.8
ii. Extractable	0.50	1.30	0.13

Table 2. *Depthwise distribution of total cadmium in upland soils as influenced by applied Cd and FYM (mg kg^{-1})*

Depth of soil column (cm)	Sandy *Onattukara*			Laterite soil			Red soil		
	Control	With FYM	No FYM	Control	With FYM	No FYM	Control	With FYM	No FYM
10	5.3	18.4 (27.8)	13.9 (17.8)	6.8	36.4 (55.8)	27.2 (38.5)	2.8	27.6 (40.7)	16.7 (22.8)
20	5.0	19.2 (31.6)	14.5 (21.0)	6.5	22.5 (30.2)	17.3 (20.4)	2.2	17.9 (25.7)	17.4 (24.9)
30	4.5	11.7 (16.0)	17.5 (28.3)	6.1	9.6 (6.6)	13.4 (13.8)	1.9	8.9 (11.5)	17.0 (24.8)
40	3.0	9.5 (13.3)	12.4 (20.9)	3.5	4.3 (1.5)	10.5 (13.2)	1.8	8.2 (10.5)	12.9 (18.2)
50	3.0	5.8 (6.2)	6.3 (7.3)	3.4	6.1 (5.1)	9.2 (5.8)	1.9	7.0 (10.0)	6.7 (7.9)
(r-value)	-0.95	-0.96	-0.66	-0.93	-0.92	-0.94	-0.85	-0.92	-0.85
Cadmium added (mg per column)	-	45.0	46.0	-	53.0	53.0	-	61.0	61.0

Value in parenthesis indicates percentage retention of applied cadmium

Table 3. *Depthwise distribution of total nickel in upland soils as influenced by applied Ni and FYM (mg kg^{-1})*

Depth of soil column (cm)	Sandy *Onattukara*			Laterite soil			Red soil		
	Control	With FYM	No FYM	Control	With FYM	No FYM	Control	With FYM	No FYM
10	23.2	130.2 (23.8)	119.6 (21.0)	43.6	183.8 (26.5)	152.4 (20.5)	16.8	178.3 (26.5)	102.5 (14.0)
20	24.5	128.5 (23.1)	118.7 (20.5)	43.2	147.2 (19.6)	143.8 (19.0)	16.5	97.5 (13.3)	108.2 (15.0)
30	25.2	90.8 (15.6)	128.1 (22.4)	48.7	154.3 (19.9)	144.5 (18.1)	17.1	116.4 (16.3)	120.0 (16.9)
40	20.6	112.4 (19.4)	103.4 (18.0)	40.5	127.5 (16.4)	147.1 (20.1)	18.3	149.6 (21.5)	183.5 (27.1)
50	17.2	97.5 (17.8)	99.0 (17.8)	40.1	136.9 (18.3)	158.0 (22.2)	20.3	160.3 (23.0)	186.8 (27.3)
(r value)	-0.77	-0.76	-0.74	-0.45	0.84	0.38	0.89	0.07	0.93
Nickel added (mg per column)	-	450	460	-	530	530	-	610	610

Value in parenthesis indicates percentage retention of applied nickel

In the column of laterite soil, retention of applied Cd in the top and bottom layers was 55.8 and 5.1 percent, respectively in the presence of farmyard manure, and in case of without farmyard manure it was 38.5 and 5.8 percent, respectively. The same trend was noted in the red soil also. Significant negative correlation was obtained for retention of Cd with depth in all the soils

Cd was retained more in the top than in the bottom layer in all soil types. It was invariably higher when the soils were treated with farmyard manure and decreased in the order laterite > red > sandy *Onattukara*. Basic analysis of the soils have revealed that their organic matter content decreased in the same order suggesting a possible relationship between retention of Cd and organic matter status in them. The addition of fresh organic matter in the form of farmyard manure has further decreased their downward mobility resulting in greater retention in the top layers.

Piccolo (1989) has attributed the increased retention capacity of added humic substance, and Karapanagiotics *et* al. (1991) have specifically identified complexation reaction responsible for greater retention of cadmium.

Nickel

The downward mobility of Ni in soil columns as seen from Table 3 reveal a similar pattern as that of Cd except that it was more uniformly distributed in the soil showing lesser difference in content between individual layers from top to bottom. Coefficient of correlation for retention of Ni with soil depth was not significant in laterite and sandy Onattikara soils. However, positive significant correlation was obtained in red soil. The mobility of Ni in soil thus appears to be more than Cd and is in agreement with the earlier report of Taylor and Griffin (1981). The higher mobility of Ni compared to Cd may be explained based on the selectivity sequence for heavy metals cited by Alliway (1990) where he has stated that Ni is the least tenaceously sorbed heavy metal on the hydroxy functional groups on the edge of kaolinite crystals and oxides of Fe in soils. The suggested sequence of these soil constituents for metals as Cd > Zn > Ni indicates a preferential retention of Cd compared to Ni.

REFERENCES

Alliway, B.J. (1990). *Heavy Metals in Soils.* Blackie, Glasgow. 330p.

AOAC (1980). *Official and Tentative Methods of Analysis.* Association of Official Agricultural Chemists, Washington. 721p.

Jackson, M.L. (1973). *Soil Chemical Analysis.* Prentice Hall of India, New Delhi. 498p.

Karapanagoitics, N.K., Sterritt, R.M. and Lester, J.N. (1991). Heavy metal complexation in sludge-amended soil, the role of organic matter in metal retention. *Environmental Technology* **12**: 1107 - 1116.

Piccolo, A. (1989). Reactivity of added humic and substances towards plant available heavy metals in soils. *Science of the Total Environment* **81-82**: 607-614.

Taylor, R.W. and Griffin, G.F. (1981). The distribution of topically applied heavy metals in the soil. *Plant and Soil* **62**: 147-152.

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Status of Heavy Metals in Soils of Paper Mill Effluent Irrigated Fields

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The heavy metals are probably the most harmful and insidious pollutants because of their non-biodegradable nature and hence to assess whether the effluent irrigation has contributed for the heavy metal accumulation in the soil, present study was undertaken at Pallipalayam in Tamil Nadu where paper mill effluent irrigation is in vogue for more than 25 years. Representative soil samples of surface (0-30 cm depth) and subsurface soil (30-60 cm depth) from the fields, which were under different periods of effluent irrigation, viz. more than 25 years, 15 years, 12 years, 9 years and control (no effluent), were collected and analyzed for heavy metals, viz. Cu, Zn, Pb and Cd by atomic absorption spectrophotometer. The study revealed that though there is heavy metal accumulation in the soil, it is below the permissible limit. But continuous effluent irrigation tends to accumulate heavy metals in the soil and hence suitable soil amendment should be applied.

*(**Key words** : Paper mill effluent, Heavy metal contamination, Micronutrients)*

Applying wastewater to agricultural lands is a more economical alternative and more ecologically sound than uncontrolled dumping of municipal and industrial effluents into lakes and streams. The utilization of the effluents for irrigation is an appropriate solution as it involves two main principles– use of soil as a treatment system preventing pollution of the surface water and use of wastewater as continuous or supplementary source of irrigation. Recently, effluent irrigation has been adopted with great vigour by most paper mills due to the effective legislation and implementation of pollution control measures by the State Pollution Control Board. Though the concept of effluent irrigation seems promising the real success can be attributed only if there is no adverse impact on the environment. The continuous effluent irrigation can create environmental problems like accumulation of undesirable proportion of toxic elements, viz. heavy metals in soils (Srinivachari *et al.*, 2000). The heavy metals accumulate in the soil which may lead to adsorption by plants. This would act as a direct link for incorporation into the human food chain. Heavy metals are probably the most harmful and insidious pollutants because of their non-biodegradable nature and their potentiality to cause adverse effects in human beings at certain level of exposure. The short term benefit of effluent irrigation should not offset the heath and environmental consideration. Hence to assess whether the effluent irrigation has contributed for the heavy metal accumulation in the soil, the present study was undertaken in an area where effluent irrigation is in vogue for more than 25 years.

METHODS AND MATERIALS

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RESULTS AND DISCUSSION

The mean concentration of Cu, Zn, Pb and Cd in the effluents which were let out for irrigation are given in Table 1. The copper content in the effluents ranged from 0.034 to 0.046 mg l^{-1} with an average

In the column of laterite soil, retention of applied Cd in the top and bottom layers was 55.8 and 5.1 percent, respectively in the presence of farmyard manure, and in case of without farmyard manure it was 38.5 and 5.8 percent, respectively. The same trend was noted in the red soil also. Significant negative correlation was obtained for retention of Cd with depth in all the soils

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Piccolo, A. (1989). Reactivity of added humic and substances towards plant available heavy metals in soils. *Science of the Total Environment* **81-82**: 607-614.

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Applying wastewater to agricultural lands is a more economical alternative and more ecologically sound than uncontrolled dumping of municipal and industrial effluents into lakes and streams. The utilization of the effluents for irrigation is an appropriate solution as it involves two main principles– use of soil as a treatment system preventing pollution of the surface water and use of wastewater as continuous or supplementary source of irrigation. Recently, effluent irrigation has been adopted with great vigour by most paper mills due to the effective legislation and implementation of pollution control measures by the State Pollution Control Board. Though the concept of effluent irrigation seems promising the real success can be attributed only if there is no adverse impact on the environment. The continuous effluent irrigation can create environmental problems like accumulation of undesirable proportion of toxic elements, viz. heavy metals in soils (Srinivachari *et al.*, 2000). The heavy metals accumulate in the soil which may lead to adsorption by plants. This would act as a direct link for incorporation into the human food chain. Heavy metals are probably the most harmful and insidious pollutants because of their non-biodegradable nature and their potentiality to cause adverse effects in human beings at certain level of exposure. The short term benefit of effluent irrigation should not offset the heath and environmental consideration. Hence to assess whether the effluent irrigation has contributed for the heavy metal accumulation in the soil, the present study was undertaken in an area where effluent irrigation is in vogue for more than 25 years.

METHODS AND MATERIALS

To assess whether the effluent irrigation has contributed for the heavy metal accumulation in the soil, present study was undertaken at Pallipalayam in Tamilnadu where paper mill effluent irrigation is in vogue for more than 25 years. Representative soil samples of surface (0-30 cm depth) and subsurface soil (30-60 cm depth) from the fields put under different periods of effluent irrigation, viz. more than 25 years, 15 years, 12 years, 9 years and field with well water irrigation (control) were collected. These soil samples were dried, powdered, passed through 2mm sieve and analyzed for, Cu, Zn, Pb and Cd by atomic absorption spectrophotometer. The effluent which was let out for irrigation was also directly collected and analyzed for Cu, Zn, Pb and Cd (APHA, 1995). Soil pH and organic carbon of surface and subsurface soil were also estimated as per the standard procedures.

RESULTS AND DISCUSSION

The mean concentration of Cu, Zn, Pb and Cd in the effluents which were let out for irrigation are given in Table 1. The copper content in the effluents ranged from 0.034 to 0.046 mg l^{-1} with an average value of about 0.039 mg l^{-1} and the zinc content varied between 0.002 mg l^{-1} and 0.011mg l^{-1} with a mean value of about 0.007mg l^{-1}. The cadmium and lead content of the effluent ranged from 0.001 to 0.019 mg l^{-1} and 0.103 to 0.267 mg l^{-1}, respectively. The results showed that the effluents let out for irrigation are well within the permissible limit as prescribed by FAO (1992) and USEPA (1992) for the effluents to be utilized for irrigation. Heavy metals in smaller proportion are required for plant growth. The concentration of heavy metals in the treated paper mill effluents was in the order of Pb>Cu>Cd>Zn.

Table 1. *Heavy metals in treated paper mill effluents*

Heavy metals	Mean	Max	Min	Irrigation standards	
				FAO (1985)	USEPA (1981)
Cu (mg/l)	0.039	0.046	0.034	0.2	0.4
Zn (mg/l)	0.007	0.011	0.002	2.0	4
Cd (mg/l)	0.008	0.019	0.001	0.01	0.02
Pd (mg/l)	0.204	0.267	0.103	5	10

Generally soils have the capacity to reduce the toxicity of' heavy metals through absorption onto the soil clay and deactivated by chemical speciation as a result of reaction with other ionic species. Additional protection against build-up of heavy metals in toxic concentration is provided by leaching. Soil texture, pH, amount of calcium carbonate, organic matter, nature and rate of waste application, and interaction with other metals are other factors which influence the heavy metal accumulation in plant uptake (Xiang *et al.*, 1999). The soil texture of the effluent irrigated field was determined and it was sandy loam (sand 68-74.3%, silt 12.2-14.2%, clay 14.8-17.8% at the surface). The soil pH and organic carbon in surface and subsurface soil of the effluent irrigated field is given in Fig 1. Irrigation with effluent altered soil pH. The pH of the surface

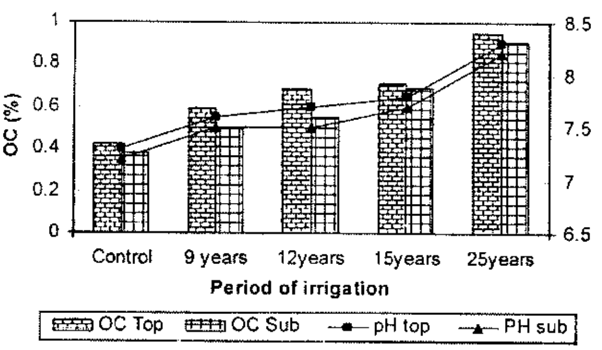

Fig. 1. Soil pH and OC in top and subsoil.

soil in effluent irrigated field ranged from 7.80 - 8.30, whereas it was about 7.30 - 7.40 in control field. The pH decreased with depth and it was observed that the pH of the subsurface soil did not have much variation. The organic carbon content increased with the effluent irrigation. The solubility and plant availability of most heavy metals in soils is known to be inversely related to pH and organic carbon. The organic matter depending upon its nature can either immobilize or mobilize metals. The presence of organic matter or its addition to soils has been shown to fix heavy metals rendering it less available to plants (Srinivachari *et al.*, 2000).

The heavy metals, viz. Cu, Zn, Pb and Cd accumulated in the surface and subsurface soils of the effluent irrigated fields for different periods (Fig 2a and b). Among the heavy metals Cu and Zn are the micronutrients required for the crop production. Heavy metals are present in the soil in different forms with varying degrees of mobility and availability to plants. The magnitude of the bioavailability of the heavy metals and phytotoxicity depends on the interrelationships of a number of factors, such as the rate and frequency of effluent

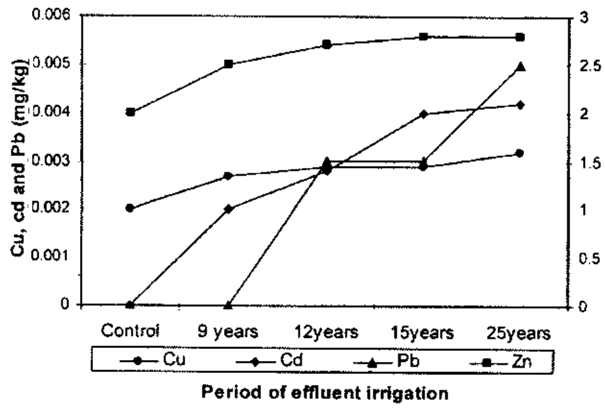

Fig. 2a. Heavy metal concentration in surface soil.

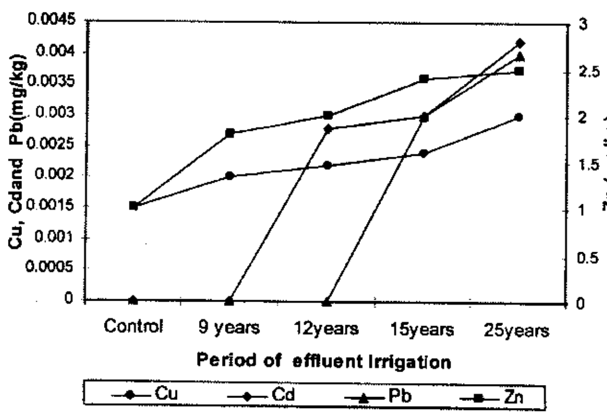

Fig. 2b. Heavy metal concentration in subsoil.

application, soil characteristics and plant species. In general most of the toxic manifestation of metals depend on their synergetic and antagonistic properties (Siebe, 1995).

The results showed that the copper content in the effluent irrigated field increased with the period of effluent irrigation in both surface and subsurface soil (Fig 2a and b). The copper content in the soils were 0.0027, 0.0029, 0.0029 and 0.0032 mg kg^{-1} of soil under 9 years, 12 years and more than 25 years of effluent irrigation, respectively, whereas in well water irrigated field (control) it was about 0.002 mg kg^{-1}.. Though the accumulation was not much, the period of irrigation increased the copper accumulation. Moreover, it was also observed that the copper concentration decreased with the depth. The zinc concentration in the soil was about 2.5, 2.7, 2.8 and 2.8 mg kg^{-1} in 9 years, 12 years and more than 25 years effluent irrigation, respectively. Srinivascharti *et al.* (2000) showed that irrigation with undiluted paper mill effluent drastically increased the available micronutrient Zn, Cu, Fe and Mn in soil over control. Moreover, use of paper mill effluent increased these micronutrient concentration in soil, that could cause imbalance in available plant nutrients.

The Pb content under 12, 15 years and more than 25 years effluent irrigation ranged from 0.003 to 0.005 mg kg^{-1}, and it was less in the subsurface soil. Lead was rapidly removed from the effluent when it passed through the soil due to the formation of complexes with the organic matter present in the soil. Due to this mechanism lead concentration in the water is generally low and is quite high in the soil. Moreover, lead is tightly held in soils and there is generally no direct relationship between the amounts in soil and concentrations in crops. Vigerrust and Selmer-Olsen (1986) summarized sludge trials which showed no crop uptake of this element. Most field experiments have failed to demonstrate any significant increase in the Pb content in the food chain. Soil is the principal source of Cd accumulated by plants. Cadmium interferes with crop production as well as it adversely affects the animal health. This is because Cd is readily bio-available for plant uptake in contaminated soils. Cadmium can accumulate in the edible portions of crop plants to levels, which could be injurious to animals if consumed for long periods of time in large quantities, whilst having no apparent detrimental effects on crops themselves. In the effluent irrigated field the cadmium concentration ranged between 0.002 to 0.0042 mg kg^{-1}. Also the study revealed that the Pb, Cd, Cu, and Zn tended to accumulate in the top layers of the soil rather than in subsurface layers. Berti and Jacobs (1996) also reported Pb, Cd, Cu, and Zn to have a tendency of accumulating in the upper layers of the soil. The texture of the soil plays an important role in the mobility of metals. For soils with only slight contamination by heavy metals, lime applications may help. Lime increases the soil pH, and thus reduces the uptake of heavy metals by the crop (Srinivasari *et al.*, 2000).

The plant-soil system has three protective mechanisms that can limit the potentially toxic trace elements in the aerial portions of a plant and so minimize health problems to human or animals. Elements that are insoluble in soil and do not accumulate in plants like Pb are absorbed into the root but being insoluble have limited translocation to shoot. Elements which applied in excess may cause phytotoxicity like Zn and Cu (Aganga *et al.*, 2005).

CONCLUSION

The study thus shows that the heavy metal concentrations in the effluents which were let out for irrigation were very minimum and within the permissible level. But continuous effluent irrigation may lead to heavy metals accumulate in the soil especially in the top layers Though the concentration of the Cu, Cd, Pd and Cd were of very low concentration, continuous monitoring and proper management practices should be taken for minimizing the deleterious effects of the heavy metal accumulation.

REFERENCES

Aganga, A.A., Machacha, S., Sebolai, B., Thema, T. and Marotsi, B.B. (2005). Minerals in soils and forages irrigated with secondary treated sewage water in Sebele, Botswana. *Journal of Applied Sciences* **5**(1): 155-161.

APHA (1995). *Standard Methods for the Examination of Water and Wastewater*, 19th Edn. AWWA, WPCF, New York. 1193p.

Berti, M.R. and Jacobs, L.W. (1996). Heavy metals in the environment; chemistry and phytotoxicity of soil trace elements from repeated sewage sludge application. *Journal of Environmental Quality* **25**: 1025-1032.

Food and Agriculture Organization (FAO) (1992). *Wastewater Treatment and Use in Agriculture,* Irrigation Paper **47**, Food and Agriculture Organization, Rome, Italy.

Siebe, C. (1995). Heavy metal availability to plants in soils irrigated with wastewater from Mexico city. In *Wastewater Management Problems in Agro-industries.* Selected Proceedings International Symposium *Third IAWQ*, held at Mexico City, Mexico.

Srinivasachari Matli, Dakshinamoorthy, M. and Arunachalam, G. (2000). Accumulation and availability of Zn, Cu, Mn and Fe in soils polluted with paper mill wastewater: Studies on the influence of paper mill effluents on the yield, availability and uptake of nutrients in rice. *Madras Agriculture Journal* **87**(4-6): 238-240.

USEPA (1992). *Guidelines for Water Reuse.* Technical Report **81**, USEPA, Washington D.C. 252p.

Vigerrust, E. and Selmer-Olsen, A.R. (1986). Basis for metal limits relevant to sludge utilization. In *Factors Influencing Sludge Utilization Practices in Europe*, R.D. Davis, H. Haeni and P.L. Hermite (eds.), pp. 26-42. Elsevier Applied Science Publishers Ltd., Barking.

Xiang, C., Ma, L.Q. and Sarigumba, T. (1999). Effects of soil on trace metal leachability from papermill ashes and sludge. *Journal of Environmental Quality* **28**: 321-333.

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Soil and Subsurface Water Quality of Acid Sulphate Soils of Coastal Region and their Temporal Variability

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Field survey was conducted in the Sundarbans region to develop strategies of efficient management of underutilized and poor quality soils like acid sulphate soils to their optimum level of productivity. The soil profile samples were collected from the farmers' fields at different locations in the area. Samples were also collected periodically from specific locations to monitor the temporal varation in soil properties. The subsurface water samples were collected periodically from the piczometers installed at different locations in the area. The pH of the soils were found to be below 5.0 at different locations and comparatively lower pH was determined in the deeper layer of the soil profile. The salinity of the soils varied from location to location and it was more at the surface than in lower layers. The Fe, Al and Mn content of the soil in all the layers of the profile were more. The organic carbon content in the soil in the upper layer was medium (0.5-0.65%) and it was low (<0.5%) in the lower layers. The soils were deficient in available P content and it varied from 1.31 to 4.28 kg P ha^{-1}. Available P content was comparatively low in the deeper layer of the soil profile. Available N content of the soil varied from low in deeper layer to medium in the surface layer of the profile. The available K content of the soils was generally at higher levels. The periodical changes in soil physicochemical properties at different soil depths indicated gradual build-up of soil salinity as the soil dried up from the month of December (after harvest of *kharif* paddy) to summer month (May). The soil acidity was also higher in the dry period. The quality of subsurface water of the piezometers installed upto 6m depth showed that there was gradual increase in EC and TDS with time. The EC and TDS values of the subsurface water increased from 20.8 dS m^{-1} and 9.9 g l^{-1} to 40.5 dSm^{-1} and 20.4 g l^{-1}, respectively during August to May. The pH of water also decreased during the same period.

***(Key words:** Acid sulphate soils, Soil quality, Temporal variability)*

Acid sulphate soils are recognized as problem soils. Existence of these soils in Indian parts of Sundarbans and other coastal of areas of the country has already been reported by many (Bandyopadhyay and Maji, 1995, Maji and Bandyopadhyay, 1995, Bandyopadhyay and Sarkar, 1987, Govinda Rajan and Venkata Rao, 1976, Ghosh *et al.*, 1976). These soils are highly underutilized. Development of strategies for reclamation and improvement of these problem soils is urgently required in order to bring up the productivity and meet the increasing demand of food in these areas. Before attempting for the reclamation and improvement, detailed soil and water quality of the acid sulphate soils of the coastal area and their temporal variability was studied in Sundarbans. An appraisal on characteristics of acid sulphate soils present in the coastal regions of India has been given by Murthy *et al.* (1983), Maji and Bandyopadhyay (1995) and Bandyopadhyay *et al.*, (2003). However, detailed informations on changes in soil properties and underground water quality in time scale under field condition are meagre. The present investigation aims to provide information on soil and subsurface water quality of acid sulphate soils in coastal Sundarbans regions and their temporal variability.

MATERIALS AND METHODS

Field survey and monitoring for soil properties and subsurface water quality were conducted during 2003 to 2005 at different locations in the cultivated parts of the Indian Sundarbans delta (latitude: 22°05' - 22°30'N, longitude: 88°30' - 88°55'E) having acid sulphate soils. The climate of this region is humid subtropical. The average annual rainfall is 1759 mm, out of which about 80% occurs during monsoon (June-October) and only very limited showers are received during rest of the period in a year. Rice is in almost the entire area grown as a single crop during the period June/July to November/December when the crop fields are submerged with rainwater. Although there are only few showers during May, the subsurface soil horizon remains moist due to shallow water table. The soil moisture and temperature regimes of this area are aquic and hyperthermic, respectively.

Soil samples from different depths were collected periodically from the farmers' fields at different locations of the area. EC_2, pH_2, available N, P and K, Org.C, extractable Al, Fe, Mn and Zn were determined following methods given by Black (1965). KCl extractable Al and DTPA extractable Fe, Mn and Zn were determined by Atomic Absorption Spectophotometer (ECIL, model-4141[1]). For determining and monitoring subsurface water quality piezometers were installed upto a depth of 6m at different locations in the cultivated farmers' fields. The water samples were collected periodically and pH, EC, TDS were determined following standard methods.

RESULTS AND DISCUSSION

Soil physicochemical and chemical properties at two locations, which were representatives of typical acid sulphate soils of coastal Sundarbans, are presented in Table 1. The pH of the soils were found to be below 5.0 and comparatively lower pH values were found in the deeper layers of the soil profile. The strong acidity of these soils was due to oxidation of pyrites and other sulphidic materials accumulated in these soils in the past (Bandyopadhyay and Maji, 1995). The amount of salt accumulated as indicated by EC_2 values varied from location to location and it was comparatively higher at the surface than at the lower layers of the soil profile. The organic C content in the soil was medium (0.50.-0.65%) and mostly low (<0.50%) in the lower layers (Table 2). The data on soil nutrient status indicated that the acid sulphate soils of coastal Sundarbans were deficient in available P content and it varied from 1.31 to 4.28 kg P ha^{-1} (Table 2). Low available P status of acid sulphate soils in Sundarbans was also reported by Bandyopadhyay *et al.* (2003). The available N content in the soil was found to be medium in the surface and low in the deeper layers in the profile. Available K content of the soil was generally at higher level due to dominant illitic clay minerals as well as K containing salt, like KCl and K_2SO_4, which contributed 0.9-3.7% of the total soluble salts (Bandyopadhyay *et al.*, 2003).

KCl extractable Al content in the profile was high in these soils and it was higher in the lower layers of the profile compared to upper layers (Table 3). DTPA extractable Fe content in the profile was also high and its distribution pattern in different soil layers was same as that of extractable Al. The high concentration of Al and Fe in the acid sulphate soils make these soils unproductive (Dent, 1986).

Table 1. *Physicochemical properties and nutrient status of acid sulphate soil*

Soil depth (cm)	Shimultala						Kheria					
	pH (1:2)	EC_2 (d Sm^{-1})	Org. C (%)	Av. N	Av. P (Kg ha^{-1})	Av. K	pH (1:2)	EC_2 (dSm^{-1})	Org.C (%)	Av. N	Av. P (Kg ha^{-1})	Av. K
0-15	4.3	4.1	0.64	312.5	3.78	512.0	4.2	8.6	0.62	372.5	4.28	489.0
15-30	4.3	4.2	0.58	314.3	3.12	486.5	4.6	7.0	0.59	354.3	3.80	436.5
30-45	4.2	3.9	0.61	289.7	3.04	431.1	4.2	5.4	0.58	349.7	3.09	412.1
45-60	4.2	4.1	0.56	310.0	2.61	412.3	4.2	5.6	0.43	315.0	2.85	410.3
60-75	4.2	3.8	0.52	256.7	2.61	412.2	4.1	5.2	0.46	286.7	2.73	398.1
75-90	4.1	4.0	0.58	216.8	1.50	411.3	4.1	5.3	0.42	226.8	1.31	401.1

Table 2. *Microelement contents (ppm) of acid sulphate soils*

Soil depth (cm)	Shimultala				Kheria			
	KCL extractable	DTPA extractable			KCL extractable	DTPA extractable		
	Al	Fe	Mn	Zn	Al	Fe	Mn	Zn
0-15	111.9	172.5	28.00	3.01	126.9	150.7	11.78	2.36
15-30	107.5	172.0	27.02	3.20	117.0	166.2	25.56	2.68
30-45	118.8	185.2	25.62	3.66	122.4	173.8	22.52	2.54
45-60	130.5	190.7	21.56	3.30	141.8	198.0	21.98	2.72
60-75	136.8	198.0	21.66	3.06	147.2	195.4	22.23	2.64
75-90	147.0	188.7	26.45	3.11	150.3	190.2	26.7	2.50

[1]Does not make any preferential suggestion of the manufacturer or the model

Table 3. *Periodical changes in soil physicochemical properties*

Soil depth (cm)	pH (1:2)						EC_2 (dSm^{-1})					
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Dec.	Jan.	Feb.	Mar.	Apr.	May
0-15	4.9	4.4	4.2	4.1	4.0	4.1	4.5	4.9	5.6	7.5	9.6	9.5
15-30	4.6	4.5	4.3	4.2	4.0	4.0	6.2	6.4	7.0	7.9	9.5	10.0
30-45	4.6	4.2	4.1	4.1	4.0	3.9	3.9	4.6	5.3	6.9	7.8	8.2
45-60	4.5	4.3	4.0	4.0	3.9	3.9	4.8	4.8	5.0	7.0	76	7.8
60-75	4.4	4.2	4.2	4.1	4.0	4.0	4.5	4.6	4.8	5.9	6.4	7.2
75-90	4.4	4.1	4.1	4.0	3.9	4.0	4.2	4.1	4.5	5.8	6.7	7.0

Application of lime might reduce the excess availability of Al and Fe. DTPA extractable Mn content in the soil was high, while Zn in the soil was low.

The changes in physicochemical properties of soil were monitored periodically during post-monsoon period when the land remained fallow (normal practice) after harvest of paddy. The results indicated gradual build-up of soil salinity as the soil dried up from the month of December (after harvest of *kharif* paddy) onwards upto the summer month (May) (Table 2). The soil acidity was also found higher during this dry period. The increase in soil acidity was due to oxidation of sulphidic materials present in the soil as observed in the earlier studies (Bandyopadhyay and Maji, 1995).

The quality of subsurface water is presented in Figs. 1 and 2. There was gradual increase in EC and TDS in subsurface water with time. The EC and TDS values increased from 20.8 dSm^{-1} and 9.9 $g\,l^{-1}$ to 40.5 dSm^{-1} and 20.4 $g\,l^{-1}$, respectively from August (monsoon) to May (summer). The concurrent decrease in pH of water was also found during this period. Very high values of salinity and TDS in the subsurface water indicated the possibility of linkage between subsurface water and brackishwater estuaries existing in the region. This highly saline subsurface water is not suitable for irrigation and due to this farmers in these areas are not able to utilize subsurface water through tubewells for cultivation of crops. Harvesting of rainwater in farm ponds for irrigation in dry months alongwith liming and high doses of P application can be a very effective technology for growing good crops in these soils.

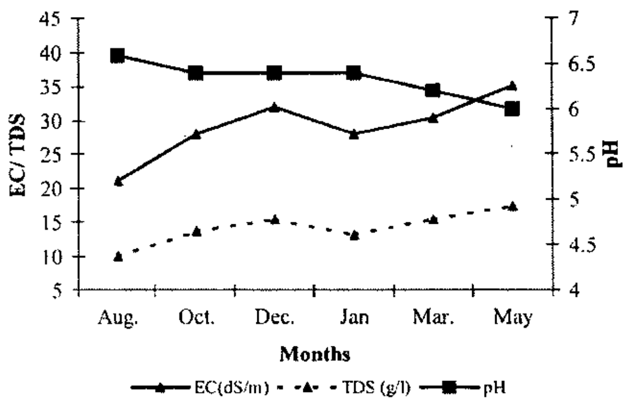

Fig. 1. *Temporal changes of subsurface water quality (Kheria)*

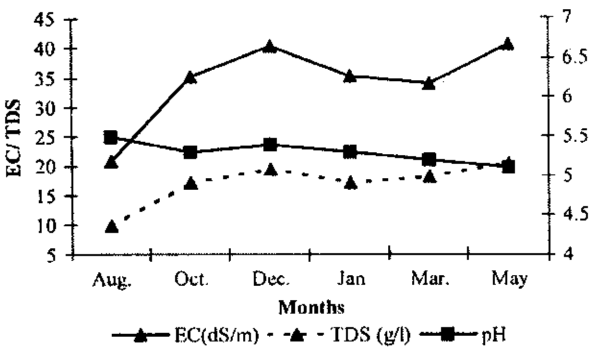

Fig. 2. Temporal changes of subsurface water quality (shimultala)

REFERENCES

Bandyopadhyay, A. K. and Sarkar, D. (1987). Occurrence of acid saline soils in coastal area in Sunderban area of West Bengal. *Journal of the Indian Society of Soil Science* **35**: 542-544.

Bandyopadhyay, B. K. and Maji, B. (1995). Nature of acid soils in Sundarbans delta and suitability of classifying them as acid sulphate or potential acid suphate soils. *Journal of the Indian Society of Soil Science* **43**: 251-255.

Bandyopadhyay, B.K., Maji, B., Sen, H.S. and Tyagi, N.K. (2003). *Coastal Soils of West Bengal- Their Nature, Distribution and Characteristics*, Bulletin No. **1/2003**, Central Soil Salinity Research Institute, Regional Research Station, Canning Town, West Bengal.62p.

Black, C.A. (1965). *Methods of Soil Analysis*, Part **1**, Agronomy Series **9**. American Society of Agronomy, Madison, Wisconsin, USA.

Dent, D. (1986). In *Acid Sulphate Soils: A Baseline for Research and Development*, ILRI, Wageningen, The Netherlands. 204p.

Ghosh, S. K., Das, D. K. and Deb, D. L. (1976). Physical, chemical and mineralogical chracterization of acid sulphate soils of Kerala. In *Acid Soils of India - Their Genesis, Characteristics and Management*, Bulletin **11**, pp. 117-133, Indian Society of Soil Science.

Govinda Rajan, S. V. and Venkata Rao, B. V. (1976). Acid soils of South India. In *Acid Soils of India - Their Genesis, Characteristics and Management*, Bulletin **11**, pp. 38-46,Indian Society of Soil Science.

Maji, B. and Bandyopadhyay, B. K. (1995). Characterization and classification of coastal soils of varius pH groups in Sundarbans, West Bengal. *Journal of the Indian Society of Soil Science* **43**: 103-107.

Murthy, R.S., Dutta Arun Kumar and Thampi, C.J. (1983). Coastal saline soils of eastern India - An appraisal. *Journal of the Indian Society Agricultural Research* **1**: 13-20.

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Characterization of Soil and Water of Brackishwater Fisheries of Coastal Region of Sundarbans, West Bengal

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In the present investigation a number of brackishwater fisheries in different parts of the coastal region of West Bengal were selected and the changes in properties in coastal soils following introduction of brackishwater fisheries were studied and compared with the soils of the nearby agricultural fields. The results showed a very high seasonal variation in the salinity of soil and water of fish farms as well as that of agricultural fields, the maximum observed during summer months. The salinity of the soils of the brackishwater fisheries was related to the salinity of water of the fish farms. The pH of water of the fish farms also showed seasonal variation. The pH of the soils in both the agricultural fields and that in the brakishwater fisheries also varied widely. In some of the areas, fish farm soils as well as the agricultural field soils were found to be highly acidic while the others were neutral to alkaline in nature. The distribution of soil salinity in the areas indicated higher soil salinity of the crop fields adjacent to fish farms, which decreased with increase in distance from the fish farms. The soils of the brackishwter fish farms showed less content of available and total nitrogen due to low organic matter accumulation and anaerobic condition of soil. The available P content of the soils of brackishwater fish farms was also lower when measured under dry condition. The available K content of soils was not influenced due to introduction of brackishwater fish farms. The available Fe and Mn content of soils increased considerably due to the introduction of brackishwater fish farms.

(***Key words**: Soil & water characteristics, Brackishwater fisheries in agricultural fields, Metallic sulphide accumulation in soil*)

In the recent years brackishwater fish farms are encroaching upon the agricultural lands at a fast rate in several coastal regions of the country, particularly, in the coastal regions of West Bengal. When an agricultural soil is submerged it brings about several changes in physicochemical and microbiological properties of soil (Ponnamperuma, 1972). Brackishwater submergence of soil brings about further changes in soil as the water is of high specific conductance and contains high concentration of cations and anions, out of which $SO_4^{=}$ ions play a special role under reduced condition of soil. The $SO_4^{=}$ ions are reduced to sulphides (Patrick and Reddy, 1978, Bandyopadhyay, 1998), of which a large portion are insoluble metallic sulphides which precipitate and accumulate in soil (Bandyopadhyay *et al.*, 2003). Oxidation of sulphides imparts acidity to soils (Bandyopadhyay and Maji, 1995, Dent, 1986). Thus, reversion of brackishwater fisheries may result into the development of acid soils. The submergence of soil increases the solubility of Fe and Mn in soil due to soil reduction (Gotoh and Partrick, 1974, Bandyopadhyay and Bandyopadhyay, 1984). Under saline water submergence of soil the transformations of N in soil is affected and the loss of N is hastened (Sen and Bandyopadhyay, 1987) while, P fixation may be induced due to excess availability of Fe and Ca in soil (Bandyopadhyay, 1987). There has been hardly any study on the impact of brackishwater fisheries on soils in the coastal region of West Bengal. The present study was undertaken to investigate into the properties and nutrient status of soils in adjacent agricultural fields due to brackishwater fisheries.

MATERIALS AND METHODS

The study was conducted in two parts, viz. field studies and microplot studies.

A. Field studies

Under field studies soil and water quality of 6 brackishwater fish farms, viz. Dhamakhali, Hindusthan Lever (HL), Hindusthan lever - Mondal (HL-M), Kusangra, N.Roy and Ghatakpukur, located at different parts of the coastal region of Sundarbans (South 24 Parganas district), West Bengal were studied. Out of these, the first 3 fisheries were fed directly with the water of brackishwater rivers only while, the Kusangra and N Roy fisheries were fed with the water of the brackishwater rivers and the pond water. The Ghatakpukur fishery was fed with the water of sewage water canal and the pond water. The lands under these brackishwater fisheries were earlier used as common agricultural fields under rice based cropping systems. The water quality and soil properties of the brackishwater fisheries were monitored in time scale to study the changes occurring in the agricultural soil now under brackishwater fisheries. The changes in the properties of adjoining crop fields were also assessed periodically to study the influence of brackishwater fisheries on the soil properties of adjoining crop fields.

B. Microplot studies

RCC tanks of 50 cm height (top open) treated as microplots were placed into the field soil in such a way that about 15 cm of the top of the tanks was above the ground level to prevent entry of any run off water from outside during the rainy season. The tanks were filled up with the soil of fish farm areas up to 25 cm and 15 cm of standing water was maintained all throughout the study period of 2 years (2004 & 2005). The pots were subjected to 3 levels of standing water salinity [EC: 1.0 dS m^{-1} (S_1), 15.0 dS m^{-1} (S_{15}) and 30.0 dS m^{-1} (S_{30})] and 3 levels [0 (C_0), 150 (C_{150}) and 300 kg ha^{-1} (C_{300})] of fresh cowdung (82 % moisture) mixed with the soil as the treatments. Cowdung was applied at these doses every month along with lime @ 40 kg ha^{-1} as a common practice followed by the farmers. Lime is applied by the farmers, as a normal practice, to maintain proper soil and water properties while, cowdung is applied as fish food supplement. In the present study, since no fish was grown in the microplots cowdung acted as additional organic matter supplied to the system to influence the soil reduction processes under submerged condition of soil. There were 9 treatments and two replications. The microplots were maintained under natural condition in open field and nylon net covering was used to prevent addition of air borne leaves or other organic residues to the soil. The insoluble metallic sulphide content of the soils was estimated by treating the wet bottom soils of the fisheries with dilute HCl (6N) in a closed system with the provision for inlet and outlet of N_2 gas flow. HCl on reacting with sulphides produced H_2S gas which was driven away with the flowing N_2 gas and passed through standard solution of I_2 or ZnOAc forming sulphides following the schematic reaction as below.

$FeS + 2HCl \rightarrow FeCl_2 + H_2S$

$ZnOAc + H_2S \rightarrow ZnS \downarrow + H_2OAc$

$I2 + H_2S \rightarrow S \downarrow + 2H^+ + 2I^-$

The reduction in the concentrated I_2 was determined by titrating it with standard sodium thiosulphate ($Na_2S_2O_3$) solution or the reduction in the concentration of Zn in ZnOAc solution was determined with Atomic Absorption Spectrophotomenter to determine the H_2S absorbed in I_2 or in ZnOAc solution as described by Bandyopadhyay and Sen (2000) and Bandyopadhyay *et al.* (2003). Dissolved oxygen (DO), biochemical oxygen demand (BOD) and gross productivity parameter was determined following the method described by Gupta (2004). The other physicochemical properties and availability of nutrients in soil were determined by standard methods.

RESULTS AND DISCUSSION

A. Field studies

The salinity of the brackishwater showed seasonal variation with time, it was lowest (Fig. 1) in the monsoon season and increased through winter season with the highest value in the summer season (April- May). The fisheries varied among themselves in respect of salinity of water due to the difference in the salinity of water with which they were fed. Highest water salinity was found in the Hindustan leaver (HL) and Hindustan Leaver- Mondal (HLM) and lowest was in the Ghatakpukur fisheries. The HL and HLM fisheries were fed with water of the brackishwater estuaries only having high seasonal variability, while Ghatakpukur fishery was fed with the pond water and the canal water carrying Kolkata city sewerage effluent, whose water salinity was lower. The salinity of the canal water in different times in the year is also shown in Fig. 1. The salinities of Kusangra and N. Roy fisheries were intermediate.

The soil salinity of brackishwater fisheries (Fig. 2) as well as the soil salinity of adjacent agricultural and rice field at a distance of 50 m also varied seasonally as the salinity of water varied. The

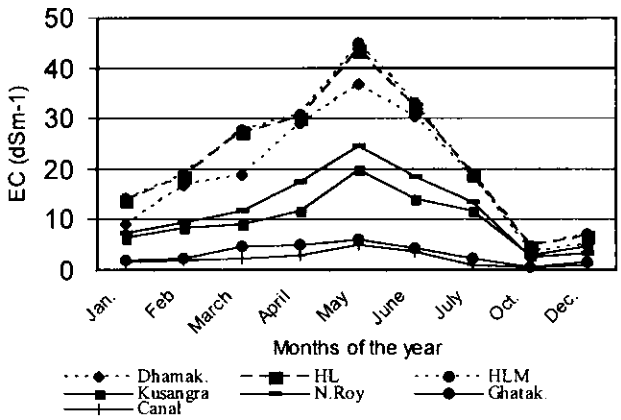

Fig. 1. Seasonal variation in water salinity of the fisheries.

salinity of surface soil (0-15 cm) was higher than that of subsurface soil (15-30 cm). The influence of brackishwater fisheries on the salinity of adjacent field reduced greatly as the distance from the fisheries increased. Since the trend was similar in all the fisheries the data for only one fishery are presented in Fig. 2.

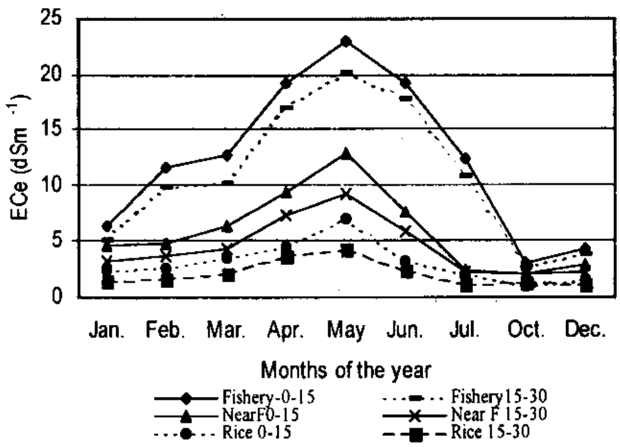

Fig. 2. Changes in soil salinity of fishery and adjoining crop field (Dhamakhali fisheries).

Comparative studies of the fish soil and adjacent crop fields showed that available N and P content of soil (measured under air dry condition) decreased under brackishwater fish farming (Table1). The results corroborated with the observations recorded by Bandyopadhyay (1998). There was an accumulation of insoluble metallic sulphide in soil under brackishwater fish cultivation. The insoluble metallic sulphide content of soil was presented as equivalent of ferrous sulphide (FeS) forms (Table 1). Insoluble metallic sulphide content of soil increased primarily with the increase in soil and water salinity as was also reported by Bandyopadhyay *et al.* (2003). The insoluble metallic sulphide content of soil was higher at higher organic matter content of soil. The insoluble sulphide content in soil of HL fishery was the highest.

The water soluble NH_4-N and NO_3-N content of standing water of brackishwater fisheries (Table 2) was quite high while the dissolved P content of the standing water was low. Thus, the present brackishwater fisheries are far from the optimum production level. The dissolved oxygen (DO) contents of the soils were below the optimum levels while the biochemical demand (BOD) content was quite high. Consequently, the gross productivity parameter (GPP) of fisheries was also low.

B. Microplot studies

The pH of microplot soil varied between 7.2 to 7.7 with not much variation in the salinity of the standing water or in the quantity of cowdung added (Table 3). The salinity of soil varied with the salinity of standing water. The lowest salinity (ECe dS m^{-1}) was 2.0 and highest was 33.0. Organic carbon (%) content of soils increased due to application of cowdung for the two years. The organic carbon

Table 1. *Nutrients (kg ha^{-1}) and insoluble sulphide (ppm) in some fish soils and adjoining crop fields*

Location	Present use	Depth (cm)	Total N	Av. N	Av. P	Av. K	FeS-S
Dhamakhali	Fish	0- 15	725	112	3.6	298	180
	Fish	15-30	502	93	2.9	282	316
	Crop	0- 15	1582	405	4.8	340	-
	Crop	15-30	1227	320	3.3	325	-
H Lever	Fish	0- 15	656	106	10.8	350	1547
	Fish	15-30	446	85	7.7	320	2463
HL Mondal	Fish	0- 15	602	105	7.8	335	613
	Fish	15-30	414	65	6.3	330	916
Kusangra	Fish	0- 15	548	98	9.2	272	98
	Fish	15-30	401	75	7.8	260	120
	Crop	0- 15	1227	315	15.7	312	-
	Crop	15-30	1004	210	12.9	300	-
N Roy	Fish	0- 15	665	118	12.8	321	284
	Fish	15-30	518	92	9.6	312	315
Ghatakpukur	Fish	0- 15	584	140	18.7	267	1705
	Fish	15-30	492	105	16.1	235	2779
	Crop	0- 15	1227	457	26.3	252	-
	Crop	15-30	781	258	21.4	275	-

***Table 2.** Productivity parameters of water in brackishwater fisheries*

Location	NH_4-N (mgl^{-1})	NO_3-N (mgl^{-1})	P (mgl^{-1})	DO (mgl^{-1})	BOD (mgl^{-1})	GPP (mg cm^{-3} h^{-1})
Dhamakhali	5.0	1.2	0.06	4.6	2.0	120.4
H Lever	6.2	3.7	0.4	7.2	4.9	270.4
HLM	5.0	3.7	0.1	5.0	3.0	189.7
Kusangra	6.2	2.5	0.1	4.6	2.9	139.6
N Roy	7.4	5.0	0.82	3.8	11.7	168.7
Ghatakpukur	12.4	7.4	0.68	6.7	30.0	230.2
Canal	18.6	18.6	0.93	1.2	18.2.0	91.8

***Table 3.** Properties of soil in microplots as influenced by treatments*

Treatment	Water properties		Soil properties			
	pH	(EC dSm^{-1})	pH	ECe (dS m^{-1})	Org.C (%)	FeS-S (ppm)
S_1-C_0	9.3	1.0- 1.2	7.3	2.1	0.60	-
S_1-C_{150}	9.1	1.0- 1.2	7.6	2.0	0.77	-
S_1-C_{300}	9.0	1.0- 1.2	7.5	2.0	0.85	-
S_{15}-C_0	8.8	15.0- 15.8	7.3	17.2	0.65	126
S_{15}-C_{150}	8.7	15.0- 15.8	7.5	17.1	0. 80	132
S_{15}-C_{300}	8.6	15.0- 15.8	7.3	16.9	0.89	163
S_{30}-C_0	8.4	30.0- 31.2	7.6	33.0	0.67	1200
S_{30}-C_{150}	8.3	30.0- 31.2	7.7	32.8	0.86	1358
S_{30}-C_{300}	8.1	30.0- 31.2	7.2	32.5	0.97	1389

content was slightly higher at higher salinity, apparently due to lower decomposition rate at higher soil and water salinity. There was a considerable accumulation of the insoluble metallic sulphide in soil at higher soil and water salinity. The insoluble metallic sulphide content of soil also increased due to the application of cowdung.

The study, thus, indicated that there may be considerable accumulation of metallic sulphides in the soils of brackishwater fisheries using water of higher salinity. The accumulation of sulphides is highly detrimental to the soil quality leading to soil acidity as outlined by Dent (1986). There was an increase in salinity of soils of the fish farms as well as of the soils of agricultural fields adjacent to the fish farms. However, the influence of the brackishwater fisheries was marginal in fields at a distance of 50 m or more. The soils of brackishwater fisheries were very poor in total N, average N and average P. The water soluble P content of some fisheries was also low. Fertilization of these soils particularly with P may increase the productivity of the fisheries. The NO_3-N and NH_4-N in water of some of the fisheries, particularly those receiving canal water, were high and this may lead to environmental pollution and low productivity of fishes. DO content and BOD content of the fisheries were suboptimal which further led to low productivity.

REFERENCES

Bandyopadhyay, A.K. (1987). Effect of long submergence of coastal acid saline soils with and without lime. *Journal of the Indian Society of Coastal Agricultural Research* **5**: 401-405.

Bandyopadhyay, B.K. and Bandyopadhyay. A.K. (1984). Transformation or iron and manganese in coastal saline soil. *Journal of the Indian Society of Soil Science* **32**: 57-61.

Bandyopadhyay, B. K. (1998). Submergence of coastal lands under brackishwater aquaculture-effects on soil properties and ecology of coastal region. *Journal of the Indian Society of Coastal Agricultural Research* **16**: 73-79.

Bandyopadhyay, B.K. and Maji, B. (1995). Nature of acid soils of Sundarbans delta and suitability of classifying them as acid sulphate or potential acid sulphate soils. *Journal of the Indian Society of Soil Science* **43**: 251-255.

Bandyopadhyay, B.K. and Sen, H. S. (2000). Production of H_2S gas and insoluble metal sulphides in rice field of coastal salt affected soils and their measurements. Proceedings International Conference *Managing Natural Resources for Sustainable Agricultural Production in 21st Century*, Vol. **2**, pp. 383-384, held at New Delhi, 14- 18 Feb, 2000. Indian Society of Soil Science, New Delhi.

Bandyopadhyay, B.K., Sen, H. S. and Maji, B. (2003). Studies on the transformation of sulphate salt under paddy cultivation in coastal saline soil and its effect on growth of rice. *Journal of the Indian Society of Soil Science* **51**:155 - 160.

Dent, D. (1986). *Acid Sulphate Soils: A Base Line for Research and Development*. Publication **39**, ILRI, Wageningen, The Netherlands.

Gotoh, S. and Patrick W.H. (Jr.) (1974). Transformation of iron in waterlogged soil as influenced by redox potential and pH. *Proceedings American Society of Soil Science* **38**: 61-71.

Gupta, R. K. (2004). In *Methods in Environmental Analysis Water, Soil and Air*. Agrobios (India), Jodhpur, India. 408p.

Partick, W.H. (Jr.) and Reddy, C.N. (1978). Chemical changes in soil. In *Soil and Rice*, pp. 361-379. IRRI, Philippines.

Ponnamperuma, F.N. (1972). Chemistry of submerged soils. *Advances in Agronomy* **24**: 29-96.

Sen, H.S. and Bandyopadhyay, B.K. (1987). Volatilization loss of nitrogen from submerged soil. *Soil Science* **143**: 34-39.

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Assessment of Ground Water Quality in Three Coastal Blocks of Orissa

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Ground water samples collected from 48 randomly selected tube/bore wells of three coastal blocks, viz. Khurda, Mahakalpara and Rajnagar of Orissa in dry season 2004 were analysed for pH, EC, Cl, Ca, Mg, Na, K and Fe. Sodium adsorption ratio (SAR) and Mg/Ca ratio of the ground waters were also worked out. More than 50% of the ground waters, occurring mostly in Mahakalpara and Rajnagar blocks, had EC higher than 0.75 dS m^{-1} indicating salinity problem and had 70 to 350 mg L^{-1} of chloride that may cause low to moderate degree of injury to plants. About 15% of the ground waters, all occurring in Mahakalpara block, had more than 350 mg L^{-1} of chloride and SAR values greater than 10, indicating potential chloride toxicity and medium to high sodium hazard. More than 10 mg L^{-1} of K was measured in 17% and more than 100 mg L^{-1} of Na was measured in about 27% of the ground water samples, occurring in Mahakalpara and Rajnagar blocks, indicated their possible contamination with seawater. Mg/Ca ratio was more than 1.00 in 37.5% and more than 1.50 in 14.6% of all the ground water samples analysed, suggesting potential sodification hazard of these waters. About 10% of the ground waters had Fe concentration exceeding 5 mg L^{-1}. Results of this study indicated contamination of ground waters of areas lying within 1-10 km of the seashore by seawater.

*(**Key words:** Ground water quality, pH, SAR, Mg/Ca ratio)*

Exploitation of ground water for irrigation is very low (13 to 14%) in Orissa while vast tracts of agricultural land remain fallow for want of irrigation during dry season. Intensification of crop production will require use of ground water for irrigation in dry season. Knowledge of ground water quality is critical to planning for its use for irrigation and understanding its management for long term productivity. Since there was scanty information on ground water quality in agriculturally important regions of Orissa, we undertook a study in that direction. Our analyses of ground waters of Balipatna and Balianta blocks of Khurda district showed high iron content (>5.0 mg Fe L^{-1}) in more than 75% of the samples surveyed (Kundu and Singh, 2004). In this paper, we report selected chemical characteristics of the ground waters in three agriculturally important coastal blocks of Orissa.

MATERIALS AND METHODS

Present study was conducted in Mahakalpara, Rajnagar and Khurda blocks of Orissa. Mahakalpara block in Kendrapara district lies within 1-5 km, Rajnagar block in the same district lies within 5-10 km, and Khurda block in Khurda district is situated within 50-60 km of the coast of Bay of Bengal. Ground water samples were collected from 17 tubewells of Mahakalpara, 13 tubewells of Rajnagar and 18 tubewells of Khurda block during dry season (March-April), 2004. The tubewells were randomly selected from within each of the blocks. Boring depth of the tubewells ranged from 3 to 365 m. Water samples freshly pumped out of each tubewell were collected in two separate, well-rinsed, polypropylene bottles: one wide-mouthed 500 ml and one 100 ml capacity. Soon after collection, pH and EC of water samples in the 500 ml bottles were measured using portable meters before storing them in ice box for subsequent analyses in the laboratory. Immediately after collection, water samples in the 100 ml bottles were acidified by adding 6 drops of 6 (N) HCl for subsequent Fe analysis.

Chloride, Ca and Mg content of the ground water samples were analyzed in the laboratory by following standard methods (Richards, 1954). Na and K concentration in the samples were determined by flame photometry, and Fe concentrations were measured by atomic absorption spectrophotometry. Sodium adsorption ratio (SAR) of the water samples were determined by the following relation:

$$SAR = Na/\sqrt{[(Ca+Mg)/2]},$$

where, the concentrations are expressed in me L^{-1}.

Mg/Ca ratio of the water samples were also worked out.

RESULTS AND DISCUSSION

pH of the ground water samples ranged from 6.0 to 8.3 (Fig. 1). pH of the ground waters of Rajnagar (ID No. 18 to 30) and Khurda (ID No. 31 to 48) blocks were lower than that of Mahakalpara block (ID No. 1 to 17). Frequency distribution of EC of 48 ground waters are presented in Table 1. More than 50% of the ground waters had EC higher than 0.75 dS m^{-1} indicating salinity problem. Ground waters of Mahakalpara and Rajnagar blocks were moderately to highly saline while that of Khurda block had no salinity problem. Five out of 17 ground waters tested in Mahakalpara block had EC higher than 3.00 dS m^{-1}. Use of such highly saline water for irrigation may reduce yield of beans and onions by 50% and yield of grain maize and potato by 25% (Ayers, 1977).

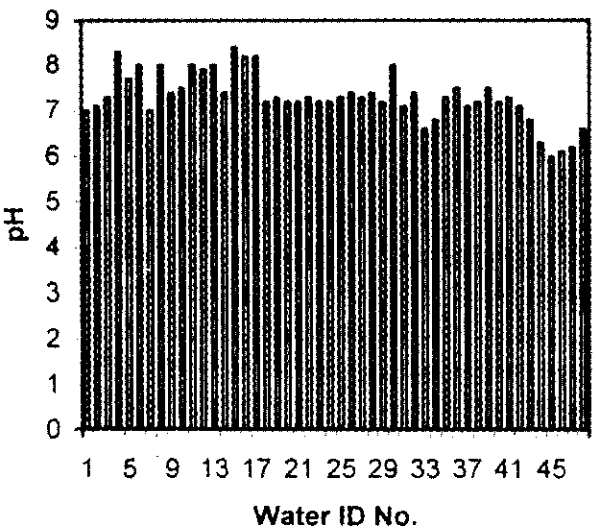

Fig. 1. pH of 48 ground waters from three coastal blocks of Orissa

Table 1. *Frequency distribution of EC of ground water samples from three coastal blocks of Orissa (Dry season, 2004)*

EC of water (dS/m)	Water class	No. of tubewells	% of total samples
<0.25	Excellent	11	22.9
0.25-0.75	Good	12	25.0
0.76-2.00	Permissible[1]	19	39.6
2.01-3.00	Doubtful[2]	1	2.1
>3.00	Unsuitable[2]	5	10.4

[1]Leaching needed if used.

[2]Good drainage needed and sensitive plants will have difficulty obtaining stands.

Data on chloride content of the ground waters are presented in Table 2. About 35% of the ground water samples had less than 70 mg L^{-1} of chloride indicating no adverse effect on plant growth. Most of these low chloride ground water occurred in Khurda block. Greater than 70 mg L^{-1} of chloride can become a production problem. The principal effect of too much chloride (Cl^-) is increase in the osmotic pressure of the substrate solution that can reduce the availability of water to plants and lead to wilting. When absorbed by plant roots, the chloride ion is transported to leaves, where it accumulates. Fifty percent of the ground water samples had 70 to 350 mg L^{-1} of chloride that may cause low to moderate degree of injury to plants. These high chloride ground waters occurred in Rajnagar and Mahakalpara blocks. About 15% of the ground water samples, occurring in Mahakalpara block, had more than 350 mg L^{-1} of chloride that can cause severe injury to crop plants if used for irrigation. Moreover, chloride ions reduce availability of soil phosphorus to plants. Soils irrigated with chloride rich waters need use of nearly 50% more fertilizer P than the recommended dose for growing crops (Minhas and Samra, 2003).

Table 2. *Frequency distribution of Cl of ground water samples of three coastal blocks of Orissa (Dry season, 2004)*

Cl of water (mg/L)	Effect on crops	No. of tubewells	% of total samples
<70	Generally safe for all plants	17	35.4
70-140	Sensitive plants show injury	12	25.0
141-350	Moderately tolerant plants show injury	12	25.0
>350	Can cause severe problems	7	14.6

SAR of 14.6% of the ground waters, all occurring in Mahakalpara block, was more than 10, indicating medium to very high sodium hazard (Table 3).

Na analysis data presented in Table 4 show that 45.8% of the ground waters, including all occurring in Khurda block, had less than 46 mg L^{-1} of Na and they have adverse effect on the growth of only sensitive crops like tomato. About 44% of the waters, including all occurring in Rajnagar and some in Mahakalpara block, had 46-230 mg L^{-1} of Na which may adversely affect growth of moderately tolerant crops like maize, potato and pepper. Remaining 10.4% of the ground water samples occurring in

Mahakalpara block had more than 230 mg L^{-1} of Na that may cause injury to even tolerant crop plants like barley, sorghum, alfalfa, sunflower and sugarbeet (Maas, 1990). More than 100 mg L^{-1} of Na measured in about 27% of the ground water samples, occurring in Mahakalpara and Rajnagar blocks, indicated their possible contamination with seawater. Water containing greater than 70 mg L^{-1} Na should not be used for overhead irrigation of ornamentals and greenhouse plants as foliar absorption of Na may lead to sodium toxicity in sensitive species. Sodium toxicity, whether due to root absorption or foliar absorption of Na, is expressed through marginal leaf burn on older foliage.

Table 3. *Frequency distribution of SAR of ground water samples from three coastal blocks of Orissa (Dry season, 2004)*

SAR of water $(mmol/l)^{1/2}$	Sodium hazard of water	No. of tubewells	% of total samples
<10	Low	41	85.4
10-17	Medium	3	6.3
18-26	High	3	6.2
>26	Very High	1	2.1

Table 4. *Frequency distribution of Na of ground water samples of three coastal blocks of Orissa (Dry season, 2004)*

Na of water (mg/L)	Effect on crops	No. of tubewells	% of total samples
<46	Sensitive plants show injury	22	45.8
46-230	Moderately tolerant plants show injury	21	43.8
231-460	Tolerant plants show injury	5	10.4
>460	Can cause severe problems	0	0

K concentration exceeded 5 mg L^{-1} in 58% and 10 mg L^{-1} in 17% of the ground water samples (Fig 2). More than 10 mg L^{-1} of K in ground water was detected in Rajnagar and Mahakalpara block, while ground waters of Khurda block had low K content. Greater than 10 mg L^{-1} of K in ground waters may indicate their contamination with seawater (Karanth, 1987). Data on Ca and Mg concentration in 48 ground water samples of the coastal blocks are presented in Fig 3. Ca concentrations ranged from 0.08 to 1.52 me L^{-1} in Khurda, 0.62 to1.40 me L^{-1} in Rajnagar, and 0.52 to 2.34 me L^{-1} in Mahakalpara block. Mg concentrations ranged from 0 to 0.98 me L^{-1} in Khurda, 0.90 to 1.84 me L^{-1} in Rajnagar, and from 0 to 2.44 me L^{-1} in Mahakalpara block. Considering 0 to 6 me L^{-1} of Ca and 0 to 2 me L^{-1} of Mg as normal for plant growth, about 12% of the ground water samples from Mahakalpara block had undesirably high Mg content. Mg/Ca ratio was more than 1.00 in 37.5% and more than 1.50 in 14.6% of all the ground water samples analysed, suggesting potential sodification hazard of these waters. More than 60% of the ground waters of Rajnagar block had high Mg/Ca ratio (>1.00).

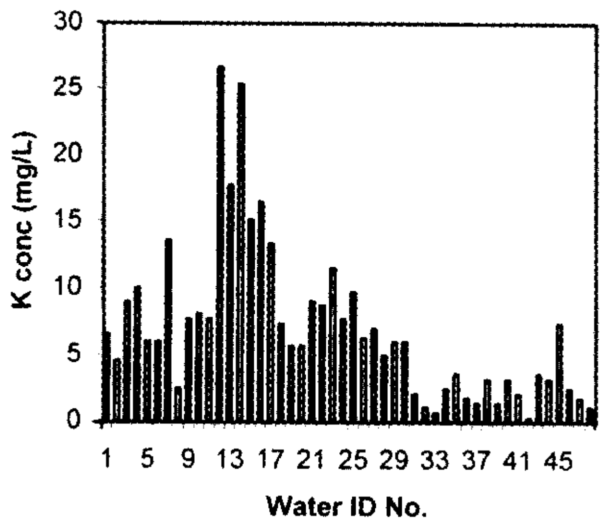

Fig. 2. K in 48 ground water samples from three coastal blocks of Orissa

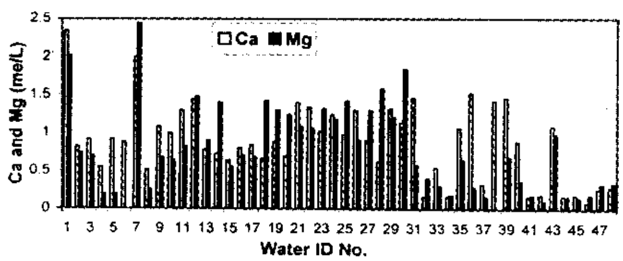

Fig. 3. Ca and Mg in 48 ground water samples from three coastal blocks of Orissa

Data on Fe contents of the ground waters analysed are summarized in Table 5. About 10% of the waters had Fe concentration exceeding 5 mg L^{-1}. Maximum recommended concentration of Fe in irrigation water is 5 mg L^{-1} (Bailey *et al.*, 1999). Higher concentration of Fe is not toxic to plants in aerated soils, but it can contribute to soil acidification and loss of availability of essential elements like phosphorus and molybdenum. Overhead sprinkling of water containing >5 mg L^{-1} of Fe may result in unsightly deposits on plants, equipment and buildings.

Table 5. *Frequency distribution of Fe in ground water samples of three coastal blocks of Orissa (Dry season, 2004)*

Fe of water (mg/L)	No. of tubewells	% of total samples
<1.0	25	52.1
1.0-5.0	18	37.5
>5.0	5	10.4

From the results of the present study it may be concluded that ground waters of the coastal belts of Orissa lying within 5 to 10 km of the shore of Bay of Bengal are partly contaminated by the seawater. Use of such ground waters for irrigation should be done carefully to avoid undesirable impact on soil health and crop growth.

REFERENCES

Ayers, R. S. (1977). Quality of water for irrigation. *Journal of the Irrigation and Drainage Division*, ASCE Vol. **103**, No. **IR2**. 140p.

Bailey,D., Bilderback, T. and Bir, D. (1999). *Water Considerations for Container Production of Plants*. Horticulture Information Leaflet No. **557**, North Carolina State University, USA.

Karanth, K. R. (1987). *Ground Water Assessment, Development and Management*. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

Kundu, D. K. and Singh, R. (2004). Assessment of ground water quality in Khurda district Orissa. *E-Planet Journal* **2**(1): 76-78.

Maas, E. V. (1990). Crop salt tolerance. In *Agricultural Salinity Assessment and Management Manual*, K.K. Tanji (ed.), pp. 262-304. ASCE, New York.

Minhas, P. S. and Samra, J. S. (2003). *Quality Assessment of Water Resources in the Indo-Gangetic Basin Part in India*. Tech. Bull. No. **1/2003**, Central Soil Salinity Research Institute, Karnal. 68p.

Richards, L. A. (ed.) (1954). *Diagnosis and Improvement of Saline and Alkali Soils*, Handbook No. **60**. US Salinity Laboratory Staff, USA. 160p.

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Hydrological Characterization of Coastal Waterlogged Areas of Orissa

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Study was conducted in three of the severe waterlogged areas of Orissa to know its hydrological variations in terms of soil physicochemical characterization, hydrogeological status and fluctuations in ground water table depth, field water level with respect to rainfall. It was observed that the average ground water table depth varied from 0-48 cm, 0-79 cm and 0-30 cm during monsoon in Erasama, Astaranga and Brahmagiri areas during the years 2000 to 2004. Non-monsoon ground water table depth fluctuated between 0.8 to 1.8 m in Ersama and Brahmagiri and within 1.2 m-2.6 m in Astaranga. Water balance study was conducted to quantify the excess rainfall, which caused waterlogging situation in these areas. Under non-saline conditions, paddy growth and grain yield declined under water depth of 20 cm in Ersama and Brahmagiri areas, whereas it declined under 90 cm water depth in Astaranga.

*(**Key words**: Hydrological characterization, Hydrogeology, Waterlogged soils)*

Among various causes, waterlogging in coastal region due to heavy rainfall has created a challenging situation in most parts of the country. Similar situation in Orissa has drawn attention of many researchers. Therefore there is a need to closely observe the hydrological variation in different waterlogged areas in order to plan for integrated management of both soil and water resources to increase the crop production. Fluctuation of ground water table depths and field water level in the coastal areas mainly depend upon the topography of the area, rainfall, water level in the sea, river flow conditions. Depth of standing water in paddy field and sustainable limit of ponding depth of water for crop production are important agronomic parameters in the management of irrigation related salinity problems. This paper deals with characterization of different hydrological parameters in regional scale, which are responsible to aggravate the waterlogging situation in different areas of coastal Orissa and their effects on rice yield.

MATERIALS AND METHODS

Three waterlogged areas (Ersama, Astaranga and Brahmagiri) were selected for the study. The ground water table depth and water level fluctuations with respect to rainfall were monitored for 3 years in selected areas. Monthly potential evapotranspration rate (ET_0) was calculated for the project sites and it was compared with the average ground water table depth. Physicochemical characteristics of soils for all these areas were studied. Experimental sites were selected on the basis of their distances from sea and field water level was monitored during the monsoon season. Total paddy yield from the plots was recorded and compared with field water level in different locations.

RESULTS AND DISCUSSION

Textural classification of topsoil in most of the waterlogged area varied from clayey to clayey loam with saturated hydraulic conductivity ranging from 0.01 to 0.1 cm h^{-1} in Erasama, 0.02 to 3.5 cm h^{-1} in Astranga and 0.02 to 4.2 cm h^{-1} in Brahmagiri. Soil was acidic and saline throughout the profile in lowlands of Brahmagiri. However, comparison between waterlogged and non-waterlogged areas showed that pH was lower but EC was higher in lowland than those in the corresponding uplands. Mostly the soils were acidic to moderately acidic in reaction, low in organic carbon content. Salinity difference was more pronounced in Brahmagiri than in Ersama and Astaranga areas. The physicochemical characteristics of Ersama showed that in waterlogged areas, soil pH in plough layer (0-15) was near neutral where as in non-waterlogged area it was acidic. Salt and nutrient contents in waterlogged profile was much higher than that of non-waterlogged soil profile. Organic carbon content in waterlogged soil increased with depth, whereas it decreased with depth in non-waterlogged areas. Bulk density in waterlogged soil was marginally lower than in non-waterlogged soil.

The average ground water table depth varied from 0-48 cm, 0-79 cm and 0-30 cm during monsoon in Ersama, Astaranga and Brahmagiri area, respectively during 2000 to 2004. Non-monsoon ground water table depth fluctuated between 0.8 to 1.8 m in Ersama and Brahmagiri and within 1.2 m-2.6 m in Astaranga. Average field water level remained upto 30 cm above ground surface (Fig. 1).

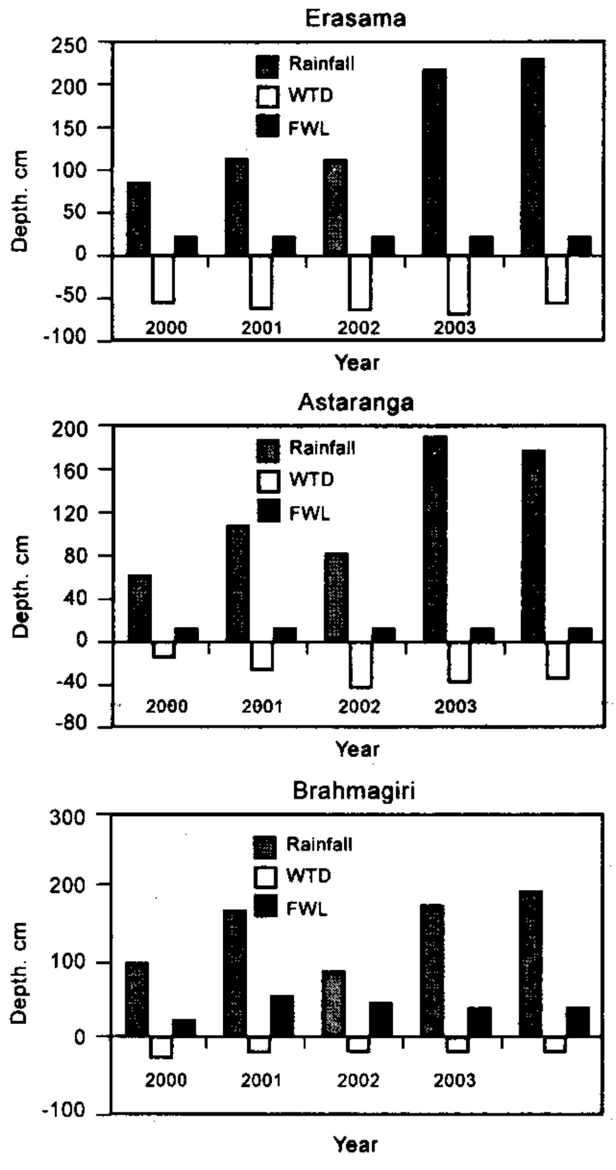

Fig. 1. Fluctuation of ground water table, field water level w.r.t. rainfall at different areas.

