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Suman Kumar Dey
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Vikram Singh
Associate Professor, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Dhananjay Tiwari
Ph.D., Scholar, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Suman Kumar Dey
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Effect of phosphorus and sulphur on the growth and yield of summer Mungbean (*Vigna radiata* L.)

Suman Kumar Dey, Vikram Singh and Dhananjay Tiwari

Abstract
A field trial was carried out at Crop Research Farm, Naini Agricultural Institute, Department of Agronomy, Sam Higginbottom University Agriculture, Technology and Sciences, Prayagraj during Zaid season, 2021 to study "Effect of phosphorus and sulphur on the growth and yield of summer Mungbean (*Vigna radiata* L.). The experiment was done in randomized block design with nine treatments replicated three times. Factors consisted of three levels of phosphorus in the form of DAP (40, 50, 60 kg/ha) and three levels of sulphur in the form of Gypsum (10, 15, 20 Kg/ha). The results revealed that application of 60 kg/ha Phosphorus + 20 kg/ha Sulphur recorded maximum plant height (43.25 cm), number of nodules/plant (29.93), plant dry weight (15.24 g), crop growth rate (13.31 g/m^2/day),number of pods/plant (23.87), number of seeds/pod (8.73), test weight (37.63 g), seed yield (970.33 kg/ha), stover yield (1597.67 kg/ha) gross return (₹ 106736.3/ha), net return (₹ 63592.3/ha) and B: C ratio (1.47). Whereas maximum relative growth rate (0.035 g/g/day) was recorded with application of 40 kg/ha Phosphorus + 20 kg/ha Sulphur and highest harvest index (38.30%) was recorded with application of 50 kg Phosphorus/ha + 20 kg Sulphur/ha.

Keywords: Mungbean, phosphorus, sulphur, growth and yield

1. Introduction
In India since prehistoric times cultivation of mungbean (*Vigna radiata* L.) is going on. We also know it as green gram Mungbean is composed of tryptophan (60 mg/g N) and lysine (4600 mg/g N) (Dotaniya *et al.*, 2019) [3]. In the human diet pulses are an important part in the form of mature dry seeds and also as green immature seeds or as green pods. Pulses can also be used as hay and straw for animals and also in the cropping system they play an important role. India is the world's largest pulses producer (25% of the world) and also import (14%) it as a source of protein supplement (Singh *et al*., 2012) [10]. Also in terms of consumption (27%) of the world.

Pulses are the rich source of protein (average 20-25%), vitamins, minerals (iron, zinc, magnesium) and fibres. Sulphur and phosphorus play an important role in the nutrition of plants. But in most cases they lack in the soils. Analysis of soils have indicated that, Indian soils contain medium to low phosphorus and are mostly deficient in sulphur (Kumawat *et al.*, 2014) [6]. There is always an important role played by phosphorus in the formation and translocation of carbohydrates, germination of seed, division of the cell, flowering, fruiting, synthesis of protein, fat & starch, maturation of crop and also in pathogen resistance. Hence, phosphorus helps to increase the dry matter, test weight, yield of mungbean and improves the quality also. Early root development is done by phosphorus, thus improving the rhizobia activity and enhancing root nodule activity for biological nitrogen fixation (BNF) (Sahu *et al.*, 2020) [9]. Like phosphorus, plant requires sulphur also. Sulphur boosts nodulation in the pulses. Sulphur not only contain amino acids (cystine, cysteine and methionine) but also help in the synthesis of vitamins (biotine and thiamine). Throughout the growing season of green gram, sulphur affects plant height, branches, number of pods, grains per pod (Kumar *et al*., 2012) [5]. Not only that, phosphorus uptake by the plant is also influenced by sulphur (Singh *et al*., 2017) [12].

Information about the combined application of phosphorus and sulphur on growth and yield of mungbean is limited. So, this present investigation entitled "Effect of phosphorus and sulphur on the growth and yield of summer Mungbean (*Vigna radiata* L.)" was conducted. The main objective was the assessment of phosphorus and sulphur levels on growth and yield of summer mungbean and to assess the economic viability of the treatments.

