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Effect of liquid biofertilizer, plant geometry and phosphorous levels on growth and yield of greengram (*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 2017 and 2018 to studies the "Effect of liquid biofertilizer, plant geometry and phosphorous levels on growth and yield of greengram (*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-Rhizobium inoculation, B_3- Phosphate solubilizing bacteria inoculation, B_4- Rhizobium + Phosphate solubilizing bacteria inoculation Respectively. Plantgeometry,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 pooled result of two year of experiment reveled that significantly higher values of plant height (65.94cm, 63.37cm and 63.80cm), plant dry weight (13.85g, 13.86g and 13.22g), number of nodules (13.93, 13.19 and 13.55), numbers of branches/plant (7.89,7.46 and 7.48), leaf area (142.20cm^{2,} 125.38cm^2 and 137.12cm^2), number of pods/plant (31.39, 31.8 and 30.40), number of grains/pod (9.62, 8.92 and 9.24), test weight (32.16g, 30.51g and 31.39g),grain yield (13.29q/ha, 12.90q/ha and 13.61q/ha) and stover yield (23.66q/ha, 23.39q/ha and 23.30q/ha) was recorded due to biofertilizer, plat geometry and phosphorous levels respectively.

Keywords: greengram, liquid biofertilizer, plant geometry, phosphorous, yield

Introduction
Pulses are important in agriculture system due to their multiple roles in dry farming because of its availability to tap moisture from dipper layer of soil by virtue of dip penetrating tap root system. Pulse also passes unique quality of fixing atmospheric nitrogen with the help of symbiotic bacteria (Rhizobium) present in root nodules. Pulses make diet balance by supplying minerals and vitamins besides providing protein as well as an abundance of food energy. Moong bean or greengram (*Vigna radiata* L.) is one eatable pulse crop belonging to family *leguminous*. It is third impotent pulse crop cultivated in India after chickpea and pigeon pea for its multipurpose uses as vegetable, pulse fodder and green manure crop. It content protein, carbohydrates, fat and fiber is range of 21-25%, 60-65%, 1-1.5% and 3.5-4.5% respectively. It seeds is more palatable, nutritive, digestible and non-flatulent and other pulse in other country. In Uttar Pradesh moong bean is cultivated on 25.9 thousand hectares with productivity 659kg/ha (anonymous 2014).

Pulses are important crop of our country are main sauce of vegetable protein. The lysine rice protein of pulses are consider to supplement the deficiency of this amino acid in cereal dietaries and brings all par with milk's protein in terms of biological efficiency. It is because of this reason that pulses are called as "Poor's man's meat". Among the different production practices, fertilizer management is an important agronomic practices for increasing crop yield and enhancing soil fertility growth of crops largely depends on the development of root system. Phosphorous is most important element that plant must require for better growth and development (Hossain and Hamid, 2007) [6]. 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 matter accumulation. In year 2016-17 the total pulse are 238.56 lakh 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) [17]. 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) [7].

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 greengram growth and development (Chaudhary *et al.* 2016) [3]. 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) [13].

My 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 greengram (*Vigna radiata* L) at crop research farm SHUATS Prayagraj.

Materials and Methods

The experiment was conducted during two consecutive *Zaid* seasons of 2017 and 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 33.46 ^{0}C to 45.20 ^{0}C and 11.90 ^{0}C to 26.60 ^{0}C, respectively in 2017 and 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 79.00% in the second week of March & lowest 24.67% was recorded in the second week of May in 2017. However, in 2018 relative humidity was highest 83.00% in the second week of April and lowest 32.00% was recorded in the last week of April. 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 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 "Effect of liquid biofertilizer, plant geometry and phosphorous levels on growth and yield of greengram (*Vigna radiata* L)" was conducted during *zaid* season 2017-2018 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 greengram has been discussed and data pertaining to various criteria use for treatment evaluation are statistically analyzed to test their significant.

Growth parameter of greengram

The pooled data on plant height of greengram 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 (65.94) 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 treatmentg_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 greengram 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.* 2013) [11].

Dry weight of greengram/plant

The maximum plant dry weight (13.85g) 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 (13.85g) was recorded in treatmentg_1 (30cm×15cm) followed by treatmentg_2 (45cm×15cm) which was found to be statically at par to treatmentg_1 (30cm×15cm). Phosphorous levels also differed significantly plant dry weight. The significantly higher plant dry weight (13.40g) 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. Similar findings were also reported by (Rathor, *et al.* 2015) [14]. 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 [9] and Gurjar *et al.* 2018 [5].

Number of branches/plant

Liquid biofertilizer differed significantly with respect to number of branches/plant and significantly higher number of branches in pooled as 7.89 in treatment B_4 (Rhizobium +PSB) 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 did not differed significantly with respect to number of branches per plant however maximum number of branches per plant (7.46) was recorded in treatmentg_1 (30cm×15cm). Phosphorous levels differed significantly at harvest and recorded maximum number of branches/plant (7.66) in treatment P_2 (60kg/ha) followed by treatment P_1 (40kg/ha) which recorded number of branches as (7.48) 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 Khan (2009) [7] and Singh *et al.* 2018 [15].

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) 13.93 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 pooled 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 treatmentg_1 (30cm×15cm) as 13.19. Phosphorous levels differed significantly at harvest and pooled data revealed that maximum number of nodules per plant (13.55) 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 greengram (Gupta *et al.* 2006). Greengram being a legume crop response more to phosphorus then nitrogen and phosphorous helps in better nodules formation similar result also reported by thesis Das and Rautaray (2017) [4].

