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Growth and Productivity Augmentation of Greengram (*Vigna radiata*) through Phosphorus Sources and Sulphur Levels

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ABSTRACT

Background: Being an efficient N- fixer, mungbean improve the soil fertility status and can thereby serve as a useful component in any viable cropping system in the country. PROM has to be a better source of phosphate application. Indian soils are deficient in organic carbon. Sulphur is mostly applied to oilseed and pulse crops found to benefit more than one crop in a sequence due to its significant residual response.

Methods: The investigation was conducted during *kharif* season of 2019 comprising five levels of phosphorus sources (Control, 16 kg P_2O_5/ha through DAP, 16 kg P_2O_5/ha through PROM, 32 kg P_2O_5/ha through DAP and 32 kg P_2O_5/ha through PROM) and three levels of sulphur (Control, 15 and 30 kg/ha) making 15 treatment combinations replicated three times in factorial randomized block design.

Result: Application of 32 kg P_2O_5/ha through PROM recorded significantly higher growth, yield attributes, yields as well as net returns (` 50440) with B:C ratio 2.93 as compared to 16 kg $P_2O_5$/ha through DAP, 16 kg $P_2O_5$/ha through PROM and 32 kg $P_2O_5$/ha through DAP. With regard to sulphur levels application of sulphur up to 30 kg/ha recorded significantly higher growth, yield attributes, yields as well net returns (` 46723) with B:C ratio 2.96 over control and 15 kg S/ha.

Key words: Chlorophyll, Greengram, PROM, Sulphur.

INTRODUCTION

Pulses are the main source of protein particularly for vegetarians and contribute about 14 per cent of the total protein for an Indian average diet (Singh *et al*., 2011). Mungbean (*Vigna radiate*) is one of the important pulse crops cultivated throughout India for its multipurpose uses as vegetable, pulse, fodder and green manure crop. It is a drought tolerant crop and can be successfully grown on well drained sandy loam to loamy soil in the areas receiving erratic rainfall. This crop is primarily grown in rainy season but with the development of early maturing varieties, it has proved to be an ideal crop of spring and summer seasons. It is a short duration *kharif* pulse crop which can be grown as catch crop between *rabi* and *kharif* seasons. Being a short duration crop, mungbean fits well in various multiple and inter cropping systems. During summer, it can be used as a green manuring crop. Phosphorus is an important nutrient after nitrogen. Indian soils are poor to medium in available phosphorus (Singh *et al*., 2015). It plays a key role in energy metabolism of all plant cells particularly nitrogen fixation in leguminous crops. For meeting out the requirement of phosphorus for various pulses or mungbean crops different sources like, DAP, SSP, rock phosphate, gypsum, phosphorus rich organic manures are used. PROM has come out to be a better source of phosphorus. The Indian soils are deficient in organic carbon. Phosphorous Rich Organic Manure (PROM) is an organic alternative and indigenous source of phosphatic fertilizer. This substance is more efficient source for adding phosphorous to soil as compared to chemical fertilizers like, DAP, MAP, SSP *etc*. Besides, PROM also supplies the phosphorus to the succeeding crops as efficiently as it nourishes the crop to which it has been applied. The farmers are not much familiar with PROM and still use traditional fertilizers for their crops. This is very serious problem for all, these fertilizer harm the soil as well as environment, livestock, humans *etc*. Sulphur deficiency is reported from various areas of the country mainly due to increased crop yield coupled with intensive farming and a drastic shift from low analysis fertilizers to high analysis fertilizers containing little or no elemental S (Krishna *et al*., 2020). Thus the study of phosphorus and sulphur to legumes is more important than that of nitrogen as later is being fixed by symbiosis with rhizobium bacteria.

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MATERIALS AND METHODS

A field study was conducted during *kharif* season of 2019 at Instructional farm of College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner (28.01°N latitude and 73.22°E longitude at an altitude of