2. Materials and Methods

The above said agronomic field trial was done during zaid season of 2021 at the Crop Research Farm (CRF) situated at 25˚39" 42" N latitude, 81˚ 67" 56" E longitude and 98 m altitude above the mean sea level (MSL), Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh. During summer weather was very hot and dry. For analysing, soil samples were collected randomly with the help of a soil auger from 0-15 cm of soil depth. Soil samples were analysed in a nearby KVK research station. Sandy loam was the soil type of the experimental area. Soil had available N (75.3 kg/ha), available P (31.78 kg/ha), available K (253.14 kg/ha), organic carbon (0.56%) and pH 7.2. In randomized block design (RBD) this experiment was done with nine treatments replicated three times. Each plot size for experiment was 3 x 3m. The treatment combination which were used for this experiment are T_1: 40 kg P/ha + 10 kg S/h, T_2: 40 kg P/ha + 15 kg S/ha, T_3: 40 kg P/ha + 20 kg S/ha, T_4: 50 kg P/ha + 10 kg S/ha; T_5: 50 kg P/ha + 15 kg S/ha, T_6: 50 kg P/ha + 20 kg S/ha, T_7: 60 kg P/ha + 10 kg S/ha, T_8: 60 kg P/ha + 15 kg S/ha and T_9: 60 kg P/ha + 20 kg S/ha. DAP, Gypsum and MOP were applied as fertilizers for the sources of N, P, K & S. All these fertilizers were applied before sowing with the common spacing of 30 cm × 10 cm for all the treatments. Variety used for sowing was PDM 139 (Samrat) and harvesting was done on 14-06-2021.

The observations of plant growth attributes were recorded by selecting five random plants from each plot. Similarly, yield attributes were recorded by selecting five random plants from each plot at the time of harvest. Experimental data collected were subjected to statistical analysis by using Fisher's method of Analysis of Variance (ANOVA). Whenever the 'F' test was found significant at 5% level Critical Difference values were calculated.

3. Results and Discussion

3.1 Growth attributes

Data presented in Table: 1 shows the effect of levels of Phosphorus and Sulphur on growth attributes of Mungbean (*Vigna radiata* L.). Plant height (cm), Number of nodules/ plant (No.), Plant dry weight (g/plant), Crop growth rate (CGR) (g/m^2 /day) and Relative growth rate (RGR) (g/g/day) come under growth attributes.

Plant height of mungbean was significantly influenced among all treatments. However, significantly higher (43.25 cm) plant height was recorded in T_9 (60 kg Phosphorus /ha + 20 kg Sulphur /ha) as compared to other treatment combinations. Whereas, T_4 and T_5 were statistically at par T_9. Phosphorus and sulphur levels also significantly influenced the number of nodules/plant. Highest (21.72) number of nodules/plant was recorded with application of T_9 (60 kg Phosphorus /ha + 20 kg Sulphur /ha) as compared to other treatment combinations. Significantly higher (15.24 g/plant) plant dry weight was recorded in T_9 (60 kg Phosphorus /ha + 20 kg Sulphur /ha) and none of the treatments were found statistically at par among themselves. CGR and RGR data was found to have significant difference in between the treatments. Highest (13.31 g/m^2/day) CGR was recorded with application of T_9 (60 kg Phosphorus /ha + 20 kg Sulphur /ha) as compared to other treatment combinations. Whereas T_3 and T_4 were found statistically at par with T_9. In case of RGR significantly highest (0.035 g/g/day) value was recorded with application of T_3 (40 kg Phosphorus /ha + 20 kg Sulphur /ha) and none of the treatments were found statistically at par among themselves.

Increase in the plant height was a result of increasing levels of phosphorus which helped in new cell formation and root development, which in turn led to better availability of nutrients and water from the deeper layer of soil for higher photosynthetic activity. Not only that, sulphur was involved in the synthesis of protein and formation of chlorophyll which ultimately resulted in more vegetative growth and subsequently increase in plant height. Higher dry weight was due to the cumulative effect of increase in plant height and number of branches which resulted in more production of dry matter in plants. Phosphorus also increases the formation of root nodule by enhancing the activity of rhizobia and there by helps in fixing more of atmospheric nitrogen in root nodule. Increase in nodule number with increasing levels of sulphur was due to increase in amount of ferredoxin. All these findings were similar to Masih *et al.* (2020) [7], Singh *et al.* (2015) [11], Venkatarao *et al*. (2017) [13] and Bharvi *et al.* (2020) [2].

