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Response of moth bean (*Vigna aconitifolia* L.) to FYM and phosphorus with and without biofertilizers and their effect on growth, yield attributes and yield

AK Katara, AN Chaudhary, MH Chavda and YB Vala

Abstract
A field experiment was carried out during the *kharif* of 2019 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to study the effect of nutrient management practices on growth and yield by moth bean (*Vigna aconitifolia* L.) comprising of twelve treatment combinations comprising, two levels of FYM (F_0: 0 t/ha, F_1: 5 t/ha), three levels of phosphorus (P_1: 20 kg P_2O_5/ha, P_2: 30 kg P_2O_5/ha and P_3: 40 kg P_2O_5/ha) and two levels biofertilizer {B_0: Without biofertilizer and B_1: With biofertilizer (*Rhizobium* + PSB)} evaluated in randomized block design with factorial concept and replicated three times. Among the different level of application FYM @5t/ha, phosphorus @40kg P_2O_5/ha and seed treatment of biofertilizer (*Rhizobium* + PSB) were recorded significantly higher value of all the growth and yield attributing characters *viz.*, plant height, dry matter/plant, number of nodules/plant, fresh and dry weight of root nodule, number of branches/plant, length of pod, number of pods/plant, seeds/pod, seed yield and stover yield. All parameters in interaction effect were found to be non-significant.

Keywords: Moth bean, farm yard manure, phosphorus and biofertilizers

Introduction

Pulses are one of the most nutritious crops on the planet for overall health. Their cultivation helps to reduce greenhouse gases and provide carbon sequestration which is good for the planet. Pulses have emerged as a viable option to improve soil health, conserve the natural resources and sustain the agricultural productivity. Among the pulses moth bean [*Vigna aconitifolia* (Jacq.) Marechal] known by several vernacular names (Math, Kheri, Madike, Bhioni, Kunkuna, Matki etc.) in different linguistic zones of India, indicates its wide social acceptance and geographic adaptation. It is an important crop of arid and semi-arid regions, especially of the Northern-Western desertic regions of Indo-Pak subcontinent.

FYM (Farm yard Manure) is the most popular and available for use as an organic source of plant nutrient by the farmers. An assessment showed each tonne farm yard manure (FYM) to be equivalent to 3.0 kg nutrients in mono cropping and 5.0 kg in double cropping in terms of yield response (Tandon, 1983) [20]. Farm yard manure seems to act directly for increasing the crop yields either by acceleration of respiratory process with increasing cell permeability and hormonal growth action or by combination of all these process. The use of FYM is the tool to improve the physical, chemical and biological properties of the soil. Farmyard manure being the source of all essential elements, improves soil organic matter and humus part of soil. It builds up the soil micro flora, which are useful to maintain the soil fertility, improve the fertilizer use efficiency and microbial activities of the soil. Application of urea in combination with FYM minimizes N loss and help in increasing N-use efficiency. On an average, FYM contains 0.50, 0.17 and 0.55 per cent of N, P_2O_5 and K_2O, respectively (Gaur, 1991) [4].

Phosphorus plays a remarkable role in the formation and translocation of carbohydrates, root development, crop maturation and resistance to pathogens. Phosphorus stimulates the symbiotic nitrogen fixation because in presence of phosphorus, bacterial cell becomes mobile which is prerequisite for migration of bacterial cell to root hair for nodulation (White *et al*., 1953) [21].

Biofertilizers, a component of integrated nutrient management is considered to be cost effective, eco-friendly and renewable source of non-bulky, low cost of plant nutrient substitute chemical fertilizers and thus play important role in agriculture system in India.

Use of biofertilizer can have a greater importance in increasing fertilizer use efficiency. The seed of pulses is inoculated with *Rhizobium* with an objective of increasing their number in the rhizosphere, so that there is substantial increase in the microbiologically fixed nitrogen for the plant growth. Seeds of pulses when inoculated with phosphate solubilising bacteria (PSB) secret acetic substances, which act as solubilizers to unavailable soil phosphorus (Khandelwal *et al.* 2012) [8]. Keeping this in view, the present investigation was undertaken to study the Response of moth bean (V*igna aconitifolia* L.) to FYM and phosphorus with and without biofertilizers and their effect on growth and yield.