Hydrogeology

In Ersama, more than 70% of the area remained waterlogged throughout the year. Hydrogeology and litholology of these waterlogged areas showed the presence of sand and gravel layers having a cumulative thickness of 10-60 m within a depth of 300-400 m, formed prolific and confined conditions in most parts of coastal Orissa. These were dominated by fairly to moderately thick and regionally extensive confined/unconfined aquifer down upto 150-300 m depth.

In the month of May, when ground water table depth was quite high (80.75 cm in Ersama, 70 cm in Brahmagiri, -166.25 cm in Astaranga), highest ET_0 (18.5 cm in Ersama, 17.54 cm in Brahmagiri, 17.94 cm in Astaranga) were recorded. Highest crop yield of 2.8-3 t ha^{-1} at 18-20 cm of ponding depth in Ersama, 2.5-3 t ha^{-1} at 88-90 cm of water level in Astaranga and 2-2.5 t ha^{-1} with 15-20 cm of water level in Brahmagiri were recorded. Crop yield, grains per panicle and grain weight were polynomially related with the ponding water depth for all three areas. It was hypothesized that adjusting the water depth can ameliorate reductions in the yield of rice under salinity stress. Crop yield drastically reduced beyond ponding depth of 20 cm in Ersama and Brahmagiri and 90 cm in Astaranga under non-saline conditions (Fig. 2). Variation in water depth due to irregularity affects rice growth and yield (Ambumozhi *et al.*, 1998).

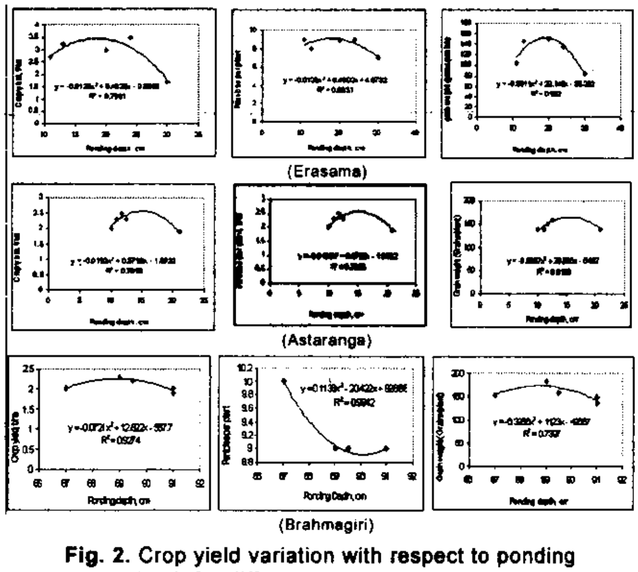

Fig. 2. Crop yield variation with respect to ponding depth for different waterlogged areas.

REFERENCES

Ambumozhi, V., Yamaji, E. and Tabuchi, T. (1998). Rice crop growth and yield as influenced by changes in ponding water depth, water regime and fertigation level. *Agricultural Water Management* **37**: 241-253.

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Natural Resources of North Coastal Andhra Pradesh – Improvement of Crop Production through Efficient Resource Management in Gudivada Watershed

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The soils of North Coastal zone of Andhra Pradesh are predominantly (>70%) red sandy loams and red sandy loams with clay base (Alfisols, Entisols and Inceptisols). The other soil types include alluvial soils (Inceptisols), coastal sands (Entisols) and black cracking clay soils (Inceptisols). The major soil constraints in different soil types in the zone are low organic matter content, light texture with less water holding capacity and rapidly drying in red sandy loams, high permeability and low water and nutrient holding capacity in coastal sands, poor drainage in alluvial soils, and saline and alkali problems interspersed in different soil types. The zone is characterized by humid to subhumid climate. The normal rainfall of the zone is about 1060 mm receiving throughout South West monsoon (61%), North-East monsoon (26%) and during winter and summer months (13%). Detailed soil survey was conducted by NBSS & LUP, Bangalore (June 2002) in Gudivada watershed in an area of nearly 300 ha and the survey results showed two major landforms, viz. transitional plains with five soil series (A,B,C,D and E) and marine plains with three soil series (F,G and H). The soils in transitional plains are very deep, clay to sandy clay (or) fine loam in texture, formed from alluvium deposit with soil constraints of imperfectly to very poor drainage, and soil salinity having substratum with salt encrustation. The soils of marine plains are also very deep, but well to excessively drained, sandy soils formed from marine sand. The annual characterization over 25 years (1978-2003) showed mean annual rainfall of 774.7 mm. Sustainable land use plans involving new cropping systems and farming systems were suggested in transitional and marine plain soils for increasing economic returns of the farmers.

(***Key words***: *Resource management, Watershed approach, North Coastal Andhra Pradesh*)

India has an extensive coastline of around 8000 km. North Coastal zone (spreading over 17,847sqkm) is one of the seven agroclimatic zones of Andhra Pradesh state (Subba Rao, 1995). The coastal region is endowed with a wide range of topographic situations, soil types, crops and is having a rich resource base of flora and fauna. Inspite of these resource potentials, the coastal region is lagging behind significantly in terms of productivity due to a number of soil, climate and water related constraints.

Grouping of geographical area on the basis of some criterion similarity is an important step in a number of studies like agroecology, soil suitability crop distribution, etc., (Patel *et al.*, 2000, Subramaniam, 1983, Sehgal *et al.*, 1989). The zonal classification done based on a diverse set of inputs although showed similarity in many physical features on a broad sense, the distribution of rainfall, biophysical constraints, such as soil and water constraints, and socioeconomic conditions of the farmers play a major role for successful land use plan in a given region. Where irrigation sources are limited, the rainfall characterization is the major factor that plays a predominant role, besides other factors such as soil site constraints (soil erosion, salinity, inundation, etc.) in planning for efficient land use models. The task is much more under coastal agroecosystem, a fragile system where climatology plays crucial role for making strategies for sustainable land use and increasing productivity of crops.

Since the essential physical resources such as land, water, nutrients and energy are limited, proper planning and management of the available resources specific to agroecological subregions is necessary to ensure maintenance of their production potential.

MATERIALS AND METHODS

Keeping in view the natural resources of North Coastal zone of Andhra Pradesh (Anon., 1991) National Agricultural Technology Project on "Land Use Planning for Management of Agricultural Resources under Coastal Agro Ecosystem" was taken up at S. Rayavaram *mandal*, Visakhapatnam district (Andhra Pradesh state) which falls under 18.4

agroecological subregion. The operational area of the pilot project has been executed in two hamlet villages (Kothapolavaram and Kotharevupolavarm) of Gudivada village, S. Rayavaram *mandal*, covering nearly 300 ha area, situated near the sea coast (within a radius of 0.5 km from sea). The latitude and longitude of the region is 17°24' and 82°49', respectively. Detailed soil survey was conducted (June 2002) using 1: 8000 scale in the pilot site with the help of NBSS & LUP, Bangalore and soil-site and water characteristics were studied in different soil series. The rainfall data over 25 years (1978-2003) was collected at S. Rayavaram *mandal* and the data were computed for annual characterization of rainfall and seasonal distribution of rainfall. Moisture availability index (MAI) was also calculated taking into consideration the rainfall, temperature, wind velocity and relative humidity of the area.

RESULTS AND DISCUSSION

North Coastal zone covers 6.5% of area of Andhra Pradesh state. The zone in general has smooth coastline along its eastern border facing the Bay of Bengal. The plains of the zone with altitude nowhere exceeding 76m are drained mainly by rivers like Nagavali, Vamsadhara, Sarada, Varaha, Champavathi, Tandava, Yeleru, Pampa, etc. Since, no major irrigation system is available, no significant and subregional agronomic variations exist in the zone.

The soils of North Coastal zone of Andhra Pradesh are predominantly (>70%) red sandy loams and red sandy loams with clay base (Alfisols, Entisols and Inceptisols). The other soil types include alluvial soils (Inceptisols), coastal sands (Entisols) and black cracking clay soils (Inceptisols). The major soil constraints in different soil types in the zone are low organic matter content, light texture with less water holding capacity rapidly drying in red sandy loams, high permeability and low water and nutrient holding capacity in coastal sands, poor drainage in alluvial soils, saline and alkali problems interspersed in different soil types. The zone is characterized by humid to subhumid climate. The normal rainfall of the zone is about 1060 mm, out of which 61% is received during South West monsoon, 26% during North-East monsoon and the remaining 13% during winter and summer months. (Anon., 1991).

Of the total geographical area of 18.02 lakh hectare in the zone, the net area sown is 53.8% and the balance is occupied by forests, barren and uncultivable land (11.1%), land under miscellaneous tree crops (1.8%), permanent pastures and other grazing lands (1.1%), current fallows (4.9%), fallow lands other than current fallows (2.4%). The rural population of the zone constitutes 79% of total population depending on agriculture. Small holdings (below one hectare) occupy 67% and large holdings (above 10 hectares) account for only 0.5% of total holdings.

Important crops raised in the zone are rice, millets, sugarcane, groundnut, sesame, mesta and tapioca. Rice is a staple food crop of the zone and accounts for 38% of total cropped area. This was followed by groundnut (15%), pulses (11%), bajra (6%), mesta (6%), sesame (4.5%), ragi (4%) and sugarcane (4%). Fruits and vegetables account for 7% of total cropped area, indicating importance given to fruit crops like mango, cashew and to a certain extent banana and guava in this region. The productivities of some of these crops are found to be less and thereby stressing the need for boosting up the yields of these crops through efficient natural resource management.

Hence, a study on "Land Use Planning for Management of Agricultural Resources under Coastal agroecosystem" was taken up at Gudivada watershed under National Agricultural Technology Project (NATP) at S. Rayavaram *mandal*, Visakhapatnam district (Andhra Pradesh state). The Detailed Soil Survey (conducted by NBSS &LUP, Bangalore in June 2002) at the pilot project site (Fig.1) showed two distinct landforms namely transitional plains and marine plains. The soils of transitional plains are categorized into five soil series (A, B, C, D and E) and marine plains into three soil series (F, G and H). The soils of inland plains (transitional plains) are very deep, imperfectly to very poorly drained, have texture varying from clay and clay loam soils, formed from alluvium deposits. The substratum is partially gleyed layer with shells or salt encrustation. The slope in these lowlands varies from 0-3% (gently sloping land). The soils of marine plains are very deep, well to excessively drained, sandy soils formed from marine sand. The slope in marine plains ranges from 1-5%, gently sloping to undulated land. The soil constraints identified in these soil series include occurrence of saline and alkali soils in the transitional plains (Soil series A, B, and C), water stagnation in transitional plains (Soil series E), low fertility status of soils in marine plains (Soil series F, G and H), salinity occurrence due to rise of water table in marine plains (Series F, G and H), monocropping of paddy in transitional plains, leaving the field fallow for *rabi* season with poor land use efficiency in marine plains raised with pure coconut cashew orchards (Table 1).

Table 1. Soil-site characteristics of pilot project area

S. No	Series	Phases	Soil texture	Slope (%)	Depth (cm)	Erosion	Drainage	Classification
1.	A	AiA1	Sandy clay	<1 %	> 150 cm	Slight	Moderately well drained	Fine, montmorillonitic, isohyperthermic, Vertic. Haplustepts
		AmA1	Clay	<1%	100 to 150 cm	Slight	Moderately well drained	
2.	B	BmA1	Clay	<1%	100 to 150 cm	Slight	Moderately well drained	Fine, mixed, isohyperthermic, typic Haplustepts
3.	C	CbA1	Loamy sand	<1%	> 150 cm	Slight	Somewhat poorly drained	Fine, mixes, isohyperthermic, Fluventic, Haplustepts
		CcA1	Sandy loam	<1%	> 150 cm	Slight	Somewhat poorly drained	
		CiA1	Sandy clay	< 1%	> 150 cm	Slight	Somewhat poorly drained	
4.	D	DbA1	Loamy sand	<1%	>150 cm	Slight	Somewhat poorly drained	Fine loamy, mixed, isohyperthermic, Typic Haplustepts
		DcA1	Sandy clay	< 1%	> 150 cm	Slight	Somewhat poorly drained	
5.	E	EmA2	Clay	< 1%	> 150 cm	Moderate	Poorly drained	Fine, mixed, isohyperthermic, Aquic Haplustepts
		EiA2	Sandy clay	<1%	> 150 cm	Moderate	Poorly drained	
6.	F	FaB1	Sandy	1 to 3 %	100 to 150 cm	Moderate	Well drained	Mixed, isohyperthermic, Typic Ustipsamments
		FhA1	Sandy clay loam	1 to 3 %	100 to 150 cm	Slight	Well drained	
7.	G	GaB1	Sandy	1 to 3%	> 150 cm	Slight	Well drained	Sandy over loamy, mixed, isohyperthermic, Typic Ustorthents.
		GaB2	Sandy	1 to 3%	> 150 cm	Moderate	Well drained	
		GbB1	Sandy	1 to 3%	> 150 cm	Slight	Well drained	
		GhB1	Sandy clay loam	1 to 3%	> 150 cm	Sandy clay loam	Well drained	
		GaA1	Sandy	<1%	> 150 cm	Sandy	Well drained	
8.	H	HaB2	Sandy	1 to 3 %	> 150 cm	Sandy	Excessively drained	Mixed, isohyperthermic, Typic Ustipsamments
		HaC2	Sandy	3 to 8%	> 150 cm	Sandy	Excessively drained	
		HbC2	Sandy	3 to 8%	> 150 cm	Sandy	Excessively drained	
		HcC2	Sandy	3 to 8%	> 150 cm	Sandy	Excessively drained	

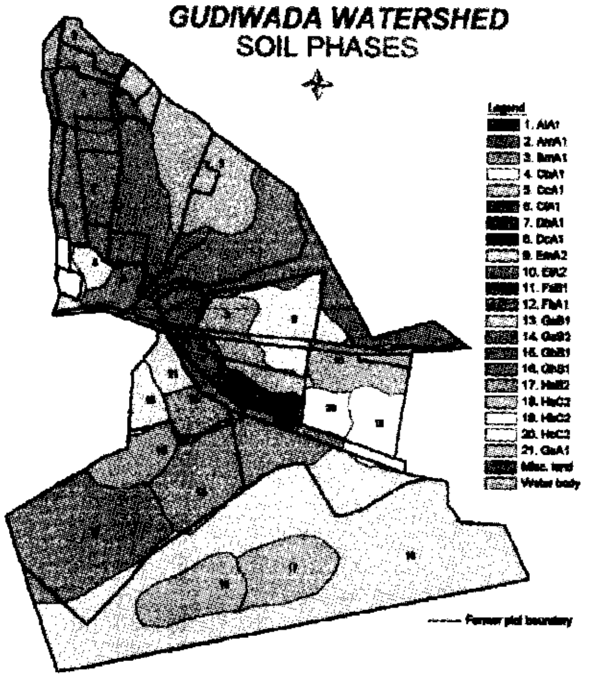

Fig. 1. Soil resource map of the pilot project area

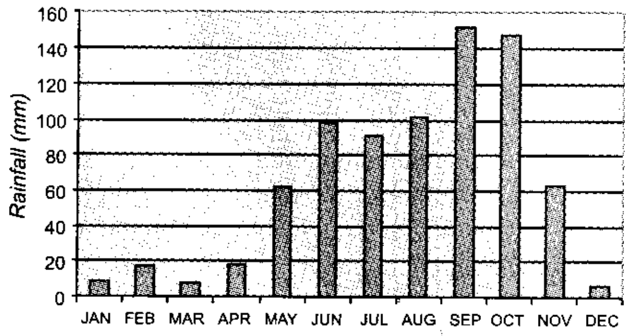

Fig. 3. Average monthly rainfall for over 25 years (1978 to 2002) of S. Rayavaram *mandal* in Visakhapatnam district.

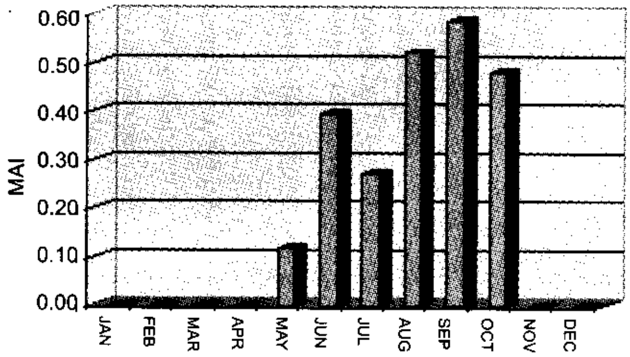

Fig. 4. Moisture availability index at S. Rayavaram *mandal* (1978-2002) of Visakhapatnam district.

The annual rainfall characterization over 25 years (1978-2002) at S. Rayavaram *mandal* showed a mean annual total rainfall of 774.7 mm. Seasonal distribution of rainfall (Fig.2) and monthly distribution of rainfall (Fig. 3) (average over 25 years) showed that more than 50% rainfall (57.2%) was received during south west monsoon followed by north east monsoon (28.1%). A meagre amount of rainfall was received during cold weather period (Jan-Feb) (3.3%) and hot weather period (Mar-May) (11.4 %). Higher moisture availability index was observed during June-October, with excessive moisture available in the month of September (Fig 4).

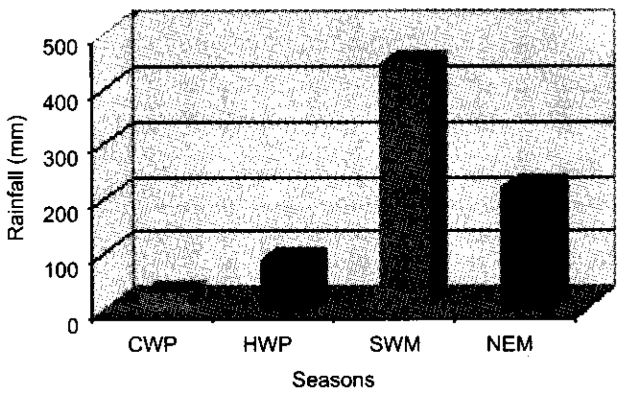

Fig. 2. Seasonal distribution of rainfall (average of over 25 years) (1978-2002) at S. Rayavaram mandal, Visakhapatnam (district)

Keeping in view the soil-site characteristics and rainfall characterization and taking into consideration the soil constraints in the pilot site, some of the following land use plans are suggested for improving the economic returns of the farmer and for sustainable land use under coastal agro-ecosystem in North Coastal Andhra Pradesh.

1) Growing of saline resistant varieties of paddy like Deepthi.
2) Introduction of rice based cropping system in monocropped paddy areas where supplementary irrigation facilities are available and the soils are free of salinity at least in surface layers.
3) Growing of silvi-pasture crops in some of the inland soils where the soils showed high salinity (due to intrusion of seawater with salts deposited on the surface soils) coupled with inundation due to subsurface ill drainage making the soil very problematic for raising any crop.
4) Growing intercrops in coconut and cashew orchards in marine soils by following proper

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Surge Drip Irrigation in Sand and Gravel Tubes

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The water-use efficiency of drip irrigation is highly dependent on evaporation losses occurring from the constantly saturated soil beneath the emitters. Advent of subsurface drip irrigation is in fact an approach to curb this efficiency. For the above study three types of tubes were prepared using sand, gravel and both sand & gravel. For the first set of experiments, in both continuous drip and surge drip irrigation methods, wetting front advances at the end of 2 hours of irrigation for each type of tube was observed and recorded for a discharge rate of 2 lph keeping the volume of water application same. For each curve the maximum horizontal and vertical wetting front advances were measured. The experiments conducted with surge drip irrigation led to a conclusion that both the horizontal waterfront advance and vertical waterfront advance were higher than those with continuous drip irrigation.

***(Key words:** Surge irrigation, Subsurface drip irrigation, Wetting front advance)*

Technological innovations are to be exploited to achieve the twin objective of optimum use of water and higher productivity. The drip irrigation method is now one of the fastest growing technologies in modern agriculture and has proved to be the most efficient one. Drip irrigation system suffers from clogging of emitter and microtubes. An alternative approach to the clogging problem is to increase the size of the emitters and microtubes. However, this may increase the discharge of microtube emitter and change the pattern of wetting in the soil thus affecting the water availability to the plants. In order to reduce this difficulty Karmelli and Peri (1974) introduced pulse/surge irrigation. Surge irrigation involves intermittent application of water at specified discharge rates in an ON-OFF irrigation cycling mode into individual furrows which should result in accelerated waterfront advance rates and minimum deep percolation losses (Coolidge *et al.*, 1982, Duke *et. al.*, 1983), thus achieving high order of irrigation application, storage and distribution efficiencies in comparison to continuous flow of water for irrigation. Another new irrigation method, namely Sand Tube Irrigation (STI) method employs a surface drip system in conjunction with a sand tube column for reducing evaporation significantly. The sand media transmits water into the profile by way of vertical and horizontal flow from the sand tube's base and circumference (Meshkat *et al.*, 1998). Sand tube method is only applicable to permanent tree/ vine crops where harvesting and other field operations do not interfere with drip irrigation systems. Keeping the facts stated above in view, experiment wass conducted to study the waterfront advance by surge drip sand tube, gravel tube and sand and gravel tube irrigation.

MATERIALS AND METHODS

The soil used in the experiment was collected from the Central Farm, O.U.A.T. The soil was collected, dried, crushed and mixed thoroughly. The dried soil was sieved with a 6 mm size sieve for use in the experiment. The percentage of sand, silt and clay was determined and texture of the soil was determined using USDA soil classification chart. The experimental set up consists of soil tank model fitted with two fibre glass plates. The dimensions of the soil tank model were: L = 92 cm, B = 91.5 cm, H = 61.0 cm. Internal angle between plexyglass plates = 115°, length of flexy glass plates = 58.0 cm (right) and 53.0 cm (left). Bottom of the soil tank and its three vertical sides were made up of metal sheet. Other vertical side has been provided with two plexyglass plates at an angle of 115 degrees. The vertical side provided with plexyglass plates at an angle was used for observing advance of waterfront. A metal mould of 8 cm internal diameter and 15 cm height was used in making sand tube, gravel tube and sand & gravel tube in the soil. The tank was filled with the test soil up to a depth of 46 cm. The metal mould was held vertically in the middle of vertical side provided with plexyglass plates. The agronomic management practices like regular application of organic manures, mixing of clay and tank silt for improving soil fertility and physical condition of soils.

5) Introduction of farming systems in marine coastal sands by introducing animal component like goat rearing in orchard areas (cashew and coconut orchards) besides raising intercrops in these orchards for increasing the income of the farmers, as mostly the areas in marine coastal sands are occupied by small farmers.

Validation of some of the suggested land use plans was made and following are some of the successful attempts.

(1) Increase in grain yield of paddy was observed by introducing salt tolerant paddy varieties like Deepthi (150 days duration) over the traditional variety, viz. Sreekakulam sannalu (165 days) in the transitional plains of the pilot project region.

(2) Increase in net returns by around 68 % was observed by introducing sweet orange as an intercrop in coconut orchards followed by banana (3.38 %) in marine plains in the pilot project area.

(3) Nutrient rich coirpith compost was found to be prepared through efficient utilization of coir (which was produced @ 3t ha^{-1} in coconut gardens) by applying plurotis (a microorganism which decomposed the coir pith quickly) @ 1 kg and single superphosphate @10 kg per tonne of coirpith in layers. The farmers in the pilot project area were found preparing the compost, applying to the fields, and getting higher yields with good quality.

REFERENCES

Anon. (1991). *Status Report of North Coastal Zone* (March), Vol. **I**. NARP, Regional Agricultural Research Station, Anakapalle.

Patel, N.R., Mandal, U.K. and Pande, L.M. (2000). Agro-ecological zoning system - A rėmote sensing and GIS perspective. *Journal of Agrometeorology* **2**(1): 1-13.

Sehgal, J.L., Mandal, D.K., Mandal, C. and Vadivelu, S. (1989). *Agro-ecological Region of India*. NBSS & LUP (ICAR), Publication **24**, Nagpur. 76p.

Subba Rao, I.V. (1995). *Soils of Andhra Pradesh*. Monograph, Andhra Pradesh Agricultural University & Hyderabad Chapter of Indian Society of Soil Science.

Subramaniam, A.R. (1983). Agro ecological zones of India. *Arch. Met. Geoph. Biocl.* Ser. **B 32**: 329-333.

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Irrigation system

A plastic bottle was kept in position on a vertical stand. It was of 2 litre capacity. The bottle was provided with a horizontal orifice at its bottom. A piece of plastic microtube of 50 cm long was fitted to the orifice. At the end of the microtube an emitter was attached. The emitter was calibrated for its discharge. In order to get higher rate of discharge a capillary tube was fitted to the end of microtube and discharge of capillary tube was also calibrated. The emitter / capillary tube was placed on top of the sand tube, gravel tube and sand & gravel tube and suitably kept in position. Constant head was maintained in the overhead bottle. Water was allowed to fall on the top of microtube through the emitter. Supply of water through emitter was considered as the irrigation ON- TIME. The supply was disconnected for certain period of time by removing the microtube/capillary tube, which was irrigation OFF-TIME.

Replacement of test soil

On completion of one experiment, sand tube, gravel tube and sand & gravel tube as well as wet soil around the mould were carefully taken out of the soil tank. The soil was dried, pulverized, sieved and reused in subsequent experiments. Sand tube, gravel tube and sand & gravel tube were again installed in the soil following the procedure explained earlier.

Calibration of emitter

The emitter was fixed at the soil surface level. Water was then supplied to the emitter through the supply bottle and a constant head of water was maintained during the period. Under that condition 500 ml of water was collected from the emitter in a graduated measuring cylinder and the time taken was recorded by a stopwatch. The discharge of emitter was found to be 2 litre per hour. In similar manner, the rate of discharge of capillary tube was determined. The capillary tube was found to be of 5 lph. The discharge of emitter/capillary tube was calculated by

$$q = v / t, \text{ lph.}$$

Experimental procedure

Transparent sheet was fixed on the plexyglass plates of the soil tank model lying in front of the sand tube for demarcating the advance of waterfront. The emitter / capillary tube was placed on the sand tube and other two tubes. Water was supplied from the bottle under constant head through the emitter to the sand tube. To start with, soil in the tank was irrigated at a rate of 2 lph through the sand tube continuously for two hours. The maximum waterfront advance both in horizontal and vertical directions was recorded at the end of two hours. The volume of water supplied during that period was also recorded. The continuous drip irrigation was followed by surge drip irrigation for three and half hours, keeping the total volume of water applied for irrigation same in both cases. In the surge drip irrigation, the irrigation ON- TIME was kept 30 minutes followed by irrigation OFF TIME of 30 minutes. In similar fashion the waterfront advance was recorded in case of gravel tube and sand & gravel tube under continuous and surge drip irrigation methods. This set of experiment constituted six experiments; two with each tube, i.e. sand tube, gravel tube and sand & gravel tube.

RESULTS AND DISCUSSION

The screened test soil was found to be sandy loam. The percentage of sand, silt and clay was 69.0, 21.6 and 9.4 percent respectively.

Comparison of wetting front advance with discharge rate of 2 lph

In order to compare the wetting front advance by continuous drip irrigation and surge drip irrigation experiments were conducted with sand tube, gravel tube and sand & gravel tube with a 2 lph emitter. Percent of increase in maximum horizontal water front advance and maximum vertical water front advance observed during irrigating the soil around sand tube, gravel tube and sand & gravel tube with water application rate of 2 lph in both the methods of continuous drip irrigation and surge drip irrigation are presented below. During continuous 120 minutes drip irrigation at the flow rate of 2 lph to the soil around the sand tube, gravel tube and sand & gravel tube with a volume of 4 lit of water the maximum horizontal water front advance was observed to be 24.5 cm, 22.0 cm and 30.5 cm, respectively. However the maximum horizontal water front advances in the soil around the sand tube, gravel tube and sand & gravel tube under surge drip irrigation with similar flow rate and with the same volume of water applied during 120 minutes total irrigation on-time achieved with a cycle of 30 minutes on-time and 30 minutes off-time of irrigation were observed to be 27.0 cm, 27.3 cm and 34.3 cm, respectively, and this corresponded to 10.20, 24.09 and 12.45 percent increase, respectively over the continuous drip irrigation (Fig. 1). It was observed that under surge drip irrigation the horizontal water front advance with sand & gravel tube was 27 percent higher than that with sand tube. It was also observed that under surge drip irrigation the horizontal water front advance with gravel tube was 1 percent higher than that with sand tube.

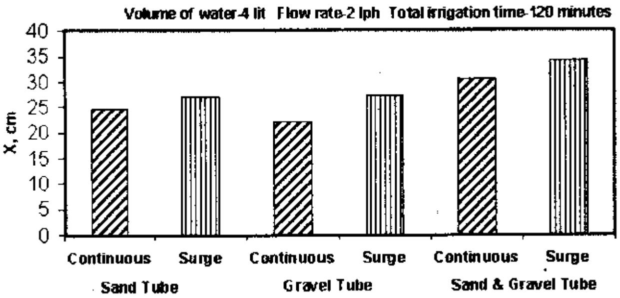

Fig. 1. Maximum horizontal water front advance, X.

During continuous 120 minutes drip irrigation to the soil around the sand tube, gravel tube and sand & gravel tube at the flow rate of 2 lph the maximum vertical water front advance was observed to be 25.0 cm, 36.5 cm and 30 cm, respectively. In case of surge drip irrigation, maximum vertical water front advance in the soil around the sand tube, gravel tube and sand & gravel tube with a cycle of 30 minutes on-time and 30 minutes off-time of irrigation with similar flow rate for the same volume of water applied during total irrigation on-time of

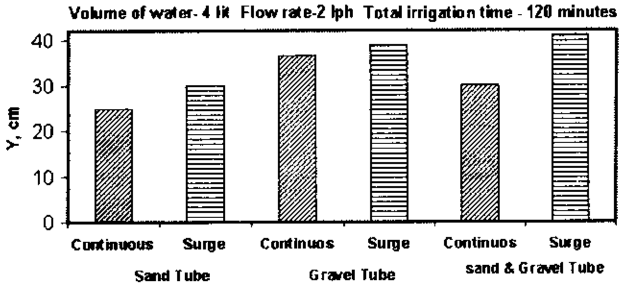

Fig. 2. Maximum vertical water front advance, Y.

120 minutes was observed to be 30.0 cm, 39.0 cm and 41.0 cm, respectively, and this corresponded to 20.00, 6.85 and 36.67 percent increase, respectively over the continuous drip irrigation (Fig. 2).

The vertical water front advance under surge drip irrigation with the above flow rate and above total irrigation on-time with gravel tube and sand & gravel tube was 30.00 percent and 36.67 percent, respectively higher than sand tube.

REFERENCES

Coolidge, P.S., Walker, W.R. and Bishop, A.A. (1982). Advance and runoff under surge flow furrow irrigation. *ASCE Journal of Irrigation and Drainage Division* **108**(IRI): 35-42.

Duke, H.R., Izuno, F.T. and Podmore, T.K. (1983). Surge irrigation management. *Agricultural Water Management* **11**(34): 279-291.

Karmelli, D. and Peri, G. (1974). Basic principles of pulse irrigation. *ASCE Journal of Irrigation and Drainage Division* **100**: 309-319.

Meshkat, M., Warner, R.C. and Workman, S.R. (1998). Comparison of water and temperature distribution profiles under sand tube irrigation. *Transaction ASCE* **41**(6): 1657-1664.

Advanced research in nutrients & crop management including horticulture and plantation crops and their utilization

J. Indian Soc. Coastal agric. Res., 24(1), 97-102, 2006 **Invited Paper**

Status and Future Prospects for Value Addition in Spices in Coastal Ecosystem

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Spices are high value export oriented crops extensively used for flavouring food and beverages, medicines, cosmetics, perfumery, etc. Value addition is a means to increase the domestic and international consumption of spices. The paper discusses products from all the major spices. Major spices are black pepper, cardamom, ginger, turmeric, chillies, nutmeg, cinnamon and clove. Value added products of black pepper and ginger are based on both fresh and dry raw material. Processing techniques contribute towards better quality products, which should be the focus in future.

*(**Key words**: Spices, Value addition, Processing, Products)*

Spices are high value export oriented crops extensively used for flavouring food and beverages, medicines, cosmetics, perfumery, etc. Spices constitute a significant and indispensable segment of culinary art which essentially add flavour, colour and taste to the food preparations. The farm level processing operations are most important for value addition and product diversification of spices. These post-harvest operations which lead to value addition include proper harvesting, washing, threshing, blanching, drying, cleaning, grading, storing and packaging. It is essential that these operations ensure proper conservation of the basic qualities like aroma, flavour, pungency, colour, etc. Each of these operations enhances the quality of the produce and the value of spice. The spices discussed here are black pepper, cardamom, turmeric, ginger, chillies, nutmeg, cinnamon and clove. The clean raw material forms the basis for diversified value added products.

Black pepper

Pepper *(Piper nigrum)* takes about 180 to 230 days after flowering to reach full maturity. Harvesting is generally done when the berries are fully mature and few starts turning from yellow to red in each spike. The stage of maturity at harvest varies depending on the final value added product to be prepared from pepper and is tabulated below:

Pepper products and the corresponding maturity stages

Product	Maturity at harvest
White pepper	Fully ripe
Black pepper	Fully mature and 1-2 berries start turning from yellow to red in each spike
Canned pepper	4-5 months
Dehydrated green pepper	10-15 days before maturity
Oleoresin	15-20 days before maturity
Pepper oil	15-20 days before maturity

The following unit operations are involved in making whole dried black pepper.

Threshing : The berries are separated from the spike usually by trampling with human legs. Mechanical threshers with capacities varying from 200 kg h^{-1} to 1200 kg h^{-1} are available which can thresh quickly and provide cleaner products.

Blanching : The quality of the black pepper can be improved by a simple treatment of dipping the mature berries taken in perforated vessel in boiling water for a minute before drying. This results in a uniform coloured black pepper and removes the extraneous impurities on the berries.

Drying : The berries are then spread on clean dry concrete floor/bamboo mats/ PVC sheets and dried in the sun for a period of 4 - 6 days. The moisture content is brought down from about 75 to 80 percent to 8-10 percent. The average dry recovery varies from 33-37 percent.

Cleaning/garbling and grading : During threshing and drying, extraneous matters like broken spikes, pinheads, stones, soil particles, etc. creep into the produce. These impurities are removed by winnowing the produce manually or by using a blower. Multiple sieve-cum-air classified type of machine whereby the impurities are easily removed is used for grading at the farmers and traders level.

Packing and storage : The graded produce is bulk packed separately in jute bags, multilayer paper bags or woven polypropylene bags.

Value added products of pepper : A variety of products have been made from pepper and are classified as 1) Green pepper based products 2) Black pepper and white pepper based products, and 3) Pepper byproducts.

1) Green pepper based products

Canned green pepper in brine, bottled green pepper in brine, bulk packaged green pepper in brine, cured green pepper (without covering tissues), frozen green pepper, freeze dried green pepper, semi-dried or dehydrated green pepper, green pepper pickle in oil/vinegar/brine, green pepper-mixed pickle in oil/vinegar/brine, green pepper flavoured products and green pepper paste.

2) Black pepper and white pepper based products

Black pepper powder, white pepper powder, white pepper whole, pepper oleoresin, pepper oil, microencapsulated pepper, other products (such as soluble pepper, pepper paste), and byproducts from pepper waste.

3) Other products

Many products, in which pepper is a major ingredient, have been developed, such as lemon pepper, garlic pepper, sauces and marinades that have pepper as the main component.

Spice mixtures and blends: Curry powders and spice blends for various culinary uses.

Pepper flavoured products: Products such as pepper mayonnaise, pepper cookies, pepper keropak, pepper tofu, etc.

Pepper extracts: pepper candies, pepper perfumes, etc.

- ***White pepper:*** White pepper is prepared by removing the outer skin of the harvested ripe berries. For removing the skin the ripe berries are packed in gunny bags or steeped as such in water tanks or running water for 7-10 days. Once the skin is softened they are rubbed by hand or trampled to remove the outer skin. The pin heads and light berries that float are separated. The deskinned berries are sundried and sold as white pepper. The recovery of white pepper varies from 22-27 percent of green pepper.
- ***Pepper oil:*** The characteristics aroma of pepper is due to the presence of volatile oil which ranges 2-5 percent. It is extracted by steam distillation or super critical extraction.
- ***Pepper oleoresin:*** It is the concentrate of all the flavour components (aroma, taste, pungency and related sensory factors). It is extracted from black pepper using solvents like acetone, ethylene dichloride, ethyl acetate, etc.
- ***Piperine:*** Piperine content ranges from 3-6 percent. The alkaloid piperine is the major constituent responsible for the biting taste of black pepper.
- ***Green pepper in brine:*** The green colour is maintained under high salinity of steeping liquid by maintaining a minimum salt level of 12 percent. Addition of small percentage of citric acid will prevent the discolouration due to phenols.
- ***Dehydrated green pepper:*** It is prepared by boiling the freshly harvested despiked pepper in boiling water for over 10 minutes which inactivates the blackening enzymes. It is then treated with sulphur dioxide to reduce the chances of darkening. The pepper is then dried in hot air oven or microwave oven to prepare dehydrated green pepper.

Cardamom

Cardamom *(Elettaria cardamomum)* plants take about two years to bear capsules and takes about 3 months after flowering for fruit maturity. Harvesting of cardamom is taken up at a time when the seeds inside the capsules have become black in colour. The pericarp at this stage will still be green in colour. Green cardamom and white cardamom are the two important products obtained from fresh cardamom. The post-harvest operations involved in the value addition of cardamom are as follows:

Green cardamom

Washing and alkali treatment: The harvested capsules carry soil or dirt on their surface and hence they are washed thoroughly in water. The capsules are then treated with 2 percent sodium carbonate solution for 10 minutes which enables to retain green colour and prevent mould growth.

Drying: The colour of cardamom gets bleached away when exposed to sunlight. Therefore, conventionally green cardamom is dried in flue type kiln or electrical drier. The cleaned capsules are dried to reduce the moisture content from 80 percent to 8-12 percent.

Garbling: It is the process of removal of flower stalk from the dried cardamom. Traditionally this is achieved by rubbing the cardamom capsules against coir mat or wire mesh and winnowed to remove any foreign matter. Hand operated mechanical garbling units are available which increases garbling efficiency and reduces damage.

Grading: The partly cleaned cardamom by garbling is to be further cleaned to remove the impurities and grade them according to size.

Cleaning of cardamom by removing the discoloured ones, split capsules and other impurities is done by manual methods. Hand operated cleaner-cum-grader provided with suitable sieves can be used for better grading of cardamom.

Packing: Cardamom capsules are packed in jute bags or wooden containers suitably lined with polythene or craft paper.

White cardamom

Bleaching is the important post-harvest operation involved in the production of white cardamom.

Bleaching: Freshly harvested or dry capsules of cardamom can be used as starting material for bleaching. Sulphur bleaching of dry cardamom capsules is the widely practised method.

Turmeric

Turmeric (*Curcuma longa*) is ready for harvest in about 7-9 months depending upon the variety, when the leaves of the plant turn yellow and starts drying.

Cleaning: Harvested turmeric rhizomes are washed in water to remove mud and other extraneous matter adhering to them. Only good fingers are separated from the bulbs and used for further processing.

Boiling/curing: Turmeric rhizomes are boiled in pure water in mild steel or galvanized iron pans till the fingers become soft. Generally, it takes about 60-90 minutes which can be tested by piercing a wooden needle. The needle will pass through the fingers without much resistance. The cooked fingers are heaped on a cleaned drying floor and left undisturbed for 4-5 hours. Cooking of turmeric is to be done with in 2 or 3 days after harvest. Boiling helps to enhance the colour and the shelf life of turmeric.

Drying: The cooked fingers are dried in the sun by spreading in thin layer on a bamboo mat or clean drying floor. It takes 10 to 12 days for drying in the sun. When fully dried, the rhizomes become hard, stiff and brittle. Dried turmeric usually has moisture content of 6-8 percent. The yield of the dry product varies from10-30 percent depending on the variety and the location where the crop is grown.

Polishing: Polishing of boiled dried turmeric rhizomes is done to smoothen the rough and hard outer surface. It improves the colour and the appearance of the dried rhizomes. Hand polishing is done by rubbing the dried rhizomes against hard clean surface of the drying floor. This is followed by winnowing to separate scales and root bases. Power operated turmeric polishers provided with wooden drum is used for polishing especially when the rhizomes have to be used for powder making.

Cleaning and grading: Cleaning and grading is generally done manually.

Packing: The graded turmeric rhizomes are bulk packed separately in jute or woven polypropylene bags.

Value added products from turmeric

Turmeric powder: Dried turmeric is powdered to a fine mesh-60 (250 μ) to be used in various end products. Turmeric rhizomes contain 4-6 percent of volatile oil and there is a great chance of losing the oil when powdered. Hence it is to be properly packed immediately after powdering.

Turmeric oil: Dried rhizomes and leaves are used industrially to extract the volatile oil. Dried rhizomes contain 5-6 percent and leaves contain about 1-1.5 percent oil. It is generally extracted by steam distillation. Super critical extraction using liquid carbon dioxide is a relatively new extraction technique for extracting volatile oil and oleoresin.

Turmeric oleoresin: Turmeric rhizomes contain about 7-14 percent oleoresin. This can be extracted using organic solvents such as acetone, alcohol, ethyl acetate, etc. The major compound in the oleoresin is the colouring principle curcumin. It is used in food preparation and pharmaceutical products.

Curcumin: The major colouring principle of turmeric is curcumin. The curcumin content in turmeric varieties varies from 3-9 percent. It is a mixture of three pigments, curcumin, demethoxy curcumin and bis-demethoxy curcumin. It is preferred in the food and pharmaceutical industry as a natural colourant.

Ginger

Ginger (*Zingiber officianale*) is used both as a fresh vegetable and as a dried spice. The crop is ready for harvest in about 8 months after planting when the leaves turn yellow and start drying up gradually. The clumps are lifted carefully with spade or digging fork and the rhizomes are separated from the dried up leaves, roots and adhering soil. Harvesting is to be done from the 6th month onwards when used as green ginger. The various post-harvest operations involved in obtaining clean dried ginger are:

Washing: It is done to remove dirt, spray residues and other foreign materials. In this process ginger is soaked in still water for about six hours and then used for peeling.

Peeling: Peeling hastens the process of drying and maintains the epidermal cells of the rhizomes, which contain essential oil responsible for aroma of ginger. Indigenously, peeling is performed by rubbing the ginger pawns soaked in water for about six hours against jute bags or by scraping with sharpened bamboo splinters. The scrapped or peeled rhizomes are again washed well and put for drying on clean drying yard.

Drying: The cleaned and peeled ginger with moisture content of about 60 percent is spread thinly under sun and the moisture content is brought down to 10 to 12 percent or even less for safe storage. It takes about 10 -15 days for complete drying. The dry ginger so obtained is known as rough or unbleached ginger. The yield of dry ginger is 19-25 percent of fresh ginger depending on the variety and the location where it is grown.

Grading: The dried ginger rhizomes are manually graded based on the external appearance.

Packing : The graded ginger is bulk packed separately in jute or woven polypropylene bags.

Value added products from ginger

Ginger powder : Dried ginger is powdered to a fine mesh-60 (250 μ) to be used in various end products.

Bleached dry ginger: The peeled ginger is soaked in thick limewater for some time and it is then fumigated with sulphur fumes and sundried for a day. The process is repeated once or twice to obtain a fully bleached white produce which is thoroughly dried and stored.

Salted ginger: Fresh ginger (with relatively low fibre) harvested at 170 -180 days after planting can be used for preparing salted ginger. Tender rhizomes with portion of the pseudostem is washed thoroughly and soaked in 30 % salt solution containing 1 % citric acid. After 14 days it is ready for use and can be stored under refrigeration.

Crude fibre: In fully matured ginger crude fibre varies from 3-8 percent. It is estimated by acid and alkali digestion of ginger powder and whatever remains is considered as fibre.

Ginger oil: Dry ginger on distillation yields 1.5 to 2.5 percent volatile oil. The main constituent in the oil is zingiberene and contributes to the aroma of the oil.

Ginger oleoresin: Dry ginger powder on treating with organic solvents like acetone, alcohol, ethyl acetate, etc. yields a viscous mass that attribute the total taste and smell of the spice. The major non-volatile principle in oleoresin is gingerol. The oleoresin content varies from 4 -10 percent.

Others: Sweet and salty products can be prepared from fresh ginger like ginger candy, ginger paste, salted ginger, crystallized ginger, etc.

Chillies

Chilli (*Capsicum annum)* is the most widely cultivated crop among the spices grown in India. Chillies are harvested when the pods are well ripened and partially withered at the plant itself. At this stage they would have superior pungency and colour. Paprika is defined as a ground red powder derived from dried fruits with desirable colour and flavour qualities.

The harvested pods are kept in heaps either indoor or in shade away from direct sunlight for 2-3 days so as to develop uniform red colour. Subsequent to this the pods are dried under the sun by spreading them out on clean, dry mat, cemented or concrete surface. The harvested chillies in ripe condition have moisture content of 70-80 percent and need to be dried for 13-15 days for the reduction of moisture to a safe moisture content of 10 percent and then stored.

In mechanical drying, the chillies are dried at a drying temperature of 50°C and at air velocity of 1.5 ms^{-1}. Solar cabinet driers and waste fired driers are also developed for drying of chillies.

Packing of dry chillies is done using jute cloth, paper or paper cartons with polythene lining of 300 gauges.

Value added products from chillies

Chilly powder: Dried Chillies are ground to fine powder to be used for various preparations.

Chilly oleoresin: Extracted from dry powder using organic solvents.

Nutmeg and Mace

Nutmeg and mace are two different spices obtained from nutmeg, *Myristica fragrans*. The fruits are harvested when they split open on ripening. Cleaning and drying are the important post-harvest operations involved.

Drying: The unshelled nutmeg is dried in the shade or under sun. The seed cover is removed mechanically or manually. It is dried to a safe moisture content of 10 percent.

The detached mace is dried in sunlight or hot air oven which retains the colour of mace.

Products from nutmeg

Nutmeg powder: Dried nutmeg is ground to fine powder to be used in various end products.

Nutmeg oil: The essential oil from nutmeg is steam distilled and the oil percentage varies from 5-15 percent.

Nutmeg oleoresin: Nutmeg oleoresin is obtained by solvent extraction of spices which contain butter also. Yield may vary from 20-30%.

Nutmegs butter: The fixed oil of nutmeg is known as nutmeg butter. Nutmeg contains 25 to 40 percent fixed oil.

Mace oleoresin: When extracted with petroleum ether mace yields 27 to 32 percent oleoresin and contains 8.5 to 22 percent volatile oil.

Mace oil: It is obtained by steam distillation of dried aril and yields 4-17 percent oil. It is a clear red or amber dark red liquid with characteristic odour and flavour. Mace oil is more expensive than nutmeg oil.

Cinnamon

Cinnamon (*Cinnamomum zeylanicum*) is obtained by drying the central part of the bark after the second or third year of planting. It is harvested from the branches which have attained greenish brown colour indicative of maturity and when the bark peels of easily. The shoots are cut for bark extraction. Following are the stages in the production of quills:

Peeling: The rough outer bark is first scraped off with a special knife. Then the scraped portion is polished with a brass rod to facilitate easy peeling. A longitudinal slit is made from one end to other and the bark is peeled off.

Rolling: The barks are packed together and placed one above the other and pressed well. The bark slips are reduced to 20 cm length and are piled up in small enclosures made by sticks. Then they are covered with dry leaves or mat to preserve the moisture for the next day's operation and also to enhance slight fermentation.

Piping: Rolled slips are taken to the piping yard for piping operations. The outer skin is scraped off with a small curved knife. The scraped slips are sorted into different grades according to thickness. The graded slips are trimmed, ends are cut and pressed over pipes. Slips are rolled into pipes and soon after they are allowed to dry. During drying, smaller quills are inserted into the bigger ones, forming smooth and pale brown compound quills, which are known as pipes. The quills are arranged in parallel lines in the shade for drying, as direct exposure to the sun at this stage would result in warping. The dried quills, thus obtained, consist of a mixture of coarse and fine types and are yellowish brown in colour. The quills are bleached, if necessary, by sulphur treatment for about 8 hours.

The process of producing quills has several byproducts, which are used in further processing:

Quillings: These are broken pieces of quills used mainly for grinding but also for distillation of oil. The pieces vary considerably in size, being about 5 to 15 or 20 cm in length and about 10-25 mm in diameter.

Feathering: These are short shavings and small pieces of leftovers in the processing of the inner bark into quills. Collectively, featherings present a shade darker colour than the quills and a shade lighter than the chips.

Chips: These are small pieces of bark, grayish brown on the outer side and a lighter brown on the inside. They are deficient in both aroma and taste and are not to be compared to the quills for flavour.

Products from cinnamon

Cinnamon bark oil: It is essentially extracted by the steam distillation of cinnamon and the oil percentage varies from 0.5 to 2.5 percent. The main constituent of this oil is cinnamaldehyde upto to 65 percent.

Cinnamon oleoresin: The dry cinnamon bark powder on treating with solvents like acetone, alcohol and ethyl acetate yields a viscous mass that attributes to the total taste and aroma of cinnamon. The oleoresin content varies from 7-10 percent.

Clove

Clove is the small, reddish brown unopened flower bud of the tropical evergreen tree *Syzygium aromaticum*. Flowering begins after fifth year of planting. Harvesting is done before the flowers start opening while the tip is fully developed and round in shape. The buds are hand picked and the length varies from 13 to 19 mm. The clove is sundried and is used as such or in the powdered form.

Products from clove

Clove oil: Clove contains 14 to 20 percent essential oil, the principal component of which is the aromatic oil eugenol extracted by distillation.

Future prospects of value addition in spices

The major hindrance in value addition is the seasonal nature of the crop. Fresh black pepper and raw ginger are available only during some months in a year. This affects the marketing of the produce. There is also a great demand for diversified value added products from spices. Some of the areas which require further attention are:

Drying: The practice of drying in clean environment to the required optimum moisture content is the most important operation for all the spices. The problem of aflatoxin contamination is most commonly reported from chillies followed by nutmeg exported from India. This problem is also reported to a lesser extent in other spices. Hence, there is a need for good artificial drying system at farm level to dry the produce even during unfavourable seasons to get quality produce.

Packaging and Storage: Spices are highly hygroscopic products and hence easily gain moisture form the atmosphere. It is thus essential to pack the dried produce in suitable packaging material and store in proper leak proof structure.

J. Indian Soc. Coastal agric. Res., 24(1), 103-106, 2006 **Invited Paper**

Future Research Strategies in Horticultural and Plantation Crops in the Background of Research Achievements under NATP

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Coastal ecosystem comprising at coastal plains with rich tropical rain forests to coastal mangroves and a wide range of crops, climatic conditions, different soils and water bodies is important in terms of economics and ecology of our country. It spans over a length of 8129 sq km covering 9 States and 2 Island ecosystems. However, this system faces a host of problems ranging from water stagnation, drought, to soil salinity. Increased agricultural productivity and profitability especially in resource poor areas are crucial to achieving the national objectives for higher growth rate. Coping with the great diversity of agroecological settings and producers across the subcontinent calls for a decentralized approach. Thus, National Agricultural Technology Project having the structural and functional rearrangement to bring in the improved management and organizational changes and promote efficiency in public sector research came into operation since 1999.

The Agro Ecosystem Directorate for the coastal region under NATP facilitated the operation of the Production System Research involving 38 projects under multi-institutional and disciplinary mode. The PSR projects could generate an array of appropriate production and value addition technologies on plantation and horticultural crops creating impacts on productivity, socioeconomics and environment. Taking the experience and lessons from NATP, the focus of the second phase of NATP's Mission was "Development of sustainable farming systems for rural livelihood security and environmental integrity by efficient use of resources through development and application of new technologies including value chain and improved governance". The priority areas of this phase are also described in this paper.

(**Key words** : *Low productivity, Livelihood security, National Agricultural Technology Project, Production oriented technologies, Post-harvest technologies & value addition*)

The coastal agroecosystem is very important among the different agroecosystems of our country both economically and environmentally. It spans over a length of 8129 sq km covering 9 States and 2 Island ecosystems. Agriculture and allied activities constitute the single largest component of India's economy, contributing nearly 27% of the total Gross Domestic Product (GDP) in the year 1999-2000 (TERI. 2002). Agriculture exports accounts for 13 to 18% of total annual exports of the country (Ministry of Finance. 2002). However, given that 62% of the cropped area is still dependent on rainfall (MoEF. 2002), Indian agriculture continues to be fundamentally dependent on the weather. Coastal agricultural region comprises of hinterland, which has a varied geometric and topographical features of mountains valleys, coastal plains, riverine systems, climatic conditions, different soils and water bodies, vegetations ranging from rich tropical rain forests to coastal mangroves and a wide range of crops that are cultivated in this region. It is most diverse and highly productive zone. The vast deltaic region of the east coast forms the rice bowl of the country. Agriculture, horticulture, agroforestry and silviculture are the various activities practised in this ecosystem. The agroclimatic conditions of the coastal zones are congenial for growing various field and horticultural crops. The region occupies commendable position in the export of horticultural produce, spices and marine products. It supports the livelihood of twenty million people whose socioeconomic conditions are very much dependent on the system.

India has a vast potential for marine fisheries development. The tropical seas around India abound in rich natural fishery resources account for annual haul of 2.8 million tonnes against potential of about 3.9 million tonnes. The base of this marine fishing industry has been assiduously built-up over half a century and consists of 2 million fishermen living in 2000 fishing villages catching fish with about 180000 artisan crafts.

Problems and prospects

The coastal areas suffer both in monsoon and post-monsoon seasons. In monsoon season, excess rainwater, prolonged water stagnation, high water table, high humidity, impeded drainage and loss of nutrients are some of the common unfavorable factors. In the post-monsoon season, high salinity of soil and ground water and also scarcity of fresh water limit crop productivity. The production is further constrained by the extensive occurrence of problem soils such as saline soils, clayey soils and eroded soils, pest and disease problems, etc. Over and above this, natural calamities like cyclones, currents and tides are common features of these areas. The present productivity level of the livestock in the coastal regions is poor mainly due to poor genetic base and lack of management practices. Coastal agriculture in lowlying areas consists of primarily rice, pulses as rice fallows and sugarcane as rotational crops. Horticulture primarily consists of plantation crops like coconut, arecanut, cocoa, spices like black pepper, ginger, turmeric, clove, nutmeg, and fruit crops like mango, banana, pine apple, guava, etc. Tuber crops like tapioca, sweet potato and elephant foot yam are also grown to some extent. Appropriate crop management practices and cropping system aiming at optimum use of land and water resources will go a long way in increasing production and rural economy. The plantation crops are having greater potential for product diversification, value addition and export earning and provide raw materials for various agro-based industries. The harvesting and post-harvesting technologies of these crops would play major role in boosting this sector of enterprises. Similarly, a challenge exists in overcoming problems related to high salinity of soil and ground water. With an estimated 1.2 million ha of brackishwater area available, coastal aquaculture is emerging as a major production activity. Apart from this, ponds, lakes tanks and rivers offer scope for inland fisheries. But production from these sources is hardly 45-50% of the potential.

National agricultural technology project

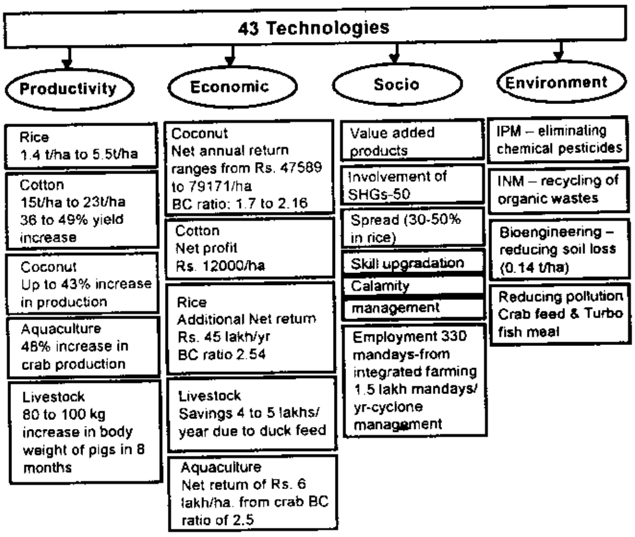
Despite the liberalization of the Indian economy, continued growth in the agricultural sector remains crucial for broader national development. Increased agricultural productivity and profitably, especially in resource poor areas, are also crucial to achieving the national objectives for rural poverty alleviation and the welfare of those living in rural areas, particularly women and other disadvantaged groups. All these needs will have to be met through intensified demands on the natural resource base.

But while the green revolution technology was the cornerstone of past success, demands for agricultural technology are now changing and diversifying. Factor productivity growth in India's green revolution areas does not match with that of some East Asian countries and may be declining; new approaches, for instance involving frontier sciences such as biotechnology as well as production systems approaches to break the yield plateau, are needed for these well endowed areas. At the same time, India must, both for economic and social reasons, invest more in technology for less well endowed areas, particularly the rainfed lands which comprise of 63 percent of its cultivated area. And in all areas, as agriculture intensifies, greater attention is needed to ensure sustainability and containment of potentially adverse impacts on the natural resource base and environments. (Kaul and Mittal, 1998).

These trends have set a new agenda for the generation, assessment and dissemination of agricultural technology. Coping with the great diversity of agro-ecological settings and producers across the subcontinent calls for a decentralized approach. It should focus on individual production systems and integrate the contributions of frontier sciences as well as conventional disciplines coupled with indigenous knowledge for augmenting productivity, stability and sustainability. In contrast to the blanket green revolution recommendations appropriate to the needs of the past, the new technologies will increasingly have to be in participatory mode not only in setting the technical agenda, but also inviting contribution of their own ideas in assessing and disseminating the results. For realization of agricultural research and developmental goals on a long term basis, it is essential to augment the productivity as well as use the natural resources more judiciously. Although the country could be broadly delineated into irrigated and rainfed ecologies for providing the required focus on the area specific developmental needs of regions bypassed by green revolution technologies, research and technology dissemination were to be supported in the following five agro-ecosystems, viz. Irrigated, Coastal, Arid, Rainfed, and Hill & mountainous.

All these call for an integrated production systemwise research management strategy, based on the technologies developed, to improve the overall productivity of the systems, thereby augmenting the quality of life of the people. For achieving this in coastal production system, NATP projects have been sanctioned in PSR mode with an overall financial outlay of 34.7 crores sanctioned under Coastal Agro-ecosystem Directorate. Thirty-nine projects have been approved under this Directorate.

IMPACTS



Future strategies in the light of NATP phase I experience

The focus of the second phase of NATP's Mission is "Development of Sustainable farming systems for rural livelihood security and environmental integrity by efficient use of resources through development and application of new technologies including value chain and improved governance" which would facilitate in:

1. Consolidating the gains of past research and strengthening infrastructure for frontier science and priority research themes. Ecoregion-specific research would be encouraged for the various agroecosystems. Support for frontline extension or TAR would encourage on-farm assessment of technologies in partnership with farmers
2. Upscaling of Technologies, research for disadvantaged groups like rural women and tribal population, and partnership with the private sector for commercialization of technologies
3. Encouraging project and need-based human capital development with greater collaboration with international research organizations
4. Strengthening social science and policy research capacity in the NARS
5. Stepping up support for biotechnology programs so that the gains reach ultimate beneficiary with due risk assessment
6. Processes, product diversification and specialized product development

To achieve the above objective, Priority Research Themes involving plantation and horticultural crops in coastal ecosystem could be:

1. Agricultural biotechnology to address the agricultural development objectives
2. High-tech and peri-urban agriculture, and precision farming
3. Post-harvest technology and value addition
4. IPM, INM, sustainable use of natural resources through resource conservation technologies, organic farming, rural energy management and management of agricultural wastes
5. Agricultural commercialization and diversification, post-harvest management of agricultural product and value addition
6. Health and nutrition of livestock and fish environment-friendly production systems
7. Farm mechanization with priorities based on views of the farming communities. For this, project funding to private sector and Indian institutes of Technology (IITS) will also be considered
8. Development of new production systems, crop and resource management practices, and pest management practices
9. Strengthening agricultural economics, rural sociology and policy research for increasing competitiveness of the agriculture, maintain technology flow, protection of intellectual property, minimize trade, market, institutional and other policy reforms, etc.
10. Database on international marketing opportunities and intelligence
11. Increasing use of information and communication technologies for human capital development through distance learning, research management, research partnership, dissemination of technologies, documentation and sharing of indigenous traditional knowledge, assessment of research needs of farmers and other clients, etc.
12. Participation of private sector in establishment of technology parks, and ensuring supply

REFERENCES

Kaul, G.L. and Mittal, J.P. (1998). In *National Agricultural Technology Project - Main Document*, ICAR, New Delhi.

Ministry of Finance. (2002). In *Economic Survey 2001-2002*, Economic Division Ministry of Finance, Government of India, New Delhi.

MoEF (2002). In *Agenda 21:An Assessment*, Ministry of Environment and Forests, Government of India, New Delhi.

TERI (2002). In *TERI Energy Data Directory and Yearbook 2001/2002,* Tata Energy Research Institute, New Delhi.

J. Indian Soc. Coastal agric. Res., 24(1), 107-113, 2006 **Invited Paper**

Enrichment of Soil Fertility Status through Biological Nitrogen Fixation with Reference to Problem Soils in Coastal Ecosystem

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The agricultural production in coastal ecosystem in the west and east coast of the country is beset with problems such as soil acidity, alkalinity, water inundation, and Al, Fe and Mn toxicity. Biological nitrogen fixation (BNF) technologies based on bioresource management are important for management of these problem soils. Efficient N_2 fixing systems with diverse group of bacteria and algae possessing various degrees of tolerance to stress conditions have been reported from problem soils. Symbiotic system formed by legume – rhizobium association not only fixes significant quantities of N_2 but also enriches soil fertility by promoting beneficial microflora, enzyme activities, mineralisation of carbon and increasing the content of major nutrients in problem soils. Coastal sand dune (CSD) legumes have been reported to be a source of efficient rhizobial strains with high degree of tolerance to environmental stress and symbiotic efficiency on cultivated edible and forage legumes. Coconut root system and rhizosphere soil in the acidic coastal ecosystem formed a favourable habitat for a number of diazotrophic bacteria with multifunctional properties. Acid tolerant and salt tolerant azospirillum strains have been isolated and their efficacy to enhance crop growth and yield under stress conditions have been demonstrated. Cyanobacterial application has been reported to be effective to bring about reduction in pH and exchangeable sodium and is recommended for reclamation of salt affected soils. Biological strategies based on BNF technologies offer an economical and ecofriendly way to manage problem soils and to support agricultural production in a sustainable way in the coastal ecosystem.

(***Key words***: *Biological nitrogen fixation, Problem soils, Soil fertility, Rhizobium, Azospirillum, Cyanobacteria*)

The agriculture in coastal ecosystem suffers from a host of problems (Yadav, 2004). The salt affected soils occupy extensive area in the east and west coast regions and include saline, sodic acid, sulphate, marshy and waterlogged lowlying areas. Soil acidity and salinity hampers crop production in the coastal ecosystem to a great extent. The soils in the west coast consists of laterites, clay loam, gravelly clay, sandy loam and coastal sand. The soils in the east coast belong to red loam, red sandy loam, sandy clay and black group. The acid sulphate soils which are highly acidic with high toxic elements occur in the lowlying areas of Kerala, Sundarbans of West Bengal, and Andaman and Nicobar Islands.

Acidic soil

Out of a total of 157 million ha of cultivable area in the country, 49 million ha are acidic in nature (Das, 1996). The area occurs in the tropical belt under humid and subhumid conditions. The problems encountered in acid soils include the acidity of the environment and the chemical changes in the soil caused by high acidity. The elemental composition of acidic soils are conspicuous with large amounts of aluminium and also iron and manganese. Decrease in the availability of phosphorus and molybdenum and lack of calcium are also encountered in acid soils. The problems in acid soil mostly result from aluminium and manganese toxicity.

Saline and sodic soils

Soils having accumulation of salts in topsoils with electrical conductivity greater than 4 dSm^{-1} is classified as saline soils. The area is found under hot and arid conditions. Sodic soils have high concentration of sodium which interfere with plant growth, but may or may not be saline. The pH of saline and sodic soils is usually above 8.5. The nutrient deficiencies encountered in such soils include reduced availability of phosphorus, iron, zinc, manganese and boron for plant growth. The problems of water availability are also common due to osmotic potential of soil.

Biological nitrogen fixation (BNF)

Nitrogen is one of the key elements limiting the growth and productivity of crops. The industrial production of nitrogenous fertilizers is by Haber-Bosch process where nitrogen and hydrogen are combined at high temperature (400 – 500°C) and pressure (200 – 1000 atm), which consumes large quantities of fossil fuels. The increasing cost and diminishing supply of fossil fuel result in the escalation of prices of nitrogen fertilizers. The concern on the use of non-renewable fossil energy sources and the detrimental effect of chemical fertilizers on soil health have been the driving force for the impetus given to biological nitrogen fixation (BNF) as an alternate source of nitrogen for sustainable crop production. On global scale, BNF provides the largest input of N to soil, which is estimated to be 175 million tonnes annually (Burns and Hardy, 1975). The industrial fixation of nitrogen is only 80 million tonnes. The research efforts over several decades revealed that there is immense scope to utilize BNF to complement and eventually substitute mineral fertilizers in agricultural production system.

BNF systems in problem soils

The process of biological nitrogen fixation offers an economically attractive and ecologically sound means of reducing external nitrogen input and improving the quality and quantity of internal resources. The strategy for improving agricultural production in problem soils should include measures to augment BNF to the benefit of crop growth and productivity. The problem soils have diverse group of beneficial diazotrophic microorganisms which form different types of associations with crop plants. The diazotrophs encountered in the problem soils are free living, associative symbiotic and obligate symbiotic types.

Legume – Rhizobium symbiosis in acid soils

The symbiotic association formed by the root nodule bacteria with legumes is the most efficient system which contributes large quantities of biologically fixed nitrogen to the crop production systems. Leguminous green manure crops have been tested for their suitability to grow in the basins of coconut palms in acidic soils. Among the nine species of green manure legumes tested, *Pueraria phaseoloides, Mimosa invisa* and *Calopogonium mucunoides* have been established well and generate green biomass to the extent of 19.43, 17.00 and 14.71 kg per basin, respectively during a growth period of 4 months during rainy season. The nitrogen contributions from these legumes are 102.61, 153.19 and 121.29 g N per basin, respectively (Thomas and Shantaram, 1984). Another trial conducted in acidic laterite soil type also revealed the suitability of the above mentioned legumes for basin management of coconut. But the biomass production was higher with a contribution of 28.45, 24.97 and 27.21 kg per basin by *P. phaseoloides, M. invisa* and *C. mucunoides*, respectively (Thomas and Shantaram, 1993). Later studies by Maheswarappa *et al.* (2003) revealed the suitability of cowpea (*Vigna unguiculata*) to generate large quantity of organic manure in the coconut basins.

Growing of the legume, *Glyricidia sepium* as alley crop in coconut garden was found to be advantageous to generate large quantities of green manure for application to coconut. Three rows of *Glyricidia* in between two rows of coconut palms with three prunings per year (February, June and October) resulted in higher biomass yield of 7970 kg ha^{-1} (Subramaniam *et al.*, 2000).

Coastal sand dune legume – rhizobium association

Coastal sand dunes are subjected to a variety of environmental perturbations such as salt spray high temperature, alkaline pH values, low level of nutrients, sand erosion and sand accretion. Several legume species were found to enrich the dune in the west coast of India through biological nitrogen fixation and these legumes were found to be tolerant to adverse soil and environmental conditions such as high temperature, high salinity and alkaline pH (Sridhar *et al.*, 2005). The most common dune wild legumes were *Canavalia callthartica* Thouars, *Canavalia maritima* Thouars, *Crotalaria retusa* L., *Crotalaria verrucosa* L. and *Derris triflorum* D.C. These legumes were functionally diverse and versatile in nutrient resource utilization. They exhibited stress tolerance (eg temperature, salinity, pH), wide sole – carbon-source utilization pattern, phosphate solublisation, nodulation and nitrogen fixation. These rhizobial isolates showed higher level of symbiotic efficiency in cultivated legumes such as cowpea (*Vigna unguiculata*), green gram (*Vigna radiata*), black gram (*Vigna mungo*) and horse gram (*Macrotyloma uniflorum*) (Arun and Sridhar, 2004). The CSD legumes were thus found to be source of efficient rhizobial strains with high degree of tolerance to environmental stresses and symbiotic efficiency on cultivated edible and forage legumes.

***Azolla – Anabaena azollae* symbiotic system**

Atmospheric nitrogen fixed by *azolla*, a free floating water fern in association with cyanobiont, *anabaena azollae*, is a potential source of organic nitrogen in rice cultivation under lowland conditions. The *azolla – anabaena* symbiotic system has been reported to contribute 15-25 tonnes of biomass from an initial inoculum of 200 kg ha^{-1} in a short duration of 20-30 days (Kannaiyan, 1993). The contribution of nitrogen has been estimated to be 40-60 kg per ha, besides the addition of organic manure, and 8.9 to 26.6% increase in grain yield of rice, as revealed in a study in farmers holding in rice growing areas of Tamil Nadu (Kannaiyan *et al.*, 2001).

Associative symbiotic\asymbiotic systems

Coconut roots and soils under the coastal agroecosystem were found to be an ideal habitat for a range of diazotrophic bacteria with multifunctional properties. Recent studies using semi-solid media revealed the occurrence of diazotrophs, such as *Azospirillum lipoferum*, *Azospirillum brasilense*, *Azospirillum amazonence*, *Herbaspirillum frisingense*, *Burkholderia* sp., *Azoarcus* sp., *Arthrobacter* sp., *Bacillus* sp., *Pseudomonas* sp., and *Xanthobacter* sp. (Prabhu and Thomas, 1998, Thomas and Prabhu, 2003). Acidophilic *Beijerinckia* spp. was found to be the most conspicuous aerobic nitrogen fixer in coconut soils. Two subspecies were consistently isolated, viz. *B. indica* subspecies *indica* and *Beijerinckia indica* subsp. *lacticogenes*. The occurrence of *Beijerinckia* in higher numbers in coconut rhizosphere and rhizoplane indicated close association of these bacteria with the palm. They were multifunctional with the properties of nitrogen fixation, production of copious amounts of gummy polysaccharides and plant growth promotion properties as evidenced by plant bioassay tests. Wide range of acetylene reduction activity from 4.47 to 590.38 nM C_2H_4 per 3 ml medium per hour has been reported for *Beijerinckia* isolated from coconut root region. Plant beneficial endophytes belonging to the genus *Bacillus* were found to be the main component of the bacterial population in the root as well as leaf tissues of coconut (Prabhu *et al.*, 2000). A wide range of component crops in the coconut based cropping and farming system including spices, fruit crops, fodder grass also harboured *Azospirillum* in different levels (Ghai and Thomas, 1989). The component crops like *Panicum maximum* significantly augmented the root associated diazotrophic bacteria in coconut palm. Inoculation studies with these diazotrophs on polybag raised coconut seedlings indicated the utility of these bacteria to enhance the vigour of coconut seedlings.

Cyanobacteria in acidic soils

Acid soils is not a preferred habitat for cyanobacteria. However, there are several reports on the occurrence of acid tolerant populations of blue green algae under acidic soil conditions. Moore (1963) reported the occurrence of non-symbiotic nitrogen fixing cyanobacteria from acidic soils. Aiyer (1963) isolated several acid tolerant species of cyanobacteria from highly acidic, *Kari* soils of Kerala having a pH of 3.8. Madhusoodanan and Dominic (1996) reported the occurrence of 26 species of Cyanobacteria in extremely acidic environments (below pH 5) of Kerala State, including 11 species within a range of pH 3.6 – 4. These strains fixed N_2 in acidic pH and showed high degree of tolerance to acidity. Tamilselvam (1998) isolated several efficient cyanobacterial cultures from acid soils of Tamil Nadu. The acid tolerant strains belonged to *Anabaena* 25%, *Westiellopsis* - 17.5%, *Nostoc* - 15.0%, *Oscillatoria* and *Phormidium* - 25%. Inoculation of composite cultures of cyanobacteria resulted in higher growth and yield of rice plants.

