Effect of Different Phosphorus Levels and Frequency of Boron Levels on Growth and Yield of Summer Green gram [*Vigna radiata*(L.)]

ABSTRACT

A field experiment was conducted at Agronomy farm, college of Agriculture & Research, (Mahatma JyotiRoaPhoole University) Achrol, Jaipur during summer season (February-April, 2022) to study the "Effect of different phosphorus levels and frequency of boron levels on growth and yield of summer Green gram (*Vigna radiata* L.*)"*. The experiment was laid out in Randomized Block Design (RBD) with twelve treatments thrice replicated. Among the different phosphorus levels and frequency of boron levels treatment T_{12}*i.e.*, P_3 (20:60:20 NPK) + 20 & 35DAS (0.2% foliar spray of borax) showed the highest performance of all treatments with a plant height (78.47 cm), number of branches/plants (13.20), number of nodules/plant (20.30), plant dry weight (10.12 g), CGR(8.50g/m^2/day), number of pods/plant (33.07), number of seeds/pod (10.33),test weight (30.20), seed yield (18.54 q/ha), straw yield (32.20 q/ha), harvest index (36.54 %). Similarly, maximum gross returns (139050INR/ha), highernet return (103054INR/ha) and highest benefit cost ratio (2.86) was also recorded in treatment 12[P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB)].

Keywords: Green gram, phosphorus, borax, dry weight, RBD, crop growth rate, yield attributes.

1. Introduction

"Green gram (*Vignaradiata*L.) is of ancient cultivation in India. In India green gram is grown in almost all parts of the country. It is grown in India during *Kharif*, but is also grown in spring or summer season in irrigated northern plains as a rabi crop in southern and south-eastern parts where is winter is mild. Green gram is an excellent source of protein (25%) with high quality of lysine (460 mg/g) and tryptophan (60 mg/g). It also has remarkable quantity of ascorbic acid when sprouted and also have riboflavin (0.21 mg/ 100 g) and minerals (3.84 g/ 100 g). In India green gram occupies 4.5 mhaarea and contributes to 2.5 mt in pulse production" (Anonymous, 2021). "In Rajasthan, it is an important pulse crop and grown in 24 lakh ha area with the production of 12.22 lakh t" (Anonymous, 2021). "Green gram contributes 14% in total pulse area and 7% in total pulse production in India. Pulse production is very low and become challenging problem against the requirement of increasing population of our country. Moreover, it has a numerous utilities and used primarily as a food crop because it is a major source of protein in cereal based diets for its high lysine content" (Chena *et al.*, 2022). "The low productivity of Green gram may be due to nutritional deficiency in soil and imbalanced external fertilization" (Awomi*et al*., 2012). Among several crop production obstacles appropriate, sustained cultivation of historical low potential cultivars, use of lows Green gram (Vigna radiata L.)has been cultivated in India since ancient times.

"The essential components that promote an increased crop output in greengram are nitrogen and boron" (Kartik*et al*., 2021). "Phosphorus is an important plant nutrient for green gram. Indian soils are poor to medium in available phosphorus" (Fardeau*et. al*., 2012)."Only about 30 per cent of the applied phosphorus is available for crops and remaining part converted into insoluble phosphorus. Phosphorus fertilization occupies an important place amongst the non-renewable inputs in modern agriculture. Phosphorus (P) and Boron (B) are an essential elements whose deficiency affects the growth and yield of different crops, especially leguminous crops. The fertility status of soil has declined due to intensive cropping without proper replenishment of nutrients" (Padbhushan and Kumar, 2015). "Crop recovery of added phosphorus seldom exceeds 20 per cent and it may be improve by the judicious management" (Rizvi*et. al*., 2014). "As the concentration of available P in the soil solution is normally insufficient to support the plant growth, continual replacement of soluble P from inorganic and organic sources is necessary to meet the P requirements of crop" (Aslam*et al*., 2010). "Additional application of P is increase nodule formation which increases nitrogen fixation transduction, macromolecular biosynthesis and respiration" (Pompelli*et al*., 2010). "Phosphorus, the master key element is known to be involved in a plethora of functions in the plant growth and metabolism" (Cheng *et al*., 2022). "Among the various factors responsible for maximizing the yield of green gram, phosphorus levels and frequency of boron levels is most important" (Padbhushan and Kumar, 2014). It is necessary to use them economically in combination with phosphorus and boron (Mubeen *et al.,* 2020), as green gram shows high response to high phosphorus levels and frequency of boron levels (Muindi *et al.* 2020).

