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Effect of phosphorus, sulfur and biofertilizers on growth, yield and quality of Moth bean

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Abstract
A field experiment was carried out during *kharif* season 2019 to find out the effect of phosphorus, sulphur and biofertilizer on growth, yield and quality of mothbean (*Vigna aconitifolia* L.) at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. Total twelve treatments of different levels of phosphorus, sulphur and biofertilizer were tested randomized complete block design with factorial concept. Among different levels, an application of 60 kg P_2O_5, 20 kg S/ha and seed inoculation of PSB recorded recorded significantly higher number of branches/plant, number of pods/plant, seeds/pod, seed yield (kg/ha) and stover yield (kg/ha) while protein content was remain unaffected.

Keywords: Phosphorus, sulfur, biofertilizers, yield, mothbean

Introduction
Mothbean is a source of food, fodder, feed, green manuring and used as pasture hence, serves as a multi-purpose crop. Green pods are delicious source of vegetables. Pulses production is very low and become challenging problem against the requirement of increasing population of our country. The pulses availability per capita was 69.9 g in 1951, by increasing in 1971, it comes to 50 g and in 1982 remained only 40 g and in 2005, it was 27 g and in 2012, it was 41.7 g. The availability of pulses is very negligible at present as against required 85 g/day per capita for balanced diet. To recover this deficit of production, it is a high time to cultivate pulses crops scientifically with increasing area (Patel *et al*., (2013) [10]. Fertilizer is an important factor which increases agriculture production. It is universally accepted that chemical fertilizer are an integral part of the package of practice for raising agricultural production to higher technological plan. Adequate crop nutrition through the use of fertilizer is a prover route for increasing crop productivity. Phosphorus is a second major nutrient for plants because of their high requirement. Phosphorus is an essential both as a part of several key plant structure compound and as catalysis in the conversion of key biochemical reaction in plant. Phosphorus is a vital component of ATP, the “Energy unit” of plants. It also involved in controlling key enzyme reaction and in the regulation of metabolic pathways (Theodorou and Plaxton, (1993) [19]. Varying in phosphorus requirements depending upon the nutrient content of the soil (Bose and Som, (1986) [3]. In integrated system, bio-fertilizers is one of the important components. Further, bio-fertilizers are low cost and eco-friendly input have tremendous potential of supplying nutrients which can reduce the chemical fertilizer dose by 25 to 50 per cent (Pattanayak *et al*., (2007) [11].

Materials and Methods
A field experiment was carried out during kharif season 2019 to find out the effect of phosphorus, sulphur and biofertilizer on growth, yield and quality of mothbean (*Vigna aconitifolia* L.) at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. Twelve treatment combinations comprising of three levels of phosphorus *viz*., 20 kg P_2O_5/ha (P0), 40 kg P_2O_5/ha (P1) and 60 kg P_2O_5/ha (P2) and two levels of sulfur *viz*., 00 kg S/ha (S0) and 20 kg S/ha (S1) and two levels of bio fertilizers without seed inoculation (B0) and with seed inoculation (B1) with PSB. Were laid out under randomized block design (RBD) with factorial concept with four replications. The soil of experimental field was loamy sand in texture, slightly alkaline in reaction and soluble salt content under safe limit. It was low in organic carbon, available N, medium in available P_2O_5 and high in K_2O content. The experimental field was cultivated by tractor drawn cultivator and it was followed by harrowing and planking to obtain fine seedbed. The experiment was laid out as per layout plan and plots were levelled manually. Nitrogen @ 20 kg/ha was applied as a basal dose in ploughed furrows before sowing as some part through

DAP and remaining through urea. As per treatment, the crop was fertilized with phosphorus @ 20, 40 and 60 kg/ha before sowing the crop in furrows in form of DAP, Sulphur @ 0 and 20 kg/ha before sowing the crop in furrows in form of gypsum and seed treatment without and with PSB before 1 hour of sowing. Mothbean variety GMO_2 was used for sowing. Before sowing, the required quantity of seeds was treated uniformly with phosphorus solubilizing bacteria culture, were used for sowing of all inoculated treatments. Whereas, uninoculated seeds were sown in respective uninoculated treatments. Sowing was done under dry condition on 5th July, 2019 by hand sowing method keeping inter-raw spacing of 45 cm. The first light irrigation was given to the crop immediately after sowing the seeds for uniform germination. The second irrigation was given to the crop to the three days after first irrigation. Thinning and gap filling were done at 13 days after sowing to maintain intra-row spacing of about 10 cm between two plants in all experimental plots.