Enrichment of soil fertility status through BNF

Application of symbiotic systems

Application of biomass of *P. phaseoloides*, *M. invisa* and *C. mucumoides* in coconut basins resulted in proliferation of beneficial microbes including total microflora and function specific microorganisms such as asymbiotic N_2 fixers and phosphate solubilisers (Thomas and Shantaram, 1987). Significant increase in the activities of dehydrogenase, phosphatase and urease enzymes was also recorded in response to incorporation of the legumes in coconut basins. Legume biomass addition also resulted in increase in the concentration of major plant nutrients, viz. N, P and K in basin soils (Thomas and Shantaram, 1993). Improvement in soil fertility status was also evident from the increased mineralisation of carbon legumes biomass incorporated coconut basins when compared with the control. The application of green manure legume biomass in acidic sandy soils was also effective to enhance intensity of mycorrhizal infection in coconut roots and the number of extramatrical spores of arbuscular mycorrhizae in basin soils (Thomas, 1987). Arbuscular mycorrhizae are known to enhance plant growth by increasing the uptake of phosphorus and other immobile nutrient elements from a large area of soil. Substitution of 50% of fertilizer nitrogen with nitrogen contributed by legume - *rhizobium* system was achieved in coconut (Thomas *et al.*, 2001). Improvement in soil fertility parameters, as evidenced by the increased nutrient levels and soil microbial biomass content, also contributed to the increased yield of coconut palms under the green manure legume - *rhizobium* treatment.

Mucuna bracteata has gained importance as a cover crop in rubber (*Hevea brasilensis*) plantations. The poor nodulation of *Mucuna* in the rubber growing soils is due to the absence of an optimum population of *Bradyrhizobium,* the cowpea group root nodulating bacterium. Seed bacterization of *M. bracteata* with an effective local isolate of *Bradyrhizobium* resulted in increased plant growth and biomass production, reduction in weed population and increased soil microbial population. Improvement in total organic carbon, nitrogen, available phosphorus and potassium in the soil was also ovserved consequent to inoculation (Jacob *et al.*, 2003).

Ecologically adapted native strains of cowpea rhizobia developed from acid soils of Kerala performed well and significantly increased the yield of cowpea grown in acid soil (Sivaprasad and Shetty, 1980, Nair and Sivaprasad, 1982).

Sowing leguminous crops simultaneously with oil palm was potentially cheaper way of boosting nitrogen levels in the palm fronds, growth and yield of fresh fruit bunches (ffb) (Broughton, 1976). Nutrient cycling studies within the developing oil palm - legume ecosystem revealed that legumes (*Centrosema pubesens* and *Pueraria phaseoloides*) contributed about 150 kg nitrogen ha^{-1} $year^{-1}$ to the system through nitrogen fixation and leguminous covers reduced leaching losses by 63 kg nitrogen ha^{-1} $year^{-1}$ (Agamuthu and Broughton, 1985).

Application of stress tolerant *azospirillum* strains

Diversity analysis of *azospirillum* spp. isolated from rice cultivated in the coastline of Tamil Nadu using PCR - RFLP of 16S rDNA revealed the occurrence of *A. brasilense* and *A. lipoferum* strains with salt tolerance and nitrogen fixation (Saleena *et al.*, 2002). They advocated that soil salinity should be taken into consideration while developing biofertilizers specifically for the coastal agricultural ecosystem. Jena and Rao (1988) reported that soil amelioration with leaching and organic matter addition improved microbial population and N_2 fixation in salt affected rice soils. Flooded soils amended with rice straw showed higher N_2 fixing activity than non-flooded soils at all salinity levels.

Acid tolerant *Azospirillum brasilense* strains isolated from the roots of finger millet plants grown in acid soils of Bihar exhibited nitrogen fixation ability in liquid medium containing different concentrations of $Alcl_3$ (0- 20 mM Al) and $Mncl_2$ (0-5 mM Mn) at different pH levels (Rai,1991). Inoculation trials with *A. lipoferum* and *Flavobacterium* sp. with barley seedlings in acid soil (pH 4.3 – 5.0) revealed that the inoculation conferred resistance to the seedlings to the stresses induced by high acidity and aluminium ions (Belimov *et al.*, 1998). The effect of inoculation was manifested as the stimulation of root growth and a decrease in the content of free proline in roots.

Growth promotion and yield increase along with saving in nitrogen fertilizer application can be achieved in a spectrum of crops including rice, vegetables and plantation crops grown in acid soils of Kerala by inoculation with acid tolerant native strains of *azospirillum* (Sivaprasad *et al.*, 2003).

Kuttanad is one of the major rice growing tracts of Kerala State. The acid sulphate soil in the region is unique in characteristics with high organic matter content (9-12%) and acidity (pH 3.5-6.0) and prone to seawater inundation, as it is lying below sea level. Isolation and characterisation of associative *diazotrophs* from rice plants revealed the occurrence of *A. lipoferum* (40%) and *A. brasilense* (60%), with capabilities to withstand the extreme soil conditions (Sivaprasad *et al.*, 2003). Some isolates grew upto pH 4.0 and at $NaCl_2$ concentrations upto 4%. N_2 fixation and IAA production *in vitro* ranged from 11 to 21 mg g^{-1} malate and 30 to 55 mg l^{-1}, respectively. *Azospirillum* inoculation significantly increased grain yield of rice in green house, experimental fields and farmers' fields and resulted in saving of 25% N. This showed that there is considerable scope for utilizing *azospirillum* technology for rice production in acid sulphate soils of Kuttanad.

Cyanobacteria for reclamation of salt affected soils

Blue green algae are relatively salt tolerant and exhibited different levels of tolerance to salt or osmotic stress. Unicellular diazotrophic strains exhibit greater level of salt tolerance (Thomas and Apte, 1984). Saxena and Kaushik (1991) reported that BGA withstand salt stress through osmotic adjustment or by creation of excess polysaccharides. A two-fold strategy for adaptation of cyanobacteria to salt stress has been reported which includes maintenance of low internal contents of inorganic ions by active transport mechanism and synthesis and accumulation of osmoprotective compounds corresponding to the osmotic potential of the surrounding medium (Reed and Stewart, 1988). Cyanobacteria contribute significant quantities of N in the rice fields. The effectiveness of adding BGA under field conditions has been reported to be equivalent to the use of 60 – 72 kg ha^{-1} of (NH_4) SO_4 (Subramanyan *et al.*, 1965). There have been several reports on the use of BGA in reclamation of alkali soils. The potential of some species of BGA to grow and colonise on salt affected soils were reported. During the rainy season, when the soil is moist, *Microcoleus clothonoplaste* first appears in space patches over the moist efflorescence of sodium salts. *Microcoleus vaginatus, Scytonena cellatum, S. javanicum, S. holmanni, Porphyrosiphon notarisi, Nostoc muscorum, N. linckia, N. commune, Anabaena ambigu, Aulosira fertilissima* are cyanobacteria commonly found in salt affected soil (Kannaiyan, 1990). The major effects of algalisation of alkali soils have been the decrease in pH and exchangeable sodium. Kaushik and Subhashini (1985) reported remarkable reduction in exchangeable sodium from 53.2 to 39.4% and it was found to be equivalent to the application of 2.5 t gypsum ha^{-1}. The mechanism by which the reduction in exchangeable sodium is brought about includes its utilization for algal metabolism, entrapment in biopolymers produced by algae, production of organic acids capable of solubilising $CaCO_3$ nodules (Roychoudhury *et al.*, 1985, Kaushik, 1989, Kannaiyan, 1990). Alagalisation also may result in increased soil organic carbon content, improvement in soil aggregation and water permeability.

CONCLUSION

Effective utilization of BNF technology in problem soils will not only provide economic benefits but also would improve and maintain soil fertility and sustainability in agricultural production. The strength of research activities in these specific areas of problem soils and the technologies developed should be effectively disseminated to the farming community to achieve adoption and large scale use of BNF technology to improve crop production in coastal ecosystem. BNF can become a major bioresource for organic and sustainable farming systems in coastal agriculture.

REFERENCES

Agamuthu, P. and Broughton, W.J. (1985). Nutrient cycling within the developing oil palm-legume ecosystem. *Agricultural Ecosystems & Environment* **13**: 111-123.

Aiyer, R.S. (1963). Comparative algological studies in rice fields of Kerala State. *Agricultural Research Journal of Kerala* **3**(1): 100–104.

Arun, A.B. and Sridhar, K.R. (2004). Symbiotic performance of fast growing rhizobial isolated from the coastal and dune legumes of west coast of India. *Biology & Fertility of Soils* **40**: 435–439.

Belimov, A.A., Kunakova, A.M. and Gruzadeva, C.V. (1998). Influence of soil pH on the interactions of associative bacteria with barley. *Microbiology* **67**(4): 463–469.

Broughton, W.J. (1976). Effect of various covers on the performance of *Elaeis guineneensis* (Jack) on different soils. In Conference *International Oil Palm Development*, D.A. Earp & W. Newall (eds.), pp. 501-525, held at Kuala Lampur.

Burns, R.C. and Hardy, R.W.F. (1975). *Nitrogen Fixation in Bacteria and Higher Plants*. Springer Verlag, New York. 189p.

Das, D.K. (1996). Soil acidity. In *Introductory Soil Science*. Kalyani Publishers, Ludhiana.

Ghai, S.K. and George Thomas, V. (1989). Occurrence of *Azospirillum* spp. in coconut based farming systems. *Plant and Soil* **114**: 235-241.

Jacob Mathew, Joseph Kochuthresiamma, Lakshmanan Radha, Jose Geetha, Kothandaraman, R. and Jacob Kuruvilla (2003). Effect of *Bradyrhizobium* inoculation on *Mucuna bracteata* and its impact on the properties of soil under *Hevea*. In Proceedings *6th International PGPR Workshop*, pp. 29-33, held at Indian Institute of Spices Research, Calicut, 5–10 Oct 2003.

Jena, P.K. and Rao, V.R. (1988). Influence of salinity, rice straw and water regime on nitrogen fixation in paddy soils. *Jourtnal of Agricultural Sciences* **11**(1): 121- 125.

Kannaiyan, S. (1990). Blue green algal biofertilizers. In *Biotechnology of Biofertilizers for Rice Crop*, Tamil Nadu Agricultural University, Coimbatore.

Kannaiyan, S. (1993). Nitrogen contribution by *Azolla* to rice crop. *Proceedings Indian Academy Sciences B* **59**(3&4): 309–314.

Kannaiyan, S., Kumar, K., Thangaraju, M. and Govindarajan, K. (2001). *Microbial Inoculant Production in Developing Countries–Success, Problems and Potentials*, TNAU, Coimbatore.

Kaushik, B.K. and Subhashini, D. (1985). Amelioration of salt affected soils with blue green algae 1. Improvement in soil properties. *Proceedings Indian National Academy* **51**: 380–389.

Kaushik, B.D. (1989). Reclamation potential of cyanobacteria in salt affected soils. *Phykos* **28**: 101–109.

Madhusoodanan, P.V. and Dominic, T.K. (1996). Isolation and characterisation of acid tolerant cyanobacteria from the low land paddy fields of Kerala, India. *Flora and Fauna* **2**(2): 113–118.

Maheswarappa, H.P., Anitha Kumari, P., Kamalakshyamma, P.G. and Shanavas, M. (2003). Cowpea (*Vigna unguiculata*) as low cost input green manure crop for basin management under root (wilt) garden. *Indian Coconut Journal* **34**(5): 11- 13.

Moore, A.W. (1963). Occurrence of non-symbiotic nitrogen fixing micro-organisms in acid soils. *Plant and Soil* **19**: 385–195.

Nair, S.K. and Sivaprasad, P. (1982). A preliminary study of nodulation on cowpea in acid soil. *Agricultural Research Journal of Kerala* **20**: 98–99.

Prabhu, S.R. and Thomas George, V. (1998). Occurrence of *Azospirillum amazonense* in the root environment of coconut palm. In Proceedings 39th Annual Conference *Association of Microbiologists of India*, held at College of Fisheries, Mangalore, 5-6 Dec, 1998.

Prabhu, S.R., Thomas George, V., Nierzwicki-Bauer, S.A. and Prasad, T.G. (2000). GA like substances producing endophytic gram positive bacteria associated with coconut palm. In Proceedings *National Seminar on Recent Advances in Plant Biology*, pp. 141-142, held at Society for Plant Physiology Biochemistry & CPCRI, Kasaragod, 3-5 Feb.

Rai, R. (1991). Isolation, characterisation and associative nitrogen fixation of acid tolerant *Azospirillum brasilense* strains associated with *Eleusine coracana* in low pH–Al rich acid soils. In *Plant–Soil–Interactions at low pH*, pp. 663-671. Kluwer Academic Publishers, Netherlands.

Reed, R.H. and Stewart, W.D.P. (1988). Physiological response of *Rivularia atra* to salinity: Osmotic adjustment in hyposaline media. *New Phytology* **95**: 595-603.

Roychoudhury, P., Kaushik, B. D. and Venkatramanan, G.S. (1985). Response of *Tolypothrix ceylonica* to sodium stress. *Current Science* **54**: 1181–1183.

Saleena, L.M., Rangarajan, S. and Nair, S.(2002). Diversity of *Azospirillum* strains isolated from rice plants grown in saline and nonsaline sites of coastal agricultural ecocystem. *Microbial Ecology* **44**: 271–277.

Saxena, S. and Kausik, B.K. (1991). Polysaccharides (biopolymers) from halotolerant cyanobacteria. *Indian Journalof Experimental Biology* **30**: 433–434.

Sivaprasad, P. and Shetty, K.S. (1980). Response of cowpea to *Rhizobium* seed inoculation. *Agricultural Research Journal of Kerala* **18**: 204–207.

Sivaprasad, P., Saskiumar, S., Joseph, P.J., Meenakumari, K.S. and Shahul Hameed (2003). Characterization and efficiency testing of *Azospirillum* isolates from acid sulphate soils. In Proceedings 6th International Workshop *Plant Growth Promoting Rhizobacteria*, held at Calicut, 5-10 Oct 2003.

Sridhar, K.R., Arun, A.B., Narula, N., Anette, D. and Merbach, W. (2005). Patterns of sole-carbon-source utilization by fast-growing coastal sand dune Rhizobia of the Southwest Coast of India. *Engineering in Life Sciences* **5**(5): 1-5.

Subramaniam, P., Biddappa, C.C., Maheswarappa, H.P., Dhanapal, R. and Palaniswami, C. (2000). Growing Glyricidia as a green manure crop in coconut garden. *Journal of Plantation Crops* **28**: 212–217.

Subramanyan, R., Relwani, L.L. and Manna, G.B. (1965). Fertility build of rice field soils by blue green algae. *Proceedings of Indian Academy of Sciences* **64** B: 262 –277.

Tamilselvam, B. (1998). Selection of fast growing and higher nitrogen fixing acid tolerant cyanobacterial culture and their utility as biofertilizer for rice. In *M.Sc.(Ag) Thesis*, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.

Thomas, J. and Apte, S.K. (1984). Sodium requirement and metabolism in nitrogen fixing cyanobacteria. *Journal of Biosciences* **6**: 771–394.

Thomas George, V. and Shantaram, M.V. (1984). *In situ* cultivation and incorporation of green manure legumes in coconut basins; an approach to improve soil fertility and microbial activity. *Plant and Soil* ***80***: 373-380.

Thomas George, V. (1987). Microbial population, enzyme activities and VA-mycorrhiza in the root region of coconut in relation to *in situ* green manuring. *Proceedings PLACROSYM-VI*: 267-274.

Thomas George, V. and Shantaram, M.V. (1987). Isolation and testing of symbiotic effectiveness of *rhizobia* for *Calopogonium mucunoides* and *Pueraria phaseoloides*. *Mysore Journal of Agricultural Sciences* **21**: 450-454.

Thomas George, V. and Shantaram, M.V. (1993). Biomass production and nodulation of green manure legumes in coconut basins in laterite soil and their influence on soil fertility. *CORD* (Jakartha) **IX**: 38-47.

Thomas George, V., Biddappa, C.C. and Prabhu, S.R. (2001). Evaluation of N_2 fixing cover legumes as green manures for nitrogen substitution in coconut palm. *Tropical Agriculture,* **78**(1): 13-18.

Thomas George, V. and Prabhu, S.R. (2003). Association of diazotrophic and plant growth promoting rhizobacteria with coconut palm (*Cocos nucifera* I.). In Proceedings *6th International PGPR Workshop,* M.S. Reddy, M. Anandaraj, S.J. Eapen, S.R. Sarma & J.W. Kloepper (eds.), pp. 20-25, held at Indian Institute of Spices Research, Calicut, 5-10 Oct., 2003.

Yadav., J.S.P. (2004). Coastal agricultural research–present status and future perspective with special reference to value addition. *Journal of Indian Socety of Coastal Agricultural Research* **22**(1&2): 1–8.

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Invited Paper

Problems and Prospects of Oilseed Production in Coastal Ecosystem

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The coastal ecosystem in India occupies 19.6 million ha covering eastern plain extending from Cauvery delta to Gangetic delta, Western Ghats, and coastal plains extending from Gujarat to Kerala. The annual rainfall ranges from 1000 to 4000 mm. With soil range of lateritic to alluvium, the growing period of crops ranges from 150-210 days. The soils have acidity, salinity or sodicity problems at different locations that limit crop productivity. Groundnut is the predominant oilseed crop in the ecosystem as second crop after rice. Rapeseeed-mustard, sesame, niger and sunflower have limited niches. Under the limitation of irrigation water for second crop of rice, oilseed crops are efficient and profitable alternatives. Selection of suitable varieties of oilseed crops with tolerance to salinity or alkalinity and pest endemics is critical for successful oilseed cultivation, and a list of suitable oilseed varieties for each state has been suggested. Maintaining optimum tilth alter *kharif* puddled paddy, maintaining optimum plant population, adequate and balanced nutrition with proper liming or other ameliorating agents, application of secondary and micronutrients are the keys for sustainable oilseed cultivation in coastal ecosystem.

(**Key words** : *Eastern & Western coastal plains, Agroecosystem characteristics, Cropping systems, Soil fertility related constraints, Oilseed varieties*)

The coastal ecosystem covers eastern plain extending from Cauvery delta to Gangetic delta and Western Ghats and coastal plains extending from Gujarat to Kerala. The ecosystem occupies an area of 19.6 million hectares representing 6% of the total geographical area of the country.

The ecosystem climate is characterized by tropical or tropical like conditions with hot summers and very mild to mild winters. The annual rainfall ranges from 1000 to1600 mm in eastern coastal plains to 2000-4000 mm in Western Ghats and plains. The annual potential evapotranspirative demand varies from 1500 to 2000 mm. Due to seasonal distribution of rains, the area experiences water stress during summer months from February to April-May. There are lateritic and alluvium derived soils in the ecosystem. The ecosystem has long growing period ranging from 150 to more than 210 days in a year. The ecosystem is divided into two distinct agro-ecoregions, namely Eastern coastal plain, i.e. hot subhumid to semihumid region, and Western Ghats and coastal plain, i.e. hot humid perhumid ecoregion.

Eastern coastal plain, hot subhumid to semihumid ecoregion

This region covers the eastern coastal plain extending from Cauvery delta to Gangetic delta covering Tamil Nadu, Andhra Pradesh, Orissa and West Bengal States. The region occupies an area of 8.5 million hectares representing 2.6% of the total geographical area of the country. This region experiences wide range of climatic conditions. The coastal parts between Kanyakumari and south of Thanjavur (Tamil Nadu) and between north Chennai and West Godavari (Andhra Pradesh) receive a mean annual rainfall of 900 to 1100 mm of which about 80% is received as winter monsoon (October-December). The potential evapotranspiration in this area varies between 1700 and 1800 mm resulting in annual water deficit of 800 to 1000 mm. This area represents semiarid climatic conditions. The remaining part of eastern coast, that lies between Nagapattinam and Chennai (Tamil Nadu) and extending to north-western part of coastal strip, including parts in northeastern Godavari (Andhra Pradesh), Orissa and West Bengal, receives a mean annual rainfall of 1200 to 1600 mm, of which 80% is received as summer monsoon (June to September). The potential evapotranspiration varies between 1400 and 1700 mm resulting in an annual water deficit of 600 to 800 mm. The length of growing period as such is much higher than the southern parts and varies from 150 to 210 days or more in a year. The area represents a subhumid (moist) climatic type. The soil temperature regime in the region is isohyperthemic. Hence, the bioclimatic variations in the ecosystem extend from semiarid to subhumid, and length of growing period ranges from 90 to 210 days or more in a year.

The dominant soil scapes representing the area are level to very gently sloping Haplaquents, Ustifluvent, Pellusterts and Ustropepts. The soils of Motto and Kalathur series typfying the Haplaquepts and Pellusterts are slightly to strongly sodic. Both are clayey in soil texture but have marked differences in their cation exchange capacity, suggesting differences in clay mineral composition of these soils. The Kalathur soils have high swell-shrink potential.

In parts of West Bengal, coastal saline soils are found and the region receives more than1500 mm of annual rainfall. In Orissa, coastal alluvial soils are found with an annual rainfall of 1440 mm. In coastal Andhra Pradesh, alluvial and black soils are noticed and the region receives 800 to 1000 mm rainfall. In parts of coastal Tamil Nadu, the average rainfall is 1136 mm, and alluvial and red soils are noticed.

Irrigation facilities are well developed in coastal regions of Andhra Pradesh and Tamil Nadu. About 35% of the cultivated area in the region is irrigated.

Crops and cropping systems

Rice is the most predominant crop in coastal region followed by groundnut. Other cereals, like pearlmillet, maize, sorghum and wheat occupy little area. Cash crops, like sugarcane, cotton and tobacco occupy sizeable areas. Pigeonpea is the most important pulse crop of the region. Under irrigation, rice-rice, rice-groundnut and jute-rice are the most important crop sequences in this region.

Under rainfed conditions, rice-fallow/lathyrus/lentil/barley/mustard/mungbean, sesamum/rice are common sequences in West Bengal. In parts of Orissa, rice-fallow/pulses/mustard/sesamum, finger millet-mustard/pulses, maize/sorghum-horsegram in uplands, rice-fallow/mungbean/fingermillet-mustard/sesamum, maize-potatos in midlands, and rice-fallow/pulses, jute-fallow/pulses in lowlands are normally followed. In Andhra Pradesh, rice-pulses/fallow/sesamum, sorghum/fingermillet/pearlmillet horsegram/fallow, *kharif* pulses/groundnut/sesamum-fallow are common sequences. In Tamil Nadu, rice fallow/pulses/sesamum, groundnut/pigeonpea/sorghum/pearlmillet/sorghum/finger millet-fallow systems are generally followed.

Cropping systems involving oilseeds

Based on the studies carried out by different organisations, some of the crop sequences involving oilseeds recommended in different parts of the region are indicated below:

West Bengal	
Medium and low lands	Rice-sunflower Pre *kharif* jute-rice-mustard Rice-rice-mustard Vegetables-rice-mustard
Low lands	Rice-rice-mustard Jute-rice-mustard Rice-sesame-mustard Sesame-vegetables Sesame-mustard
Orissa	
Uplands and Midlands (Rainfed)	Rice-groundnut Rice-safflower Rice/potato-sesame Groundnut-maize
Uplands (Irrigated)	Maize-groundnut-vegetables Fingermillet-maize-groundnut
Midlands (Rainfed and Irrigated)	Fingermillet-mustard Jute-mustard Rice-castor Rice-mustard Rice-sesame
Mid and Lowlands (Irrigated)	Rice-potato-sesame Jute-rice-groundnut Rice-groundnut-fingermillet Rice-mustard-rice
Andhra Pradesh	
Rainfed	Rice-groundnut Groundnut-groundnut Mungbean-groundnut Urdbean-groundnut Groundnut-Urdbean Groundnut-Mungbean Castor
Irrigated	Rice-groundnut Rice-rice-sesame
Tamil Nadu	
Rainfed	Groundnut-fallow Fallow-groundnut Sesame-fallow Fallow-groundnut
Irrigated	Fingermillet-rice-groundnut Soybean-rice-groundnut Groundnut-rice-maize Rice-rice-groundnut Urdbean-rice-sesame Rice-rice-sesame Fingermillet-rice-soybean

In addition, wherever groundnut is grown during *kharif*, intercrop of pigeonpea can be introduced.

Soil fertility management

Most of the coastal saline soils are deficient in nitrogen. Besides lesser utilization of nitrogenous fertilizer, especially in coastal areas, slow rate of mineralization of soil organic nitrogen may lead to inadequate release of native soil nitrogen to the plant available form in the salt affected soils primarily due to decrease in the population and activity of microbes with increase in soil salinity. The level of phosphorus in the coastal saline soils is highly variable, and depends largely on the nature and degree of salinity. Very little work has been done on the transformation and availability of P to crops in coastal saline soils. The availability of potassium depends largely on the parent material, clay minerals and weathering conditions. It also depends on the nature and amount of salts in the soil. Most of the east coast saline soils are rich in both available and non-available forms of K and there might not be any depletion of available K content of soil even after repeated crop cultivation without K fertilizer. Available S content in this region varied from 4.5 to 27.0 mg kg^{-1} with a mean value of 13.9 mg kg^{-1}. Coastal saline soils of West Bengal contain high Mg and the soils become hard and dry and get deflocculated when wet, leading to impeded drainage. Work done so far on the role of micronutrients in coastal saline soils is scanty. The soils are generally rich in micronutrients, such as Fe, Mn, Zn, Cu, B and Mo. Distribution of available Cu, Fe, Mn, B and Zn content in coastal soils vary from 0.2-25.6, 4.8-369.0, 2.5-335.0, 002-1.02 and 0.1-19.7 mg kg^{-1}, respectively.

However, there are other location specific problems, *viz.* Fe toxicity in the soils of Orissa. Thus, a large number of soil problems associated with deficiency and toxicity of several nutrients, besides the problem of waterlogging, are met with in eastern coastal area, and accordingly the management technologies especially for oilseed crops should be location specific.

Western *ghats* and coastal plain, hot humid perhumid ecoregion

This agro-ecoregion constitutes Sahyadris and Western coastal plains of Maharashtra, Karnataka, Goa and Kerala States including Nilgiri hills of Tamil Nadu. South Gujarat coastal region is also included. The region occupies an area of 11.1 million hectare representing 3.4% of the total geographical area of the country.

The climate of the region is typified by tropical like conditions with hot and humid summers and warm winters. The mean annual temperature varies between 25 and 28 °C. The mean annual rainfall exceeds 2000 mm in most of the areas. Though rainfall covers the potential evapotranspirative demand of 1400 to 1600 mm, calculated on annual basis, the water balance shows a deficit of 300 to 400 mm of water per annum owing to seasonal dry spells occurring especially during February to April. The region is represented by a long growing period ranging between 150 and 170 days in a year. At places it exceeds 210 days in a year. The area experiences udic soil moisture and isohyperthermic soil temperature regime. The major soils of the region include red and lateritic soils of the Sahyadris and the alluvium derived soils of the coastal plains. These soils qualify for Dystropepts, Eutropepts, Hapludulfs, Haplaquepts and localised Haplorthex. The soils of Trivandrum and Kunnamangalan series, typifying Dystropepts and Haplorthox, respectively are very deep, clayey, strongly to moderately acidic in nature and are poor in base saturation. Because of the dominance of kaolinite clay mineral, they are low in retentive capacity suggesting poor inherent fertility.

In Surat and Valsad districts of South Gujarat coming under this region, medium to deep heavy black, coastal alluvium and lateritic soils are found. The annual rainfall ranges from 1000 to 1500 mm. In coastal Maharashtra and Goa, both lateritic and red soils are found. The rainfall ranges from 2000 to 2500 mm. In Karnataka, alluvial, laterite and lateritic soils are found in coastal and *ghat* region. The annual rainfall ranges from 1500 to 6350 mm in various parts. In Kerala, forest and hill soils on uplands, laterite and lateritic soils in midland and alluvial soils in lowlands are present. The annual rainfall is around 2400 mm.

About 15% of the cultivated area in the region is irrigated by different sources.

Crops and cropping systems

Plantation crops occupy large area in this region. Among arable crops, rice is the most important one. Other crops like sorghum, groundnut, wheat, chickpea, pigeonpea, sugarcane and cotton occupy small area. Under irrigated conditions, rice-rice, rice-groundnut, rice-sorghum are important crop sequences. In rainfed conditions, rice-fallow/pulses, fallow-sorghum, cotton-fallow, fingermillet-pigeonpea in Gujarat, rice-pulses/fallow, maize/groundnut-fallow in Maharashtra and Goa, rice-fallow/pulses/groundnut in Karnataka, rice/pulses/cassava, sesame/fallow in Kerala are predominant crop sequences.

Cropping systems involving oilseeds

The heavy rainfall during *kharif* season makes it difficult to introduce oilseed crops except niger on hill tops. The recommended cropping systems involving oilseeds in different parts of the region are indicated below:

Gujarat	Rice-groundnut Rice-safflower
Maharashtra	Rice-groundnut Sesame-*rabi* pulses (uplands, rainfed) Niger-*rabi* pulses
Karnataka	Rice-rice-groundnut Rice-groundnut (rainfed)
Kerala	Rice-sesame Rice-rice-groundnut Rice-rice-sesame

Soil fertility management

Impeded drainage, inundation and ingress of seawater have led to the development of salinity and alkaline conditions rendering vast tracts of *Khar*, *Pokhali* and *Kole* land unsuitable for cultivation.

Certain location specific problems are also encountered in the coastal soils, *viz.* Fe toxicity in highly permeable sandy soils in parts of Gujarat, and highly leached low fertility lateritic soils in Maharashtra, Karnataka and Kerala. Soils of this coast are characterized by high organic carbon, low to medium P, and low K status. Secondary nutrients like S, Ca and Mg, and among the micronutrients, Zn are the major limiting factors for crop productivity. Available S content in west coast varied from 1.0 to 100.0 mg kg^{-1} with a mean content of 23.1 mg kg^{-1}. Available Zn, Fe, Mn, Cu, B and Mo contents in the coastal region of Maharashtra varied from 0.02 to 16.50, traces to 122.0, 0.04 to 198.3, 0.26 to 24.58, 0.10 to 4.20 and 0.025 to 2.90 mg kg^{-1}, respectively. Crop failures due to acidification and salinization are common in the acid sulphate and tidal marshy areas of Kerala. Fe and Al toxicities are also observed in the acid laterite and lateritic soils, besides inadequate amounts of K and Ca occur in acid soils and coarse textured soils.

The acid sulphate soils with distinct characteristics occur in the lowlying areas of Kerala and are highly acidic having toxic content of soluble Fe and Al. These soils mostly develop as a result of drainage of those soils that are rich in pyrites (FeS_2), which on oxidation, produce sulphuric acid in the presence of excess SO_4 ions, and are very poor in available P but rich in organic matter. Iron, Al and Mn concentrations can be depressed by lime applications thereby creating favourable environment for the crop.

Thus, a large number of soil problems associated with deficiency and toxicity of several nutrients beside the problem of waterlogging are met with in western coastal area, and accordingly the management technologies for oilseed crops should be location specific.

Choice of crop varieties

Selection of appropriate varieties suited for the agroclimatic region is a basic prerequisite for achieving higher productivity of oilseeds. Some of the varieties of oilseed crops recommended for coastal region are indicated below:

East coast region

Tamil Nadu	Groundnut	VRI-2, VRI-4, VRI-5, ALR-2, ALR-3, ICGS-76, ICGV-86590, ICGV-86325, Vemana, Apoorva, GPBD-4, DRG-12
	Sesame	TMV-3, TMV-4, TMV-5, TMV-6, CO-1, TSS-6, Paiyur-1, VRI-1
	Sunflower	KBSH-1, KBSH-44, TCSH-1, CO-1, CO-2, DRSF-108, TNAUSUF-7, PAC-1091, Jwalamukhi, PAC-36, MLSFH-47, SH-416, ProsSun-09, Morden
Andhra Pradesh	Groundnut	ICGV-86590, K-134, Tirupati-3, ICGV-86325, DRG-12, Kadiri-4, JCC-88, Kadiri-5, Kadiri-6, ICGS-76, Apoorva
	Sesame	Gauri, Madhavi, Rajeshwari, Yallamanchili 1,2, Swetha til, TCS-94
	Sunflower	APSH-11, KBSH-1, KBSH-44, NDSH-1, SH-416, DRSF-108, PAC-1091, MLSFH-47, Jwalamukhi, Morden
	Niger	No.71, Gaudaguda local

Orissa	Groundnut	RSHY-1, OG-52-1, ICGS-44, Dh-86, TG-3, Smruti
	Rapeseed-Mustard	*Toria:* M-27, Agrani, Parbati,, Anuradha, Yellow *sarson*: Benoy, Jhumka, Ragini Mustard : Pusa bold, Pusa Agrani, Pusa Bahar Black mustard: Surya
	Sesame	T-85, Vinayaka, Kanaka, Kalika, Uma, Usha, Nirmala, Prachi.
	Castor	Jyoti, GCH-4, GCH-5, GCH-6, DCH-177
	Niger	IGP-76, No.71, GA-5, GA-10
West Bengal	Groundnut	ICGS-44, ICGS-76
	Rapeseed-mustard	*Toria*: M-17, Agrani, Parbati, Anuradha Yellow *sarson*: Benoy, Jhumka, Ragini Mustard: Pusa bold, Pusa Agrani, Pusa Bahar. Black Mustard: Surya
	Sunflower	KBSH-1, KBSH-44, Jwalamukhi, PAC-36, PAC-1091, Pro Sun-09, Morden, DRSF-108
	Sesame	Rama, Tilothama
West coast region		
Gujarat	Groundnut	Somnath, ICGS-37, CG-20, TG-26, GG-7, Dh-86, GG-4, GG-5, GG-13, GG-3, GAUG-11
	Sesame	Parva-1, Gujarat Til-1, Gujarat Til-2, Gujarat Til-10.
	Niger	IGP-76, NRS-96-1, Gujarat Niger-1, RCR-317.
Maharashtra	Groundnut	TAG-24, TKG-19A, JL-220, LGM-2, AK-159, TG-26, Phule Vyas, Manikya, Manjira
	Sesame	Phule Til-1, N-8, Tapi, JLT-26, AKT-64, AKT-101
	Niger	N-5, IGP-76
Karnataka & Goa	Groundnut	ICGV-86590, ICGV-86325, DRG-12, R-8808, DSG-1, R-9251, GPBD-4.
Kerala	Sesame	Kayankulam-1, Thilothama, Soma, Surya, Thilak, Thiladhara, Thilarani
	Groundnut	TG-3

Tillage and crop establishment

In coastal regions, lands after harvest of rice can be utilised for introduction of oilseeds, like groundnut, rapeseed-mustard, sunflower, sesame, etc. However, due to puddling during rice cultivation, the soils are compacted losing normal structure. Proper land preparation and establishment of crops are critical for success of the oilseed crops in rice fallows. One can think of zero and minimum tillage for planting of oilseed crops in rice fallows under rainfed conditions. With protective irrigation, normal land preparation and planting can also be adopted. Wherever zero or minimum tillage is followed in crops, like mustard and sunflower, higher seed rate can be used and excess seedlings can be thinned out later.

For successful cultivation of oilseeds in the coastal region, choice of suitable varieties, tillage and crop establishment, appropriate crop nutrition are very important. Besides, supplemental irrigation, integrated pest management and crop specific management will go a long way in improving the overall oilseed productivity. There is considerable potential for introduction of oilseed crops in different crop growing situations in both east and west cost regions which needs to be popularised for enhanced and stable farm income.

J. Indian Soc. Coastal agric. Res., 24(1), 119-121, 2006 **Invited Paper**

Improved Crop Management Practices in Coastal Ecosystem of Goa

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The West coast in general and Goa, in particular, vividly depict the typical coastal environment with sea shores, backwaters, lagoons, marshy areas and hinterlands with varied topography. Improved red kernelled rice varieties like Mo-17 (6.19 t ha^{-1}) in place of the ruling variety Jyoti (3.64 t ha^{-1}), popularization of medium duration rice IET-17527 in place of Jaya, introduction of rice hybrids like KRH-2 (6.44 t ha^{-1}) and Sahyadri (6.92 t ha^{-1}) for enhanced grain yields, in addition to introduction of scented fine grain varieties like Pusa Suagndh-2 (4.82 t ha^{-1}), are suggested as viable options for improved profitability in rice. Among the different rice based cropping systems practised in the region, rice-vegetable (brinjal) sequential cropping system was found to be the more productive and profitable over other cropping systems. Use of high yielding varieties of groundnut like TAG-24 have shown great promise both in terms of yield (21.7 q ha^{-1}) and returns. Coconut based high density multi-species cropping system with inclusion of banana, pineapple and pepper is more productive and profitable on a sustainable basis. Studies conducted in this direction have clearly shown the superiority of systems approach involving dairy through intercropping of high yielding forages in coconut garden. Further, groundnut and pine apple as intercrops in cashew have shown great promise both for increased productivity and profitability. Integrated farming systems, like rice-brinjal system with mushroom and poultry (Rs.77, 305 ha^{-1}) for rainfed lowlands, coconut + fodder + dairy (Rs.32, 335 ha^{-1}) for uplands, rice + fish for lowlying paddy fields (with a fish production of 1250 kg ha^{-1} in addition to rice), poultry + fish combination for fish ponds, etc. have shown greater promise in the region.

*(**Key words** : Improved crop management, Coconut- and cashew-based farming, Integrated farming systems, Rehabilitation of mine waste dump, Value addition, Goa coastal area)*

Coastal ecosystem is unique not only in its wide range of topography, soils and climate but also in terms of crop biodiversity. The warm humid tropical climate of the region favour a variety of flora and fauna, which needs to be conserved and suitably utilized for economic development of the area.

Agricultural production in coastal areas is often threatened by natural calamities; heavy rainfall leading to degradation of cultivable land due to soil erosion, waterlogging, depletion of soil fertility, excessive exploitation of mangroves/fishes, intrusion of seawater, emergence of new pests and diseases and pollution of water bodies. Hence, emphasis needs to be given to improve the coastal agriculture in sustainable manner through effective resource management.

The west coast in general and Goa, in particular vividly depict the typical coastal environment with sea shores, backwaters, lagoons, marshy areas and hinterlands with varied topography. Goa has a coast line of about 101 km where the elevated land mass is bordered by a narrow to moderately wide strip of land ranging between 100 to 300 m in width and consisting of length of 71 km of sandy beaches.

The State of Goa receives an annual rainfall of 2800 to 4200 mm. Though the coastal lower *Ghats* receive higher rainfall, still many places experience severe scarcity of water during summer months as the maximum rainfall is concentrated during four months of the monsoon period (unimodal). As a result of this moisture stress and drought, remunerative irrigated crops and plantation crops invariably suffer. As the mining activity is also being practised in this region, soil is being exposed to natural vagaries of erosion at an alarming rate due to lack of vegetative cover. As such, development of land and water together with sustainable production system on watershed basis, alternate land use through social and agro-forestry, aquaculture, agro-based enterprises involving horticulture, livestock and fisheries would be rewarding.

Further, the rich productivity is getting fast eroded in the coastal regions because of deforestation and human settlements. Out of the total geographical area of 3, 61,113 ha of the State, about 40 percent is net sown area and forest covers about 34 percent. The typical coastal climate with hot humid weather and varied types of topographical situations and soil types are suitable for a variety of field and horticultural crops. Coastal areas have rich potential for rice based cropping systems, horticultural plantations and medicinal and aromatic plants of high export value. They are ideal for commercial aquaculture, dairy, piggery, duckery, poultry and agro-forestry.

The improved crop management systems for the region are as follows:

Coastal lowlands: Rice-based systems - Rice-Rice, Rice-Cowpea, Rice-groundnut, Rice-vegetables, Rice-Fish systems.

Coastal midlands: Coconut and arecanut-based cropping systems with inclusion of banana, pineapple, spices and farming systems with dairy, etc.

Coastal hilly subsystem: Cashew-based systems involving intercropping of groundnut, pine apple, medicinal and aromatic plants, etc.

As the region has more potential with 60 percent of the cultivated area covered with horticultural crops, more thrust needs to be given for the development of horticultural crops.

Crop management practices

Rice and rice-based cropping systems dominate the lowlands of the region, while cashew and coconut based systems the uplands. Rice-rice system is practised to a limited extent, while rice-pulse, rice-groundnut and rice-vegetable dominate the scenario. Cashew is grown less intensively mostly as monocrop while coconut gardens are often inter/mix cropped with banana, spices, like pepper, vanilla, etc. in the region.

Rice is grown in three typical topographical situations, *viz.* rainfed uplands, rainfed lowlands and the saline areas especially along the coast. Fragmented land holdings, lack of commercial approach, low profitability owing to increased cost of cultivation coupled with inadequate processing and marketing infrastructure are making rice production non-viable in the present scenario. Selection of proper genotypes for the situation coupled with improved management practices hold the key in this direction. Improved red kernelled rice varieties, like Mo-17 (6.19 t ha^{-1}) in place of ruling variety Jyoti (3.64 t ha^{-1}), popularization of medium duration rice IET-17527 in place of Jaya, introduction of rice hybrids, like KRH-2 (6.44 t ha^{-1}) and Sahyadri (6.92 t ha^{-1}) for enhanced grain yields, in addition to introduction of scented fine grain varieties, like Pusa Suagndh-2 (4.82 t/ha), Vasuamti (4.70 t ha^{-1}) and Pusa-2511 (4.57 t ha^{-1}) are suggested as viable options for improved profitability as evidenced by the research results of the institute for the last three years (Manjunath *et al.*, 2005).

Among the different rice-based cropping systems practised in the region, rice-vegetable (brinjal) sequential cropping system was found to be more productive and profitable over other cropping systems. The system recorded the highest productivity in terms of rice grain equivalent yield (11122 kg ha^{-1}). The higher productivity was due to the higher yield obtained with brinjal having bigger sized fruits (average weight of more than 250 g per fruit) and more number of fruits per plant (Manjunath, 2002). As the system was found to deplete more N and K from soil, additional fertilizer application of the nutrients is suggested. Among the other important vegetable crops, okra, chillies, cluster beans, vegetable cowpea, amaranthus, raddish, etc. are important. Efforts are being made to identify suitable high yielding variety in each of these crops along with the standardization of package.

Further, rice-groundnut and rice-cowpea systems are the common cropping systems in rice fallows under residual moisture situations. Use of high yielding varieties of groundnut like TAG-24 have shown great promise both in terms of yield (21.7 q ha^{-1}) and returns.

Sugarcane is the only commercial crop grown in the region with relatively lower yield. The local cane production is far short of demand for the only sugar factory of the State. Further, higher labour cost in cane production is reducing the profit margin. Attempts are being made to identify varieties with higher tonnage and recovery besides tolerance to white woolly aphid menace. Varieties, like Co-85002 (147 t ha^{-1}) and Coc-671 (114 t ha^{-1}) are quite promising.

Coconut-based cropping/farming systems

In the middle valleys and plains, coconut and arecanut gardens dominate the production systems. The local Benaulim and Calangute varieties of coconut, although are stable yielders under average management, wide scope exists for improved cultivars like DXT and especially the selections involving local varieties. A wide scope exists for intensification of cropping in these plantations especially with high value crops. Studies conducted at ICAR Research Complex for Goa over the last 6-7 years indicated that high density multi-species cropping system with inclusion of banana, pine apple and pepper is more productive and profitable on a sustainable basis.

The gross income obtained from the system was Rs. 2, 00,748 ha^{-1} while the net return was 1, 55,365 ha^{-1}. The benefit: cost ratio (BCR) of the system was 1:3.42, as compared to 1:0.22 in the monocropping system. The average net profit per ha obtained from the individual crops were: coconut - Rs.34, 796, pineapple - Rs.11,238, banana - Rs.59, 471 and glyricidia - Rs.2, 250. This indicates that banana is the most profitable intercrop in coconut followed by pineapple (Manjunath and Singh, 2005).

Flowers have a special place in Goa, being a tourist destination. Attempts to introduce flowers like gladiolus have yielded good returns. Efforts are being made to standardize the package of cutflower production.

Cashew-based cropping systems

In the initial period of establishment of intensive cashew gardens with grafts of improved varieties, it was recommended for taking up intercrops for the first few years depending upon the location. It was possible to grow intercrops, such as pineapple, papaya, annual drumstick, cucurbitaceous vegetables, groundnut, cowpea, etc. in the region. This is the most important practice to tide over the gestation period of the garden. Careful selection of intercrops to achieve appropriate temporal and spatial sequence should be ensured to avoid the crop competition over a period of time (Desai and Adsule, 2002). Studies conducted in this direction at ICAR Research Complex for Goa have clearly shown the superiority of systems approach in cashew involving crops, like groundnut and pineapple as intercrops both for increased productivity and profitability.

Rehabilitation of mine waste dump

Mining is a major industry in Goa and vast areas of dumping grounds with mine waste are causing ecological problems. Keeping this in view, rehabilitation studies were attempted. Tree species, like cashew and use of soil amendments, like poultry manure have been found useful to avoid ecological hazards.

Integrated farming systems

The integration of allied enterprises with other agricultural activities has shown a good promise for higher returns from each farm area. Further, some of the byproducts of these enterprises serve as valuable manure available for recycling to the crop component within the system. These integrated systems should provide scope to also bring improvement in soil health for sustainability in production on long term basis.

Studies conducted at ICAR Research Complex for Goa have shown that rice-brinjal system integrated with mushroom and poultry (Rs.77,305/ha) for rainfed lowlands, Coconut + fodder + dairy (Rs.32,335 ha^{-1}), for uplands, rice + fish for lowlying paddy fields with a fish production of 1250 kg ha^{-1} in addition to rice, poultry + fish combination for fish ponds, etc. are highly useful.

Value addition

A wide scope exists for processing and value addition in many of the commodities especially in fruits, flowers and vegetables. Preservation of bread fruit, preparation of kokum syrup, juice, etc. have been attempted in this direction.

Future thrusts

The future thrusts should include intensified research and development efforts for protection of biodiversity, mangroves, advance forecasting for natural calamities, improved irrigation and drainage systems, use of low cost machinery for agricultural operations including post-harvest aspects, use of integrated community approach and its effective co-ordination, etc. Further, improvement of market intelligence and guarantee facilities in the light of expanded export opportunities under WTO are essentially required.

REFERENCES

Desai, A. R. and Adsule, P. G. (2002). Cashew farming systems- an account of their types in Goa Region. In Extended Summaries National Conference *Coastal Agricultural Research,* pp. 122-124, held at ICAR Research Complex for Goa, Old Goa, Goa, 6-7 Apr, 2002.

Manjunath, B. L. (2002). Sustainable rice production through selection of cropping systems. In Extended Summaries National Conference *Coastal Agricultural Research*, pp. 113-115, held at ICAR Research Complex for Goa, Old Goa, Goa, 6-7 Apr, 2002.

Manjunath, B. L. and Singh, S. P. (2005). *Systems Approach in Coconut for Higher Productivity and Profitability.* In Technical bulletin No. **6**, pp. 23-24, ICAR Research Complex for Goa, Old Goa, Goa.

Manjunath, B. L., Talaulikar Sunerta, M. and Korikanthimath,V.S. (2005). Improved profitability in rice through selection of genotype and processing. In Extended Summaries National Seminar *Rice and Rice Based Systems for Sustainable Productivity,* pp. 173-175, held at ICAR Research Complex for Goa, Old Goa, Goa, 18-19 Oct, 2005.

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Effect of Integrated Nutrient Management on Soil Properties and Yield of Rice Grown in Salt Affected Soils of Coastal Andhra Pradesh

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A field experiment was conducted during *kharif*, 2001 and 2002 on salt affected silty clay loam soil to study the effect of integrated nutrient management practices involving inorganic, organic and biological sources of N on soil salinity, dehydrogenase activity, nutrient availability and rice yields. The results indicated that the soil salinity decreased and dehydrogenase activity increased significantly with the application of glyricidia @ 5t ha^{-1} and remaining N through inorganic source. Grain and straw yields of rice significantly increased with combined application of glyricidia and inorganic source of N. The nutrient availability after harvest of paddy is found maximum in treatment receiving green leaf manure (Glyricidia) and inorganic N. Biofertilizers did not show improvement in the yield of rice but improved the microbiological properties of soil.

(***Key words*** *: Integrated nutrient management, Organic sources of N, Soil properties, Nutrient availability, Rice, Coastal saline soil)*

Integrated plant nutrient management using all possible sources of nutrients aims at sustainable productivity with minimum disturbance in natural soil health and environment without escalation of cost of fertilizers. It is well recognized that to safeguard the soil health, a judicious combination of organic and inorganic N usage is essential. The supplementary and complementary use of organic manures and chemical fertilizers will augment the efficiency of both the substances to maintain a high level of soil productivity and rice production (Lian, 1994). Organic N added through various sources unlike inorganic fertilizer must undergo decomposition and mineralisation before N becomes available to rice plant. Apart from N, organic manures contain appreciable amounts of P and K. Further, the decomposition products like organic acids act on soil minerals bringing about dissolution of minerals and releasing micronutrients. The present study was undertaken to know the effect of integrated nutrient supply system on crop yield and to monitor the changes in soil properties.

MATERIALS AND METHODS

Field experiment was conducted during *kharif*, 2001 and 2002 on salt affected silty clay loam soil at Agricultural Research Station, Ghantasala situated in Krishna District of Andhra Pradesh to study the effect of integrated nutrient management on soil properties and yield of rice. The salient characteristics of the soil are presented in Table 1. The experiment was laid out in split-plot design with four replications. Rice variety MTU-2077 was taken as test crop. There were eight main plot treatments and two subplot treatments. The main plot treatments comprised of inorganic N (urea) alone and in combination with organic sources of N from different locally available materials whereas the subplot treatments were with or without biofertilizers.

Total nitrogen application for all treatments except for control was same. The composition of different organic sources of N is given in Table 2. After the harvest of rice soil samples were collected and analyzed for available N, P & K, pH, salinity following standard procedures described by Black (1965). Soil dehydrogenase activity was analysed for estimating microbial activities in soil (Singh *et al.*, 1999). The details of treatments are given below.

Main plot treatments

T_1: Control (Farmers' practice) 60:40:30 (NPK-kg ha^{-1})

T_2: Recommended dose of NPK - 80:40:30 kg ha^{-1}

T_3: Half recommended dose of N

T_4: Dhaincha - 5 t ha^{-1}

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T_5: Green leaf manure - 5 t ha^{-1}

T_6: FYM - 5 t ha^{-1}

T_7: Azolla - 500 kg ha^{-1}

T_8: Pressmud - 5 t ha^{-1}

Subplot treatments

Bo: Without biofertilizer

B1:With biofertilizer (Azospirillum)

Nitrogen was applied in the form of urea for the treatments T_4 to T_8 after duly considering the N present in organic and biofertilizers. Nitrogen-use efficiency was calculated by the formula.

$$NUE = \frac{\text{Yield in N applied plot (kg ha}^{-1}\text{) - yield in control plot (kg ha}^{-1}\text{)}}{\text{kg of N applied}}$$

Table 1. *Physicochemical properties of the experimental soil*

Soil properties	
pHs	8.1
ECe	4.92 dSm^{-1}
Organic carbon	0.70%
Available N	265 kg ha^{-1}
P	18.5 kg ha^{-1}
K	490.9 kg ha^{-1}
Texture	Silty clay loam
CEC Cmol (p^+) kg^{-1}	43.48

Table 2. *Chemical composition of the organic manures on dry weight basis*

Nutrients (%)	*Sesbania aculeata*	FYM	*Azolla microphylla*
N	3.0	1.20	2.20
P	0.47	0.21	0.27
K	2.00	1.96	2.01
C	38.5	26.9	40.00
C: N ratio	12.8	22.4	18.20

pHs

Continuous cropping for 2 years with rice-pulse rotation decreased soil pH from initial level of 8.1 to 7.7 in 0-15 cm soil depth. However, the soil pH was not significantly influenced by different treatments.

Soil salinity (ECe)

Electrical conductivity of soils varied from 1.5 dSm^{-1} to 2.9 dsm^{-1} with mean value of 2.2 dSm^{-1} at 30 DAT under different treatments. There was decrease in ECe of soil at 60 DAT over 30 DAT and it ranged from 0.8 to 1.2 dSm^{-1} with a mean value of 1.0 dSm^{-1}. At harvest, the ECe of soil increased over that at 60 DAT. Among treatments, glyricidia application @ 5 t ha^{-1} and remaining N through inorganic N proved superior in reducing the electrical conductivity.

Nutrient availability

Addition of organic manures significantly increased available N over control (Table 3). Maximum availability of N was in glyricidia treated soil. In general, green manures recorded higher availability of N compared to farmyard manure, azolla and pressmud. The same trend was observed in N, P_2O_5 and K availability at both stages. Higher availability of N in glyricidia leaves contain up to 2.7% nitrogen and have a narrow C:N ratio of about 13 (Kang and Mulongoy, 1989). The succulent nature of glyricidia underwent rapid decompositon in submerged soil acids on decomposition, which altered the mechanism of reduction and chelation (Patrick and Mahapatra, 1968) and solubilization of insoluble phosphates by acids (Pareek and Gaur, 1973). Wider C:P ratio in farmyard manure, pressmud was responsible for low release of P. Increase in available K was mainly due to displacement of K from clay by ammonium under submerged condition and also added by liberated acids decomposition products of organic acid.

Nitrogen use efficiency (NUE)

The NUE of added organic source of N was highest under glyricidia and followed by dhaincha (Table 4). This could be due to relatively higher availability of N, lower C:N ratio, succulent nature of glyricidia compared to the organics (Nagarajah *et al.*, 1989).

Grain and straw yield

Glyricidia was significantly superior in enhancing the rice yield over pressmud and azolla application. Combination of 5 t ha^{-1} of glyricidia and remaining N through fertilizer recorded high grain and straw yield followed by dhaincha @ 5 t ha^{-1} with inorganic N. The lowest yields were obtained with half recommended dose of N (Table 4). The higher yield in organic manure applied plots was due to improvement of physical properties and supply of nutrients on mineralization leading to higher uptake.

From these findings, it may be concluded that continuous combined application of chemical fertilizers and organic manures increased NUE, available N, P and K, and decreased pH and ECe

Table 3. *Nutrient availability (kg ha^{-1}) after harvest of paddy*

Treatment	N content			P content			K content		
	2001	2002	Pooled	2001	2002	Pooled	2001	2002	Pooled
T_1	302.9	278.4	290.6	19.2	20.3	19.7	466.9	480.2	473.6
T_2	324.2	304.5	314.4	19.2	19.5	19.3	473.1	516.0	494.5
T_3	224.2	213.3	218.7	17.2	17.5	17.4	465.9	469.0	467.4
T_4	292.5	309.3	300.9	20.2	20.2	20.2	501.7	518.0	509.9
T_5	320.0	310.3	315.1	22.2	20.9	21.6	539.9	529.2	534.5
T_6	304.2	308.6	306.4	22.0	20.4	21.2	514.1	509.4	511.7
T_7	284.7	287.6	286.1	19.7	19.5	19.6	478.1	501.2	489.7
T_8	289.5	288.7	289.1	19.9	20.5	20.2	487.8	505.4	496.6
SEm$\pm$	9.0	9.4	6.5	1.6	1.3	0.9	15.7	9.9	8.2
CD at p=0.05	N.S	19.0	12.8	N.S	2.6	1.7	N.S	20.0	16.2

Table 4. *Grain and straw yields (kg ha^{-1}) and NUE of paddy during* kharif, *2001 & 2002*

Treatment	Grain yield			Straw yield			NUE
	2001	2002	Pooled	2001	2002	Pooled	Pooled
T_1	3763	4160	3962	5563	5106	5334	5.3
T_2	3923	4803	4363	5803	5288	5545	10.3
T_3	3248	3827	3538	5133	4783	4958	-
T_4	3912	4991	4451	5788	5442	5615	21.4
T_5	4357	5301	4829	6559	5697	6128	27.1
T_6	3978	4916	4447	6128	5387	5758	17.5
T_7	3770	4690	4230	5586	5126	5356	12.6
T_8	3818	4718	4268	5702	5201	5452	5.9
SEm$\pm$	190	154	129	197	156	67.5	-
CD at p=0.05	383	312	253	399	314.1	132.2	-

content of soil over the initial value, whereas soil fertility deterioration was observed under chemical fertilizer treatments.

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REFERENCES

Black, C.A. (1965). *Methods of Soil Analysis*, Part-1. American Society of Agronomy, Madison, Wisconsin,USA.

Kang, B. T. and Mulongoy, K. (1989). *Glyricidia sepium* as a source of green manure in an alley cropping system. In *Glyricidia Production and Use*, N.Glover (ed.). Nitrogen Fixing Tree Association, Hawaii, and USA.

Lian, S. (1994). In *Combined Use of Chemical and Organic Fertilizers*. University of Pertainian, Malaysia and Food 'fertilizers, Technology Center, Taiwan. 237p.

Nagarajah, S., Nene, N.V. and Alberto, M.C.R. (1989). Effect of Sesbania, Azolla and rice straw incorporation on the kinectics of NH_4-N, K, Fe, Mn, Zn and P in some flooded rice soils. *Plant and Soil* **116**: 27-48.

Pareek, R.P. and Gaur, D.C. (1973). Release of phosphate from tricalcium and rock phosphate by organic acids. *Current Science* **42**: 278-279.

Patrick, W.H., Jr. and Mahapatra, I.C. (1968). Transformation and availability to rice of nitrogen and phosphorus in water logged soil. *Advances in Agronomy* **29**: 323-359.

Singh Dhyan, Chhonkar, P.K. and Pandey, R.N. (1999). In *Soil Plant Water Analysis - A Methods Manual*, pp.120-122. Indian Agricultural Research Institute (ICAR), New Delhi.

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Management of Basal Stem Rot Disease of Palms in India: Early Detection of Ganoderma Infection through PCR Technology

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Basal stem rot (BSR) caused by different species of *Ganoderma* is an important disease of the palms including oil palm. Integrated disease management (IDM) is possible for management of this disease if it is diagnosed at the early stage of infection. Visual and morphological detection are not reliable, and the use of advanced techniques like ELISA, even with monoclonal antibody, is not fool proof. DNA based PCR technology is so far the most reliable technique and several pairs of *Ganoderma* specific primers are already reported. A pair of *Ganoderma* specific primers, namely *Gan*1 and *Gan*2 were used for 20 isolates, which were earlier identified and suspected as different species of *Ganoderma*. The isolates were collected from oil palm and coconut plantations. Results indicated that only four isolates were *Ganoderma*. To optimize and economise the techniques, the reaction volume was reduced to 12.5μl, and different concentrations of enzyme (*Taq* polymerase), primer and DNA per reaction were used. Concentrations of 0.25 U of enzyme, 2.5 ng of each primer and 5 ng DNA were found enough for detection. Annealing temperature from 50-55°C did not show any difference in detection.

***(Key words**: Palm disease, Ganoderma infection, Disease management, PCR-based technique)*

Basal Stem rot is a disease, which affects the palms and caused by different species of *Ganoderma*. In case of oil palm the disease is a problem mainly in the older plantations. It is already an established disease in coconut and causes considerable economic losses every year. Cross infectivity of the *Ganoderma* from coconut to oil palm is also well established and also reported in India (Hymavathi *et al.*, 2002, Mandal *et al.*, 2003). In case of palms, the symptoms are noticed usually at a very late stage. When the brackets of the fungi are seen outside, considerable damage might have already taken place and most of the times survival of the palms becomes impossible. However, detection at the early stage gives ample scope to manage the disease and the palm to recover. Regular survey is an important aspect to detect any symptom of BSR disease in the plantations. However, since visual detection is not fool proof, accurate diagnostic technique, which is specific and readily adaptable to large scale testing for detecting *Ganoderma* in palms at an early stage of infection, would benefit decision making for appropriate disease control. Some progress on development of precise technique for early detection of *Ganoderma* may be achieved through enzyme-linked immunosorbent assay (ELISA), Monoclonal antibody and PCR techniques. In India ELISA with polyclonal antibodies have been used so far as advanced technology. But ELISA with polyclonal as well as monoclonal antibodies are reported to be non-specific. So far PCR-based assay appears to be more specific. Keeping this in mind attempts have been made to standardize a protocol using *Ganoderma* specific primers to identify the fungi, which can finally be used as a regular detection tool.

MATERIALS AND METHODS

Suspected *Ganoderma* isolates collected from different oil palm and coconut gardens were used as experimental material. DNA extraction was carried out from the actively growing mycelia of the fungi using extraction buffer (Mandal *et al.*, 2003). Two primers (desalted), namely *Gan*1 and *Gan* 2 (Utomo and Niepold, 2000) were custom synthesized from Bangalore Genei and used for the PCR amplification. Concentrations of the reagents which were maintained same in all the cases were: dNTPs 0.5uM (each), $MgCl_2$: 1.5mM (along with 10X buffer). Denaturing temperature was 94°C, extension temperature was 72°C, and the amplification was carried out for 39 cycles.

RESULTS AND DISCUSSION

Amplification with the primers was carried out with 20 isolates, all of which were suspected as different species of *Ganoderma*. Confirmation of *Ganoderma* would help in management of the disease. During the detection process, the *Gan*1 and *Gan*2 primers were used, which produced an amplification product of 167bp as described by Utomo and Niepold (2000). During the study, first a standard procedure with 1.0 unit of *Taq* polymerase enzyme, 15ng of each primer, 20ng of DNA were used in 25 ml of PCR reaction mixture. Presence of the bands were observed in only 4 isolates out of 20 suspected *Ganoderma* isolates. These were repeated and same result was observed. Two of the negative isolates were collected from coconut garden and were identified as *G. applanatum* and *G. lucidum* earlier on the basis of morphological characters. According to Utomo and Niepold (2000) *Gan*1 and *Gan*2 are *Ganoderma* specific primers and if so, the morphological identification needs to be verified. Other isolates, which were thought to be Ganoderma so far, are also mostly negative except the four. However, after this result, it is time to cross check field condition of the palms with the positive and negative results.

To optimise and also economise the detection techniques, the volume of PCR reaction mixture was reduced to 12.5 *u*l with no difference in result. Different concentrations of DNA (5ng, 10ng and 15ng), primer (2.5ng each), *Taq* polymerase (0.25 and 0.5 U) and different annealing temperatures did not show any difference in amplification pattern. Concentrations of 0.25 U of enzyme, 2.5ng of each primer and 5ng DNA were found enough for detection. DNA concentration isolated from pure culture may not be a limitation, however, the technique needs to be standardized with DNA of the field samples like root bits or the stem tissues. However, when primer concentrations of 2.5ng, 5.0ng and 7.5ng for each primer were used, it was found that the concentration of amplified product was considerably low in case of 2.5ng.

Incorporation of PCR techniques in management of basal stem rot is new in India and so far no report is found, where the IDM practices are conducted on the basis this techniques. A few important points are observed from this study, which need to be considered seriously during the future course of action. Several isolates, which are suspected as *Ganoderma*, may not be the same. If the morphological identification by electron microscope is authentic, the use of the specific primer pair needs to be verified. Several other primers specific to *Ganoderma* may also be adopted for detection. Another very important aspect is the economics of the detection process. With the reduction of the volume of PCR reaction mixture, reduced quantity of enzyme and considerably reduced cost of 'Thermal Cycler', it is not difficult to analyse a large number of samples. Works on all the above aspects have been taken up and a simple DNA extraction technique from field samples is being standardized. It is expected that very soon BSR disease management of palms would be relying on PCR-based detection of *Ganoderma*.

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REFERENCES

Hymavathi, K., Kochu Babu, M., Mandal, P.K., Chander Rao, S. and Rethinam, P. (2002). Incidence of basal stem rot of oil palm in Andhra Pradesh. *International Journal of Oil Palm* **2**(2): 35-37.

Mandal, P.K., Hymavathi, K., Jayanthi, M. and Kochu Babu, M. (2003). Cross infectivity study of Ganoderma lucidum isolates from coconut to oil palm and their genetic diversity study by RAPD and AFLP. *International Journal of Oil Palm* **3&4**: 57-60.

Utomo, C. and Niepold, F. (2000). Development of diagnostic methods for detecting *Ganoderma*-infected oil palms. *Phytopathology* **148**: 507-514.

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Coconut Yield Prediction in Bay Islands Using Artificial Neural Network

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A study on Artificial Neural Network (ANN) for the forecasting of coconut yield taking into account the weather conditions was carried out. Data and information relating to coconut yield from CARI research farm were collected monthly from 1985 to 2001. Weather data such as average monthly rainfall, average monthly temperature, relative humidity, wind speed, evaporation and sunshine hours of relevant period were also obtained. Distributed neural network is applied to yield prediction in coconut. A multilayered perceptron with back propagation algorithm has been applied. The results elucidate that the ANN has potential and ability to forecast coconut yield accurately despite small set of data available.

*(**Key words**: Coconut yield prediction model, Climatic parameters)*

The Andaman and Nicobar Islands consist of about 572 islands from North to South, covering a geographical area of 8249 km^2 spread over a length and breadth of 700 km and 250 km, respectively. These islands are situated between 6° and 14° N latitude and 92° and 94° E longitude in the Bay of Bengal. The general terrain, land formation and topography of Andaman group of Islands are hilly and undulating, enclosing narrow valleys. The hot humid tropical climate prevalent in the close proximity of equator has enriched the landmass with evergreen forests. The average annual rainfall in these islands is 3000 mm, mean relative humidity ranges from 80 to 90 percent with mean minimum temperature of 23.2°C and mean maximum temperature of 30.7°C.

Coconut is the major crop of the islands. The main economy of the people directly depends on the fortunes of this crop. Hence any disturbance in the coconut sector would affect the well being of the coconut farming community. A & N islands contribute an area of 24,796 ha under coconut cultivation (Rethinam *et al.*, 2001). The total palm population is 44.584 lakh bearing and 3.956 lakh non-bearing with an annual production of 87.5 million nuts. Compared to the national average productivity of 7821 nuts per ha, the productivity of A & N islands is only 3536 nuts per ha. This can be attributed to the close planting, negligence and lack of adequate management practices.

Neural network approach

The application of the Artificial Neural Network (ANN) approach to forecasting task has gained a great deal of interest from researchers in many areas of study for quite sometime. The main advantage of the ANN approach is that it does not require any assumption of functional relationship between its input variables and the corresponding output. Instead, it is able to learn and build its own non-linear model from a relationship between input variables and output during the training process (Camago *et al.*, 1999). The network is feed forward multilayer network under the back propagation learning used for yield prediction (Haskett, *et al.*, 1998).

The aim of this study is to investigate the important factors that influence coconut yield, especially the weather variables, and also to understand the potential of ANN to perform the forecasting task of coconut yield. It could lead the way for the coconut yield prediction and understanding of factors controlling yield, which would benefit the agriculturist in the future.

MATERIALS AND METHODS

The Andaman and Nicobar Islands belong to humid tropical islands and it is 1200 km away from Indian mainland. The observations of weather variables such as rainfall, maximum and minimum temperature, relative humidity in the morning and evening, and wind speed for 17 years since 1985 have been collected from the basic records of agrometeorological station of Central Agricultural Research Institute, Port Blair and India Meteorological Department regional center located at Port Blair. Data on coconut yield experiments conducted in the farm of Central Agricultural Research Institute, Port Blair have also been collected from 1985 to 2001 and monthly average has been worked out. In order to assess the dependability, weather and crop data from basic records have been subjected to coefficient of variation analyses.

Structure of ANN

The Neural Network used in this study is a multilayered feed forward network using a back propagation learning algorithm. The architecture of the ANN chosen here consists of three layers: an input layer, a hidden layer, and an output layer. Several ANN models with different input factors and different number of neurons in a hidden layer were experimented. C programming was used as an ANN tool in this experiment.

Training and testing

The training and testing were created according to inputs of ANN model. Rainfall, average mean temperature, etc. were selected to build the training and testing according to the structure of the model. From the data records selected, one data record was set aside for testing purpose, called testing set, and these data record was not presented to ANN during the training session, but it would be presented to the ANN after training session was completed (Haykin,1999). Therefore total number of data recorded in a training set was 17. For the purpose of the experiment, each data record had a chance and was assigned with a testing set once. By performing this, potential of ANN for forecasting of yield was evaluated. Thus, ANN's of each model were trained and tested. Each ANN was trained until the Mean Square Error (MSE) decreased and reached 0.01 or the number of iteration exceeded 100,000 when the training session stopped. The MSE was the summation of the square of the difference between the desired and actual outputs of the network for the entire training pattern. Then the testing set was presented to the trained ANN in order to determine the accuracy of the forecast: MSE = $\frac{1}{2}\Sigma[E(p)-X(p)]^2$, where E(p) was the desired output and X(p) was the actual output.

RESULTS AND DISCUSSION

The training pairs and patterns of both inputs and outputs are shown in Table 1. The forecast performance of ANN result is presented in Fig.1. From Fig. 1 it could be demonstrated that the ANN of each model was able to perform a forecasting task in a satisfactory manner. In this study it was indicated that there was no need to discard the data record which has sudden change since it helped contributing knowledge during training of ANN.

Table 1. *Collection of patterns from the concerned farm in Bay islands*

Input Patterns										Output
Year	RF	Tmax	Tmin	Rhm	Rhe	Ws	RD	Evp	Ssh	Yield
1985	125	29.7	23.2	77	80	7.6	53	3.57	6.5	44
1986	164.5	29.9	22.1	76.5	79.4	8.05	173	4.35	7.2	61
1987	258.4	30	22.9	77	78.8	6.7	181	4.09	6.5	47
1988	277	28.8	23.3	90	77.4	7.1	144	3.86	6.6	69
1989	230.9	29	23.25	86.75	74.6	7.7	164	3.82	6.9	57
1990	193.9	30	23.63	85.64	72.7	7.4	124	3.7	6.4	55
1991	255.4	30.2	23	86.6	72.4	10.59	125	4.23	5.8	57
1992	220.4	29.7	22.63	87.4	75.2	10.84	120	3.98	6.6	38
1993	188.4	31	23	89.7	75.9	10.2	152	4.32	6.4	42
1994	258.7	31	23.5	88.1	81.4	8.7	120	4.56	6.7	54
1995	297.2	31.4	23.7	90.7	79.5	9.6	140	4.5	6.4	58
1996	267.2	31.9	23.33	81.08	77.8	9.9	188	4.88	6.2	60
1997	209.8	30.5	23.82	89.6	75.2	10	111	5	7.3	34
1998	176.3	31	23.5	91.19	77.3	9.3	192	4.4	5.6	41
1999	199	30.1	21.3	90.2	81.6	9.3	209	4.2	6.4	97
2000	238.2	30.4	23.3	89.9	76.6	9.3	154	3.8	6.5	66
2001	211.2	30	23.4	88.4	78	10.1	159	4.56	6.4	55

Note: RF: Rainfall, Tmax: Maximum temperature, Tmin: Minimum temperature, Rhm: Relative humidity (morning), Rhe: Relative humidity (evening), Ws: Wind speed, RD: Rainy days, Evp: Evaporation, Ssh: Sunshine hours

Similarly this led to better performance of ANN in general, except forecasting particular data record where ANN had difficulty to adjust from the results of the experiment. ANN thus showed its potential and ability to forecast coconut yield quite accurately.

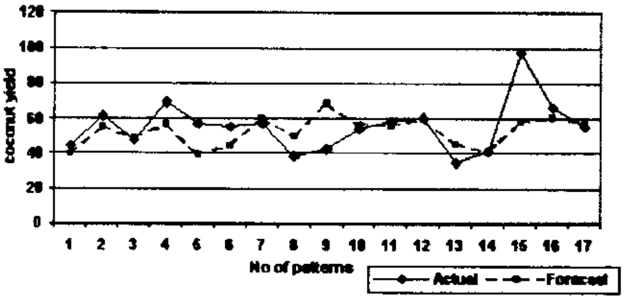

Fig. 1. Prediction performance of the network trained by using BPA for two years lag period

CONCLUSION

ANN can be used to perform forecasting. The forecast outputs trace the actual production very well for all levels of coconut yields. It is observed from the experiment that the amount of rainfall, wind velocity, relative humidity, rainy days have strong influence on yield of coconut, while the average temperature and evaporation have less influence, and do not contribute any positive effect on the forecast. This could be the result of several factors such as the small set of data used for the experiment or the fact that the temperature data available was from a single location at CARI Metrological station, which was not quite relevant to the production areas in the experiment.

REFERENCES

Camago, M., Ortolani Altino Aldo, Pedro Mario Jose Jr. and Rosa Sidney Marcos (1999). *Agrometeorological model for yield prediction of orange cultivar Valencia. Bragantia* **58**(1): 171-178.