234.7 m amsl). The experiment comprising five levels of phosphorus sources (Control, 16 kg P_2O_5/ha through DAP, 16 kg P_2O_5/ha through PROM, 32 kg P_2O_5/ha through DAP and 32 kg P_2O_5/ha through PROM) and three levels of sulphur (Control, 15 and 30 kg/ha) making 15 treatment combinations replicated three times in factorial randomized block design. The soil of experimental site was loamy sand having 0.09% organic carbon, 8.2 pH, 115, 14 and 212 kg/ha available N, P and K, respectively. Greengram 'IPM 2-3' was sown on 23 July 2019 at 30 cm row spacing and was harvested on 30 September 2019. Phosphorus was applied through DAP and PROM fertilizer as per treatments as basal application in furrows. The weighed quantity of DAP and PROM was broadcasted uniformly in earmarked plots and thoroughly mixed in soil before sowing. The weighted quantity of gypsum was broadcasted uniformly in earmarked plots and thoroughly mixed in soil before sowing. In addition to rainfall received during the crop season, two light irrigations were given through sprinkler system during long and dry spell period to ensure optimum growth, development and yield of green gram. To keep the experimental crop free from weed, hoeing and weeding was done at 3-4 weeks after sowing with the help of hand hoe locally called as Kassia. In order to test the significance of variance in experiments, the data obtained for various treatment effects were statistically analyzed as per procedure described by Panse and Sukhatme (1985). The critical differences were calculated to assess the significance of treatment means wherever, the "F" test was found significant at 5 per cent and/or at 1 per cent level of significance.

RESULTS AND DISCUSSION

Growth attributes

The growth parameters viz. plant height at harvest, no. of root nodules at 45 DAS, branches/plant at harvest and chlorophyll content (45 DAS) were favorably influenced by different sources of phosphorus. Among the sources, application of 32 kg P_2O_5/ha through PROM significantly increased the all growth parameters as compared to control, 16 kg P_2O_5/ha through DAP, 16 kg P_2O_5/ha through PROM and 32 kg P_2O_5/ha through DAP, respectively (Table 1). However, 16 kg P_2O_5/ha through DAP and 16 kg P_2O_5/ha through PROM remained at par with each other. Phosphorus is second most indispensable nutrient required in adequate amounts in available form for growth and development of plants. Phosphorus is also associated with many vital functions and it contributes to better plant growth. Data in reference to comparative efficacy of phosphorus sources revealed that out of two phosphorus sources, PROM is most effective in increasing the growth parameters as compared to DAP. The favorable effect of phosphorus through PROM on growth parameters could be attributed to better availability of phosphorus for long duration which enhanced extensive root system. Intensive rooting thus encouraged effective utilization of nutrients. Further, PROM as a source of phosphorus contains organic matter as well as various essential nutrients prepared by organic manure and rock phosphate and serves as a rich source of energy for various micro-organisms. It also enhanced the performance of these micro-organisms for various beneficial functions in soil thus provided higher available phosphorus to plants (Singh *et al*., 2015). Addition of PROM enhances the activity and population of *Rhizobium* bacteria in roots of mung bean and thus increased the availability of nitrogen for plant growth. Phosphorus rich organic manure (PROM) increased the total root nodules per plant in green gram over DAP (Singh *et al.,* 2015). The findings of this present experimentation are in close conformity with those of Aechra *et al*. (2017) in cow pea and Yadav *et al.* (2017) in green gram who reported that plant height, no. of branches per plant, total root nodules and total chlorophyll content significantly increased with the application of PROM as compared to DAP. Similar results in clusterbean were also reported by Bairwa *et al.* (2019) who observed the plant height, number of branches per plant

Table 1: Effect of phosphorus sources and sulphur levels on growth attributes of greengram.

Treatment	Plant height at harvest	No. of root nodules at 45 DAS	No. of branches per plant	Chlorophyll content (mg/g) at 45 DAS
Sources of phosphorus (kg/ha)				
Control	38.68	27.22	4.69	3.01
16 kg P through DAP	43.17	30.09	5.46	3.37
16 kg P through PROM	44.76	31.03	6.14	3.53
32 kg P through DAP	48.47	32.89	6.77	3.77
32 kg P through PROM	50.55	34.67	7.46	3.96
SEm±	0.60	0.40	0.25	0.06
CD (P= 0.05)	1.73	1.17	0.72	0.17
Levels of sulphur (kg/ha)				
Control	42.19	29.38	5.05	3.18
15	45.69	31.45	6.36	3.58
30	47.49	32.71	6.90	3.83
SEm±	0.46	0.31	0.19	0.04
CD (P= 0.05)	1.34	0.90	0.56	0.13

and dry matter accumulation increased significantly with the application of PROM as a source of phosphorus.