Material and Methods

A field experiment was conducted at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *kharif* season of the year 2019. The present experiment comprising of twelve treatment combinations comprising, two levels of FYM (F_0: 0 t/ha, F_1: 5 t/ha), three levels of phosphorus (P_1: 20 kg P_2O_5/ha, P_2: 30 kg P_2O_5/ha and P_3: 40 kg P_2O_5/ha) and two levels biofertilizer {B_0: Without biofertilizer and B_1: With biofertilizer (*Rhizobium* + PSB)} evaluated in randomized block design with factorial concept and replicated three times. Biofertilizer was given as seed treatment at the time of sowing and FYM was incorporated in soil before sowing.

The FYM contain 0.57% N, 0.31% P_2O_5 and 0.45% K_2O. The seeds of moth bean were treated with mid formulation of *rhizobium* and phosphate solubilizing bacteria (PSB) were inoculated with seed at 10 ml/kg seed just before sowing of the seed as per the treatments and dried in the shed. Moth bean variety "Gujarat Moth-2" was sown on 5th July, 2019 using 15 kg/ha seed rate by maintaining intra row spacing of 45 cm. Required quantity of farmyard manure were applied in plot as per treatment and partially covered with soil at 20 days before sowing. Entire quantity of inorganic fertilizers was applied through urea & SSP as basal dose as per treatment in previously opened furrows before sowing of seeds and covered with thin layer of soil. Observation on plant growth, yield attributes and yield were recorded as per standard procedure. Data on different aspects of moth bean crop were subjected to statistical analysis as per the procedure of randomized block design with factorial concept by computer system at the computer center, Department of Agricultural Statistics, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District: Banaskantha (North Gujarat). The values of calculated "F" was worked out and compared with the value of table "F" at 5 per cent level of significance. The value of S.Em.± and co-efficient of variation (C.V. %) was also calculated.

Results and Discussion

Effect on growth attributes

The data pertaining to various growth attributes studied *viz*., plant height at 30 DAS and harvest, dry matter/plant at harvest, number of nodules/plant at 45 DAS, fresh and dry weight of root nodules/plant (mg) and number of branches/plant as influenced by various treatments are presented in table 1.

Table 1: Effect of FYM, phosphorous and biofertilizer on growth parameters of moth bean

Treatment				Plant height (cm)		Dry matter per plant at harvest (g)	Number of nodules per plant at 45 DAS Fresh weight of nodules per plant (mg)	Fresh weight of nodules per plant (mg) Dry weight of nodules per plant (mg)	Dry weight of nodules per plant (mg)	Number of branches per plant
				30 DAS	At Harvest					
[A]	FYM (t/ha)									
	F_0	:	0	12.80	25.96	8.51	15.69	68.41	53.80	6.36
	F_1	:	5	14.08	28.61	9.19	17.84	75.87	61.20	7.14
	S.Em.±			0.24	0.49	0.17	0.17	1.08	1.13	0.15
	C.D. (P=0.05)			0.69	1.45	0.51	0.50	3.17	3.30	0.45
[B]	Phosphorus (kg/ha)									
	P_1	:	20	12.90	26.11	8.39	15.73	69.48	54.72	5.67
	P_2	:	30	13.26	27.41	8.99	16.90	72.60	58.01	7.01
	P_3	:	40	14.17	28.34	9.18	17.67	74.33	59.77	7.58
	S.Em.±			0.29	0.60	0.21	0.21	1.32	1.38	0.19
	C.D. (P=0.05)			0.84	1.77	0.63	0.61	3.88	4.05	0.55
[C]	Biofertilizer									
	B_0	:	Without biofertilizer	13.09	26.45	8.57	15.55	70.03	55.38	6.48
	B_1	:	With biofertilizer (*Rhizobium* + PSB)	13.80	28.13	9.13	17.98	74.24	59.61	7.03
	S.Em.±			0.24	0.49	0.17	0.17	1.08	1.13	0.15
	C.D. (P=0.05)			0.69	1.45	0.51	0.50	3.17	3.30	0.45
Interaction										
	F × P, F × B, P × B, F × B × P			NS	NS	NS	NS	NS	NS	NS
	C. V. %			7.42	7.66	8.36	4.28	6.35	8.31	9.62