The data on plant height, number of branch, seed index, number of pods per plant, number of seed per pod, seed yield, straw yiled and protein content were recorded.

Result and Discussion

(A) Effect of Phosphorus on growth, yield and quality of mothbean

Effect of different levels of phosphorus on plant height of mothbean was found non-significant at harvest. This indicated that uniform plant height were found under all treatments.

Significantly the maximum number of branches/plant (8.02) were observed in the treatment P_2O_5 (60 kg P_2O_5/ha), which is remaining statically at par with P1 (40 kg P_2O_5/ha).Whereas, significantly lowest number of branches/plant (6.67) were noticed with the P0 (20 kg P2O5/ha) treatment. Increase in number of branches/plant due to phosphorus could be ascribed to the overall improvement in plant growth, vigour and production of sufficient photosynthetic. These results corroborate the work of Punia *et al.* (1993) [12] in mustard crop, Newange *et al.* (2011) [8] in chickpea crop, Awomi *et al.* (2012) [1] in mungbean crop and Kumavat *et al.* (2014) [7] in greengram crop.

The significantly the highest number of pods/plant (17.15) and seeds/pod (7.73) were recorded under the application of 60 kg P_2O_5/ha (P2), which is at par with 40 kg P_2O_5/ha (P1). Significantly the lowest number of pods/plant (14.0) and seeds/pod (6.92) were recorded under the treatment P0 (20 kg P_2O_5/ha). The favourable effect of phosphorus application on number of pods/plant and seeds/pod was mainly dueto its primary role in photosynthesis by way of rapid energy transfer and there by increased photosynthetic efficiency and thus, increased in total biomass production and translocation in plant parts. These all together resulted in to overall increase in above characters. These results are in close conformity with those of Kumawat *et al.* (2009) [6], Patel *et al.* (2013) [10], Kumawat *et al.* (2014) [7], Rathour *et al.* (2015) [15] and Sipai *et al.* (2016) [17].

Data pertaining to seed index (g) was found to be not significant influenced due to levels of phosphorus.

A close examination of data indicated that phosphorus application manifest their significant effect on seed yield. The increasing level of phosphorus exhibited the increment in seed yield of mothbean crop up to P2 (60 kg P_2O_5/ha). An application of 60 kg P_2O_5/ha registered significantly maximum seed yield (702kg/ha), which is at par with P1 (40 kg P_2O_5/ha) treatment (656 kg/ha). The lowest seed yield (551 kg/ha) was recorded under P0 (20 kg P_2O_5/ha) control. On average, the application of 60 kg P_2O_5/ha and 40 kg P_2O_5/ha increased seed yield to tune of 10.04 and 9.38 per cent over the 20 kg P_2O_5/ha (P0), respectively. Seed yield was significantly higher with treatment P2 (60 kg P_2O_5/ha) might be due to the fact that, excess assimilates stored in the leaves and later translocate into seeds at the time of senescence, ultimately led to higher seed yield. These findings are in conformity with those reported by Rana *et al.* (2005) [14], Gajera *et al.* (2014) [5], Kumawat *et al.* (2014) [7], Sipai *et al.* (2016) [17] and Yadav *et al.* (2017) [21] in green gram crop.

Stover yield (kg/ha) of mothbean was found significant due to phosphorus application. Significantly the highest stover yield (1135 kg/ha) was found with treatment P2 (60 kg/ha), which is par with treatment (1109 kg/ha) P2 (40 P_2O_5 kg/ha). Significantly the lowest stover yield (972 kg/ha) was recorded under the treatment P0 (20 kg P_2O_5/ha). On average, the application of 60 kg P_2O_5/ha and 40 kg P_2O_5/ha increased stover yield to tune of 8.81 and 8.61 per cent over the 20 kg P_2O_5/ha (P0), respectively. Increase in stover yield was might be due to increase in growth and development in terms of plant height, branches and dry matter accumulation by improved nutritional environment in rhizosphere and plant system. The present findings confirmed the report of Patel (2004) [9] in chickpea crop and Kumawat *et al.* (2014) [7] in green gram crop.