Haskett, J., Pachepski, Y. and Adcock, B. (1998). *Use of Artificial Neural Networks to Simulate Soybean Crop Yield as Affected by Global Change.* United States Department of Agriculture, Agriculture Research Service, USA.

Haykin S. (1999). *Neural Networks a Comprehensive Foundation.* Prentice Hall International, Inc.

Rethinam, P., George Rajeev, P., Thomas, P.T. and Gopalakrishnan Reman (2001). Problems and prospects of coconut industry in Andaman and Nicobar Islands. *Indian Coconut Journal* **XXXII** (2): 2-11.

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Integrated Nutrient Management for Coastal Salt Affected Soils of India under Rice-based Cropping System

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Due to various soil, water and agroclimatic constraints the coastal areas are generally monocropped with rice grown in the *kharif* season only. The response of crops to the application of inorganic fertilizers is poor, due to which farmers use minimum amount of fertilizers leading to poor yield of the crop. The results of an experiment on integrated nutrient management conducted simultaneously in 4 coastal states of India (West Bengal, Orissa, Andhra Pradesh and Tamil Nadu) indicated that yield of crops was better when combined sources of nitrogen, viz. inorganic and organic were applied to soil instead of inorganic sources alone. Locally available non-conventional organic sources were found to be highly potential. For coastal saline soils of West Bengal city compost and locally available green leaves (equal mixture of locally available *Glyricidia sp.*, *Delonix sp.* and *Exoecaria agallocha*) can be very effective organic sources of N. For coastal regions of Andhra Pradesh and Tamil Nadu leaves of locally available leguminous tress like *Glyricidia* and *Derris indica*, respectively were found to be highly beneficial organic sources. For Orissa, application of green manure (*Sesbania*) and placement of urea supergranules increased the yield of rice. Use of biofertilizers and the residual effect of organic sources enhanced the yield of all the crops in the subsequent *rabi* season. The fertility status of soils improved due to application of organic sources of nutrients, while application of inorganic source of N showed little or no improvement in soil nitrogen status in most of the cases. Application of organic sources of N to soil in combination with inorganic nitrogen fertilizer improved the microbial activities in soil and thus the soil health.

(**Key words:** *Integrated nutrient management, Locally available organic sources, Biofertilizer*)

The coastal saline soils in India are distributed along the 8129 km long coastline in the eastern and western coast of the country spreading over 12 states and union territories, viz. West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Maharashtra, Gujarat, Goa, Duman & Diu, Pondicherry, Andaman & Nicobar Group of Islands, and Lakshadip & Minicoy Islands. The fertilizer use efficiency and yield of crops are generally poor in of the coastal saline soils. Efficient utilization of applied fertilizers is one of the most important requirements for increasing the yield of crops in coastal saline soils. Suvarna Latha and Sankara Rao (2001) observed that sustainable higher yield of crops in coastal saline soils could be achieved through judicious and integrated use of available organic sources of plant nutrients along with inorganic fertilizers. Dubey and Verma (1999) observed that integrated use of organics and fertilizers improved soil fertility and produced synergetic effect on the yield of crops on coastal soils. Prasad *et al.* (1984) reported that besides addition of nutrients to soil the application of organic manures enhanced release of native sources of nutrients and reduced fixation of nutrients in soil. Similar observation was also recorded by Reddy and Reddy (1998). Bandyopadhyay and Rao (2001) observed that integrated nutrient management using inorganic, organic and microbiological sources of nutrients improved fertilizer use efficiency and soil quality leading to sustainable higher yield of crops in saline soils. The present experiment was, therefore, conducted simultaneously on the coastal saline soils of different coastal states in India with an objective of developing integrated nutrient management practices for the coastal saline soils.

MATERIALS AND METHODS

Field experiments were conducted simultaneously on the identified hot spot soils in the coastal regions of four coastal states on the east coast of the country, viz. West Bengal, Orissa, Andhra Pradesh and Tamil Nadu. The location of the experimental sites were: Canning (South 24

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Parganas district) in West Bengal, Gadakujang (Jagatsingpur district) in Orissa, Ghantasala (Krishna district) in Andhra Pradesh, Vallapallam (Nagapattinam district) in Tamil Nadu. The salient characteristics of the hot spot soils at the experimental sites are presented in Table 1.

The field experiments at all the locations were conducted both in *kharif* and *rabi* seasons under split-plot design with 8 main plot treatments, 2 subplot treatments and 4 replications. The main plot treatments (T) comprised of inorganic nitrogen (urea) alone and combined sources of inorganic and organic sources (use of locally available organic sources and waste materials were stressed) of nitrogen. The 2 subplot treatments (B) were: without biofertiliser (B_0) and with biofertiliser (B_1 : *Azotobacter* and *Azospirillum* in equal proportions). The details of the treatments at different experimental sites are given in Table 2.

The experimental areas were under rice-based cropping system, and hence rice (Oryza *sativa*) was grown as test crop during *kharif* (2001 and 2002) on all the experimental sites. In *kharif* both the organic sources and inorganic sources of N, as treatments, were applied along with the recommended basal doses of P and K for the area. Micronutrients were not applied since the soils were rich in micronutrients. In choosing the organic sources the locally available sources/waste materials were given priority. In the following *rabi* season (2001-02 and 2002-03) the residual effect of organic sources of nutrients applied in *kharif* were tested. Thus, in *rabi* season no organic sources of N were applied, only the inorganic sources of N were applied as the treatments. The subplot treatments (with or without biofertilizers) were applied in both the seasons. In *rabi*, the test crops in the experimental sites were different, since the test crops were selected in accordance with the dominant crop sequences followed in the area after rice in *kharif*. The crops grown in *rabi* at different sites were: chilli (*Capsicum annum)* and lady's finger (*Abelmoschus esculentus)* in West Bengal, rice in Orissa, black gram (*Vigna mungo*) in Andhra Predesh and rice in Tamil Nadu. The details of the treatments in *kharif* and *rabi* seasons are given in Table 2.

Soil samples collected after the harvest of crops were analyzed for salinity, pH, and available N, P, K following standard methods (Black, 1965). Microbial biomass carbon (MBC) of soil was determined by fumigation extraction method as described by Joergensen (1995). The dehydrogenase activity of soil was determined following the method of Casida *et al.* (1964).

Subplot treatments in *kharif and rabi* were as follows:

B_0: Without biofertilizer

B_1: With biofertilizer (*Azotobacter* and *Azospirillum* in equal proportions)

RESULTS AND DISCUSSION

Yield of crop (rice) in *kharif*

The data on grain yield of rice (Table 3) in *kharif* indicated that the yield of rice was, in general, better in treatments where combined sources of organic and inorganic nitrogen were applied compared to farmers' practice (T_1) and full dose of N (T_2). The trend was similar at all the experimental sites. At Canning the application of green leaf (T_5) emerged as the best treatment producing significantly higher yield of grain over full dose of N (T_2). There was however no significant difference among the organic matter treatments (T_4-T_8). Biofertilizer application (B_0 and B_1), however, was not found significant. Lowest yield of rice was recorded under control (T_1). T_5 (leaves of locally available trees + urea) emerged as very effective treatment at all the experimental sites except in Orissa where T_4 (*Sesbania* + urea) emerged as the best treatment. Application of biofertilzers showed significant positive effect on the yield of rice at Vallapallam but it was not significant at other locations.

***Table 1**. Salient characteristics of hot spot soils at different experimental sites in the coastal region*

Characteristics	West Bengal	Andhra Pradesh	Tamil Nadu	Orissa
Texture	Sic-sicl	Sicl	l-sic	sl
pH	6.5	8.1	7.8	5.7
CEC (mmol p^+kg^{-1})	17.0	43.5	9.2	9.1
ECe (dSm^{-1})	7.8	4.9	4.2	6.4
ESP	15	9.2	22.0	10.3
Org. C (%)	0.8	0.7	0.4	0.9

Table 2. *Details of treatments at different experimental sites*

Treatment	West Bengal		Orissa		Andhra Pradesh		Tamil Nadu	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1: Farmers' practice (urea in 1 split)	20 kg N ha^{-1}	20 kg N ha^{-1}	0 kg N ha^{-1}	0 kg N ha^{-1}	60 kg N ha^{-1}	0 kg N ha^{-1}	50 kg N ha^{-1}	50 kg N ha^{-1}
T_2: Full Recommended dose of N (urea in 3 splits)	100 kg N ha^{-1}	120 kg N ha^{-1}	50 kg N ha^{-1}	30 kg N ha^{-1}	80 kg N ha^{-1}	20 kg N ha^{-1}	150 kg N ha^{-1}	150 kg N ha^{-1}
T_3: Half of Recommended dose of N (urea in 3 splits)	50 kg N ha^{-1}	60 kg N ha^{-1}	25 kg N ha^{-1}	15 kg N ha^{-1}	40 kg N ha^{-1}	10 kg N ha^{-1}	75 kg N ha^{-1}	75 kg N ha^{-1}
T_4: Locally available organic source/ waste materials @ 5 t ha^{-1} (on fresh wt. basis) + urea (3 splits) to make full recommended dose of N (T_2)	*Sesbania* + urea	Do	*Sesbania* + urea	Do	*Sesbania* + urea	Do	*Sesbania* + urea	Do
T_5: Do	Leaves of local trees** + urea	Do	Leaves of local trees (*Ipomoea*) + urea	Do	Leaves of local trees (Glyricidia) + urea	Do	Leaves of local trees (*Derris indica*) + urea	Do
T_6: Do	FYM + urea	Do	FYM + urea	Do	FYM + urea	Do	FYM + urea	Do
T_7: Do	Azolla + urea	Do	USG	USG 30kg N ha^{-1}	Azolla + urea	Do	Azolla + urea	Do
T_8: Do	City Compost + urea	Do	-	-	Press mud + urea	Do	Spent wash + urea	Do

** Equal mixture of *Glyricidia sp., Delonix sp.* and Geon (*Exoecaria agallocha*)

Table 3. *Grain yield of rice (t ha^{-1}) in* kharif *at different locations (pooled over 2 years)*

Treatment	Canning (WB)	Gadakujang (Orissa)	Ghantasala (AP)	Vallapallam (TN)
T_1	3.11	4.62	3.96	4.17
T_2	4.04	4.95	4.36	4.76
T_3	3.66	4.89	3.54	4.76
T_4	4.26	5.52	4.45	5.08
T_5	4.30	5.04	4.83	5.51
T_6	4.24	4.84	4.45	4.87
T_7	4.29	4.94	4.23	4.87
T_8	4.23	-	4.27	4.82
CD at p=0.05	0.17	0.24	0.25	0.21
B_0	4.03	5.04	4.19	4.80
B_1	4.16	4.90	4.34	4.91
CD at p=0.05	NS	NS	NS	0.08

NS = Non-significant

Root density of rice

The data indicated that the root growth of rice in *kharif* improved considerably (Fig. 1) due to the application of organic sources of nutrients as compared to inorganic treatments alone (T_1-T_3). Better growth of roots might have resulted in the better yield of crops than those under inorganic source supplemented treatments (T_4-T_8).

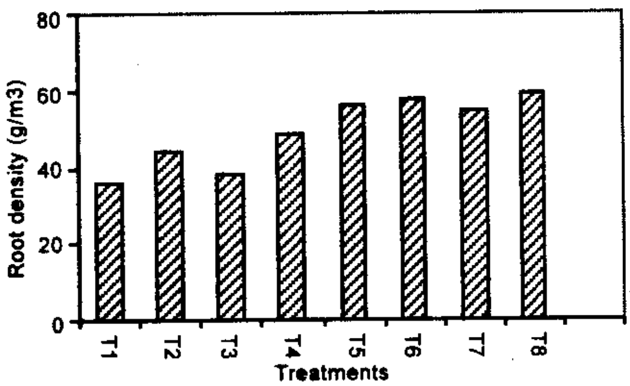

Fig. 1. Root density of rice at different treatments in *kharif* (Canning)

Yield of crops in *rabi* season

The residual effect of organic sources of nutrients on yield of different crops in the *rabi* season was also significant over farmers' practice (T_1), half dose of N treatment (T_3), and even over the full dose of N treatment (T_2). As the trend was similar in all the states, the data for West Bengal (Canning) only are presented here (Table 4) for discussion. The data on the yield of both chilli and lady's finger (*rabi* 2002-03) revealed that the yield of both the crops was highest due to the residual effect of green leaf (T_5) + urea and significantly higher than other treatments. The treatments of residual effect of *sesbania* (T_4) + urea, those of city compost (T_8) + urea, FYM (T_6) + urea and azolla (T_7) + urea showed significant higher yield of both the crops over other solely inorganic source of N applied treatments (T_1-T_3). However, the impact of the treatments with residual effect of organic sources (T_4- T_8) differed among themselves in increasing the yield of crops. Unlike *kharif* season the application of biofertilizer (*Azotabacter* and *Azospirillum*) was found to have a significant positive effect on the yield of crops. However, the interaction effects of biofertilizer and treatments (BxT) were not significant.

Available N, P and K status of soil

There was a general increase in the available N content of soils in all the treatments where combined sources of N (T_4-T_8) were applied (Table 5). The available P status of soil also showed significant improvement in inorganic + organic treated plots (T_4-T_8) at all the locations compared to inorganic N treatments (T_1-T_3). The results, thus, corroborate with the observations of Prasad *et al.* (1984) that application of organic sources of nutrients enhanced the release of natural sources of nutrients. The soil of Ghantasala (AP) was deficient in P but the available P status of soil increased considerably due to application of combined sources of nutrients. However, the effect of the organic sources on increasing the available P content of soil differed according to the sources used. At Canning, the available K content of soil was not influenced significantly due to the application of any of the treatments but at Ghantasala and Vallapallam the available K content of soil increased significantly when both the inorganic and organic sources of nutrients were applied alone and in combination. The findings, thus, support the observation of Dubey and Verma (1999) who observed that combined application of organic and inorganic sources of nutrients improved soil fertility and produced synergistic effect on yield of crops.

Table 4. *Yield (t ha^{-1}) of lady's finger and chilli (fruit) at Canning in* rabi *season (2002-03)*

Treatment	Lady's finger			Chilli (green)		
	B_0	B_1	Mean	B_0	B_1	Mean
T_1	6.20	8.56	7.38	1.03	1.52	1.28
T_2	7.60	10.05	8.83	1.26	1.80	1.53
T_3	6.79	9.60	8.20	1.15	1.47	1.31
T_5	8.57	10.43	9.50	1.64	2.12	1.88
T_6	8.33	9.78	9.06	1.42	1.78	1.60
T_8	8.54	9.90	9.22	1.50	1.81	1.66
Mean	7.67	9.72	8.70	1.33	1.75	1.54
CD at p=0.05						
B	0.061			0.055		
T	0.072			0.064		
B x T	NS			NS		

NS = non-significant

Table 5. *Available nutrients in soil after the harvest of* rabi *crop of second year experiment at different locations*

Treatments	Canning, WB			Ghantasala, AP			Vallapallam, TN		
	N	P	K	N	P	K	N	P	K
T_1	261.0	16.8	520	260.1	5.7	355.2	157.8	15.6	352.6
T_2	266.4	17.0	518	299.9	6.5	382.2	166.2	18.5	362.8
T_3	263.9	17.1	522	220.9	5.4	348.4	165.7	16.6	359.8
T_4	287.3	17.9	516	268.6	6.6	403.5	172.4	19.5	366.5
T_5	296.7	17.9	520	295.1	7.9	412.6	184.3	23.2	363.1
T_6	283.2	18.6	515	273.2	7.7	393.0	181.0	18.2	364.8
T_7	290.1	18.3	520	262.9	7.3	376.4	175.6	16.2	362.6
T_8	293.5	18.3	518	267.1	7.4	384.6	180.3	19.2	374.3
CD at p=0.05	11.5	0.9	NS	10.5	0.40	7.9	1.2	0.7	2.4

Soil microbiological parameters

The soil samples collected at harvesting stage of rice were analyzed for various microbiological parameters, namely microbial biomass carbon and dehydrogenase activity to indicate the total microbial activity in soil, which in turn, indicated the overall soil health status. Organic matter supplemented treatments, on the whole, were found better with regard to soil microbial activity (Table 6). City compost + urea (T_5) emerged as the best among all the treatments in terms of all the microbial parameters in case of Canning soil. The findings of these experiments, thus, agree the views of Bandyopadhyay and Rao (2001) that integrated application of organic and inorganic sources of nutrients to saline soils improved the soil quality, which might lead to sustainable higher yield of crops.

Table 6. *Dehydrogenase activity (μg TPF g^{-1} h^{-1}) after harvest of rabi crop and microbial biomass carbon in soil (pool of 2 years' data)*

Treatment	Dehydrogenase activity (ug TPF g^{-1} h^{-1})		MBC (ug g^{-1} h^{-1})
	Canning WB	Ghantasala, AP	Canning, WB
T_1	2.22	19.5	106
T_2	3.48	21.1	145
T_3	2.72	18.2	126
T_4	3.84	22.1	158
T_5	4.55	20.1	193
T_6	3.76	22.1	177
T_7	4.27	19.5	178
T_8	4.00	22.0	247
CD at p=0.05	0.09	1.3	10.26

REFERENCES

Bandyopadhyay, B.K. and Rao, D. L. N. (2001). Integrated plant nutrient management in saline soil. *Journal of the Indian Society of Coastal Agricultural Research* **19**: 35-58.

Black, C.A. (1965). In *Methods of Soil Analysis*, Part-II. American Society of Agronomy, Madison, Wisconsin, USA

Casida, L. E. Jr., Klein, D. A. and Santoro, T. (1964). Soil dehydrogenase activity. *Soil Science* **98**: 371-376.

Dubey, R. P. and Verma, B. S. (1999). Integrated nutrient management in rice-rice-cowpea sequence under humid tropical Andaman islands. *Indian Journal of Agronomy* **44**: 73-76.

Joergensen, R. G. (1995). Microbial biomass. In *Methods in Microbiology and Biochemistry*, K. Alef and P. Nannipieri (eds.), pp. 380-386. Academic Press, London, UK.

Prasad, B., Singh, A. P. and Singh, M. K. (1984). Effect of poultry manure as source of zinc, iron and as a complexing agent on zinc and iron availability and crop yield in a calcareous soil. *Journal of the Indian Society of Soil Science* **32**: 519-521.

Reddy, G. B. and Reddy, S. M. (1998). Effect of organic manures and nitrogen levels on soil available nutrient status in maize-soybean cropping system. *Journal of the Indian Society of Soil Science* **46**: 474-476.

Suvarna Latha, A. J. and Sankara Rao,V. (2001). Integrated use of fertilizers and poultry manure on nutrient availability and yield of rice. *Journal of the Indian Society of Coastal Agricultural Research* **19**: 153-157.

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Integrated Nutrient Management and Planting Density on the Productivity of Rice in Coastal Ecosystem

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An experiment was conducted at Cropping Research Centre, Karamana for four consecutive seasons from 2001-02 to 2002-03 to evaluate the influence of farmyard manure, fertilizers and plant density on rice yield in the coastal rice ecosystem. The study was conducted in a split plot design with the combination of manures and fertilizers in the main plot and plant density in the subplot. A linear increase in rice yield was noticed with an increase in recommended dose of fertilizer (RDF) above 25 or 50%. Manuring of FYM @ 5 t ha^{-1} and plant density of 33 and 50 hills per square meter during *kharif* and *rabi* seasons registered significant yield improvement. The soil fertility status was not appreciably influenced by the treatments. The economic analysis revealed that a commensurate benefit was not achieved by increasing fertilizers above the RDF or by manuring due to the high cost of these inputs.

***(Key words** : Rice, Integrated nutrient management, Planting density)*

Rice area in Kerala has declined from 32 percent in 1974-75 to about 10 percent during 2001-02 and has caused irreversible transformation to the fragile coastal ecosystem of the state. Rice-rice sequential cropping is the major cropping system prevailed in the coastal ecosystem. The crop removal of nutrients is much higher than its addition in such area. Long term fertilizer experiments conducted at different ecosystems have clearly revealed that the combined application of organic manures and chemical fertilizers into the soil leads to an increase in productivity and sustains soil health for a longer period (Nambiar, 1994). Organic source of nutrient applied to the preceding crop benefits the succeeding crop to a great extent (Hegde and Dwivedi, 1992). Since organic source cannot meet the total nutrient requirement of modern agriculture integrated use of nutrient seems to be an alternate option. Lack of plant density is another major constraint noticed in the farmers field in achieving the targeted yield. Hence, a study was conducted with a view to the optimise combination of organic and inorganic sources of nutrients and plant density in a rice-rice cropping system.

MATERIALS AND METHODS

The experiment was conducted at the Cropping Systems Research Centre of Kerala Agricultural University, Karamana during the consecutive *kharif* and *rabi* seasons from 2001-02 to 2002-03. The soil of the experimental field belongs to very deep type tropofluvents, sandy clay loam in texture with a pH of 5.5, organic carbon of 0.69%, and 11.2 and 48.5 kg ha^{-1} available phosphorus and potassium, respectively. The area enjoys a bimodal rainfall from mid-May to the end of November with a total rainfall of 1700 mm per annum. The experiment was laid out in a split plot design, replicated thrice, keeping combination of fertilizer and manure (FYM) levels in the main plot and plant density in the subplot. The fertilizer level included the recommended dose of fertilizers (RDF) of 90:45:45 kg ha^{-1} of NPK as F1 and 125 and 150 percent of RDF as F2 and F3, respectively with no manure control (M0). FYM @ 5 t ha^{-1} and 7.5 t ha^{-1} (M1 and M2, respectively) was applied during *kharif* season as other treatments in the main plots. The subplot treatments comprise of three plant densities, viz. 25, 33 and 41 hills per square meter and 41, 50 and 63 hills per square meter as D1, D2 and D3 during *kharif* and *rabi* seasons, respectively. The test variety was Aiswarya, a medium duration rice variety resistant to blast and blight disease, and BPH. All other operations were done as per the package of practices recommended by Kerala Agricultural University.

RESULTS AND DISCUSSION

Rice yield

The rice productivity was remarkably higher during *kharif* season and an increase of 31.1% in grain yield was noticed over *rabi* season (Table 1). Though the biometric characters did not vary between the seasons the partitioning of accumulated dry matter varied considerably due to the rainfall pattern. The later part of the crop growth period received very little rainfall.

Table 1. *Yield of rice (kg/ha) as influenced by fertilizers, manure and plant density*

Fertilizer combinations	Kharif			Rabi		
	2001-02	2002-03	Pooled mean	2001-02	2002-03	Pooled mean
F1	4033	4059	4046	3352	2876	3114
F2	4225	4362	4294	3444	3146	3295
F3	4475	4485	4480	3474	3268	3371
CD(p=0.05)	123.3	66.8	92.1	54.7	41.0	49.1
Manures						
M0	3909	4212	4061	3223	3045	3134
M1	4326	4321	4324	3487	3163	3325
M2	4498	4372	4435	3559	3081	3320
C.D(p=0.05)	123.3	66.8	92.1	54.7	41.0	49.1
Plant density						
D1	4205	4217	4221	3333	3051	3192
D2	4362	4449	4406	3552	3201	3377
D3	4166	4240	4203	3405	3037	3221
C.D(p=0.05)	67.1	38.2	50.1	49.9	25.1	38.2

Table 2. *Soil nutrient status during* kharif *and* rabi *seasons of 2002-03*

Fertilizer combinations	Kharif			Rabi		
	Org. carbon %	P (kg/ha)	K (kg/ha)	Org. carbon %	P (kg/ha)	K (kg/ha)
F1	0.71	12.25	45.79	0.68	12.11	50.27
F2	0.70	10.82	47.97	0.68	11.37	55.20
F3	0.70	11.80	48.54	0.68	11.38	53.42
CD(p=0.05)	NS	NS	NS	NS	NS	NS
Manures						
M0	0.69	12.12	45.20	0.68	12.10	54.31
M1	0.71	11.12	47.93	0.69	11.42	51.97
M2	0.71	11.63	49.17	0.69	11.34	52.61
C.D(p=0.05)	0.01	NS	NS	NS	NS	NS
Plant density						
D1	0.70	11.51	49.76	0.69	11.80	51.57
D2	0.70	11.43	47.95	0.68	11.57	52.99
D3	0.7	11.92	44.59	0.68	11.49	54.33
C.D(p=0.05)	NS	NS	NS	NS	NS	NS

The increased level of RDF showed a linear response in grain yield during the *kharif* and *rabi* seasons indicating that present RDF was not sufficient to attain enhanced yield under continuous cropping of rice. A similar trend of yield due to higher nutrient application above the present RDF was reported from the various centres of AICRP on cropping systems (Anon., 2003).

The effect of manuring either at 5 or 7.5 t ha^{-1} during *kharif* and its influence during *rabi* season indicate that its impact was appreciable on grain yield over no manuring. It is also evident that there was no variation in yield between the two levels of manuring.

Among the three plant densities tried 33 and 50 hills per square meter during *kharif* and *rabi* seasons recorded appreciably higher yield over lower plant densities.

Soil fertility

The influence of treatments on soil fertility status at the end of *kharif* and *rabi* seasons of 2002-03 are given in Table 2. The organic carbon content of FYM applied treatments recorded a significant

Table 3. *Economics of effect of treatments on rice yield (pooled mean of four seasons)*

Fertilizer combinations	*Kharif*			*Rabi*		
	Fixed cost (Rs/ha)	Variable cost (Rs/ha)	Total cost (Rs/ha)	Gross Income (Rs/ha)	Net Income (Rs/ha)	B:C ratio
F1	19790	2506	24816	33160	8344	1:1.34
F2	19790	3307	25617	33986	8369	1:1.33
F3	19790	4014	26324	34704	8380	1:1.32
Manures						
M0	23065	-	23065	33654	10589	1:45
M1	23065	2520	25585	634312	9277	1:37
M2	23065	5040	28105	36712	8607	1:31
Plant density						
D0	18785	6560	25345	33652	8307	1:1.33
D1	18785	6800	25585	34290	8705	1:1.34
D2	18785	7040	25825	33509	7684	1:1.30

improvement over control during the *kharif* seasons. Variation in fertilizers, manure and plant population did not influence the soil fertility after two year period of experimentation.

Economics

An increase in RDF recorded a slight increase in net income. However the B:C ratio indicated a reverse trend indicating that a commensurate benefit on additional expenditure due to increased application of fertilizer was not attainable. In case of manuring the net income and B:C ratio was less as compared to no manuring treatment which indicated that short term benefit in yield was not attainable through manuring. The plant density clearly revealed that either the recommended plant population or its lower level was economically viable based on the data on net income and B:C ratio (Table 3).

REFERENCES

Anon. (2003). *Annual Report*, AICRP, PDCRS. Project Directorate for Cropping Systems Research. Modipuram, Meerut.

Hegde, D.M. and Dwivedi, B.S. (1992). Nutrient management in rice-wheat cropping system in India. *Fertiliser News* **37**: 27-41.

Nambiar, K.K.M. (1994). *Soil Fertility and Crop Productivity under Long Term Fertilizer Use in India*. ICAR, New Delhi.144p.

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Yield, Soil Properties and Quality of Coleus (*Coleus forskohlii* briq.) Influenced by Organics and Inorganics in the Coastal Thoothukudi District of Southern Tamil Nadu

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The medicinal coleus is gaining momentum among the farmers of coastal districts of Southern Tamil Nadu especially in dry tracts due to its high export potential. A field experiment was conducted in the Alfisol during 2004-05 to study the effect of organics and inorganics on the yields, quality of Coleus (*Coleus forskohlii* Briq.) and soil fertility in the coastal Thoothukudi district. The experiment was laid out on a randomized block design with two factors, *viz.* fertilizers and manures. The levels of fertilizer were 0, 50% and 100% NPK. The organic manure treatments were control, vermicompost @ 5 t ha^{-1}, bio-pressmud @ 7.5 t ha^{-1}, composted coirpith @ 12.5 t ha^{-1}, poultry manure @ 5 t ha^{-1}, and farmyard manure @ 10 t ha^{-1}. The result revealed that the highest oil content (0.83 %) was recorded with the application of poultry manure alone @ 5 t ha^{-1}. However, the highest yield of essential oil, tuberous roots and shoot biomass per hectare was obtained with the combined application of 100 % NPK + poultry manure @ 5 t ha^{-1}. The soil available N increased due to the application of 100 % N, P, K fertilizer along with poultry manure @ 5 t ha^{-1}. However, marginal increase was observed with soil available P and K. The highest soil organic carbon was registered with the application of composted coirpith at the rate of 12.5 t ha^{-1}. The maximum benefit-cost ratio of 3.73 was registered with the combined application of 100 % NPK along with poultry manure @ 5 t ha^{-1}.

(**Key words** : *Coleus, Organic manures, Inorganic fertilizers, Crop yield, Oil content & yield, Soil properties*)

In Tamil Nadu medicinal coleus is grown in an area of about 600 ha with the total production of 1000 tonnes of dried tuberous roots. The dry climatic condition prevailing in the coastal tracts is conducive for growing this crop. Therefore a field experiment was taken up to find out the influences of organics and inorganics on the yield of coleus (*Coleus forskohlii*) crop, changes in soil fertility status and economics in the coastal Thoothukudi district of southern Tamil Nadu.

MATERIALS AND METHODS

Field experiment was conducted in 2004-05 on sandy clay loam soil, classified under Typic Haplustalf. The soil was low in CEC {18.3 cmol (p$^+$) kg^{-1}}. The fertility status of the soil was low with respect to organic carbon (0.40 %), available N (191 kg ha^{-1}) and P (10.6 kg ha^{-1}) status. The available K (230 kg ha^{-1}) status was medium.

The treatment details are: M_0F_0 – Control, M_0F_2 -100% NPK (40: 60: 50 kg ha^{-1}), M_1F_0- Vermicompost @ 5 t ha^{-1}, M_1F_1- Vermicompost @ 5 t ha^{-1} + 50% NPK, M_1F_2- Vermicompost @ 5 t ha^{-1} + 100% NPK, M_2F_0 - Bio-pressmud @ 7.5 t ha^{-1}, M_2F_1- Bio-pressmud @ 7.5 t ha^{-1} + 50% NPK, M_2F_2 - Bio-pressmud @ 7.5 t ha^{-1} + 100% NPK, M_3F_0 - Composted coirpith @ 12.5 t ha^{-1}, M_3F_1 - Composted coirpith @ 12.5 t ha^{-1} + 50% NPK, M_3F_2 - Composted coirpith @ 12.5 t ha^{-1} + 100% NPK, M_4F_0 - Poultry manure @ 5 t ha^{-1}, M_4F_1 - Poultry manure @ 5 t ha^{-1} + 50% NPK, M_4F_2 - Poultry manure @ 5 t ha^{-1} + 100% NPK, M_5F_0 - Farmyard manure @ 10 t ha^{-1}, M_5F_1 - Farm yard manure @ 10 t ha^{-1} + 50% NPK, M_5F_2 - Farmyard manure @ 10 t ha^{-1} + 100% NPK. The organic manures, *viz.* Vermicompost, Bio-pressmud, Composted coirpith, Poultry manure and Farmyard manure were applied and incorporated in the respective plots seven days prior to planting as per pre-determined design at scheduled rates.

The recommended dose of NPK @ 40:60:50 kg ha^{-1} was applied in the form of urea (46% N), single superphosphate (16% P_2O_5) (SSP), and muriate of potash (60% K_2O) (MOP). Fifty percent of recommended dose of N was applied at 20 days after planting and the rest at 30 days after first application. The full dose of P & K was applied as basal dressing. The yield of tuberous root and shoot biomass were recorded at harvest. The soil fertitity status was also studied after the harvest of the crop by adopting standard procedures. The essential oil content in tuberous roots was estimated by hydro-distillation in Cocking and Middleton apparatus.

RESULTS AND DISCUSSION

Tuberous roots yield

The application of inorganic fertilizers showed significant influence on the yield of tuberous roots (Table 1). The significantly highest yield of tuberous roots (13.0 t ha^{-1}) was recorded with the application of 100 percent recommended dose of NPK fertilizer. The different organic manures also showed significant influence on the yield of tuberous roots. The application of poultry manure @ 5 t ha^{-1} recorded significantly highest yield of tuberous roots (13.5 t ha^{-1}). The interaction effect of fertilizers and manures also showed significant influence on the yield of tuberous roots. The significantly highest yield of 17.3 t ha^{-1} was obtained with the application of 100 percent recommended dose of NPK fertilizers along with poultry manure @ 5 t ha^{-1}. The significant effect was due to combined application of organics and inorganics might be due to higher photosynthates produced by the crop. The poultry manure along with inorganic NPK fertilizers application increased the plant height and number of laterals per plant, thereby enhanced the photosynthetic activity. Similar findings was also reported by Sundharaiah *et al.* (2000) and Nair and Mohandas (2003). Dutt (1999) while supporting this idea stated that reason for increased productivity by organic manure application was due to its richness in plant nutrient status including micronutrients and plant growth hormones.

Table 1. *Effect of organics and inorganics on the yield (t ha^{-1}) of tuberous roots and shoot biomass in coleus*

Tuberous roots yield

	Treatments	Control (F_0)	50% NPK (F_1)	100% NPK (F_2)	Mean
M_0	Control	5.50	6.60	8.80	6.97
M_1	Vermicompost @ 5 t ha^{-1}	7.50	10.3	12.7	10.2
M_2	Bio-pressmud @ 7.5 t ha^{-1}	7.50	11.1	15.5	11.3
M_3	Composted coirpith @ 12.5 t ha^{-1}	6.70	8.20	12.3	9.23
M_4	Poultry manure @ 5 t ha^{-1}	8.35	14.8	17.3	13.5
M_5	Farmyard Manure @10 t ha^{-1}	7.10	9.20	11.1	9.12
	Mean	7.11	10.1	13.0	

	SEm±	CD (at p=0.05)
M	0.42	0.9
F	0.30	0.6
MxF	0.74	1.55

Shoot biomass yield

	Treatments	Control (F_0)	50% NPK (F_1)	100% NPK (F_2)	Mean
M_0	Control	33.4	40.3	46.1	39.9
M_1	Vermicompost @ 5 t ha^{-1}	42.1	57.3	65.7	55.0
M_2	Bio-pressmud @ 7.5 t ha^{-1}	42.7	59.4	71.5	57.9
M_3	Composted coirpith @ 12.5 t ha^{-1}	37.3	48.4	65.0	50.2
M_4	Poultry manure @ 5 t ha^{-1}	44.2	68.0	71.9	61.3
M_5	Farmyard Manure @10 t ha^{-1}	41.7	51.6	61.3	51.5
	Mean	40.2	54.1	63.5	

	SEm±	CD (at p=0.05)
M	2.04	4.3
F	1.44	3.0
MxF	3.53	7.4

Shoot biomass yield

The significant influence of shoot biomass yield was noticed with the application of organic manures and NPK fertilizers (Table 1). The significantly highest shoot biomass yield of 63.5 t ha^{-1} recorded due to the application of 100 percent recommended dose of NPK fertilizers was followed by 50 percent recommended dose of NPK fertilizers (54.1 t ha^{-1}). The application of organic manures also significantly increased the shoot biomass yield from 39.9 t ha^{-1} to 61.3 t ha^{-1}. The highest shoot biomass yield of 61.3 t ha^{-1} was obtained with the application of poultry manure @ 5 t ha^{-1} which was at par with the application of bio-pressmud @ 7.5 t ha^{-1} (57.9 t ha^{-1}). The interaction of fertilizers and manures also showed significant influence on the shoot biomass yield. The highest yield of 71.9 t ha^{-1} was obtained with the application of 100 percent recommended dose of NPK along with poultry manure @ 5 t ha^{-1}. Increased availability of macro and micronutrients by organic manures for better growth is considered to be the reason for the enhanced yield. Smith (1950) stated that nearly 60 percent of the nitrogen is present as uric acid in poultry manure, which readily changes to ammoniacal form of nitrogen and becomes available to plant. This resulted in increased growth and yield of plants. Further, the ready supply of macronutrients from NPK fertilizer promoted higher yield.

Essential oil content and yield

The application of NPK fertilizers and organic manures showed significant influence on yield of essential oil in coleus (Table 2). The application of poultry manure @ 5 t ha^{-1} recorded the highest essential oil yield of 18.3 lit ha^{-1}. Among the fertilizers, 100% recommended dose of NPK fertilizers recorded

Table 2. *Effect of organics and inorganics on yield of essential oil in coleus and soil organic carbon*

Essential oil yield (lit ha^{-1})

Treatments		Control (F_0)	50% NPK (F_1)	100% NPK (F_2)	Mean
M_0	Control	4.59	8.09	9.10	7.26
M_1	Vermicompost @ 5 t ha^{-1}	10.5	11.7	14.0	12.0
M_2	Bio-pressmud @ 7.5 t ha^{-1}	9.78	13.2	16.9	13.3
M_3	Composted coirpith @ 12.5 t ha^{-1}	8.28	9.87	13.2	10.4
M_4	Poultry manure @ 5 t ha^{-1}	12.4	18.0	24.7	18.3
M_5	Farmyard Manure @10 t ha^{-1}	9.10	10.5	11.5	10.4
	Mean	9.09	11.9	14.9	

	SEm±	CD (at p=0.05)
M	0.86	1.8
F	0.61	1.3
MxF	1.48	3.1

Soil organic carbon (%)

Treatments		Control (F_0)	50% NPK (F_1)	100% NPK (F_2)	Mean
M_0	Control	0.269	0.300	0.331	0.300
M_1	Vermicompost @ 5 t ha^{-1}	0.396	0.363	0.363	0.374
M_2	Bio-pressmud @ 7.5 t ha^{-1}	0.363	0.394	0.394	0.384
M_3	Composted coirpith @ 12.5 t ha^{-1}	0.460	0.457	0.474	0.464
M_4	Poultry manure @ 5 t ha^{-1}	0.393	0.410	0.443	0.415
M_5	Farmyard Manure @10 t ha^{-1}	0.363	0.410	0.394	0.389
	Mean	0.374	0.389	0.400	

	SEm±	CD (at p=0.05)
M	0.02	NS
F	0.01	0.03
MxF	0.03	NS

highest yield of 14.9 lit ha^{-1}. In the interaction effect, the 100% recorded dose of NPK+ poultry manure @ 5 t ha^{-1} recorded highest yield of 24.7 lit ha^{-1}. This could be attributed to the better use efficiency of nutrients as reported by Singh *et al.* (1973). However, the result revealed that the highest oil content (0.83%) was recorded with the application of poultry manure alone @ 5 t ha^{-1}. The maximum benefit-cost ratio of 3.73 was registered with the combined application of 100% NPK with poultry manure @ 5 t ha^{-1}.

Soil properties

The application of different organic manures showed significant influence on the soil organic carbon (Table 2). The values ranged from 0.30 to 0.46 percent. The composted coirpith registered significantly higher soil organic carbon content (0.46 percent) than the other treatments. This was followed by poultry manure (0.42 percent) application. The highest organic carbon was obtained under highest application of coirpith @ 12.5 t ha^{-1}. Similar result was obtained by Paramasivan (2002). The soil available N was increased by the application of 100% N, P, K fertilizer along with poultry manure @ 5 t ha^{-1}.

Srivastava (1985) opined an appreciable increase in soil available nutrients with the application of poultry manure and its performance was better than the FYM. Further, the combined application of 100% NPK with poultry manure reduced the loss of inorganic fertilizers due to chelation and immobolisation, which favoured slow and steady release as reported by Kale *et al.* (1992).

The highest benefit-cost ratio was recorded in 100 percent recommended dose of NPK fertilizers along with poultry manure @ 5 t ha^{-1}. The increased yield of tuberous roots due to the better nutrient availability recorded with the above treatment could be the reason as stated by Talashilkar *et al.* (1997).

REFERENCES

Dutt Chalsani (1999). Coconut farming-growing the organic way. *Agriculture and Industry Survey* **IX**(6): 22.

Kale, R.D., Bano, K., Sreenevasan, M.N. and Bhagyaraj, D.J. (1992). Influence of warm cast on the growth and mycorhizal colonization of two ornamental plants. *South Indian Horticulture* **35**: 433-437.

Nair, G.M. and Mohandas, C. (2003). Agronomic investigation on the growth and yield of Coleus (*Solenostemon rotundifolius*). In *Annual Report*, CTCRI, pp. 45-47.

Paramasivam, M. (2002). Effect of organic manure and inorganic manure on soil properties, yield and quality of bhendi in alfisols of Tamiraparani tract. *M.Sc.(Ag.) Thesis*, Tamil Nadu Agricultural University, Killikulam.

Singh, K., Gill, I.S. and Srivastava, O.P. (1973). Studies on poultry manure in relation to vegetable production in potato. *Indian Journal of Horticulture* **30**: 537-541.

Smith, R. (1950). Poultry manure- a fertilizer. *Poultry Digest* **9**: 550-551.

Srivastava, O.P. (1985). Role of organic matter in soil fertility. *Indian Journal of Agricultural Chemistry* **18**: 10-15.

Sundharaiya , K., Nainar, P., Ponnuswami, V., Jaya jasmine, A. and Muthuswami, M. (2000). Effect of inorganic nutrients and spacing on the yield of marunthukathiri (*Solanum khasianum* Clarke). *South Indian Horticulture* **48**(1-6): 168-171.

Talashilkar, S.C., Dosani, A.A.K., Mehta, V.B. and Powar, A.G. (1997). Integrated use of fertilizers and poultry manure to groundnut crop. *Journal of Maharastra Agricultural University* **22**(2): 205-207.

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The Effect of Azolla and Blue Green Algae on Yield of Rice and Subsequent Crops on Coastal Saline soils

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In field experiments on coastal saline soils of Sundarbans, West Bengal azolla (Azolla microphylla) and blue green algae (Nostoc sp.) were applied to rice (cv. Swarna) in *kharif* at different doses of inorganic N fertilizer (20, 50, 100 kg N ha^{-1} as urea). The various treatments were T_1: 20 kg N ha^{-1} applied as basal; T_2: 20 kg N ha^{-1} (basal) + azolla @ 1 t ha^{-1} (fresh weight basis); T_3 : 20 kg N ha^{-1} (basal) + azolla @ 1 t ha^{-1} + blue green algae (*Nostoc* sp.) inoculated in soil; T_4 : 50 kg N ha^{-1} (3 splits); T_5: 50 kg N ha^{-1} (3 splits) + azolla @ 1 t ha^{-1} (fresh weight basis); T_6: 50 kg N ha^{-1} (3 splits) + azolla @ 1 t ha^{-1} (fresh weight basis) + blue green algae (*Nostoc* sp.) inoculated in soil; T_7 : 100 kg N ha^{-1} (3 splits); T_8: 100 kg N ha^{-1} (3 splits) + azolla @ 1 t ha^{-1} (fresh weight basis); T_9: 100 kg N ha^{-1} (3 splits) + azolla @ 1 t ha^{-1} (fresh weight basis) + blue green algae (*Nostoc* sp.) inoculated in soil. In *rabi* the residual effect of biofertilizers (azolla and blue green algae) applied in *kharif* were tested on chilli and lady's finger grown with recommended dose of fertilizer (120 kg N ha^{-1}) applied as urea in 3 splits equally to all the treatments. The results indicated that the yield of rice at different levels of inorganic N fertilizer increased with the application of biofertilizers. Among the treatments the combination of azolla and blue green algae produced better yield of rice at all levels of inorganic N fertilizers. The residual effect of N fertilizers as well as that of biofertilizers was significant on the yield of subsequent *rabi* crops. The effects of the treatments on salinity and organic carbon content of soil were not significant.

(Key words: *Azolla, Blue green algae, Biofertilizer)*

Although coastal saline soils are deficient in N the efficiency of N fertilizers is very poor due to salinity in soil, poor water management options, deep waterlogging with no demarcation between the plots during *kharif*, etc. The poor marginal farmers hardly apply chemical fertilizers due to their poor efficiency. As a result, the yield of crops in the region is one of the poorest in the country. Under this situation use of biofertilizers like azolla and blue green algae may be quite effective in increasing the yield of rice in wetland rice. Prasad *et al.* (1990) observed that integrated nutrient management is required for achieving better N fertilizer use efficiency of rice. Green manures can contribute substantially to the nitrogen requirement of rice. Satapathy (1996) reported increase in rice yield when azolla was applied along with N fertilizer. Gopalaswamy *et al.* (1997) observed higher efficiency of N fertilizer when blue green algae was applied. Dubey and Sharma (1995) reported that azolla and blue green algae can be effectively utilized for partial meeting of N requirement of rice. Similar observation was also reported by Mahapatra and Sharma (1998). Singh *et al.* (1988) reported improvement in soil fertility and N uptake by rice due to application of *Sesbania*, azolla and blue green algae. Mandal *et al.* (1999) observed that application of azolla and blue green algae to wetland rice field brings about several changes in physical, chemical and biological properties of soil and soil-water interface which are conducive for increasing the yield of rice. The present experiment was conducted to study the direct and residual effect of azolla and blue green algae applied to rice in combination with the inorganic N fertilizer on soil fertility and yield of crops under rice based cropping system in coastal saline soils of West Bengal.

MATERIALS AND METHODS

Field experiments were conducted at the experimental farms of CSSRI, Regional research Station, Canning and KVK, Ramkrishna Ashram, Nimpith in the district of South 24-Parganas, West Bengal. Both the experimental soils represented typical coastal saline soils of West Bengal and taxonomically fall under the order of Entisols (Fine mixed hyperthermic Typic Endoaquents and Fine loamy mixed hyperthermic Aeric Endoaquents, respectively). The soils were fine textured (silty clay and silty clay loam, respectively), both saline, almost neutral in pH (7.0 and 7.9, respectively), medium in nitrogen (total N 0.07 and 0.06 percent, respectively), and organic C (0.6 and 0.65 percent, respectively), but rich in available P (24.2 kg and K 580 kg K ha^{-1}, respectively). The soil of Canning (ECe 7.8 dS m^{-1}) was more saline than that of Nimpith (ECe 5.2 dS m^{-1}). Split-plot design was followed for the field experiments at both the locations. There were two main plot treatments (with and without *Sesbania)*, 9 subplot treatments with various combinations of inorganic N (urea) and biofertilizer (azolla and blue green algae) and 3 replications. The details of the treatments for both *kharif* and *rabi* are given below.

I. ***Kharif* season**

A. ***Main plot treatments***

S* : With *Sesbania* (*Sesbania aculeata* @ 10 t ha^{-1} on fresh weight basis)

WS* Without *Sesbania*

B. ***Subplot treatments***

T_1: 20 kg N ha^{-1} applied through urea as basal

T_2: T_1 in combination with azolla (*Azolla microphylla*) @ 1 t ha^{-1} (fresh weight basis)

T_3: T_1 in combination with azolla @ 1 t ha^{-1} and blue green algae (*Nostoc sp.*) inoculated in soil

T_4: 50 kg N ha^{-1} applied through urea in three splits

T_5: T_4 in combination with azolla @ 1 t ha^{-1}

T_6: T_4 in combination with azolla @ 1 t ha^{-1} and blue green algae (*Nostoc sp.*) inoculated in soil

T_7: 100 kg N ha^{-1} applied through urea in three splits

T_8: T_7 in combination with azolla @ 1 t ha^{-1}

T_9: T_7 in combination with azolla @ 1 t ha^{-1} and blue green algae (*Nostoc sp.)* inoculated in soil

II. ***Rabi* season**

A. ***Main plot treatments***

The residual effect of S* and WS* treatments applied in *kharif* was studied

B. ***Subplot treatments***

T_1- T_3 : 20 kg N ha^{-1} applied through urea as basal

T_3- T_6 : 80 kg N ha^{-1} applied through urea in 3 splits

T_7- T_9: 160 kg N ha^{-1} (Full recommended dose) applied through urea in 3 splits

Rice (cv. Swarna) in *kharif* and in *rabi*, chilli (cv. Suryamukhi) and lady's finger (cv. Anamika), were grown as test crops. In *kharif* all the organic (*Sesbania*, azolla and blue green algae) and inorganic (urea) sources of nitrogen were applied but in *rabi* no organic sources were applied but the residual effects of the organic sources applied in *kharif* were studied. However, inorganic sources of nutrients (urea) were applied as per the treatments. A basal dose of P in the form of single superphosphate @ 20 kg P_2O_5 ha^{-1} was applied both in *kharif* and *rabi* seasons. K was not applied as the soils contained high quantity of available K and there was no response of K fertilizers. Soil samples from the fields were analyzed for salinity, pH, organic carbon, total N, available P and K following standard methods.

RESULTS AND DISCUSSION

***Kharif* season**

Grain and straw yield of rice

The grain yield data of rice were pooled over the two locations and analyzed statistically. The main plot effect, i.e. application of *Sesbania* resulted in significant increase in grain yield of rice (Table 1). Application of azolla proved to be very beneficial in influencing rice yield at all levels of inorganic N (urea) application. Application of azolla along with blue green algae also improved the yield of rice significantly when combined with 100 kg N (T_9) but not with 20 kg N (T_3) and 50 kg N (T_6). Highest yield was obtained under the treatment of 100 kg N + azolla + blue green algae (T_9). The crop yield at Nimpith was marginally better than at Canning, which may be due to lower soil salinity at Nimpith.

The initial salinity of soil decreased to < ECe, 2 dS m^{-1} in both the locations during *kharif* season due to waterlogging and washing following the monsoon rains. The soil salinity increased again during harvest of *kharif* rice at the cessation of monsoon rains. However, the effect of the treatments on the differences in pH and salinity of soil was not significant (Table 2). The effect of *Sesbania* application (main plot treatment) on organic carbon content of the soils was statistically significant at both the locations (Table 2). There was also a definite increase of organic carbon content of soil due to the application of azolla (subplot treatments). The interaction effect of the main plot and the subplot treatments were, however, not significant. Thus, the application of biofertilizers like azolla and blue green algae is very effective in increasing the fertility and yield of crops on coastal salt affected soils although the treatments did not influence the salinity of the soils. The increase in yield was probably due to better efficiency of the fertilizers as well as due to improvement of the microbial health of the soil on application of the biofertilizers as also observed by others (Prasad *et al.*, 1990), Mandal *et al.*, 1999).

Table 1. *Grain yield (t ha^{-1}) of rice under different treatments during* kharif *(combined over two locations, i.e. Canning and Nimpith)*

Treatment	With Sesbania (S)			Without Sesbania (WS)			Mean of Canning	Mean of Nimpith	Mean of two locations
	Canning	Nimpith	Mean	Canning	Nimpith	Mean			
T_1	2.62	3.15	2.89	2.44	3.05	2.75	2.53	3.10	2.82
T_2	2.86	3.19	3.03	2.64	3.17	2.91	2.75	3.18	2.97
T_3	2.97	3.30	3.14	2.69	3.28	2.99	2.83	3.29	3.06
T_4	3.26	3.36	3.31	2.84	3.34	3.09	3.05	3.35	3.20
T_5	3.71	3.35	3.53	3.36	3.35	3.36	3.54	3.35	3.45
T_6	3.80	3.45	3.63	3.47	3.43	3.45	3.64	3.44	3.54
T_7	3.49	3.53	3.51	3.46	3.52	3.49	3.48	3.53	3.51
T_8	3.56	3.75	3.66	3.50	3.64	3.57	3.53	3.70	3.62
T_9	3.81	4.05	3.93	3.40	3.79	3.60	3.61	3.92	3.77
Mean	3.34	3.46	3.40	3.09	3.40	3.24	3.22	3.43	3.32
CD at p=0.05	S: NS			S x T: NS			Lx T: 0.234	L: 0.14	
	T: 0.12			L x S: NS			L x S x T: NS		

NB: S, Main plot treatment, *Sesbania*; T, Subplot treatment; L, Location

Table 2. *Soil organic carbon, salinity and pH at harvest*

Treatment	Soil Organic C (%)						Canning		Nimpith	
	Canning			Nimpith			pH	ECe (dS m^{-1})	pH	ECe (dS m^{-1})
	S*	WS*	Mean	S*	WS*	Mean				
T_1	0.77	0.68	0.73	0.82	0.78	0.80	6.83	5.1	6.95	4.95
T_2	0.78	0.76	0.77	0.85	0.82	0.84	6.35	5.3	6.95	4.95
T_3	0.81	0.78	0.80	0.86	0.82	0.84	6.43	5.2	7.10	4.10
T_4	0.76	0.71	0.74	0.81	0.79	0.80	6.78	5.0	6.85	4.85
T_5	0.84	0.86	0.85	0.83	0.81	0.82	6.53	5.3	6.78	4.78
T_6	0.85	0.79	0.82	0.86	0.83	0.85	6.38	5.3	6.93	4.93
T_7	0.78	0.73	0.76	0.79	0.78	0.79	7.05	5.1	6.90	4.90
T_8	0.80	0.78	0.79	0.85	0.82	0.84	6.40	5.3	7.00	4.00
T_9	0.79	0.76	0.78	0.84	0.81	0.83	6.38	5.2	6.90	4.90
Mean	0.80	0.76	0.78	0.83	0.81	0.82	6.57	5.2	6.93	4.93
CD at p=0.05										
B	0.02			0.009			NS		NS	
T	0.04			0.03			NS		NS	
B x T	NS			NS			NS		NS	

NB: S, Main plot treatment, *Sesbania*; T, Subplot treatment; S*, *Sesbania*; WS*, Without *sesbania*

Rabi season

Chilli yield (combined over locations) showed (Table 3) that application of azolla + 100 kg N ha^{-1} (T_8) and azolla + blue green algae + 100 kg N ha^{-1} (T_9) resulted in highest yield and both the treatments were at par. Lowest yield was obtained at T_1. The effect of main plot treatment was not significant. Since the results in case of yield of lady's finger were similar in trend to that of chilli the data on the yield of lady's finger are not presented.

It was, therefore, concluded that azolla and blue green algae may be a prospective and cheap alternative to chemical fertilizers for coastal soils for higher crop yields. The residual effect of azolla and blue green algae is also significant and they increased the organic matter content of the soils, which may lead to sustainable increase in yield of crops through ecofriendly approach.

Table 3. *Mean yield of chilli (t ha^{-1}) during* rabi

Subplot treatment	With Sesbania (S)			Without Sesbania (WS)			Location (L)		Mean
	Canning	Nimpith	Mean	Canning	Nimpith	Mean	Canning	Nimpith	
T_1	1.15	1.42	1.29	1.09	1.24	1.17	1.12	1.33	1.23
T_2	1.42	1.61	1.51	1.31	1.42	1.37	1.37	1.52	1.45
T_3	1.43	1.62	1.53	1.35	1.41	1.38	1.39	1.52	1.46
T_4	1.39	1.79	1.59	1.40	1.59	1.50	1.40	1.69	1.55
T_5	1.51	1.90	1.70	1.50	1.69	1.60	1.51	1.80	1.66
T_6	1.69	2.00	1.85	1.59	1.78	1.69	1.64	1.89	1.77
T_7	1.56	2.21	1.89	1.59	1.92	1.76	1.58	2.07	1.83
T_8	1.81	2.46	2.14	1.71	1.99	1.85	1.76	2.23	2.00
T_9	1.89	2.41	2.15	1.88	2.00	1.94	1.95	2.21	2.08
Mean	1.54	1.94	1.74	1.49	1.67	1.58	1.52	1.81	1.67
CD at p=0.05		S : NS		S x T: NS		L x T: 0.234		L: 0.14	
		T: 0.12		L x S: NS		L x S x T: NS			

NB: S, Main plot treatment, *Sesbania*; T, Subplot treatment; L, Location

REFERENCES

Dubey, S.K. and Sharma, R.S. (1995). Utilization of azolla and blue green algae as biofertilizer to meet practical nitrogen needs of rice. *Advances in Agricultural Research in India* **4**: 134-140.

Gopalaswamy, G., Raj, S.A. and Ranganathan, T.B. (1997). Biofertilizer application strategy to rice (*Oryza sativa*). *Indian Journal of Agronomy* **42**: 68-73.

Mahapatra, B.S. and Sharma, G.L. (1998). Effect of Azospirillum, Gyanobacteria and Azolla bio-fertilizers on productivity of lowland rice. *Indian Journal of Agronomy* **33**: 368-371.

Mandal, B., Vlek, P.L.G. and Mandal, L.N. (1999). Beneficial effects of blue-green algae and azolla, excluding supplying nitrogen, on wetland rice fields. *Biology and Fertility of Soils* **28**: 329-342.

Prasad, R., Sharma, S.N., Singh, S., Prasad, M., Prasad, R., Prasad, M., Singh, S., Kumar, V., Shotriya, G.C. and Kaore, S.V. (1990). Nitrogen management, In *Soil Fertility and Fertilizer Use*, Vol IV, *Nutrient Management and Supply System for Sustaining Agriculture in 1990s*, pp.41- 53. Indian Farmers' Co-operative Ltd.

Satapathy, K.B. (1996). Tolerance of azolla to chemical nitrogen fertilizer in rice field. *Indian Journal of Plant Physiology* **1**: 243-246.

Singh, A.L., Singh., P.K. and Singh, P.L. (1988). Comparative studies on the use of green manuring, organic manuring and azolla and blue-green algal biofertilizers to rice. *Journal of Agricultural Sciences*, UK **110**: 337-343.

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Biological Properties of Coastal Soils under Rice and Groundnut Cultivation Using Different Organics

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In the coastal soils, the microbial load and enzymatic activities are found low due to high pH and low organic matter content. Hence, to study the influence of different organics on the soil biological properties, two field experiments were carried out in coastal soils one each on rice (pH- 8.92, EC- 1.94 dS m^{-1} and ESP- 29.80) and groundnut (pH- 8.45 and EC- 1.24 dS m^{-1}). Various bio-resources, viz. *Sesbania rostrata*, enriched FYM, *azospirillum* and *phosphobacterium* along with 75 % NP for rice and composted coirpith and humic acid along with Zn and B for groundnut were evaluated in the field experiments. The results of the field investigations revealed that 75 % NP + 25 % N substituted through *Sesbania rostrata* + 25 % P substituted through enriched FYM recorded highest microbial populations and enzymatic activities in the soil and highest yield of rice. With regard to groundnut, the application of composted coirpith @ 10 t ha^{-1} and humic acid @ 20 kg ha^{-1} along with Zn + B registered highest biological populations, enzymatic activities and, in turn, the yield of groundnut.

***(Key words:** Organics, Microbial populations, Enzymatic activities)*

Soil enzymatic activities are considered as the overall health index of the soil. High salinity and poor organic matter status of the coastal soils affect the nutrient availability, microbial count and enzyme activity. In coastal areas of Tamilnadu, rice and groundnut are the two extensively cultivated crops with lower yields as compared to the normal soils. Hence, an attempt has been made in the present investigation to study the influences of various bio-resources in improving the soil biological properties of coastal areas and, in turn, the yield of rice and groundnut.

MATERIALS AND METHODS

To study the influences of bio-resources on the soil biological properties of coastal soils, field investigations were carried out during Nov 2004-April 2005 on rice and groundnut. The field experiment for rice was conducted in coastal sodic soil (pH- 8.94, EC- 1.94 d S m^{-1}, Organic carbon- 0.24 %) in Alapakkam village and field experiment for groundnut was conducted in coastal sandy soil (pH- 8.45, EC-1.24 dSm^{-1}, Organic carbon - 0.26%) in Pichavaram village of Cuddalore district in Tamilnadu.

The treatments studied for rice include T_1- Control (100% NPK), T_2- 75% NP + 25% N through *Sesbania rostrata* + 25% P through superphosphate enriched FYM, T_3- 75% NP + 25% N through *Sesbania rostrata* + *phosphobacterium*, T_4- 75% NP + *azospirillum* + 25% P through superphosphate enriched FYM, and T_5- 75% NP + *azospirillum* + *phosphobacterium*. The treatments for groundnut were: T_1- Control; T_2- recommended NPK; T_3- T_2 + $ZnSO_4$ @ 25 kg ha^{-1} + boron @ 10 kg ha^{-1}; T_4- T_2 + T_3 + composted coirpith @ 10 t ha^{-1}; T_5- T_2 + T_3 + humic acid @ 20 kg ha^{-1} and T_6- T_2 + T_3 + composted coirpith @ 10 t ha^{-1} + humic acid @ 20 kg ha^{-1}. Both the experiments were laid out in randomised block design with three replications. Rice variety ADT 36 and groundnut variety VRI 2 were used in these studies. The recommended NPK doses of 120: 38: 38 for rice and 17: 34: 54 for groundnut were followed. Periodic soil samples at critical stages of rice and groundnut were taken and analysed for their microbial populations by standard plate count method as proposed by Cynathia (2003). The enzymatic activities of urease by urea distillation method (Tabatabai and Bremner, 1972), phosphatase by p-nitrophenol colorimetric method (Tabatabai and Bremner, 1969), dehydrogenase by TTF colorimetric method (Casida *et al.*, 1964) and cellulase by DNS colorimetric method (Denison and Koehn, 1977) were also analysed at the critical stages.

RESULTS AND DISCUSSION

Microbial populations

The estimation of total microbial population in the rice cultivated coastal sodic soil implied that the bio-resource application in the soil significantly increased the populations of bacteria, fungi and actinomycetes (Table 1). The combined application of *Sesbania rostrata* + enriched FYM recorded 42.50 X 10^{-6} g^{-1} soil of bacteria, 21.50 X 10^{-5} g^{-1} soil of fungi and 19.75 X 10^{-4} g^{-1} soil of actinomycetes. This was followed by the application of *Sesbania rostrata* + *phosphobacterium*, and *azospirillum* + enriched FYM. In the groundnut experiment also the microbial population of the coastal sandy soil showed a spur with various bio-resource treatments. Of the different treatments studied, the combined addition of composted coirpith and humic acid along with Zn + B was favorable in registering the maximum number of bacteria (32.00 X 10^{-6} g^{-1} soil), fungi (16.33 X 10^{-5} g^{-1} soil) and actinomycetes (11.33 X 10^{-4} g^{-1} soil). The individual application of composted coirpith and humic acid also played an important role in improving the soil microbial load. In both the experiments, the control registered the least microbial populations. The increased availability of carbon and nitrogen due to minaralization of applied organics resulted in increased populations of microbes (Perucci, 1990, 1992).

Enzymatic activity

There was a marked increase in the enzymatic activities of the soil due to the addition of various organics. In the experiment on rice (Table 2), the highest amount of urease activity (58.75 mg NH_4- N g^{-1} soil per 24 h), phosphatase activity (32.75 mg P-nitrophenol g^{-1} soil per h), dehydrogenase activity (187.50 mg TTF g^{-1} soil per 24 h) and cellulase activity (45.50 mg DNS g^{-1} soil h^{-1}) were recorded with the conjoint application of *Sesbania rostrata* for substitution of 25 % N and enriched FYM for substitution of 25 % P in the soil. The individual application of *Sesbania rostrata* and enriched FYM along with biofertilizers followed this treatment. In the groundnut experiment (Table 3), the conjoint application of composted coirpith and humic acid recorded the maximum enzymatic activities in the soil. It recorded 53.70 mg NH_4- N g^{-1} soil per 24 h of urease, 25.20 mg P- nitrophenol g^{-1} soil per h of phosphatase, 155.96 mg TTF g^{-1} soil per 24 h of dehydrogenase, and 24.33 mg DNS g^{-1} soil h^{-1} of cellulase activities. The application of composted coirpith alone and humic acid alone in the soil also had their influence in increasing the enzymatic activity in the coastal sandy soil. The control treatment recorded the least amount of enzymatic activity in both the field experiments. The increase in the soil enzymatic activity may be ascribed to the easily biodegradable organic matter imposed in the soil, which stimulates the growth of soil microorganisms (Perucci, 1992).

Table 1. *Effect of various bio-resources on the microbial populations of rice cultivated coastal sodic soil*

Treatment	Azospirillum	Phosphobacterium	Bacteria	Fungi	Actinomycetes
T_1	0.32	3.75	31.00	13.25	14.25
T_2	0.52	5.25	42.50	21.50	19.75
T_3	0.45	7.50	38.75	18.50	17.25
T_4	1.10	4.75	32.00	17.00	15.50
T_5	0.95	6.00	29.25	15.75	14.25
Sed	0.04	0.25	1.32	0.12	0.62
CD at p=0.05	0.08	0.50	2.65	0.25	1.27

Azospirillum, Phosphobacterium and Bacteria- 10^{-6} g^{-1} soil; Fungi - 10^{-5} g^{-1} soil; Actinomycetes- 10^{-4} g^{-1} soil

Table 2. *Effect of various bio-resources on the enzymatic activity of rice cultivated coastal sodic soil*

Treatment	Urease	Phosphatase	Dehydrogenase	Cellulase
T_1	37.25	18.50	135.00	17.75
T_2	58.75	32.75	187.50	45.50
T_3	52.50	24.50	169.75	41.75
T_4	47.50	28.25	158.00	28.50
T_5	42.00	21.75	147.50	21.00
SEd	1.30	0.88	4.89	1.10
CD at p=0.05	2.60	1.75	9.78	2.20

Urease- mg NH_4 g^{-1} soil per 24 h; Phosphatase- mg p-nitrophenol g^{-1} soil h^{-1}; Dehydrogenase- mg TTF g^{-1} soil per 24 h; Cellulase- mg DNS g^{-1} soil h^{-1}.

Table 3. *Effect of various bio-resources on the microbial populations and enzymatic activity of groundnut cultivated coastal sandy soil*

Treatment	Microbial population			Enzyme activity			
	Bacteria	Fungi	Actinomycetes	Urease	Phosphatase	Dehydrogenase	Cellulase
T_1	10.33	3.99	3.67	19.27	14.17	89.13	12.66
T_2	12.99	4.67	4.33	27.57	18.11	110.50	15.03
T_3	12.66	4.99	4.67	27.63	20.36	114.00	16.00
T_4	21.33	9.33	7.33	44.00	24.50	141.76	21053
T_5	18.67	7.67	5.33	42.13	21.57	135.50	18.43
T_6	22.67	11.00	8.33	51.70	27.50	151.90	24.50
S Ed	0.56	0.31	0.26	1.58	0.83	3.63	0.74
CD at p=0.05	1.02	0.62	0.52	3.15	1.65	7.26	1.49

Bacteria- 10^{-6} g^{-1} soil; Fungi - 10^{-5} g^{-1} soil; Actinomycetes- 10^{-4} g^{-1} soil, Urease- mg NH_4 g^{-1} soil per 24 h; Phosphatase- mg p-nitrophenol g^{-1} soil h^{-1}; Dehydrogenase- mg TTF g^{-1} soil per 24 h; Cellulase- mg DNS g^{-1} soil h^{-1}.

Yield of rice and groundnut

The enhanced microbial and enzymatic activities were reflected in realizing higher yield of rice and groundnut (Tables 4 and 5). Addition of *Sesbania rostrata* and enriched FYM as substitution for 25 % N and P of chemical fertilizers (T_2) recorded highest grain (5166 kg ha^{-1}) and straw (6868 kg ha^{-1}) yield, which represented 25.95 % and 24.18 % increase over the control treatment. In the case of groundnut also the highest pod yield of 1790.0 kg ha^{-1} and haulm yield of 2214.4 kg ha^{-1} were recorded with the organic treatment T_6, the combined application of composted coirpith @ 10 t ha^{-1} and humic acid @ 20 kgha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1}. This represented 37.14 % increase in pod yield and 22.52 % increase in haulm yield over control. The beneficial influence of incorporation of various organics towards the increase in the yield of rice and groundnut could have been due to the fact that salt affected soils undergo reduction in pH, decrease in redox potential and other physicochemical changes and thereby increasing availability of several plant nutrients in higher amounts (Anand Swarup, 1992).

Table 4. *Effect of various bio-resources on the yield of rice in coastal sodic soil*

Treatments	No. of tillers/ hill	No. of panicles	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	6.75	6.25	3825	5207
T_2	11.25	10.50	5166	6868
T_3	11.00	8.25	4827	6661
T_4	8.75	7.50	4537	6302
T_5	7.50	6.75	4268	5926
SEd	1.27	0.57	89.42	91.38
CD at p=0.05	2.55	1.13	179.53	182.76

Table 5. *Effect of various bio-resources on the yield of groundnut in coastal saline soil*

Treatment	No. of pods per plant	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1	16.99	1125.2	1715.8
T_2	17.33	1390.6	1935.7
T_3	17.66	1425.5	1947.8
T_4	21.00	1605.7	2150.0
T_5	18.66	1525.8	2028.3
T_6	23.66	1790.0	2214.4
SEd	0.46	33.77	36.55
CD at p=0.05	0.92	67.53	73.10

REFERENCES

Casida, L.E., Klein, D.A. and Santoro Thomas (1964). Soil dehydrogenase activity. *Soil Science* **98**: 371-376.

Cynathia, S.A. (2003). *Microbiological Methods*, 5th Edn. Butlerworth Publications, London.

Denison, D.A. and Koehn, R.D. (1977). Assay of cellulases. *Mycologia* **LXIX**: 592.

Perucci, P. (1990). Effect of the addition of municipal solid waste compost on microbial biomass and enzyme activities in soil. *Biology and Fertility of Soils* 10: 221- 226.

Perucci, P. (1992). Enzyme activity and microbial biomass in a field soil amended with municipal refuse. *Biology and Fertility of Soils* **14**: 54-60.

Swarup Anand (1992). Effect of organic amendments on the nutrition and yield of wetland rice and sodic soil reclamation. *Journal of Indian Society of Soil Science* **40**: 816- 822.

Tabatabai, M.A. and Bremner, J.M. (1969). Use of P-nitrophenyl phosphate for assay of soil phosphatase activity. *Soil Biology and Biochemistry* **1**: 301-307.

Tabatabai, M.A. and Bremner, J.M. (1972). Assay of urease activity in soil. *Soil Biology and Biochemistry* **4**: 479-487.

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Response of Groundnut to Micronutrients along with Organics in Coastal Sandy Soils

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Coastal sandy soils dominate majority of the coastal areas, which show deficiencies of major and micronutrients. Availability of micronutrients, when applied along with organic manures, in soil increases and their absorption by crops are improved. Hence, a field experiment was conducted during January- April 2005 to study the response of groundnut to micronutrients along with organics in coastal sandy soil (pH-8.45, EC- 1.14 dS m^{-1} and available NPK of 112.0, 7.5 and 169.0 kg ha^{-1}). Six treatments, viz. T_1- Absolute control, T_2- recommended NPK, T_3- T_2 + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1}, T4- T_2 + T_3 + composted coirpith @ 10 t ha^{-1}, T_5- T_2 + T_3 + humic acid @ 20 kg ha^{-1}, and T_6- T_4 + T_5 were studied under randomized block design with three replications using groundnut var. VRI 2. From the outcome of the field experiment, it was concluded that the application of composted coirpith @ 10 t ha^{-1} + humic acid @ 20 kg ha^{-1} along with Zn and B was most effective in increasing the availability of major and micronutrient of the soil. This treatment recorded the highest pod yield of 1790.0 kg ha^{-1} and haulm yield of 2214.4 kg ha^{-1} as compared with control, which registered 1125.2 kg ha^{-1} of pod and 1715.8 kg ha^{-1} of haulm, respectively.

(***Key words:*** *Micronutrients, Organics, Groundnut*)

Groundnut being a major crop is extensively cultivated in coarse textured sandy soils of the coastal areas. Coastal sandy soils have low organic matter status and also exhibit poor nutrient status especially micronutrients. Availability of micronutrients, when applied along with organics, in soil increases and their absorption by crops are improved. Hence, a study was undertaken to find out the response of groundnut to micronutrients along with organics in coastal sandy soils.

MATERIALS AND METHODS

To study the response of groundnut to micronutrients along with organics in the coastal sandy soils, a field experiment was conducted in Pichavaram, a coastal village of Cuddalore district in Tamilnadu during Jan- April, 2005. The experimental soil was sandy in texture with pH-8.45, EC- 1.14 dS m^{-1}, and available NPK of 112.0, 7.5 and 169.0 kg ha^{-1}, respectively. Six treatment, viz. T_1- Absolute control; T_2- recommended NPK; T_3- T_2 + $ZnSO_4$ @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1}, T4- T_2 + T_3 + composted coirpith @ 10 t ha^{-1}; T_5- T_2 + T_3 + humic acid @ 20 kg ha-^{1}, T_6- T_4 + T_5, were studied under randomized block design with three replications using groundnut var. VRI 2.

Humic acid was extracted from lignite as per the procedure proposed by Stevenson (1965). Required quantities of lignite humic acid was dissolved in 0.01N KOH and applied to soil. Recommended fertilizer dose (N:P:K) for groundnut as 17: 34: 54 kg ha^{-1} was followed. Periodic soil samples at flowering, peg formation and harvest stages were taken and analysed for their nutrient contents as per the standard procedure given by Jackson (1973). The pod and haulm yield were recorded separately.

