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Original Research Article

Effect of Various Sources of Nitrogen and Phosphorus on Growth, Yield and Economics of Summer Green Gram (*Vigna radiata* L. Wilczek)

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Green gram, Nitrogen, Phosphorus, *rhizhobium*, PSB and vermicompost

A B S T R A C T

A field experiment was conducted at the College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand to evaluate the effect of various sources of nitrogen and phosphorus on growth and yield attributes of summer green gram (*Vigna radiata* L. Wilczek) during summer season of 2018-19. The experiment consists of fifteen treatment combinations comprised of five levels of nitrogen sources (N_1: only inoculation with *rhizobium*, N_2: 20 kg N/ha through vermicompost, N_3: 10 kg N/ha through vermicompost + inoculation with *rhizobium*, N_4: 20 kg N/ha through neem cake and N_5: 10 kg N/ha through neem cake + inoculation with *rhizobium*) and three levels of phosphorus sources (P_1: 20 kg P_2O_5/ha + inoculation with PSB, P_2: 40 kg P_2O_5/ha and P_3: 40 kg P_2O_5/ha + inoculation with PSB). The results revealed that application of vermicompost @ 20 kg N/ha recorded significantly higher growth and yield attributes among the various sources of nitrogen applied. While significantly higher growth and yield attributes were obtained with application of 40 kg P_2O_5/ha + PSB inoculation in green gram. The application of 20 kg N/ha through vermicompost and 40 kg P_2O_5/ha + inoculation with PSB secured the higher BCR of 3.06 and 2.99, respectively.

Introduction

The production of pulses however, does not commensurate with the demand in the country. The per capita availability of pulses in India has been continuously decreasing which is at present 55.90 g/day/capita against the minimum requirement of 85 g/day/capita for balanced diet as recommended by World Health Organization (WHO) and Food and Agricultural Organization (FAO). It is the high time to cultivate pulses crops scientifically with increasing area (Patel *et al.*, 2013).

Green gram [*Vigna radiata* L. Wilczek] is one of the most ancient and extensively grown leguminous crops of India. It is the third important pulse crop after chickpea and pigeon pea, cultivated throughout India for its multipurpose uses as vegetable, pulse, fodder and green manure crop (Karpechenko, 1925). Its seed is more palatable, nutritive, digestible and non-flatulent than other pulses grown in world. It is a good source of protein (20-24%), carbohydrates (60-62%), water (10%), fat (1.0%), fiber (4.0%) and ash (3.0%). Owing to all these characteristics, it is considered a good substitute of animal protein and forms a balanced diet when it is taken with cereals (Delice *et al*., 2011).

Among the various factors of crop production, proper management of fertilization plays a pivotal role in increasing green gram production next to variety and irrigation. Optimum fertilizer application either in form of organic or inorganic is one of the well-established techniques for increasing crop production.

Integration of organic manures and inorganic fertilizer materials has been found to be promising not only in maintaining higher productivity of crops and for providing stability in crop production, besides improving soil physical conditions (Hati *et al.*, 2007). Biofertilizers, a component of integrated nutrient management and are considered to be cost effective, eco-friendly and renewable source of non-bulky, low cost plant nutrient supplementing fertilizers in sustainable agriculture system in India (Rao, 2007).

Vermicompost is an organic manure produced by earthworm feeding on biological waste material and plant residue & it contains 2.1-2.6% N, 1.5-1.7% P and 1.4-1.6% K, 10 to 52 ppm Cu, 186.60 ppm Zn, 930.00 ppm Fe and plant growth promoting substances such as NAA, cytokinins, gibberellins, *etc.* (Giraddi *et al*., 2006). Neem cake is the residue obtained from neem seed kernels which have been crushed to extract the oil & it contains 5.2% N, 1.0% P and 1.4% K. Neem cake reduces alkalinity in soil, as it produces organic acid on decomposition.