2. Materials and Methods

Field experiment was conducted during summer season (February-April, 2022) at Agronomy farm, college of Agriculture & Research, (Mahatma JyotiRoaPhoole University) Achrol, Jaipur (Rajasthan). The experimental site is located at 26^{0}53'29'' N latitude, 75^{0}46'24'' E longitude and at an altitude of above mean sea level. The soil of the experimental field was loamy sand in texture having alkaline pH (7.6), low in organic carbon (0.20%) and available Nitrogen (127.23 kg ha^{-1}), available Phosphorus (18.21 kg ha^{-1}) and available Potassium (192.15 kg ha^{-1}) and available sulphur in form of sulphate (8.0 ppm) content. A recommended Green gram variety (**RMG-268**) was taken for the study. The experiment was laid out in Randomized Block Design (RBD) with two factor different levels of phosphorus [20:40:20 kg ha^{-1} (P_1),20:50:20 kg ha^{-1} (P_2), 20:60:20 kg ha^{-1} (P_3)] and boron [no application, 20 & 35 DAS, 0.2% foliar spray of borax] with twelve treatments combination on a plot size of 3 x 3 m^2. Before sowing, line were formed in the field as the spacing in treatments. Green gram was sown in line and covered with the soil. Green gram seeds were hand dibbled on 26.03.2022. The total quantity of nitrogen, phosphorus and potassium as per treatment in the form of Urea (46%), single super phosphate (16%) and MOP (60%) respectively were applied below the seeds at the time of sowing. The initial B status was 498ppm. Boron spray 0.2% solution of borax was prepared and spraying was done at 20, 35 and both 20 & 35 days after sowing. All the agronomic practices were carried out uniformly to raise the crop. For taking data on yield and yield components on Green gram five plants were selected randomly in each plot.

2.1 Crop Growth Rate (g m^{-2} day^{-1})

It represents dry weight gained by a unit area of crop in a unit time expressed as g m^{-2} day^{-1} (Radford, 1967). The values of plant dry weight at 15, 30, 45 and 60 DAS intervals were used for calculating the CGR. It was calculated with the help of following formula.

$$\text{Crop Growth Rate} = \frac{W2 - W1}{} \ (\text{g m}^{-2}\ \text{day}^{-1})$$

$$t_2 - t_1$$

Where,

W_1 = dry matter production per unit area at time t_1

W_2 = dry matter production per unit area at time t_2

t_1 = days to first sampling

t_2 = days to second sampling

3. Results and discussion

3.1 Growth Parameters

3.1.1 Plant height (cm)

The result revealed that a significantly higher plant height (78.47cm) was recorded with the treatment 12[P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB)]. However, treatment 11[P_3 (20:60:20NPK) + 35 DAS (0.2% FsB)] were found to be statistically at par with treatment 8[P_2 (20:50:20 NPK) +20&35 DAS (0.2% FsB)] and lowest plant height (70.50) was observed in treatment 1 [P_1 (20:40:20 NPK)][Table 1].Plant height will also rise with the addition of phosphorus (60 kg/ha). It may be caused by the establishment of new cells, which encourage plant vigor and speed up leaf development, which aids in the collecting of more solar energy and the better utilization of nitrogen, which aids in greater growth qualities (Anand*et al.,* 2022). further, Boron (0.2%) plays a role in a variety of physiological functions, including the activation of enzymes, electron transport, chlorophyll synthesis, stomatal regulation, and others that gradually raise plant height (Kaisher*et al.,* 2010).