Differences in protein content (%) in seed due to application of phosphorus was to be non-significant.

(B) Effect of Sulfur on growth, yield and quality of mothbean

Effect of different levels of sulfur on plant height of mothbean was found to be non-significant at harvest.

Significantly more number of branches/plant (7.68) were observed in S1 (20 kg P2O5/ha) over S0 (7.02) treatments. Among different sulphur treatment, S1 (20 kg/ha) recorded highest number of branches/plant (7.68) as compared to preceding levels. The increase in number of branches/plant might be due to sulphur is a part of aminoacid (cystine), which helps in chlorophyll formation result in high photosynthetic These results are in accordance with those of Thakur and Patel (2004) [18], Bhosle *et al.* (2011) [2], Ram and Katiyar (2013) [13] and Kumawat *et al.* (2014) [7] in green gram

Significant variation in number of pods/plant and number of seeds/pod were observed due to the sulphur treatments. Significantly the highest number of pods/plant (16.26) and number of seeds/pod (7.54) were recorded under the treatment S1 (20 kg S/ha) over no sulphur treatment *i.e.* control. The increase in seed yield was mainly due to enhanced rate of photosynthesis and carbohydrate metabolism by sulphur application. Thus, bioactivities of Sulphur might have played important role in improving yield attributes like number of pods/plant. These results supported by Patel *et al.* (2013) [10] and Sipai *et al.* (2016) [17] green gram crop. Seed index (g) was found to be not significant influenced due to levels of sulfur.

The treatment S1 (20 kg S/ha) found significantly superior in respect of seed yield (656 kg/ha) over the control. Significantly the lowest seed yield (617 kg/ha) recorded under S0 (0 kg S/ha) treatment. On an average, the application of 20 kg S/ha (S1) increased seed yield to the tune of 9.38 per cent over the control (S0), respectively Increase in the yield due to sulphur application might be due to increase in plant height, number of branches/plant, number of pods/plant were important growth and yield attributes having significant positive correlation with the seed yield. The present findings are in close accordance with those reported by Sipai *et al.* (2016) [17] and Saini (2017) [16].

Results indicated that the treatment S1 (20 kg/ha) recorded significantly the highest stover yield (1126 kg/ha) over S0 (0 kg S/ha) (1018 kg/ha). On an average, the application of 20 kg S/ha (S1) increased stover yield to the tune of 8.74 per cent over the control (S0), respectively. Reason for increasing haulm yield might be of sulphur made the plants more efficient in photosynthetic activity and thereby enhancing carbohydrate metabolism in the plant. Finally, the beneficial effects of all attributes were reflected on stover yield. The present findings are in confirmation with those reported by Deekshitulu and Subbaiah (1997) [4] and Tomar *et al.* (1997) [20] in mustard.

Differences in protein content (%) in seed due to application of phosphorus was to be non-significant.

(C) Effect of Biofertilizers on growth, yield and quality of mothbean

Plant height of mothbean did not vary due to PSB treatments

Seeds inoculated with PSB had shown their significant effect on number of branches/plant. Significantly the highest number of branches/plant was recorded under B1 treatment (7.72) over B0 treatment (6.97). The number of branches/plant increased significantly under seed inoculation with PSB. The increase in number of branches/plant might be due to the reason that, phosphobacteria dissolved insoluble phosphorus in the soil, making it available to the crop plants for profuse root and vegetative growth and produced growth promoting substances. Similar results have been reported by Patel *et al.* (2013) [10] and Gajera *et al.* (2014) [5].

Number of pods/plant and seeds/pod were significantly influenced due to phosphorus solubilising bacteria treatment. Significantly the maximum number of pods/plant (16.37) and number of seeds/pod (7.54) were recorded under the treatment B1 (with PSB) over B0 (without PSB) treatment. Inoculation of seed with PSB liquid biofertilizer might have helped in reducing phosphorus fixation by its effect and also solubilizing the unavailable form of phosphorus leading to more uptake of nutrient and reflected in better yield attributes. Other reason might be due to inoculation with PSB liquid biofertilizer increased availability of phosphorus and also favoured higher nitrogen fixation, dry matter accumulation, rapid growth, higher absorption and utilization of phosphorus and other plant nutrient and ultimately positive resultant effect on growth and yield attributes, which led to increase the value of yield attributes and yield. These results are similar with Kumawat *et al.* (2014) [7] and Patel *et al.* (2013) [10].