3.2 Yield attributes

Data presented in Table: 2 reveals the effect of levels of Phosphorus and Sulphur on yield attributes of Mungbean (*Vigna radiata* L.). Yield attributes include the parameters like pods/ plant (No.), seeds/pod (No.), test weight (g), seed yield (kg/ha), stover yield (kg/ha) and Harvest index (%).

The number of pods per plant was significantly increased due to the different treatment combinations. Significantly higher (23.87) number of pods per plant was recorded with application of T_9 (60 kg Phosphorus /ha + 20 kg Sulphur /ha). Number of seeds/pod was recorded significantly higher (8.73) with application of T_9 (60 kg Phosphorus /ha + 20 kg Sulphur /ha). Significantly highest (37.63 g) 1000 seed weight was recorded in application of T_9 (60 kg Phosphorus /ha + 20 kg Sulphur /ha). Whereas, T_6 and T_8 were statistically at par with T_9. Data of seed yield of mungbean shows significant differences in between the different treatment combinations. The highest (970.33 kg/ha) seed yield was recorded with application of T_9 (60 kg Phosphorus /ha + 20 kg Sulphur /ha). Stover yield was increased significantly with the increase in doses of phosphorus and sulphur. Significantly highest (1597.67 kg/ha) stover yield was recorded in T_9 (60 kg Phosphorus /ha + 20 kg Sulphur /ha) and T_7 and T_8 were statistically at par with T_9. In case of harvest index there was no significant difference in between the treatment combinations. However, highest (38.30%) harvest index was recorded in T_6 (50 kg Phosphorus /ha + 20 kg Sulphur /ha).

Phosphorus levels resulted in higher number of branches having more number of pods, weight of thousand grains (test weight) which was due to maximization of photosynthesis and respiration, storage of energy, cell division and elongation which ultimately leads to enhancement in seed production. Sulphur is a source amino acid (Cystine), which helps in formation of chlorophyll, photosynthesis and enzyme activation which leads to increase in the number of pods per plant, seeds per pod and 1000 grain weight. The improvement in yield attributes was due to the balanced environment of nutrient availability. Increase in straw yield was because of sulphur application having a combined effect of increased plant height, number of leaves per plant and number of branches/plant i.e. increased growth parameters. This finding is in close conformity to those of reported by Arun Raj *et al.* (2018) [1], Parashar *et al.* (2020) [8], Yadav *et al.* (2017) [14] and Gajera *et al.* (2014) [4].

3.3 Economics of treatments

In the Table: 3 economic evaluation in between the treatments is done on the basis of gross return, net return and B:C ratio. Economics of different treatment vary from cost of cultivation and market price of produce. It was observed that T_9 (60 kg Phosphorus /ha + 20 kg Sulphur /ha) registered maximum gross return (₹ 106736.3/ha), net return (₹ 63592.3/ha) and B:C ratio (1.47). This might be due to higher yield in T_9 (60 kg Phosphorus /ha + 20 kg Sulphur /ha) as compare to other treatment combinations.

4. Conclusion

Thus, on the basis of above field experiment it can be concluded that mungbean variety PDM 139 (Samrat) fertilized with 60 kg Phosphorus/ha + 20 kg Sulphur/ha sustained higher seed yield (970.33 kg/ha), stover yield (1597.67 kg/ha), net return (₹ 63592.3/ha) and B:C ratio (1.47) in the zaid season (2021) of Prayagraj, Uttar Pradesh.

Table 1: Effect of levels of Phosphorus and Sulphur on growth attributes of Mungbean (*Vigna radiata* L.)