3.1.2 Number of branches/plant

The result revealed that a significantly higher number of branches/plant (13.20) was recorded in treatment 12 **[**P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB). However, treatment 11 **[**P_3 (20:60:20NPK) + 35 DAS (0.2% FsB)]is statistically at par with the treatment 8[P_2 (20:50:20 NPK) +20&35 DAS (0.2% FsB)]and lowest number of branches/plant (7.15) was observed in treatment 1[P_1 (20:40:20 NPK)][Table 1]. The significant and maximum number of branches/plant was with the application of phosphorus (60 kg/ha) might be due to the penetration of roots to deeper depths, resulting in more absorption of water and nutrients (Gupta*et al.,* 2006). Further, maximum number of branches/plant might be due to the application of boron (0.2%) promoting root and shoot growth, flower fertility and essential nutrient for nodule forming bacteria therefore, increased nodule count resulting in increasing in effect of number of branches/ plant (Karthik *et al.,* 2021).

3.1.3 Number of nodules/plant

The result revealed that a significantly higher number of Nodules /Plant (20.30) was recorded in treatment 12 [P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB) (Table 1). However, treatment 11 [P_3 (20:60:20NPK) + 35 DAS (0.2% FsB)] were statistically at par with the treatment 8 [P_2 (20:50:20 NPK) +20&35 DAS (0.2% FsB)] and lowest number of nodules/plant (10.12) was observed in treatment 1 [P_1 (20:40:20 NPK)] [Table 1]. “The application of phosphorus (60 kg/ha) increased the number of nodules per plant, which may have affected the protein production that results in an increase in nodules. Similar outcomes were in accordance with Satya, 2021. Boron (0.2%) could be responsible for the beneficial effects on plant metabolism and biological process activity, as well as their stimulating effect on photosynthetic pigments and enzyme activity, which in turn supported vegetative development” (Nasar*et al.*, 2018)

3.1.4 Plant dry weight (g)

Data found that significantly higher plant dry weight (10.12 g) was obtained in the treatment 12 [P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB)]@75DAS.However, treatment 11 [P_3 (20:60:20NPK) + 35 DAS (0.2% FsB)] were statistically at par with the treatment 8 [P2 (20:50:20 NPK) +20&35 DAS (0.2% FsB)].“The phosphorus, which is a key component of nucleoproteins and lipoids, is abundant in the meristematic zone, which may have aided in cell division and multiplication as well as nitrogen fixation, carbohydrate transformation, and cell division, all of which contribute to increased plant development” (Sahu*et al.*, 2021). “In terms of dry matter and crop growth rate, the impact of micronutrient application on cowpea growth can be characterized in terms of the metabolic role of micronutrients in the plant”(Imran and Amanullah, 2021).

3.2 Yield parameters

3.2.1 Number of pods/plant

The result revealed that a significant and higher number of pods/plant (33.07) was recorded in treatment 12 **[**P_3(20:60:20NPK) + 20 & 35 DAS (0.2% FsB)].However, treatment 11 [P_3 (20:60:20NPK) + 35 DAS (0.2% FsB)] were statistically at par with the treatment 8 [P_2 (20:50:20 NPK) +20&35 DAS (0.2% FsB)] and lowest number of pods/plant (21.19) was observed in treatment 1 [P_1 (20:40:20 NPK)] [Table 2]. “The maximum number of pods/plant with application of phosphorous (60kg/ha). Enhanced root growth, improved root proliferation, and enhanced nutrient availability and absorption might all be contributing factors”(Sarawgi*et al.*, 2012). “The maximum number of pods/plant was observed with the application of boron (0.2%) might be due to the formation of flower and pollen grain thus increases the pods/plant”(Saha*et al.*, 1996)