Leaf area

Liquid biofertilizers differed significantly with respect to leaf area of greengram at harvest in pooled data. Significantly higher leaf area (142.20cm^2) 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 differed significantly with respect to leaf area of greengram and higher leaf area (141.22cm^2) was recorded in treatmentg_1 (Row spacing 30cm×15cm). Phosphorus levels differed significantly with respect to leaf area in greengram. Significantly higher leaf area was recorded in treatment P_2 (60kg/ha) which recorded significantly higher leaf area (137.12cm^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 greengram 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 Bhat *et al.*. (2010) [2] 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 Bhattacharya (2012) [1].

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 (31.39) 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 (31.18) was recorded in treatmentg_1-(Row spacing 30cm x15cm). The table 2 also revealed that levels of phosphorus differed significantly with respect to no. of pods/plant and maximum no. of pods/plant (30.40) 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 [12], Kumar *et al.* 2012 [8] and Patel *et al.* 2013 [11].

Number of grain per pod

Critical review of table 2 showed that liquid biofertilizers differed significantly in pooled with respect to no. of grains/pod and significant higher no. of grins/pod (9.62) was recorded in treatment B_4 (Rhizobium +PSB) 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) respectively. Plant geometry did not differed significantly with respect to number of grains/pods. The table 2 also revealed that levels of phosphorus differed significantly with respect to number of grains/pods and maximum number of grains/pods (9.24) 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 grains/pods were found due to different levels of phosphorous. In general 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 grain/pods. Positive responses in terms of yield attributes due to application of phosphorous and liquid biofertilizer have also will reported by Rathour *et al.* 2015 [14] and Kumar *et al.* 2012 [8].

Test weight

A perusal of the table2 clearly revealed that liquid biofertilizers differed significantly in pooled with respect to test weight and significant higher of test weight (32.16g) 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 (31.39g) 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 Uddim *et al.* 2009 and Yadav *et al.* 2007.

Grain yield

A perusal of the table2 clearly revealed that liquid biofertilizers differed significantly in pooled with respect to grain yield and significant higher of grain yield (13.29q/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 (13.61q/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 Uddime *et al.* 2009

Stover yield

A perusal of the table2 clearly revealed that liquid biofertilizers differed significantly in pooled with respect to stover yield and significant higher of stover yield (23.66q/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 (23.59) was recorded in treatmentg_1-(Row spacing 30cmx15cm). 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 [16] and Rathour *et al.* 2015 [14].

Table 1: Effect of liquid biofertilizer, plant geometry and phosphorous levels on growth parameter of greengram.

Treatment		Plant height(cm)	Dry weight(g)	No. of nodules	No. of branch	Leaf area (cm^2)
Liquid biofertilizer						
B_1	Untreated	55.80	11.70	11.82	6.58	120.33
B_2	Rhizobium	63.97	13.42	13.52	7.62	138.02
B_3	PSB	61.48	12.90	12.99	7.32	132.65
B_4	Rhizobium +PSB	65.94	13.85	13.93	7.89	142.20
	F test	S	S	S	S	S
	SEd±	2.58	0.54	0.62	0.26	5.35
	CD (P=0.05)	5.26	1.10	1.27	0.53	10.90
Plant geometry						
G_1	Row Spacing (30cm×15cm)	63.37	13.85	13.19	7.46	141.22
G_2	Row Spacing (45cm×15cm)	60.22	12.09	12.94	7.24	125.38
	F test	S	S	S	S	S
	SEd±	2.74	0.57	0.66	0.27	5.67
	CD (P=0.05)	5.58	1.16	1.34	0.56	11.57
Phosphorus levels						
P_1	40kg ha^{-1}	62.49	13.22	13.27	7.48	135.44
P_2	60kg ha^{-1}	63.80	13.40	13.55	7.66	137.12
P_3	80kg ha^{-1}	59.10	12.29	12.38	6.93	127.34
	F test	S	S	S	S	S
	SEd±	2.24	0.47	0.54	0.22	4.63
	CD (P=0.05)	4.56	0.95	1.10	0.45	9.44

Table 2: Effect of liquid biofertilizer, plant geometry and phosphorous levels yield parameter of greengram.

Treatment		No. of pods/plant	Grins/pod	Test weight	Grain yield (q/ha)	Stover yield (q/ha)
Liquid biofertilizer						
B_1	Untreated	26.43	7.89	27.47	11.59	20.02
B_2	Rhizobium	30.33	9.03	31.52	12.98	22.92
B_3	PSB	29.14	8.67	30.33	12.49	22.06
B_4	Rhizobium +PSB	31.39	9.62	32.16	13.29	23.66
	F test	S	S	S	S	S
	SEd±	1.31	0.51	1.21	0.63	0.74
	CD (P=0.05)	2.66	1.04	2.46	1.29	1.50
Plant geometry						
G_1	Row Spacing (30cm×15cm)	31.18	8.92	30.51	12.90	23.59
G_2	Row Spacing (45cm×15cm)	27.47	8.69	30.23	12.27	20.73
	F test	S	S	NS	S	S
	SEd±	1.38	0.54	1.28	0.67	0.78
	CD (P=0.05)	2.82	1.10	2.61	1.37	1.59
Phosphorus levels						
P_1	40kg ha^{-1}	29.76	8.90	30.71	12.19	22.25
P_2	60kg ha^{-1}	30.40	9.24	31.39	13.61	23.30
P_3	80kg ha^{-1}	27.81	8.26	29.01	11.96	20.93
	F test	S	S	S	S	S
	SEd±	1.13	0.44	1.05	0.55	0.64
	CD (P=0.05)	2.31	0.90	2.13	1.12	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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