J. Indian Soc. Coastal Agric. Res. 39(1): 52-60 (2021)

Management of Nitrogen and Phosphorous in Green Gram (*Vigna radiata*) by Foliar Supplementation of Urea Phosphate in Acidic Inceptisols

M. MONICA, A. K. DASH, N. PANDA*, A. P. MISHRA, S. G. SAHU and M. PRUSTY

Department of Soil Science & Agricultural Chemistry,
Odisha University of Agriculture and Technology, Bhubaneswar - 751 003, Odisha, India

Received: 31.03.2021 Accepted: 06.05.2021

Foliar fertilization is key to correct the diagnosis of plant nutrient deficiencies. Under certain situations, the foliar application is more economical and efficient than soil application. Foliar fertilization of crops sometimes adds to soil fertilization. It provides more rapid utilization of nutrients by stomata in less time, particularly in the daytime. Foliar application of urea phosphate (UP), acidic water-soluble fertilizer, along with blanket fertilizer doses can influence the photosynthetic activity as well as yield, nutrient use efficiency and economics of the crop green gram. A field experiment was conducted during 2015-2016 to study the present hypothesis. The experimental design was laid out in randomized block design (RBD) with 3 replications having 10 treatments. These treatments were T_1: control (no nutrient); T_2: 50% of the recommended dose of fertilizer (RDF) for N and P; T_3: 75% of RDF for N and P; T_4: 100% RDF for N and P; T_5: 50% of RDF for N and P + twice foliar spray (FS) of 1% UP; T_6: 50% of RDF for N and P + twice FS of 2% UP; T_7: 75% of RDF for N and P + twice FS of 1% UP; T_8: 75% of RDF for N and P + twice FS of 2% UP; T_9: 100% of RDF for N and P + twice FS of 1% UP; T_{10}: 100% of RDF for N and P + twice FS of 2% UP. The total chlorophyll content in green gram leaves at different growth stages due to different treatments varied from 2.57 to 4.01 mg g^{-1} fresh weight. Irrespective of the treatments, an increasing trend of total chlorophyll content was observed up to 29 days of sowing and the highest content was observed with T_{10} (4.01 mg g^{-1} fresh weight). Yield attributes like grain (834.1 kg ha^{-1}) and straw (2535.4 kg ha^{-1}) yield were recorded highest with T_{10} (100% of RDF+twice FS of 2% UP) whereas the lowest value was observed with T_1. Similarly, uptake of nutrients (N-55.5 kg ha^{-1}; P-8.6 kg ha^{-1}; and K-27.0 kg ha^{-1}) in green gram leaves at harvest stages were also recorded maximum in T_{10}. The highest nutrient use efficiency (16.3 kg of grain per total kg of nutrient) was recorded with T_2 whereas apparent nutrient recovery of N (97.5 %) and K (26.3%) were recorded highest with T_{10}. The highest cost of cultivation (₹ 19025), gross income (₹ 38370), net return (₹ 19345) and benefit-cost ratio (2.02) was also observed with T_{10} (100% of RDF for N and P + twice FS of 2% UP).

(***Key words:*** *Foliar spray, Green gram, Nitrogen, Phosphorous, Urea Phosphate*)

India is the highest producer as well as consumer of pulses in the world and contributes 25.5% of total global pulse production. Green gram is the third important pulse crop of India, grown in nearly 8% of the total pulse area of the country. In Odisha, pulses are cultivated in an area of 20.8 lakh ha with a production of 10.6 lakh tonnes and productivity of 508 kg ha^{-1} out of which green gram shares 42% (Statista, 2020). Green gram is an important crop to overcome protein malnutrition. The efficient use of inputs is required to enhance the productivity of this important pulse crop. Nutrient management technology is oriented towards better utilization of nutrients that may be available readily and efficiently so that the nutrient uptake by plants can be maximized (Pandey, 1999).

Foliar fertilization provides more rapid utilization of nutrients and permits the correction of observed deficiencies in less time than would be required by soil application (Fageria *et al*., 2009, Monica *et al*., 2020a). It will work as a visible economic way to supplement the plant nutrients for more efficient fertilization (Panda and Mandal, 2018). It is also helpful for quick and efficient utilization of nutrients, elimination of losses through leaching and fixation as well as regulating the uptake of nutrients by the plant (Manonmani and Srimathi, 2009). However, the fertilizer source utilized for foliar application must be water-soluble for efficient foliar fertilization (Monica *et al*., 2020b). Foliar fertilization of water-soluble fertilizers involves application of the nutrients on the plant canopy through spraying and the

**Corresponding author:* E-mail: npandasoils@gmail.com

nutrients gets absorbed at the site of application (Prakash *et al*., 2011). Nutrient element depletion from leaves during this late period in the growing season may be a limiting factor affecting grain or pod formation and thus foliar fertilizer application during this period can prevent nutrient element depletion, and therefore, increase grain or pod yield (Chowdhury *et al*., 1985). However, aerial spraying of concentrated fertilizer (urea) on crop resulted in a rapid increase in the total leaf nitrogen (N) and chlorophyll contents (Humbert and Hanson, 1952). In addition, foliar fertilization is also credited for rapid correction of micronutrient deficiencies, enhancement in vegetative growth, photosynthetic pigments, and the number of root nodules (Yakout *et al*., 1984).