Effect of FYM

Significantly higher plant height at 30 DAS (14.08 cm) and at harvest (28.61 cm) were observed in F_1 (5 t/ha) over F_0 treatments. This might be due to organic manures contain almost all essential elements in variable quantities, which had synergistic effect with other essential elements for their availability. Phosphorus encourages formation of new cells, promotes plant growth and vigor and hastens leaf development, which helps in harvesting more solar energy and better utilization of nitrogen which resulted in to higher growth attributes. The present findings are in close accordance with those reported by Singh *et al.* (2010) [18] in chick pea and Jat *et al.* (2012) [6] in green gram.

Dry matter accumulation per plant at harvest was significantly more dry matter accumulation/plant at harvest (9.19 g) were observed in F_1 (5 t/ha) over F_0 treatments. This might be due to optimum supply and availability of nutrients for longer duration from FYM which help in better uptake of nutrients resulted into more synthesis of nucleic acid and amino acid, amide substances in growing region and meristematic tissue ultimately enhancing cell division and thereby improved growth attributes. These results are in accordance with the findings of Jat *et al.* (2012) [6] in green gram.

Significantly the maximum number of root nodules/plant at 45 DAS (17.84) were observed in the treatment F_1 (5 t/ha). This might be due to application of FYM provided the micronutrients like molybdenum along with all other essential elements which might have acted as co-enzyme for formation of root nodules resulting in better nodule formation and nitrogen fixation by supplying assimilates to the roots and better environment in rhizosphere for growth and development. These results are in close vicinity with the findings of Jat *et al.* (2012) [6] in green gram.

Significantly the highest fresh (75.87 mg) and dry weight (61.20 mg) of root nodules/plant were recorded under the treatment F_1 (5 t/ha) over no F_0 treatment *i.e.* control. Application of FYM might have enhanced the population of desired microbes in the rhizosphere during the early stage of infection by improving the physical, chemical and biological properties of soil. Higher population of the desired microorganisms will always have greater possibilities of infection and consequently formation of more healthy and effective root nodules having higher amount of fresh and dry weight. These findings are in agreement with those reported by Jat *et al.* (2012) [6] in green gram.

Number of branches/plant (7.14) was significantly observed in F_1 over F_0 treatments. The FYM offers more balanced nutrition and favourable soil conditions for better growth of the plant. The availability of phosphorus also increased due to FYM, which might be solubilised the insoluble phosphate present in the soil in to the soluble form. Thus, higher availability of nutrients might be reflected on higher number of branches/plant. These results are already in agreement with the findings reported by Chaudhary *et al.* (2008) [2] in chickpea and Singh *et al.* (2010) [18] in kabuli chickpea.

Effect of phosphorus

Among the different levels, application of P_3 (40 kg P_2O_5/ha) recorded significantly higher plant height at 30 DAS (14.17 cm) and at harvest (28.34 cm). This might be due to acceleration of various metabolic process, internodes elongation and synthesis of higher photosynthates due to adequate supply of P through chemical fertilizers. These results are in closed conformity with Awomi *et al.* (2012) [1] mungbean and Gajera *et al.* (2014) [3] in green gram.

Significantly higher dry matter accumulation/plant of moth bean (9.18 g) was recorded with application of P_3 (40 kg P_2O_5/ha) but it was at par with P_2 (30 kg P_2O_5/ha) treatment (8.99 g). This might be due to the increase in dry matter accumulation is contributed to enhancement of number of branches/plant and plant height with application of Phosphorus. These results are in accordance with the findings of Awomi *et al.* (2012) [1] in mungbean and Singh *et al.* (2013) [17] in green gram.