Successive increase in sulphur level up to 30 kg/ha significantly increased the plant height at at harvest, no. of root nodules at 45 DAS, no. of branches per plant at harvest and chlorophyll content at 45 DAS as compared to control and 15 kg S/ha (Table 1). The increase in growth characters under sulphur fertilization might be due to improved sulphur availability, which in turn enhanced the photosynthetic activity and plant metabolism resulting in to better growth. It is also obvious due to the fact that sulphur application has been reported to improve availability of sulphur itself and other nutrients, which are considered as important for growth and development of plants. The overall improvement in vegetative growth of crop with the sulphur application in present investigation is corroborate with the findings of Prajapat *et al.* (2011). The positive influence of S fertilization on plant height and branches might be attributed to the increased metabolic processes in plant which is seems to have promoted meristematic activities which causes expansion of photosynthetic surface and higher apical bud growth. Further, the improved nutritional environment at cellular level and chlorophyll content appear to have increased photosynthetic rate. Thus, the improved in growth and development of plants in present investigation might be the reason of photosynthetic rate, enhanced metabolic activities and leading to improvement in plant height as well as branches and ultimately assimilation of dry matter accumulation at successive growth stages. The higher sulphur content in plants is known to have important role in the better development and thickening of xylem and collenchyma tissues. These favourable results might have resulted in the stronger stem thereby increasing no. of branches per plant. Jaswal *et al.* (2019) also reported that plant height of black gram increased significantly with increasing doses of sulphur.

Yield attributes and yield

Application of phosphorus at 32 kg P_2O_5/ha through PROM significantly increased the pods/plant and test weight and also the seed, straw and biological yield (Table 1) over 16 kg P_2O_5/ha through DAP, 16 kg P_2O_5/ha through PROM and 32 kg P_2O_5/ha through DAP. However, 16 kg P_2O_5/ha through DAP and 16 kg P_2O_5/ha through PROM found at par with each other. Lower dose of PROM application was probably not able to release adequate quantity of phosphorus in soil for crop growth as reported by Bairwa *et al.* (2019). Phosphorus has been recognized as essential nutrient for all living organisms and plays a very important role in conservation as well as transfer of energy in metabolic reactions of all living cells including biological energy transformation, root development and also in proliferation as it improve root nodule and biological nitrogen fixation by supplying assimilates to roots. P is the main constituent of various co-enzymes, ATP and ADP which serves as energy currency in plants. Phosphorus influences photosynthesis, phospholipids, synthesis of nucleic acids, membrane transport, cytoplasmic streaming and biosynthesis of proteins. Increased availability of P in the soil, improved the status of available nutrient resulting into a greater uptake. The uptake of available nutrients might have improved the photosynthetic synthesis and then translocations to the different parts for promoting the meristematic development in apical buds and inter calary meristems, ultimately increased the root and shoot development. This increase in yield and yield attributes by PROM may be due to an organic source of nutrition which contains organic matter and several essential nutrients with phosphorus and provide food for beneficial microorganism in field. The PROM application to soil might have increased the availability of nutrients due to increase in no. of micro fauna which bring out transformation of nutrients. Beneficial effect of PROM is also related to

Table 2: Effect of phosphorus sources and sulphur levels on yield attributes and yields of greengram.

Treatment	Pods/ plant	Seeds/ pod	Pod length (cm)	Test weight (g)	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Sources of phosphorus (kg/ha)								
Control	28.1	8.56	6.27	26.16	763	1703	2466	30.91
16 kg P through DAP	30.3	8.69	6.49	28.11	851	1889	2740	31.17
16 kg P through PROM	31.2	8.78	6.62	28.94	934	2028	2962	31.36
32 kg P through DAP	34.3	8.83	6.86	30.32	1001	2198	3199	31.26
32 kg P through PROM	36.1	8.91	6.99	31.64	1117	2386	3502	31.82
SEm±	0.55	0.26	0.18	0.45	19	45	51	0.66
CD (P= 0.05)	1.59	NS	NS	1.29	54	132	146	NS
Levels of sulphur (kg/ha)								
Control	27.4	8.48	6.36	27.45	826	1836	2662	30.85
15	32.9	8.87	6.74	29.17	945	2057	3003	31.37
30	35.8	8.91	6.84	30.48	1029	2228	3257	31.69
SEm±	0.42	0.20	0.14	0.35	14	35	39	0.51
CD (P= 0.05)	1.23	NS	NS	1.00	42	102	113	NS

improvement in the soil physical properties as well as soil health. The ample availability of nutrients due to application of PROM might have increased yield attributes because nutrient supply favorably influenced the synthesis of chlorophyll and thus increased the carbohydrate metabolism. The favorable effect leads to increase in translocation of photosynthates towards seed, resulting in the formation of bold grains (Kumawat *et al.* 2013). The overall improvement in seed yield due to the application of PROM may be attributed to cumulative effect of growth parameters as well as yield attributes such as no. of pods/ plant, no. of seeds/pod and test weight. The increase in straw yield significantly with phosphorus through PROM could be attributed in increased vegetative growth as evident from dry matter and branches per plant possibly as a result of the effective uptake and utilization of nutrients absorbed through its extensive root system developed under phosphorus fertilization. The biological yield is being a function of seed and straw yields. Thus, significant increase in biological yield with the application of phosphorus through PROM could be ascribed to the increased seed and straw yields. The faster rate of improvement in seed yield as compared to straw yield to phosphorus fertilization led to significant improvement in biological yield thereby suggesting better source and sink relationship. These results are in the conformity with those of Kumawat *et al.* (2013), Singh *et al.* (2015) and Bairwa *et al.* (2019).