Field crop research on foliar fertilization was possibly started in the late 1940s and early 1950s (Girma *et al*., 2007). Unlike many technologies, its pace followed an unpredictable sequence of events. In the early 1980s, studies on foliar application of fertilizers investigated for selected crops, including cereals (Girma *et al*., 2007). However, the research was limited to crop such as green gram (*Vigna radiata* L.).

The information regarding the time and dose of application of water-soluble fertilizers in different crops are not sufficient. Therefore the present investigation was undertaken to study the effect of foliar application of urea phosphate for green gram crop and to determine the doses as well as the time of application of urea phosphate on the same crop.

MATERIALS AND METHODS

Experimental site and initial soil properties

The study was conducted in the farmer's field at village Tailasahi, Delang Block of Puri District, Odisha, India during *rabi* 2015 and 2016. The experimental site is located at 20°06′40″ N latitude and 85°44′3.6″ E longitude. This district is one of the coastal districts of Odisha, where more than 60% of farmers were cultivating green gram (*Vigna radiata*) as the second remunerative crop in *rabi* after *kharif* rice. The initial soil samples (0-15 cm depth) were collected before sowing the crop and the post harvest samples were collected from individual treatment plots. The soil samples were dried under shade, crushed, sieved through a 2 mm sieve and were preserved in polythene with proper label for soil chemical analysis by adopting standard methods as described by (Page *et al*. 1982; Panda, 2019). The texture of the experimental site was sandy loam (70.4% sand, 14.5% silt and 15.1% clay). The soil was acidic (pH 5.34) in reaction, non-hazardous with electrical conductivity (0.14 dS m^{-1}), medium in organic carbon content (6.3 g kg^{-1}), low in mineralizable nitrogen content (193 kg N ha^{-1}), Bray's available phosphorus (18.7 kg P_2O_5 ha^{-1}) and available potassium (NH_4OAc extractable) content (194 kg K_2O ha^{-1}).

Experimental design and treatment details

The experimental design of the present experiment was Randomised Block Design (RBD) with 3 replications and 10 treatments *viz*., T_1: control (no nutrient); T_2: 50% of the recommended dose of fertilizer (RDF) for N and P; T_3: 75% of RDF for N and P; T_4: 100% RDF for N and P; T_5: 50% of RDF for N and P + twice foliar spray (FS) of 1% UP; T_6: 50% of RDF for N and P + twice FS of 2% UP; T_7: 75% of RDF for N and P + twice FS of 1% UP; T_8: 75% of RDF for N and P + twice FS of 2% UP; T_9: 100% of RDF for N and P + twice FS of 1% UP; T_{10}: 100% of RDF for N and P + twice FS of 2% UP. In this study, urea phosphate was applied twice in the particular treatments as foliar spray one after 15 days after sowing (DAS) and another at 30 DAS. The recommended dose of fertilizer for the green gram crop taken is 20:40:40 N: P_2O_5:K_2O per hectare. The nitrogen and phosphorus were applied as per the treatments. However, the recommended dose of potassium was applied in the form of muriate of potash (MOP) to all plots equally. The crop green gram, cv- *NVL1*, seeds along with fertilizers was sown in the plots manually with a spacing of 20 cm x 10 cm after inoculation with rhizobium culture. The size of the individual plots were 4 m x 5 m.

Characteristics and preparation of urea phosphate solution

Urea phosphate a water soluble fertilizer contains 17% nitrogen (N) and 44% water soluble phosphorus (P_2O_5). It has 0.5% moisture by weight and 0.5% insoluble matter in solution. In this experiment, 1% and 2% of urea phosphate (UP) solution were prepared with distilled water having pH 6.9. The pH of the urea phosphate solution prepared with distilled water was found to be 2.2.

Time of application

Day timing of foliar fertilization is an important aspect for efficient absorption and also to avoid leaf injury of applied fertilizer materials (Fageria *et al*., 2009). For efficient absorption of foliar fertilization, leaf stomata's should be open and the temperature should not be too high to cause the burning of plant foliage. In the afternoon when the air temperature was low (after 3 pm) foliar fertilization was done in the present experiment.