Significantly higher number of root nodules/plant was recorded higher (17.67) under the treatment P_3 (40 kg P_2O_5/ha). This might be due to supply of adequate phosphorus to plant with application of 40 kg P_2O_5/ha through inorganic fertilizer attributed to better nodulation in roots of moth bean as phosphorus basically involved in several energy transformation processes and biochemical reactions including nitrogen fixation. These findings corroborated by Patel *et al.* (2013) [14] in green gram and Sipai *et al.* (2016) [19] in green gram.

Significantly the highest fresh (74.33 mg) and dry weight (59.77 mg) of root nodules/plant were recorded under the application of 40 kg P_2O_5/ha (P_3) but it was at par with P_2 (30 kg P_2O_5/ha) treatment fresh (72.60 mg) and dry weight root nodules per plant (58.01 mg). This might be due to P as 40 kg P_2O_5/ha increased the availability of phosphorus to the plant at early growth stages play a fundamental role in metabolism, growth, development and reproduction led to significant increase in fresh and dry weight of nodules per plant. These results are in conformity with the findings of Gajera *et al.* (2014) [3] and Patel *et al.* (2013) [14] in green gram.

Number of branches/plant (7.58) was significantly observed in the treatment P_3 (40 kg P_2O_5/ha). This was 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 Awomi *et al.* (2012) [1] in green gram and Patel *et al.* (2013) [14] in green gram.

Effect of biofertilizer

Seed inoculation with *rhizobium* and PSB (B_1) produced significantly taller plants at 30 DAS (13.80 cm) and at harvest (28.13 cm). The increase in growth mainly plant height might be due to production of higher photosynthates because of inoculation with biofertilizers (*Rhizobium* and PSB). The increase in plant height with combination of *rhizobium* and PSB is quite obvious because nitrogen obtained from biological nitrogen fixation influenced favorably the meristematic activity, which increased the number and length of internodes ultimately resulting in better growth. These results are in conformity with those reported by Yadav and Malik (2005) [22] and Kumavat (2009) [11] in green gram.

Treatment B_1 (with biofertilizers *rhizobium* and PSB) registered significantly higher dry matter accumulation/plant at harvest (9.13 g). This might be due to spectacular improvement in growth parameters *i.e.*, plant height, number of branches and number of root nodules. These results are also supported by Kehlon and Sharanappa (2006) [7] in cowpea and Gajera *et al.* (2014) [3] in green gram.

An application of seed treatment with *rhizobium* and PSB (B_1) produced significantly higher number of root nodules/plant (17.98). This might be due to combined inoculation of *rhizobium* and phosphate solubilizing bacteria (PSB) showed positive effect on formation of nodules on the roots of the legumes indicating the synergistic association between them. Increased nitrogenous activity by *rhizobium* and PSB produce plant growth hormones like IAA, auxins, gibberellins and vitamins which are conducive to better nodulation. These results are also supported by Mishra (2003) [13] and Kehlon and Sharanappa *et al.* (2006) [7] in cowpea.

Significantly the maximum fresh (74.24 mg) and dry weight (59.61 mg) of root nodules/plant were recorded under the treatment B_1 (*Rhizobium* + PSB). This might be due to inoculation with biofertilizers (*rhizobium* + PSB) resulted in greater nodulation and higher atmospheric nitrogen fixation as well as solubilizing of fixed soil phosphorus in to available form. Thus, it increase the availability of fixed as well as applied N and P to the plants which in terms increased cell formation, cell division and cell elongation leading to improvement in nodulation. These results are in line of those reported by Gajera *et al.* (2014) [3] in green gram.

Significantly the highest number of branches/plant was recorded under B_1 treatment (7.03). This might be due to the reason that, *rhizobium* fix atmospheric nitrogen in the soil and 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 Kumavat *et al.* (2010) [10] and Gajera *et al.* (2014) [3] in green gram.

Interaction effect

Interactions effect of FYM, phosphorus and biofertilizer with respect to various growth attributes studied *viz*., plant height at 30 DAS & harvest, dry matter/plant at harvest, number of nodules/plant at 45 DAS, fresh and dry weight of root nodules/plant (mg) and number of branches/plant was found to be non-significant.

Effect on yield attributes and yield

The data pertaining to various yield attributes studied *viz*., number of pods/plant, number of seeds/pod, length of pod (cm), test weight (g), seed yield (kg/ha) and stover yield (kg/ha) as influenced by various treatments are presented in table 2.