RESULTS AND DISCUSSION

Soil available nutrients

Compared to control, all the organics applied in the soil improved the nutrient status of the coastal sandy soil. Among the treatments, the application of composted coirpith @ 10 t ha^{-1} + humic acid @ 20 kg ha^{-1} + Zn + B recorded maximum contents of major nutrients with 123, 118 and 109 kg ha^{-1} of N, 17.4, 16.5 and 13.9 kg ha^{-1} of P and 179, 166 and 163 kg ha^{-1} of K at flowering, peg formation and harvest stages, respectively (Table 1). The same treatment also recorded the highest secondary nutrient contents (8.7 kg ha^{-1} of S, 2.52 cmol p $^{(+)}$ kg^{-1} of Ca and 0.91 cmol p $^{(+)}$ kg^{-1} of Mg at harvest stage) (Table 2) and micronutrients (0.65 ppm of Zn and 0.13 ppm of B at harvest stage) (Table 3). This was followed by the application of composted coirpith + Zn + B and humic acid + Zn + B. The control recorded the least amount of all the nutrients. The increased nutrient availability suggested release of

Table 1. *Effect of various organics and micronutrients on the major nutrient availability in the coastal sandy soil (kg ha^{-1})*

Treatments	Alkaline $KMnO_4$- N			Olsen- P			NH_4OAC- K		
	FS	PFS	Har	FS	PFS	Har	FS	PFS	Har
T_1	105	97	89	6.8	6.1	5.2	152	136	132
T_2	114	101	93	15.3	13.2	11.5	167	148	143
T_3	101	100	91	15.0	13.0	11.4	156	143	139
T_4	118	112	101	17.1	15.8	13.3	173	160	157
T_5	113	106	96	16.7	15.2	12.5	168	154	152
T_6	123	118	109	17.4	16.5	13.9	179	166	163
SEd	2.28	3.36	3.61	0.12	0.13	0.10	2.65	2.64	2.27
CD at p=0.05	4.56	6.73	7.22	0.24	0.26	0.20	5.30	5.28	4.53

(FS- Flowering Stage; PFS- Peg Formation Stage; Har- Harvest Stage)

Table 2. *Effect of various organics and micronutrients on the secondary nutrient availability in the coastal sandy soil*

Treatments	$CaCl_2$- S (kg ha^{-1})			NH_4OAC- Ca (C mol $P^{(+)}$ kg^{-1})			NH_4OAC- Mg **(C mol $P^{(+)}$ kg^{-1})**		
	FS	PFS	Har	FS	PFS	Har	FS	PFS	Har
T_1	7.6	6.3	5.8	2.49	2.43	2.39	1.89	1.83	1.79
T_2	7.8	6.9	6.4	2.51	2.45	2.41	1.91	1385	1.81
T_3	7.9	6.8	6.4	2.53	2.48	2.43	1.92	1385	0.82
T_4	9.5	8.5	8.4	2.59	2.52	2.48	1.96	1391	0.87
T_5	8.8	8.2	7.9	2.55	2.49	2.45	1.94	1387	0.85
T_6	10.6	9.6	8.7	2.62	2.56	2.52	1.99	1395	0.91
SEd	0.16	0.15	0.13	0.03	0.04	0.03	0.03	0.03	0.02
CD at p=0.05	0.32	0.29	0.25	0.05	0.08	0.05	0.05	0.05	0.04

(FS- Flowering Stage; PFS- Peg Formation Stage; Har- Harvest Stage)

Table 3. *Effect of various organics and micronutrients on the micronutrient availability in the coastal sandy soil (ppm)*

Treatments	DTPA- Zn			Hot Water- B		
	FS	PFS	Har	FS	PFS	Har
T_1	0.49	0.41	0.37	0.09	0.07	0.05
T_2	0.51	0.43	0.39	0.11	0.08	0.05
T_3	0.70	0.64	0.57	0.16	0.12	0.09
T_4	0.73	0.68	0.62	0.18	0.14	0.11
T_5	0.70	0.66	0.60	0.16	0.13	0.10
T_6	0.76	0.70	0.65	0.21	0.17	0.13
SEd	0.01	0.03	0.02	0.03	0.02	0.01
CD (p=0.05)	0.02	0.05	0.04	0.05	0.04	0.02

(FS- Flowering Stage; PFS- Peg Formation Stage; Har- Harvest Stage)

nutrients either from the applied organics or release from the nutrient bearing minerals possibly due to the organic acid production (Duraisamy and Mani, 2002). Further, the complexation of applied organics with micronutrients might have mobilized and increased the availability of Zn and B in the soil (Babu, 1989).

Yield of groundnut

The results of the study indicated the positive response of groundnut to micronutrient application along with organics. The yield of groundnut with the application of $ZnSO_4$ and boron has increased to 1390.6 and 1935.7 kg ha^{-1} of pod and haulm yield, respectively as compared to1225.2 and 1715.8 kg ha^{-1} in control (Table 4). While with the application of organic composted coirpith, the pod and haulm yield has further increased to 1425.5 and 1947.8 kg ha^{-1}, respectively showing the beneficial influence of organics along with micronutrients. The highest pod yield of 1790.0 kg ha^{-1} and haulm yield of 2214.4 kg ha^{-1} were recorded with T6 with the combined application of composted coirpith @ 10 t ha^{-1} + humic acid @ 20 kg ha^{-1} + ZnSO4 @ 25 kg ha^{-1} + borax @ 10 kg ha^{-1}. This represents 26.6 percent increase

***Table 4.** Effect of various organics and micronutrients on the yield of groundnut (kg ha^{-1})*

Treatments	No. of pods per plant	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1	16.99	1225.2	1715.8
T_2	17.33	1390.6	1935.7
T_3	17.66	1425.5	1947.8
T_4	21.00	1605.7	2150.0
T_5	18.66	1525.8	2098.3
T_6	23.66	1670.0	2214.4
SEd	0.46	33.77	36.55
CD at p=0.05	0.92	67.53	73.10

in pod yield and 22.54 percent in haulm yield, over the control. The application of composted coirpith + Zn + B registered next best in yield. The positive response of applied organics towards the yield of groundnut can be attributed to the availability of sufficient amount of plant nutrients throughout the growth period and especially at critical growth period of the crop resulting in better uptake, plant vigour and superior yield attributes (Rao and Sitarammaya, 2000).

REFERENCES

Babu, M. (1989). Influence of Lignite-humic acids and gypsum on the performance and composition of groundnut in a calcareous clay soil. *M.Sc.(Ag.) Thesis*, Annamalai University, India.

Duraisamy, V.P. and Mani, A.K. (2002). Impact of fertilizer nitrogen, coirpith and biofertilizers on the availability and uptake of micronutrients under sorghum in a calcareous mixed black soil. *Mysore Journal of Agricultural Sciences* **4**: 289-293.

Jackson, M.L. (1973). *Soil Chemical Analysis*. Prentice Hall of India.

Stevenson, F.J. (1965). Gross chemical fractions of organic matter, In *Methods of Soil Analysis*, Part **II**, C.A. Black, D.D. Evans, J.L. White, L.E. Ensminger & F.E. Clark (eds.), pp. 1409-1421, American Society of Agronomy, Madision., Wis.

Rao Sundar, S. and Sitarammaya, M. (2000). Proceedings International Confenerence *Managing Natural Resources for Sustainable Agriculture Production in the 21st Century* **3**, held at New Delhi. 1464p.

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Effect of Different Organic Sources of Nutrients along with Inorganic Sources of Rice-Lentil-Sesame Cropping Sequence in Coastal Zone of West Bengal

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A field experiment was conducted during pre-rainy, rainy (*kharif*) and winter season (*rabi*) of 2004-2005 under medium land situation in coastal soil at Regional Research Station (Coastal Saline Zone), Bidhan Chandra Krishi Viswavidyalaya, Kakdwip 24 Pgs (S), W. B. to evaluate the effect application of different sources of organics and inorganic fertilizers singly or in combination in rice fields on crop growth and yield of rice-lentil sesame sequence. The seed yield and growth components of all the crops were maximum when organic manure was applied along with inorganic fertilizer @ 75% of the recommended dose. The effect of fishmeal was as good as farmyard manure (FYM), if not sometimes better. The maximum equivalent rice yield in rice-lentil-sesame sequence was obtained from the fishmeal applied crops.

(***Key words:*** *Fishmeal, FYM, Paddy straw, Organic manure, Rice-Lentil-Sesame sequence*)

With the objective of utilizing the organic resource for substituting the chemical fertilizers partly, which may reduce expenditure on costly inorganic import, a field experiment was conducted on a coastal soil at RRS (CSZ), Kakdwip, 24 Pgs. (South) under rice-lentil-sesame cropping system.

MATERIALS AND METHODS

The field experiment was carried out during 2004-05 under medium land soil having on an average BD 1.27 g cm^{-1}, sand 18.58%, silt 38.52%, clay 40.91%, pH 6.4, EC 1.25 dSm^{-1}, organic mater 0.57%, P_2O_5 ha^{-1} 15.2 kg and K_2O ha^{-1} 515.0 kg at the regional research station (coastal saline zone), Bidhan Chandra Krishi Viswavidyalaya, W. B. The climate of this zone is subtropical with mean annual rainfall of 1763 mm and mean maximum and minimum temperature of 32.5^{0}C and 13.5^{0}C, respectively. The experiment was laid out in randomised block design with 9 treatments replicated thrice. The crops in sequence were rice (cv. Khitish), lentil (cv. Asha) and sesame (cv. Tilotoma). The dried fish, amply available in this zone was decomposed and the well decomposed fishmeal (WDFM) containing 6.92 N, 5.11 P_2O_5 and 1.45 K_2O and farmyard manure (FYM) containing 0.62 N, 0.32 P_2O_5 and 0.76 K_2O were used as organic source of plant nutrients. Physical and chemical composition of WDFM, FYM and paddy straw were estimated by following the conventional standard procedures. The different treatments applied in rice field were: T_1: NPK 100% of the recommended dose (RD) to all the crops, T_2: NPK 75% of the RD to all the crops, T_3: NPK 50% of the RD to all the crops, T_4: T_2 + 10 t FYM ha^{-1} only to rice, T_5: T_3 + 10 t FYM ha^{-1} only to rice, T_6: T_2 + 2 t well decomposed fishmeal ha^{-1} only to rice, T_7: T_3 + 2 t well decomposed fishmeal ha^{-1} only to rice, T_8: T_2 + 4t paddy straw ha^{-1} only to rice, and T_9: T_3 + 4 t paddy straw ha^{-1} only to rice.

RESULTS AND DISCUSSION

The effect of organic sources was reflected on the yield component of rice. In general, the organic manured plots gave higher yield component than the only inorganically fertilized crops (Table 1).

The yield component of rice, i.e. no. of matured panicle m^{-2}, no. of spikelet $panicle^{-1}$, percentage of filled grain, and 1000 grain weight were higher due to combined application of inorganic and organic manured plots. The highest no. of matured panicle m^{-2}, no. of spiklet $panicle^{-1}$ were found in the T_6 (NPK 75% + 2t WDFM) and it was statistically at par with T_4, T_7, T_8 and T_1. The effect of well decomposed fishmeal was at par with FYM, or sometimes better than FYM. In case of fishmeal 50% NPK + 2t WDFM was statistically at par with the 100% and 75% NPK + 2 t WDFM.

The residual effect of the organic sources was also observed on the following crop (lentil) in the sequence. The yield components of lentil, i.e. no. of

Table 1. *Effect of different nutritional treatments on yield components of different crops in sequence*

Treatments	Rice				Lentil			Sesame		
	No. of panicle/ m^2	No. of spikelet panicle^{-1}	% of filled grain	1000 grain wt (g)	No. of pod plant^{-1}	No. of seeds pod^{-1}	1000 seed wt (g)	No. of capsule plant^{-1}	No. of seeds capsule^{-1}	1000 seed wt (g)
T_1	300.2	78.6	75.0	20.45	68.4	1.92	18.51	59.26	53.65	3.14
T_2	268.9	73.1	68.2.	21.34	56.2	1.86	19.20	54.16	48.89	3.12
T_3	253.5	68.1	68.5	20.12	44.7	1.82	18.16	48.24	42.62	2.95
T_4	323.6	83.2	78.7	21.25	71.6	1.98	18.95	57.14	53.81	2.74
T_5	300.4	75.4	71.9	20.26	58.3	1.87	18.85	51.87	47.11	2.92
T_6	328.4	84.4	79.2	20.92	72.9	1.98	17.95	57.59	54.71	3.09
T_7	313.2	74.3	73.8	21.34	59.2	1.89	18.72	52.91	46.42	3.15
T_8	306.2	80.9	73.6	21.39	67.1	1.90	18.56	55.14	51.16	2.68
T_9	288.0	73.4	71.0	20.21	53.3	1.82	18.42	49.98	43.45	2.76
SEm(±)	8.96	4.25	4.19	0.92	2.86	0.05	0.61	2.96	2.26	0.19
CD at p=0.05	28.63	13.58	NS	NS	9.13	NS	NS	9.46	7.22	NS

Table 2. *Effect of different nutritional treatments on yield and yield equivalence of different crops in sequence*

Treatments	Yield (kg ha^{-1})			Equivalent yield of rice (kg ha^{-1})
	Rice	Lentil	Sesame	
T_1	3326	872	971	2629
T_2	2905	695	896	7442
T_3	2472	532	775	6171
T_4	3545	885	923	2769
T_5	3305	719	812	7706
T_6	3619	897	939	8921
T_7	3381	730	830	7864
T_8	3392	832	906	8400
T_9	3084	659	792	7240
SEm (±)	75.21	18.47	15.42	-
CD at p=0.05	240.38	59.02	49.28	-

pod plant^{-1}, no. of seeds pod^{-1} and 1000 seed wt were also higher in the plot previously applied with organic + inorganic fertilizer which was statistically at par with the 100% inorganically fertilized crops. It was also observed that 50% NPK + previously 2t WDFM applied plot was statistically at par with the 100% NPK fertilized plot.

The positive residual effect was also observed on the succeeding crop (sesame) in this sequence. The yield components of sesame like no. of capsule plant^{-1}, no. of seeds capsule^{-1} and 1000 seed weight was also statistically at par with 100% inorganic fertilized crops and 50% inorganic +previously organic applied plots.

Yield of rice was the highest in T_6 treatment which was statistically at par with T_4, T_7 and T_8 (Table 2). The similar observation was also reported by Patil *et al.* (2000). It was clear clearly seen that the positive residual effect of organic manure was also found on the succeeding lentil and sesame crops. This findings was similar to Mondal *et al.* (1996). They opined that the *rabi* crop seed yield was the highest when grown after rice fertilized with 100% of the recommended dose of NPK + 10 t FYM ha^{-1}.

The equivalent yield of rice (Table 2) in this sequence was highest under the treatment T_6 (75% NPK + 2t WDFM) which was closely related to T_4 and T_1.

Therefore, the yield can be improved for all crops in rice-lentil-sesame cropping system by substituting the inorganic fertilizers partly (25%) by organic manures like FYM, fishmeal, paddy straw, etc.

REFERENCES

Mondal, S. S., Saha, B. C., Mandal, B. K., Chatterjee, B. N. and Chowdhury, P. P. (1996). Effect of potassium, sulphur, farm yard manure and crop residues on the yield of rice, mustard and potato in a Gangetic alluvial soil of West Bengal. *Journal of Potassium Research* **12**(4): 382-390.

Patil, S. H., Talashikar, S. C. and Mehta, V. B. (2000). Integrated nutrient management using fishmeal and fertilizer for rice (*Oryza sativa*). *Indian Journal of Agricultural Sciences* **70**(1): 31-33.

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Microbial Dynamism In Organic Cultivation of *Bhendi* under Island Ecosystem

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Substitution of inorganic sources of fertilization and plant protection with organic sources resulted in identification of the treatment comprising of Navdanya mulch during summer with crop debris along with recommended FYM, Neem cake and Psuedomonads as an effective cultivation technique. This treatment not only helped the plants to overcome the stress caused by the heavy rainfall but also increased the productivity at par with the treatment with 50 percent organic and 50 percent inorganic.

(***Key words***: *Microbial dynamics, Organic & inorganic fertilizers*)

The Andaman and Nicobar Islands situated between 6°45'-13°41' N latitudes and 92°2'-93 °57' E longitudes in the Bay of Bengal, occupying an area of 8249 sq km (8.25 lakh ha) comprising of 572 Islands/Islets/rocks, are characterized by hilly terrains with heavy rainfall (3000 mm) and high relative humidity of 75-90 percent. Cultivation of vegetables in these islands poses challenge to the scientific community and farmers because of heavy rainfall distributed throughout the year and the prevalence of wide variety of diseases and pest caused due to high relative humidity. This resulted in extensive usage of fertilizers and pesticides. Substitution of these inorganic sources with organic source in a phased manner was suggested as the need to protect the ecosystem and simultaneously meet the requirement of vegetables in these islands. Benefits from increasing organic inputs to soil include greater soil N mineralization potential as well as improved physical properties such as more rapid water infiltration and greater soil aggregation. Such changes occur even with only small changes in total soil organic matter (SOM) due to enhancement of active SOM pools. Active SOM, which is comprised of soil microbial biomass (MB) and microbial metabolites and recently added labile organic inputs to soil, has a complete turnover time in the order of one year, while the remainder of SOM has a complete turnover time in the order of 500 yr. With this background the present study was undertaken to analyse the role of microbial dynamism in *bhendi* cultivation with organic amendments in the soil.

MATERIALS AND METHODS

The seeds of *bhendi* variety Arka Annamika were sown in the field at a spacing of 45 x 30 cm during the month of June 2004. The crop was cultivated as rainfed because of continuous daily rains during the monsoon period. The following are the treatments taken on nutrient application:

T_1- Control

T_2- Recommended dosage of fertilizer of *bhendi*

T_3- Purely organic (Navdanya mulch + crop debris + FYM +neem cake + psuedomonas, panchagavya spray during flowering, etc.)

T4- 50% organic + 50% of recommended NPK

The soil samples were collected from individual plots replicated 3 times and analysed for the presence of bacterial, fungal and other microbial population along with organic carbon content. A serial dilution was performed by adding of 1g of soil to 99 ml of sterile distilled water and diluted serially to 10^{-5} dilution. For bacterial and fungal enumeration methods described by Paul and Clark (1998) and Harrigan and McCance (1990) were followed.

RESULTS AND DISCUSSION

Since the trial was attempted during the peak rainy season, there was a substantial reduction from the potential yield of the crop. However, among the different treatments the plants from the plots, where all kinds of organic amendments were carried out, showed highest survival under heavy rainfall when compared with the control and full dosage of NPK. When soil samples were analyzed for organic carbon,

Table 1. *Effect of organic amendments on microbial, soil and yield of* bhendi *var. Arka Annamika*

Treatment	Bacteria Cfu/g	Fungi Spores/g	Moisture content (%)	Carbon content (%)	pH	Yield q/ha
T1	37×10^5	56×10^4	14.16	0.3	5.29	232.33
T2	42×10^5	67×10^4	14.92	0.36	5.352	55.00
T3	145×10^5	108×10^4	15.26	0.64	6.54	320.00
T4	100×10^5	80×10^4	14.94	0.66	6.48	344.00
CD at p=0.05	7.50	5.06	0.30	0.04	0.08	28.84
SEd	3.06	2.06	0.12	0.02	0.03	13.61

T_1- Control; T2- recommended dosage of fertilizer of *bhendi*; T3- purely organic (Navdanya mulch + Crop debris + FYM +Neem cake + Psuedomonas, Panchagavya spray during flowering etc.); T4- 50% organic + 50% of recommended NPK

beneficial bacterial growth and significant increase were found both in organic carbon content and bacterial counts (Table 1). The various microbial population that was found in soil with organic treatments were *Bacillus, Micrococcus, Clostridium, Psuedomonas, Agromyes, Xanthomonas, Acetobacter*, etc. The treatment of pure organic (T3) registered the highest bacterial (145×10^5 Cfu g^{-1}) and fungal (108×10^4 spores g^{-1}) population, while the lowest colonies of 37×10^5 Cfu g^{-1} (bacterial) and 56×10^4 spores g^{-1} (fungal) were found in control where no organic amendments were applied. However, the treatments where no inputs were applied and where recommended dosage of inorganic forms of NPK were applied were found to be at par with each other. This increase in the microbial population led to the increase in soil pH, which signified the role of microbes in decomposition of organic crop debris, which were applied in the pure organic plot.

Microbial biomass has been proposed as an early indicator of changes in total SOM. With its dual role as a pool of labile nutrients and as the agent of decomposition of organic materials in soil, MB may be a sensitive indicator of changes in active SOM. The composition of the microbial community, in particular the proportions of bacteria and fungi, may also influence C and N turnover of active SOM (Holland and Coleman, 1987). Higher decomposition increased the organic carbon content of the soil, thereby increasing the fertility level of the soil which finally resulted in the increased yield of 320.00 q ha^{-1} under organic treatment. The organic system of green manure cover crops was used in place of winter fallow, and animal manure used as N source was comparatively better than the conventional system of inorganic N fertilization. Because of the reduced fallow and increased organic inputs in the organic relative to the conventional soil, higher active SOM was expected in the organic soil (Collins *et al.*, 1992, Wander *et al.*, 1994). However, on statistical analysis of yield it was found that the treatments T1 (Control) and T2 (recommended NPK) were at par with, and treatments T3 (pure organic) and T4 (50% organic and 50% inorganic) were at par. This signified that amendments of soil with pure organic compound not only increased the organic carbon, moisture and other soil properties but also fetched comparatively higher yield even under heavy rainfall.

The moisture content was found to be the highest in the soils amended with organic sources followed by the soils with 50 percent of organic source applied alongwith 50 percent inorganic source. This may be due to plant biomass applied as soil mulch in organic plots.

REFERENCES

Collins, H.P., Rasmussen, P.E. and Douglas Jr., C.L. (1992). Crop rotation and residue management effects on soil carbon and microbial dynamics. *Soil Science Society of America Journal* **56:** 783-788.

Harrigan, W.F. and McCance, M.E. (1990). *Laboratory Methods in Food and Dairy Microbiology*, 8th Edn. Academic Press, London.

Holland, E.A. and Coleman, D.C. (1987). Litter placement effects on microbial and organic matter dynamics in an agroecosystem. *Ecology* **68:** 425-453.

Paul, E.A. and Clark, F.E. (1998). *Soil Microbiology and Biochemistry*. Academic Press Inc., New York.

Wander, M.M., Traina, S.J., Stinner, B.R. and Peters, S.E. (1994). Organic and conventional management effects on biologically active soil organic matter pools. *Soil Science Society of America Journal* **58:** 1130–1139.

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Growth, Yield and Quality of Fodder Maize as Affected by Nitrogen, Azotobacter and Zinc

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A field trial was conducted at the Agricultural College Farm, Bapatla to study the influence of fertilizer nitrogen, azotobacter and zinc on the performance of fodder maize. The highest plant height (207.6cm), average number of leaves plant^{-1} (16.7), leaf to stem ratio (1.01), leaf area index (6.02) and dry matter accumulation (9.45 t ha^{-1}) were recorded by applying 100% recommended dose of nitrogen (120 kg ha^{-1}) + azotobacter seed inoculation + 0.5% $ZnSO_4$ foliar spray at 30 days after sowing. The highest green and dry fodder yields (44.6 and 8.9 t ha^{-1}, respectively), crude protein (8.98%), total ash (9.90%) and the lowest crude fiber contents (23.6%) were also registered by the same treatment. However, 75% RDN + azotobacter seed inoculation + 0.5% $ZnSO_4$ foliar spray at 30 days after sowing and 100% RDN + azotobacter seed inoculation + 0.5% $ZnSO_4$ foliar spray at 30 days after sowing were statistically comparable indicating the possibility to reduce 25% of RDN when azotobacter seed inoculation and 0.5% $ZnSO_4$ foliar spray were given to fodder maize.

(Key words: *Fodder maize, Azotobactor, Nitrogen, Zinc)*

Livestock is the integral component of agriculture and its contribution to our national economy is enormous. Even though India holds the highest livestock population, the milk productivity of cattle is low due to poor management practices (Babu *et al.*, 2002).

The present fodder production is inadequate and there is a wide gap between the demand and availability of green fodders in our country. Hence, there is every need to improve the fodder production by adopting proper management practices. Maize is one of the most important fodder crops with all desirable qualities and its productivity can be increased through fertilizer nitrogen management. With the escalated cost of the nitrogenous fertilizers, it is now necessary to use azotobacter to supply the nitrogen needs of fodder maize. Zinc deficiency is frequently reported in maize and every step is to be taken to rectify the zinc deficiency in fodder maize. Hence, a field trial was planned and conducted to study the growth, yield and quality of fodder maize as affected by nitrogen, azotobacter and zinc.

MATERIALS AND METHODS

The field experiment was conducted at the Agricultural College Farm, Bapatla during *kharif*, 2003. The site of the experiment is located in coastal area of the Krishna-Godavari Agro-climatic Zone of Andhra Pradesh. The experimental soil was a clay loam with low available nitrogen (275 kg ha^{-1}), high available P_2O_5 (52 kg ha^{-1}), high available potassium (920 kg ha^{-1}) and low available Zn (0.59 ppm). In all, nine treatments as detailed in Table 1 are tested in randomized block design replicated thrice.

Bold and healthy seeds of fodder maize (African tall cv.) was sown on 16.8.2003 at a spacing of 30 x 10 cm and harvested on 14.10.03. Before sowing, seed was inoculated with azotobacter culture as per the treatments. Nitrogen was applied as per the treatments (50% basal application + 50% at 30 days after sowing) through urea. Phosphorus and potassium were applied at recommended doses (40 kg P_2O_5 and K_2O ha^{-1}, respectively) through single superphosphate and muriate of potash, respectively as basal application in all the treatments. $ZnSO_4$ @ 0.5% was sprayed at 30 days after sowing by using 500 liters of spray solution ha^{-1} as per the treatments.

RESULTS AND DISCUSSION

Data on growth parameters (Table 1) of fodder maize indicated the significant effect of treatments. The maximum plant height, number of leaves, leaf area index, leaf to stem ratio and dry matter accumulation was recorded by the treatment (T_8) receiving 100% recommended dose of nitrogen (RDN) + azotobacter seed inoculation + 0.5% $ZnSO_4$ foliar spray at 30 days after sowing which was at par with all other treatments containing azotobacter seed inoculation irrespective of dose of nitorgen. All these growth parameters were significantly lowest under

Table 1. *Fodder maize growth characters at harvest as influenced by different treatments*

Treatments	Plant height (cm)	No. of leaves	Leaf to stem ratio	Leaf area index	Dry matter accumulation (t ha^{-1})
T_1- Control	98.0	12.3	0.44	1.67	3.66
T_2- 100% RDN(120 kg ha^{-1})	202.4	16.0	0.92	5.92	8.97
T_3- 75% RDN	140.0	14.0	0.76	5.17	7.02
T_4- 100% RDN + azotabacter	207.0	16.5	1.00	6.00	8.39
T_5- 100% RDN + 0.5% $ZnSO_4$ spray	201.2	16.0	0.96	5.97	9.01
T_6- 75% RDN + azotabacter	183.1	15.4	0.94	5.87	8.64
T_7- 75% RDN + 0.5% $ZnSO_4$ spray	140.9	14.0	0.77	5.19	7.11
T_8- 100% RDN + azotabacter + 0.5% $ZnSO_4$ spray	207.6	16.7	1.01	6.02	9.45
T_9- 75% RDN + azotabacter + 0.5% $ZnSO_4$ spray	183.8	15.7	0.95	5.84	8.70
Sem±	13.9	0.4	0.03	0.21	0.49
CD (p = 0.05)	41.8	1.3	0.10	0.64	1.47

RDN = Recommended dose of nitrogen

Table 2. *Yield and quality parameters of fodder maize as influenced by different treatments*

Treatments	Green fodder (t ha^{-1})	Dry fodder (t ha^{-1})	Crude protein (%)	Crude fibre (%)	Total ash (%)
T_1- Control	17.1	3.4	6.46	27.8	7.7
T_2- 100% RDN	42.5	8.5	8.92	23.8	9.8
T_3- 75% RDN	33.0	6.3	8.00	24.7	8.8
T_4- 100% RDN + azotabacter	44.5	8.8	8.96	23.7	9.9
T_5- 100% RDN + 0.5% $ZnSO_4$ spray	42.5	8.5	8.94	23.8	9.8
T_6- 75% RDN + azotabacter	41.0	8.3	8.83	24.4	9.6
T_7- 75% RDN + 0.5% $ZnSO_4$ spray	33.1	6.4	8.08	24.7	8.8
T_8- 100% RDN + azotabacter + 0.5% $ZnSO_4$ spray	44.6	8.9	8.98	23.6	9.9
T_9- 75% RDN + azotabacter + 0.5% $ZnSO_4$ spray	41.0	8.7	8.88	24.4	9.7
SEm±	2.3	0.6	0.20	0.9	0.2
CD (p = 0.05)	7.0	1.7	0.60	2.6	0.7

RDN = Recommended dose of nitrogen

control treatment. The superiority of all treatments receiving N fertilizers over control showed the beneficial effect of the nutrient. Similar beneficial impact of nitrogen on growth parameters of maize was also reported by (Sood *et al.*, 1994). Azotobacter is a free living rhizospheric gram negative bacterium which had potential to fix atmospheric nitrogen. It also possesses other properties like ammonium excretion, production of vitamines and growth substances, auxines, gibberellins and cytokinines. Hence, these improve the growth parameters of maize (Singh *et al.*, 1993).

Data on yield and quality parameters of fodder maize (Table 2) were also significantly influenced by the treatments. The highest green and dry fodder yields, the highest crude protein, total ash and the lowest total ash content were recorded by applying 100% RDN + azotobacter seed inoculation + 0.5% $ZnSO_4$ foliar spray at 30 DAS (T_8 treatment) and like the data on yield and growth parameters these were at par with all treatments receiving azotobacter seed inoculation irrespective of N application dose. The minimum data were obtained in each under control. Nitrogen being a major constituent of chlorophyll molecule, it might have played a positive role in increasing the photosynthetic activity and ultimately reflected in higher yields with better quality parameters. Similar favourable results were also reported by Ammaji and Suryanarayana (2002). The increase in forage yield with better quality due to Azotobacter seed inoculation can be attributed to nitrogen fixation in the soil and the nitrogen so fixed helped the crop to perform better. Similar results were also reported by Mishra *et al.* (1998). Nitrogen is a constituent of oxides, amino acids, nucleic acids, enzymes, nucleotides and proteins. The nitrogen supplied through fertilizer, and the nitrogen fixed by azotobacter could be the reason for the higher crude protein contents in fodder maize. Ayub *et al.* (2000) too reported similar results. The reason for the highest crude fibre content in control and lower crude fibre content in fertilizer applied treatments might be due to the negative correlation between the nitrogen application and crude fibre content in fodder maize (Krishna *et al.*, 1998).

Application of fertilizer nitrogen, nitrogen fixed by azotobacter and zinc supplied through foliar spray might have helped in higher accumulation of all essential plant nutrients in fodder maize as reflected by higher total ash content in these treatments. Similar results were also reported by Shende *et al.* (1975) and Krishna *et al.* (1998).

From the foregoing studies it can be concluded that to achieve better growth and higher green and dry fodder yields with better quality in coastal areas of Andrha Pradesh fodder maize may be applied with 75% RDN + Azotobacter seed inoculation + 0.5% $ZnSO_4$ foliar spray at 30 DAS.

REFERENCES

Ammaji,P. and Suryanarayana, K. (2002). Influence of different levels of nitrogen on yield and nutritive parameters of cereal fodder varieties. *Journal of Research* **30**(4): 11-16.

Ayub, M., Tanveer,A., Ahmad, R. and Tariq, M. (2000). Fodder yield and quality of two maize varieties at different nitrogen levels. *The Andhra Agricultural Journal* **47**(1&2): 7-11.

Babu, J. B., Venkata Subramanian, V., Singh, D. K. and Rao, S. P. V. V. S. (2002). *Improved Fodder Production Technologies for Higher Milk Productions*, Krishi Vignan Kendra, CTRI, Rajahmundry. 103p.

Krishna, A., Rai Khelkar, S.V. and Sambasiva Reddy, A. (1998). Effect of planting pattern and nitrogen on fodder maize (*Zea mays*) intercropped with cowpea (*Vigna unguiculata*). *Indian Journal of Agronomy* **43**(2): 237-240.

Mishra, M., Pattoshi, A. K. and Jena, D. (1998). Effect of biofertilization on production of maize (*Zey mays*). *Indian Journal of Agronomy* **43**(2): 307-310.

Shende, S. T., Apte, R. G. and Singh, T. (1975). Multiple action of Azotobacter. *Indian Journal of Genetics and Plant Breeding* **35**:314-315.

Singh, R., Sood, B. R. and Sharma V. K. (1993). Response of forage maize (*Zea mays*) to Azotobacter inoculation and nitrogen. *Indian Journal of Agronomy* **38**(4): 555-558.

Sood, B. R., Singh Gurudev and Kumar Naveen (1994). Evaluation of maize fodder varieties for forage yield under different levels of nitrogen. *Forage Research* **20** (2 & 3): 208-209.

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Response of Rice to Nutrients and Biofertilizers in Coastal Agroecosystem of Karnataka

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A field experiment was carried out in the farmer's field at Mirjan village, Kumta *taluka* of Karnataka to study the response of paddy to nutrient and biofertilizers. The study area was representative of the agro-ecological subregion 19.3 covering Karnataka coast. The experiment was laid out in RBD with three replications. MTU-1001 was the test variety. The present investigation indicated that dry matter, yield components, *viz.* number of productive tillers per hill, panicle length, panicle weight, number of grains per panicle, thousand grain weight and yield were highest with the application of 150% RDF + biofertilizers + $ZnSO_4$ @ 25 kg ha^{-1}.

(***Key words*** *: Rice, Biofertilizer, Zinc sulphate)*

Rice is the principal cereal crop of Karnataka. The productivity of rice in coastal Karnataka is low due to heavy rainfall, inadequate and improper time of application of nutrients. The heavy rainfall results in leaching of nutrients like nitrogen and potassium which leads to poor fertility condition of soil like low pH, iron and aluminium toxicity causing the main constraints for the low productivity of rice.

Nitrogen applied in lowland rice is lost from soil through leaching and denitrification. Majority of the coastal rice soils of Karnataka are low to medium in phosphorus. Acidic reaction and high content of Fe and Al oxides cause phosphorus deficiency in these soils. Most of the coastal soils of Karnataka are low to medium in potassium due to heavy leaching. Among the micronutrients zinc is the most important plant nutrient, whose widespread deficiency has become serious nutritional problem in rice limiting its yield in coastal areas (Chatterjee and Maiti, 1981).

Since increasing cost of fertilizers particularly nitrogenous and phosphatic poses severe constraints to our farmers particularly on small and marginal farmers, it became imperative to search for alternative low cost resources to relieve the pressure on nitrogenous and phosphatic fertilizers. In this context, alternative low cost resources like biofertilizers have gained prime importance in the recent decades. In view of the above, the present investigation was taken up with the objective to study the response of rice to nutrients and biofertilizers in coastal agroecosystem of Karnataka.

MATERIALS AND METHODS

The study area belonged to the Mirjan village of Kumta *taluk*, located between 14°29′ 33.8″ N latitude and 74°25′ 27.6″ E longitude. It was representative of the agro-ecological subregion 19.3 covering Karnataka coast of around 350 km (Sehgal *et al.*, 1992). A field experiment was carried out in the farmer's field at Mirjan village to study the response of paddy to nutrient and biofertilizers. The following treatments were designed based on the identified soil fertility constraints to study the response of rice.

T_1 = Control
T_2 = *Azospirillum* + PSB
T_3 = RDF (Recommended dose of fertilizer)
T_4 = RDF + *Azospirillum* + PSB
T_5 = RDF + 25 kg $ZnSO_4$ ha^{-1}
T_6 = RDF + 25 kg $ZnSO_4$/ha + *Azospirillum* + PSB
T_7 = 150% RDF
T_8 = 150% RDF + *Azospirillum* + PSB
T_9 = 150% RDF + $ZnSO_4$ 25 kg ha^{-1}
T_{10} = 150% RDF + $ZnSO_4$ 25 kg ha^{-1} + *Azospirillum* + PSB

The experiment was laid out in RBD with three replications. MTU-1001 was the test variety. The recommended package of practice for rice was followed in raising the crop.

RESULTS AND DISCUSSION

From the experimental results, it was observed (Table 1) that the growth parameters such as plant height, number of tillers per hill, number of leaves per hill, leaf area per plant, leaf area index and dry matter production were highest in the treatment which received 150 percent RDF, biofertilizers and $ZnSO_4$ @ 25 kg ha^{-1} (T_{10}).

Application of RDF and 150 percent RDF significantly increased the dry matter production over control as soils were low in nutrient status. Increased nitrogen availability at higher levels of nitrogen might have been responsible for profuse tillering and ultimately high dry matter. Treatment T_{10} (150 percent RDF + $ZnSO_4$ + BF) recorded the highest dry matter at all the growth stages of the crop. It varied from 186.8 to 60.6 q ha^{-1} at harvest stage. Combined application of nutrients and biofertilizers caused significant variation in total dry matter production over control T_1 (no nutrients and biofertilizers) at all the crop growth stages. Nitrogen imparts vigorous vegetative growth, as a result long and wide leaves were formed, and hence the high LAI and dry matter. These findings were in accordance with the findings of Devasenamma *et al.* (1999). The beneficial effects of *Azospirillum* could be attributed to a single or a combination of (1) increased associative biological nitrogen fixation in the rhizosphere, (2) production of plant growth promoting substances, that favours rice growth and nutrient utilization, and (3) increased nutrient availability through solubilization of immobilized nutrients by inoculated bacteria. All these resulted in vigorous plant growth and high dry matter production. Application of higher doses of inorganic phosphate with phosphorus solubilizing bacteria resulted in better root growth and better availability of phosphorus which resulted in higher dry matter production.

Significant response of rice to $ZnSO_4$ might have been due to its deficiency in soil and immediate availability of applied $ZnSO_4$ to plants. As zinc was a part of various enzymes and hormones, it favoured increased synthesis of enzymes and hormones along with the metabolisation of major nutrients, which would in turn promote the growth components (Sarkar *et al.*, 1998).

The grain yield differed significantly with different treatments (Table 2). Maximum grain yield of 111.2 q ha^{-1} was obtained by the application of 150 per cent RDF + BF + $ZnSO_4$ (T_{10}) and lowest yield of 45.3 q ha^{-1} was recorded in T_1 (control). The increased yield was due to the higher magnitude of yield components, i.e. more number of effective tillers (16.1), better panicle length (25.7 cm), mean panicle weight (3.5 g), number of grains per panicle (148) and 1000 grain weight (30.1 g). Kumari *et al.* (2000) reported that increased nitrogen levels from 40 to 120 kg ha^{-1} brought about significant increase in grain yield over control. The increase in yield due to biofertilizer inoculation might have not been solely due to nitrogen fixation or phosphate solubilization, but because of several other factors such as release of growth promoting substances, control of plant pathogens, proliferation of beneficial organisms in the rhizosphere. These findings were in accordance with Kundu and Gaur (1980). PSB solubilized inorganic phosphates in the soil and made them available to the crop which resulted in better yield.

Table 1. *Effect of nutrients and biofertilizers on growth data at harvest*

Treatments	Height (cm)	No.of tillers per hill	No.of leaves per hill	Leaf area (cm^2)	LAI	Total dry matter (q/ha)
T_1 = Control	98.5	12.0	48.5	437.3	2.19	60.7
T_2 = Biofertilizers	104.5	13.2	61.2	503.3	2.52	73.0
T_3 = RDF	107.2	13.3	61.6	780.7	3.94	92.7
T_4 = RDF + Biofertilizers	108.9	13.4	64.9	937.3	4.69	104.9
T_5 = RDF + $ZnSO_4$ 25 kg/ha	111.3	13.8	74.8	964.0	4.82	115.8
T_6 = RDF + $ZnSO_4$ 25 kg/ha + Biofertilizers	123.5	15.3	79.2	1444.7	7.22	147.9
T_7 = 150% RDF	120.9	14.0	71.0	1200.0	6.00	134.4
T_8 = 150% RDF + Biofertilizers	121.9	15.2	78.5	1340.0	6.70	144.8
T_9 = 150% RDF + $ZnSO_4$ 25 kg/ha	124.4	15.8	85.5	1509.3	7.55	158.6
T_{10} = 150% RDF + $ZnSO_4$ 25 kg/ha + Biofertilizers	127.7	16.0	88.6	1620.7	8.10	186.8
S.Em±	4.4	0.8	3.9	50.8	0.25	7.8
CD at p=0.05	13.0	2.3	11.7	150.8	0.75	23.1

Table 2. *Effect of nutrients and biofertilizers on yield and yield attributes*

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index	Productive tillers/hill	Length of panicle (cm)	Mean panicle weight (g)	No. of grains per panicle	Test weight (g)	Productive tillers/hill	Length of panicle (cm)	Mean panicle weight (g)
T_1 = Control	45.3	49.5	0.47	10.7	19.3	1.4	94.0	19.5	10.7	19.3	1.4
T_2 = Biofertilizers	57.1	59.7	0.48	12.5	21.7	1.9	117.0	22.2	12.5	21.7	1.9
T_3 = RDF	84.0	88.3	0.49	13.0	21.7	2.0	118.3	23.7	13.0	21.7	2.0
T_4 = RDF + Biofertilizers	88.4	90.9	0.49	13.4	23.0	2.4	123.3	24.0	13.4	23.0	2.4
T_5 = RDF + $ZnSO_4$ 25 kg/ha	92.3	96.0	0.49	13.6	23.3	2.5	124.7	25.8	13.6	23.3	2.5
T_6 = RDF + $ZnSO_4$ 25 kg/ha + Biofertilizers	102.5	117.4	0.47	15.2	24.7	3.0	133.0	27.3	15.2	24.7	3.0
T_7 = 150% RDF	97.4	101.9	0.49	14.4	23.7	2.9	130.0	26.6	14.4	23.7	2.9
T_8 = 150% RDF + Biofertilizers	99.3	104.3	0.48	14.6	24.4	2.9	132.3	26.8	14.6	24.4	2.9
T_9 = 150% RDF + $ZnSO_4$ 25 kg/ha	107.7	123.3	0.47	15.5	24.8	3.3	139.0	28.3	15.5	24.8	3.3
T_{10} = 150% RDF + $ZnSO_4$ 25 kg/ha + Biofertilizers	111.2	127.6	0.47	16.1	25.7	3.5	148.0	30.1	16.1	25.7	3.5
S.Em±	3.6	3.4	0.2	0.8	1.1	0.2	7.8	1.2	0.8	1.1	0.2
CD at p=0.05	10.6	10.0	NS	2.3	3.4	0.5	23.2	3.4	2.3	3.4	0.5

These findings were in accordance with Datta *et al.* (1982). Grain yield was also influenced by higher dose of potassium. Application of zinc had significantly increased the grain yield. Sriramachandrasekharan and Mathan (1988) reported that application of zinc irrespective of zinc sources increased the number of panicles per m^2. This was due to enhanced activity of the metallo enzymes like protinases and peptidsase. The accelerated physiological activities might be the probable reason for higher yield.

It was observed that combined application of inorganic fertilizers, $ZnSO_4$ and biofertilizers recorded the highest yield. The yield obtained by the combined application of biofertilizers and $ZnSO_4$ @ 25 kg ha^{-1} (T_{10} and T_6) were significantly superior to their individual application indicating the synergistic effect of Zn on the activity of microorganisms.

Response curves for nitrogen, phosphorus and potassium were fitted using the polynomial equation, $Y = ax^2 + bx + c$, where y=Yield and x=Levels of nutrients. Response curve for N, P and K respectively are;

1) a= -0.0015, b= 0.6433, c = 44.33,

2) a= -0.0015, b= 0.6433, c = 44.33,

3) a= -0.0008, b= 0.514, c = 44.33

The response curves indicate that the crop responded significantly upto 150 percentage recommended dose of N, P and K and there was a chance that the variety might have responded to higher level of NPK than 150% RD NPK. The benefit-cost analysis of rice cultivation showed that the treatment T_{10} (150% RDF + biofertilizers + $ZnSO_4$ @ 25 kg ha^{-1}) recorded the highest benefit-cost ratio of 4.1.

Form the present investigation it could be concluded that dry matter, yield components, viz. number of productive tillers per hill, panicle length, panicle weight, number of grains per panicle, 1000 grain weight and yield were highest with the application of 150% RDF + biofertilizers + $ZnSO_4$ @ 25 kg ha^{-1}.

REFERENCES

Chatterjee, B.N. and Maiti, S. (1981). In *Principles and Practices of Rice Growing*, pp.154-191. Oxford and IBH Publications Co., New Delhi.

Datta, M., Banik, S. and Guptha, P.K. (1982). Studies on efficiency of phytohormone producing phosphate solubilizing *Bacillus firmis* in augmenting paddy yield in acid soils of Nagaland. *Plant and Soil* **69**(3): 365-373.

Devasenamma, V., Reddy, M.R. and Rajan, M.S.S. (1999). Effect of varying levels of nitrogen on growth and nitrogen uptake of rice hybrids. *The Andhra Agricultural Journal* **46**(1&2): 124-125.

Kumari, M.B.G.S., Subbaiah, G., Veeraraghavaiah, R. and Rao, C.V.H. (2000). Effect of plant density and nitrogen levels on growth and yield of rice. *The Andhra Agricultural Journal* **47**(3&4): 188-190.

Kundu, B.S. and Gaur, A.C. (1980). Establishment of nitrogen fixing and phosphorus solubilizing bacteria in the rhizosphere and their effect on yield and nutrient uptake of wheat crop. *Plant and Soil* **57**(2): 223-230.

Sarkar, R.K., Sasmal, T.K., Chakraborty, A.A. and Bala, B. (1998). Effect of micronutrient on physiological parameters in relation to yield of sunflower (*Helianthus annuus* L.) in rice fallow gangatic alluvial soil. *Indian Journal of Agricultural Science* **68**: 238-240.

Sehgal, J.L., Sohanlal and Pofali, R.M. (1992). Sandy soils of India. *Agropedology* **2**: 1-15.

Sriramachandrasekharan, M.V. and Mathan, K.K. (1988). Influence of Zinc sources of the yield components, dry matter production and yield of rice (Var. IR-60). *Madras Agricultural Journal* **75**(5-6): 200-203.

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Efficacy of Source and Levels of Sulphur on Rice (*Oryza sativa*) in Red Lateritic Soil of Orissa

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Field experiments were carried out during 2000 and 2001 on red lateritic soil of Central Agricultural Research Station, O.U.A.T., Bhubaneswar, Orissa to study the efficacy of sulFer 95, gypsum and elemental S at different doses. The result of the experiment revealed that sulphur application significantly increased the yield and sulphur uptake in rice. Amongst various sources of S, sulFer 95 was found superior to other sources. Sulphur applied @ 40 kg ha^{-1} from sulFer 95 increased the grain and straw yield, sulphur uptake and economics of rice in red lateritic soil.

(**Key words:** *Rice yield, Sulphur as fertilizer, S uptake, Red lateritic soil*)

The productivity of rice can be increased with the application of NPK along with sulphur. Sulphur as one of the essential nutrients has key role in root development, chlorophyll formation, protein and oil synthesis. Use of high analysis S free fertilizer, inadequate or no use of organic manures, cultivation of high yielding and hybrid varieties along with intensive cropping are the major causes of sulphur deficiency in Indian soils. Indian soils showed about 36 percent deficiency of S. Several workers have shown varied response of rice to S fertilization (Raju and Reddy, 2001, Vaiyapuri and Sriramchandra sekhran, 2001 and Singh and Singh, 2002).The present experiment was undertaken to find out the effective source and proper dose of S to rice crop in red lateritic soils of Orissa.

MATERIALS AND METHODS

The experiment was carried out in red lateritic loamy sand (Aeric aplaquept) at Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar during *kharif* 2000 and 2001. The soil had organic carbon 0.415%, 15% $CaCl_2$ extractable S 9.6 ppm, and pH 5.8. The experiment was laid out in randomised block design with eight treatments consisting of three sources of S such as sulFer 95, gypsum and elemental sulphur. Both sulFer 95 and gypsum were applied @ 20, 40 and 60 kg ha^{-1} alongwith elemental sulphur @ 40 kg ha^{-1}. One month-old rice seedling variety Lalat was transplanted at 20 x 10 cm spacing with three to four seedlings per hill on 13.07.2000 & 20.07.2001. In each plot 11.75 kg N ha^{-1} and 30 kg ha^{-1} of both P_2O_5 and K_2O were applied through urea, diammonium phosphate and muriate of potash as basal. The different doses of S from various sources were applied at planting according to the treatments. At tillering stage 30 kg N ha^{-1} in the form of urea was top dressed just 15 days after planting. Rest 18.25 kg N ha^{-1} through urea was top dressed at panicle initiation stage. After harvest of crop, S content of leaf, grain and straw was determined by turbidity method. (Chesnin and Yien, 1951). Rice grain and straw yield were recorded from each plot at full maturity stage after harvesting, threshing and sun drying. The economics of rice was calculated depending upon the prevailing market price of input and output of the locality.

RESULTS AND DISCUSSION

Biological yield

The perusal data in Table 1 revealed that application of various sources of S at different doses significantly influenced the grain and straw yield of rice during both the years of experimentation. During 2000, sulFer 95 @ 40 kg ha^{-1} recorded the highest grain yield (3940 kg ha^{-1}) followed by same sulFer 95 at 60 kg ha^{-1}, which were at par. SulFer 95 applied @ 20 kg ha^{-1} recorded higher grain yield than gypsum applied @ 40 and 60 kg ha^{-1} during 2000. The maximum grain yield was obtained with application of sulFer 95 @ 60 kg ha^{-1} (3875 kg ha^{-1}) followed by gypsum @ 60 kg ha^{-1} (3638 kg ha^{-1}) being at par with other treatments excepting elemental sulphur @ 40 kg ha^{-1} and no-sulphur treatment during the year 2001. In the pooled data, the highest grain yield of rice was produced with application of sulFer 95 @ 60 kg S ha^{-1} (3864 kg ha^{-1}) closely followed by the same source of S @ 40 kg ha^{-1} which were at par with gypsum @ 60 kg S ha^{-1}. The

Table 1. *Grain and straw yield of rice as affected by different sources and levels of S in rice*

Treatments	Grain yield (kg ha^{-1})			% increase over control	Straw yield (kg ha^{-1})			% increase over control
	2000	2001	Mean		2000	2001	Mean	
Control S @ 0 kg ha^{-1}	3144	2625	2885	-	3240	2860	3052	-
SulFer 95 @ 20 kg S ha^{-1}	3590	3275	3433	18.99	4320	3450	3885	27.73
SulFer 95 @ 40 kg S ha^{-1}	3940	3475	3708	28.53	4760	3570	4165	36.47
SulFer 95 @ 60 kg S ha^{-1}	3852	3875	3864	33.95	4700	4307	4504	47.58
Gypsum 95 @ 20 kg S ha^{-1}	3314	3410	3362	16.53	4160	3325	3743	22.64
Gypsum 95 @ 40 kg S ha^{-1}	3446	3375	3411	15.18	4600	3470	4035	32.21
Gypsum 95 @ 60 kg S ha^{-1}	3556	3638	3597	24.68	4560	4187	4374	43.32
Elemental sulphur @ 40 kg S ha^{-1}	3175	2925	3050	5.72	3550	3375	3463	13.47
C.D at p = 0.05	156	675	325	-	323	603	441	-

Table 2. *Sulphur concentration, total uptake and economics in rice (mean of two years)*

Treatments	S content in leaf (%)	S content in grain (%)	S content in straw (%)	Grain yield kg ha^{-1}	Straw yield kg ha^{-1}	Total S kg ha^{-1}	Net profit uptake (Rs ha^{-1})	Cost benefit ratio
Control S @ 0 kg ha^{-1}	0.105	0.041	0.033	2885	3052	2.26	5884	0.62
SulFer 95 @ 20 kg S ha^{-1}	0.111	0.055	0.038	3433	3885	3.71	8405	0.84
SulFer 95 @ 40 kg S ha^{-1}	0.120	0.061	0.042	3708	4165	3.98	9339	0.89
SulFer 95 @ 60 kg S ha^{-1}	0.144	0.060	0.047	3864	4504	4.42	9731	0.88
Gypsum 95 @ 20 kg S ha^{-1}	0.109	0.055	0.028	3362	3743	2.94	8207	0.84
Gypsum 95 @ 40 kg S ha^{-1}	0.122	0.057	0.044	3411	4035	3.60	8215	0.81
Gypsum 95 @ 60 kg S ha^{-1}	0.128	0.058	0.043	3597	4374	3.93	9021	0.86
Elemental sulphur @ 40 kg S ha^{-1}	0.115	0.061	0.041	3050	3463	3.25	5282	0.47
C.D at p = 0.05	0.023	-	-	325	441	1.67	-	-

Cost of the produce:
Rice grain = Rs. 480.00 per quintal
Rice straw = Rs. 50.00 per quintal

maximum percent increase in grain yield of rice over control was noticed in sulFer 95 applied @ 60 and 40 kg S ha^{-1}. During both the years (2000 and 2001) the straw yield was at par with application of S @ 40 and 60 kg ha^{-1} applied through sulFer 95 and gypsum respectively which were significantly higher than other treatments. Maximum percent increase of straw yield over no-sulphur treatment was observed in sulFer 95 @ 60 kg ha^{-1} followed by gypsum @ 60 kg ha^{-1}. Application of sulphur enhanced the rice yield due to the fact that S plays pivotal role in the formation of chlorophyll, activation of enzyme and synthesis of protein. It is in line with the finding of Raju and Reddy (2001), Vaiyapuri and Sriramchandrasekharan (2001) and Singh and Singh (2002). Amongst the various sources of S, sulFer 95 gave encouraging result because the granules of sulFer 95 readily dispersed when wetted in soil and provided sustained supply of S to meet the nutritional demand of crop at all stages of growth. The elemental sulphur was not found as an effective source as it was insoluble and not immediately available, thus failed to satisfy the short term need of the crop.

Uptake of sulphur

During both the years mean S content in the leaf, grain and straw was increased with application of higher doses of S in all sources (Table 2). Application of S significantly increased the total S uptake over no-sulphur treatment. The highest uptake of S was recorded with application of sulFer 95 @ 60 kg S ha^{-1} (4.42 kg ha^{-1}) being at par with all the sources of S at different levels. The uptake of S at higher level was increased due to increase in dry matter productivity coupled with high nutrient content that led to high S uptake. It is in agreement with the finding of Vaiyapuri and Sriramchadra sekhran (2001) and Singh and Singh (2002). SulFer 95 recorded higher uptake of S compared to other sources which might be due to the fact that granular micronised elemental S particles with unique oxidation rate provided reliable sulphate formation and controlled sulphate release.

Economics

The data presented in Table 2 indicated that application of 60 kg S ha^{-1} through sulFer 95 increased the net profit (Rs 9731.00 ha^{-1}) closely followed by the same source of S @ 40 kg ha^{-1} (Rs 9339.00 ha^{-1}). Considering the cost-benefit ratio, sulFer 95 @ 40 kg ha^{-1} gave the maximum value of 0.89 followed by same source of sulFer 95 @ 60 kg ha^{-1} (0.88). Elemental S gave the least net profit due to its lesser efficacy and higher price of the product.

Therefore, it may be concluded that application of sulFer 95 @ 40 kg S ha^{-1} may be recommended to augment the yield of *kharif* rice in red lateritic soils of Orissa.

REFERENCES

Chesnin, L. and Yien (1951). Turbidimetric determination of available sulphur. *Soil Science Society of American Proceedings* **15**: 149-151.

Raju, R.A. and Reddy, M.N. (2001). Response of hybrid and conventional rice to gliricidia loppings, sulphur and zinc application. *Fertiliser News* **46** (11): 61-62.

Singh, C.L. and Singh, U.N. (2002). Effect of N and S nutrition on growth and yield of rice cultivars. *Research on Crops* **3** (3): 643-646.

Vaiyapuri, V. and Sriramchandrasekhran, M.V. (2001). Integrated use of green manure and sulphur on nutrient uptake and rice yield. *Journal of Ecobiology* **13** (3): 223-227.

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Effect of Nitrogen and Potassium on Seed Yield, Seed Quality and Fruit Yield of Tomato (*Lycopersicon esculentum*)

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In this experiment, different levels of nitrogen and potash were tried with an objective to standardize the nutrient levels for seed yield, quality and fruit yield of tomato var. Utkal kumari, a newly developed popular variety of tomato for coastal Orissa. The wide range of variation was observed by the application of nitrogen with respect to seed yield, quality and fruit yield of tomato. With each increase in the level of nitrogen from 50 kg to 150 kg ha^{-1} there was commendable increase in the fruit yield, but further increase of the nitrogen beyond 150 kg ha^{-1} reduced the yield considerably. All the observations recorded in relation to seed yield, fruit yield and yield attributing characters clearly indicated the superiority of N (150 kg ha^{-1}) over other treatments except single fruit weight (g). With each increase in the level of potash from 75 to150 kg ha^{-1} significant decrease in the yield of tomato was observed. The highest value relating to yield attributing characters like flowers per plant, final fruit retention per plant and average fruit weight were recorded when potash was applied @ 75 kg ha^{-1}. This clearly indicated the superiority of K (75 kg ha^{-1}) over the higher levels of potash tried. As regards the combined effect of N and K with respect to tomato fruit yield, seed yield and other yield attributing characters, the best result was obtained when N @150 kg ha^{-1} along with K 75 kg ha^{-1} were applied to the plant.

(**Key words:** *Tomato, Seed yield & quality, Fruit yield, Nitrogen, Potassium*)

Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular vegetables grown in India. Among different varieties BT-10, released as Utkal Kumari has wide acceptance both by the coastal growers and consumers due to its normal fruit shape, excellent sugar to acid blending, bacterial wilt tolerance and higher yields. Quality seed production is a major researchable issue, since post-germination crop performance largely depends on quality of seed. Although commercial seed production units are on rise the technology with concrete scientific recommendations are not available in tomato seed production. In this communication we report the nitrogen and potash required for quality seed production in tomato using a locally released variety BT-10 suitable for coastal Orissa.

MATERIALS AND METHODS

An experiment was laid out at the Horticulture Research Station, Department of Horticulture, OUAT, Bhubaneswar in the year 2000-2001 during *rabi* season. The soil of the experimental field was sandy loam in texture with soil pH slightly towards acidic side. Eight treatments consisting of four levels of nitrogen (N_1, 50; N_2, 100; N_3, 150; N_4, 200 kg ha^{-1}) and two levels of potash were tested in a factorial randomized block design with three replications. The breeder seeds of tomato variety (BT-10 or Utkal kumari) were treated with Thiram (3 g kg^{-1}) and sown in the nursery in 1st week of September, 2000 and 2001, and then twenty-eight days old healthy and uniform seedlings were uprooted and transplanted at a spacing of 60 & 50 cm. FYM @ 250 q ha^{-1} was applied at the time of field preparation and phosphorus @ 50 kg ha^{-1} was applied before planting uniformly to all the treatments. Full dose of K and half of N were applied at the time of transplanting as per treatment and the remaining N was top-dressed after 40 days. Five plants per plot were selected randomly for recording observations on different characters, such as yield attributes, fruit yield, seed yield, and seed quality attributes. The seeds were extracted by fermentation method.

RESULTS AND DISCUSSION

In the present study the wide range of variation was observed by the application of nitrogen with respect to growth, development, yield of fruit and seed in tomato (Table 1). With increase in the levels of nitrogen from 50 kg to 150 kg ha^{-1} there was commendable increase in the fruit yield, but further increase of nitrogen beyond 150 kg per hectare reduced the yield considerably.

Table 1. *Effect of N and K on seed yield, its quality and yield attributing character of tomato variety Utkal Kumari*

Treatments	Plant height (cm)	Number of branches per plant	Height at which 1st flower appeared (cm)	Flowers per plant (no.)	Fruit retention per plant (no.)	Average fruit weight (g)	Yield (q/ha)	Weight of seed per kg of fruit	Seed yield per plant(g)	1000 seed weight	Germination (%)
N_1K_1 ($N_{50}K_{75}$)	75.24	7.82	17.45	65.32	22.82	28.51	236.27	2.77	1.8	2.28	83.33
N_1K_2 ($N_{50}K_{150}$)	79.28	8.45	18.01	71.57	23.13	29.36	241.69	3.12	2.11	2.31	85.42
N_2K_1 ($N_{100}K_{75}$)	83.41	10.12	24.19	76.97	24.06	31.41	275.16	3.89	2.78	2.45	86.32
N_2K_2 ($N_{100}K_{150}$)	88.62	10.91	25.33	89.79	25.91	32.72	285.56	4.11	3.31	2.53	88.41
N_3K_1 ($N_{150}K_{75}$)	105.86	12.76	37.81	134.39	29.87	42.19	333.28	4.83	5.83	2.93	90.32
N_3K_2 ($N_{150}K_{150}$)	100.31	13.81	39.02	108.67	26.32	38.26	317.58	5.00	4.85	3.12	92.32
N_4K_1 ($N_{200}K_{75}$)	95.32	11.43	41.42	119.7	23.81	44.42	320.81	4.13	4.36	2.98	95.32
N_4K_2 ($N_{200}K_{150}$)	89.14	12.81	42.37	99.32	24.14	38.33	310.65	3.92	3.53	3.01	93.48
C.D at p=0.05 (N x K)	0.26	0.16	0.5	3.63	0.22	0.18	2.7	0.31	0.69	0.15	0.93

Similarly, in case of seed production, maximum quantity of seed extracted per plant and weight of seeds per kg of fruit were recorded by the application of 150 kg N ha^{-1}. But further increase in levels of N to 200 kg per hectare reduced the yield considerably. All the observations recorded in relation to yield and yield attributing characters clearly indicated the superiority of N (150 kg N ha^{-1}) treatment to other treatments except single fruit weight (g), which was maximum under 200 kg N ha^{-1} (Table 1).

With increase in level of potash from 75 to 150 kg ha^{-1} significant decrease in the yield of tomato was observed. The highest values relating to yield attributing characters like number of fruits per plant and single fruit weight were recorded when potash was applied @ 75 kg ha^{-1}. This clearly indicated the superiority of K (75 kg ha^{-1}) over the higher levels of potash tried. With respect to seed yield maximum amount of seed was extracted per plant (g) when potash was applied @ 75 kg ha^{-1}. But for the characters like weight of seeds per kg of fruit and 1000 seed weight (g), maximum value was marked (Table 1) with higher levels of potash (150 kg per ha^{-1}).

The different levels of N and K had significant influence on seed yield, its quality, and yield of tomato (Table 1). The synergistic effects of N and K have been highlighted below. The pooled data for 2000 and 2001 in Table 1 indicated that the growth characters and almost all seed quality characters except 1000 seed weight were significantly influenced by the nitrogen and potassium application. Nitrogen increased the photosynthetic efficiency and rate of assimilation, which reflected on the bumper vegetative growth. Potassium applied in combination with nitrogen triggered the translocation of essential amino acids, activated enzymatic activities, and improved efficient use of applied nutrients. Therefore, balanced potassic nutrition with nitrogen is essential for a crop like tomato.

In the present study the combined effect of nitrogen and potassium exhibited very meaningful impact on the production of food as well as seed yield. Maximum tomato yield was recorded with N_3K_1 (333.28 q ha^{-1}) that surpassed the yield of other combinations significantly. The maximum yield of tomato was due to the optimum application of N and K fertilizers. On the other hand, the higher levels of N and K exhibited more vegetative growth as the higher levels of nutrient were mostly used for the physiological expression of the plant, contributing yield attributing characters. With respect to weight of seeds per plant, maximum value was recorded with N_3K_1 (5.83g per plant), which surpassed all the treatment combinations, but maximum seeds extracted per kg of fruit were recorded with N_3K_2 (5.00 g per kg of fruit), which remained at par with N_3K_1, thereby proving the superiority of the treatment combination N_3K_1 (Table 1).

The findings of the result are in concurrence with with the findings of Ruiz (1986), Subbaih and Perumal (1986), Kalloo(1989), Mehta and Saini (1986), Cerne (1990), Ashcroft and Jones (1993) and Locascio *et al.* (1997).

The combined application of 150 kg N and 75 kg K ha^{-1} was the best treatment to obtain good yield of tomato as well as maximum quantities of quality seeds than rest other treatment combinations. The result of course offers the scope to further continue the experiment by slightly increasing the dose of N and K to get conclusive result.

REFERENCES

Ashcroft, W.J. and Jones, K.H. (1993). Response of processing tomatoes to applications of nitrogen and potassium. In *Plant Nutrition from Genetic Engineering to Field Practice*, Proceedings *12th International Plant Nutrition Colloquium*, pp. 21-26, held Sept, 1993.

Cerne, M. (1990). Different kinds and levels of nitrogen in tomatoes. *Acta Horticulture* **277**: 179-182.

Kalloo, G. (1989). Tomato (*Lycopersicon esculentum* Mill). *Indian Horticulture* **33**(4) & **34**(1): 12-15.

Locascio, S.J., Hochnuth, G.J., Rhoods, F.M. and Olson (1997). Nitrogen and potassium application scheduling effects on drip irrigated tomato yield and leaf tissue analysis. *Horticultural Science* **32**(2): 230-235.

Mehta, B.S. and Saini, S.S. (1986). Effect on N,P&K fertilizers on the plant growth, flowering on yield of tomato cultivar Solan gola (*Lycopersicon esculentum* Mill). *Haryana Journal of Horticultural Science* **15**(1/2): 91-94.

Ruiz, S.R. (1986). Response of tomatoes for the fresh market to NPK fertilization and split application. *Agriculture Tecnica* **46**(4): 415-422.

Subbiah, K. and Perumal, R. (1986). Effect of N, K and $CaCl_2$ on yield and nutrient uptake in tomato. *South Indian Horticulture* **34**(2): 82-99.

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Effect of Potassium on Yield and Nutrient Absorption by Groundnut

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A field experiment was conducted to study the effect of potassium, zinc and FYM on yield and nutrient absorption by groundnut (cv. G-10) at Maktupur village near Mangarol. The results revealed that pod and haulm yields, matured pod, N, P, K, Ca, Mg and Na uptake by pod and haulm, and soil available K, except the N uptake by pod and P uptake by haulm, were significantly affected by different treatments. Significantly, highest pod (3420 kg ha^{-1}) and haulm (4785 kg ha^{-1}) yields were recorded with treatment T_5 (100 kg K_2O ha^{-1} +10 kg $ZnSO_4$ ha^{-1}).

*(**Key Words:** Potassium levels, Groundnut yield, Nutrient absorption)*

Groundnut being an important oilseed and food crop in Gujarat is cultivated mostly in the coastal belt of Saurashtra where soil salinity is a serious problem. The soils in coastal area are poor in fertility and productivity. No work on nutrients management aspects of K in groundnut has been done. Therefore, the present investigation was undertaken.

MATERIALS AND METHODS

A field experiment was conducted on coastal saline soils during *kharif* 2003 in RBD with four replications at Maktupur village near Mangarol Agricultural Research Station, JAU, Junagadh, growing groundnut cv. G-10. The experimental soils has texture silty clay loam, ECe 4.70 dSm^{-1}, pHs 7.6, $CaCO_3$ 267 g kg^{-1} and ESP 2.35. Soil had 4.25 g kg^{-1} of organic carbon and 140, 20.5 and 90 kg ha^{-1} of available N, P and K, respectively. The different treatments evaluated in this study included; T_1- control, T_2-25 kg K_2O ha^{-1}, T_3-50 kg K_2O ha^{-1}, T_4-100 kg K_2O ha^{-1}, T_5-100 kg K_2O + 10 kg $ZnSO_4$ ha^{-1} and T_6 -10 t ha^{-1} FYM. The RD of N @ 12.5 kg ha^{-1} and P_2O_5 @ 25 kg ha^{-1} were applied as basal for all the treatments in the form of urea and DAP respectively. At maturity, pod and haulm yields were recorded and representative plant and soil samples were also collected and analysed (Jackson, 1973).

RESULTS AND DISCUSSION

Pod and haulm yield as well as number of matured pod per plant were significantly affected by different treatments (Table 1). Significantly, higher pod (3420 kg ha^{-1}) and haulm (4785 kg ha^{-1}) yields were recorded with application of 100 kg K_2O ha^{-1} + 10 kg $ZnSO_4$ ha^{-1} (T_5), which were 19.8 and 8.1 percent higher over control (2855 kg ha^{-1}) in that order. The highest mature pod per plant was also noted with treatment T_5. However, treatment T_2, T_3, T_4 and T_6 also produced significantly higher pod yield as compared to control. Beneficial effect of K on groundnut yield under saline condition was probably due to diminished Na content in plant, thus created favourable cationic ratio in soil solution which led to increased absorption of other nutrients. Our findings are in close conformity with the finding of Zaidi *et al.* (1994).

The N, P, K Ca, Mg and Na uptake by pod and haulm were also affected significantly by the different treatments, except N uptake by pod and P uptake by haulm (Table 2). The higher uptake of P, K, Ca and Mg by pod and N, K, Ca and Mg by haulm were recorded with treatment T_5. However, treatment T_5 was at par with treatment T_4 in most of the cases, whereas the lowest and highest Na accumulation in pod and haulm were also noted with

***Table1.** Effect of different treatments on pod and haulm yield, number of matured pod and soil available K in saline soil*

Treatments	Pod (kg ha^{-1})	Haulm (kg ha^{-1})	No. of matured pod/plant	Soil available K (kg ha^{-1})
T_1	2855	4424	24	88.3
T_2	3013	4523	25	98.2
T_3	3224	4673	29	113.2
T_4	3287	4678	31	132.5
T_5	3420	4785	37	137.5
T_6	2958	4465	25	100.2
CD at p=0.05	65	69	2	7.0

Table 2. *Effect of different treatments on nutrient absorption by groundnut in saline soils*

Treatments	Uptake by pod (kg ha^{-1})					
	N	P	K	Ca	Mg	Na
T_1	55.0	6.09	16.1	9.84	7.93	12.1
T_2	59.0	7.23	17.7	10.47	8.82	11.7
T_3	64.3	8.38	20.0	11.60	10.08	11.2
T_4	67.1	8.64	21.2	12.16	9.70	10.6
T_5	55.3	8.96	23.4	12.82	10.18	10.4
T_6	58.6	7.84	18.0	10.87	8.65	11.6
C.D. at p=0.05	NS	0.95	0.93	0.95	0.35	0.76
Uptake by haulm (kg ha^{-1})						
T_1	34.0	8.18	36.1	34.0	21.9	49.8
T_2	35.4	8.70	37.9	35.2	23.3	41.8
T_3	37.1	9.35	41.5	37.1	24.1	38.7
T_4	37.1	8.50	42.7	36.3	26.9	35.3
T_5	38.1	9.59	46.0	37.7	27.2	34.3
T_6	35.7	8.25	37.2	34.3	22.3	38.3
C.D. at p=0.05	1.7	NS	2.0	1.4	3.4	2.0

NS = Non-significant

treatment T_5 and T_1, respectively. The increase in uptake of N, P, K, Ca and Mg due to potassium application in saline soils was due to its increased content and yield.

Soil available K_2O after harvest of crop was affected significantly by different treatments (Table 1). Significantly higher soil available K (137.5 kg ha^{-1}) was noted with treatment T_5 as compared to control (88.2 kg ha^{-1}). However, treatment T_5 and T_4 were at par with each other but significantly superior to the remaining treatments. The different treatments produced non-significant effect on soil available N and P.

It may be referred that application of K with Zn (100 kg K_2O ha^{-1} + 10 kg $ZnSO_4$) produced maximum pod and haulm yield and nutrients absorption by groundnut in coastal saline soils.

REFERENCES

Jackson, M. L. (1973). *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.

Zaidi, P. H., Khan, F. A. and Chaturvedi, G. S. (1994). Physiological role of potassium under stress environment. *Fertilizer News* **39**(9): 47-49.

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Effect of Phosphate Solubilizers on Groundnut under Coastal Saline Soil Condition

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A field experiment was conducted to test the phosphate solubilizers with and without 50 % recommended dose (RD) as water soluble P (DAP) and water insoluble P (rock phosphate, RP) on coastal saline soils during *kharif* 2001 at Agricultural Research Station, J.A.U., Khapat (Dist: Porbandar, Gujarat) with groundnut cv. GG-13. Groundnut pod yield increased significantly with the application of 50 % RD (urea + RP) + Y_1 (T_{12}), which was 29.9 and 52.1 percent higher over those obtained under full dose (100% RD in form of urea and RP, T_7) and control, respectively. Irrespective of source of P fertilizer, the yeast culture *Geotricum spp.* was the best for higher pod yield of groundnut. Seed inoculation with PSM and rock phosphate application produced 11 percent higher pod yield over seed inoculation with PSM. Soluble P fertilizer of DAP has an adverse effect on PSM and reduced 22.5 percent of groundnut pod yield as compared to that of seed inoculation with PSM alone. Thus, the uses of PSM culture with rock phosphate saved 50 percent P fertilizer for obtaining higher production of groundnut, and yeast culture *Geotricum spp.* was the best for coastal saline soil of Saurashtra.