Analysis of plant samples

The grains and straws after harvest were kept separately in envelopes, labelled properly and dried in a hot air oven at 60ºC. Each sample was ground separately with the help of a Willy mill to pass through 20 mesh sieve and was used for the analysis of different nutrient elements. As per the method outlined by (Piper, 1950; Panda, 2019), 1 g of ground plant sample was predigested with 20 ml of concentrated HNO_3 followed by digestion with 10 ml of diacid (HNO_3 : $HClO_3$ = 3:2) on a hot plate at 100ºC for elemental analysis. The content was then filtered and preserved for further analysis of plant nutrient. After suitable dilution of the aliquot, the samples were analyzed by standard instruments specific for a particular nutrient elements like N, P and K.

Analysis of total chlorophyll content

One gram of finely cut and well-mixed representative of leaf samples were taken in a clean mortar and grounded to a fine pulp with the addition of 20 mL of 80% acetone. It was then centrifuged at 5000 rpm for 5 minutes. The supernatant was transferred to a 100 mL volumetric flask and the absorbance was taken at 645 and 663 nm against the solvent 80% acetone as blank. The total chlorophyll content was calculated by using the following formula (Witham *et al*., 1971).

Total chlorophyll content (mg g^{-1} tissue) =

$$[20.2\,(A_{645}) + 8.02(A_{663})] \times \frac{V}{(1000 \times W)} \quad (1)$$

Where;

A = Absorbance at specific wavelengths

V = Final volume of chlorophyll extract in 80% acetone

W = Fresh weight of tissue extracted

Nutrient efficiency

The following formulas were also used for the analysis of nutrient efficiency in green gram.

Nutrient use efficiency (kg-grain kg-nutrient^{-1}) =

$$\frac{(GY_n - GY_0)}{(NU_n - NY_o)} \quad (2)$$

Where,

GY_n = Grain yield with nutrients

GY_0 = Grain yield without nutrients

NU_n = Nutrient uptake with added nutrients

NU_0 = Nutrient uptake without added nutrients

Apparent nutrient recovery (ANR) =

$$\frac{(\text{Nutrient uptake in nutrient treated plot - Nutrient uptake in control})}{(\text{Nutrient applied})} \times 100 \quad (3)$$

Harvest index

Harvest index of the crop was calculated based on the following formula

$$\text{Harvest Index (HI)} = \frac{\text{Economic yield (grain yield)}}{\text{Biological yield (Grain + Straw yield)}} \quad (4)$$

Statistical analysis

The mean value of data for the two years on different parameters was recorded at the end of the harvest of the crop. The data were statistically analyzed to correlate the findings. The analysis of variance (ANOVA) of different variables of different treatments was statistically calculated at p = 0.05 level of significance (Panse and Sukhatme, 1985)

RESULTS AND DISCUSSION

Photosynthetic activity

Total chlorophyll content in the leaves of the crop is an indicator of the performance of the photosynthetic activity. The results on the photosynthetic activity in terms of total chlorophyll content in green gram are depicted in Table 1. Total chlorophyll content of leaves collected at 15 DAS indicated significantly the highest value of 2.57 mg g^{-1} of fresh weight with T_{10} (100% of RDF for N and P + twice FS of 2% UP) whereas the lowest value of 1.56 mg g^{-1} of fresh weight was observed with T_1 (control). Total chlorophyll content due to application of T_9 (100% of RDF for N and P + twice FS of 1% UP) was not significantly higher than

Table 1. *Effect of urea phosphate on total chlorophyll content of green gram leaves at different growth stages*

Treatments	Chlorophyll content (mg g^{-1}) of fresh leaves			
	15 DAS	22 DAS	29 DAS	37 DAS
T_1	1.56	2.06	2.55	1.65
T_2	1.63	2.13	2.74	1.82
T_3	1.84	2.35	2.95	2.07
T_4	2.04	2.52	3.13	2.21
T_5	1.81	2.30	2.89	1.99
T_6	1.88	2.36	2.98	2.07
T_7	2.10	2.59	3.04	2.14
T_8	2.27	2.78	3.40	2.50
T_9	2.39	2.88	3.48	2.90
T_{10}	2.57	3.4	4.01	3.09
SEm	0.20	0.20	0.21	0.23
LSD (p = 0.05)	0.59	0.60	0.63	0.69

T_1: control (no nutrient); T_2: 50% of recommended dose of fertilizer (RDF) for N and P; T_3: 75% of RDF for N and P; T_4: 100% RDF for N and P; T_5: 50% of RDF for N and P + twice foliar spray (FS) of 1% UP; T_6: 50% of RDF for N and P + twice FS of 2% UP ; T_7: 75% of RDF for N and P + twice FS of 1% UP; T_8:75% of RDF for N and P+ twice FS of 2% UP; T_9: 100% of RDF for N and P + twice FS of 1% UP; T_{10}: 100% of RDF for N and P + twice FS of 2% UP

