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Response of phosphorous levels, liquid biofertilizer and spacing on yield and yield attributes of green gram (*Vigna radiata* L.)

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Abstract
An experiment was conducted at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.) during *zaid* season of 2018 to studies the "Response of phosphorous levels, liquid biofertilizer and spacing on yield and yield attributes of green gram (*Vigna radiata* L)". the experiment laid out in RBD (factorial) with 24 treatment and each replicated in thrice *viz.* four levels of liquid biofertilizer B_1 untreated, B_2-Rhizobiun inoculation, B_3- Phosphate solubilizing bacteria inoculation, B_4- Rhizobium +Phosphate solubilizing bacteria inoculation Respectively. Plant geometry, G_1-row spacing 30cm×15cm, G_2-row spacing 45cm×15cm and three levels of phosphorous, P_1-40kg/ha, P_2-60kg/ha, P_3-80kg/ha. The result of one year of experiment revealed that significantly higher values of plant height (66.64cm, 65.05cm and 62.97cm), plant dry weight (14.94g, 15.61g and 14.36g), number of nodules (13.86, 13.09 and 13.43), numbers of branches/plant (7.86, 7.43 and 7.59), leaf area (134.19cm^2, 140.20cm^2 and 128.29cm^2), number of pods/plant (30.59, 32.00 and 29.30), number of grains/pod (9.70, 8.98 and 9.28), test weight (32.27g, 30.44g and 31.18g) and grain yield (13.15q/ha, 12.99q/ha and 13.60q/ha) was recorded due to biofertilizer, plat geometry and phosphorous levels respectively.

Keywords: Green gram, liquid biofertilizer, plant geometry, phosphorous, yield

Introduction
Pulses are important not only for their value as human food, but also because of high protein content for livestock. It has been important component of Indian agriculture enabling the land to restore fertility by fixing atmospheric nitrogen, so as to produce reasonable yields of succeeding crops and to meet out the demand of dietary requirement regarding proteins, carbohydrates and other nutrient sources. On an average, pulses contain 22-24 percent protein as against 8-10 percent in cereals. A good amount of lysine is present in the pulses. Pulses vary in maturity periods, hence, are useful in different cropping systems. Greengram locally called as moog or mug (*Vigna radiata* L. Wilczek) belongs to the family Leguminosae, which fixes atmospheric nitrogen and improves soil fertility by adding 20-25kg N ha-1. Being a short duration crop and having wider adaptability, it can be grown in summer as well as in *kharif* season. It is an important ruling crop in summer season, locally known as 'Vaishakhi Mug'. The yield of summer greengram is comparatively more than that of *kharif* crop, mainly because the controlled moisture conditions through irrigation, abundant sunshine and less pest and disease infestation. The greengram foliage left over after picking of mature pods can either be fed to livestock or it may ploughed in situ as a green manure to enrich soil with organic matter. Employment is provided to the farmers and the agricultural labours during off season. Greengram is a very short duration crop so it can be grown as catch crop.
Addition of phosphorous enhances root development and improve supply of other nutrient and water to growing parts of plant altimetry resulting in and increased photosynthetic area and thereby more dry accumulation. In year 2016-17 the total pulse are 238.56 lakhs hectare and production of India was 18.25 million tones with productivity of 765kg/ha. India is largest producer and consumer of pulse in word, accounting for 25% of globule production and 50% consumption (Saraswati *et al.* 2004) [20]. Phosphorous solubilizing bacteria play on maser role in phosphorous nutrition by enhancing its availability to plants through release from in organic and inorganic soil phosphorous pools by sobulization and minimization. Use of PSB as inoculates increase phosphorus uptake. Greater efficiency of PSB has been reported through co-inoculation with other beneficial bacteria and mycorrhiza (khan *et al.* 2009) [9].
Row spacing is management practices which can be varied without substantially increasing production cast. Row orientation and configuration (also defined as planting geometry) can

influence natural bio-regulation of plant morphogenesis and interception of photosynthetically active incident solar radiation. Changes and plant density has been reported to change spectra light quality and influence green gram growth and development (Chaudhary *et al.* 2016) [5]. Increase in yield can be ensured simply, by maintaining appropriate plant population through different planting patterns. Planting pattern influences radiation interception and utilization of moisture from soil (Rehan, 2002) [16]

Meagre research work has been done on inoculation of liquid biofertilizer, row spacing and phosphorous levels in U.P. condition. Considering the above and views the present an experiment was conducted in year 2017-2018 to studies "Effect of liquid biofertilizer, plant geometry and phosphorous levels on growth and yield of green gram (*Vigna radiata*L) at crop research farm SHUATS Prayagraj.