Nitrogen is an important element for the growth and development of most plants. Nitrogen is also an integral part of chlorophyll, which is the primary absorber of light energy needed for photosynthesis. The Supply of nitrogen is related to carbohydrate utilization. Phosphorus is second most critical plant nutrient. But for pulses, it assumes primary importance, owing to its important role in root proliferation, which are the seat of biological N fixation and helps plants to draw nutrients from lower layers and consequently thrive under moisture stress conditions. Application of phosphorus also plays an important role in growth, development and maturity of crop. Hence, phosphorous has referred to as the *"master key element"* in crop production (Taliman *et al.,* 2019).

Materials and Methods

A field experiment was carried out at the College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand to elicit the effect of various sources of nitrogen and phosphorus on growth and yield attributes of summer green gram (*Vigna radiata* L. Wilczek) during summer season of 2018-19. The experiment was laid out in randomized block design (Factorial) and replicated four times. There were 15 treatment combinations comprising 5 levels of nitrogen sources (N_1: only inoculation with *rhizobium*, N_2: 20 kg N/ha through vermicompost, N_3: 10 kg N/ha through vermicompost + inoculation with *rhizobium*, N_4: 20 kg N/ha through neem cake and N_5: 10 kg N/ha through neem cake + inoculation with *rhizobium*) and 3 levels of phosphorus sources (P_1: 20 kg P_2O_5/ha + inoculation with PSB, P_2: 40 kg P_2O_5/ha and P_3: 40 kg P_2O_5/ha + inoculation with PSB). The entire quantity of vermicompost, neem cake and SSP fertilizers were applied as basal application before sowing of crop. *Rhizobium* and PSB were applied as seed treatment (5 ml/kg seed) and at 30 DAS as soil drenching (1 lit./ha). The soil of experimental field was loamy sand in texture, low in nitrogen (240.4 kg N/ha), medium in available phosphorus (46.37 kg P_2O_5/ha) and high in available potash (303.4 kg K_2O/ha). For the plot observation, selected five random plants in net plot area and tagged it for further observation.

Results and Discussion

Effect of sources of nitrogen

The results (Table 1) revealed plant population at 20 DAS and at harvest were found non-significant due to application of various sources of nitrogen in green gram. The growth characters *viz.*, plant height at 30, 60 DAS and at harvest (16.31, 44.22 and 46.75 cm respectively), number of nodules per plant (36.98), dry weight of nodules per plant (45.66 mg/plant) and number of branches per plant (5.02) showed significant improvement with application of 20 kg N/ha through vermicompost (N_2). However, it also remained at par with treatment N_4 in terms of plant height 60 DAS and at harvest and treatment N_3 with respect to all above mentioned growth characters except plant height at 30 DAS and number of branches per plant. It might be due to basal application of vermicompost supplied all essential nutrients, growth hormones and enzymes to plant, which favours rapid cell division and ultimately results into better growth of plant. These results are in collaborated with research findings reported by Murugan *et al.* (2011), Bahadur & Tiwari (2014), Prajapati (2014), Kachariya (2015) and Singh *et al.* (2017) in green gram crop.

It is evident from the data presented in Table 2 that significantly higher number of pods per plant (33.81), number of seeds per pod (11.85), seed yield (1395 kg/ha) and haulm yield (1971 kg/ha) were obtained with application of 20 kg N/ha through vermicompost (N_2) and remained at par with treatment N_4 & N_3 in green gram. While application of various sources of nitrogen did not indicate any significant variation on harvest index and test weight in green gram. Vermicompost application might have increased the efficiency of added chemical fertilizer in soil, activities of N fixing bacteria and increased rate of humification. Humic acid in vermicompost might have enhanced the availability of both native and added nutrients in soil and as a result improved growth and yield attributes and yield of the crop significantly. Vermicompost also supply phosphorus which increased availability of phosphorus in soil, being a major structural element of cell and helped in cell elongation, greater availability of photosynthates, metabolites and nutrients to develop reproductive structures which ascribed to increased growth parameters and lead to higher yield attributes and yields of green gram crop. These results are in conformity with those reported by Kachariya (2015), Sardar *et al.* (2016), Rajkhowa *et al.* (2017) and Bhadu *et al.* (2018) in green gram.