T_{10} (100% of RDF for N and P + twice FS of 2% UP). After 22 DAS a significantly highest total chlorophyll content of 3.41 mg g^{-1} of fresh weight was also observed with T_{10} (100% of RDF for N and P + twice FS of 2% UP) whereas the lowest value of 2.06 mg g^{-1} of fresh weight was observed with T_1 (control). For a particular level of nutrients, the chlorophyll content was higher due to the application of twice FS of 2% UP than that of 1% UP as more amount of nitrogen was applied through 2% foliar application which indirectly affects the chlorophyll content. At 29 DAS, significantly the highest total chlorophyll content of 4.01 mg g^{-1} fresh weight was recorded with T_{10} (100% of RDF for N and P + twice FS of 2% UP) and the lowest value of 2.55 mg g^{-1} fresh weight was observed with T_1. At 37 DAS of green gram, total chlorophyll content was 3.09 mg g^{-1} of fresh weight with T_{10} (100% of RDF for N and P + twice FS of 2% UP) whereas the lowest value of 1.65 mg g^{-1} fresh weight was observed with T_1 (control). The total chlorophyll content of green gram leaves at 37 DAS was less than that of the value observed with 29 DAS. Total chlorophyll content was increased from 15 DAS to 29 DAS and thereafter the value was decreased at 37 DAS. It was indicated that the mean total chlorophyll content was increased with an increased dose of nutrient due to the availability of more nitrogen which is helpful for the formation of more chlorophyll. Chlorophyll content increased up to the active vegetative growth stage and thereafter the value decreased during the reproductive stage (Pramanik *et al*., 2013). The mechanism might be due to polar and lipophilic transport systems of leaf cuticle that allow fertilizer molecules to move from the external to the internal environment through foliar spray which increases the leaf N content (O'Connor *et al*., 2018) as well as the total chlorophyll content.

Yield and yield attributes

Yield is the product of multiplicative interactions of several yield attributing components (Burtan and Devane, 2008). The influence of foliar supplementation of UP along with the recommended dose of nutrients on yield and yield attributing characters of the test crop green gram is depicted in Table 2. Significantly highest pod yield of 834.1 kg ha^{-1} was observed with T_{10} (100% of RDF for N and P + twice FS of 2% UP) whereas the lowest value of 720.8 kg ha^{-1} was observed with T_1

Table 2. *Effect of urea phosphate on yield and yield attributing characters of green gram*

Treatments	Pod yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
T_1	686.8	2181.0	31.5
T_2	737.4	2232.3	33.0
T_3	746.9	2262.3	33.0
T_4	774.1	2332.9	33.2
T_5	754.5	2281.2	33.1
T_6	769.8	2320.7	33.2
T_7	766.3	2261.5	34.0
T_8	787.3	2371.9	33.2
T_9	801.6	2439.9	33.0
T_{10}	834.1	2535.4	32.9
SEm	21.42	63.90	-
LSD (p = 0.05)	63.65	189.87	-

T_1: control (no nutrient); T_2: 50% of recommended dose of fertilizer (RDF) for N and P; T_3: 75% of RDF for N and P; T_4: 100% RDF for N and P; T_5: 50% of RDF for N and P + twice foliar spray (FS) of 1% UP; T_6: 50% of RDF for N and P + twice FS of 2% UP ; T_7: 75% of RDF for N and P + twice FS of 1% UP; T_8:75% of RDF for N and P+ twice FS of 2% UP; T_9: 100% of RDF for N and P + twice FS of 1% UP; T_{10}: 100% of RDF for N and P + twice FS of 2% UP (control). The yield advantage of 2.3, 3.6 and 7.4% were recorded with T_2 (50% of RDF for N and P), T_3 (75% of RDF for N and P) and T_4 (100% of RDF for N and P) respectively over control, whereas the pod yield due to T_2, T_3 and T_4 were not significant with each other. The yield advantage of 2.3 and 4.4 % was observed with T_5 (50% of RDF for N and P+ twice FS of 1% UP) and T_6 (50% of RDF for N and P + 2% FS of UP) respectively over T_2 (50% of RDF for N and P). The yield advantage of 3.5% and 5.4% was observed with T_7 (75% of RDF for N and P+ twice FS of 1% UP) and T_8 (75% of RDF for N and P+ twice FS of 2% UP) respectively over T_3 (75% of RDF for N and P). Yield advantage of 3.5 and 7.8% was observed with T_9 (100% of RDF for N and P + twice FS with 1% UP) and T_{10} (100% of RDF for N and P + twice FS of 2% UP) respectively over T_4 (100% of RDF for N and P). In all the three cases, it was observed that the grain yield of green gram was higher due to combined application of soil as well as foliar application of UP than that of soil application of nutrients alone. The pod yield of green gram was higher due to foliar application of 2% UP than that of 1% foliar spray. These results are in accordance with the finding of (Lavanya and Ganapathy, 2011). Rapid absorption of nutrients from foliar fertilization of urea phosphate through leaf cuticle is thought to be more efficient than that of other fertilizers due to its smaller size and neutral charge (O'Connor *et al*., 2018).