3.2.2 Number of seeds/pod

The data recorded that significant and higher number of seeds/pod (10.33) was recorded in treatment 12 **[**P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB)]. However, treatment 11 [P_3 (20:60:20NPK) + 35 DAS (0.2% FsB)] were statistically at par with the treatment 8 [P_2 (20:50:20 NPK) +20&35 DAS (0.2% FsB)] and lowest number of seeds/pod (7.50) was observed in treatment 1 [P_1 (20:40:20 NPK)] [Table 2]. “The application of phosphorus (60 kg/ha) resulted in the highest number of seeds/pod, which may be attributable to the increased availability of other plant nutrients that led to an increase in carbohydrate development and their remobilization to the plant's reproductive parts, which are the closest sinks. Given that phosphorus is known to promote blossoming and fruiting, which may have encouraged the plants to develop more pods and allowed for higher plant growth increased development of seed/pod numbers”(Lokhande*et al.*,2018).

3.2.3 Test weight

Significant and maximum test weight (30.20 g) was recorded in treatment 12 [P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB)] and though there was no significant difference among all treatments.

3.2.4 Seed yield (q/ha)

The significantly higher Seed yield (18.54 q/ha) was observed in treatment 12 [P_3(20:60:20NPK) + 20 & 35 DAS (0.2% FsB)]. However, treatment 11 [P_3 (20:60:20NPK) + 35 DAS (0.2% FsB)] were statistically at par with the treatment 8 [P_2 (20:50:20 NPK) +20&35 DAS (0.2% FsB)] (Table 2).“The treatment showed significant and greater seed production withphosphorous (60 kg/ha). Phosphorus may be responsible for the increased photosynthesis and assimilate translocation to various plant parts for the crop's enhanced growth and yield-attributing characteristics, as seen in the number of pods/plant and number of seeds/pods. Later on, the excess assimilates stored in the leaves were translocate towards sink development, which ultimately contributed to higher seed yield (Phogat, 2016). Further, maximum in seed yield with the application of boron (0.2%) might be due to physiological processes and plant growth also adequate nutrition is a critical for increases yield and quality of crops”(Chena *et al*., 2017).

3.2.5 Stover yield (q/ha)

At harvest the data recorded more stover yield (32.20 q/ha) in Treatment 12 [P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB)]. However, treatment 11 [P_3 (20:60:20NPK) + 35 DAS (0.2% FsB)] were statistically at par with the treatment 8 [P_2 (20:50:20 NPK) +20&35 DAS (0.2% FsB)] (Table 2).“Significant and higher stover yield was observed with application Phosphorous (60kg/ha). Possibly as a result of the improved nutritional environment of the rhizosphere and plant system leading to better plant metabolism and photosynthetic activity, plants have grown and developed more in terms of height, branches, and dry matter” (Sarawgi*et al*., 2012). Boron also increases the amount of chlorophyll in leaves, which increases the generation of biomass and photosynthetic, which are efficiently transmitted to the roots for growth and to supply the energy needed for nutrient intake, which results in higher biological yields (Ravindra*et al*.,2022).

3.2.6 Harvest index (%)

At harvest, the data recorded maximum harvest index (36.54 %) in treatment treatment 12 [P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB)]and though there was no significant difference among all treatments.

Table – 1Effect of different levels of phosphorus and Boron on growth attributes of summer green gram

T.No.	Treatment	Plant height (cm)	Number of branches/ plant	Number of nodules/ plant	Plant dry weight (g)	CGR (g/m^2/day)

