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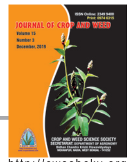

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Influence of phosphorus and liquid biofertilizers on yield and economics of mothbean [*Vigna aconitifolia* (Jacq.) Marechal]

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ABSTRACT

A field experiment was conducted in kharif, 2020 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Uttar Pradesh to assess the influence of phosphorus and liquid biofertilizers on yield and economics of mothbean. The results of the experiment revealed that application of phosphorus at 30 kg ha^{-1} basal and seed inoculation by phosphate solubilizing bacteria and Rhizobium showed significant enhancement in terms of 100-seed weight (2.21g), number of pods plant^{-1} (20.40), number of seeds pod^{-1} (3.87), seed yield (452.88 kg ha^{-1}), haulm yield (1026.22 kg ha^{-1}) and harvest index (30.62%) along with the highest benefit:cost ratio (2.33) over other treatments.

Keywords: Economics, mothbean, phosphate solubilising bacteria, phosphorus, *Rhizobium* and yield.

Mothbean (*Vigna aconitifolia* (Jacq.) Marechal) is a minor legume crop, known by different names as moth, dewbean, matbean, matki, etc. Mothbean seeds contain nearly 24% protein, some essential vitamins, and adequate quantity of essential amino acids, predominantly lysine and leucine (Kumar and Singh, 2001). A number of commonly known foodstuffs prepared from mothbean are mothdal, kheeche, bhujia, mangori and papad. Being a leguminous crop, roots of the mothbean plants form a symbiotic association with *Rhizobium* bacteria, and fix atmospheric nitrogen, facilitating the nitrogen supply in rhizosphere to fulfil the crop demand. Mothbean has an extensive and deep root system with copious growth and thick vegetation which prevents weed infestation, soil erosion, and conserves soil moisture in long run (Yadav *et al*., 2004). Since the growth period of mothbean is very less, it is mostly cultivated on dry land regions having low annual rainfall with minimum cultural practices. Mothbean in India grows in an area of 1.32 million hectare, mostly in the states of Gujarat, Rajasthan, Uttar Pradesh, Karnataka, Haryana and Maharashtra. The production and productivity of moth bean in India are 175.3 million tons and 133 kg ha^{-1}, respectively (Prasad, 2013). Several factors are responsible for lower productivity of mothbean. Some of them include sub-optimal cultivation in marginal lands with very less inputs, prevalence of moisture stress condition, inadequate management of diseases and insect pests, delayed sowing, and lack of high-yielding varieties. Out of several yield-limiting factors, phosphorus deficiency is a major obstacle in achieving the maximum yield of mothbean (Patel *et al*., 2008). Use of phosphorus along with biofertilizers helps to ameliorate the quality of seeds and enhances the crop yield and the subsequent crop as well (Choudhary *et al.,* 2017). Seed treatment by both *Rhizobium* sp. and phosphate solubilizing bacteria (PSB) helps the plants to easily assimilate nutrients from the rhizosphere. This also increases the accessibility of fix phosphate by extracting insoluble phosphorus from rhizosphere and cuts down the application of chemical fertilizers (Chakrabarti *et al*., 2007). Hence, it was felt necessary to study the extent of meeting up the phosphorus requirement of mothbean crop through the combined application of chemical fertilizer and biofertilizers to realize to the yield increment and economic feasibility of fertilizer combination.

A field experiment was conducted in *kharif*, 2020 at the Crop Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The soil texture of experimental field was sandy loam under central Gangetic alluvium, with neutral soil pH (7.2), EC- 0.34 dSm^{-1}, low in available nitrogen (203.7 kg ha^{-1}), and medium in available phosphorus (17.2 kg ha^{-1}). The experiment was laid out in a randomized complete block design with three replications. The treatments were T_1- control *i.e.*, application of 20-40-0 kg ha^{-1} NPK as basal (farmer's practice), T_2- seed inoculation (*Rhizobium*) + 20 kg ha^{-1} P, T_3- seed inoculation (*Rhizobium*) + 30 kg ha^{-1} P, T_4- seed inoculation (*Rhizobium*) + 40 kg ha^{-1} P, T_5- seed inoculation (*PSB*) + 20 kg ha^{-1} P, T_6- seed inoculation (*PSB*) + 30 kg ha^{-1} P, T_7- seed inoculation (*PSB*) + 40 kg ha^{-1} P, T_8- seed inoculation (*Rhizobium* + *PSB*) + 20 kg ha^{-1} P, T_9- seed inoculation (*Rhizobium* + *PSB*) + 30 kg ha^{-1} P, T_{10}- seed inoculation (*Rhizobium* + *PSB*) + 40 kg ha^{-1} P. The mothbean variety 'RMO 40' was sown at a seed rate of 15 kg ha^{-1} in 2nd week of June, 2020. As per treatments, the seeds were inoculated with liquid *Rhizobium* and liquid PSB at an hour before sowing. For single inoculation, seeds were soaked in liquid