The highest net returns of 54,903 ₹ /ha was obtained with application of 20 kg N/ha through vermicompost (N_2) followed by application of 10 kg N/ha through vermicompost + inoculation with *rhizobium* (N_3). While the lowest value (32,626 ₹ /ha) was recorded with only inoculation of seed with *rhizobium* (N_1). In case of BCR, the highest value of 3.06 was recorded under treatment N_3 (10 kg N/ha through vermicompost + inoculation with *rhizobium*) and it was followed by N_2 treatment (20 kg N/ha through vermicompost). It might be due to less cost of cultivation incurred and more net returns obtained under N_3 treatment as compared to other treatments (Table 3).

Table.1 Effects of various sources of nitrogen and phosphorus on growth attributes of summer green gram

Treatments	Pl. pop^n (per meter row length)		Pl. height (cm)			No. of nodules/pl.	Dry wt. of nodules (mg/pl.)	No. of branches/pl.
	Initial	Harvest	30 DAS	60 DAS	At harvest			
Sources of nitrogen (N)								
N_1	9.09	8.90	13.85	39.39	41.43	36.33	44.45	3.30
N_2	9.59	9.36	16.31	44.22	46.75	36.98	45.66	5.02
N_3	9.32	9.16	15.05	42.82	44.91	35.48	43.30	4.17
N_4	9.46	9.22	15.62	43.63	45.42	32.97	38.90	4.60
N_5	9.21	9.09	14.88	41.94	43.75	33.85	40.27	3.85
S.Em. ±	**0.21**	**0.17**	**0.33**	**0.76**	**0.78**	**0.80**	**1.30**	**0.12**
C.D. at 5 %	**NS**	**NS**	**0.94**	**2.18**	**2.23**	**2.28**	**3.71**	**0.35**
Sources of phosphorus (P)								
P_1	9.22	9.01	14.58	41.38	43.34	33.99	40.28	3.59
P_2	9.35	9.17	15.08	42.31	44.50	35.16	42.82	4.20
P_3	9.44	9.27	15.77	43.51	45.52	36.21	44.45	4.77
S.Em. ±	**0.16**	**0.13**	**0.25**	**0.59**	**0.60**	**0.62**	**1.01**	**0.10**
C.D. at 5 %	**NS**	**NS**	**0.73**	**1.69**	**1.73**	**1.77**	**2.88**	**0.27**
N × P interaction								
S.Em. ±	**0.36**	**0.30**	**0.57**	**1.32**	**1.35**	**1.38**	**2.25**	**0.22**
C.D. at 5 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C.V. %	**7.65**	**6.51**	**7.52**	**6.25**	**6.09**	**7.88**	**10.60**	**10.27**

Table.2 Effects of various sources of nitrogen and phosphorus on yield attributes of summer green gram

Treatments	No. of pods/pl.	No. of seeds/pod	Seed yield (kg/ha)	Haulm yield (kg/ha)	Harvest index (%)	Test wt. (g)
Sources of nitrogen (N)						
N_1	26.89	10.37	875	1368	39.28	43.24
N_2	33.81	11.85	1395	1971	41.63	45.03
N_3	31.28	11.07	1300	1822	41.39	44.15
N_4	32.98	11.42	1330	1880	41.29	44.82
N_5	29.85	10.78	1140	1553	42.49	43.65
S.Em. ±	**0.91**	**0.28**	**35**	**54**	**1.11**	**0.64**
C.D. at 5 %	**2.59**	**0.81**	**101**	**154**	**NS**	**NS**
Sources of phosphorus (P)						
P_1	28.59	10.63	1047	1525	40.95	43.35
P_2	31.24	11.14	1251	1759	41.31	44.33
P_3	33.06	11.52	1327	1872	41.39	44.86
S.Em. ±	**0.70**	**0.22**	**27**	**42**	**0.86**	**0.50**
C.D. at 5 %	**2.01**	**0.63**	**78**	**119**	**NS**	**NS**
N × P interaction						
S.Em. ±	**1.57**	**0.49**	**61**	**94**	**1.92**	**1.11**
C.D. at 5 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C.V. %	**10.17**	**8.85**	**10.14**	**10.89**	**9.32**	**5.04**

Table.3 Effects of various sources of nitrogen and phosphorus on economics of summer green gram