T_1	P_1 (20:40:20 NPK)	70.50	7.15	10.12	6.68	5.01
T_2	P_1 (20:40:20 NPK) +20 DAS (0.2% FsB)	73.11	8.98	13.50	7.14	6.32
T_3	P_1 (20:40:20 NPK) +35DAS (0.2% FsB)	73.56	9.31	14.42	8.42	6.91
T_4	P_1 (20:40:20 NPK) +20&35 DAS (0.2% FsB)	74.12	10.75	15.20	9.11	7.92
T_5	P_2 (20:50:20 NPK)	72.69	7.70	12.96	7.62	5.42
T_6	P_2 (20:50:20 NPK) +20 DAS (0.2% FsB)	73.42	8.30	14.31	8.21	6.88
T_7	P_2 (20:50:20 NPK) +35 DAS (0.2% FsB)	73.72	9.63	14.78	8.71	6.10
T_8	P_2 (20:50:20 NPK) +20&35 DAS (0.2% FsB)	76.99	11.40	17.89	9.56	7.01
T_9	P_3 (20:60:20 NPK)	72.89	8.81	13.32	7.92	5.79
T_{10}	P_3 (20:60:20NPK) + 20 DAS (0.2% FsB)	73.99	9.72	14.07	8.80	7.42
T_{11}	P_3 (20:60:20NPK) + 35 DAS (0.2% FsB)	77.12	11.70	18.32	9.81	8.11
T_{12}	P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB)	78.47	13.20	20.30	10.12	8.50
F-test		S	S	S	S	NS
SEm(±)		0.29	0.32	0.36	0.31	0.35
CD at 5%		0.86	0.94	1.05	0.90	1.03
CV		0.69	5.69	4.16	6.26	8.98

Table – 2. Effect of different levels of phosphorus and Boron on yield attributes of summer green gram

T. No.	Treatment	Number of pods/plant	Number of seeds/pod	Test weight (g)	Seed yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
T_1	P_1 (20:40:20 NPK)	21.19	7.50	25.47	10.23	17.21	37.27
T_2	P_1 (20:40:20 NPK) +20 DAS (0.2% FsB)	25.98	8.22	25.57	13.11	21.55	37.84
T_3	P_1 (20:40:20 NPK) +35DAS (0.2% FsB)	27.72	7.20	26.00	14.01	23.12	37.72

T_4	P_1 (20:40:20 NPK) +20&35 DAS (0.2% FsB)	28.92	9.40	26.50	14.89	27.16	35.41
T_5	P_2 (20:50:20 NPK)	22.37	7.80	25.87	11.60	18.52	38.51
T_6	P_2 (20:50:20 NPK) +20 DAS (0.2% FsB)	26.32	8.85	26.90	13.40	22.20	37.63
T_7	P_2 (20:50:20 NPK) +35 DAS (0.2% FsB)	28.05	8.70	27.10	14.20	25.73	35.55
T_8	P_2 (20:50:20 NPK) +20&35 DAS (0.2% FsB)	30.91	9.80	29.39	16.85	29.13	36.64
T_9	P_3 (20:60:20 NPK)	23.11	8.01	27.62	12.72	20.65	38.12
T_{10}	P_3 (20:60:20NPK) + 20 DAS (0.2% FsB)	29.69	9.78	28.01	14.52	26.52	35.38
T_{11}	P_3 (20:60:20NPK) + 35 DAS (0.2% FsB)	32.72	10.07	29.78	17.20	30.52	36.04
T_{12}	P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB)	33.07	10.33	30.20	18.54	32.20	36.54
F-test		S	S	NS	S	S	NS
SEm(±)		0.35	0.31	1.53	0.34	0.33	0.78
CD at 5%		1.03	0.92	4.42	0.99	0.98	2.30
CV		2.22	6.17	8.32	4.09	2.35	3.68

3.1 Economics

The result showed that higher gross return (139050 INR/ha), higher net returns (103054 INR/ha) and highest benefit cost ratio (2.86) was also recorded in treatment 12 [P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB)] as compared to other treatments.

Higher net returns, gross returns and B:C ratio was recorded with the application of phosphorus(60kg/ha) might be due to greater increase in grain and straw yield resulted higher benefit cost ratio. These results are in conformity with those observed by (Singh *et al*., 2004)

Table – 3 Total cost of cultivation (INR/ha), gross return (INR/ha), net return (INR/ha) and benefit cost ratio.