Levels of biofertilizer (PSB) did not exert any significant effect with respect to seed index. This might be due to the fact that seed index (g) of seed is governed by genetically characters of plants. Similar results were found by Gajera *et al*. (2014) [5].

The result revealed that the levels of PSB had significant influence on seed yield of mothbean. Significantly the highest seed yield (659 kg/ha) was recorded under treatment B1 (with PSB) over B0 (without PSB) (614 kg/ha). On an average, the application of B1 (with PSB) increased seed yield to the tune of 9.42 per cent over the control (B0) (without PSB), respectively. The increase in seed yield due to PSB liquid biofertilizer inoculation may be attributed to solubilization of native (insoluble) or applied phosphorus in soil by bacteria and thus, making it available for plant use which in turn helps to put forth profuse growth and produced more seed yield. Similar observations were also made by Patel *et al.* (2013) [10].

Stover yield (kg/ha) of mothbean significantly influenced by seed treatment with PSB. Stover yield recorded significantly the highest (1145 kg/ha) with inoculation of PSB liquid biofertilizer over uninoculation of PSB liquid biofertilizer. On an average, the application of B1 (with PSB) increased stover yield to the tune of 8.89 per cent over the control (B0) (without PSB), respectively. Increase in stover yield might be due to inoculation with PSB, which increased availability of phosphorus and favoured higher nitrogen fixation, dry matter accumulation, rapid growth, higher absorption and utilization of P and other plant nutrients and ultimately positive resultant effect on growth and yield attributes, which led to increase the stover yield. These results found similar with Patel *et al.* (2013) [10].

Differences in protein content (%) in seed due to application of biofertilizer was found to be non-significant.

Table 1: Effects of different levels of phosphorus, sulfur and biofertilizers on plant height, number of branches per plant, number of pods per plant, number of seed per pod, seed index, protein content, seed yield and stover yield

Treatments	Plant height at harvest (cm)	Number of branches/plant	Number of pods/plant	Number of seeds/pod	Seed index (g)	Protein content (%)	Seed yield (kg/ha)	Stover yield (kg/ha)
Phosphorus levels (P)								
P0: 20 kg/ha	25.65	6.67	14.00	6.92	3.75	21.25	551	972
P1: 40 kg/ha	26.38	7.37	15.82	7.48	3.95	21.59	656	1109
P2: 60 kg/ha	28.37	8.02	17.15	7.73	4.18	22.41	702	1135
S. Em.±	0.85	0.29	0.46	0.133	0.13	0.42	16.95	34.88
C.D. at 5%	NS	0.87	1.37	0.40	NS	NS	49.73	102.30
Sulphur levels (S)								
S0: 00 kg/ha	26.15	7.02	15.06	7.21	3.92	21.81	617	1018
S1: 20 kg/ha	27.45	7.68	16.26	7.54	4.00	21.70	656	1126
S. Em.±	0.69	0.24	0.38	0.11	0.11	0.34	13.84	28.47
C.D. at 5%	NS	0.71	1.12	0.33	NS	NS	40.60	83.53
Biofertilizer levels (B)								
B0: Without PSB	26.43	6.97	14.93	7.20	3.86	21.50	614	1000
B1: With PSB	27.17	7.72	16.37	7.54	4.05	21.99	659	1145
S. Em.±	0.69	0.24	0.38	0.11	0.11	0.34	13.84	28.47
C.D. at 5%	NS	0.71	1.12	0.33	NS	NS	40.60	83.53
Interactions (P × S, S × B, P × B, P × S × B)								
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	11.00	14.02	10.31	6.46	11.87	6.78	9.22	11.26

(D) Effect of interaction

The interaction of different levels of phosphorus, sulfur and biofertilizers were found non-significant for plant height, number of branch, seed index, Number of pods per plant, number of seed per pod, seed yield, straw Yield and protein content in mothbean.

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