Increasing level of sulphur up to 30 kg/ha significantly increased number of pods per plant, test weight, seed, straw and biological yield which was significantly higher compared to control and 15 kg S/ha (Table 2). However, number of seeds per pod, pod length and harvest index was found non-significant due to different sulphur levels. The overall improvement in yield attributes seems to be due to balanced nutritional environment as well as efficient and greater partitioning of metabolites and adequate translocation of the nutrients towards developing the reproductive structures *i.e.* sinks. The sulphur application might have increased the availability of nutrient to green gram due to improved nutritional environment, which in turn, favourably influenced the energy transformation activation of enzymes, chlorophyll synthesis as well as increased carbohydrate metabolism. Sulphur is a very essential element which increases the root growth, promotes nodule formation and stimulates seed formation ultimately resulting into better growth and development of plants, which might have increase the yield of green gram. Baviskar *et al.* (2010) also reported that treatment receiving sulphur 50 kg/ha produced significantly highest green pod and straw yields over control and 25 S/ kg ha. This may be due to the bioactivities of sulphur might have played important role in improving yield attributes like pods per plant, pod length and there by pod yield/ plant ultimately increase in pod and straw yield. Tripathi *et al.* (2011) reported that the application of sulphur through gypsum might have encouraged yield attributes and total biomass and resultant in increase seed yield. The increase in these characters might be due to the important role of sulphur in energy transformation, activation of enzymes and in carbohydrate metabolism. Yield of any crop is the cumulative effect of its yield attributing characters like pods/ plant, seeds/pod and test weight. Hence, seed yield of mungbean also significantly increased with sulphur fertilization. The sulphur application increased the straw yield might be due to the cumulative effect of improvement in plant height, dry matter accumulation and number of branches. Biological yield is the function of seed and straw yield, as higher seed and straw yields together showed a significant increase in it. The similar findings also corroborate with the findings of Das (2017) and Dharwe *et al.* (2019) who observed the superiority of higher sulphur over control and enhancing seed and straw yield of summer green gram.

Economics

The data (Table 3) explicit that significant increase in net returns and B:C ratio was observed due to different sources of phosphorus application. The highest net returns (50440) was fetched when mungbean crop fertilized with 32 kg P_2O_5/ha through PROM over control, 16 kg P_2O_5/ha through DAP, 16 kg P_2O_5/ha through PROM and 32 kg P_2O_5/ha through DAP, respectively. As net returns is calculated by multiplying the seed and straw yields by their sale prices and subtracting the cost of cultivation including treatment cost. As the price of PROM is very low in comparison to the DAP, hence application of PROM was found profitable over DAP, therefore, led to the maximum returns as it provided a B:C ratio of 2.93. The highest net return of ` 46723/ha with B:C ratio of 2.96 was recorded with the application of S @ 30 kg/ha followed by application of sulphur @ 15 kg/ha which realized net return of ` 41120/ha and B: C ratio of 2.71. This was due to comparatively better increase in yield over other treatments. These results are also with the conformity of findings of Verma and Kushwaha (2020).

Table 3: Effect of phosphorus sources and sulphur levels on economics of greengram

Treatment	Net returns (`/ha)	B:C ratio
Sources of phosphorus (kg/ha)		
Control	31435	2.48
16 kg P through DAP	35488	2.53
16 kg P through PROM	39082	2.56
32 kg P through DAP	45221	2.91
32 kg P through PROM	50440	2.93
SEm±	1146	0.05
CD (P= 0.05)	3320	0.14
Levels of sulphur (kg/ha)		
Control	33156	2.38
15	41120	2.71
30	46723	2.96
SEm±	888	0.04
CD (P= 0.05)	2572	0.11

CONCLUSION

Application of 32 kg phosphorus through PROM and 30 kg/ha S is remunerative in maximizing the growth and yield of green gram on loamy sand soils of Agro-climatic zone I-C (Hyper Arid Partially Irrigated Western Plain Zone). These treatments significantly provided the higher seed yield (1117 and 1029 kg/ha) and net returns (` 50440 and 46723/ha).

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