T. No.	Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return ((INR/ha)	Benefit cost ratio
T_1	P_1 (20:40:20 NPK)	27772	76725	48953	1.76

T_2	P_1 (20:40:20 NPK) +20 DAS (0.2% FsB)	30550	98325	67775	2.21
T_3	P_1 (20:40:20 NPK) +35DAS (0.2% FsB)	31120	105075	73955	2.37
T_4	P_1 (20:40:20 NPK) +20&35 DAS (0.2% FsB)	33218	111675	78457	2.36
T_5	P_2 (20:50:20 NPK)	28772	109500	80728	2.80
T_6	P_2 (20:50:20 NPK) +20 DAS (0.2% FsB)	30550	100500	69950	2.28
T_7	P_2 (20:50:20 NPK) +35 DAS (0.2% FsB)	31550	106500	74950	2.37
T_8	P_2 (20:50:20 NPK) +20&35 DAS (0.2% FsB)	33328	126375	93047	2.79
T_9	P_3 (20:60:20 NPK)	30440	95400	64960	2.13
T_{10}	$P_{3 (}$20:60:20NPK) + 20 DAS (0.2% FsB)	32240	108900	76660	2.37
T_{11}	$P_{3 (}$20:60:20NPK) + 35 DAS (0.2% FsB)	34328	129000	94672	2.75
T_{12}	P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB)	35996	139050	103054	2.86

4. Conclusion

Under Eastern Rajasthan, green gram raised yield up to 18.54 q/ha in treatment 12[P_3(20:60:20NPK) + 20& 35 DAS (0.2% FsB)]. Which has been proved to be better option for getting higher production and productivity under

Conflict of Interest: Authors declare that they have no conflicts of interest.

6. REFERENCES

Anonymous, 2021. Green gram Outlook Report (2021). Agricultural Market Intelligence Centre, ANGRAU.

Anand, A., Umesha, C., Sanodiya, L.K., 2022. Effect of phosphorous and molybdenum on yield and economic of black gram (*Vigna mungo* L.). *The Pharma Innovation Journal* 11(5), 1417-20.

Aslam, M., Hussain, N., Zubair, M., Hussain, S.B., Baloch, M.S., 2010. Integration of organic and inorganic sources of phosphorus for increased productivity of mung bean (*Vigna radiata* L.). *Pakistan Journal of Agriculture Science* 47, 111-114.

Awomi, T.A., Singh, A.K., Kumar, M., Bordoloi, L.J., 2012. Effect of phosphorus, molybdenum, and cobalt nutrition on yield and quality of mungbean (*Vignaradiata* L.) in acidic soil of Northeast India. *Indian Journal of Hill Farming* 25(2), 22-26.

Chena, R., Devendra, S., Jat, B.L., 2017. Effects of different phosphorus levels and frequency of boron levels on growth and yield of greengram. *Advance Research Journal of Crop Improvement* 8(1), 49-61.

Cheng, H., Yuan, M., Tang, L., Shen, Y., Yu, Q., and Li, S., 2022. Integrated microbiology and metabolomics analysis reveal responses of soil microorganisms and metabolic functions to phosphorus fertilizer on semiarid farm. *Science of the Total Environment* 817, 152878.

Fardeau, J.C., Zapata, F., 2012. Phosphorus fertility recapitalization of nutrient-depleted tropical acid soils with reactive phosphate rock: An assessment using the isotopic exchange technique. *Nutrient Cycling in Agroecosystems* 63(1), 69 - 77.

Gupta, A., Sharma, V., Sharma, G. D. and Chopra, P. 2006. Effect of biofertilizers and phosphorus levels on yield attributes, yield and quality of urdbean (Vignamungo L.).*Indian Journal of Agronomy*51(2): 142-144.

Imran, Amanullah, 2021. Phosphorus and boron application optimizing biofortification of P and productivity of french bean (*Phaseolus vulgaris* L.). *Communications in Soil Science and Plant Analysis* 52(22), 2876-2883.

Kaisher, M.S., Rahman, M.A., Amin, M.H.A., Amanullah, A.S.M., Ahsanullah, A.S.M., 2010. Effects of sulphur and boron on the seed yield and protein content of mung bean. *Bangladesh Research Publications Journal* 3(3), 1181-1186.