Effect of FYM

Significantly the highest number of pods/plant (16.73) and number of seeds/pod (6.78) were recorded under the treatment F_1 (5 t/ha). This was due to the fact that suppling of ample amount of nutrients in form of chemical fertilizer, organic manure and bio-fertilizer must have increased carbohydrate accumulation and their remobilization to reproductive parts of the plant, being closest sink and hence, resulted into increased flowering, fruiting and seed formation and thus more number of seeds per pod. Similar results were obtained by, Mahetele and Kushwaha (2011) [12] in pigeonpea.

Significantly more length of pod at harvest (5.19 cm) were observed in F_1 (5 t/ha). This might be due to application of organics which improved the physicochemical and biotic properties of soil which in turn benefited plant by providing balanced nutrition to crop as and when needed which helped in production of a greater number of yield parameters and ultimately increased the moth bean yield. These results are in close conformity with the results of Mahetele and Kushwaha (2011) [12] in pigeonpea.

Seed yield (kg/ha) and Stover yield (kg/ha) were found significantly superior in treatment F_1 (5 t/ha) in respect of seed yield (754 kg/ha) and stover yield (1313 kg/ha). This might be due to prolonged availability of moisture due to addition of organic manure might have resulted into increased uptake of nutrients, release of phytohormones and organic acids which provided food for the beneficial bacteria. Slow release of nutrients from decomposed organic matter, loose and friable soil condition due to organic matter application and significant nitrogen fixation due to formation of more root nodules might be the probable reasons for the maximum plant growth and yield attributes are resulted in higher seed and stover yield. These results are in agreement with those reported by Saini *et al.* (2014) [16] in green gram and Zadode *et al.* (2014) [23] in pigeon pea.

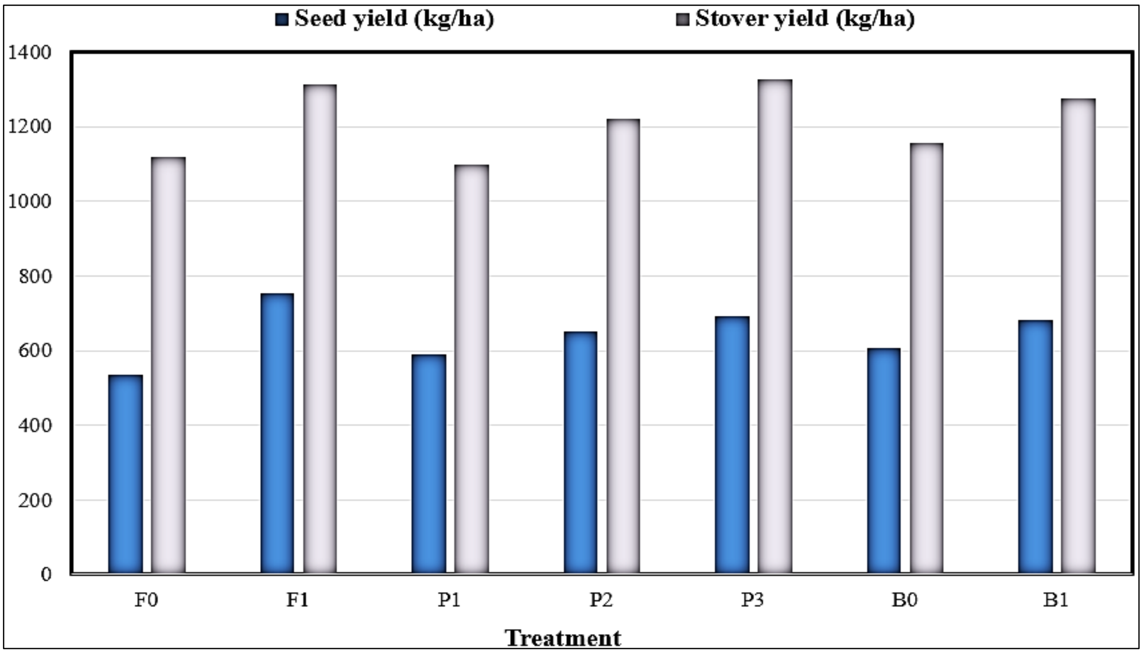

Fig 1: Effect of FYM, phosphorus and biofertilizer on seed yield and stover yield of moth bean

Effect of phosphorus

The data in Table 2 showed that the effect of phosphorus (40 kg P_2O_5/ha) on number of pods/plant and number of seeds/pod were found significantly. This was due to 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 results are in close conformity with those of Awomi *et al.* (2012) [1] in green gram and Kumar *et al.* (2012) [9].