Materials and Methods

The experiment was conducted during two consecutive *Zaid* seasons of 2018 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) which is located at 25^0 24' 42'' N latitude, 81^0 50' 56'' E longitudes and at an altitude of 98 m above the mean sea level. The soil samples were collected randomly from 0 to 15cm depth from 5 spots of the experimental field in both the years just before layout of experiment. A representative homogenous composite sample was drawn by mixing all these soil samples together, which was analyzed to determine the physico-chemical properties of the soil. The soil was sandy loam in texture, medium in organic carbon and low in available nitrogen, phosphorus and medium in potassium. The weekly mean of maximum & minimum temperatures during the crop season ranged from 33.37 ^{0}C to 42.26 ^{0}C and 16.01 ^{0}C to 26.17 ^{0}C, respectively in 2018. The relative humidity was highest 83.00% in the second week of March & lowest 32.00% was recorded in the second week of May in 2018. The experiment was laid out in Randomized Block Design (4×2×3 factorial). The three factors were liquid biofertilizer, plant geometry and different levels of phosphorus are 4 levels *i.e.* Untreated, Rhizobium inoculation, PSB (Phosphate Solubilizing Bacteria), Rhizobium +PSB, (30cm×15cm), (45cm×15cm) three levels of phosphorous @40, 60 and 80kg/ha, respectively comprising of 24 treatment combinations each replicated thrice. Treatments were randomly arranged in each replication, divided into 72 plots.

Statistical Analysis

The data recorded the course of research experiment were subjected statistical analysis as per method of variance the significant and significant and non-significant of the treatment effect were judged with the help of "F" variance test. Calculated "F" valve was compared with table value of "F" at 5%levels of significant. If the calculated value was more than table value, the effect was considered to be significant.

Result and Discussion

The finding of the investigation entitled "Response of phosphorous levels, liquid biofertilizer and spacing on yield and yield attributes of green gram (*Vigna radiata*L)" was conducted during *zaid* season 2018 at crop research farm department of agronomy SHUATS Prayagarj. In this research paper, the pooled data for effect of liquid biofertilizer, plant geometry and levels of phosphorous on growth and yield of green gram has been discussed and data pertaining to various criteria use for treatment evaluation are statistically analyzed to test their significant

Growth parameter of green gram

The pooled data on plant height of green gram at harvest has been presented in table 1. A perusal of pooled data revealed that plant height differed significantly with respect to liquid biofertilizer. The highest plant height (66.64cm) at harvest was recorded in treatment B_4 (Rhizobium +PSB) followed by B_2 (Rhizobium) and B_3 (PSB) and were found to be statistically at par to treatment B_4 (Rhizobium +PSB). Plant geometry also showed significant did not different however maximum plant height in polled was recorded in treatment G_1 (30cm×15cm). Table 1 also revealed that phosphorous levels differed significantly with respect to plant height and maximum plant height was recorded in Treatment P_2 (60kg/ha) followed by treatment P_1 (40kg/ha) which was found to be statistically at par to treatment P_2 (60kg/ha).

The probable reason for recording significantly higher plant height may be due to fact that seed inoculation with Rhizobium +PSB led to better uptake and translocation of plant nutrient to green gram pant. The other reason may due to the fact that inoculation benefitted the plants by providing atmospheric nitrogen and rendering the insoluble phosphorous available form. The enhance availability of phosphorous favored better root development, nitrogen fixation and rate of photosynthesis ultimately resulting into maximum plant height. These findings are in accordance with the findings of (Patel *et al.* 2012).

Dry weight of green gram/plant

The maximum plant dry weight (14.94g) was recorded in treatment B_4 (Rhizobium +PSB) at harvest followed by treatment B_2 (Rhizobium) and B_3 (PSB) which were found to be statistically at par to treatment B_4 (Rhizobium +PSB). Plant geometry had significant effect on plant dry weight at harvest and maximum plant dry weight (15.61 g) was recorded in treatment G_1 (30cm×15cm) followed by treatment G_2 (45cm×15cm) which was found to be statically at par to treatment G_1 (30cm×15cm). Phosphorous levels also differed significantly plant dry weight. The significantly higher plant dry weight (14.36g) was recorded in treatment P_2 (60kg/ha) followed by treatment P_1 (40kg/ha) which was found to statistically at par to treatment P_2 (60kg/ha).