Karthik, B., Umesha, C., Sanodiya, L. K., Priyadarshini, A.S., 2021. Impact of nitrogen levels and application of boron on yield and growth of green gram (*Vigna radiata* L.). *In Biological Forum–An International Journal* 13(3), 08-11.

Lokhande, P.B., 2018. Effect of phosphorus and zinc on yield and quality of greengram (*Vignaradiata* L.) in Inceptisol. *International Journal of Engineering Sciences and Computing* 8(7), 18647-18649.

Mubeen, A., Saeed, M.T., Saleem, M.F., Wahid, M.A., 2020. Zinc and boron application improves yield, yield components and gross returns of mungbean (*Vignaradiata* L.). *Journal of Arable Crops andMarketing* 2(2), 79-87.

Muindi, E.M., Muindi, C.M., Ndiso, J., 2020. The effects of combining farm yard manure, starter nitrogen, phosphorus and zinc on growth and yield of green grams. *Journal of Agriculture and Ecology ResearchInternational* 20(4), 1-9.

Nasar, J., Qiang, G., Alam, A., 2018. Groundnut response to boron and molybdenum. *Journal of Science FrontierResearch*: D Agriculture and Veterinary 18(1), 16-22.

Padbhushan, R., Kumar, D., 2014. Influence of soil and foliar applied boron on green gram in calcareous soils. *International Journal of Agriculture, Environment and Biotechnology* 7(1), 129-136.

Padbhushan, R., Kumar, D., 2015. Yield and nutrient uptake of green gram (*Vigna radiata* L.) as influenced by boron application in boron-deficient calcareous soils of Punjab. *Communications in Soil Science and PlantAnalysis* 46(7), 908-923.

Phogat, M., 2016.Effects of phosphorus and sulphur interaction on blackgram in rice-blackgram cropping system of coastal saline soils. *Legume Research*31 (2): 79-86.

Pompelli, M.F., Barata-Luís, R., Vitorino, H.S., Gonçalves, E.R., Rolim, E.V., Santos, M.G., Endres, L., 2010. Photosynthesis, photoprotection and Antioxidant activity of purging nut under drought deficit and recovery. *Biomass and Bioenergy* 34(8), 1207-1215.

Ravindra, J., Swaroop, N., Thomas, T., 2022. Response of NPK, zinc and boron fertilization on physico-chemical properties of soil under summer green gram (*Vigna radiate* L.) cultivation in an inceptisol of Prayagraj, (Uttar Pradesh). *International Journal of Plant and Soil Science* 34(20), 1-8.

Rizvi, A., Khan, M.S., Ahmad, E., 2014. Inoculation impact of phosphate-solubilizing microorganisms on growth and development of vegetable crops. Phosphate Solubilizing Microorganisms: Principles and Application of Microphos Technology, 287-297.

Saha, A., Mandal, B.K., Mukhopadyay, P., 1996. Residual effect of boron and molybdenum on the yield of succeeding green gram in summer. *Indian Agriculturist* 40, 11-16.

Sahu, S., Shankar, T., Maitra, S., Adhikary, R., Mondal, T., Duvvada, S.K., 2021. Impact of phosphorus and sulphur on the growth and productivity of green gram (*Vigna radiata*). *Research on Crops*, 22(4), 345-358.

Sarawgi, S. K., Chitale, S., Tiwarp, A., Bhoi, S., 2012. Effect of phosphorus application alongwith PSB, Rhizobium and VAM on P fractionation and productivity of soybean (Glycine max). *Indian Journal of Agronomy*, *57*(1), 55-60.

Satya, M.S.S., 2021. Performance of black gram (*Vigna mungo* L. Hepper) under phosphorus and boron fertilization in acid Inceptisol of Meghalaya. *Journal of Environmental Biology* 42, 534-543.

Singh, Y. P., & Singh, R., 2004. Interaction effect of sulphur and phosphorus on growth and nutrient content of black gram (Phaseolus mungo L.). *Journal of the Indian Society of Soil Science*, *52*(3), 266-269.