Treatments	Yields (kg/ha)		Gross realization (₹ /ha)	Cost of cultivation (₹ /ha)	Net realization (₹ /ha)	BCR
	Grain	Stover				
Sources of nitrogen (N)						
N_1	875	1368	53868	21242	32626	2.54
N_2	1395	1971	85671	30768	54903	2.78
N_3	1300	1822	79822	26075	53747	3.06
N_4	1330	1880	81680	30386	51294	2.69
N_5	1136	1553	69713	25884	43829	2.69
Sources of phosphorus (P)						
P_1	1047	1525	64345	26302	38043	2.45
P_2	1248	1759	76639	27086	49553	2.83
P_3	1327	1872	81492	27225	54267	2.99

Note: Selling price: Seed: ₹ 60.00/kg, Stover: ₹ 1.00/kg

Effect of sources of phosphorus

Close examinations of data (Table 1) indicated that plant population at 20 DAS and at harvest were found non-significant due to application of various sources of phosphorus in green gram. Application of 40 kg P_2O_5/ha + inoculation with PSB (P_3) produced significantly higher growth attributes viz., plant height at 30, 60 DAS and at harvest (15.77, 43.51 and 45.52 cm respectively), number of nodules per plant (36.21), dry weight of nodules per plant (44.45 mg/plant) and number of branches per plant (4.77) in green gram. The increase in plant growth could be attributed to better proliferation of roots and increased nodulation due to higher phosphorus availability. Phosphorus also promotes formation of new cells, cell elongation, plant vigour and hasten the leaf development, which helps in harvesting more solar energy, better utilization of nitrogen which in turn leads to higher plant growth in green gram. These results are in close agreement with those of Jat *et al.* (2013), Naik (2014), Chaudhari (2015) and Khan *et al.* (2017) in green gram.

The data tabulated in Table 2 revealed that significantly higher number of pods per plant (33.06), number of seeds per pod (11.52), seed yield (1327 kg/ha) and haulm yield (1872 kg/ha) were recorded with application of 40 kg P_2O_5/ha + inoculation with PSB (P_3). Phosphorus applied through different sources were failed to express its significant effect on harvest index and test weight in green gram. Increase in yield attributes might be due to excess assimilates stored in the leaves and later it translocated into seeds at the time of senescence. Phosphorus application not only plays a vital role in root development and proliferation, but also improves nodulation and nitrogen fixation by supplying assimilates to roots.

The increase in photosynthetic activities of plant and root system enabled the plants to extract more water and nutrients from the soil depth, resulted into better growth and development of plant, and ultimately led to higher yield. The earlier findings of Kumawat *et al.* (2014), Rathour *et al.* (2015), Kumar *et al.* (2017), Rekha *et al.* (2018) and Chaudhari *et al.* (2019) corroborate the similar results.

The data given in Table 3 indicated that the highest net returns of 54,237 ₹/ha was secured with application of 40 kg P_2O_5/ha + inoculation with PSB (P_3) in green gram and it was followed by application of 40 kg P_2O_5/ha (P_2).

The lowest net returns was obtained from treatment P_1 (20 kg P_2O_5/ha + inoculation with PSB).

Interaction effect

Interactions of various sources of nitrogen and phosphorus did not exert any significant effect on growth parameters, yield attributes and yield of green gram.

On the basis of the present results, it could be concluded that for securing the higher seed yield and economic returns from summer green gram cultivation (cv. GAM 5), the crop should be fertilized with 20 kg N/ha through vermicompost (*i.e.,* 1.50 t/ha) or 20 kg N/ha through neem cake (*i.e.,* 0.80 t/ha) or 10 kg N/ha through vermicompost (*i.e.,* 0.75 t/ha) + *rhizobium* and 40 kg P_2O_5/ha through SSP (*i.e.,* 250 kg/ha) + PSB or 40 kg P_2O_5/ha through SSP (*i.e.,* 250 kg/ha) as a basal application. *Rhizobium* (GMBS 1 strain) and PSB (PBA 17 strain) should be applied as seed treatment (5 ml/kg seed) and soil drenching (1 lit./ha) at 30 DAS under middle Gujarat condition.

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