Significantly higher length of pod of moth bean (4.98 cm) was recorded with application of P_3 (40 kg P_2O_5/ha). This increment was attributed due to supply of phosphorus, resulted in amplified photosynthetic activity and helps to develop a ramified root system and thus empowers the plant to withdraw extra water and nutrient from deeper layers, resulted in better growth and yield attributes and ultimately increase pod length. Present results are in concordant with the finding of Patel *et al.* (2013) [14] in green gram.

An application of 40 kg P_2O_5/ha registered significantly maximum seed yield (694 kg/ha) but it was at par with P_2 (30 kg P_2O_5/ha) treatment (652 kg/ha) and significantly the highest stover yield (1328 kg/ha). This 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 and stover yield. Second probable reason for increasing seed and stover yield might be due to phosphorus application not only plays important role in root development and proliferation, but also improves nodulation and N fixation by supplying assimilates to the roots. Increased availability of phosphorus owing to its application in soluble form to the soil which was otherwise deficient in phosphorus concentration might have led to significant improvement in the concentration and uptake of this nutrient which in turn helped in early root development and ramification. The increase in uptake of phosphorus thereby increasing the sink in terms of flowering and grain setting. These findings are in conformity with those reported by Awomi *et al.* (2012) [1].

Effect of biofertilizer

Significantly the maximum number of pods/plant (16.26) and number of seeds/pod (6.64) were recorded under the treatment B_1 (with PSB) over B_0 (without PSB) treatment. Inoculation of seed with *rhizobium* and PSB liquid biofertilizer might have helped in nitrogen fixation and 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. These results are similar with Gajera *et al.* (2014) [3] in green gram and Sipai *et al.* (2016) [19] in green gram.

Examination of data presented in Table 2 revealed that treatment B_1 (with biofertilizers *rhizobium* and PSB) registered significantly higher length of pod at harvest (4.86 cm). *Rhizobium* might have increased the availability of nitrogen which in turn resulted into higher production of assimilates as well as their balanced partitioning between source (vegetative part-haulm) and sink (reproductive part-pod) ultimately increased the pod length. Greater root extension under higher availability of phosphorus due to seed inoculation with PSB might have helped in greater uptake of other nutrients especially micro and secondary nutrients enhanced photosynthesis, production of photosynthates and higher partitioning between vegetative and reproductive structures might have helped in improving the yield attributes. These results are in close conformity with the results of Gajera *et al.* (2014) [3] in green gram.

Significantly the highest seed yield (683 kg/ha) and Stover yield (1276 kg/ha) were recorded under treatment B_1 (with *Rhizobium* + PSB) over B_0 (without *Rhizobium* + PSB). This was due to *rhizobium* and PSB liquid biofertilizer inoculation may be attributed to fixation of nitrogen and 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 and stover yield. Other reason might be due to inoculation of PSB, increased availability of phosphorus and favoured higher nitrogen fixation, dry matter accumulation, rapid growth, higher absorption and utilization of phosphorus and other plant nutrients and ultimately positive resultant effect on growth and yield attributes, which led to increase the seed and stover yield. Similar observations were also made by Gupta and Sharma (2006) [5] in urd bean and Kehlon and Sharanappa (2006) [7] in cow pea.