The probable reasons for maximum dry weight and increase in yield attributes resulted in better growth and plant height ultimately resulting higher dry weight. This may be the result of biofertilizer inoculation of co-ordinate interplay of growth and development character (Goud and Reddy, 2007). Similar findings were also reported by Rathor, *et al.* (2015) [17]. Application of phosphorus fertilizers not only increased the plant growth but also improved nutrient availability for prolonged period for plant growth. Phosphorus is the main constituent of ADP and ATP which acts as energy currency within plants. Almost every metabolic reaction of any significance proceeds via phosphate derivatives, phosphorus application influences photosynthesis, biosynthesis of proteins and phospholipids, nucleic acid synthesis, membrane transport and cytoplasm streaming. These findings are in conformity with the fining of (Mishra & Singh 2013), Patel *et al.* 2017 [11] and Gurjar *et al.* 2018 [7].

Number of branches/plant

Liquid biofertilizer differed significantly with respect to number of branches/plant and significantly higher number of branches in year 2018 as 7.86 in treatment B_4 (Rhizobium +PSB) followed by treatment B_2 (Rhizobium) which were found to be statistically at par to treatment B_4 (Rhizobium +PSB). Plant geometry did not differed significantly with respect to number of branches per plant however maximum number of branches per plant (7.43) was recorded in treatment G_1 (30cm×15cm). Phosphorous levels differed significantly at harvest and recorded maximum number of branches/ plant (7.59) in treatment P_2 (60kg/ha) followed by treatment P_1 (40kg/ha) which recorded number of branches as 7.36 and was found to be statistically at par to treatment P_2 (60kg/ha)

The probable reasons for maximum number of branches at harvest and pooled might be due to the fact that seed inoculation with *Rhizobium* and phosphobacteria of liquid based biofertilizer, plant geometry and phosphorous improve the growth for a prolong period. The number of fruit bearing branches is a genetically controlled factor so it differed significantly among three factors under study. The inter-row spacing affected the fruit bearing branches, which might be due to better availability of light, moisture nutrients, etc. in case of varying spacing. These results are in agreement with those of Amruta *et al.* (2015) [1], Khan (2000) and Singh *et al.* 2018 [18].

Number of nodules/plant

Liquid biofertilizer differed significantly with respect to number of nodules/plant and significantly higher number of nodules/plant was recorded in treatment B_4 (Rhizobium +PSB) 13.89 and followed by treatment B_2 (Rhizobium) and B_3 (PSB) which were found to be statistically at par to treatment B_4 (Rhizobium +PSB). The data revealed that plant geometry did not differed significantly with respect to number of nodules per plant. However, maximum number of nodules/plant was recorded in treatment G_1 (30cm×15cm) as 13.28. Phosphorous levels differed significantly at harvest, the data revealed that maximum number of nodules per plant (13.43) was recorded in treatment P_2 (60kg/ha) followed by treatment P_1 (40kg/ha) which was found to be statistically at par to treatment P_2 (60kg/ha). The probable reasons maximum number of nodules might be due to increases availability of phosphorous and PSB which enhance biological nitrogen fixation in green gram (Gupta *et al.* 2006). Green gram being a legume crop response more to phosphorus then nitrogen and phosphorous helps in better nodules formation similar result also reported by (Manke *et al.* 2008), Das and Rautaray (2017) [6].