Significantly highest mean stover yield of 2535.4 kg ha^{-1} was observed with T_{10} (100% of RDF for N & P+ twice FS of 2% UP) whereas the lowest value of 2181.0 kg ha^{-1} was observed with T_1 (control). Stover yield was increased due to the combined application of nutrients in the soil as well as foliar application of UP than that of nutrient applied in soil irrespective of the level of nutrients applied alone. This result conforms with the findings of Rathod *et al.* (2012).

The harvest index is the ratio of pod yield and the total above-ground biomass that indicates the efficiency of the crop to assimilate partition to the economic parts. In the present study, the highest harvest index of 33.9% was observed with T_7 (75% of RDF for N and P + twice FS of 1% UP) whereas the lowest value of 31.5% was observed with T_1 (control). Harvest index was increased with increasing level of nutrients applied in the soil. Combined application of plant nutrients through the soil and foliar spray recorded a higher amount of harvest index than that of nutrients applied through soil alone. This value was increased with the combined application of nutrient up to 75% of RDF for N and P along with a foliar spray of 1% UP. But the value was decreased with the combined application of 100% of RDF N and P with foliar spray of either 1% or 2% UP. Similar work was also carried out by Jagathjothi *et al*. (2012) and Azarpour *et al*. (2014).

Nutrient uptake

Total nutrient uptake was calculated by adding the uptake of nutrient by green gram grain and stover. Nutrient content was multiplied with the yield to express the nutrient uptake by the crop. The present investigation revealed that, highest total nitrogen uptake of 55.50 kg N ha^{-1} was recorded (Table 3) with T_{10} (100% of RDF for N and P + twice FS of 2% UP) whereas the lowest value of 32.47 kg N ha^{-1} was recorded with T_1 (control). The nitrogen uptake by T_1 (control) was not significant with T_2 (50% of RDF for N and P), T_3 (75% of RDF for N and P) whereas the value was significantly higher with T_4 (100% of RDF for N and P). The nitrogen uptake was increased with increasing doses of nutrient

Table 3. *Effect of foliar supplementation of urea phosphate on nutrient uptake by green gram*

Treatments	Total nutrient uptake (kg ha^{-1})		
	Nitrogen (N)	Phosphorus (P)	Potassium (K)
T_1	32.5	3.4	15.5
T_2	35.9	5.3	20.0
T_3	38.3	5.7	21.8
T_4	41.2	6.6	23.5
T_5	41.0	6.5	21.0
T_6	42.6	6.8	21.6
T_7	41.8	6.7	22.2
T_8	45.9	7.1	23.6
T_9	44.6	7.7	25.0
T_{10}	55.5	8.6	27.0
SEm	2.49	0.54	0.82
LSD (p = 0.05)	7.41	1.62	2.43

T_1: control (no nutrient); T_2: 50% of recommended dose of fertilizer (RDF) for N and P; T_3: 75% of RDF for N and P; T_4: 100% RDF for N and P; T_5: 50% of RDF for N and P + twice foliar spray (FS) of 1% UP; T_6: 50% of RDF for N and P + twice FS of 2% UP ; T_7: 75% of RDF for N and P + twice FS of 1% UP; T_8:75% of RDF for N and P+ twice FS of 2% UP; T_9: 100% of RDF for N and P + twice FS of 1% UP; T_{10}: 100% of RDF for N and P + twice FS of 2% UP applied in soil. Significantly highest phosphorus uptake of 8.62 kg P ha^{-1} was recorded (Table-3) with T_{10} (100% of RDF for N and P + twice FS of 2% UP) whereas the lowest value of 3.43 kg P ha^{-1} was recorded with T_1 (control). Total phosphorus uptake was increased due to the addition of graded doses of nutrients and in T_2, T_3 and T_4 it was significantly higher as compared to T_1.