Table 2: Effect of FYM, phosphorous and biofertilizer on yield attributes and yield of moth bean

Treatment			No. of pods/plant	No. of seeds/pod	Length of pod (cm)	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
[A]			**FYM (t/ha)**					
	F_0	: 0	13.81	6.06	3.81	24.90	536	1119
	F_1	: 5	16.73	6.78	5.19	26.45	754	1313
	S.Em.±		0.33	0.15	0.08	0.54	12.45	27.85
	C.D. (P=0.05)		0.98	0.44	0.22	NS	36.50	81.69
[B]			**Phosphorus (kg/ha)**					
	P_1	: 20	14.25	5.75	3.92	25.22	589	1097
	P_2	: 30	15.45	6.51	4.60	25.83	652	1222
	P_3	: 40	16.11	7.00	4.98	25.98	694	1328
	S.Em.±		0.41	0.18	0.09	0.66	15.24	34.11
	C.D. (P=0.05)		1.19	0.54	0.27	NS	44.71	100.05
[C]			**Biofertilizer**					
	B_0	: Without biofertilizer	14.28	6.19	4.14	25.36	608	1155
	B_1	: With biofertilizer (*Rhizobium* + PSB)	16.26	6.64	4.86	25.99	683	1276
	S.Em.±		0.33	0.15	0.08	0.54	12.45	27.85
	C.D. (P=0.05)		0.98	0.44	0.22	NS	36.50	81.69
[D]			**Interaction**					
	F × P, F × B, P × B, F × B × P		NS	NS	NS	NS	NS	NS
	C. V. %		9.24	9.94	7.17	8.86	8.18	9.72

Interaction effect

Interactions effect of FYM, phosphorus and biofertilizer with respect to various yield attributes studied *viz*., number of pods/plant, number of seeds/pod, length of pod (cm), test weight (g), seed and stover yield (kg/ha) was found to be non-significant.

Economic

Effect of FYM: It is seen from the data given in Table 3 that the highest net return of ₹23,142/ha was obtained under the treatment F_1 (5 t FYM/ha). Similarly, the highest benefit: cost ratio (BCR) of 1.94 were recorded with treatment F_1 (5 t/ha) treatment. These findings are in conformity with those reported by Rathod *et al.* (2015) [15] in pigeonpea.

Effect of Phosphorus

There was an appreciable increase in net realization due to phosphorus application as shows in Table 3. The highest net returns of ₹ 21,793/ha was obtained with 40 kg P_2O_5/ha. An application of 40 kg P_2O_5/ha also gave the highest benefit: cost ratio (BCR) of 1.97 in comparison with other levels.

Effect of biofertilizer: It was evident from the data presented in Table 3, that the highest net return ₹21,421/ha were secured under treatment B_1 (*Rhizobium* + PSB) as compared to B_0 (without biofertilizer). Treatment B_1 (*Rhizobium* + PSB) recorded highest benefit: cost ratio (BCR) (1.97). These findings are in conformity with those reported by Gupta and Sharma (2006) [5] in urd bean.

Table 3: Effect of FYM, phosphorus and biofertilizer on net realization and benefit: cost ratio (BCR)

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Total cost of cultivation	Gross realization (₹/ha)	Net realization (₹/ha)	BCR
FYM (F)						
F_0: 0 t/ha	536	1119	19291	34398	15107	1.78
F_1: 5 t/ha	754	1313	24724	47866	23142	1.94
Phosphorus levels (P)						
P_1: 20 kg/ha	589	1097	21576	37544	15968	1.74
P_2: 30 kg/ha	652	1222	21921	41564	19643	1.90
P_3: 40 kg/ha	694	1328	22526	44319	21793	1.97
Biofertilizer (B)						
B_0: Without Biofertilizer	608	1155	21930	38779	16849	1.77
B_1: With Biofertilizer (*Rhizobium* + PSB)	683	1276	22084	43505	21421	1.97

Selling price: Moth bean seed @ ₹60 kg/ha, Moth bean stover @ ₹2 kg/ha.

Conclusion

In view of the results obtained, it could be concluded that for securing higher growth, yield attribute and yield of *kharif* moth bean, the crop should be fertilized with 5 tonnes FYM/ha, phosphorus 40 kg/ha and seed treatment with (*Rhizobium* + PSB) each @ 10 ml/kg seed along with recommended dose of nitrogen (20 kg N/ha).

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