Leaf area

Liquid biofertilizers differed significantly with respect to leaf area of green gram at harvest in pooled data. Significantly higher leaf area (134.94cm^2) was recorded in treatment B_4 (Rhizobium +PSB) and followed by treatment B_2 (Rhizobium inoculation) was found to be statistically at par to treatment B_4 (Rhizobium +PSB) respectively. Plant geometry differed significantly with respect to leaf area of green gram and higher leaf area (140.20cm^2) was recorded in treatment G_1 (Row spacing 30cm×15cm). Phosphorus levels differed significantly with respect to leaf area in green gram. Significantly higher leaf area was recorded in treatment P_2 (60kg/ha) which recorded significantly higher leaf area (128.29cm^2) followed by treatment P_1 (40kg/ha) and was found to be statistically at par to treatment P_2 (60kg/ha). The probable reason for recording higher leaf area to overall improvement in the growth of green gram achieved at 60kg P_2O_5/ha could be ascribed to their pivotal role in several physiological and bio- chemical processes *viz.* root development, photosynthesis, energy transfer. These observations are in line with the findings of Prakash *et al.* (2004) [20], who reported that major plant nutrients mainly phosphorus had a positive effect on growth parameters in pulses. These findings are in close conformity to those of Yadav and Singh (2014) [23] Bhattacharya and laxmi (2005) and Bhattacharya (2006).

Number of pods/plant

A perusal of the table 2 clearly revealed that liquid biofertilizers differed significantly in pooled with respect to number of pod/plant and significant higher number of pod/plant (30.59) was recorded in treatment B_4 (Rhizobium +PSB) and followed by treatment B_2 (Rhizobium) and treatment B_3 (PSB) which were found to be statistically at par to treatment B_4 (Rhizobium +PSB) respectively. Plant geometry also differed significantly with respect to number of pod/plant and significantly higher number of pod/plant (32.00) was recorded in treatment G_1-(Row spacing 30cmx15cm). The table 2 also revealed that levels of phosphorus differed significantly with respect to number of pods/plant and maximum number of pods/plant (29.30) was recorded in treatment P_2-(60kg/ha) followed by treatment P_1-(40kg/ha) and was found to be statistically at par to treatment P_2-(60kg/ha).

The probable reasons for significant variation in yield attributing parameter like number of pods/plant were found due to different levels of phosphorous. In journal overall improvement in yield attributing character because of phosphorous increased photosynthesis activity of the plant and helps to develop more extension root system and thus enable the plant to extracts more water and nutrient on the soil depth resulting in better development plant growth and yield attributes like number of pods/ plant. Positive responses in terms of yield attributes due to application of phosphorous and liquid biofertilizer have also will reported by Patil *et al.* 2011 [14], Kumar *et al.* 2012 [10] and Patel *et al.* 2013 (green gram 3).

Test weight

A perusal of the table 2 clearly revealed that liquid biofertilizers differed significantly in pooled with respect to test weight and significant higher of test weight (32.27g) was recorded in treatment B_4 (Rhizobium +PSB) and followed by treatment B_2 (Rhizobium inoculation) and treatment B_3 (PSB) which were found to be statistically at par to treatment B_4 (Rhizobium +PSB) respectively. Plant geometry did not differed significantly with respect to test weight. The table 2 also revealed that levels of phosphorus differed significantly with respect to test weight and maximum test weight (31.18 g) was recorded in treatment P_2-(60kg/ha) followed by treatment P_1-(40kg/ha) and was found to be statistically at par to treatment P_2-(60kg/ha). The probable reason recoding higher test weight may be attributed towards the genetic variability and bold grain size similar result were reported Tiwari *et al.* (2016), Uddim *et al.* 2009 and Yadav *et al.* 2007.

Grain yield

A perusal of the table 2 clearly revealed that liquid biofertilizers differed significantly in pooled with respect to grain yield and significant higher of grain yield (13.15q/ha) was recorded in treatment B_4 (Rhizobium +PSB) and followed by treatment B_2 (Rhizobium inoculation) and treatment B_3 (PSB) which were found to be statistically at par to treatment B_4 (Rhizobium +PSB) respectively. Plant geometry did not differed significantly with respect to grain yield. The table 2 also revealed that levels of phosphorus differed significantly with respect to grain yield and maximum grain yield (13.60q/ha) was recorded in treatment P_2-(60kg/ha) followed by treatment P_1-(40kg/ha) and was found to be statistically at par to treatment P_2-(60kg /ha). Maximum grain yield was recorded due to higher number of pods/ plant longer pod size, more number of branches and bold seed size and higher test weight these result are in conformity to those reported by Bhat *et al.* (2010) [4] and Uddime *et al.* 2010