Significantly highest potassium uptake 27.02 kg K ha^{-1} was recorded with T_{10} (100% RDF + twice FS of 2% UP) whereas the lowest value of 15.54 kg K ha^{-1} was recorded with T_1 (control). This might be due to the synergistic effect of N and P with K. However, an uptake value of 20.02 kg K ha^{-1} was recorded with T_2 (50% RDF) as compared to T_1 where a value of 15.54 kg K ha^{-1} was recorded. The uptake value due to the imposition of T_3 (75% RDF) was not significantly higher than that of T_2 (50% RDF). But it was significantly higher than that of T_1. Total potassium uptake value (23.53 kg K ha^{-1}) due to T_4(100% of RDF) was significantly higher than that of T_1. It was observed that at a particular level of nutrient, application of 2% UP foliar spray recorded a higher amount of total nutrients uptake than that of 1% UP foliar spray. The combined application of nutrient through the soil along with foliar spray recorded higher nutrient uptake than that of the nutrient applied through soil alone. This might be due to the availability of more nutrients which was taken up by the plants in more quantity. The probable mechanism may be the number of aqueous pores depends on the cuticle type, number of stomata or trichomes and pH of the fertilizer solution applied to the cuticle and thus it enhances the nutrient concentration in the cell sap through both stomata as well as aqueous pores (Eichert, 2013).

Nutrient use efficiency

Nutrient use efficiency (NUE) is crucial to develop strategies for improvement in agroecosystems particularly rice-pulse ecosystems (Jagathjothi *et al*., 2012; Pramanik and Bera, 2013). It is the response in pod yield per unit of fertilizer nutrient applied. The results pertaining to the nutrient efficiencies of green gram is presented in Table 4. The highest nutrient use efficiency (16.0 kg of grain kg $nutrient^{-1}$) was observed with T_5 (50% of RDF for N and P + twice FS of 1% UP) whereas the lowest value of 11.0 kg of grain per kg of nutrient observed with T_4 (100% of RDF for N and P). Nutrient use efficiency was reduced due to an increase in nutrient levels in T_2 (50% of RDF for N and P), T_3 (75% RDF) and T_4 (100% RDF) treatments. Due to the addition of 75% of RDF for N and P, the nutrient use efficiency was reduced than the addition of 50% RDF. The efficiency value was reduced due to the addition of 100% of RDF for N and P in T_9 and T_{10}. A nutrient use efficiency of 11.2 kg grain per kg nutrient was observed with T_{10} (100% of RDF for N and P + twice FS of 2% UP) as compared to that of T_9 (100% of RDF for N and P + twice FS of 1% UP).

***Table 4.** Effect of urea phosphate foliar application on nutrient use efficiency by green gram*

Treatments	Nutrient use efficiency	Apparent recovery (%)		
		N	P	K
T_1	-	-	-	-
T_2	16.3	34.0	9.2	22.4
T_3	14.1	39.2	7.4	20.9
T_4	11.0	43.6	7.8	20.0
T_5	16.0	71.8	13.8	24.5
T_6	15.7	74.6	14.4	25.7
T_7	14.2	48.6	10.3	19.4
T_8	13.9	72.3	11.0	24.0
T_9	11.2	55.8	10.3	22.6
T_{10}	11.2	97.5	11.9	26.3

T_1: control (no nutrient); T_2: 50% of recommended dose of fertilizer (RDF) for N and P; T_3: 75% of RDF for N and P; T_4: 100% RDF for N and P; T_5: 50% of RDF for N and P + twice foliar spray (FS) of 1% UP; T_6: 50% of RDF for N and P + twice FS of 2% UP ; T_7: 75% of RDF for N and P + twice FS of 1% UP; T_8:75% of RDF for N and P+ twice FS of 2% UP; T_9: 100% of RDF for N and P + twice FS of 1% UP; T_{10}: 100% of RDF for N and P + twice FS of 2% UP

Highest apparent recovery of N (97.5%) was observed with T_{10} (100% of RDF for N and P + twice FS of 2% UP) whereas the lowest value of 34.0% was observed with T_2 (50% of RDF for N & P). Nitrogen apparent recovery of 39.2% was observed with T_3 (75% of RDF for N and P) which was higher than T_2 (50% of RDF for N and P) and lower than the value (43.6 %) recorded with T_4 (100% of RDF for N and P). Similarly, a value of 74.6% was observed with T_6 (50% of RDF for N and P + twice FS of 2% UP) than the value of 71.8% recorded with T_5 (50% of RDF for N and P + twice FS of 1% UP). In T_8 (75% of RDF for N and P + twice FS of 2% UP) it was 72.3% than that of 48.6% with T_7 (75% of RDF for N and P + twice FS of 1% UP). The highest apparent phosphorus recovery (14.42%) was observed with T_6 (50% of RDF for N and P + twice FS of 2% UP) whereas the lowest value of 7.41% was observed with T_3 (75% of RDF for N and P). Apparent potassium recovery was recorded highest with T_{10} (100% of RDF for N and P + twice FS of 2% UP). A definite pattern of change in N, P and K apparent recovery was not seen in crop green gram.