(**Key Words:** *Phosphate solubilizers, Groundnut yield, Diammonium phosphate, Rock phosphate, Saline soil*)

Phosphorus limits the crop production because the crop utilizes only about 20% of applied phosphorus and rest converted into insoluble form, especially in calcareous saline and saline sodic soil, where it is converted into tricalcium phosphate. In this context, there is a need to have a comprehensive approach to P application for sustainable crop production to enhance its use efficiency (Singh and Sharma, 1994). Microbial solubilization of P from rock phosphate has also been studied under Indian conditions (Gaur and Gaind, 1992). But no study was made to study the effect of P solubilizing microorganism on yield of different crops under saline and saline sodic soil condition. The Life Science Department of Bhavnagar University, Bhavnagar (Gujarat) has isolated some phosphate solubilizing culture from coastal saline soil in their laboratory. Therefore, the present experiment has been conducted with the objectives (i) to evaluate the different PSM culture and (ii) to workout the economics of the use of PSM in conjunction with P chemical fertilizers.

MATERIALS AND METHODS

A field experiment was conducted on coastal saline soil during *kharif* 2001 in RBD with four replications at Agricultural Research Station, J.A.U., Khapat, (Dist: Porbandar, Gujarat) growing groundnut cv.GG -13. The treatments comprised of T_1: recommended Dose (RD) of N and P through Urea and DAP (water soluble P), T_2: 50% RD of N and P through urea and DAP, T_3: T_2 + seed inoculation with B_{17}, T_4: T_2 + seed inoculation with B_{28}, T_5: T_2 + seed inoculation with Y_{11}, T_6: T_2 + seed inoculation with Y_1, T_7: RD of N and P through Urea and RP (water insoluble P), T_8: 50 % RD of N and P through Urea and RP, T_9: T_8 + seed inoculation with B_{17}, T_{10}: T_8 + seed inoculation with B_{28}, T_{11}: T_8 + seed inoculation with Y_{11}, T_{12}: T_8 + seed inoculation with Y_1, T_{13}: seed inoculation with B_{17}, T_{14}: seed inoculation with B_{28}, T_{15}: seed inoculation with Y_{11}, T_{16}: seed inoculation with Y_1, T_{17}:control (no fertilizer and PSM application) and T_{18}: control (farmers' practices). The experimental soil has texture silty loam, EC $_{(2.5)}$ 2.8 dSm^{-1}, pH $_{(2.5)}$ 8.5, $CaCO_3$ 36 g kg^{-1}, ESP 8.5, O.C. 5.6 g kg^{-1}, available P_2O_5 31.4 kg h^{-1}, available K_2O 450 kg h^{-1}. The RD of N and P were applied at basal. Two phosphate solubilizing bacterial strains B_{17}: *Bacillus sphaericus* and B_{28}: *Psedomonas cepacia*, and two yeast culture Y_{11}: *Issatchentia orientates* and Y_1: *Geotricum spp.* were isolated from saline soils by the Life Science Department of Bhavnagar University and were used to inoculate the seeds. Bacterial culture contained 10^8 cells mL^{-1} and yeast culture had 10^7 CFU mL^{-1}. At maturity, representative plant and soil samples were collected and analyzed accordingly as per the stranded method given by Jackson (1973).

***Table 1.** Effect of different phosphate solubilizing culture on groundnut under coastal saline soil*

Sr.	Treatment	Yield (kg/ha)		Plant height	No of Branches
		Pod	Haulm	(cm)	(plant^{-1})
1	Full RD* (Urea+DAP)(C)	764	1146	31.13	5.90
2	50% RD (Urea+DAP)	670	1007	28.93	5.73
3	50% RD (Urea+DAP)+B_{17}	569	1077	29.67	5.83
4	50% RD (Urea+DAP)+B_{28}	514	938	26.00	5.77
5	50% RD (Urea+DAP)+Y_{11}	563	1060	29.00	6.93
6	50% RD (Urea+DAP)+Y_1	563	1042	27.07	5.90
7	Full RD (Urea+RP)	663	1164	29.40	6.57
8	50% RD (Urea+RD)	597	1146	29.53	6.20
9	50% RD (Urea+RP)+B_{17}	584	1164	29.47	6.07
10	50% RD (Urea+RP)+B_{28}	764	921	31.30	5.80
11	50% RD (Urea+RP)+Y_{11}	794	1250	29.53	6.43
12	50% RD (Urea+RP)+Y_1	861	1289	29.20	6.12
13	B_{17} Culture	834	921	30.13	6.43
14	B_{28} Culture	573	1008	29.07	5.87
15	Y_{11} Culture	545	1163	30.43	6.20
16	Y_1 Culture	757	1007	30.33	6.53
17	Control	566	990	29.47	5.90
18	Local Control	545	1146	29.27	6.03
	SEm$\pm$	66.4	126.2	1.02	0.43
	CD at p=0.05	191	363	2.92	1.25
	CV %	17.7	20.2	5.95	12.3

RD* : Recommended dose

RESULTS AND DISCUSSION

Effect on yield and yield attributes

Groundnut pod yields (861 kg ha^{-1}) (Table 1) increase significantly with the application of 50% RD (Urea + RP) + Y_1 (T_{12}), which was 29.9 and 52.1 percent higher over these obtained under full dose (100% RD in form of Urea and RP, T_7) and that of control, respectively. These findings confirm the results of Dubey *et al.* (1999).

The data in Table 2 indicated that irrespective of source of P fertilizer, the yeast culture Y_1 (*Geotricum spp*) produced the higher pod yield of the groundnut (712 kg ha^{-1}). Seed inoculation with PSM and rock phosphate application produced 11 percent higher pod yield over seed inoculation with PSM. Soluble P fertilizer of DAP had an adverse effect on PSM and reduced 22.5 percent of groundnut pod yield as compared to that under seed inoculation with PSM alone.

Effect on soil

The data (Table 3) on Olsen's available P status after harvest of crop indicated that significantly higher available P (42.8 kg ha^{-1}) was noted under the treatment of 50 % RD (Urea + DAP) + B_{17} (T_3) and 50 % RD (urea + RP) + Y_{11} (T_{11}). Significantly lower EC was recorded under the treatment of seed inoculation with B_{28}.

***Table 2.** Effect of P fertilizer and PSM culture on pod yield (kg ha^{-1}) of groundnut*

Culture	0 % RD	50 % RD (DAP)	50 % RD (RP)	Mean
B_{17}	834	569	584	577
B_{28}	573	514	764	639
Y_{11}	545	563	794	679
Y_1	757	563	861	712
Mean	676	552	750	651
50% RD	-	672	597	635
100% RD	-	764	663	714

Effect on P content and uptake

The plant analysis data (Table 3) indicated that significantly higher P content in pod was observed under the treatment of 50 % RD (urea + RP) + B_{28}

Table 3. *Effect of different phosphate solubilizing culture on soil and plant properties in coastal saline soil*

Sr.	Treatment	Soil analysis		Plant analysis			
		EC (1:2.5) dSm^{-1}	Av. P in soil (kg h^{-1})	Pod: P Cont. (%)	Pod: P Uptake (kg h^{-1})	Haulm: P Cont. (%)	Haulm: P Uptake (kg h^{-1})
1	Full RD* (Urea+DAP)(C)	38.2	0.70	0.260	1.99	0.123	1.42
2	50% RD (Urea+DAP)	36.4	0.53	0.252	1.67	0.114	1.16
3	50% RD (Urea+DAP)+B_{17}	42.8	0.57	0.262	1.50	0.120	1.30
4	50% RD (Urea+DAP)+B_{28}	41.0	0.83	0.263	1.35	0.133	1.24
5	50% RD (Urea+DAP)+Y_{11}	40.0	0.67	0.265	1.78	0.127	1.34
6	50% RD (Urea+DAP)+Y_1	37.3	0.73	0.273	1.53	0.130	1.35
7	Full RD (Urea+RP)	40.0	0.57	0.262	1.74	0.115	1.32
8	50% RD (Urea+RD)	35.5	0.50	0.260	1.56	0.122	1.38
9	50% RD (Urea+RP)+B_{17}	38.2	0.77	0.269	1.56	0.129	1.53
10	50% RD (Urea+RP)+B_{28}	41.9	0.70	0.325	1.95	0.112	1.04
11	50% RD (Urea+RP)+Y_{11}	42.8	0.73	0.263	2.06	0.128	1.60
12	50% RD (Urea+RP)+Y_1	41.0	0.47	0.266	2.21	0.121	1.57
13	B_{17} Culture	37.3	0.43	0.261	2.25	0.120	1.09
14	B_{28} Culture	41.0	0.37	0.245	1.41	0.120	1.21
15	Y_{11} Culture	35.5	0.60	0.265	1.44	0.122	1.42
16	Y_1 Culture	36.4	0.57	0.271	2.05	0.125	1.26
17	Control	33.7	0.53	0.265	1.49	0.103	1.02
18	Local Control	34.6	0.40	0.255	1.38	0.111	1.29
	SEm$\pm$	3.86	0.11	0.017	0.17	0.006	0.167
	CD at p=0.05	11.1	0.31	0.049	0.50	0.017	0.48
	CV %	17.4	32.0	11.1	17.34	8.45	22.1

(T_{10}), whereas significantly higher P uptake was observed under the treatment of seed inoculation with B_{17}. In case of haulm, significantly higher P content and uptake were recorded under the treatments of 50 % RD (urea + DAP) + B_{17} (T_4) and 50 % RD (urea + RP) + Y_{11} (T_{11}), respectively.

REFERENCES

Dubey, A.V., Vaishya, U.K., Bapat, P.N. and Tomar, V.S. (1999). Phosphate solubilizing efficiency of some microorganisms in Vertisol. *Journal of the Indian Society of Soil Science* **47**(1): 161-174.

Gaur, A.C. and Gaind, S. (1992). Proceedings National Seminar *Organic Farming*, held Nov, 1992. 130p.

Jackson, M.L. (1973). *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd, New Delhi.

Singh, K.D. and Sharma, B.M. (1994). In *Phosphate Research in India*, G. Dev (ed.), PPIC–India Programme, Dundahera, Gurgaon. 47p.

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Effect of Phosphate Solubilizers on Pearl Millet under Coastal Saline Soil

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A field experiment was conducted on coastal saline soil during *kharif*-2001 in RBD with four replications at Agricultural Research Station, J.A.U., Mahuva, (Dist. Bhavnagar, Gujarat) growing pearl millet cv. GHB-235. The results of experiment indicated that application of 50% recommended dose (RD) in the form of urea and rock phosphate with seed inoculation with Yeast *Issatchentia orientates* gave significantly higher grain yield (19.3 %) of pearl millet over full RD in the form of urea and DAP (control). Irrespective of source of P fertilizer, among the different PSM cultures, yeast culture raised the grain yield levels of pearl millet, while bacteria were rather less effective compared to the former. Thus, the PSM culture with rock phosphate saved 50 percent P fertilizer for obtaining higher production of pearl millet and yeast culture was the best for coastal saline soil of Saurashtra.

(***Key Words:*** *Phosphate solubilizers, Grain yield of pearl millet, Diammonium phosphate, Saline soil)*

In the soils of Saurashtra, the response of *Bajra* crop to phosphorus is not consistent under rainfed conditions. In this situation the use of biofertilizers particularly PSM can significantly contribute to increase the P availability and its adsorption can help to increase crop production economically by saving the chemical fertilizers. The Life Science Department of Bhavnagar University, Bhavnagar (Gujarat) has isolated some phosphate solubilizing culture from coastal saline soil in their laboratory. Therefore, the present experiment has been conducted with the objectives (i) to evaluate the different PSM culture and (ii) to workout the economics of the use of PSM in conjunction with P chemical fertilizers.

MATERIALS AND METHODS

A field experiment was conducted on coastal saline soil during *kharif* 2001 in RBD with four replications at Agricultural Research Station, J.A.U., Mahuva (Dist: Bhavnagar, Gujarat) growing pearl millet cv. GHB-235. The treatments comprised of T_1: recommended dose (RD) of N and P (80:40 kg ha^{-1}) through urea and DAP (water soluble P), T_2: 50 % RD of N and P through urea and DAP, T_3: T_2 + seed inoculation with B_{17}, T_4: T_2 + seed inoculation with B_{28}, T_5: T_2 + seed inoculation withY_{11}, T_6: T_2 + seed inoculation with Y_1, T_7: RD of N and P through urea and RP (water insoluble P), T_8: 50 % RD of N and P through urea and RP, T_9: T_8 + seed inoculation with B_{17}, T_{10}: T_8 + seed inoculation with B_{28}, T_{11}: T_8 + seed inoculation with Y_{11}, T_{12}: T_8 + seed inoculation with Y_1, T_{13}: seed inoculation with B_{17}, T_{14}: seed inoculation with B_{28}, T_{15}: seed inoculation with Y_{11} and T_{16}: seed inoculation with Y_1. The experimental soil has texture silty clay loam, $EC_{(2.5)}$ 4.9 dSm^{-1}, $pH_{(2.5)}$ 8.9, $CaCO_3$ 32.7 g kg^{-1}, ESP 12.3, O.C. 6.3 g kg^{-1}, available P_2O_5 39.7 kg ha^{-1}, available K_2O 381 kg ha^{-1}. The RD of N of 80 kg ha^{-1} was applied in two equal splits at basal and at 28 days after sowing as urea, whereas P @ 40 kg ha^{-1} was applied per treatment. Two phosphate solubilizing bacterial strains B_{17}: *Bacillus sphaericus* and B_{28}: *Psedomonas cepacia*, and two yeast culture Y_{11}: *Issatchentia orientates* and Y_1: *Geotricum spp.* were isolated from saline soils by the Life Science Department of Bhavnagar University and were used to inoculate the seeds. Bacterial culture contained 10^8 cells mL^{-1} and yeast culture had 10^7 CFU mL^{-1}. At maturity, representative plant and soil samples were collected and analyzed accordingly as per the stranded method given by Jackson (1973).

RESULTS AND DISCUSSION

Effect on yield and yield attributes

The grain and fodder yields of pearl millet were significantly affected due to different treatments (Table 1). Application of 50 % recommended dose (RD) in the form of urea and rock phosphate+ seed inoculation with Y_{11} (*Issatchentia orientates*) gave significantly higher grain (2896 kg ha^{-1}) yield (19.3 %) of pearl millet over their full RD in the form of urea and DAP (control). This treatment (T_{11}) was at par

Table 1. *Effect of different phosphate solubilizing culture on yield, content and uptake by pearl millet, and soil properties after harvest of the crops*

Sr.	Treatment	Yield (kg/ha)		No. of tillers/ plant	Plant height (cm)	Length of ear head (cm)	1000 seed weight (g)	Soil analysis		Plant analysis			
										Grain		Grain	
		Grain	Fodder					Av. P (kg/ha)	EC dS/m (1:2.5)	P (%)	P uptake (kg/ha)	P (%)	P uptake (kg/ha)
1	Full RD* (Urea+DAP)(C)	2427	5552	5.30	183.3	22.57	7.68	38.40	2.27	0.204	4.94	0.122	6.75
2	50% RD (Urea+DAP)	2177	5385	4.87	186.0	21.80	8.15	37.95	2.73	0.190	4.16	0.115	6.21
3	50% RD (Urea+DAP)+B_{17}	2208	7115	4.73	182.3	23.53	8.67	54.61	2.63	0.234	4.83	0.134	9.50
4	50% RD (Urea+DAP)+B_{28}	2531	4687	5.60	188.0	24.07	8.60	53.76	2.63	0.267	6.72	0.134	6.35
5	50% RD (Urea+DAP)+Y_{11}	2646	6770	5.20	189.3	22.13	8.25	46.08	2.87	0.225	5.95	0.133	9.01
6	50% RD (Urea+DAP)+Y_1	2656	5208	6.00	185.0	21.57	8.25	33.28	2.00	0.245	6.50	0.129	6.73
7	Full RD (Urea+RP)	2479	4510	5.33	187.7	24.00	8.28	38.40	1.97	0.242	6.01	0.139	6.28
8	50% RD (Urea+RP)	2312	4687	5.73	181.7	22.67	7.68	37.55	2.83	0.250	5.78	0.119	5.59
9	50% RD (Urea+RP)+B_{17}	2260	5729	5.60	183.0	23.47	8.40	40.96	2.97	0.244	5.53	0.118	6.75
10	50% RD (Urea+RP)+B_{28}	2208	4167	6.03	182.0	23.87	8.62	44.37	2.50	0.230	5.07	0.137	5.74
11	50% RD (Urea+RP)+Y_{11}	2896	6594	5.73	188.3	23.87	9.00	50.35	2.80	0.239	6.95	0.141	9.32
12	50% RD (Urea+RP)+Y_1	2448	6250	5.57	179.3	22.00	8.18	40.11	2.90	0.252	6.20	0.119	7.48
13	B_{17} Culture	2615	5906	5.93	190.3	23.80	8.68	38.40	2.47	0.261	6.79	0.122	7.15
14	B_{28} Culture	2167	5208	5.87	187.7	21.80	8.75	30.72	2.67	0.234	5.10	0.135	7.10
15	Y_{11} Culture	2427	5906	5.13	186.3	22.27	8.68	41.81	2.07	0.263	6.38	0.131	7.73
16	Y_1 Culture	2187	5031	5.47	178.7	21.93	8.85	34.99	2.13	0.266	6.76	0.138	7.22
	S Em$\pm$	126.0	343.0	0.31	3.76	0.82	0.328	2.10	0.25	0.008	0.48	0.006	0.60
	CD at p=0.05	364.0	991.0	N.S.	NS	NS	NS	6.05	NS	0.025	1.39	0.017	1.73
	CV %	9.05	10.72	9.7	3.52	6.23	6.75	8.78	16.91	6.37	14.19	7.92	7.96

with 50 % RD (urea + DAP) + B_{17} (T_5), followed by same dose + seed inoculation with Y_1 (T_6). While, in case of fodder yield, application of 50 % RD (urea + DAP) + B_{17} (*Bacillus sphaericus*) (T_5) gave significantly higher fodder (7115 kg ha^{-1}) yield (28.2% yield over control), followed by 50 % RD (urea + DAP) +Y_{11} (T_5), 50 % RD (Urea + RP)+Y_{11} (T_5) and 50 % RD (urea + RP)+Y_1 (T_{12}). These treatments were statistically at par. All yield attributing characters were unaffected due to application of different treatments. The increase in crop yield with bacterial or yeast culture inoculation may be due to mobilization of soil P. Similar findings were reported by Dubey (2000) and Polara *et al.* (2004).

Effect on soil properties

Soil analysis data (Table 1) indicated that significant variation was found in soil available P. Application of 50 % RD (urea + DAP)+B_{17} recorded significantly higher P content in soil, followed by treatment T_4 and T_{11} and they were at par with each other. Soil EC value was unaffected by different treatments.

Effect on P content and uptake

Post harvest of the plant analysis data (Table 1) indicated that application of 50% RD (urea + DAP) + B_{28} (T_4) recorded significantly higher P content in grain, followed by treatments in decreasing order T_{16}>T_{15} >T_{13} >T_{12}> T_8> T_6> T_9>T_7. These treatments were at par with each other. On other hand significantly higher P uptake by grain was recorded with the treatment of 50% RD (urea + RP) + Y_{11} (T_{11}), followed by treatments in decreasing order T_{13}>T_{16} >T_4 >T_6> T_{15}> T_{12}> T_7>T_5>T_8 and were at par with each other. In case of P content of fodder, application of 50% RD (urea + RP) + Y_{11} (T_{11}) recorded the higher P content, followed by the order T_7>T_{16} >T_{10} >T_{14}> T_3> T_4> T_5>T_{15}>T_6. While, P uptake by fodder was noted in the treatment T_3 (50% RD in form of urea and DAP + B_{17}) followed by T_{11} and T_5, which were at par with each other.

REFERENCES

Dubey, S.K. (2000). Effectiveness of rock and supper phosphate amended with phosphate solubilizing microorganisms in soybean grown on vertisols. *Journal of the Indian Society of Soil Science* **48**(1): 71-75.

Jackson, M.L. (1973). *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.

Polara, J.V., Babaria, N. B. and Solanki, M.S. (2004). Effect of phosphorus solubilizer on wheat under coastal saline soil condition. National Seminar *Advances in Coastal Agriculture and Value Addition from National Perspectives*, held at Central Plantation Crops Research Institute, Kasaragad, Kerala, 21-24 Jan, 2004.

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Yield and Quality Characters of Nendran Banana (Musa AAB group) as Influenced by Potassium Nutrition in a Red Loam Soil of Kerala

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The influence of varied levels of K on the yield and quality of banana cv. Nendran in a red loam soil of Vellayani was studied by conducting a field experiment with the crop using seven levels of K as treatments. Considering both yield and quality aspects of Nendran banana K application @ 225 K_2O per plant, which was 75 percent of the existing recommended package, was found to be the most ideal in the red loam soil of Vellayani. The treatment recorded the highest bunch yield (26.2 t ha^{-1}) which was significantly higher than that of all other treatments. The important quality characters, total sugars, non-reducing sugars, pulp-peel ratio and shelf-life varied significantly with the treatments showed increasing trend with increase in K supply.

***(Key words:** Nendran banana, Yield & quality, Potassium nutrition)*

Banana, the choice fruit crop of every Indian is cultivated in an area of 106050 ha in Kerala with a production of 770000 t (Anon., 1994). Nearly 50 percent of this area is occupied by Nendran (*Musa* AAB group), the most popular commercial variety alone. K has been recognized as the key element in banana nutrition, the effect of the element being manifested on the quantitative and qualitative aspects of the crop. The K requirement of banana is also much more than in any other crop. K is the costliest nutrient, since the country's entire requirement is met from external sources. The applied K is liable to wastage through leaching and runoff due to its high solubility. The problem is all the more grave in Kerala where the major soil clay type is kaolinitic with low cation exchange capacity and rainfall distribution pattern is highly erratic.

In a scenario like this it was felt highly imperative to reappraise the present fertilizer schedule to formulate a more systematic and judicious need based programme so as to ensure maximum efficiency and minimum wastage of the fertilizer. The present study was undertaken with the specific objective of studying the yield and quality traits of Nendran banana under different levels of K nutrition.

MATERIALS AND METHODS

A field experiment in randomized block design with three replications was conducted in the Palappoor area of Thiruvananthapuram district during August 1991 – May 1992 using Nendran banana raised as an irrigated crop. Geographically the area is situated 8°5' North latitude, 77°1' East longitude and at an elevation of 29 M above MSL. The soil of the site belonged to the taxonomic class, loamy kaolinitic isohyperthermic aeric tropic fluvaquent. On fertility basis it was rated high in organic C, medium in available N and P, high in available K, adequately rich in micronutrients. The soil reaction was acidic and electrical conductivity of the soil solution was within safe limits.

The treatments were seven levels of potassium for irrigated Nendran banana, viz. 300 g K_2O per plant applied in five equal splits, first as basal and the rest at one, two, four, five and six months after planting (Anon., 1989). They were k_0 (no K), k_1 (75 g), k_2 (150 g), k_3 (225 g), k_4 (300 g), k_5 (450 g) and k_6 (600 g) K_2O per plant. N and P were applied uniformly to all plots @ 190 g and 115 g per plant, respectively, besides farmyard manure @ 10 kg per plant. Nine plants were maintained in each plot. Yield was recorded as the weight of fully matured bunch including the peduncle. The quality characters of the fruit, viz. shelf life, pulp-peel ratio, total solids, vitamin C, proteins, total, reducing and non-reducing sugars, acidity and s' gar-acid ratio were estimated using standard analytical procedures outlined by Ranganna (1977). The analyses were done on samples of the middle finger in the top row of the second hand of each bunch designated by Gottriech *et al.* (1964) as the index finger.

Table 1. *Effect of K levels on the yield and some quality characters of Nendran banana in a Vellayani red loam soil*

Treatment	Bunch yield (kg)	Shelf life (number of days)	Pulp-peel ratio	Total solids (%)	Vitamin C (mg $100g^{-1}$)	Protein (%)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugar (%)	Acidity (%)	Sugar-acid ratio
k_0	5.17	3.00	3.09	17.90	1.07	6.43	16.62	5.32	10.74	0.132	40.30
k_1	7.00	3.67	3.17	19.33	1.07	6.93	18.49	6.14	11.43	0.111	55.32
k_2	9.13	4.00	3.18	18.13	1.14	7.18	20.47	4.55	15.12	0.090	49.91
k_3	10.47	5.67	3.22	19.30	1.18	8.34	22.19	3.96	17.32	0.085	46.59
k_4	8.67	5.67	3.26	18.57	1.42	8.15	22.10	4.48	16.74	0.098	45.71
k_5	8.80	6.00	3.23	20.10	1.19	8.08	22.16	4.27	17.00	0.094	45.99
k_6	8.83	6.33	3.28	20.63	1.47	8.17	24.28	4.56	18.73	0.083	54.94
CD at p=0.05	1.32**	0.82**	0.08**	NS	NS	NS	1.18*	1.28*	0.98**	NS	NS

*Significant at p=0.05, **Significant at p=0.01, NS - Non-significant

RESULTS AND DISCUSSION

The mean values of yield and estimated parameters are given in Table 1. The different K levels exerted significant influence on the bunch weight which showed an increasing trend with increase in the quantity of K applied upto k_3 level and then decreased gradually. The bunch yield of 10.47 kg (26.2 t ha^{-1}) recorded by k_3 (225 g K_2O per plant) was significantly higher than that by all other treatments. The response shown in terms of yield to increasing levels of K application upto the k_3 level even in a soil inherently high in the nutrient is indicative of the role of K in banana nutrition. Decreased yields above k_3 level might be due to the nutrient imbalances caused by excessive K uptake.

The results of quality analysis also highlight the role of K in banana nutrition further. The important quality character, viz. shelf life, pulp-peel ratio, total, reducing and non-reducing sugars showed significant response to differential levels of K application, all of them in general showing definite favourable disposition to increased nutrient application. The highest level of K (600 g K_2O per plant) recorded the highest values for all these characters except in reducing sugars. The other quality characters, viz. total solids, acidity, proteins, vitamin C and sugar-acid ratio showed definite improvement with increase in K levels though statistically non-significant.

The improvement in storage life of banana is attributed to the increased firmness of pulp and rind brought about by K nutrition. The enhanced production of ascorbic acid under adequate K nutrition might be responsible according to Prevel (1989) for the slowing down of the oxidation processes leading to enzymatic browning on the peel of the banana fruit which is taken as the index of deterioration of fruit quality. K has also a role in decreasing cell respiration which otherwise will lead to cell wall degradation as a consequence of pectin solubilisation under enhanced activity of the enzymes polygalacturonase and pectin esterase (Almazan, 1991).

The increase in pulp-peel ratio with higher K levels was mainly due to the increase in pulp weight which was the consequence of satisfactory activity of the enzymes involved in starch and protein synthesis under an adequate supply of K.

The total sugars were maximum at the highest level of K application and minimum at the control. Reducing sugars, on the other hand, showed a reverse trend. Nitsos and Evans (1969) proved that deficiency of K resulted in decreased activity of the enzyme sucrose synthetase and increased activity of the hydrolytic enzymes, amylase and saccharase. This led to accumulation of soluble carbohydrates especially monsaccharides. On the other hand, an adequate K supply ensured optimal functioning of sucrose synthetase and suppression of hydrolases, the net result of which was the build-up of greater quantity of sugars in the proplastids. The non-reducing sugars being a computed derivative of the total and reducing sugar contents followed the same trend as that in total sugars, showing increasing trend with increasing K levels.

REFERENCES

Almazan, A.M. (1991). Chemical changes in some cooking banana and plantain cultivars during ripening. *Tropical Science* **31**(4): 335-346.

Anon. (1989). In *Package of Practices Recommendations*, pp. 132-139, Kerala Agricultural University, Thrissur.

Anon. (1994). *Farm Guide*. Farm Information Bureau, Government of Kerala.

Gottriech, M., Bradu, D. and Halevy, Y. (1964). A simple method for determining average banana fruit weight. *Ktavani* **14**: 161-162.

Nitsos, R.E. and Evans, H.J. (1969). Effect of univalent cations on the activity of particulate starch synthetase. *Plant Physiology* **44**: 1260-1266.

Prevel Martin, P. (1989). Physiological processes related to handling and storage quality of crops. In *Methods of K Research in Plants*, IPI, Berne, Switzerland.

Ranganna, S. (1977). *Manual of Analysis of Fruit and Vegetable Products*. Tata McGraw Hill Publishing Company Ltd., New Delhi.

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Optimizing Microwater Resource Design and Integrated Farming System Approach for Enhancing Productivity of Waterlogged Area

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A study was undertaken in a 1.75 ha coastal, perennial waterlogged area in WTCER research farm. Rainfall and other climatic factor analysis, soil analysis, water balance, and water table fluctuation studies at shallow depth up to 2 m were done. A waterlogged waste land of an area 0.264 ha was modified to elevated platforms and depressions through land modification, and plantations with high transpiration trees like *Acacia mangium* and *Casuarinas* were done. Its effect on ground water table fluctuation was studied. Rainfall was higher than evaporation during 24th week to 43rd week causing water congestion and excess water was stored in ponds for aquaculture and for irrigating *rabi* crops including vegetables and other cash crops. Evaporation was higher than rainfall during 44th week to 23rd week which indicated that irrigation was required if any crop was to be grown during this period. Land modification by excavating ponds for storing excess water was desirable. The soils of the experimental plots are highly acidic, low in organic carbon, low in available nutrients, and high in iron content. Growth of tree species *Acacia mangium* was faster in terms of height, growth and collar diameter than *Casuarina*. The land modification has changed the water table regime making it better and suitable for crop growth in comparison to other plots. Satisfactory establishment of tree species as biodrainage component suggested further influence on the water table regime making it suitable for other crops.

*(**Key words:** Waterlogging, On-farm-reservoir, Integrated farming system, Biodrainage)*

The problem of waterlogging is very severe in coastal and deltaic region of eastern India in which water stagnation and rise of water table above ground surface is more than 1m in many places during monsoon. So no crop or paddy with an average yield of only 0.5 to 0.75 t ha^{-1} is obtained during *kharif* season. After monsoon also due to rise in water table no other cash crop or remunerative crop is possible except paddy with very low return in terms of yield and pricing. But very limited research work had been taken up to mitigate the problems of waterlogging. The quality of water is however suitable for irrigation as well as aquaculture purpose.

WTCER Research farm at Mendhasal, Khurda has about 1.75 ha of lowlying area, which suffers from waterlogging and was taken for experimental jurisdiction. During monsoon the depth of ponding water was more than 50 cm and during driest period (May) of a year the water table varied between 50-150 cm below ground level. The water quality was good and only paddy is grown in *kharif* with 0.5 t ha^{-1} average yield. The soil was acidic with low available nutrient and iron toxicity is present. The land was suitable for ploughing during May and early June and high water table restricted growing of any other crop during *rabi* season. The plot in the lowest elevation having an area of about 0.264 ha was a degraded wasteland due to perennial waterlogging over years. Many researchers have worked on on-farm reservoir design etc. using water balance model in medium and upland, where the pond water could be used for supplemental irrigation or life saving irrigation (Sanchez-Cohen *et al.*, 1997, Ambast *et al.*, 1998, Panigrahi, 2001). Heuperman (1999) found out the lowering of water table due to biodrainage for 10 years possible through planting trees having high water requirement. So this study was thought of with the objectives of optimizing micro-level water resources design in waterlogged area using water balance simulation modeling at field level; and reclamation study of waterlogged area through biodrainage and cultivation of water loving co-existing crops.

Anon. (1989). In *Package of Practices Recommendations*, pp. 132-139, Kerala Agricultural University, Thrissur.

Anon. (1994). *Farm Guide*. Farm Information Bureau, Government of Kerala.

Gottriech, M., Bradu, D. and Halevy, Y. (1964). A simple method for determining average banana fruit weight. *Ktavani* **14**: 161-162.

Nitsos, R.E. and Evans, H.J. (1969). Effect of univalent cations on the activity of particulate starch synthetase. *Plant Physiology* **44**: 1260-1266.

Prevel Martin, P. (1989). Physiological processes related to handling and storage quality of crops. In *Methods of K Research in Plants*, IPI, Berne, Switzerland.

Ranganna, S. (1977). *Manual of Analysis of Fruit and Vegetable Products*. Tata McGraw Hill Publishing Company Ltd., New Delhi.

MATERIALS AND METHODS

The location of the study area was WTCER research farm (Deras farm, Mendhasal, Khurda). The soil pH varied between 5.5 to 6.5; soil texture was sandy clay loam; soil organic carbon was low (< 0.5%); soil available nitrogen was low (<280 kg ha^{-1}); soil available potassium medium (50-170 mg kg^{-1} soil); soil available phosphorous medium (5-10 mg kg^{-1} of soil); iron toxicity was present; ground water table varied from 20-40 cm as minimum water table depth and 50-150 cm as maximum water table depth from ground surface during December to June. During monsoon it was above ground surface. The yield of shallow aquifer was low. The land was unsuitable for ploughing except during May- early June, left fallow in many years. Present cropping pattern was only paddy during *kharif* with cropping intensity <100% and yield of paddy varied between 0.5 to 0.75 t ha^{-1}.

For determining the design and dimensions of the ponds, collection and analysis of climatic data (rainfall, pan evaporation, etc.) for the period 1975-2003 for Bhubaneswar were done. Different probability distribution functions (PDF) were fitted to the maximum one day rainfall data. SMADA software has been used for this analysis. From this analysis maximum one day rainfall for different return periods were found out which would be utilized for further design of different hydraulic structures. Physicochemical properties of the study area were done using standard laboratory procedures.

Reclamation of waterlogged waste land area through plantation of trees like *Acacia mangium* and *Casuarina equisetifolia* and cultivation of water loving co-existing crops was taken up in experimental plot. An area of 2640 m^2 was converted into four elevated platforms of 20 m x 20 m each with the excavated soils from the adjacent 20 m x 10 m area and also from a strip of 110 m x 4 m (Fig. 1). The experimental ponds were 27 m x 27 m, 30 m x 30 m, and 34 m x 34 m at the top with 2 m depth and side slope 1:1 in experimental plot 1, 2 and 3, respectively. The excavated soils were spread around the pond to elevate the surrounding area so as to keep the water table below 2 m from ground surface. Hume pipes of 30 cm diameter and 4 m length were used as inlet and emergency outlet of the pond. Since the objective of the study was to store excess water for reclamation of waterlogged area, the area of the ponds was kept within 20 to 25% of the total area considering the water balance component of the study area. There was a net increase in elevation of platforms by 0.65 m in comparison to original ground level. *Acacia mangium* and *Casuarina equisetifolia* were planted in two platforms (starting from right) each with a spacing of 2 m x 2 m in the fourth week of July 2004. The layout of the experimental plot 4 is given in Fig. 1.

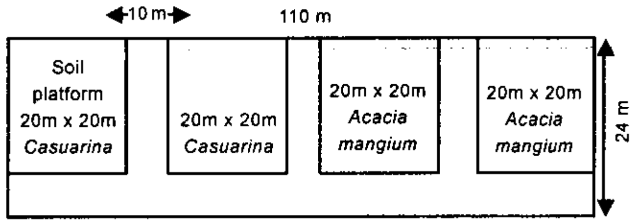

Fig. 1. Layout of biodrainage experimental plot

RESULTS AND DISCUSSION

Rainfall analysis and hydrology

The annual rainfall varied between 951.6 mm (1996) to 2218.7 mm (2001) with 55% of all the years have rainfall below normal. Eighty-four percent of the total rainfall occurs between June to October. Normal rainy days in a year are 105, maximum was 129 (1983), and minimum was 86 days (1979). The weekly maximum, minimum and normal rainfall observed during 1975-2003 are given in Fig. 2. The comparison of weekly rainfall and evaporation is given in Fig. 3. From Fig. 3 it is observed that the rainfall was higher than evaporation during 24th week to 43rd week causing water congestion and excess water was stored in ponds for aquaculture and for irrigating *rabi* crops including vegetables and other cash crops. Evaporation was higher than rainfall during 44th week to 23rd week indicating that irrigation was required if any crop was to be grown during this period.

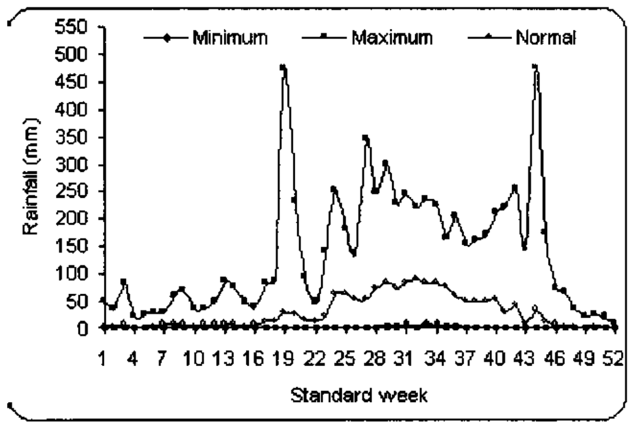

Fig. 2. Weekly maximum, minimum and normal rainfall observed during 1975-2003

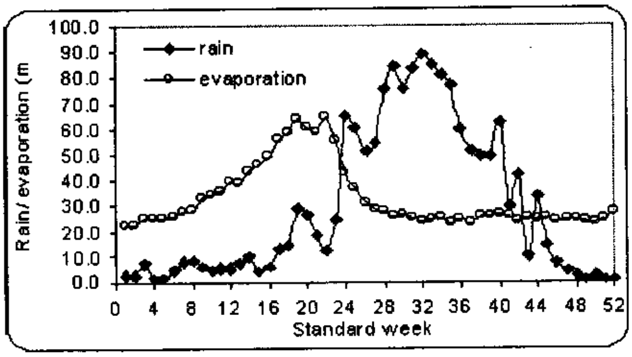

Fig. 3. The comparison of weekly rainfall and evaporation

The weekly rainfall data at different probability levels are given in Fig. 4. Depending upon the requirement of rainfall at different probability levels design of different structures was considered such as field *bunds*, ponds, emergency spillway, drainage system, etc.

It was found that Log Pearson type III PDF fitted well (Fig. 5) to the observed data.

The water table fluctuation with respect to rainfall (mm) in different standard meteorological week was given in Fig. 6. The different notations used in the figure are: EP stands for experimental plot number and P denotes platform number (elevated portion where soil was deposited) and D denotes depressions from where soil was excavated to form the platform.

From Fig. 6 it was observed that in Experimental plot 4 (EP 4), the water table below ground level was deeper in comparison to other experimental plots. The desirable condition for any crop to grow better was that the water table should be below root zone depth (i.e. 2 m in many cases), otherwise the area was called as waterlogged. Hence after the first year of work, where the biodrainage component was negligible, it was seen that the land modification alone had changed the water table regime making it better and suitable for crop growth in comparison to other plots.

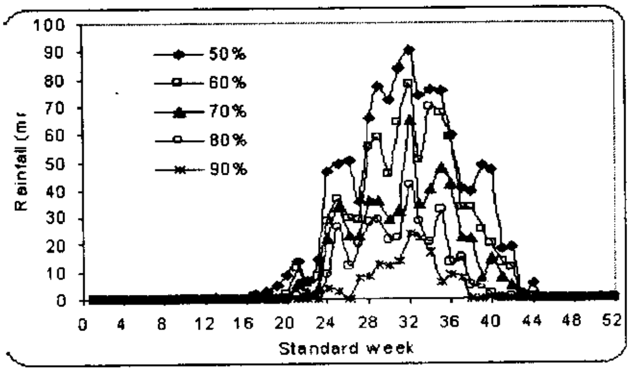

Fig. 4. Weekly rainfall at different probability levels at Bhubaneswar

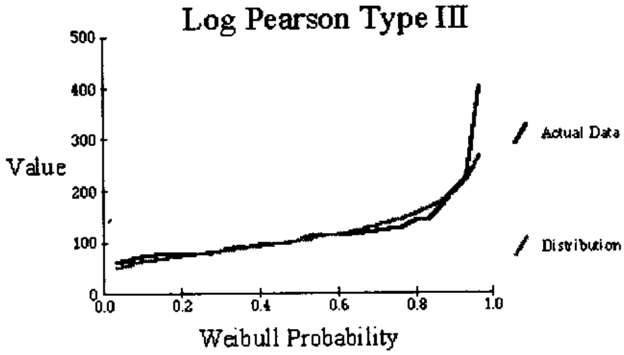

Fig. 5. Fitting of maximum one day rainfall with Log Pearson type III distribution

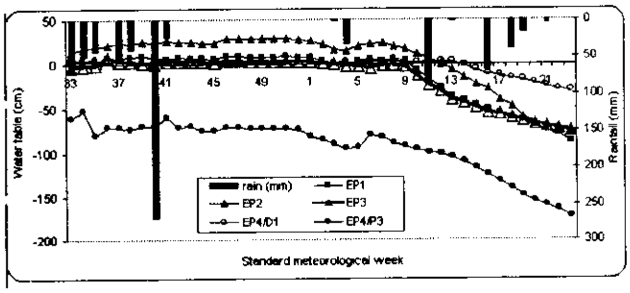

Fig. 6. Water table fluctuation in different experimental plots and rainfall in 2004

Soil analysis

The soil analysis showed that the experimental plots 1, 2, and 3 have highly acidic soil with pH ranging between 3.5 to 4 for top soil and with increase in depth the pH varied between 3.6 to 4.1 up to a depth of 60 cm which might have happened due to continuous waterlogging and washing of top soil and base materials. The pH of the soils of the raised beds/ platforms was closer to neutral or slightly acidic values ranging from 5.6 to 6.5. The available organic carbon was very low in almost all plots. The organic carbon (OC) varied from 0.21 to 0.46% for plot 1, 0.39 to 0.67 for plot 2, 0.29 to 0.46 for plot 3. In experimental plot 4, the OC on platforms were however still low: 0.16-0.42 for platform 1, and 0.20-0.32 for platform 4. This might have happened as platforms were made with the help of soils excavated from the adjacent depressions. The top soil of the platform was the soil excavated from lower depth. The OC of soils of the depressions was lowest: 0.17-0.23 for depression 1 and 0.13-0.16 for depression 3.

Growth parameters of biodrainage plantation

The different growth parameters observed in biodrainage plantation is given in Table 1 for *Acacia mangium* and *Casuarina equisetifolia*. The different growth parameters observed were height (cm), collar diameter (mm), and diameter at breast height (DBH) (mm) at the time of planting and then at every 3 months after planting (MAP).

Table 1. *Growth parameters observed in biodrainage plantation*

Parameters	*Acacia magium*			*Casuarina equisetifolia*		
Time since plantation	Height (cm)	Collar diameter (mm)	DBH (mm)	Height (cm) (cm)	Collar diameter (mm)	DBH (mm)
During planting	40.0	3.5	-	67.5	4.0	-
3 MAP	91.5	8.9	-	105.3	10.1	-
6 MAP	148.3	38.7	20.6	209.6	23.6	11.3
9 MAP	292.8	73.6	36.2	342.4	50.3	20.7
12 MAP	361.2	92.0	51.4	428.0	60.8	31.1

In *Acacia mangium*, the net increment in plant height over initial was 128.8%, 270.8%, 632%, 803% after 3, 6, 9 and 12 months after planting (MAP), respectively. The net increment (NI) in collar diameter was 154%, 1057%, 2002%, and 2528%, respectively during the same period. However DBH (diameter at breast height, i.e. at 1.37 m from ground) was recorded as 20.6 mm, 36.2 mm and 51.4 mm at 6, 9 and 12 MAP, respectively. In *Casuarina equisetifolia* plant height increased to 105.3 cm (net increment of 56%), 209.6 cm (NI 210%), 342.4 cm (NI 407%), and 428.0 cm (NI 534%) after 3, 6, 9 and 12 months after planting, respectively. The net increment in collar diameter was 152%, 490%, 1157%, and 1420% after 3, 6, 9, and 12 MAP respectively. The diameter at breast height attained 11.3 mm, 20.7 mm and 31.1 mm after 6, 9, and 12 months after planting. Thus *Acacia mangium* was faster both in terms of height and collar diameter than *Casuarina*. However *Casuarina* stem was less tapering than *Acacia mangium* at 12 months after planting. The average mortality of trees after one year for both the species was very less (< 6%).

From all above observations it could be said that the reclamation of waterlogged degraded area through biodrainage gave encouraging results.

REFERENCES

Ambast, S.K., Sen, H.S. and Tyagi, N.K. (1998). *Rainwater Management for Multiple Cropping in Rainfed Humid Sunderbans Delta (W.B.)* Bulletin No. **2/98**, Central Soil Salinity Research Institute, Karnal.

Heuperman, A. (1999). Hydraulic gradient reversal by trees in shallow water table areas and repercussions for the sustainability of tree growing systems. *Agricultural Water Management* **39**: 153-167.

Panigrahi, B. (2001). Water balance simulation for optimum design of on-farm reservoir in rainfed farming system. *Ph.D. Thesis*, Indian Institute of Technology, Kharagpur.

Sanchez-Cohen, I., Lopes, V.L., Slack D.C. and Fagel, M.M. (1997). Water balance model for small-scale water harvesting systems. *Journal of Irrigation and Drainage Engineering*, ASCE **123**(2): 123-128.

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Feasibility of Intercrops in Drip Irrigated Banana in Coastal Orissa

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Drip irrigation systems are very suitable for orchard crops especially in the areas where water is scarce or expensive. But, longer gestation period of orchard crops is a major constraint towards crop diversification by small and marginal farmers. This constraint can be overcome by having an intercrop. So, in order to evaluate the feasibility of intercrops in drip-irrigated banana, an experiment was conducted at the Water Technology Center for Eastern Region research farm, Bhubaneswar, which lies in the coastal belt of Orissa. The treatments were (1) sole banana, (2) banana plants with unirrigated turmeric, (3) banana plants with unirrigated cowpea, (4) banana plants with microtube-irrigated turmeric, (5) banana plants with microtube-irrigated cowpea, (6) banana plants with extension tube-irrigated turmeric, and (7) banana plants with in-line dripper-irrigated cowpea. The microtubes and extension tubes were taken out of the laterals to irrigate the intercrops whereas the in-line dripper was taken out directly from the submain. Microtubes and extension tubes taken out of laterals did not affect the quantity and uniformity of distribution of water to banana. The intercrops did not affect the vegetative growth and yield of main crop banana. Both the intercrops were feasible and cost effective and between the two, turmeric was more remunerative. The additional benefits from the turmeric intercrop irrigated by microtubes and extension tubes were Rs. 24,700.00 and Rs. 24,200.00 per hectare per season, respectively. The additional benefits from the cowpea intercrop irrigated by microtubes and in-line drippers were Rs 11,000.00 and Rs. 7200.00 per hectare per year, respectively.

(***Key words*** : *Banana, Drip irrigation, Intercrop*)

Drip irrigation systems are suitable for orchard crops. But the long gestation period in case of orchard crops is a major constraint towards crop diversification by small and marginal farmers. Here intercropping can be useful where the vacant space left by the long duration and wide spaced crops are suitably utilized by the short duration and close spaced crops in order to obtain an increased and early income from the land. Banana being a relatively long duration and wide spaced crop, there are good opportunities for growing of intercrops. Leguminous intercrops have the potential to increase the fertility status of the soil and thereby compliment the main crop banana. Different workers have worked on different intercrops in banana. Chacko and Reddy (1981) found that at Bangalore, intercropping with cowpea drastically reduced weed growth with corresponding higher yield in Robusta banana. For Basrai banana spaced at 1.8 x 1.8 m in medium black soil in South Gujurat, the most economic intercrop was turmeric (Chundawat *et al.*, 1984), although it did not have any significant effect on growth, fruit yield and quality. Some farmers take early cauliflower, cabbage and yam in early growth period of ratoon crop which are harvested before flowering of banana. Maharana and Das (1986) found onion to be the best in Orissa. According to Baghel *et al.* (1986), intercropping of banana (*Muga indica*) with moong (*Vigna radiata*), urid (*Vigna mungo*), soybean (*Glycine max*), groundnut (*Arachis hypogea*) and cowpea (*Vigna unguiculate*) had no significant adverse effect whereas intercrops gave additional returns, *Vigna mungo* being the best intercrop. In Kerala, intercropping with vegetables, such as brinjal, colocasia, yam, discorea, chillies and ladies finger in wetland is common. Nybe *et al.* (1991) reported that intercrop with banana was most effective and economic method of weed control compared among different weed control measures.

But as no studies have been done on intercrops in drip irrigated banana, a study was conducted at WTCER, Bhubaneswar to evaluate the performance of different intercrops in such systems. In the present study, two intercrops, i.e. turmeric and cowpea have been tried.

MATERIALS AND METHODS

The banana plants (robusta cultivar) were planted in the last week of June'2002 in the WTCER research farm, Mendhasal, Bhubaneswar. The intercrops, namely turmeric and cowpea were tried with different irrigation systems. The treatments were sole banana (T-1), banana with unirrigated turmeric (T-2), banana with unirrigated cowpea (T-3), banana with microtube-irrigated turmeric (T-4), banana with microtube-irrigated cowpea (T-5), banana with extension tube with dripper-irrigated turmeric (T-6), and banana with in-line dripper-irrigated cowpea (T-7). Drip irrigation system was installed and started operating from mid-November'2002. Irrigation to the banana plants was applied at the rate of IW/CPE=0.8 as this was found as the best irrigation schedule in the existing situation (Srivastava, 1999). Canopy area was taken as the base for area of application of water. In this method, the total amount of water applied to the banana plants up to 31st May was 492 mm. The amount of rainfall during the above period was 110 mm. The microtubes or extension tubes were taken out of lateral lines to irrigate the intercrops. The in-line dripper tube was taken out directly from the submain line to irrigate the cowpea intercrop. The layout of the microtubes, extension tubes and in-line drippers are shown in Fig. 1. During the experiment, one crop of turmeric was taken. Turmeric was planted in the month of June and irrigation was given only after the rainy season was over. Due to it's short duration, two crops of cowpea were taken up, one during *kharif* and other during *rabi*. No irrigation was applied to the *kharif* cowpea crop.

The hydraulics of the drip irrigation was studied by comparing the uniformity coefficient and discharge of the drippers along the laterals (i) where no tubes were taken out, (2) where microtubes were taken out, (3) where extension tubes were taken out and (4) where in-line drippers were provided between the laterals. The emission uniformity was calculated using the following relationship:

$$EU = (1 - m/D) \times 100\%, \qquad (1)$$

where, EU= Emission uniformity, D = Average discharge of the emitter, m = Mean deviation of the discharge from the average.

Vegetative growth parameters of the banana under different treatments were observed on 31st January '2003, 31st March '2003 and 30th June'2003 and compared with each other. The yield and number of fingers per bunch in different

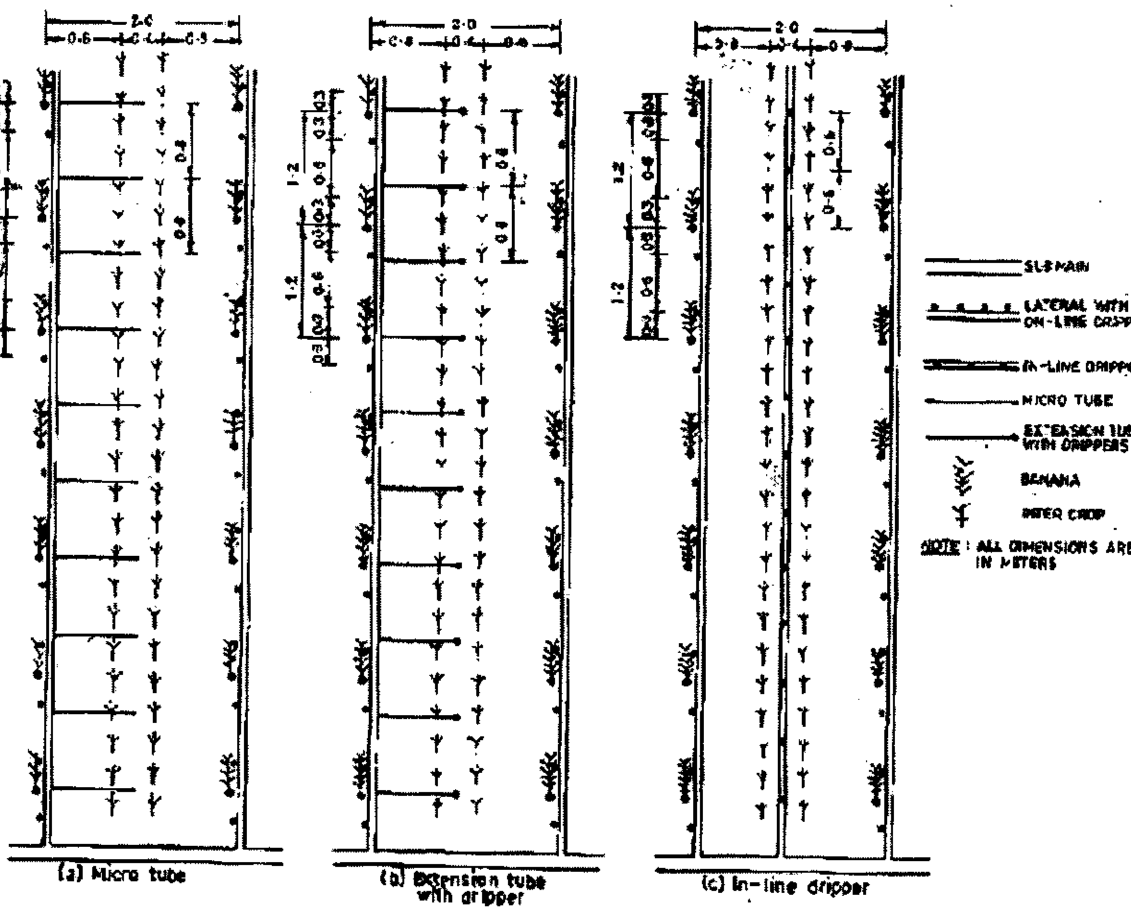

Fig. 1. Methods of irrigation of inter crops

treatments were also recorded. The vegetative growth and weed population in both the intercrops were monitored. Among vegetative growth parameters, in case of turmeric, plant height and leaf area were observed. In case of cowpea intercrop, only plant height was observed. The yield of turmeric and cowpea intercrops under various treatments were recorded and the additional benefit from intercrops under different treatments was calculated considering the cost of seeds, fertilizers, irrigation system, labour, pesticide, etc.

RESULTS AND DISCUSSION

Hydraulics of drip system

The emission uniformity and discharge of the drippers as affected by the modification of the laterals is shown in Table 1. The emission uniformity along the laterals where no modification was done was found to be 89%. The emission uniformity of the dripper along a lateral line was 86% where microtubes were taken out and 87% where extension tubes were taken out. The emission uniformity was 88.5% where in-line drippers were taken out between the laterals. The discharge of the drippers varied from 3.4 to 3.6 liters per hour among different treatments. So, it indicates that the water application and distribution to the banana plants through drippers were not significantly affected by the modifications carried out to irrigate the intercrops.

Vegetative growth parameters and yield of banana

The vegetative growth parameters of banana were measured in the last week of January, March and June. The vegetative growth parameters indicated that there was no significant difference between the different treatments except in case of pseudostem girth values in the last week of March and June. There was no significant difference between the fruit yield values and number of fingers per bunch under different treatments. But the yield and number of fingers per bunch were less in no-intercrop treatment when compared with other treatments. This indicated that the intercrops did not have any adverse effect on the banana crop. The pseudostem girth values recorded in the last week of March and June in cowpea-intercropped banana were significantly higher than these in no-intercrop treatment. So cowpea may have same beneficial effect on banana. This may be attributed to the leguminous nature of the crop (fixation of nitrogen) and the control of weeds.

Table 1. *Emission uniformity and discharge as affected by modifications for irrigating intercrop*

Modification in the system for main crop	Emission uniformity (%)	Average discharge (lph)
Without any modification	89.0	3.60
With microtube for irrigation of intercrop	86.0	3.40
With dripper and extension tube for intercrop	87.0	3.55
With in-line drippers	88.5	3.50

Vegetative growth parameters, yield and weed population in intercrops

The vegetative growth parameters, yield and weed population in turmeric intercrop with different irrigation treatments are shown in Table 2. The height of the plants and leaf area in case of microtube-irrigated turmeric were marginally better than extension tube-irrigated plants. But the yields were marginally better in case of extension tube-irrigated plants. This can be attributed to lower weed growth in case of extension tube-irrigated turmeric crop in comparison to microtubes. The vegetable growth parameters, yield and weed population were lowest under no irrigation treatment. Lesser weed growth in no irrigation treatment could be attributed to lower water availability.

The vegetative growth parameters, yield and weed population in cowpea intercrop with different irrigation treatments is shown in Table 3. The yield and plant height were better in microtube irrigation treatment. So, microtube was the most suitable method of irrigating cowpea intercrop. The weed populations in cowpea intercrops were much less than that under turmeric intercrops. So, cowpea intercrops were suitable for weed control.

Table 2. *Vegetative growth, yield and weed population in turmeric*

Treatment	Plant height (cm)	Leaf area (cm^2)	Yield (kg/m^2)	Weed (g/m^2) population
Microtube	80.0	332.5	1.01	620
Extension tube	79.5	312.0	1.05	480
No irrigation	52.5	206.0	0.59	320

Table 3. *Vegetative growth, yield and weed population in cowpea*

Treatment	Plant height (cm)	Yield (g/m^2)	Weed population (g/m^2)
Microtube	36.0	345	65
In-line dripper	31.0	271	75
No irrigation	20.5	74	80

Additional income from intercrops

The additional benefits from the turmeric and cowpea intercrop were calculated considering the yield, cost of irrigation system, cost of seeds and fertilizers, cost of labour and other costs. The benefit in case of turmeric intercrop irrigated by microtube or extension tube with dripper were almost equal, viz. Rs.24,700.00 per ha and Rs. 24,200.00 per ha, respectively. In case of no irrigation (only rainfall was received), the net benefit was Rs.10, 000.00 per ha. This indicated that some irrigation was required for the turmeric intercrop following monsoon. The microtubes or the extension tubes were equally good for drip-irrigated turmeric intercrops. The annual benefit per ha from the intercrop could be further increased if some other intercrop was taken after turmeric was harvested.

The additional net benefit per ha in case of cowpea intercrop in *rabi* season were Rs. 4400.00 and Rs. 600.00 for microtube irrigation and in-line dripper irrigation, respectively. In case of no-irrigation there was a loss of Rs.700.00 per ha. This indicated that the profit from in-line dripper-irrigated *rabi* cowpea intercrop was negligible and the unirrigated *rabi* cowpea intercrop was a losing proposition. The additional net benefit in case of unirrigated *kharif* cowpea intercrop was Rs. 6600.00 per ha. So the total benefit from a *kharif* cowpea intercrop and microtube-irrigated *rabi* cowpea intercrop will be Rs. 11,000.00 per ha, which was quite less than a single crop of turmeric.

Thus, the irrigated intercrop in drip irrigated banana was feasible from hydraulic as well as economic points of view. If properly planned, the returns from the intercrop should pay for the drip system in two years. As the intercrop like turmeric cannot be grown in surface irrigated banana (the turmeric will rot when the irrigation water will accumulate in between banana rows) the benefits from intercrop can be an added incentive to shift to drip irrigation for banana. However the selection of the crop should be done on the basis of its capability to grow under the shade as well as its economics. In fact cowpea may have some beneficial effect on banana due to its leguminous nature.

CONCLUSION

The cowpea intercrop is remunerative to a lesser extent. Microtube irrigation is suitable for irrigating the cowpea intercrop.

REFERENCES

Baghel, B.S., Surnaik, D.A. and Pathak, A.C. (1986). Intercropping of legumes in Basrai dwarf Banana. *Research Development Reporter* **3**: 7-9.

Chacko, E. K. and Reddy, A. (1981). Effect of planting distance and intercropping with cowpea on weed growth in banana. Proceedings *Eighth Asian Public Weed Science Society Conference*, pp. 137-44.

Chundawat, B.S., Joshi, H. H. and Patel, N.C. (1984). Studies on intercropping in Basrai banana. *South Indian Horticulture* **32**: 23-25.

Maharana, J. and Das, A. K. (1986). Effect of spacing and intercrop on the shooting and harvesting of banana cv. Robusta. *Orissa Journal of Horticulture* **9**: 34-39.

Nybe, E.V., Abraham, C.T., Suma, A. (1991). Weed management in banana cv.Nendran with cowpea as an intercrop. *Agricultural Research Journal of Kerala* **29**(1/2): 3-56.

Srivastava, R.C. (1999). Performance evaluation of drip irrigation system for orchard crops. In *Annual Report*, WTCER, pp. 99-100.

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Effect of Organic Mulch, Soil Amendments and Soil Configuration on Yield of Onion and Soil Properties

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A field experiment was conducted to study the effect of surface organic mulch, soil amendment and soil configuration on the yield of onion crop under a silty loam soil in coastal region of Saurashtra in Gujarat. Pearl millet husk was used as surface organic mulch applied at 3t ha^{-1}. Gypsum was broadcast at 5 t ha^{-1} and incorporated before sowing. The furrow of 15 cm deep by 45 cm wide was made. The results revealed the treatment of flat bed with surface organic mulch gave significantly higher onion bulb yield. The effects of the gypsum and soil configuration were found non-significant on the yield of onion bulb in the pooled data. The maximum net return of Rs. 22220 ha^{-1} with net CBR 1:22.2 was also noted with flat bed under mulch treatment.

***(Key words** : Onion yield, Organic mulch, Soil amendments, Soil configuration)*

Onion is one of the major cash crops grown in Mahuva and Talaja under Shentruji command area. Farmers use ground water, which is over-exploited in this area. Because of over-exploitation, its quality deteriorated rapidly. Under such condition the soil properties and thereby crops yield were adversely affected. A field experiment was therefore planned to conduct on farmer's field of Mahuva *taluka* to study the effect of soil configuration, organic mulch and soils amendments on the yield of onion.

MATERIALS AND METHODS

A permanent site field experiment was conducted on coastal soil of Saurashtra for three years during *rabi* season from the year 2000 to 2003 in RBD with four replications at the farmers' field (Village:Vadli, *Taluka*: Mahuva, Dist: Bhavnagar) with crop onion, cv. Talaja red (Local variety). The treatments were T_1: Flat bed (Fb, Control), T_2: Fb + Mulch (3 t ha^{-1}), T_3: Fb + Gypsum (5 t ha^{-1}), T_4: Fb + Mulch (3 t ha^{-1}) + Gypsum (5 t ha^{-1}), T_5: Ridge and Furrow (R& F), T_6: R&F+ Mulch (3 t ha^{-1}), T_7: R&F + Gypsum (5 t ha^{-1}), T_8: R& F + Mulch (3 t ha^{-1}) + Gypsum (5 t ha^{-1}). The experimental soil had texture silty loam, EC (dS m^{-1}) 1.3, pH 8.2, $CaCO_3$ 28 g kg^{-1}, ESP 8.5, OC 4.3 g kg^{-1}, available P_2O_5 35.4 kg ha^{-1} and available K_2O 510 kg ha^{-1}. The half N and full P_2O_5 and K_2O of RD-recommended dose (75.0 : 60.0: 50.0 N : P_2O_5 : K_2O kg ha^{-1}) were applied as basal and remaining half dose of N of RD as split at 30 days after planting of onion seedlings. The plant spacing of 15 x 10 cm was adopted for onion seedlings. The mean annual rainfall of the area was about 400 mm with erratic distribution. The slope of the study area was less than 2 percent, with little variation in physiography. The onion crop grown in plots was subjected to irrigation by flood system. The values of EC (dS m^{-1}) and pH of the irrigation water were 2.26 and 7.88, respectively.

RESULTS AND DISCUSSION

The onion bulb yields were significantly affected due to different treatments (Table 1). The pooled results revealed that the treatment of flat bed with surface organic mulch gave significantly higher onion bulb yield and was at par with the treatment of ridge and furrow with mulch. The surface organic mulch under irrigated conditions resulted in higher initial infiltration rates (Arika and Lenga, 2000). Such an improved trend in the onion bulb yield, following mulching, could possibly be attributed to moderated soil hydrothermal regime (Sharma and Parmar, 1998) which resulted in an enhanced growth and activity of roots and shoots. The effects of the gypsum and soil configuration were found non-significant on the yield of onion bulb in the pooled data.

The perusal of data presented Table 2 revealed that the treatment of flat bed with mulch gave significantly higher bulb yield of onion. Similarly, the maximum net return of Rs. 22220 ha^{-1} with net CBR 1:22.2 was also noted under flat bed with mulch treatment.

Table 1. *Effect of different treatment on bulb yield of onion (t ha^{-1})*

Treatment	Bulb yield (t ha^{-1})			Pooled
	2001-02	2002-03	2003-04	
Fb (Control)	42.73	63.20	47.69	51.21
Fb+Mulch (M)	46.09	76.63	65.75	62.82
Fb+Gypsum(G)	44.89	66.44	56.02	55.78
Fb+M+G	48.99	64.59	53.71	55.76
R & F	43.92	55.79	50.47	50.06
R & F+Mulch	51.07	68.76	50.93	56.92
R & F+Gyp.	44.26	61.81	49.08	51.72
R & F+M+G	49.80	63.20	51.16	54.72
SEm±	1.69	1.64	2.04	2.20
CD at p=0.05	4.94	4.81	6.01	6.66
C.V. %	7.23	5.03	7.69	6.54

Table 2. *Economics of treatments for* rabi *onion crop*

Treatment	Bulb Yield (t ha^{-1})	Additional bulb yield over control (t ha^{-1})	Additional bulb yield income over control (Rs. ha^{-1})	Total additional expenditure over control (Rs. ha^{-1})	Total additional income over control (Rs. ha^{-1})	Net CBR
Fb (Control)	51.21	-	-	-	-	-
Fb+Mulch	62.82	11.61	23220	1000	22220	1: 22.22
Fb+Gypsum	55.78	4.57	9140	1250	7890	1: 6.31
Fb+M+G	55.76	4.55	9100	2250	6850	1: 3.04
R & F	50.06	-1.15	-2300	1000	-3300	-
R & F+Mul.	56.92	5.71	11420	2000	9420	1: 4.71
R & F+Gyp.	51.72	0.51	1020	2250	-1230	-
R & F+M+G	54.72	3.51	7020	3250	3770	1: 1.16

Price of the materials considered and application charge :

Onion bulb	: 2.00 Rs. kg^{-1}	Husk of pearl millet (mulch)	: 1000 Rs. t^{-1}
Gypsum	: 250 Rs. t^{-1}	Cost of ridge and furrow	: 1000 Rs. ha^{-1}

REFERENCES

Arika, C.N. and Lenga, F.K. (2000). Effect of mulch application method on soil moisture characteristics and maize yield in a semiarid region of Kenya. *Journal of Indian Society of Soil Science* **48**: 9-15.

Sharma, P.K. and Parmer, D.K. (1998). Effect of phosphorus and mulching on the uptake of secondary nutrients and productivity of wheat at different growth stages on Alfisol from Western Himalayas. *Journal of Indian Society of Soil Science* **46**: 67-70.

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Feasibility Studies of Growing Pumpkin as Intercrop in Coconut under Coastal Littoral Sandy Soil

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Coconut is grown in coastal littoral sandy soil, which occurs all along the coastal sandy tract of the West and East coasts of the Peninsular India lying mostly in Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Orissa and Maharastra. Coastal littoral sandy soils are mainly skeletal soils, consisting of 99.1 percent sand particle characterized by poor water holding capacity, high infiltration rate, easy leachability and low inherent fertility status. Even though coconut is a widely spaced crop, the interspace cannot be utilized for growing of intercrops in sandy soils under normal conditions. However, by adopting proper soil and water conservation measures intercropping can be practised in the coconut garden under coastal sandy soil. Keeping this in mind , a field experiment was conducted to study the feasibility of growing pumpkin as intercrop in the coconut garden by adopting various soil and water conservation methods under coastal sandy soil at Central Plantation Crops Research Institute, Kasaragod, Kerala during October 2004 to February 2005. The treatments included soil moisture conservation measures, viz. one layer dried coconut husk burial in the pits and sowing of pumpkin, coirpith application in the pits and sowing of pumpkin, and control (without any soil and water conservation measures) and sowing of pumpkin. The experimental results revealed that pumpkin can be successfully grown as intercrop in the coconut garden in coastal sandy soils. Among the treatments, coirpith application in the pits and sowing of pumpkin, resulted in higher pumpkin yield (10.1 tonnes ha^{-1}).

*(**Key words:** Coastal sandy soil, Husk and coirpith, Pumpkin yield)*

Coconut in India is primarily a crop of small farmers. About 98% of the coconut holdings in the country are less than 2.0 ha and more than 90% of them are less than 1.0 ha in size. The income derived from such small holdings is not sufficient to sustain even the small families. Coconut based intercropping systems, involving cultivation of compatible crops in the interspaces of coconut offer considerable scope for increasing production and productivity per unit area, and more efficient utilization of resources like sunlight, soil, water and labour. Vegetable crops constitute one such group of annuals which can be conveniently grown as intecrops in a coconut garden to alleviate such problems. India is the second largest producer of vegetables in the world and accounts for about 15% of the world's production of vegetables. One of the ways to increase the production of vegetables is through intercrops in the coconut garden. Various research workers have reported about the feasibility of growing vegetable in a coconut garden in different countries (Abilay, 1983, Liyanage *et al.*, 1984, Rethinam, 1989, Hegde *et al.*, 1993).

Coconut, the tree of heaven is highly amenable for cultivating intercrops in the interspaces because of its wider spacing. In India, coconut is cultivated in about 1.92 million hectares. Growing of vegetables in between the coconut palm in coastal littoral sandy soil is not feasible under normal management practices. This is mainly because of poor inherent physicochemical properties of the coastal sandy soil. The coastal sandy soils are mainly skeletal soils consisting of 99.1 percent sand particles. So growing any annual/biannual/perennial in the interspaces of coconut palm is possible only by improving the physiochemical properties of soil. Pumpkin (*Cucurbita moschata* Poir) is one of the popular cucurbits grown in India. Low cost of production, long keeping quality and comparatively high content of caroteine in fruits have enhanced the usefulness of the crop. Keeping this in view, a field experiment was started with the objective to study the feasibility of growing pumpkin as intercrop in the coconut garden in coastal sandy soil under different soil and water conservation measures.

MATERIALS AND METHODS

The investigation was carried out from the period November 2004 to February 2005 at Central Plantation Crops Research Institute, Kasaragod (12°30′ N latitude and 75°00′ E longitude with an elevation of 10.7 m above mean sea level).

The experiment was laid out in the 40 year-old WCT coconut garden. The soil of the experimental field was sandy (Quartzip samments) having 99.1 percent sand, 0.2 percent silt and 0.7 percent clay. The pre-experimental physicochemical properties of the soil of the experimental field are given in the Tables 1 (a,b).

Table 1a. *Physical characteristics of the experimental field soil*

1.	Field capacity (%)	4.2
2.	Permanent wilting point (%)	0.44
3.	*In situ* bulk density g.cm^{-3}	1.66
4.	Texture	
	Clay (%)	0.7
	Silt (%)	0.2
	Fine sand (%)	3.3
	Coarse sand (%)	95.8
	Textural class	Sandy soil

Table 1b. *Chemical composition of the experimental field soil*

1.	Available nitrogen (kg ha^{-1})	34.8
2.	Available phosphorus (kg ha^{-1})	23.05
3.	Available potassium (kg ha^{-1})	12.5
4.	Organic carbon (%)	0.139

The experiment was laid out in randomized block design with seven replications and three treatments. The treatments are T_1: Coconut husk burial in the pits, T_2: 5 cm thick coirpith application in the pits, and T_3: Control. For the husk burial, a pit was opened measuring 75 cm wide and 30cm deep, and one layer of husk was applied in a convex manner (husks from 10 coconuts was used to cover the pits). In the case of T_2 treatment, trench was opened measuring 75 cm wide and 30 cm deep and 10 kg of coirpith per pit was applied. In the control plot only pits were opened. Application of farmyard manure @ 2.5 t and vermicompost @ 2.5 t per ha were applied uniformly to all the treatments. Then the pits were filled with soil and the sowing was taken up. Sowing was done during the month of November 2004. Cultural practices as recommended by the Kerala Agricultural university was adopted for pumpkin (Kerala agricultural university, 2002). Sprinkler system of irrigation was practised with 20 mm of water at IW/CPE ratio of 1.0.