Stover yield

A perusal of the table 2 clearly revealed that liquid biofertilizers differed significantly in pooled with respect to stover yield and significant higher of stover yield (23.16q/ha) was recorded in treatment B_4 (Rhizobium +PSB) and followed by treatment B_2 (Rhizobium inoculation) and treatment B_3 (PSB) which were found to be statistically at par to treatment B_4 (Rhizobium +PSB) respectively. Plant geometry also differed significantly with respect to stover yield and significantly higher stover yield (24.53) was recorded in treatment G_1-(Row spacing 30cmx15cm) followed by G_2-()The table 2 also revealed that levels of phosphorus differed significantly with respect to stover yield and maximum stover yield (23.30q/ha) was recorded in treatment P_2-(60kg/ha) followed by treatment P_1-(40kg/ha) and was found to be statistically at par to treatment P_2-(60kg/ha). Maximum stover yield were obtained owing to higher dry matter accumulation and better root development through phosphorous resulting into maximum uptake of nutrient and moisture which ultimately led to higher stover yield. These results similar to those reported by Samant 2014 [19], Rajesh *et al.* 2013 [15] and Rathod and Gawande 2014.

Table 1: Response of liquid biofertilizer plant geometry and different levels of phosphorous on growth parameter of green gram.

Treatment		Plant height (cm)	Dry weight (g)	No. of nodules	No. of branch	Leaf area (cm^2)
Liquid biofertilizer						
B_1	Untreated	56.40	12.57	11.71	6.46	113.29
B_2	Rhizobium	64.65	14.42	13.41	7.53	129.95
B_3	PSB	62.14	13.87	12.89	7.22	124.94
B_4	Rhizobium +PSB	66.64	14.94	13.89	7.86	134.94
	F test	S	S	S	S	S
	SEd±	2.33	0.55	0.58	0.40	4.22
	CD (P=0.05)	4.75	1.11	1.19	0.82	8.61
Plant geometry						
G_1	Row Spacing (30cm×15cm)	65.05	15.61	13.28	7.43	140.20
G_2	Row Spacing (45cm×15cm)	59.86	12.29	12.84	7.11	110.98
	F test	S	S	NS	NS	S
	SEd±	2.47	0.58	0.62	0.43	4.48
	CD (P=0.05)	5.04	1.18	-	-	9.13
Phosphorus levels						
P_1	40kg ha^{-1}	62.97	14.23	13.11	7.36	127.82
P_2	60kg ha^{-1}	64.26	14.36	13.43	7.59	128.29
P_3	80kg ha^{-1}	60.13	13.26	12.34	6.85	120.66
	F test	S	5	S	S	S
	SEd±	2.02	0.47	0.50	0.35	3.66
	CD (P=0.05)	4.11	0.96	1.03	0.71	7.45

Table 2: Response of liquid biofertilizer plant geometry and different levels of phosphorous on yield parameter of green gram.

Treatment		No. of pods/plant	Grins/pod	Test weight	Grain yield (q/ha)	Stover yield (q/ha)
Liquid biofertilizer						
B_1	Untreated	25.84	7.93	27.30	11.44	19.89
B_2	Rhizobium	29.65	9.09	31.28	12.76	22.60
B_3	PSB	28.50	8.72	30.06	12.35	21.80
B_4	Rhizobium +PSB	30.59	9.70	32.27	13.15	23.16
	F test	S	S	S	S	S
	SEd±	1.02	0.48	1.15	0.83	0.74
	CD (P=0.05)	2.07	0.98	2.34	1.07	1.50
Plant geometry						
G_1	Row Spacing (30cm×15cm)	32.00	8.98	30.44	12.99	24.53
G_2	Row Spacing (45cm×15cm)	25.29	8.74	30.02	11.85	19.19
	F test	S	NS	NS	NS	S
	SEd±	1.08	0.54	1.22	0.88	0.78
	CD (P=0.05)	2.20	-	-	-	1.60
Phosphorus levels						
P_1	40kg ha^{-1}	29.18	8.90	30.49	11.71	21.91
P_2	60kg ha^{-1}	29.30	9.28	31.18	13.60	23.18
P_3	80kg ha^{-1}	27.46	8.40	29.02	11.96	20.49
	F test	S	S	S	S	S
	SEd±	0.88	0.41	0.99	0.72	0.64
	CD (P=0.05)	1.79	0.85	2.03	1.47	1.30

Conclusion

It can be conculated from the two year investigation that forgetting maximum grain yield farmer should adopted bubble seed inoculation technique by rhizobium and PSB spacing of 30cmx15cm and 60kg/ha phosphorous should be adopted to maximum grain yield.

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