Economics

The benefit-cost ratio of different treatments taking green gram as the test crop is presented in Table 5. The highest benefit-cost ratio (2.02) was observed with T_{10} (100% of RDF for N & P + twice FS of 2% UP) whereas the lowest value of 1.9 was observed with T_1 (control). The benefit-cost ratio was slightly higher due to the application of graded doses of nutrient application. Benefit-cost ratio (1.99) was the same for both T_5 (50% of RDF for N and P + twice FS of 1% UP) and T_6 (50% of RDF for N and P + twice FS of 2% UP). The benefit-cost ratio was slightly higher (1.97) for T_8 (75% of RDF for N and P + twice FS of 2% UP) than that of values of 1.95 observed in T_7 (75% of RDF for N and P + twice FS of 1% UP). This higher income was because full application of the recommended dose of nutrient along with supplemental nutrients as foliar spray of urea phosphate increased the crop yield by over 7.19% over the treatment where only recommended dose of nutrients were apllied. A similar type of result was also reported by Monica *et al*. (2020b).

Table 5. *Economics of urea phosphate foliar application in green gram*

Treatments	Total cost (₹)	Gross income (₹)	Net return (₹)	B:C
T_1	16600	31094	15194	1.87
T_2	17115	33920	16805	2.00
T_3	17747	34359	16611	1.94
T_4	18380	35607	17227	1.94
T_5	17440	34708	17268	2.00
T_6	17765	35409	17644	2.00
T_7	18072	35251	17179	2.00
T_8	18397	36216	17818	2.00
T_9	18705	36872	18167	1.97
T_{10}	19025	38370	19345	2.02

T_1: control (no nutrient); T_2: 50% of recommended dose of fertilizer (RDF) for N and P; T_3: 75% of RDF for N and P; T_4: 100% RDF for N and P; T_5: 50% of RDF for N and P + twice foliar spray (FS) of 1% UP; T_6: 50% of RDF for N and P + twice FS of 2% UP ; T_7: 75% of RDF for N and P + twice FS of 1% UP; T_8:75% of RDF for N and P+ twice FS of 2% UP; T_9: 100% of RDF for N and P + twice FS of 1% UP; T_{10}: 100% of RDF for N and P + twice FS of 2% UP

From this study, it was concluded that application nutrients like N and P as urea phosphate through foliar supplementation along with soil applied nutrients produced higher pod yield and yield attributes than that of only soil applied nutrients. A significant variation in photosynthetic activity on foliar supplementation of UP was also recorded in terms of total chlorophyll content. Among the foliar supplementation, 2% UP applied twice produced more pod yield and stover yield than that of 1% UP, irrespective of soil applied nutrients. The benefit-cost ratio and economics of crop green gram were observed better with 100% RDF (N and P) as soil application along with 2% UP as foliar supplementation. The nutrient use efficiency was better with treatments receiving 50% RDF with 1% UP as foliar supplementation (T_5). Whereas, the apparent nutrient recovery of nutrients like N and P were better in treatments T_{10} (100% of RDF for N and P + twice FS of 2% UP) and T_6 (50% of RDF for N and P + twice FS of 2% UP) respectively. Hence foliar supplementation of urea phosphate @2% at 15 DAS and 30 DAS could enhance the photosynthetic activity, pod yield and economics of green gram as compared to soil applied nutrients alone.

ACKNOWLEDGEMENTS

Authors are highly thankful to IFFCO, New Delhi for providing the fund for carrying out the experiment.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Azarpour, E., Moraditochaee, M. and Bozorgi, H.R. (2014). Effect of nitrogen fertilizer management on growth analysis of rice cultivars. *International Journal of Bioscience* **4**(5): 35-47.

Burton, G.W. and Devane, E.M. (2008). Breeding for yield potential and stress adaptation in cereals. *Critical Reviews in Plant Sciences* **27**: 377-412.

Chowdhury, I.R., Paul, K.B., Eivazi F. and Bleich, D. (1985). Effects of foliar fertilization on yield, protein, oil and elemental composition of two soybean varieties. *Communications in Soil Science* *and Plant Analysis* **16**(7): 681-692.

Eichert, T. (2013). Foliar nutrient uptake - of myths and legends. In Acta Horticulturae 984: Proceedings of the VIIth IS on *Mineral Nutrition of Fruit Crops*, S . Poovarodom and S. Yingjajaval (eds.), 69-76.