Soil samples were collected on the fourth day after irrigation from 0-30 cm depth using tube augur and soil moisture was estimated by gravimetric method. Observations on growth characters were taken from five tagged plants per treatment at the time of harvest. Statistical analyses were done following Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The results revealed that soil drawn from husk and coir pith treatments retained higher soil moisture content during the rainless period (Nov-Feb) compared with that in control plots (Fig. 1). Higher soil moisture content in the coirpith/husk burial treatments due to coirpith/husk materials could absorb and retain more moisture in the soil. Child (1964) also reported that coir dust improved the retention of moisture in the soil.

Growth and yield parameters

Pumpkin responded well to husk and coirpith application (Table 2). The coirpith application and husk had significantly influenced the growth and yield parameters. It is clearly evident from the data

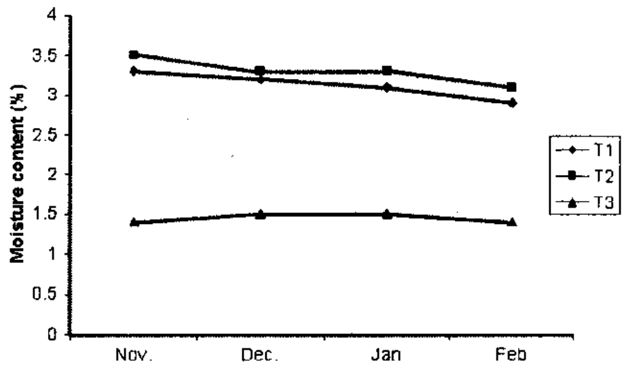

Fig. 1. Effect of different treatments on soil moisture content

Table 2. *Effect of different treatments on growth and yield parameters of pumpkin*

Treatment	Vine length (cm)	Fruit/vine (cm)	Fruit diameter (cm)	Fruit length (cm)	Average fruit wt (kg/fruit)	Fruit yield (t/ha)
T_1	632	2.8	60.6	27.4	1.94	9.46
T_2	656	2.8	62.6	29.0	2.10	10.12
T_3	542	1.9	51.3	23.6	1.26	6.21
CD at p = 0.05	62	0.2	8.0	NS	0.40	0.87

that when the soil was incorporated with coirpith or husk, irrespective of the source used, the yield of pumpkin increased significantly compared to that under control. The yield under coirpith and husk application were however, at par. Higher fruit yield under husk and coirpith application may be due to beneficial effect of coirpith application and husk in the pits, viz. higher soil moisture availability and increased nutrient availability and enhanced biological activities in the rhizosphere. It has been found that by incorporation of 2 percent weight of coirpith with sandy soil, the water holding capacity of the latter was increased by 40 percent. Thus, pumpkin can be successfully grown as intercrop in coconut gardens under coastal sandy soil with soil and water conservation measures.

REFERENCES

Abilay, R.M. (1983). Breeding of selected upland crops partial shade tolerance. Proceedings Symposium *Coconut Based Farming Systems*, pp. 14-18. Philippines Coconut Authority, Manila.

Child, R. (1964). *Coconuts*. Longmans, London. 216p.

Gomez, K.A. and Gomez, A.A. (1984). *Statistical Procedures for Agricultural Research*, 2nd Edn. John Wiley and Sons, New York. 680p.

Hegde, M.R., Mohammed Yusuf and Gopalasundaram, P. (1993). Intercropping of vegetables in coconut gardens. In *Advances in Coconut Research and Development*, M.K. Nair *et al.* (eds.), pp. 407-412.

Kerala Agricultural University (2002). *Package of Practices Recommendations: Crops*, 12th Edn., A. I. Jose *et al.* (eds.), Kerala Agricultural University, Trichur. 278p.

Liyanage, M. de. S., Tejwani, K.G., and Nair, P.K.R. (1984). Intercropping under coconut in Srilanka. *Agroforestry Systems* **2**: 215-225.

Liyanage, M. de. S., Jayasekara, K.S. and Fernadopulle, M.N. (1993). Effects of application of coconut husk and coir dust on the yield of coconut. *COCOS* **9**: 15-22.

Rethinam, P. (1989). In *Research Highlights of AICCAIP*, 1972-79, pp. 11-12, Central Plantation Crops Research Institute, Kasargod.

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Floral Biology of Moringa in Karaikal (*Moringa oleifera* Lam)

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Studies were carried out at the Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal during September 2003 to December 2004 to gather information on floral biology in moringa (*Moringa oleifera* Lam.) cvs. PKM 1 and PKM 2. Flowering was observed throughout the year and peak flowering was recorded during April-May and September-October, while peak fruiting was observed during May and October for summer and rainy season, respectively. Anthesis continued throughout the day with two peak time at 9.30 am and 6.30 pm. Stigma was receptive a day prior to opening and continued upto the day of opening with maximum receptivity. Pollen grains exhibited good germination and maximum pollen tube growth was noticed in 15 percent sucrose medium. Pollen viability percent on acetocarmine staining method was 98 percent in PKM 1 and 99 percent in PKM 2. Pollen grains stored in refrigeration (3°C) lost viability within seven days and under room temperature (25°-30°C) within three days.

(***Key words:*** *Floral biology, Moringa, Anthesis, Stigma receptivity, Pollen tube growth)*

The knowledge of floral biology is a pre-requisite for embarking upon a crop breeding and hybridization programme. The success of pollination and fertilization depends upon whether the signals carried by the pollen are recognized by the receptors in the stigma, pollen viability, pollen germination, pollen production and other pollination steps. Moringa (*Moringa oleifera* Lam) is one of the commercial vegetable crops in India especially in South India in which time of anthesis, anther dehiscence, pollen viability, germination and stigma receptivity, and fruit set studies have not been undertaken in details. Moreover in this crop, even though thousands of flowers were produced per tree, fruits are not developed from all the flowers formed. The fruit yield can be increased if the knowledge of exact floral biology, varieties and seasonal effects were known to the growers and researchers. Therefore the present investigation was carried out on floral biology of two moringa varieties (cv. PKM and PKM 2) in summer and rainy season which will serve as a guide to the breeder to develop efficient breeding and maximize fruit yield.

MATERIALS AND METHODS

The experimental materials consisted of two varieties of moringa, viz. cv. PKM 1 and PKM 2. Twenty-five bearing plants in each variety were selected and marked for recording observation on duration of flowering, monthly count of total inflorescence and fruits produced during each month, anthesis time, stigma receptivity, pollen production, viability, pollen tube growth, pollination study, and fruit set carried out in summer and rainy reasons.

RESULTS AND DISCUSSION

The results of the present study on phenology and floral biology revealed that the moringa flowered throughout the year. There were two peaks of flowering, viz. October-November (rainy season) and April-May (summer season) with corresponding two fruiting peaks during October (rainy) and May (summer) in both the varieties. Continuous flowering and fruiting in moringa was reported by Pushpaganthan *et al.* (1996) and Sindhu (2002). The two periods of peak fruiting in moringa was reported by Muthuswamy (1954) and Indira and Peter (1988) in South India, which support the present findings (Table 1). There were two anthesis peaks, one at 9.31 to 10. 00 am and the second around at 6.31 to 7.00 pm on the same day in both the varieties during summer and rainy season (Table 2), which was earlier reported by Jyothi *et al.* (1990) and Babu and Rajan (1996) in moringa, and thus supports the present finding of two peaks rather than one peak flowering in moringa as earlier reported by Devar *et al.* (1981) and Subramanian *et al.* (1997).

Table 1. *Phenlogy of flowering, fruiting in moringa*

Month	Total number of inflorescence per tree		No. of flowers per inflorescence		Total number of fruits produced per tree	
	PKM 1	PKM 2	PKM 1	PKM 2	PKM 1	PKM 2
Rainy Season						
October 2003	308	227	12195	589	106	90
November 2003	240	210	9210	4812	95	78
December 2003	141	196	3362	4158	46	60
January 2004	23	55	1795	2815	31	28
February 2004	75	68	6110	3153	64	36
Summer Season						
March 2004	218	105	6321	7210	86	75
April 2004	285	264	10554	11246	158	158
May 2004	308	285	11026	10141	171	189
June 2004	264	245	7154	6754	141	114
July 2004	227	228	6143	5992	85	85
August 2004	246	185	5754	5027	58	64
Rainy Season						
September 2004	285	207	7785	4223	79	76

Table 2. *Anthesis in moringa*

Time	Mean number of flowers opened in an inflorescence			
	PKM 1		PKM 2	
	Summer season	Rainy season	Summer season	Rainy season
8.00am to 8.30 am	09	11	08	11
8.31 to 9.00 am	10	13	10	12
9.01 to 9.30 am	11	15	10	14
9.31* to 10.00 am	14	17	13	18
10.01 to 10.30 am	7	11	8	12
10.31 to 11.00 am	5	8	6	9
11.01 to 12.00 am	5	7	4	9
11.01am to 5.00 pm	Less than 2 flowers opened			
5.01 to 5.30 pm	11	14	10	10
5.31 to 6.00 pm	12	14	12	13
6.01 to 6.30 pm	13	17	12	14
6.31 * to 7.00 pm	18	21	17	20
7.01 to 7.30 pm	12	15	14	16
7.31 to 8.00 pm	10	12	11	16
8.01 to 8.30 pm	8	10	10	12
8.31 to 9.00 pm	7	9	9	11
9.01 to 9.30 pm	6	9	8	10
9.31 to10.00 pm	6	8	5	9
10.01 to11.30 pm	Less than 2 flowers opened			
11.31 to 5.00 am	No flowers opened			
5.31 to 6.30 am	5	7	6	8
6.31 to 7.30 am	6	8	7	9
7.31 to 8.00 am	8	10	7	10

* Peak time of anthesis - 9.31 to 10.00 am to 6.31 to 7.00 pm

The stigma was receptive one day prior to opening and continued with maximum receptivity of 88 and 96 percent based on pollen adherence, and 72 and 84 percent in PKM1 and PKM2 due to controlled pollination on the day of opening with a sudden decline in receptivity thereafter (Table 3). This was in agreement with the findings of Devar *et al.* (1981) and Ashish *et al.* (2003) in moringa. The results of the estimation of pollen production revealed that the average pollen count per anther in summer season was 8000 and the total pollen per flower was 38,000 in PKM1, while in PKM2 these were 8100 and 38500, respectively. In rainy season, the count was 7675 and 36500 in PKM1 and 7900 and 37250 in PKM2, respectively. Higher pollen production might have contributed to the better fruit set and higher fruit production in summer season as reported by Sindhu (2002) which was in agreement with the present finding.

Pollen grains failed to germinate in water in the *in-vitro* germination studies. High pollen germination percentage and pollen tube growth were obtained in 5 to 20 percent sucrose media with highest values observed in 15 percent sucrose (Table 4) and thereafter a slight decline was noticed which also support the findings of Sindhu (2002) in moringa.

In pollen storage studies under refrigerated condition, viability declined to a negligible level within seven days, and under room temperature the viability was totally lost within 3 days. Refrigeration has been reported to extend the viability in cocoa (Simmons, 1976) which supports the present finding in moringa.

The fruit set percentage (Table 5) was 42.00, 16.00, 32.00, 64.00 in PKM 1 and 47.20, 24.00, 36.00, 68.00 in PKM2 under natural pollination, natural selfing, natural crossing and assisted crossing, respectively. Maximum fruit set was obtained in assisted crossing, i.e. 64.00 and 68.00 percent in PKM1 and PKM2, respectively. The flowers, which were emasculated and bagged, did not set any fruit revealing the entomophilous nature of the crop. The results fully agree with the findings of Devar *et al.* (1981) in moringa.

Table 3. *Stigma receptivity in moringa based on pollen grain adherence and fruit set after controlled pollination*

Variety	Stage of flower	Total number of flowers observed in each variety	Pollen grain adherence		Fruit set after controlled pollination	
			No. of stigma with sticky surface	Percent	No. of stigma with sticky surface	Percent
PKM1	One day prior to opening	25	15	56	11	44
	On the day of opening	25	23	88	18	72
	One day after opening	25	4	12	01	04
PKM2	One day prior to opening	25	17	64	14	56
	On the day of opening	25	24	96	21	84
	One day after opening	25	7	16	3	18

Table 4. *Loss in pollen viability on storage under refrigeration and room temperature is moringa*

Days of Storage	Refrigerated storage (3°C)						Room temperature (25 – 30°C)					
	Staining (%)		Germination (%)		Pollen tube growth (10 x 45 x)		Staining (%)		Germination (%)		Pollen tube growth (10 x 45 x) M	
	PKM1	PKM2	PKM1	PKM2	PKM1	PKM2	PKM1	PKM2	PKM1	PKM2	PKM1	PKM2
1	97	98	86.89	97.78	280.00	282.80	96.00	96.98	86.00	86.86	98.26	98.46
2	90	91	80.61	81.51	245.90	248.6	55.73	56.34	18.00	20.00	–	–
3	82	84	73.44	75.23	142.53	146.0	22.72	23.27	7.00	8.00	–	–
4	79	78	70.75	69.85	120.70	119.6	–	–	–	–	–	–
5	65	67	58.21	59.99	70.75	73.0	–	–	–	–	–	–
6	60	62	53.73	55.51	44.02	45.5	–	–	–	–	–	–
7	41	40	36.71	35.81	29.36	28.6	–	–	–	–	–	–

***Table 5.** Fruit set in moringa under different methods of pollination*

Methods of pollination	Number of flowers under observation in each variety	Fruit set (Number)		Fruit set (percent)		Remarks
		PKM1	PKM2	PKM1	PKM2	
Flower buds merely bagged	25	10.50	11.80	42.00	47.20	Natural pollination (Open pollination)
Flower buds not emasculated but bagged	25	4.00	6.00	16.00	24.00	Natural selfing (self pollination)
Flower buds emasculated and kept open	25	8.00	9.00	32.00	36.00	Natural out-crossing
Emasculated crossed and bagged	25	16.00	17.00	64.00	68.00	Assisted crossing (hand pollination)
Emasculated and bagged	25	-	-	-	-	No pollination

REFERENCES

Ashish, J.S., Hundal and Dhall, R.K. (2003). Floral biology studies in chilli (*Capsicum annuum* . L). *Vegetable Science* **30**(2): 173–175.

Babu, K.V.S. and Rajan, S. (1996). Floral biology of annual drumstick (*Moringa oleifera Lam*). *Journal of Tropical Agriculture* **34**: 133–135.

Devar, K.V., Reddy Narayana, M.A. and Thimmaraju (1981). Studies on the floral biology of moringa (*Moringa oleifera* Lam). *Mysore Journal of Horticultural Science* **26**(1): 44–53.

Indira, P.V. and Peter, K.V. (1988). *Under-exploited Tropical Vegetables*. Technical Bulletin No. **4**, Drectorate of Extension, Kerala Agricultural University, Thrissur. 68p.

Jyothi, P.V., Atluri, J.B. and Reddy, C.S. (1990). Pollinations ecology of *Moringa oleifera* Lam. *Proceedings Indian Academy of Science (Biological Science)* **100**: 33–42.

Muthuswamy, S. (1954). The culture of drumstick (*Moringa oleifera* Lam) in South India. *South Indian Horticuture* **2**: 18–21.

Pushpaganthan, P., Rajasekaran, S. and Biju, S.D. (1996). *Muringa* (*Moringa oleifera* Lam). Technical Bulletin **10**, Tropical Botanical Garden and Research Institute, Thiruvananthapuram. 107p.

Simmons, J. (1976). In *Cocoa Production: A Hand Book on Cocoa Production, Economic and Botanic Perspective*, pp. 337 - 341. Pager Publishers, New York.

Sindhu, K. Mathew (2002). Studies on floral biology and fruit development in drumstick (*Moringa oleifera* Lam). *M.Sc (Hort.) Thesis*, College of Agriculture, KAU, Vellayani, Thiruvananthapuram.

Subramanian S., Jansirani, P., Veeravagathatham, D. and Thamburaj. S. (1997). In *Botany of Vegetable Crops*, pp.54. K. R. S. Screen Printers, Coimbatore.

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Effect of Chemicals, Varieties and Seasons on Growth, Yield and Quality of Moringa in Coastal Region of Karaikal

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The investigations were carried out to study the influence of seasons, chemicals and varieties on growth, yield and quality in moringa under coastal systems of Karaikal in U.T. of Pondicherry. Various growth regulators and chemicals were sprayed in PKM1 and PKM2 moringa varieties in summer and rainy seasons. Among the chemicals, spray of mepiquat chloride at 50 ppm produced more number of fruits per tree, yield per tree, followed by NAA at 20 ppm. Spray of GA at 20 ppm produced more fruit length. The iron and protein content of the leaves revealed that NAA at 20 ppm produced highest value.

*(**Key words** : Moringa, Fruit yield & quality ,Growth hormones, Chemicals)*

Drumstick or Moringa (*Moringa oleifera* Lam) is one of the important vegetable crops in South India. The leaves, fruits and flowers are used as vegetables being nutritious. For exploitation of this crop for commercialization, growth retardants, regulators and chemicals play a major role especially for improvement of traits on quantitative and quality characters. The hormonal regulation of flowering and fruit set have been successfully established in other vegetable crops, and it paved way for use of chemicals in moringa. The present experiment was undertaken to study the influence of growth hormones and chemicals on growth, yield and quality of moringa fruits and leaves.

MATERIALS AND METHODS

The experiment was conducted from January 2003 to December 2004 in the orchard of Dept. of Horticulture, Pandit Jawaharlal Nehru College of Agriculture & Research Institute, Karaikal using hundred and eight moringa plants in each cultivar, viz. PKM1 and PKM2. Spraying of chemicals was done on whole tree at 90 DAS in the main field, for which 108 moringa trees of uniform vigour were selected and divided into two lots each having 54 trees. The first lot of 54 trees were tagged (27 PKM1 and 27 PKM2) for taking observation on summer seasons (S_1), and the second lot was used for taking observation in rainy season. The experiment was laid out in split-plot design with three replications. The treatment detail as follows.

Main plot – Season (S)

S_1 - Summer season, S_2 – Rainy season

Subplot – Chemicals (C)

C_1 – Control – water spray, C_2 – Cycocel – 250 ppm, C_3 – Ethrel – 250 ppm, C_4 – NAA – 20 ppm, C_5 – GA (20 ppm), C_6 – 2, 4 – D (5 ppm), C_7 – Salicyclic acid (0.5%), C_8 – Mepiquat chloride (50 ppm), C_9 – Urea (1%)

Sub - subplot: Varieties (V)

V1 – PKM 1, V2 – PKM -2

The observations on number of fruits per tree, yield per tree, length of the fruit, fruit flesh content, iron and protein content in leaves were recorded in different treatments with respect to varieties and seasons.

RESULTS AND DISCUSSION

The number of fruits per tree in PKM1 (163.4) and PKM2 (169.8) was more in summer season than in rainy season (Table 1). Among the varieties PKM 2 recorded highest number of fruits per tree than PKM 1 in both the seasons. Among the chemicals, spray of NAA at 20 ppm recorded highest number of fruits per tree in both the season and summer season was found to be better compared to rainy season for harvesting higher number of fruits per tree. During summer season, the trees experienced higher heat units and clear sunshine during their ontogeny while rainy season had experienced cloudy weather and low temp regimes (Kumar, 2001). The increase in number of fruits would possibly be attributed to the higher flower longevity resulting from the inhibition of ethylene biosynthesis by blocking the conversion of 1 amino cyclopropane – 1 carboxylic acid to ethylene. The more number of fruits obtained per

Table 1. *Effect of chemicals and seasons on fruit characters of moringa varieties PKM 1 and PKM 2*

Chemicals	Number of fruits per tree				Yield per tree (kg)				Fruit length (cm)			
	Summer season		Rainy season		Summer season		Rainy season		Summer season		Rainy season	
	PKM 1	PKM 2	PKM 1	PKM 2	PKM 1	PKM 2	PKM 1	PKM 2	PKM 1	PKM 2	PKM 1	PKM 2
C_1 - Control	136.6	142.3	127.0	131.0	23.13	24.0	20.9	23.1	70.2	128.2	62.7	114.9
C_2 – CCC 250 ppm	168.3	170.6	150.6	150.3	27.70	28.7	25.4	26.0	77.0	130.8	72.0	122.2
C_3 – Ethrel 250 ppm	154.0	152.0	132.6	130.6	25.2	24.8	22.1	21.8	78.32	132.0	74.3	124.8
C_4 – NAA20 ppm	219.0	222.6	191.0	193.3	28.4	30.3	26.4	25.4	82.7	136.8	77.8	128.5
C_5 – GA 20 ppm	170.6	171.6	150.3	150.3	28.3	29.4	23.9	24.6	95.7	139.3	90.3	130.3
C_6 – 2,4 – D5 ppm	138.6	141.0	126.6	128.3	22.2	22.5	20.8	21.4	71.1	125.4	65.3	115.7
C_7 – Salicyclicacid 0.5%	164.0	166.6	144.0	144.0	26.8	27.6	23.8	24.7	75.4	128.2	70.7	120.1
C_8 – mepiquatchloride 50 ppm	178.0	181.0	156.3	159.0	32.4	35.1	26.6	28.7	76.9	131.5	71.8	122.9
C_9 – Urea 1%	142.0	180.3	140.3	176.3	23.4	24.4	22.7	23.7	72.4	129.4	67.9	1212.1
Mean	163.4	169.8	146.5	151.4	26.4	27.4	23.4	24.5	77.7	131.28	-	122.3

	Number of fruits per tree SEd±	Number of fruits per tree CD at p=0.05	Yield per tree SEd±	Yield per tree CD at p=0.05	Fruit length SEd±	Fruit length CD at p=0.05
Seasons (S)	1.03	4.45**	0.14	0.63**	0.20	0.87**
Chemicals (C)	1.26	2.57**	0.43	0.88**	0.33	0.69**
Variety (V)	0.52	1.06**	0.13	0.27**	0.15	0.30**
S at C	1.97	5.25*	0.59	0.29**	0.49	1.09**
C at S	1.78	3.63**	0.61	1.24**	0.47	0.97**
S at V	1.16	NS	0.20	NS	0.25	0.88**
V at S	0.74	NS	0.19	NS	0.21	0.43**
C at V	1.68	3.43**	0.52	1.06**	0.46	0.94**
V at C	1.58	3.20**	0.41	0.83**	0.45	0.91**
S at CV	2.31	NS	0.70	NS	0.63	NS
C at SV	2.38	NS	0.73	NS	0.65	NS
V at SC	2.23	NS	0.58	NS	0.64	NS

** = Significant; NS = Non-significant

Table 2. *Effect of chemicals and seasons on quality characters of moringa varieties PKM 1 and PKM 2*

Chemicals	Fruit flesh (g/fruit) content				Leaf iron content (mg/100g)				Leaf protein content (g/100g)			
	Summer season		Rainy season		Summer season		Rainy season		Summer season		Rainy season	
	PKM 1	PKM 2	PKM 1	PKM 2	PKM 1	PKM 2	PKM 1	PKM 2	PKM 1	PKM 2	PKM 1	PKM 2
C_1 - Control	70.5	125.5	67.3	122.5	8.81	8.86	7.46	7.50	6.64	7.01	8.70	10.58
C_2 – CCC 250 ppm	83.7	135.5	77.3	131.4	9.80	9.88	6.91	6.94	7.20	7.61	8.52	11.61
C_3 – Ethrel 250 ppm	75.7	124.5	71.4	120.5	7.35	7.37	8.98	6.75	7.36	7.83	8.62	8.62
C_4 – NAA20 ppm	86.6	139.3	80.6	133.3	9.63	9.67	9.45	9.48	7.44	7.89	8.77	11.67
C_5 – GA 20 ppm	93.8	135.5	88.4	128.5	8.77	8.87	8.24	8.26	7.25	7.69	8.65	11.44
C_6 – 2,4 – D5 ppm	68.7	118.5	16.3	116.7	7.47	7.49	8.73	8.77	7.22	7.65	8.61	8.77
C_7 – Salicyclicacid 0.5%	82.2	134.0	75.2	127.6	6.66	6.69	7.27	6.62	6.82	7.26	8.44	8.25
C_8 – mepiquatchloride 50 ppm	83.6	134.4	76.5	126.6	7.08	7.08	9.16	9.14	6.86	7.04	8.34	8.54
C_9 – Urea 1%	75.5	120.9	69.9	114.5	7.37	7.42	8.47	8.49	6.72	7.13	8.29	9.01
Mean	80.0	129.8	74.4	125.1	8.10	8.14	8.07	7.77	7.06	7.45	8.55	9.84
	SEd±		CD at p=0.05		SEd±		CD at p=0.05		SEd±		CD at p=0.05	
Seasons (S)	0.09		0.42**		0.19		0.83**		0.01		0.02**	
Chemicals (C)	0.11		0.22**		0.88		1.80**		0.02		0.04**	
Variety (V)	0.04		0.09**		0.40		0.83**		0.01		0.02**	
S at C	0.17		0.48**		1.19		2.50 **		0.03		0.06**	
C at S	0.15		0.31**		1.25		2.54**		0.03		0.06**	
S at V	0.10		0.42**		0.45		NS		0.01		0.03**	
V at S	0.06		0.13**		0.57		NS		0.01		0.03**	
C at V	0.14		0.30**		1.24		2.52**		0.03		0.06**	
V at C	0.13		0.28**		1.22		2.49**		0.03		0.06**	
S at CV	0.20		0.41**		1.70		NS		0.04		0.06**	
C at SV	0.20		0.42**		1.75		NS		0.04		0.09**	
V at SC	0.19		0.40**		1.73		NS		0.04		0.09**	

** = Significant; NS = Non-significant

tree by NAA application is in agreement with the findings of Barai and Sarkar (1999) in chillies, EL – Habbasha *et al.* (1999) in tomato and Hussaini and Babu (2004) in *bhendi.*

The spray of mepiquat chloride at 50 ppm was more efficient than others in increasing fruit and yield per tree. Gasti *et al.* (1997) reported that yield increase in potato with mepiquat chloride at 150 ppm spray supported the present findings in moringa. Seasonal studies revealed that summer season was better (32.4 kg and 35.1 kg per tree) than rainy season, and among the varieties PKM 2 (27.4 and 24.5 kg per tree) recorded higher yield in both the seasons. The fruit length was highest in GA at 20 ppm in both the varieties. Among the seasons summer season recorded more length (95.7 and 139.3 cm) of fruits. The IAA oxidase content, which was low in the summer seasons, should have facilitated better auxin level in the system, which in turn, could have improved the fruit length. This is in accordance with the findings of Hussaini and Babu (2004) in *bhendi* with GA treatment for more fruit length. The flesh content was also higher with GA at 20 ppm followed by NAA at 20 ppm (Table 2). This is in line with the findings of Kumar *et al.* (2003). Among the treatments NAA at 20 ppm proved excellent for leaf iron and protein content in both the seasons and PKM 2 recorded the higher value.

REFERENCES

Barai, B.K. and Sankar, K.P. (1999). Effect of growth regulator on the yield improvement in chilli. *Environmental Ecology* **17**(8): 539 - 542.

EL-Habbasha, K.M., Gomaa, H.M.A.M and Mohamed, S.S. (1999). Response of tomato plants to foliar spray with growth regulators under different seasons. *Egyptian Journal of Horticulture* **25**(i): 109.

Hussaini Bala, M.G. and Hari Babu, K. (2004). Effect of plant bioregulators on yield and yield attributes of *bhendi* cv Arka Abhay. *Orissa Journal of Hort.iculture* **32**(1): 108 - 109.

Kumar Vijaya, R.M., Vijayakumar, M., Chezhiyan, N., Bangarusamy and Bala Mohan, T.N. (2003). Studies on the month of souring and growth regulating treatments in annual moringa. *Ph.D. (Hort) Thesis*, Tamilnadu Agricultural University, Coimbatore.

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Leaching Pattern of Common Salt Applied as Partial Substitute for Muriate of Potash in the Red Loam Soils of Kerala

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A glass column experiment was conducted at the College of Agriculture, Vellayani to study the retention and leaching pattern of common salt which may be treated as a partial substitute for muriate of potash in the acid soils of Kerala. Three levels of common salt were surface applied in the columns and leached with 20 ml fractions of sodium free distilled water. The leachates were analysed for the Na content. In the study with 66 mg salt and 10 cm soil column, 87% of the added salt was recovered in the first two lots (40 ml) of leaching water. In 20 cm soil column, 77.6% salt was recovered in 100 ml water and with 40 cm soil column, 75% of salt was removed down to 40 cm depth with 200 ml water. A similar trend was noticed when the experiment was repeated with 100 mg salt. The results show that retention of Na in this soil is negligible and hence partial substitution of K by Na will not pose any threat to the soil physical properties.

*(**Key words:** Leaching pattern, Common salt, Partial substitution of muriate of potash, Red loam soils)*

The importance of K in plant growth has been widely recognised. Although Na is not considered essential, it has been reported that Na can replace K in some of the functions in certain plants. Studies conducted in the College of Agriculture, Vellayani with several crops proved that common salt can be used as a partial substitute for the costly muriate of potash in the plants tested. In many experiments, it was shown that by substituting half the requirement of K by Na of common salt the yield can be increased without affecting the quality of the yield. But since Na^+ is known for contributing to salinity, continous and long term use of common salt as a partial substitute for muriate of potash may lead to salinisation of soil if it gets adsorbed and thereby accumulated in the soil. Therefore, large scale use of common salt as a partial substitute for muriate of potash may be recommended only after careful study about its retention and leaching pattern through the profile. The results of such a scientific study are presented in this paper.

MATERIALS AND METHODS

Soil sample for the leaching experiment was collected from the Instructional Farm, College of Agriculture, Vellayani. The soil belonged to the family of Loamy skeletal, Kaolinitic, Isohyperthermic Rhodic Haplustult with an acidic reaction and low status of K. Glass columns of 50 cm length and 3 cm internal diameter were used for the study. Air-dried, sieved sample of less than 2 mm size was packed in these columns at different depths, viz. 10, 20 and 40 cm with 3 replications each. Soil was weighed and packed uniformly by gentle tapping in these columns so as to achieve the desired field bulk desity. Soil moisture was maintained at field capacity. Three levels of common salt, i.e. 0, 66 and 100 mg were taken for the study. The levels were arrived at taking into consideration the highest rate of potash fertilizer recommended as per the package of practices of Kerala Agricultural University. The highest recommended dose of K is 750 kg ha^{-1} equivalent to 1245 kg MOP ha^{-1} for banana. When fifty percent of this is substituted with common salt it would come to around 66 mg per column surface area. A higher rate of 100 mg salt was included for the study. The columns were fixed vertically on wooden stands using clamps. Salt @ 0, 66 and 100 mg was surface applied. Then the columns were leached with sodium free distilled water. The leachates were collected in separate beakers and analysed for the Na content directly using a Flame Photometer as described by Jackson (1973). From this the quantity of commn salt that is leached off in each 20 ml fraction was worked out. Quantity of salt obtained from the no-salt treated column was subtracted from the others.

RESULTS AND DISCUSSION

The percentage salt recovery with addition of leaching water is presented in Table 1.

In the 10 cm soil column under 66 mg salt treatment, 52 % of the added salt, i.e. 34.32 mg was recovered with the first lot of (20 ml) leaching water. With further addition of 20 ml, almost 87 %

***Table 1.** Salt recovery from 66 and 100 mg added salt with each 20 ml fraction of leaching water*

Qty of water	10 cm column (a)	10 cm column (b)	20 cm column (a)	20 cm column (b)	40 cm column (a)	40 cm column (b)
20 ml	34.32	54	—	—	—	—
20 ml	23.1	37.75	0.42	0.55	—	—
20 ml	1.98	3.0	19.8	28.0	—	—
20 ml	1.02	0.89	22.4	32.5	0.98	3.5
20 ml	0.97 (93%)	0.81.(96.45 %)	8.6	7.5	22.2	32.1
20 ml			0.8	1.6 (70.15%)	15.8	25.5
20 ml			0.75 (80%)	0.8	7.5	7.5
20 ml				0.5	2.3	3.75
20 ml					1.4	1.5
20 ml					1	1.18 (75.03 %)
20 ml					0.95	0.98
20 ml					0.90 (80.3%)	0.90

(a) 66 mg salt addition, (b) 100 mg salt addition

of salt was leached down below 10 cm depth. Thereafter with each 20 ml lot of water added, only small quantity of salt was recovered. In the 20 cm soil column, addition of first lot of water could not leach down the salt beyond 20 cm depth. It needed 100 ml water (equivalent to 14 cm rainfall) to recover 77.6% of added salt. In the 40 cm column, 140 ml water was required to leach down 70% of salt added.

From this it is clear that a total of 140 ml water was only required to leach down the added salt below 40 cm level. This was equivalent to 20 cm of rainfall. Kerala receives about 3000 mm rainfall annually. The predominant clay mineral in Kerala is kaolinite, which is having a low CEC. Moreover, Na^+ and Cl^- are two ions that are having a very high mobility. The high rainfall and rolling topography together with proximity to the sea and low CEC of soils favour easy removal of any salt left in the soil after crop removal. The two main seasons of cultivation in Kerala coincide with the south-west and north-east monsoons. By the time the monsoon is in full swing, fertilizer application for the crops will be over. Hence, there will be ample rain to leach off any salt that is left in the soil without absorption by the plants.

A similar trend was obtained when 100 mg salt was leached with 20 ml lots of water. In the 10 cm column 54% of the added salt was leached off in the first 20 ml lot itself. By leaching with 40 ml water, 91.75% of the salt added was washed off below 10 cm depth. In the 20 cm soil column, 68% of the salt was recovered by leaching with 100 ml of water. In the 40 cm soil column, with 120 ml distilled water about 60% of the salt was removed from 40 cm depth.

Hence, from this study it became clear that any portion of added salt, left after crop removal could be leached off from the root zone by the time first few showers were received during the initial months of the rainy season. This study also showed that fifty percent substitution of K by Na of common salt will not pose any threat to the soil physical properties since the Na ions are not adsorbed by the soil colloids.

REFERENCES

Jackson, M.L. (1973). *Soil Chemical Analysis.* Prentice Hall of India Pvt. Ltd, New Delhi, India.

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A Rice CSRC(S) 21-2-5-B-1-1 (IET 17343) Bears Promise for the Coastal Shallow Water Condition

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A vast area of lands measuring over 7.0 m ha^{-1} all around the coastline is presently less productive due to salinity and waterlogging, etc. during the main season. Varieties generated through incorporation of adaptability trait of the traditional varieties with the high yield potential of the improved ones may be grown in such areas. One such genotype, CSRC(S) 21-2-5-B-1-1 (IET 17343) has been reported which is not only tolerant to coastal saline soils in *kharif* but yields over 4.0 tonnes of grains per hectare also.

(***Key words:*** *Rice yield, Salinity tolerance, Shallow water depth)*

A vast area of land measuring over 7 million ha all around the coastline is presently less productive due to salinity and waterlogging, etc. Varieties generated through incorporation of adaptability trait of the traditional varieties with the high yield potential of the improved ones may be grown in such areas.

Rice forms the staple food for the majority of the people in India and it provides their income, employment and subsistence. In the vast coastal saline soils, measuring over 7.0 mha mostly the traditional varieties of rice are adapted in the main season of *kharif*. Obviously, the productivity level is quite low (1.5-2.0 t ha^{-1}) due to multiple stresses of waterlogging, soil salinity and other associated hazards. The ecology being harsh, the utilization of the areas for enhancing production and productivity of rice is emphasized through the creation of better varieties by incorporation of adaptability trait of the indigenous varieties with the high yield potential of the improved ones (Siddiq, 1994) and screen out the cultivars on the spots of stresses. Here in the paper one such attempt has been reported for its performance in the coastal shallow water (15-30 cm) condition in *kharif*.

MATERIALS AND METHODS

CSR6 is a photoperiod sensitive adapted variety suited to the coastal areas with shallow to semi-deep water (15-45 cm) in *kharif* season and was purified from the local variety Nonasail. On the other hand, Pankaj is a photoperiod sensitive high yielding variety suiting to the normal soils with shallow water (around 20 cm) in *kharif*. In an attempt to incorporate the adaptability trait of CSR6 with the high yielding potential of Pankaj, a recombinant breeding programme was under taken in 1989 with CSR6 as the pollen parent and Pankaj as the ovule parent.

The progenies were grown in the field and the F_3 generation was exposed to moderately high soil salinity (6.0 -8.0 dSm^{-1}) and intermediate (Shallow: 15-30 cm) waterlogging, and plant-to-row progeny method was followed in the subsequent generations till the stable population was obtained. A stable culture designated as CSRC(S) 21-2-5-B-1-1 was nominated to the Screening trial (NSASN) of the AICRIP. It was promoted to the Co-ordinated trial SATVT and evaluated in the multi-location coastal saline sites during *kharif* 2002 to 2004. The culture (IET 17343), due to its consistent better performances in the coastal areas, was recommended by the AICRIP for submission to the Variety Identification Committee (VIC) in 2005.

RESULTS AND DISCUSSION

The mean grain yield performance (t ha^{-1}) of CSRC(S) 21-2-5-B-1-1 (IET 17343) at Canning over the years (*kharif* 2002 to 2004) was 4.33 t ha^{-1} with a heading duration of 121 days, followed by the qualifying culture 91-H2-6-B-2 (IET 17340) having yield level of 3.73 t ha^{-1}, whereas the national check for coastal salinity CST 7-1 and the local check SR26B had yielded 3.76 and 4.10 t ha^{-1}, respectively under a soil salinity range of 6.0 to 8.0 dSm^{-1} (Table 1). The seed-to-seed duration of IET 17343 was 140-145 days, same as that of the local check SR26B.

The plant height of the culture was 97 cm suiting well to coastal shallow water (15-30 cm). Mandal and Sen (2001) had reported a culture CSRC(S) 2-1-7 (SUMATI) showing similar plant height and good yield (4.0 t ha^{-1}) under release by the Central Variety Release Committee (CVRC).

Table 1. *Summary of grain yield (t/ha) performances of the salt tolerant rice varieties/ cultures in the Co-ordinated (SATVT) Trials at Canning (kharif 2002-2004)*

	IET No.	Grain yield				Plant ht (cm) Mean	Heading (d)
		2002	2003	2004	Average		
CSRC(S)21-2-5-B-1-1	17343	4.34	4.50	4.15	4.33	97	121
91-H2-6-B-2	17340	3.47	3.50	4.22	3.73	96	104
NDRK 5072	17336	3.40	3.26	-	3.33	82	104
CST 7-1	Check	3.67	4.17	3.43	3.76	84	110
Jaya	Check	2.18	3.86	2.43	2.82	83	98
Local (SR 26B)	Check	3.82	4.11	4.38	4.10	142	121

Table 2. *Summary of grain yield (t/ha) performances of the rice varieties/cultures in Co-ordinated (SATVT) Trials in coastal saline soils (kharif 2002-2004)*

Year	No. of Trials	CSRC(S) 21-2-5-B-1-1	Check variety			Qualifying culture	
1st year 2002	7	3.60	3.11	2.54	3.65	2.91	2.99
2nd year 2003	3	4.38	3.43	2.89	3.48	3.06	2.85
3rd year 2004	5	3.92	4.08	2.97	3.86	3.71	-
Mean over years		3.97	3.54	2.80	3.66	3.23	2.92
% Increase/Decrease			+12.15	+41.79	+8.47	+22.90	+35.96

Table 3. *Grain yield (t/ha) (performances of the elite salt tolerant rice varieties/cultures in the Co-ordinated (SATVT) Trials under the coastal states (Kharif 2002-2004)*

State	Location	Year	CSRC(S) 21-2-5-B-1-1 (IET 17343)	Check Varieties			Qualifying Varieties	
				CST 7-1	Jaya	Local	*IET 17340	*IET17336
West Bengal		2002	4.34	3.67	2.18	3.82	3.47	3.40
	Canning	2003	4.50	4.17	3.86	4.11	3.50	3.26
		2004	4.15	3.43	2.43	4.38	4.22	-
	Mean		4.33	3.76	2.82	4.10	3.73	3.33
	Gosaba	2003	3.30	2.80	0.85	2.49	2.17	1.61
		2004	3.25	4.67	1.58	3.33	2.22	-
	Mean		3.28	3,48	1.22	2.91	2.20	1.61
State (W.B)	Mean		3.80	3.62	2.02	3.50	2.96	2.47
		2002	3.75	3.06	1.68	3.99	3.12	2.54
Orissa	CRRI	2003	5.33	3.82	3.95	3.84	3.51	3.67
		2004	3.81	3.63	2.99	3.13	3.21	-
State (Orissa)	Mean		4.30	3.50	2.87	3.65	3.28	3.10
A.P.	Machli-	2002	4.15	2.39	2.29	3.22	2.18	3.42
	Patnam	2004	4.49	3.33	3.41	3.96	-	-
State(AP)	Mean		4.32	2.86	2.85	3.59	2.18	3.42
M.S.	Panvel	2002	3.38	2.66	2.45	3.09	1.61	2.53

*IET 17340 : 91-H_2-6-B-2

*IET 17336: NDRK 5072

The Co-ordinated trials (SATVT) under the AICRIP conducted at the coastal saline sites over the years (*kharif* 2002-2004) showed the culture producing a mean grain yield of 3.97 t ha^{-1}, followed by the qualifying culture 91-H2-6-B-2-IET 17340) (3.23), whereas the national check variety CST 7-1 yielded 3.54 t ha^{-1} (Table 2). The culture had produced highest mean grain yield in West Bengal (3.80), Orissa (4.30), A.P. (4.32) in the Co-ordinated trials over the years (Table 3).

Mandal (2004) had reported a culture CSRC(S) 5-2-2-5 (IET 12855) producing a mean grain yield of 4.24 t ha^{-1} over years at Canning. The grain type of the culture (IET 17343) was short bold.

Mandal (1966) had reported a culture CSRC(S) 11-5-0-2 (IET 13428) with medium fine grain having an yield potential of over 4.0 tha^{-1} and suiting to the coastal shallow to semideep water (20-40 cm). The culture may be of use in the coastal shallow water (15-30 cm) situation where suitable high yielding varieties are very few. It is also moderately tolerant to major pests and diseases of rice.

REFERENCES

Mandal, A.B. (1996). CSRC(S)11-5-0-2, a promising rice for coastal intermediate lands of West Bengal. *Journal of Indian Society of Coastal Agricultural Research* **14**(1&2): 181-184.

Mandal, A.B. and Sen, H.S. (2001). CSRC(S) 2-1-7, a rice variety for the coastal saline soils of India. *Journal of Indian Society of Coastal Agricultural Research* **19**(1&2): 173-178.

Mandal, A.B. (2004). CSRC(S) 5-2-2-5, a promising rice variety for the coastal shallow water. *Journal of Indian Society of Coastal Agricultural Research* **22**(1&2): 199-204.

Siddiq, E.A. (1994). Genetic resources and breeding strategies for improvement of rice in coastal India. *Journal of Indian Society of Coastal Agricultural Research* **12**(1&2): 47-57.

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Evaluation of Tomato (*Lycopersicon esculentum* Mill.) Varieties under Coastal Saline Soils of Sundarbans

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Performance of tomato varieties under heavy textured coastal saline soils of Sundarbans was studied. Experiment was carried out under varying levels of soil salinity to find out the suitable tomato varieties and to know their physiological behaviour. Eight varieties of tomato were collected from IARI, Pusa, New Delhi. Growth data revealed that plant height, total branch number, spreading branch length and root volume reduced with the increase in soil salinity, flowering was also delayed by about 10-12 days due to salt stress. Leaf water potential of different varieties increased with the increase in soil salinity but in case of Pusa Early Dwarf, Pusa Rohini and Pusa Sheetal the increment due to salinity was less than in other varieties. Sodium and potassium accumulation in tissue revealed that with the increase in salinity Na accumulation increased but the reverse trend was found in case of K accumulation. Yield data revealed that among the eight varieties Pusa Rohini, Pusa 120, Pusa Early Dwarf, Pusa Gourav and Pusa Uphar produced significantly higher yield than Pusa Sadabahar, Pusa Ruby, Pusa Sheetal under varying levels of soil salinity.

*(**Key words** : Tomato, Physiological characters, Sodium & Potassium absorption, Saline soil)*

India has a total of 8.0 million hectares of salt affected soils (Yadav *et al.*, 1983) and out of this 3.1 million hectares lie all along the coastline of the country. This coastal saline tract is the most unproductive and agriculturally backward area of the country. The lower productivity of crops is due to high salt accumulation in the soil and poor quality of water for irrigation.

Considerable effort has been made to increase production of cereal crops, fibre crops, oilseeds, etc. in this belt but not much work has been initiated to identify/evaluate cultivars of vegetable crops. Since tomato is grown in various types of soils from sand to heavy clay it has been chosen for the heavy textured saline soils of this region. Therefore, an experiment was conducted at CSSRI, RRS Canning Town, West Bengal in microplots to evaluate tomato varieties which is commercially viable and have good market value being one of the most popular and widely cultivated vegetables in the world ranking second in importance to potato in many countries (Bose *et al.*, 1993).

MATERIALS AND METHODS

The experiment was carried out at Central Soil Salinity Research Institute, RRS Canning Town, West Bengal in microplots (2 m X 2 m size) with varying levels of soil salinity. The salinity levels (i.e. ECe 2.30, 5.61 and 8.20 dSm^{-1}) were created artificially by adding of saline river water diluted in different proportions. The average composition of river water at salinity level of EC 35 dSm^{-1} at 25°C was Na = 7571.3, K = 269.2, Ca = 403.8, Mg = 778.0, Cl = 314.3, SO_4 = 969.1 ppm and pH = 7.8.

Seeds of eight varieties of tomato, viz. Pusa Sadabahar, Pusa Rohini, Pusa Ruby, Pusa 120, Pusa Early dwarf, Pusa Gourav, Pusa Sheetal, Pusa Uphar were collected from Vegetable Division, IARI, Pusa, New Delhi. One-month old tomato seedlings were planted at different salinity levels. Three replications were followed in each treatment. Normal management practices were followed, fertilizers were applied at the rate of 100:60:60 kg of N:P:K ha^{-1}. Irrigation was given from deep tubewell (EC_{iw} 1.30-1.67 dSm^{-1}) as and when required.

The observations were taken on plant height, total number of branches, spreading length, root volume, 50% flowering date, leaf water potential, sodium and potassium accumulation of plant tissues. The fruit yield was recorded and their characteristics were also noted. Sodium and potassium in plant tissues were analysed by flame photometer as described by Jackson (1967). Leaf water potential was estimated by pressure bomb.

RESULTS AND DICUSSION

Data (Table 1) revealed that height, spreading branch length and total branch number were very

Table 1. *Effect of salinity on some phenotypic characteristics of tomato varieties*

Vars.	Ht. of plant (cm) Salinity levels (ECe dSm^{-1})			Total branch No Salinity levels (ECe dSm^{-1})			Spread branch (cm) Salinity levels (ECe dSm^{-1})		
	2.30	5.61	8.20	2.30	5.61	8.20	2.30	5.61	8.20
P.Sadabahar	43.4	35.5	32.6	19	18	10	49.5	40.1	38.5
P.Rohi.	68.8	58.0	53.0	20	17	17	80.5	69.0	52.0
P.Ruby	56.3	52.0	52.0	22	17	17	105.3	100.8	65.8
P.120	68.0	68.7	60.0	24	23	18	101.1	72.3	69.0
P.Ear.dw	72.1	60.8	47.6	18	18	17	75.1	68.0	46.8
P.Gourav	78.0	65.0	48.0	22	15	15	79.3	69.7	87.8
P.sheetal	81.0	67.0	51.0	18	19	17	76.1	75.1	67.0
Uphar	80.0	71.3	57.0	19	18	15	111.3	88.0	75.1

Table 2. *Effect of salinity on sodium and potassium accumulation and leaf water potential in different varieties of tomato*

Varieties	Leaf water potential (MPa) Salinity levels (ECe dSm^{-1})			Sodium content (% D.M) Salinity levels (ECe dSm^{-1})			Potassium content (% D.M) Salinity levels (ECe dSm^{-1})		
	2.30	5.61	8.20	2.30	5.61	8.20	2.30	5.61	8.20
P.Sadabahr	-1.5	-2.0	-2.5	1.7	2.7	3.5	2.4	2.1	1.5
P.Rohini	-2.0	-2.0	-2.3	1.2	2.4	3.1	2.5	2.3	1.3
P.Ruby	-1.5	-2.4	-2.8	1.5	2.3	3.0	1.9	2.4	1.7
P.120	-1.9	-2.3	-2.9	1.8	2.0	2.8	2.4	2.3	2.2
P.Ear.dw	-2.0	-2.0	-2.3	1.3	2.0	2.6	2.3	2.2	2.0
P.Gourav	-1.8	-2.2	-2.7	1.5	2.4	3.3	2.5	2.0	1.8
P.sheetal	-1.1	-1.8	-2.0	1.2	2.9	3.0	2.7	1.9	2.0
P.uphar	-2.1	-2.6	-3.0	1.6	2.2	3.2	2.6	2.3	1.0

much reduced with the increase in salinity in all the varieties. Spreading branch length was more than height of the plant and it gradually decreased with the increase in salinity. Among the different varieties maximum height was noticed in Pusa Sheetal, Pusa Uphar and Pusa Gourav but in case of spreading branch Pusa Uphar, Pusa 120 and Pusa Ruby had the maximum length of branch. Root volume also gradually decreased with the increase in salinity. It was observed that under control Pusa Early dwarf (17.5ml) and Pusa Uphar (18.0 ml) had maximum root volume, and also under highest salinity stress they produced maximum root volume (11.0 ml and 12.0 ml, respectively).

Leaf water potential data (Table 2) revealed that it decreased with the increase in soil salinity which means that the plant was suffering from water stress. Tomar and Ghildayal (1973) and Dutt (1976) observed similar results in case of rice, wheat and barley crops. It was very interesting to observe that among the eight varieties Pusa Rohini, Pusa Early dwarf and Pusa Sheetal were having higher leaf water potential than other varieties and it was noticed that these varieties also performed well under salt stress and gave better yields.

Sodium and potassium accumulation data in Table 2 showed that with the increase in soil salinity sodium accumulation increased irrespective of the varieties but reverse was true in case of potassium accumulation, but interestingly it was also noticed that under higher salinity stress Pusa Sheetal, Pusa Early dwarf and Pusa 120 accumulated more amount of potassium than the other five varieties. From other observations also it was noticed that these three varieties were superior. This may be due to high potassium ion specificity in plant tissues. These varieties could survive well and produced more yield. Since we know potassium is an essential element for many biochemical pathways, decline of potassium in the tissues always produce disorders in growth. Earlier Bal *et al.* (1984, 1986) had also found that tolerant variety/species accumulated more amount of potassium.

Table 3. *Effect of salinity on fruit characteristics of different varieties of tomato*

Varieties	ECe 2.30 dSm^{-1}				ECe 5.61 dSm^{-1}				ECe 8.20 dSm^{-1}			
	Girth (cm)	Length (cm)	Fruit wt. (g)	Vol. of Fruit (g)	Girth (cm)	Length (cm)	Fruit wt. (g)	Vol. of Fruit (g)	Girth (cm)	Length (cm)	Fruit wt. (g)	Vol. of Fruit (g)
P.Sadabahar	11.9	4.2	38.6	45.1	10.1	4.3	24.4	36.2	9.8	4.0	23.1	33.5
P.Rohini	14.2	3.9	51.6	51.1	13.5	3.7	38.1	45.0	13.5	3.3	37.9	36.3
P.Ruby	16.1	3.7	63.0	70.0	15.5	3.4	44.1	54.0	13.0	3.0	27.7	30.5
P.120	16.9	3.6	55.0	60.0	16.0	3.5	46.5	51.3	15.7	3.1	44.0	51.0
P.Ear.dw	17.4	5.0	83.4	88.7	15.2	4.9	60.5	63.5	12.0	4.3	34.0	47.2
P.Gourav	12.8	4.7	32.8	88.1	108	3.4	20.7	35.5	10.3	3.2	18.1	25.0
P.sheetal	13.6	3.3	33.0	43.1	11.6	2.9	30.0	38.6	11.3	2.8	21.0	28.0
P.uphar	16.1	4.5	45.6	50.3	15.7	3.8	37.0	46.3	13.1	3.6	35.7	39.0

Table 4. *Effect of salinity on yield of tomato and their reduction percentage over control (ECe 2.3 dSm^{-1}) (data expressed in g per plant)*

Varieties	Salinity levels (ECe dSm^{-1})			Reduction % of yield	
	2.30	5.61	8.20	5.61	8.20
P.Sadabahar	360.9	217.2	184.2	39.8	49.0
P.Rohini	649.7	431.5	321.5	34.0	50.0
P.Ruby	594.1	406.1	360.6	31.3	39.0
P.120	596.7	437.3	412.1	26.7	31.0
P.EarlyDwarf	551.1	527.7	420.6	4.2	23.7
P.Gourav	826.0	469.5	198.2	43.2	76.0
P.Sheetal	417.3	307.7	246.6	26.3	41.0
P.Uphar	687.7	512.2	342.2	25.5	50.2

(CD at p= 0.05= 141.07)

Fruit characteristics data were collected and it was found that girth, length, single fruit wt. and volume of fruit were reduced with the increase in salinity (Table 3). But under highest salinity (ECe 8.20 dSm^{-1}) level, fruit characteristics of vars. Pusa Rohini, Pusa 120, Pusa Early dwarf and Pusa Uphar were superior to other tested varieties. The yield data (Table 4) revealed that between control and salinity there were significant differences of yield but between the salinity levels it was not significant. Among the eight varieties Pusa Rohini, Pusa 120, Pusa Early dwarf, Pusa Gourav and Pusa Uphar produced significantly higher yield than Pusa Sadabahar, Pusa Ruby and Pusa Uphar under different salinity levels. Under control Pusa Gourav had produced maximum fruit yield than other seven varieties, and Pusa Sadabahar produced minimum yield.

REFERENCES

Bal, A. R. and Dutt, S. K. (1984). Effect of soil salinity on growth of *Coix-lachryma jobi* L. *Indian Journal of Plant Physiology* **XXVII** (6): 398-400.

Bal, A. R., Joshi, Y. C. and Ali Qadar (1986). Differences between salt tolerant and sensitive rice genotypes in relation to sodium and potassium accumulation at three growth stages. *Current Agriculture* **10**: 65-69.

Bose, T. K., Som, M. G. and Kaleir, J. (1993). *Vegetable Crops*. Naya Udyog, 224-280.

Dutt, S.K.(1976). The leaf water potential of wheat and barley and its relation to soil salinity and alkalinity. *Biologia Plantarum* (PRAHA) **18**(4): 299-300.

Jackson,M.L. (1967). *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.

Tomar, V.S. and Ghildyal, B.P. (1973). Determination of water status of the rice plants. *Indian Journal of Agricultural Science* **43**: 754-759.

Yadav, J.S.P., Bandopadhyaya, A. K. and Bandopadhyaya, B. K. (1983). Extent of coastal saline soils of India. *Journal of Indian Society of Coastal Agricultural Research* **1**(1): 7-12.

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Evaluation of Released Varieties of Groundnut for Salt Tolerance

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Study was conducted in 2005 at NRCG, Junagadh to screen 72 released cultivars of groundnut (Spanish: 36 and Virginia: 36) in the saline environment for further use in the advanced field research with the objective to enhance the tolerance to salinity and increase crop production. The experiment was done under controlled laboratory condition at constant salinity levels (EC 0.5, 4, 8 and 12 dS m^{-1}) of irrigation water. It was found that saline water of EC 4 dS m^{-1} can safely be used for irrigation in majority of the varieties of groundnut without any significant adverse effect. The reduction in the dry matter yield at 8 and 12 dS m^{-1} salinity was significant but the percent reduction due to increasing salinity was greater in Spanish group than in the Virginia group. Threshold salinity of different varieties in both Spanish and Virginia group varied depending upon the relative tolerance. Varieties under Virginia group showed more tolerance than the Spanish. Based on the data from this study all the 72 tested varieties were classified under sensitive, moderately sensitive and moderately tolerant varieties under both Spanish and Virginia group on the basis of threshold salinity values. Relative salinity tolerance for different varieties was also worked out at 90 %, 75 % and 50 % relative yield in relation to control.

(***Key words:*** *Groundnut, Water salinity, Relative tolerance, Growth Characteristics*)

Salinity limits water uptake by plants by reducing the osmotic potential and thus total potential of soil water. In order to utilize the saline soils and use of saline water for irrigation it is very important to evaluate the different crops and their varieties for tolerance to salinity under varying soil types and agro-climate conditions.

Information on tolerance of majority of the crops to salinity is available but the research information regarding the salt tolerance of different released varieties of groundnut is lacking. Groundnut is an important oilseed crop in India and accounts for 45% of the area and 55 % of the production of total oilseeds in the country. About 88% of the area under groundnut cultivation in India is rainfed and is confined to varying types of soils affected by salinity problems associated with saline ground water. Therefore, a study was conducted to screen the released cultivars of groundnut (Spanish and Virginia group) in the saline environment for further use in the advanced field research with the objective to enhance the tolerance to salinity and increased productivity in this environment.

MATERIALS AND METHODS

An experiment was conducted in *kharif* 2005 to evaluate the tolerance of 72 released cultivars of groundnut under constant irrigation water salinity levels (EC 0.5, 4, 8 and 12 dS m^{-1}) at NRCG, Junagadh. Out of 72 released cultivars 36 belong to Spanish group, 19 and 17 belong to Virginia bunch and Virginia runner group, respectively.

Observation on germination, plant height, dry matter yield and root length were recorded at the early stage of crop growth for the purpose of this screening study in the saline environment. These varieties under study were released from different states of the country. There were 288 treatments (72 varieties x 4 salinity of irrigation water) in three replications. Four kilogram of sand was filled in each pot (total 864 pots) and these pots were provided with holes at the bottom in order to provide free drainage. Five seeds were sown in each pot. Irrigation with different saline water in order to meet the evapotranspiration need was given during the period of experiment. Crop was harvested after 20 days of sowing.

RESULTS AND DISCUSSION

Laboratory experiment was conducted to evaluate 72 released cultivars under varying saline environment. It was found that the final germination at 12 days after sowing of majority of released cultivars was not affected at 4 dS m^{-1} salinity of irrigation water whereas the germination at 8 to 12 dS m^{-1} salinity was significantly lower over the control (0.5 dS m^{-1}). At high salinity level, the germination in all the released cultivars under

Spanish group (SB) was significantly lower than in Virginia group (V). The difference in germination between Virginia runner (VR) and Virginia bunch (VB) was non-significant (Table 1). Data on periodic germination under varying salinity showed that high salinity (8 to 12 dS m^{-1}) delayed the germination by about 5-6 days (Table 2), which further affected the plant growth and dry matter yield. Decrease in germination, plant height, dry matter yield and root length of different released cultivars under both Spanish and Virginia group at 4 dS m^{-1} salinity over control varied between 1 to 15 percent (Table 2) and these differences are non-significant at 4 dS m^{-1} salinity. The relative decrease in yield at 8 dS m^{-1} over control varied between 10 to 45 percent. The decrease in yield at high salinity levels (at 8 and 12 dS m^{-1}) was greater in Spanish than in Virginia group. Data presented in Table 2 further indicated that in case of cultivars under Virginia runner and Virginia bunch, the reduction in yield at 8 dS m^{-1} was less than 25 % (varied between 10 to 24 %). Hence at this reduction level, water of 8 dS m^{-1} salinity could also be used in some of the varieties under Virginia group. Aljibury and Telabany (1982) reported decrease in seed production with increasing salinity from 2 to 11.3 dS m^{-1}, and Lauter and Meiri (1989) found that higher levels of NaCl (70 and 105 m M concentration) caused seed damage prior to pod maturity and much lower yield. The threshold salinity* of 72 released cultivars under Spanish and Virginia group were estimated based on these tolerance limits, and the cultivars are grouped into sensitive, moderately sensitive and moderately tolerant to salinity (Table 3). Greater the value of the threshold salinity for a given cultivar more will be its tolerance. K 134, GG 2, GG 6, ICGS 44, TG26, Kadiri 4 and Girnar were some of the promising varieties of groundnut under Spanish bunch, which were moderately tolerant (threshold salinity ranging from 2 to 4 dS m^{-1}) to salinity. DRG 17, TMV 10, ICGV 86325, GG 20, ICGS 76 under Virginia bunch and GAUG 10, Somnath, TMV 4, Chandra, ALR 3 under Virginia runner were also the moderately salt tolerant varieties.

Data on dry matter yield of 72 released varieties of groundnut at different increasing salinity from 0.5 to 12 dS m^{-1} were used for regression analysis and majority of the tested varieties showed the linear

Table 1. *Effect of saline water irrigation on periodic germination (%) of groundnut*

ECiw (dS/m)	Days after sowing (DAS)					
	5	6	8	9	10	12
	Spanish Group					
0.5	46	70	77	78	79	79
4	0	37	73	75	76	77
8	0	0	39	54	59	61
12	0	0	2	5	7	10
CD at p=0.05	10	17	14	13	12	12
	Virginia Bunch					
05	49	74	77	79	80	80
4	8	41	60	78	79	79
8	0	5	16	67	71	72
12	0	0	0	33	47	58
CD at p=0.05	7	8	9	6	8	9
	Virginia Runner					
0.5	68	82	83	84	85	85
4	14	53	68	77	78	78
8	0	11	26	72	73	74
12	0	0	0	44	58	68
CD at p=0.05	4	7	7	8	8	8

* Threshold salinity for each crop or variety is the level of salinity beyond which the crop yields decrease at a rate which is uneconomic in production.

***Table 2.** Performance of groundnut to saline water irrigation*

ECiw dS/m	Germination (%)			Plant height (cm)			Root length (cm)			Dry matter yield/pot (g)		
	SB	VR	VB	SB	VR	VB	SB	VR	VB	SB	VR	VB
0.5	79	84	80	28.1	29.5	29.4	6.75	9.78	9.05	0.69	0.87	0.82
4	77	78	79	23.6	27.9	28.8	5.99	9.67	8.53	0.60	0.73	0.79
8	61	74	72	17.2	26.5	25.7	4.07	8.24	7.42	0.38	0.66	0.70
12	10	68	58	3.2	21.4	20.5	1.20	7.35	6.33	0.04	0.55	0.48
CD at p=0.05	12	8	8.7	1.3	1.7	2.8	0.9	1.6	1.2	0.09	0.22	0.14

ECiw dS/m	Percent decrease over control											
	Germination (%)			Plant height (cm)			Root length (cm)			Dry matter yield/pot (g)		
	SB	VR	VB	SB	VR	VB	SB	VR	VB	SB	VR	VB
0.5	0	0	0	0	0	0	0	0	0	0	0	0
4	3	8	13	16	6	2	11	1	6	13	16	4
8	23	13	10	39	10	13	40	16	18	45	24	15
12	87	20	28	89	28	30	82	23	30	94	37	42

SB=Spanish Bunch, VR=Virginia Runner, VB=Virginia Bunch

***Table 3.** Threshold salinity of irrigation water for different cultivars of groundnut at germination*

Salinity tolerance rating		
Sensitive	Moderately sensitive	Moderately tolerant
Threshold salinity of water (dS/m)		
< 0.87	0.87 - 2.0	2.0 - 4.0
Spanish Bunch		
ICGS 37, SB XI, JL 220, VRI 4, ICG(FDRS) 10	VRI 3, ICGV 86590, JL 286, Tirupati 2, Girnar 1, DRG 12, CO 3, GG 7, RG 141, Tirupati 4, Dh 3-30, ICG(FDRS) 4	K 134, GG 2, GG 6, ICGS 11, GG 5, VG 9521, TMV 2, JL 24, TG 17, VRI 2, TG 26, GG 4, AK 12-24, Kadiri 4, CO 2, TAG 24, ALR 2, ICGS 44, GG 3
Virginia Bunch		
CSMG 884, LGN 2, BG 3, BG 2, B 95	T 64, BG 1, BAU 19, HNG 10, ICGS 5, M 522, GG 20, ICGS 76	DRG 17, MA 16, TMV 10, BAU 13, ICGV 86325
Virginia Runner		
S 230, Karad 4-11, M 335, Tirupati 3, Kaushal	Chandra, TMV 4, Punjab 1, ALR 3	M 13, RS 1, M 197, GAUG 10, Somnath

straight line relationship. R^2 value was quite high in majority of the cases. From these 72 nos. of regression equations, the relative yield at different salinity water of irrigation water in relation to control was estimated for all the 72 released varieties and data on relative salinity tolerance for some of promising cultivars under Spanish and Virginia group in groundnut are listed in Table 4. These data served only as guide to the relative salinity tolerance among different varieties of groundnut. Listed varieties under Spanish group (Table 4) showed 10 % reduction in dry matter yield (90 % relative yield over control) at salinity between 3 to 4 dS m^{-1}, whereas similar reduction in yield was observed at 4.5 to 7 dS m^{-1} salinity in case of Virginia group which indicated that salt tolerance of cultivars under Virginia group were greater than the Spanish group. Earlier Girdhar (1999, 2004 and 2005) reported the tolerance of different crops to soil and water salinity in the following decreasing order : Sugarcane > Sunflower > Mustard > Wheat > Pearl millet > Dhaincha > Rice > Guar > Sorghum > Groundnut > Maize.

In most of the above crops, the salinity at which reduction was greater than 50 % was unsafe or hazardous. Sometimes the yield at a given salinity may be significantly affected but the percent decrement in yield at that salinity level may be in the safe limit on the basis of economic return.

Table 4. *Tolerance and yield potential of selected released cultivars of groundnut influenced by irrigation water salinity (ECiw)*

Variety	Relative yield potential		
	90 %	75 %	50%
Spanish Bunch	Salinity of the irrigation water (dS/m)		
TAG 24	4.1	7.3	12.5
DRG 12	4.0	13.4	19.2
GG 4	4.0	11.9	16.8
Kadiri 4	4.0	6.7	11.2
GG 2	3.9	6.0	9.4
ICGS 37	3.9	8.8	16.8
ICGS 44	3.5	5.6	9.2
VRI 3	3.5	5.8	13.4
JL 24	3.4	5.2	8.1
ICG(FDRS) 4	3.2	9.6	20.2
Girnar 1	3.1	5.2	8.6
Virginia Bunch			
ICGV 86325	7.0	20.1	41.8
M 522	5.8	12.4	23.5
GG 20	5.0	14.2	29.7
ICGS 76	4.5	14.2	30.4
Virginia Runner			
Somnath	7.1	18.6	37.7
TMV 4	6.2	13.7	26.3
Chandra	6.1	13.3	25.1
ALR 3	5.1	12.6	25.0
Punjab 1	4.6	11.0	21.7

In conclusion, it may be clarified here that these results can be used as guide to select the relative tolerance among different varieties of the groundnut in a given soil and climatic condition.

REFERENCES

Aljibury, L.K. and Talabany, D. (1982). Effect of different saline levels on yield and oil content of peanut seeds. *Journal of Research for Agriculture and Water Resources* **1**(2): 121-127.

Girdhar, I.K. (1999). Use of poor quality water in coastal agriculture. Journal of *Indian Society of Coastal Agricultural Research* **17**(1&2): 48-54.

Girdhar, I. K. (2003). Response of groundnut to saline water irrigation and soil salinity in Saurashtra area of Gujarat. National Symposium *Resource Management for Eco-friendly Crop Production*, pp.65, held at Kanpur, U.P., 26-28 Feb, 2003.

Girdhar, I.K., Bhalodia, P.K., Dayal Devi and Misra, J.B. (2004) . Response of different genotypes of groundnut to saline water irrigation in Saurashtra region of Gujarat. *Journal of Indian Society of Coastal Agricultural Research* **22**(1 & 2): 110-112.

Girdhar, I. K., Bhalodia, P. K., Misra, J. B., Girdhar Veena and Dayal Devi (2005). Performance of groundnut (*Arachis hypogaea L.*) as influenced by soil salinity and saline water irrigation in black clay soils. *Journal of Oilseed Research* **22**(1): 183-187.

Lauter, D.J. and Meiri, A. (1990). Peanut pod development in pegging and rooting zones salinized with sodium chloride. *Crop Science* **30**(3): 660-664.

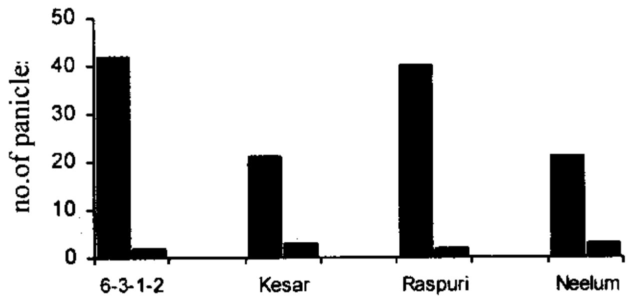

Fig. 1. Effect of *Psuedomonas* on flowering in Mango genotype

Effect of cincturing with growth regulators on flowering and fruit size

The data (Table 1) showed that when trees were cinctured with 2, 4-D at flowering stage, maximum increase over control in panicle retention (33 nos. in 6-3-1-2) of all the varieties was obtained. The variety Raspuri was able to retain 25 panicles under the treatment of 2, 4-D whereas in control only 2 panicles were retained.

With regard to fruit yield (Table 1) there existed significant difference among the treatments under all the varieties. In general all the varieties cinctured with 2, 4-D showed higher fruit yield than NAA and Alar. The variety 6-3-1-2 cinctured with 2, 4-D recorded the highest fruit numbers of 159.50 followed by Raspuri (55.50). The use of auxin for control of fruit drop was earlier reported by Ram and Sirohi (1979). The response of NAA and Alar for fruit retention was earlier compared by Arora and Singh (1964).

Thus the fruits sprayed with 0.2% *Psuedomonas* from the time of flower bud initiation till harvest at an interval of 20 days followed by cincturing with 2,4-D @ 10 ppm gave higher flowering and fruit retention in mango trees under coastal ecosystem. Moreover the response of local open pollinated clones to the treatment was more than the introduced varieties.

Table 1. *Effect of cincturing on panicle and fruit numbers in mango*

Treatments	Varieties							
	6-3-1-2		Kesar		Raspuri		Neelam	
NAA	3.5	5.00	4.5	8.5	8.5	6.5	3.5	4
2, 4-D	33	159.50	11	22	25	55.5	13	26.5
Alar	8	7.00	6.5	11.5	13	7.5	7	6
Control	2	1.50	2.5	1.5	2	1.5	2.5	1.5
CD at p=0.05	0.88	1.60	1.38	1.39	0.53	3.5	0.53	1.6
SEd	0.39	0.71	0.61	0.61	0.24	1.55	0.24	0.7

REFERENCES

Arora, K.S. and Singh Ranjit (1964). Effect of plant growth regulators on fruit drop, fruit quality and seed germination in mango. *Indian Journal of Agricultural Sciences* **34**: 46-55.

Chacko, E.K. (1968). Studies on physiology of flowering and fruit growth in mango (*Mangifera indica L.*). *Ph. D. Thesis*, IARI, New Delhi.

Damodaran, T., Medhi, R.P., Attri, B.L., Suryanarayana, M.A. and Beena, S. (2001). Performance of open pollinated local clones of mango in Bay Islands. *Journal of Andaman Science* **17**(1&2): 91-93.

Damodaran, T., Medhi, R.P., Damodaran, V. and Rai, R.B. (2005). Tips for farmers–on rejuvenation of old/unproductive mango trees of Bay Islands. *The Daily Telegrams*, A & N Islands.

Galar Sauco, V. (1997). Mango world production. *Acta Horticulture* **455**: 15-22.

Howie, W.J., Cook, R.J. and Weller, D.M. (1987). Effects of soil matric potential and cell motality on wheat root colonization by florescent *pseudomonas* suppressive to take all. *Phytopathology* **77**: 286-292.

Mayer, A.M. and Harel, E. (1979). Polyphenol oxidase in higher plants: a review. *Phytochemistry* **18**: 193-215.

Ram, S. and Sirohi, S.C. (1979). Studies on fruit drop in mango. Mango Workers Meeting *Research Reports on Mango*, held at Panaji, Goa, 2-5 May, pp.432-433.

Robertse, P.J., De Wet, E. and Coetzer, L. (1988). The influence of temperature and boron on pollen germination of *Mangifera indica. South African Mango Growers Association Yearbook* **8**: 4-6.

Singh, R.N., Majumder, P.K., Sharma, D.K. and Rathore, D.S. (1968). Effect of defruiting on bearing behaviour of mango (*Mangifera indica* L.) cv. Dashehari. *Indian Journal of Horticulture* **25**: 64-65.