Treatment No.	Treatment combinations	Plant height (cm) 60 DAS	Number of nodules/ plant 60 DAS	Plant dry weight (g/plant) 60 DAS	Crop growth rate (CGR) (g/m^2 /day) 45-60 DAS	Relative growth rate (RGR) (g/g/day) 45-60 DAS
1	40 kg P/ha + 10 kg S/ha	40.87	15.18	12.25	9.30	0.027
2	40 kg P/ha + 15 kg S/ha	42.38	16.80	13.21	10.15	0.033
3	40 kg P/ha + 20 kg S/ha	41.84	19.05	14.23	12.64	0.035
4	50 kg P/ha + 10 kg S/ha	42.72	18.57	14.63	13.20	0.028
5	50 kg P/ha + 15 kg S/ha	42.52	20.03	13.88	11.52	0.022
6	50 kg P/ha + 20 kg S/ha	41.43	18.92	13.22	9.81	0.034
7	60 kg P/ha + 10 kg S/ha	42.31	20.35	13.96	11.11	0.030
8	60 kg P/ha + 15 kg S/ha	41.96	21.02	14.54	12.27	0.030
9	60 kg P/ha + 20 kg S/ha	43.25	21.72	15.24	13.31	0.031
	F- test	S	S	S	S	S
	S. Em (+)	0.26	0.2	0.20	0.53	0.006
	CD (P = 0.05)	0.79	0.59	0.60	1.58	0.020

Table 2: Effect of levels of Phosphorus and Sulphur on yield attributes yield of Mungbean (*Vigna radiata* L.)

Treatment No	Treatment combinations	Number of Pods/ plant	Number of Seeds/pod	Test weight (g)	Seed yield (Kg/ha)	Stover yield (Kg/ha)	Harvest index (%)
1	40 kg P/ha + 10 kg S/ha	15.20	4.33	31.06	716.33	1301.33	35.43
2	40 kg P/ha + 15 kg S/ha	17.53	5.87	32.99	799.33	1350.00	37.15
3	40 kg P/ha + 20 kg S/ha	18.60	6.60	31.58	815.67	1470.33	35.72
4	50 kg P/ha + 10 kg S/ha	19.20	7.20	33.23	813.00	1434.33	36.18
5	50 kg P/ha + 15 kg S/ha	20.33	6.73	34.21	807.67	1475.33	35.41
6	50 kg P/ha + 20 kg S/ha	20.40	7.13	35.69	893.67	1442.50	38.30
7	60 kg P/ha + 10 kg S/ha	20.40	7.33	33.62	833.33	1481.00	36.01
8	60 kg P/ha + 15 kg S/ha	21.47	7.27	37.12	900.33	1559.33	36.61
9	60 kg P/ha + 20 kg S/ha	23.87	8.73	37.63	970.33	1597.67	37.78
F-test		S	S	S	S	S	NS
S. Em (±)		0.36	0.25	1.03	19.05	33.50	0.73
CD (P = 0.05)		1.08	0.75	3.09	57.11	100.45	--

Table 3: Effect of levels of Phosphorus and Sulphur on economics of Mungbean (*Vigna radiata* L.)

Treatment No.	Treatment Combinations	Total cost of cultivation (₹/ha)	Gross Returns (₹/ha)	Net Returns (₹/ha)	B:C ratio
1	40 kg P/ha + 10 kg S/ha	36569	78796.3	42227.3	1.15
2	40 kg P/ha + 15 kg S/ha	39269	87926.3	48657.3	1.24
3	40 kg P/ha + 20 kg S/ha	42069	89723.7	47654.7	1.13
4	50 kg P/ha + 10 kg S/ha	37119	89430	52311	1.41
5	50 kg P/ha + 15 kg S/ha	39819	88843.7	49024.7	1.23
6	50 kg P/ha + 20 kg S/ha	42619	98303.7	55684.7	1.31
7	60 kg P/ha + 10 kg S/ha	37644	91666.67	54022.67	1.44
8	60 kg P/ha + 15 kg S/ha	40344	99036.67	58.692.67	1.45
9	60 kg P/ha + 20 kg S/ha	43144	106736.3	63592.3	1.47

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