Fageria, N.K., Barbosa Filho, M.P., Moreira, A., Guimaraes, C.M. (2009). Foliar fertilization of crop plants. *Journal of Plant Nutrition* **32**: 1044-1064

Girma, K., Martin K. L., Freeman K.W., Mosali J., Teal R. K., Raun W. R., Moges S. M., and Arnall D. B. (2007). Determination of optimum rate and growth for foliar applied phosphorus in corn. *Communications in Soil Science and Plant Analysis* **38**: 1137-1154.

Humbert, R.P. and Hanson, N.S. (1952). *Spec. Release No. 64, Plantation Archives*, Hawaiian Sugar Planter Association., Lihue Plantation Company, Lihue, Kauai, pp. 1-11.

Jagathjothi, N., Muthukrishnan, P. and Amanullah, M.M. (2012). Influence of foliar nutrition on growth and yield of transplanted rice. *Madras Agricultural Journal* **99**(4-6): 275-278.

Lavanya, G.A. and Ganapathy, M. (2011). Effect of DAP, NAA and residual effect of inorganic fertilizers and organic manures on growth and yield of green gram in rice based cropping sequence. *Journal of Agricultural Technology* **7**(3): 599-604.

Manonmani, V. and Srimathi, P. (2009). Influence of mother crop nutrition on seed and quality of blackgram. *Madras Agricultural Journal* **96**(16): 125-128.

Monica, M., Dash, A. K., Panda, N. and Prusty, M. (2020a). Effect of urea phosphate foliar supplementation on yield, nutrient uptake and grain quality of rice (*Oryza sativa* L.) in acid Inceptisols. *ORYZA-An International Journal on Rice* **57**(2):132-138

Monica, M., Dash, A. K., Panda, N., Sahu, S.G., Prusty, M. and Pradhan, P.P. (2020b). Photosynthetic activity, yield, nutrient use efficiency and economics of rice (*Oryza sativa* L.) as influenced by foliar supplementation of urea phosphate. *Journal of the Indian Society of Soil Science* **68**(4): 423-430.

O'Connor, K., Hébert, F., Powers, J.E., Jordan, K.S. and Lyons, E.M. (2018). Leaf morphology explains the disparity between annual bluegrass and creeping bentgrass growth under foliar fertilization. *Journal of Plant Nutrition* **41**(5): 596-608.

Page, A.L., Millar, R.H. and Keeney, D.R. (1982). *Methods of Soil Analysis: Part 2, Chemical and Microbiological Properties*, 2nd edition, No. 9, Soil Science Society of America, Madison, Wisconsin, USA.

Panda, N. (2019). *Soil, Plant, Water and Seed Testing: A Text Book*, Kalyani Publishers, New Delhi, India.

Panda, N. and Mandal, P. (2018). Effect of foliar application of micronutrients on yield, nutrient uptake and storage quality of onion (*Allium cepa L.*) grown in *Alfisols. Journal of the Indian Society of Coastal Agricultural Research* **36**(2): 86-91.

Pandey, S. (1999). Adoption of nutrient management technologies for rice production: economic and institutional constraints and opportunities. *Nutrient Cycling in Agroecosystems* **53**: 103-111.

Panse, V.G. and Sukhatme, P.V. (1985). *Statistical Methods for Agricultural Workers*, Indian Council of Agriclutural Research, New Delhi, India.

Piper, C.S. (1950). *Soil and Plant Analysis*, University of Adelaide, Australia.

Prakash, N.B., Chandrashekar, N., Mahendra, C., Patil, S. U., Thippeshappa, G. N. and Laane, H. M. (2011). Effect of foliar spray of soluble silicic acid on growth and yield parameters of wetland rice in hilly and coastal zone soils of Karnataka, South India. *Journal of Plant Nutrition* **34**(12):1883-1893.

Pramanik, K. and Bera, A.K. (2013). Effect of seedling age and nitrogen fertilizer on growth, chlorophyll content, yield and economics of hybrid rice. *International Journal of Agronomy and Plant Production* **4**(S): 3489-3499.

Rathod, S.L. and Gawande, M.B. (2012). Response of greengram varieties to different fertilizer grades. *International Journal of Science and Research* **3**(7): 1313-1315.

Statista (2020). *Volume of Pulses Production across Odisha in India from Financial Year 2009 to 2019*, Published by Statista Research Department, Nov 24, 2020, https://www.statista.com/statistics/1020218/india-pulses-production-volume-in-odisha.

Witham, F.H., Blaydes, D.F. and Devlin, R.M. (1971). *Experiments in Plant Physiology*, Van Nostrand, New York, USA. 245 p.

Yakout, G.M., Saad, A.M., Ashour, N.I., and Thalooth. A.T. (1984). Response of soybeans to combined foliar and soil fertilization. In: *World Soybean Research Conference – III*, Iowa State University, Ames, Iowa, USA. p. 95.