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Induction of Flowering in Mango under Island Ecosystem

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To study the effect of *Psuedomonas* on floral development on mango (*Mangifera indica L.*), Raspuri, Kesar, Neelam and 6-3-1-2 trees were exposed to spray from the month of June 04 to March 05. Results showed higher levels of flower induction in trees treated with 0.2% of *Psuedomonads* in all the varieties. However, the local open pollinated clone 6-3-1-2 exhibited higher number of panicles than the others. To retain the induced flowers four treatments with bioregulators were introduced as root cincturing ones. Among them the panicles cinctured with 2,4-D @ 10 ppm gave the highest number of fruits finally.

(***Key words:*** *Mango flowering, Psuedomonas, Cincturing, Fruit retention*)

Mango is one of the most important fruits of the tropics and is cultivated in more than 100 countries at both tropical and subtropical latitudes (Galar Sauco, 1997). Due to the long history of cultivation in this subcontinent, about a thousand cultivars of mango are known to exist in India. A wide range of cultivars is available in the Bay Islands alone. Most of the islanders are early settlers who brought with them varied clones/varieties available from the mainland India. Though flower bud differentiation in India occurs between October and December, the flowering behaviour in Andaman Islands is completely different (Damodaran *et al.*, 2001). Flowering habit varies from clone to clone under the island conditions. Most of the local clones have an erratic habit of producing some crops round the year. The typical tropical climate of high continuous rainfall and high humidity with bright sunshine make most of the mangoes avoid the floral phase and maintain vegetative phase (Damodaran *et al.*, 2005). Only with the intervention technologies this can be made to flower. Works at Central Agricultural Research Institute, Port Blair on induction of flowering and retention of fruits served as tools for mango production.

MATERIALS AND METHODS

The experiment was conducted between March 2004 to Febrauary 2005 on 6 year-old mango trees of cv. Raspuri, Neelam, Kesar and 6-3-1-2 in the farm located near Garacharma in South Andaman. Trees were sprayed with *Psuedomonas* @ 0.2 % from March 04 to Febrauary 05. From the month of October with the initiation of flowers the branches were cinctured and applied with Alar @ 50 ppm, NAA @ 100 ppm and 2, 4-D @ 10 ppm along the twine tied to the cinctured area of the branches. The experiment was carried out in randomized block design with four replications and six trees under each variety.

RESULTS AND DISCUSSION

Effect of *Psuedomonas* on flowering

The trees of all the varieties sprayed with 0.2% of *Psuedomonas* showed significant increase in the flowering percentage as compared with their control. There existed significant difference between the varieties in flowering in response to the treatment with *Psuedomonas* (Fig. 1). Among the varieties the variety 6-3-1-2 showed the highest number of panicles (42.00) followed by Raspuri (40.00). Number of panicles in the varieties Neelam and Kesar were found to be 20.00 and 22.00, respectively. The variation in number of panicles between the varieties may be due to the differential behaviour of the genotypes in response to the treatment and bearing habit of the clones (Robertse *et al.*, 1988). The endophyte *Psuedomonas* apart from acting as component of induced systemic resistance in the plant to anthracnose also initiated flowering due to the existence of auxins in the system (Howie *et al.*, 1987). The auxins are known to favour vegetative growth and may inhibit or promote flowering and fruiting in mango, if present in high concentrations (Chacko, 1968, Singh *et al.*, 1968). The application of *psuedomonas* increases the level of flowering enzyme polyphenol oxidase along with other enzymes (Mayer and Harel, 1979).

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Inhibition of Polypathogenic Fungi by Leaf Extracts of Mango (*Mangifera indica* L.)

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***Mangifera indica* L. is a tree commonly planted in the home gardens of coastal ecosystem of tropical regions. A preliminary study assessed the influence of mango leaf extract [5, 10, 15, 25 and 50 % (w/v)] on the growth of certain fungi [*Phytophthora palmivora, Colletotrichum gloeosporioides, Alternaria solani, Fusarium solani, Rhizoctonia bataticola, Sclerotium rolfsii., Macrophomina phaseolina* and *Phomopsis vexans*] that infect many crops and cause substantial economic loss to farmers in the home gardens of Kerala. Mango leaf extract suppressed the growth of all the fungi except *S. rolfsii*. A remarkably high degree of inhibition was noticed in *R. bataticola* (up to 89 %) and *P. palmivora* (up to 47 %), two pathogens that infest numerous crops in homesteads. The mango leaf extract offers immense potential for eco-friendly and sustainable disease management.**

(Key words: *Mango leaf extract, Antifungal, Eco-friendly disease management)*

There is growing ecological concern over the toxicity and intrinsic hazards arising out of the improper fungicide use for the control of air, soil and seed borne diseases. Various species of plants and their constituents are gaining importance in crop disease management as potent fungi toxicants in view of their selective properties, low cost and safety to ecosystem. The botanicals containing secondary plant substances which control the diseases caused by various fungi, bacteria and virus in plants (Fawcet and Spencer, 1970) are superior to synthetic pesticides because of biodegradability, target specificity and low mammalian toxicity. Mango (*Mangifera indica* L.) is a widely adapted tree commonly planted in the home gardens of tropical regions. Certain phytochemicals have been identified in different parts of mango (Duke, 1992) and the allelopathic effects of mango on crops have also been reported (Jacob and Nair, 1998). The present study was undertaken to assess the allelopathic effects of mango leaf extract against common phytopathogenic fungi of crops in Kerala.

MATERIALS AND METHODS

The study was undertaken at the College of Agriculture, Padannakkad, Kasaragod, North Kerala during 2002. Eight test fungi, viz. *Phytophthora palmivora* Butler, *Colletotrichum gloeosporioides* Penzig, *Alternaria solani* (Ellis and Martin) Jones and Grout, *Fusarium solani* Snyder and Hansen, *Rhizoctonia bataticola* (Taub.) Butler, *Sclerotium rolfsii* Sacc., *Macrophomina phaseolina* (Tassi) Goid and *Phomopsis vexans* (Sacc. and Syd.) were isolated from the infected parts of various crops.

Isolation of test fungi

Plant part showing early infection was cut into small pieces and surface sterilized with 0.1 % (w/v) mercuric chloride for 1 min followed by three washings in sterile distilled water. Sterilized infected tissue bits were plated on Potato Dextrose Agar (PDA) medium containing the antibiotic sporidex (a.i. Cephalexin) and incubated in laboratory condition at room temperature (25 ± 3°C). Pure culture of the pathogens was obtained by single spore/mycelium isolation method. The pathogenicity of all the above fungi was tested on respective plant parts under laboratory condition. The respective fungi were re-isolated from the infected tissues to prove Koch's Postulates. The pure cultures of fungi were maintained in PDA medium supplemented with sporidex antibiotic under laboratory condition.

Preparation of mango leaf extracts and media

Fresh extracts of mango leaf of 100 % (w/v) were prepared in distilled water. For this mature healthy leaves of *Mangifera indica* L. were collected from trees maintained at College of Agriculture, Padannakkad, Kasaragod. Leaves were thoroughly washed under running tap water and shade-dried for 1 h to remove their wetness. Five hundred gram of the leaf was weighed out, chopped to 0.5 cm size and homogenized in a mixer after adding 200 ml of distilled water. The homogenate was initially filtered through a layer of absorbent cotton and subsequently through three layers of muslin cloth to remove all plant debris. The filtrate was collected and the residue was again homogenized twice in a mixer, each time with 100 ml of distilled water and filtered through absorbent cotton and three layers of muslin cloth to collect the excess extract. The final volume of the extract was made to 500 ml with distilled water to form 100 % aqueous extract. PDA media containing 5, 10, 15, 25 and 50% (v/v) leaf extract were prepared. To solidify the media, variable amounts of agar were added and sterilized in autoclave at 120°C and 15 pounds pressure for 20 min.

Inoculation of fungi on PDA containing extracts

The sterilized PDA containing extracts were poured into sterilized petri dishes (9 cm dia) after cooling to luke warm temperature of 40°C. The media was inoculated with 9 mm discs taken from growing edges of 5 day-old cultures of test fungi and incubated at laboratory condition (25 ± 3°C). The growth of fungi on different concentrations of various extracts was measured as the diameter of mycelial growth of fungi (cm) at 3, 5 and 7 days after inoculation (DAI). The PDA medium alone served as the control. The percent inhibition/stimulation was calculated using the formula:

Inhibition/stimulation (%) = [(T-C)/C] x 100

Where, C and T are mycelial growth (cm) of test fungi in control and treatment, respectively. All treatments were replicated thrice and average values were used for interpretation. The data were subjected to analysis of variance for completely randomized design.

RESULTS AND DISCUSSION

The aqueous extracts of leaf of *M. indica* significantly inhibited mycelial growth of the different test fungi (Table 1).

Aqueous leaf extract at 25 and 50 percent inhibited growth of *P. palmivora* significantly. The 50 % extract caused nearly 33% suppression of mycelial growth. At 5 and 7 DAI, suppression of growth was observed with 15 and 25% concentration also. The inhibition caused by the 50% extract at 7 DAI was remarkable (48%). Sivasithambaram *et al.* (1981) reported the effectiveness of eucalyptus leaf and bark extracts in inhibiting the mycelial growth of *Phytophthora cinnamomi.*

The growth of *C. gloeosporioides* was significantly inhibited by 15, 25 and 50% at 3 DAI. However, at 7 DAI the inhibition caused by the 50% extract alone was significant. Reports of inhibition of mycelial growth of *Colletotrichum falcatum* by leaf extracts of other plants (*Polyalthia longifolia* and *Parthenium hysterophorus*) are available (Kishore *et al.*, 1982). The suppression caused by the extract, though statistically significant, was very low. At 5 and 7 DAI, the effects were insignificant.

A. solani was significantly inhibited by all concentrations of leaf extract at 3 and 5 DAI. However, degree of inhibition decreased as days progressed and at 7 DAI inhibitory effects were very low and statistically non-significant. Inhibition of mycelial growth of *Alternaria* spp. by plant extracts are available (Senthilnathan and Narasimhan, 1994).

The inhibition of *F. solani* was significant at all concentrations at both 3 and 5 DAI. Higher extract concentrations (25 and 50%) resulted in remarkable inhibition.

The growth of *R. bataticola* was inhibited significantly at all concentrations at 3, 5 and 7 DAI. Even low concentration (5%) of leaf extract resulted in more than 50% suppression of mycelial growth at 3 DAI and the effect was at par with that of higher concentrations. Renu (1981) reported the inhibition of mycelial growth of *Rhizoctonia solani* by aqueous leaf extracts even at low concentration. At higher concentrations (25 and 50%) the inhibition was notably high and it ranged from 70-90 %. A similar trend was observed at 5 and 7 DAI.

The mango leaf extracts did not inhibit growth of *S. rolfsii*. The growth of *M. phaseolina* was suppressed at 3 DAI. The inhibitory effects were less at lower concentration but increased at higher concentrations. The inhibitory effect at all concentrations except 5% on *P. vexans* was evident at 5 DAI. It is to be noted that these fungi by virtue of their fast growing nature covered the petriplates quickly and further mycelial growth in control was limited by the size of the petriplate. Therefore, in these fungi, the mycelial growth and inhibition at 3 DAI were to be considered for a more realistic inference.

Several phytochemicals have been identified in various plant parts of *Mangifera indica*, viz. Alanine, alpha-pinene, beta-pinene, gallic acid, gallotannic acid, isoleucine, isomangiferolic acid, kaempferol, lauric acid, limonene flower, linoleic acid, linolenic acid, mangiferic acid, mangiferine, mangiferol, mangiferolic acid, mangiferonic acid, myristic acid, p-coumaric acid, palmitic acid, quercetin, tannin and threonine (Duke, 1992). The inhibition of mycelial growth and spore germination of various phytopathogenic fungi by water extracts of many plants has been reported (Jain and Pathak, 1970, Joy *et al.*, 2004).

Table 1. *Effect of mango leaf extract on fungi (mycelial growth in cm)*

Concentration (%)	*P. palmivora*			*C. gloeosporioides*			*A. solani*			*F. solani*		
	3 DAI	5 DAI	7 DAI	3 DAI	5 DAI	7 DAI	3 DAI	5 DAI	7 DAI	3 DAI	5 DAI	7 DAI
0	2.87 (0.00)	4.30 (0.00)	6.57 (0.00)	4.80 (0.00)	7.33 (0.00)	8.63 (0.00)	5.23 (0.00)	7.27 (0.00)	8.37 (0.00)	6.37 (0.00)	9.00 (0.00)	9.00 (0.00)
5	2.83 (-1.39)	3.97 (-7.67)	6.23 (-5.18)	4.63 (-3.54)	6.80 (-7.23)	8.63 (0.00)	3.97 (-24.09)	6.23 (-14.31)	7.97 (-4.78)	4.83 (-24.18)	6.80 (-24.44)	9.00 (0.00)
10	2.67 (-6.97)	3.87 (-10.00)	5.47 (-16.74)	4.27 (-11.04)	6.83 (-6.82)	8.40 (-2.67)	4.00 (-23.52)	6.10 (-16.09)	8.03 (-4.06)	4.43 (-30.46)	6.83 (-24.11)	9.00 (0.00)
15	2.57 (-10.45)	3.57 (-16.98)	4.67 (-28.92)	4.07 (-15.21)	6.07 (-17.19)	8.17 (-5.33)	3.83 (-26.77)	6.10 (-16.09)	8.03 (-4.06)	4.40 (-30.93)	6.77 (-24.78)	9.00 (0.00)
25	2.07 (-27.87)	2.97 (-30.93)	4.20 (-36.07)	4.07 (-15.21)	6.13 (-16.37)	8.20 (-4.98)	3.77 (-27.92)	5.57 (-23.38)	7.83 (-6.45)	4.17 (-34.54)	6.40 (-28.89)	8.73 (-3.00)
50	1.93 (-32.75)	2.67 (-37.91)	3.43 (-47.79)	3.63 (-24.38)	5.83 (-20.46)	7.47 (-13.44)	3.33 (-36.33)	5.13 (-29.44)	7.30 (-12.78)	4.27 (-32.97)	6.30 (-30.00)	8.33 (-7.44)
CD at p=0.05	0.62	0.593	1.026	0.537	0.551	0.783	0.732	0.6	NS	0.532	0.313	0.296

Concentration (%)	*R. bataticola*			*S. rolfsii*			*M. phaseolina*			*P. vexans*		
	3 DAI	5 DAI	7 DAI	3 DAI	5 DAI	7 DAI	3 DAI	5 DAI	7 DAI	3 DAI	5 DAI	7 DAI
0	3.00 (0.00)	5.77 (0.00)	8.23 (0.00)	9.00 (0.00)	9.00 (0.00)	9.00 (0.00)	6.83 (0.00)	9.00 (0.00)	9.00 (0.00)	5.63 (0.00)	8.63 (0.00)	9.00 (0.00)
5	1.33 (-55.67)	1.63 (-62.09)	2.53 (-69.26)	9.00 (0.00)	9.00 (0.00)	9.00 (0.00)	6.07 (-11.13)	9.00 (0.00)	9.00 (0.00)	5.63 (0.00)	8.53 (-1.16)	9.00 (0.00)
10	1.13 (-62.33)	1.30 (-69.77)	1.40 (-82.99)	9.00 (0.00)	9.00 (0.00)	9.00 (0.00)	6.1 (-10.69)	9.00 (0.00)	9.00 (0.00)	5.5 (-2.31)	8.23 (-4.63)	9.00 (0.00)
15	0.97 (-67.67)	1.07 (-75.12)	1.00 (-87.85)	9.00 (0.00)	9.00 (0.00)	9.00 (0.00)	5.8 (-15.08)	9.00 (0.00)	9.00 (0.00)	5.53 (-1.78)	7.93 (-8.11)	9.00 (0.00)
25	0.90 (-70.00)	0.90 (-79.07)	0.77 (-90.64)	9.00 (0.00)	9.00 (0.00)	9.00 (0.00)	5.8 (-15.08)	9.00 (0.00)	9.00 (0.00)	5.1 (-9.41)	7.57 (-12.28)	9.00 (0.00)
50	0.90 (-70.00)	0.90 (-79.07)	0.83 (-89.91)	9.00 (0.00)	9.00 (0.00)	9.00 (0.00)	5.2 (-23.87)	9.00 (0.00)	9.00 (0.00)	4.73 (-15.99)	7.33 (-15.06)	9.00 (0.00)
CD at p=0.05	0.97	0.84	0.70	NS	NS	NS	0.551	NS	NS	0.406	0.340	NS

Value in the paranthesis is percent control of the disease

The varied effect of leaf extract on growth of the different test fungi was possibly due to the differential response of leaf extract to different fungi, i.e. certain plants having toxic impact against specific pathogens might have been less inhibitory to other pathogens (Mishra and Tewari, 1993).

The inhibition of the phytopathogenic fungi by mango leaf extract offers a cheaper and environmentally safer alternative to fungicides for the control of phytopathogenic fungi causing diseases in multiple crops in home gardens. But, comprehensive field experiments are necessary before any conclusion is made on antifungal effects of mango leaf for which the results of this preliminary investigation will form a base.

REFERENCES

Duke, J. A. (1992). *Handbook of Phytochemical Constituents of Grass Herbs and other Economic Plants.* Boca Raton, FL, CRC Press.

Fawcet, C.H. and Spencer, D.M. (1970). Plant chemotherapy with natural products. *Annual Review of Phytopathology* **8**: 403-416.

Jacob, J. and Nair, A.M. (1998). Allelopathic effect of leaf leachates of multipurpose trees. *Allelopathy Journal* **6**: 81-85.

Jain, J.P. and Pathak, V.N. (1970). Antifungal activity in leaf extracts of certain plants. *Journal of Science and Technology* **8**: 58.

Joy, M., Jacob, J., Smitha, K.P. and Nair, R.V. (2004). Inhibitory effects of cashew (*Anacardium occidentale* l.) on polypathogenic fungi. *Allelopathy Journal* **13**: 47-56.

Kishore, N., Dubey, N.K., Tripathi, R.D. and Singh, S.K. (1982). Fungitoxic activity of leaves of some higher plants. *National Academy of Science Letters* **5**: 9-10.

Mishra, M. and Tewari, S.N. (1993). *In vitro* studies on the mycitoxic properties of *Acacia arabica*, *Adhatoda vasica* and *Pongamia glabra*. In Proceedings National Symposium *Botanical Pesticides in Integrated Pest Management*, M.S. Chari & G. Ramaprasad (eds.), pp. 413-416, Indian Society of Tobacco Science, Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh.

Renu, A. (1981). Evaluation of higher plants for their fungitoxicity against *Rhizoctonia solani*. *Ph.D. Thesis*, Gorakhpur University, Bihar.

Senthilnathan, V. and Narasimhan, V. (1994). Effect of plant extracts/products on mycelial growth and spore germination of *Alternaria tenuissima* inciting the blight of onion and the nature of the antifungal components. In *Crop Diseases: Innovative Techniques and Management*, K. Sivaprakasam & K. Seetharaman (eds.), pp. 307-313. Kalyani Publishers, Ludhiana.

Sivasithambaram, K., Smith, L.D.J. and Goss, O.M. (1981). Effect of potting media containing fresh sawdust and composted tree barks on *Phytophthora cinnamomi* Rans. *Australian Plant Pathology* **10**: 20-25.

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Influence of Substitution of Potassium by Sodium on the Control of Fusarium Wilt in Solanaceous Vegetables

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Chilli and tomato are two important and popular vegetables under the family Solanaceae. These are affected by a major soil borne diseases caused by *Fusarium oxysporum* f.sp. solani. In K/Na substitution trials conducted in the Kerala Agricultural University, it was observed that in plots with sodium as a partial substitute for potassium, the occurrence of diseases in general was considerably reduced. Based on this, preliminary trials were taken up with chilli and tomato in pot culture experiments using different concentrations of salt (NaCl) as treatments. The treatments having capacity for disease suppression were further evaluated in microplot experiments. Comparing the scores in different treatments with control, it could be inferred that Na applied in solution form gave an inherent capacity to resist infection by Fusarium in these crops. This was followed by the K/Na substitution treatment.

(***Key words:*** *Fusarial wilt, Potassium/sodium substitution, Chilli, Tomato*)

Chilli and tomato are two important and popular vegetables under the family Solanaceae. These vegetables all over the world are affected by a major soil borne disease caused by *Fusarium oxysporum* f.sp. solani. The occurrence of the disease becomes serious during summer season which is the most favourable time for raising vegetables in Kerala. The losses due to this fusarial wilt may go even up to 80 percent in cases of severe infection (Padmodaya and Reddy,1998). The fungus enters the root system, establishes and blocks the coducting tissues resulting in wilting of the plants and consequently a complete loss of the crop.

During the investigations conducted in the Kerala Agricultural University on the possibility of substitution of potassium in muriate of potash by sodium in common salt as a fertilizer for agricultural crops, it was observed that in plots with sodium as a partial substitute for potassium, the occurrence of diseases in general was considerably reduced. Elmer (1992) reported that common salt when applied to asparagus plants affected by fusarial wilt could control the disease. In plots where salting was a practice, the occurrence of disease was not observed. Coincident with the discontinuation of the salting practice, there was an increase in the number of reports of destructive crown and root rot diseases. In Kerala also, it was an age old practice among the farmers to apply ash and common salt in coconut gardens. Hence an investigation was carried out in the College of Agriculture, Vellayani to study the effect of substitution of potassium by sodium on the disease suppression of fusarial wilt in the solanaceous vegetables, chilli and tomato.

MATERIALS AND METHODS

Preliminary trials were taken up with chilli and tomato in pot culture experiments. Salt (NaCl) at different concentrations were given as treatments. The treatments selected are given in Table 1. There were eight treatments and three replications for each crop. Plants were grown in pots and *Fusarium oxysporum* was applied after its establishment. The severity of the disease was measured based on the percentage wilting. Treatments which were found to have ability for suppression of disease in this study were further evaluated in microplot experiments. There were five treatments and four replications in this experiment for each crop. Treatments in these experiments are listed in Table 2. Plants were raised following the package of recommendations of the Kerala Agricultural University. N:P:K were applied @ 75:40:25 kg ha^{-1} for all the treatments except T_7. In T_7 instead of full K, half the dose was applied as K and half was applied as equivalent Na of common salt. In the other treatments, salt was applied in powder form and also as solution. A control was also kept in each replication. The pathogen (*Fusarium oxysporum*) causing wilt disease was inoculated to the healthy seedlings one month after transplanting. The plants were observed for wilting symptoms as indicated by drooping of leaves, curling of leaf margins and stunted growth of the plant and scored for the wilt incidence.

Table1. *Mean wilt percentage infested by* F. oxysporum *under pot culture experiment*

Treatment	Method of application	Chilli	Tomato
T1. 0.5 % salt solution	foliar	59	55
T2. 1 % salt solution	foliar	60	77
T3. 0.5 % salt solution	soil application	37	40
T4. 0.5 g salt powder	soil application	36	32
T5. 1g salt powder	soil application	38	36
T6. 1.5 g salt powder	soil application	41	42
T7. 50%K+50% Na (substitution)	as fertilizer in soil	21	15
T8. Control		70	79

Table 2. *Mean wilt percentage infested by* F. oxysporum *under microplot experiment*

Treatment	Method of application	Chilli	Tomato
T1. 0.5 g salt powder	soil application	40	38
T2. 1 g salt powder	soil application	52	68
T3. 0.5 % salt solution	soil application	28	23
T4. 50%K+50% Na (substitution)	as fertilizer in soil	32	25
T5. Control		91	100

RESULTS AND DISCUSSION

Results of the preliminary studies conducted revealed that the minimum percentage of wilt incidence was recorded in treatment T_7 which received 50 % K and 50 % Na in both the crops. In chilli the percentage of incidence was 21 and in tomato,15. In the case of chilli, the next minimum incidence was recorded in the treatment T_4 followed by T_3. In tomato also the second minimum incidence was observed in T_4 followed by T_5. Maximum wilt incidence recorded was in treatment T_3, i.e. 60 and 77 for chilli and tomato, respectively. Control plants recorded maximum wilt incidence of 70 and 79 percentage, respectively for chilli and tomato.

From the microplot experiment it was revealed that out of the two methods of application, viz. powder and solution form of common salt, application of 0.5 % solution of NaCl recorded the minimum percentage wilt of 23 and 28 in tomato and chilli, respectively which was followed by the substituted treatment T_4. Except in the substituted treatment, in all other treatments, the NaCl application was done over and above the normal recommended dose of N, P and K. In the treatment T_1 (where sodium chloride was applied in powder form) the percentage wilt incidence was 40 in case of chilli and 38 for tomato. Control plants recorded a wilting percentage of 91 and 100, respectively for chilli and tomato. Comparing the scores in different treatments with control, it can be inferred that Na either in powder or in solution form applied in addition or substitution supplies an inherent capacity to resist infection by *fusarium*.

When Na was applied along with K at 50:50 combinations, the plant uptake of K was found increasing in several crops (Sudharmaidevi *et al.*, 2002). An increase in K content in plants was favourable because K was a factor in defence mechanisms of plants against diseases and insect pests. It induced various biochemical and histological changes in the plant which, in turn, form this mechanism that induced capability for the plants to resist bacterial and fungal attack. Na was also reported to have fungicidal action especially against *fusarium* as reported by Elmer (1992). Hence, it can be concluded that the practice of 50% substitution of K by Na was beneficial in terms of savings in fertilizer cost, added income from increased yield, and enhanced ability for disease control in these crops.

REFERENCES

Elmer,W.H. (1992). Suppression of fusarium crown and root rot of asparagus with sodium chloride. *Phytopthology* **82**: 97-104.

Padmodaya, B. and Reddy, M.R. (1998). Screening of *Trichoderma* sp against *Fusarium oxysporum* f. sp. *lycopersioni* causing wilt in tomato. *Journal of Mycology and Plant Pathology* **26**: 266-270.

Sudharmaidevi, C.R., Padmaja, P. and Sunu, S. (2002). Common salt as a partial substitute for muriate of potash in agriculture. Proceedings *XII Swadeshi Science Congress*, CTCRI, Trivandrum.

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Bio-efficacy of Botanicals against *Lasioderma serricorne* (Fab.), Cigarette Beetle in Tobacco Seed Storage

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The cigarette beetle, *Lasioderma serricorne*, a serious pest of stored tobacco, also causes considerable damage to tobacco seed during storage. The dry leaf powders of six plants, viz. *Clerodendron inerme*, *Phyllanthus amarus*, *Andrographis paniculata*, *Azadirachta indica*, *Pongamia glabra* and *Datura stramonium* were tested for their efficacy against cigarette beetle in tobacco seed storage at 2.5 and 5.0 % (w/w) concentrations. The leaf powder of *Andrographis paniculata* recorded the lowest number of life stages of the pest followed by the leaf powder of *Clerodendron inerme* at 5% concentration. The leaf powder of *Clerodendron inerme* could protect the tobacco seed even at concentration as low as 1.5%. There was no adverse effect of this treatment on the germination of tobacco seed. The efficacy of *Clerodendron inerme* leaf powder was retained for six months, whereas that of *Andrographis paniculata* was observed only for four months at 5% concentration . The possibility of using these treatments in tobacco seed storage was discussed.

(Key words: *Cigarette beetle, Tobacco seed storage, Bio-efficacy of botanicals)*

The cigarette beetle, *Lasioderma serricorne* is a serious pest of stored tobacco leaf and tobacco products like cigarettes, cigars and chewing tobacco (Jones, 1913). Besides tobacco the insect also attacks virtually any product made from plant or animal material including rice, ginger, pepper, dried fish, dates, seeds, dried flowers, pyrethrum powder (an insecticide), rodenticide baits, dried or pelleted pet food, straw upholstery stuffing, cotton seed meal, books, and rodent droppings (Ali *et al.*, 1974, Patil *et al.*, 1988) . The cigarette beetle is of major concern in tobacco seed storage as it causes considerable loss of seed if proper protection measures are not adopted. It has been a practice in Central Tobacco Research Institute, the sole authorized agency to produce and supply tobacco seed, to spray the seed with Malathion 50 EC by a ultra-low volume sprayer in an undiluted form to protect it from the damage by cigarette beetle. Though the practice is very effective in checking the pest, considering the ability of the pest to develop resistance to insecticides quickly (Chouhan *et al.*, 1984) it has been contemplated to test botanicals against this pest as an ecologically safe alternative. Thus dry leaf powders of six plant species have been tested under the present study for their efficacy to protect tobacco seed from damage by *Lasioderma serricorne* under storage.

MATERIAL AND METHODS

Test insect: The initial culture of cigarette beetle was collected from infested tobacco leaf samples of previous season. These were then reared on wheat flour fortified with 5% Brewer's yeast at 27 $\pm$ 2°C and 65 $\pm$ 5% relative humidity. The procedure developed by Fletcher (1977) was used for collecting eggs for use in the bio-assays.

Plant material: The leaves of three medicinal plants, viz. *Andrographis paniculata, Phyllanthus amarus* and *Clerodendron inerme* and three other plant species, *viz. Azarirachta indica, Pongamia glabra* and *Datura stramonium* were dried under shade and powdered for use in the bio-assays.

Bio-assays: Bio-assays were conducted taking 25 g of tobacco seed in plastic , ventilated containers and mixing the seed thoroughly with dry leaf powders at 0.5 to 5% (w/w) concentrations. Untreated seed was used as control and all the treatments were inoculated with fixed number of freshly laid eggs of *L. serricorne* and were replicated thrice. To assess the persistence of efficacy of promising treatments, the treated seed was inoculated with eggs of the test insect at monthly intervals and the life stages of the pest were counted at regular intervals. The effect, if any, of the treatments on the germination of tobacco seed was assessed by subjecting the treated seed to germination test on wet filter paper.

RESULTS AND DISCUSSION

Among the three medicinal plants tested *Andrographis paniculata* and *Clerodendron inerme* were found to affect the growth of *Lasioderma serricorne* adversely at 2.5 and 5% concentrations. The lowest mean larval population was recorded in the treatment with *Andrographis paniculata* at 5% followed by the same plant at 2.5% concentration and *Clerodendron inerme* at 5% concentration (Table 1). No pupal stage of the pest was recorded in the treatments with *Andrographis paniculata* and *Clerodendron inerme* at both concentrations tested. Significant reduction in the mean number of life stages of *L.serriorne* was recorded in these treatments compared to control. The medicinal plant *Phyllanthus amarus* did not have any influence on the test insect at the concentrations tested. Among the three other plant species tested for their bio-efficacy against *Lasioderma serricorne*, only *Azadirachta indica* could affect the growth of the insect at 5% concentration (Table 2). In an earlier study with *Spodoptera litura*, it was observed that the acetone extract of *Andrographis paniculata* had very strong antifeedant activity against the third instar larvae (Gunasekaran *et al.*, 1985).

Table 1. *Potential of three medicinal plants as seed protectants of tobacco*

Treatments	Mean no. of larvae	Mean no. of pupae	Mean no. of life stages
Clerodendron inerme 2.5%	2.5 (5.33)	1.00 (0.00)	2.50 (5.33)
Clerodendron inerme 5.0%	1.52(1.33)	1.00 (0.00)	1.52 (1.33)
Andrographis paniculata 2.5%	1.38 (1.00)	1.00 (0.00)	1.38 (1.00)
Andrographis paniculata 5.0%	1.24 (0.67)	1.00 (0.00)	1.24 (0.67)
Phyllanthus amarus 2.5%	2.38 (4.67)	7.83 (60.33)	8.14 (65.33)
Phyllanthus amarus 5.0%	2.43 (5.00)	7.81 (60.00)	8.28 (67.67)
Control	2.90 (7.67)	8.29 (67.67)	8.90 (78.33)
SEm$\pm$	0.20	0.12	0.18
CD at p = 0.05	0.62	0.37	0.54
CV %	16.99	5.26	6.70

Figures in parentheses are original treatment means

Table 2. *Efficacy of selected plant species as seed protectants of tobacco against* L.serricorne

Treatments	Mean no. of larvae	Mean no. of pupae	Mean no. of life stages
Azadirachta indica 2.5%	3.26 (9.67)	2.87 (7.33)	4.24 (17.00)
Azadirachta indica 5.0%	2.44 (5.00)	1.63 (1.67)	2.76 (6.67)
Pongamia glabra 2.5%	1.72 (2.00)	4.32 (17.67)	4.55 (19.67)
Pongamia glabra 5.0%	1.91 (2.67)	4.04 (15.33)	4.36 (18.00)
Datura stramonium 2.5%	1.66 (2.00)	4.31 (17.67)	4.55 (19.67)
Datura stramonium 5.0%	2.94 (7.67)	3.37 (10.33)	4.35 (18.00)
Control	1.82 (2.67)	4.19 (16.67)	4.51 (19.33)
SEm$\pm$	0.24	0.16	0.07
CD at p=0.05	0.75	0.48	0.22
CV %	18.97	7.67	2.92

Figures in parentheses are original treatment means

Table 3. *Potential of* Andrographis paniculata *and* Clerodendron inerme *as tobacco seed protectants at lower concentrations*

Treatments	Mean no. of larvae	Mean no. of pupae	Mean no. of life stages
Andrographis paniculata 0.5%	1.72 (2.00)	2.91 (7.67)	4.45 (19.67)
Andrographis paniculata 1.0%	2.66 (6.33)	3.21 (9.33)	4.08 (15.67)
Andrographis paniculata 1.5%	1.24 (0.67)	4.51 (19.33)	4.58 (20.00)
Andrographis paniculata 2.0%	1.88 (2.67)	3.78 (13.33)	4.12 (16.00)
Clerodendron inerme 0.5%	2.56 (5.67)	1.00 (0.00)	2.56 (5.67)
Clerodendron inerme 1.0%	1.24 (0.67)	1.00 (0.00)	1.24 (0.67)
Clerodendron inerme 1.5%	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Clerodendron inerme 2.0 %	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Control	1.81 (2.67)	4.19 (16.67)	4.51 (19.33)
SEm$\pm$	0.26	0.16	0.15
CD at p=0.05	0.78	0.48	0.46
CV %	26.88	11.04	9.14

Figures in parentheses are original treatment means

Table 4. *Persistence of efficacy of* Andrographis paniculata *and* Clerodendron inerme *as seed protectants of tobacco*

Treatments	Mean no. of larvae	Mean no. of pupae	Mean no. of life stages
Andrographis paniculata 2.5 % 2 months	1.97 (3.00)	3.21 (9.38)	3.64 (12.33)
Andrographis paniculata 2.5 % 4 months	1.63 (1.67)	3.82 (13.67)	4.03 (15.33)
Andrographis paniculata 2.5 % 6 months	1.24 (0.67)	4.20 (16.67)	4.28 (17.33)
Andrographis paniculata 5.0 % 2 months	1.24 (0.67)	1.66 (2.00)	1.79 (2.67)
Andrographis paniculata 5.0 % 4 months	1.52 (1.33)	2.70 (6.33)	2.94 (7.67)
Andrographis paniculata 5.0 % 6 months	1.38 (1.00)	3.50 (11.33)	3.64 (12.33)
Clerodendron inerme 2.5 % 2 months	1.38 (1.00)	1.00 (0.00)	1.38 (1.00)
Clerodendron inerme 2.5 % 4 months	2.49 (5.33)	1.90 (2.67)	2.99 (8.00)
Clerodendron inerme 2.5 % 6 months	1.58 (1.67)	2.99 (8.00)	3.26 (9.67)
Clerodendron inerme 5.0 % 2 months	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Clerodendron inerme 5.0 % 4 months	1.79 (2.33)	2.02 (3.33)	2.58 (5.67)
Clerodendron inerme 5.0 % 6 months	1.38 (1.00)	2.63 (6.00)	2.82 (7.00)
Control	1.81 (2.67)	4.19 (16.67)	4.51 (19.33)
SEm$\pm$	0.24	0.20	0.19
CD at p=0.05	0.70	0.61	0.56
CV %	26.59	13.47	11.10

Figures in parentheses are original treatment means

When the promising treatments, i.e *Andrographis paniculata* and *Clerodendron inerme* were tested at lower concentrations (0.5 to 2.0%), it was found that *Clerodendron inerme* recorded significantly lower mean number of larvae compared to control at 1.5 and 2.0% concentrations (Table 3). The treatment with *Clerodendron inerme* did not record any pupal stage of the pest even at concentration as low as 0.5%. This treatment could inhibit all the growth stages of cigarette beetle at concentrations of 1.5 and 2%. The medicinal plant *Andrographis paniculata* was found to be ineffective at a concentration below 2%.

In the experiment to test the persistence of efficacy of *Andrographis paniculata* and *Clerodendron inerme* as seed protectants of tobacco, it was observed that the differences among the treatments for mean number of larvae were non-significant (Table 4) because the pest crossed larval stage by the time data were recorded. Significant reduction in mean number of pupae was recorded with *Clerodendron inerme* at 2.5 and 5% concentrations for a period of 6 months after treatment. *Andrographis paniculata* recorded significantly lower mean number of pupae at 5% concentration for a period of 4 months only. Similar trend was observed when the mean number of life stages of the insect was considered for comparison.

Table 5. *Effect of botanicals on tobacco seed germination*

Treatment	Mean no. of seeds germinated
Andrographis paniculata 0.5%	4.58 (20.00)
Andrographis paniculata 1.0%	4.43 (18.67)
Andrographis paniculata 1.5%	4.51 (19.33)
Andrographis paniculata 2.0%	4.43 (18.67)
Andrographis paniculata 2.5%	4.43 (18.67)
Andrographis paniculata 5.0%	3.99 (15.00)
Clerodendron inerme 0.5%	4.51 (19.33)
Clerodendron inerme 1.0%	4.55 (19.67)
Clerodendron inerme 1.5%	4.51 (19.33)
Clerodendron inerme 2.0%	4.55 (19.67)
Clerodendron inerme 2.5%	4.43 (18.67)
Clerodendron inerme 5.0%	3.95 (14.67)
Control	4.55 (19.67)
SEm$\pm$	0.05
CD at p=0.05	0.16
CV %	2.10

Figures in parentheses are original treatment means

When methanol extracts from 30 aromatic medicinal plant species and five plant essential oils were tested for their insecticidal activities against *Lasioderma serricorne* (F.) adults using direct contact application and fumigation methods, good insecticidal activity was achieved with extracts of *Agastache rugosa* whole plant, *Cinnamomum cassia* bark, *Illicium verum* fruit and *Foeniculum vulgare* fruit in a filter paper diffusion method (Soon *et al.,* 1995). In an experiment to test the repellent action of dry and fresh leaves of 51 commonly found plant species against *Lasioderma serricorne*, it was observed in Baroda, India (Ambadkar and Khan, 1994) that six plants, namely *Rawolfia canescens, Vinca rosea, Tamarindus indica, Euphorbia neriifolia, Acalypha hispida* and *Coleus barbatus* had 100% repellance both in wet and dry condition.

The germination of tobacco seed was adversely affected by *Andrographis paniculata* and *Clerodendron inerme* at 5 % concentration only (Table 5). These two treatments did not have any adverse effect on the viability of tobacco seed at 2.5% concentration at which they were found very effective against *L.serricorne.*

Thus, dry leaf powders of *Clerodendron inerme* and *Andrographis paniculata* could be integrated in the management programme of *Lasioderma serricorne* in tobacco seed storage as they were effective and ecologically safe and could protect the seed for a period of six months.

REFERENCES

Ali, A.D., Donia, A.R. and El-sawaf, S.K. (1974). The influence of natural food on the development and reproductive rate of *Lasioderma serricorne* Fab. (Col:Anobiidae). *Bull de. La. Soc. Ent.d' Egypte* **58**: 45-53.

Ambadkar, P.M. and Khan, D.H. (1994). Screening of responses of adult cigarette beetle, *Lasioderma serricorne* F. (Coleoptera: Anobiidae) to fresh and dried leaves of 51 plant species for possible repellent action. *Indian Journal of Entomology* **56**(2): 169-175.

Chouhan, J.S. and Yadav, T.D. (1984). Toxicity of baythion, etrimfos and malathion against different stages of *Lasioderma serricorne, Stegobium paniceum* and *Latheticus oryzae. Indian Journal of Entomology* **46**(3): 277-283.

Fletcher, L.W. (1977). A procedure for collecting large number of eggs of *Lasioderma serricorne* (F.). *Journal of Stored Products Research* **13**: 87-88.

Gunasekaran, K., Chelliah, S., Regupathy, A. and Jayaraj, S. (1985). In *Behavioral and Physiological Approaches in Pest Management,* pp 31-33, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.

Jones, C.R. (1913). The cigarette beetle (*Lasioderma serricorne)* in the Philippines Islands. *Philippine J. Sci.D.Gen.Bio.Ethnol. Anthropol.* **8**: 1-61.

Patil, A.P., Thakur, S.G. and Mohalkar, P.R. (1988). Incidence of pests of turmeric and ginger in West Maharashtra. *Indian Cocoa Arecanut and Spices Journal* **12**: 8-9.

Soon Kima, Chan Parka, Myung-Hee Ohhb, Hyung-Chan Choc and Young-Joon Ahn (1995). Contact and fumigant activities of aromatic plant extracts and essential oils against *Lasioderma serricorne* (Coleoptera: Anobiidae). *Journal of Stored Products Research* **39**(1): 11-14.

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Post-harvest Quality Enhancement of Guava (*Psuidium guajava* L.) by Chemical Treatment

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Guava (*Psuidium guajava L.*) is highly perishable and cannot be stored for long in ambient condition. An experiment was carried out to find the influence of various chemicals on post-harvest shelf life enhancement. Two synthetic fungicides, viz. Topsin M (Thiophanate methyl) and Bavistin (Carbendazim) were applied within the permissible limit, and $CaCl_2$ and GA_3 were used for the experiment. The post-harvest application of GA_3 (100ppm) was found relatively superior to other treatments in extending the shelf life.

(Key Words: Guava, Post-harvest quality, Chemical treatment)

Guava (*Psuidium guajava L.*) is a popular fruit subtropical in origin, belongs to the family *Myrtaceae*. It is the fifth important fruit in India covering an area of 1.51 lakh ha with a total production of 18.0 lakh tonnes (Chadha, 2001). This is highly nutritious and rich in Vitamin-C (210 mg per 100 g) and carbohydrates (11.2 g per 100 g), (Gopalan *et al.*, 1991). Therefore, it is an ideal fruit for the nutritional security.

Guava however is highly perishable and cannot be stored longer in ambient condition. Because of its perishable nature, these are disposed off immediately after harvesting in the local market and a very small quantity is sent to distant markets. To minimize post-harvest losses for better returns and to avoid market glut it is necessary essential to store the fruits. Extension of shelf life can be possible by checking the rate of transpiration, respiration and microbial infection. Keeping the above aspect in view an experiment was carried out to find the influence of various chemicals on post-harvest shelf life enhancement of guava.

MATERIALS AND METHODS

This experiment was conducted to study the effect of various post-harvest chemical treatments on storage life of guava. Topsin M (Thiophanate methyl) and Bavistin (Carbendazim) are two synthetic fungicides which are used for treatment of fruits at post-harvest stage (Bhutani *et al.*, 1993). These two chemicals are used at 0.1% and 0.2% levels each. The solutions were made with distilled water. The permissible dose for these two chemicals is 0.05-0.2%. After 10-15 days of treatment no residual toxicity remains in the fruits and is fit for consumption. $CaCl_2$ was used at 1% and 2% level solution with distilled water and was used in the experiment.

Gibberellin was used at 100 ppm and 200 ppm levels. For preparing 100 ppm solution in this experiment 200 mg of GA_3 was first dissolved in 2 ml of ethyl alcohol and the final volume was made up to 2 litres by adding distilled water to it.

Uniform sized good unblemished matured fruits of Harijha variety were procured with utmost care so as to avoid any type of physical damage to the fruits. The fruits were washed properly with distilled water and air dried. The collected fruits for each treatment were kept separately. One lot was kept as such for control and the other lots were dipped in respective chemicals for 10 minutes duration. Then the solutions were drained and fruits were kept on the table for surface drying. After air drying each separate lot was packed in polyethylene bags (100 gauges having 10-15% vent) and stored under room temperature (25-30°C) with proper labeling. Visual colour changes and firmness of the fruits were observed from time to time.

The observations on juice content, pulp weight, peel weight, seed weight, biochemical observations such as TSS, acidity, reducing sugar and total sugar content were carried out using standard biochemical methods (A.O.A.C., 1980).

RESULTS AND DISCUSSIONS

The highest juice content (20.2 %) was recorded when guava fruits received GA_3 treatment at 200 ppm at post-harvest stage. The lowest juice content was recorded under control, i.e. 17.69% without any chemical treatment (Table 1).

Topsin M and Bavistin chemicals are reported to control fungus such as *Rhizopus spp., Penicillium spp., Aspergillus spp.*, etc., which are most commonly associated with the rotting of guava fruits. Likewise, calcium is largely responsible to act as a bridge to bind sugar and phosphate derivatives and finally form a large polymer and extends the shelf life of fruits by checking the internal break down of the fruits (Amen, 1987). Post- harvest application of Gibberellin slows down the ethylene production and reduces the rate of respiration leading to low rate of oxidative metabolism and pectin hydrolysis through decline catalase and Poly Methyl Esterase (PME) activity (Suryanarayan and Gaud, 1984). Biochemical and other tests were carried out on fruits after 12 days of storage when it was found that most of the fruits were turning yellow and becoming soft, thus loosing consumer acceptability.

The pulp weight was significantly influenced by the chemical treatments. The highest pulp weight (81.75%) was recorded when the guava fruits received GA_3 (200 ppm) at post-harvest stage. The peel weight and seed weight were not significantly affected by the chemical treatments given to the fruits at post-harvest stage. The peel weight remained in the range of 13.82 - 14.95 g per 100 g of fruit weight whereas the seed weight remained in the range of 4.40 - 4.83 g per 100 g of fruit weight (Table 2).

In the biochemical parameters studied the TSS of the treated fruits was significantly influenced by the treatments. The treatment of GA_3 (100 ppm) recorded the highest TSS, i.e. 20.2^{0}B followed by 20.0^{0}B in GA_3 (200 ppm) application. Rest of the treatments were found to be statistically inferior to these treatments in respect of the character under reference (Table 3).

Table 1. *Effect of various post-harvest chemical treatments on juice content of guava fruits*

Treatments	% Juice content
Topsin M 0.1%	17.70
Topsin M 0.2%	17.70
Bavistin 0.1%	17.71
Bavistin 0.2%	17.72
$CaCl_2$ 1%	17.82
$CaCl_2$ 2%	17.83
GA_3 100 ppm	19.91
GA_3 200 ppm	20.02
Control (Water)	17.69

Table 2. *Effect of various post-harvest chemical treatments on peel weight, pulp weight and seed weight of guava fruits per 100 g*

Treatments	Pulp weight (g)	Peel wt (g)	Seed wt (g)
Topsin M 0.1%	80.27	14.89	4.83
Topsin M 0.2%	80.25	14.90	4.81
Bavistin 0.1%	80.33	14.87	4.78
Bavistin 0.2%	80.32	14.88	4.72
$Cacl_2$ 1%	80.74	14.51	4.74
$Cacl_2$ 2%	80.79	14.44	4.76
GA_3 100 ppm	81.52	13.91	4.51
GA_3 200 ppm	81.75	13.82	4.40
Water	80.18	14.95	4.82

The acidity of the guava fruits was not affected by the chemical treatments given to the fruits at the post-harvest stage. Highest percentage of reducing sugar (7.55%) was recorded in the controls followed by (7.45%) in bavistin (0.1%) treatment. The lowest % of reducing sugar (6.95%) was recorded under GA_3 application. The highest % of total sugar (15.55%) was recorded when the fruits received GA_3 (100 ppm) treatment. The lowest % of total sugar obtained, i.e. 14.85% was in $CaCl_2$ (1%) treatment (Table 3).

Table 3. *Effect of various post-harvest chemical treatments on TSS, acidity, reducing sugar and total sugar of guava fruits*

Treatments	TSS °B	Acidity (%)	Reducing sugar (%)	Total Sugar (%)
Topsin M 0.1%	19.20	0.106	7.11	15.27
Topsin M 0.2%	18.59	0.119	7.10	15.28
Bavistin 0.1%	19.16	0.119	7.07	15.25
Bavistin 0.2%	18.93	0.118	7.45	15.25
$Cacl_2$ 1%	18.68	0.112	7.05	14.85
$Cacl_2$ 2%	18.68	0.112	7.17	14.90
GA_3 100 ppm	20.20	0.106	6.95	15.55
GA_3 200 ppm	20.00	0.109	7.00	15.30
Water	18.40	0.110	7.55	15.20

REFERENCES

Amen, K.I.A. (1987). Effect of post harvest calcium treatment on storage life of guava fruit. *Journal of Agricultural Sciences* **18**(4): 127-137.

A.O.A.C. (1980). *Official Methods of Analysis*, 11th Edn, Association of Official Analytical Chemist, Washington, D.C.

Bhutani, A.M. and Joshi, D.L. (1993) Effect of chemicals and packing methods on ripening and storage of Guava (*Psidium guajava* L.) cv. Sadar. Golden Jubilee Symposium *Horticultural Research–Changing Scenario*, Horticulture Society of India. 346p.

Chadha, K.L. (2001). *Handbook of Horticulture*, Directorate of Information & Publications of Agriculture, Indian Council of Agricultural Research, New Delhi.

Gopalan, C., Sastri, B.V.R. and Balasubramanian, S.C. (1991). *Nutritive Value of Indian Foods*, National Institute of Nutrition, ICMR, Hyderabad.

Suryanarayan, V. and Goud, P.V. (1984). Effect of post harvest ethrel treatment on ripening of sapota fruits. *The Andhra Agricultural Journal* **31**(4): 308-311.

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Varietal Effect on Post-harvest Conditional of Betel Leaves

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Betel vine is an important cash crop in Orissa. The present paper deals with the effect of cultivation practices on conditioning performance and biochemical quality changes in betel leaves. The quality analysis indicates that though most of the nutritional components such as protein, carbohydrates and total ash content remained fairly constant, there was a noticeable difference in the conditioning parameters. These changes in conditioned leaves probably contribute towards its better consumer acceptability.

*(**Key words:** Betel leaves, Post-harvest quality, Conditioning, Biochemical changes)*

Betelvine, commonly known as *Pan* (*piper betle* L.) is a perennial, dioecious, evergreen creeper grown in moist, tropical and sub-tropical regions of India. The betel leaf is cultivated either under forest ecosystem with support or in artificially created shaded condition, locally known as "*baraj*". There are two major kinds of *baraj* in practice. Depending on the soil type it is termed as *Mati baraj* (clay soil) and *Bali baraj* (sandy soil). Though betelvine was originated in Malaysia, at present it is an important cash crop in different parts of India. In India it is cultivated in about 55000 hectares with annual turnover of Rs. 900 crores providing livelihood to about 15 million people. The annual yield of the betel leaf in India varies from 600 to 700 bundles ha^{-1} (1 bundle = 10,000 leaves) and the average yield per plant varies from 60 to 80 leaves $year^{-1}$. In Orissa betelvine is cultivated in an area of over 4000 ha in the coastal districts of Balasore, Bhadrak, Cuttack, Puri, Khurda, Jagatsingpur, Kendrapara, Ganjam, Gajapati, Nayagarh. Godi Bangla, Noua Cuttack, Sanchi, Birkoli are some popular varieties grown in Orissa. An extensive survey indicates that a greater percentage of betel leaves in the state are used for conditioning. Conditioning is a process in which the green colour of the leaves is changed to yellow / white which are highly demanded by a group of consumers. The process not only fetches high price because of consumer preference but also increases the shelf life of the leaves to a noticeable extent. The present paper deals with the effect of *baraj* type on conditioning performance and on nutritional changes that occur during the process of conditioning.

MATERIALS AND METHODS

A field survey was conducted in the Paradeep district of Orissa to assess varietal influence grown on different types of soil (*baraj* type) on the conditioning performance of the betel leaves. An experiment was carried out in the growers-cum processors traditional chamber to study the effect. For this purpose the samples of green betel leaves were collected both from *Bali baraj* and *Mati baraj*. Those were then subjected to traditional conditioning process of alternate heating and cooling. Disease and insect free matured betel leaves of same variety were collected from the farmers of Balipatna area of Puri district (*Mati baraj*) and Kujang area of Paradeep district (*Bali baraj*). The leaves were washed properly, bundled in 50 each, covered with moist cloth and brought to the traditional VAT on the same day. The betel leaves were traditionally conditioned using the VAT, made up of brick, clay and bamboo strips. Heat was generated inside the VAT by burning charcoal. After heating the leaves were subjected to a cooling period of about 36 to 72 h depending on the atmospheric weather conditions. This process was repeated 3 to 4 times till the colour of the leaves were changed to yellow. Both types of leaves were also stored by using traditional method of packaging. Number of heat and cooling cycles causing damaged and rotten leaves were estimated on percentage. For each group of samples quality analysis was made to obtain the proximate composition (moisture content, protein, fat, carbohydrate, fibre and some minerals). Quality analysis has been made using the standard methods (AOAC, 1990).

RESULTS AND DISCUSSION

The results (Table 1) indicated that the samples collected from *Mati baraj* took longer period to achieve the same intensity of conditioning as compared to that of *Bali baraj*. This was because it required more number of charges. Around four times charging was required. The percentage damage was also high both as heat damaged leaves (14% as against 4%) and rotten leaves (2% as against no rotten leaves). *Bali baraj* leaves were left with less number of green leaves thus showing a better efficiency of the system. The water holding capacity of the *Bali baraj* (sandy soil) was less because of which the growth was slow. The leaves were relatively thick and the heat resistance was more. This might have been one of the contributing factors for better conditioning performance. There was a significant difference in the storability, which could affect the market price. A thirty day-storage experiment indicated that conditioned leaves from *Bali baraj* could safely be stored for 13 days without rotting, whereas the storability of conditioned leaves from *Mati baraj* was only for eight days.

Table 1. *Test report of the conditioning experiment in traditional VAT*

Parameters	*Mati baraj*	*Bali baraj*
No of charges	4	3
No of heat damaged leaves	14%	4%
No of rotten leaves	2%	0%
No of green leaves	4.5%	0.5%
Sensory score	6	8
Storability		
Without rotting	8 days	13 days
Rotten % after 15 days	12%	2%
after 30 days	45%	25%

The qualities of the conditioned leaves from both the *Baraj* type were tested to be at par with those of initial qualities of the leaves. Table 2 shows the major components of the betel leaves from both the *baraj* types before and after conditioning. Examining the changes in nutritional components that occurred in both types of leaves it is inferred that the rate of change in both the cases are almost the same. Therefore the changes appeared to be due to the conditioning process. *Baraj* type (soil type) does not have any impact on the nutritional components of the leaves.

CONCLUSION

The process of conditioning of betel leaves not only enhances the taste (for a particular group) but also extends the storage life of the leaves. Moreover, the cost of such conditioned leaves is much higher than the general unprocessed ones, which earns more profits to the growers. The present paper infers exclusively that *bali baraj* leaves have better conditioning characteristics with less damaged leaves which requires less number of charges for the process. There was virtually no change in moisture, protein, carbohydrate, Vit-C and calcium content during the process which indicates that these are independent of the *baraj* type. The chlorophyll, essential oil, tannin and fibre content of the conditioned leaves were remarkably lower than those of green leaves from both soil types which was due to the conditioning process.

Table 2. *Effect of conditioning and* baraj *type on quality parameters of the leaves*

Quality parameter	*Mati baraj* leaves		*Bali baraj* leaves	
	Fresh	Conditioned	Fresh	Conditioned
Moisture content %	85.58	84.15	85.80	84.82
Protein %	2.40	2.48	2.42	2.54
Fat %	0.80	0.50	0.85	0.40
Carbohydrate %	5.80	5.50	5.65	4.46
Fibre %	2.30	1.40	2.10	1.20
Chlorophyll (mg/100g)	72.55	6.30	75.46	4.50
Vit-C (mg/100g)	80	85	80	86
Tannin (mg/100g)	700	300	750	250
Calcium (mg/100g)	350	350	355	348
Essential oil (mg/100g)	280	60	290	88

REFERENCES

AOAC (1990). *Official Methods of Analysis*, 15th Edn, Association of Official Analytical Chemists, Washington DC.

International Symposium on

Management of Coastal Ecosystem: Technological Advancement and Livelihood Security

October 27-30, 2007

at

Science City, Kolkata, India

Organized by

Indian Society of Coastal Agricultural Research

Central Soil Salinity Research Institute, Regional Research Station

Canning Town, South 24 Parganas, West Bengal, India

Website : www.iscar.org.in

In Collaboration with

Indian Chamber of Commerce, Kolkata

Central Research Institute for Jute and Allied Fibres (ICAR), Barrackpore

Central Soil Salinity Research Institute (ICAR), Karnal

Central Inland Fisheries Research Institute (ICAR), Barrackpore

Indian Society of Soil Science-Kolkata Chapter, Kolkata

Veterinary Council of India (West Bengal State), Kolkata

Coastal areas are among the world's most productive but ecologically fragile regions. Some 60% of humanity lives in the coastal; almost 90% of marine protein is presently derived from coastal areas; and it is estimated that more than half of the world's potentially recoverable hydrocarbon resources are located beneath coastal regions. Despite good endowments, the productivity growth rate in various economic sectors in coastal areas is poor considering the huge resource potential. Moreover, these regions serve diverse human needs for food, energy, transport, and recreation, and provide sites for urban development, industry, agriculture, forestry, fisheries, and trade.

Coastal resources exist in environments comprising complex dynamic geo-morphological and ecological systems that are extremely sensitive to misuse by man. The use and management of such resources must be based on scientific knowledge of the interacting features and processes characteristic of coastal areas. There is widespread evidence of damage and impoverishment of coastal resources where this knowledge is unavailable, or has not been applied to the solution of coastal problems. The recent devastating *Tsunami* of Indian Ocean already warned all concerned for immediate attention of the problem, which inspite of its mammoth devastation is not more than the tip of the gigantic coastal problem iceberg. The coastal system might be heading for more devastation if appropriate precautions are not taken right now. Except a few exceptionally developed countries, the situation is, in general critical throughout the globe because of i) the urgent demand for social, economic, and technological development; ii) the paucity of knowledge applicable to the needs of the nations; iii) the great complexity of tropical and sub-tropical coastal systems; and iv) the lack of capital resources and trained manpower to solve these problems.

In such precarious situation of the coasts almost all over the Globe, the need of the hour is to concentrate, share experiences and shoulder responsibilities to preserve the very vital but fascinating ecological system of our mother Earth. Hence, The Indian Society of Coastal Agricultural Research, Canning Town, South 24 Parganas, West Bengal, India, proposes an International Symposium on **'Management of coastal ecosystem: Technological advancement and livelihood security'** to be held during October 27-30, 2007 at Science City, Kolkata, West Bengal, India encompassing the following topics:

Symposium topics

- **Sub-theme – I : Sustainable development of coastal areas through agriculture and allied activities** - crop husbandry in agri-horti production system including water management and crop protection, fisheries, animal husbandry; conservation, restoration and management of coastal soil resources and technology transfer with special emphasis on socio-economic matrix for poverty alleviation.
- **Sub-theme – II : Wetland management, mangroves and agro-forestry** - coastal wetlands, mangrove forests, coastal dunes, estuaries, deltas and lagoons; coastal degradation, rehabilitation of damaged ecosystems; monitoring of coastal environment, water quality management, water pollution, sediment pollution, land based sources of pollution, toxic organisms and harmful algal blooms, bio-indicators of pollution and monitoring, pollution control, waste water treatment, reuse and recycling, hazardous and solid waste management, transboundary pollution issues.
- **Sub-theme – III : Coastal disaster management for improved livelihood security-** Nature and extent of natural disaster: underlined meteorological and seismic factors, modelling approach for their predictions and post-disaster immediate and long term sustainable measures.
- **Sub-theme – IV : Oceanography, coastal energy and information technology** - coastal and marine ecosystems, marine microbiology, protection of marine and coastal habitats, problem of exotic and invasive marine species, coastal management tools and instruments, coastal engineering, coastal hydrodynamics & non-conventional energy use, communications and data network; use of remote sensing technology and geographic information systems and computer cartography in coastal zone management.
- **Sub-theme – V : IPR, Coastal policy** - integration of science and policy issues, legal, economic and social issues, economic instruments, restoration of livelihood, international aspects.

The objectives of the International Symposium

- To provide a platform to discuss important and urgent coastal issues on advances in new technology, programmes, strategies, policies and research as well as development initiatives for improved agriculture & allied activities.
- To address issues on socio-economic condition of the inhabitants in coastal areas and poverty alleviation.
- To address issues on nature & extent of natural disaster and the factors affecting it, and suggest remedial measures.
- To bring together all key-stakeholders including scientists, industry, NGOs, corporate houses and the public to promote new partnerships for the sustainable development by conserving biodiversity and maintaining ecological balance of the coastal regions of the world.

Target Participants

The International Symposium aims to attract diverse participants from scientific community, industry, government, NGOs, developers, engineers, coastal interest groups, planners, coastal managers and decision-makers from different countries.

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Address of the Office of the Organising Secretary

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NOTE: Regarding symposium papers, accommodation, tour and any clarifications of general nature queries may be sent to the office of Indian Society of Coastal Agricultural Research mentioned above. Papers may also be sent to the Conveners for the respective sub-topics.

Location at a glance

Kolkata (earlier known as Calcutta) is the cosmopolitan Capital City of the State of West Bengal in India, situated at Latitude 22° 33′ N, Longitude 88° 20′ E, Altitude 5.18 m above mean sea level, Distance from see 96.56 km from Bay of Bengal, International Time (+5 ½) hours from GMT, Temperature Winter (November - March, 12 - 27° C), Summer (April - October, 24 - 38° C), Average Rainfall 1600 mm, Total Population 15.97 million (2001), Language spoken Bengali, Hindi, Urdu and Engish.

Presentation of papers

The papers of the symposium will be presented through oral and poster presentation. Oral presentation will be restricted to invited papers only. For oral papers, the invited authors are requested to follow MS Power Point (MS Office XP or higher version compatible) slides presentation with minimum animation and authors are also requested to note that no 'Slide Projector' or 'Over Head Projector' will be provided. Presentation will be made only through LCD projectors. For poster presentations authors are requested to prepare their posters in such a way that can be displayed within a poster board area of 100 cm x 100 cm. The font size and style used in the posters should be such as to be viewed at least from a distance of 100 cm. Title of the paper, name of the author (s) along with the affiliation with full address and E-Mail should be placed at the top/ beginning of the body of the paper. Papers accepted for presentation are likely to be published as 'Extended Summary' in the form of proceedings or as special issue of the journal of the Society. For pre-seminar publication an 'Abstract' not exceeding 400 words should invariably be sent along with Extended Summary.

Extended Summaries

Extended summaries of papers are required for all invited oral and poster presentations. It should be limited to 4 double space typed A4 size papers typed in 12 point (New Times Roman) font with 1 inch (25 mm) margins all around inclusive of tables/figures and very selected references. The title should be followed by the names of the author(s) with the name of the person presenting underlined with their affiliation.

List of the Conveners and the Sub-topics of the Symposium*

Name and email address of the Convener	Sub-topics
Prof. Saroj Kumar Sanyal Director of Research Bidhan Chandra Krishi Viswavidyalaya PO: Kalyani - 741 235, Dist: Nadia, WB, India Mobile : +91-9830247072 Email: sarojsanyal@yahoo.com, sarojsanyal@hotmail.com	• Water pollution, sediment pollution, land based sources of pollution, toxic organisms and harmful algal blooms, bio-indicators of pollution and monitoring, pollution control, waste water treatment, reuse and recycling, hazardous and solid waste management, transboundary pollution issues
Prof. Amar Som Choudhury Professor, Department of Entomology Bidhan Chandra Krishi Viswavidyalaya PO: Krishi Viswavidyalaya – 741 252, Dist. Nadia West Bengal, India, Mobile: +91-9433178577 Email: somamarkly@rediffmail.com	• New frontiers of crop protection for improving productivity in the field of agriculture and horticulture
Prof. Biswapati Mandal Professor, Department of Soil Science, Bidhan Chandra Krishi Viswavidyalaya PO: Kalyani – 741 235, Dist. Nadia, WB, India Mobile: +91-9433533598 Email: mandalbiswapati@rediffmail.com	• Soil inventorization • Conservation and management of coastal soil and other resources • Soil microbiology • Soil ecology
Prof. Rati Kanta Ghosh Professor, Department of Agronomy Bidhan Chandra Krishi Viswavidyalaya PO: Krishi Viswavidyalaya - 741 252, Dist: Nadia West Bengal, India, Mobile: +91-9433145340 Email: rkgbckv@rediffmail.com, rkgbckv@yahoo.com	• Crop husbandry in agricultural production system • Crop improvement/plant breeding in agricultural crops
Prof. Pranab Hazra Professor, Department of Vegetables Faculty of Horticulture Bidhan Chandra Krishi Viswavidyalaya PO: Krishi Viswavidyalaya - 741 252, Dist: Nadia West Bengal, India, Mobile: +91-9433259721 Email: hazrap@rediffmail.com	• Crop husbandry in horticultural production system • Crop improvement/breeding in horticultural crops
Prof. Atanu Sarkar Director of Extension Education Faculty of Horticulture Uttar Banga Krishi Viswavidyalaya PO: Pundibari, Pin - 736 165, Dist: Coochbehar West Bengal, India, Mobile: +91-9434686364 Email: dee_ubkv@yahoo.com	• Transfer of technology and human resource development for efficient coastal zone management
Prof. Abhijit Saha Associate Professor Department of Agro-meteorology Bidhan Chandra Krishi Viswavidyalaya PO: Kalyani - 741 235, Dist: Nadia, West Bengal, India Mobile: +91-9433317027 Email: asaha_bckv@yahoo.co.in	• Nature and extent of natural disaster: underlined meteorological and seismic factors, modelling approach for their predictions and post-disaster immediate and long term sustainable measures

Dr. K.K. Vass Director Central Inland Fisheries Research Institute, Barrackpore – 700120, West Bengal, India Mobile : +91-94330-30339 Email: kuldeepvaas@rediffmail.com	• Coastal aquaculture and enhancing productivity through an integrated approach • Environmental issues and disease management in coastal aquaculture system • Livelihood & socio-economic upliftment of coastal fisheries • Mechanization and value addition for coastal fisheries • Biodiversity conservation and genetic improvement • Participatory approach in coastal productivity management
Dr. Asis Bhattacharya Former Mission Director, Department of Space At present, Emeritus Scientist, Presidency College College Street, Kolkata - 700 009, India Mobile: +91-9433010382 Email: asisbh@yahoo.co.in	• Application of remote sensing and GIS for agriculture and allied activities • Communications and data networking for efficient coastal zone management
Dr. Sugata Hazra Director, School of Oceanographic Studies Jadavpur University, Kolkata - 700 032, India Phone: +91-33-24146628/24146242 Email: sugata_hazra@yahoo.com And **Dr. Pranabes Sanyal** Ex Additional Principal Chief Conservator of Forests 57 D, Purna Das Road, Kolkata - 700 029, India Mobile: +91-9433355760 Email: pranabes@hotmail.com	• Coastal and marine ecosystem, Marine microbiology • Protection of coastal and marine habitats • Problem of exotic and invasive marine species • Coastal zone management and tools
Dr. R. Kalpana Sastry Principal Scientist, Agricultural Research Systems Management and Policies Division National Academy of Agricultural Research Management, Hyderabad – 500 030 *Contact Address* 204, Arun Apartments, Red Hills Hyderabad - 500 008, India Phone: +91-40-24581304 (O) Mobile: +91-9848867225 Email: kalpana@naarm.ernet.in	• IPR - integration of science and policy issues • Legal, economic and social issues • Economic instruments • Restoration of livelihood • International aspects

* Authors are requested to send the papers to the Conveners or seek clarification if any with the Conveners for the respective sub-topics. They may also send the papers to the Society's office.

Registration fee

The following registration fees can be paid either in cash or through a Bank Draft payable on Kolkata (Calcutta) drawn in favour of **'Indian Society of Coastal Agricultural Research'.** The Registration Form duly filled in and signed along with the Bank Draft should be sent to Mr. S.K. Dutt, Treasurer, Indian Society of Coastal Agricultural Research, Central Soil Salinity Research Institute Regional Research Station, Canning Town, South 24 Parganas, West Bengal, India, PIN – 743 329, FAX: +91-3218-255084, Mobile: +91-9831189282, E-Mail: iscar.c@gmail.com , iscar.symposium@gmail.com , sanatdutt@gmail.com, iscar@rediffmail.com. Cancellation of registration at no stage is permitted and therefore registration fees will not be refunded in any case. Registrations including payment of registration charges can be made by normal mode of payment. The Registration form and the papers may also be submitted **online**.

Category	Without late fee (15th July 2007)		With late fee	
	SAARC Countries	International Delegates	SAARC Countries	International Delegates
Participants	Rs. 3000	200 US $	Rs. 4000	250 US $
Students/ Research Scholar	Rs. 1000	100 US $	Rs. 1500	150 US $
Accompanying person	Rs. 1000	100 US $	Rs. 1000	100 US $

General Information

Language
The language of the Symposium will be English. No interpretation or translation service can be provided.

Visas
All foreign delegates should possess a valid passport and a visa for India.

Health Requirement
A vaccination certificate against yellow fever is required for delegates arriving from or travelling through endemic areas in Africa and South America.

Customs
On arrival in India, please complete customs regulations formalities. Airports operate the conventional green and red channels. Valuable articles such as videos and cameras may be brought in subject to re-export and should be declared to the custom authorities. Duty free shopping is available on arrival and departure at the International Airport.

Currency
There is no restriction on the import of foreign currency into India. You may please transform or exchange some of your currency into Indian rupee at authorized money changers or banks.

Airport Tax
Rs. 500/- is payable at the time of International departure for all countries except Afghanistan, Bangladesh, Maldives, Myanmar, Nepal, Pakistan and Sri Lanka in which case the tax is Rs. 150.

Voltage
The electricity line voltage is 220 volt AC with 50 Hz frequency.

Medical Aid
Emergency medical aid will be available at the Symposium venue.

Important deadlines

• Symposium duration	**27-30, October 2007 (4 days)**
• Submission of Extended summary & Abstract	**15 July 2007**
• Submission of extended summary (Invited Lead Paper only)	**16 August 2007**
• Registration without late fee	**16 August 2007**
• Intimation for accommodation	**30 August 2007**
• Intimation for post symposium tour	**30 August 2007**

NOMINATIONS FOR THE AWARD OF FELLOWS

Nominations are invited for the award of **'Fellow of Indian Society of Coastal Agricultural Research'** for the year 2007-08. Four scientists will be awarded the fellow of the society from among the nominations received.

The nominated scientist should either be a life member of the society or annual member for the last 10 years. Nominations in the prescribed proforma (printed overleaf) must be proposed and seconded by a member of the society. Nominations must reach the office of the society latest by **15-08-2007**. All nominations must be accompanied by a bio-data of the nominated member and also a brief outline of his/her contributions to the development of agriculture in the coastal areas.

As per existing rules, all nominations received within the due date will be scrutinized by a selection committee headed by the president of the society and the award will be conferred on the selected member at the International Seminar of the Society to be held at Kolkata from 27-30 October, 2007.

NOMINATION FORM FOR THE AWARD OF "FELLOW" FOR 2007

To:
The Secretary, I.S.C.A.R.
CSSRI, RRS-Canning
P.O. Canning Town-743329,
Dist. South 24-Parganas, WEST BENGAL

Sub : Nomination for fellow of ISCAR for 2007

Dear Sir,

I do hereby nominate

Dr./Shri ....

Designation ....

Membership No: ....

for the award of 'Fellow' of Indian Society of Coastal Agril. Research for 2007

Proposed by :

Dr./Shri ....

Designation ....

Address ....

....

.... *(Signature of Proposer)*

....

Membership No: ....

Seconded by :

Dr./Shri ....

Designation ....

Address ....

....

.... *(Signature of Seconder)*

....

Membership No: ....

I do hereby agree to the above proposal.

(Signature of nominee)

N.B: All proposals must be accompanied by the bio-data of the nominee and his/her contributions to the development of agriculture in the coastal areas.

Tel : 03218-255085, 255241 *Fax : 03218-255084* *e-mail : iscar@rediffmail.com*

INDIAN SOCIETY OF COASTAL AGRICULTURAL RESEARCH

CENTRAL SOIL SALINITY RESEARCH INSTITUTE, REGIONAL RESEARCH STATION

P.O. Canning Town (743329), South 24 Parganas, West Bengal (India)

MEMBERSHIP APPLICATION FORM

To
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Indian Society of Coastal Agricultural Research
CSSRI, Regional Research Station,
P.O. Canning Town, South 24 Parganas, West Bengal (India)

Dear Sir,

I am sending herewith the sum of Rupees ....

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Signature

Please fill up the Form in BLOCK LETTERS

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