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Rhizobium spp. and liquid PSB (*Bacillus megaterium* var. *phosphatica*) separately and then shade dried. For dual inoculation, seeds were first soaked in liquid *Rhizobium*, then dried thereafter soaked in liquid PSB and shade dried. Fertilizers were applied 5 cm deep according to the treatments in the lines at a spacing of 30 cm x 10 cm. Data on yield attributes *viz*. number of pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight and yield (seed and haulm) were recorded during harvest. The observed data were statistically analysed by ANOVA technique at 5% significance level (Gomez and Gomez, 1984). Donald and Hamblin (1976) method was applied to calculate the harvest index. Data on production economics *viz*. cost of cultivation (₹ ha^{-1}), gross return (₹ ha^{-1}), net return (₹ ha^{-1}) and benefit : cost ratio were calculated as per cost of inputs incurred during cultivation and income gained from harvested produce.

The results of the experiment revealed that the yield attributes *viz*. number of pods plant^{-1} (20.40), number of seeds pod^{-1} (3.87) and 100-seed weight (2.21 g) were significantly enhanced by the application of phosphorus at 30 kg ha^{-1} and seed inoculation by *Rhizobium* and PSB (Table 1).

It was found that the basal dose of phosphorus at 30 kg ha^{-1} and seed inoculation by liquid *Rhizobium* and PSB remarkably influenced the number of pods plant^{-1}, number of seeds pod^{-1} and 100-seed weight over control. It was possibly, due to an easier assimilation of essential elements such as phosphorus, nitrogen, potassium, sulphur, etc., by the plants, owing to the increased metabolic activities of microorganisms in the rhizosphere (Togay *et al*., 2008; Namvar *et al*., 2011). Another reason for improved yield attributes might be the regulation of carbohydrate metabolism and photosynthesis in leaves by phosphorus which could limit the vegetative growth, particularly during the reproductive stage of the plant. The availability of phosphorus during reproductive stage of crop might control the starch:sucrose in the source (leaves) and sink organs (reproductive parts) (Giaquinta and Quebedeaux, 1980). Hence, application of phosphorus and seed inoculation by *Rhizobium* + PSB might have improve

Table 1: Influence of phosphorus and liquid biofertilizers on yield attributes and yield of mothbean

Treatments	Pods plant^{-1}	Seeds pod^{-1}	100-seed weight (g)	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)
Control- 20:40:0 kg ha^{-1} NPK (Farmer's practice)	17.93	3.63	1.88	233	737	24.00
Rhizobium + 20 kg ha^{-1} P_2O_5	13.80	3.05	1.73	129	644	16.87
Rhizobium + 30 kg ha^{-1} P_2O_5	14.67	3.46	1.80	176	557	23.97
Rhizobium + 40 kg ha^{-1} P_2O_5	18.07	3.69	1.90	241	723	25.04
PSB + 20 kg ha^{-1} P_2O_5	16.47	3.22	1.72	146	584	20.06
PSB + 30 kg ha^{-1} P_2O_5	18.73	3.79	2.15	346	926	27.28
PSB + 40 kg ha^{-1} P	18.20	3.77	2.07	288	863	25.09
(*Rhizobium* + PSB) + 20 kg ha^{-1} P_2O_5	18.47	3.69	1.98	270	783	25.62
(*Rhizobium* + PSB) + 30 kg ha^{-1} P_2O_5	20.40	3.87	2.21	453	1026	30.62
(*Rhizobium* + PSB) + 40 kg ha^{-1} P_2O_5	19.60	3.83	2.18	431	1009	29.91
SEm (±)	**0.72**	**0.05**	**0.02**	**12.39**	**31.14**	**1.51**
LSD (0.05)	**2.15**	**0.16**	**0.08**	**36.82**	**92.55**	**4.50**

Table 2: Production economics as influenced by different treatments in mothbean

Treatments	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
Control- 20:40:0 kg ha^{-1} NPK (Farmer's practice)	15748	26240	10492	0.67
Rhizobium + 20 kg ha^{-1} P_2O_5	13793	15526	1733	0.13
Rhizobium + 30 kg ha^{-1} P_2O_5	14793	19859	5067	0.34
Rhizobium + 40 kg ha^{-1} P_2O_5	15793	27030	11238	0.71
PSB + 20 kg ha^{-1} P_2O_5	13783	16920	3138	0.23
PSB + 30 kg ha^{-1} P_2O_5	14783	38279	23496	1.59
PSB + 40 kg ha^{-1} P	15783	32270	16487	1.04
(*Rhizobium* + PSB) + 20 kg ha^{-1} P_2O_5	13823	30098	16271	1.18
(*Rhizobium* + PSB) + 30 kg ha^{-1} P_2O_5	14823	49393	34565	2.33
(*Rhizobium* + PSB) + 40 kg ha^{-1} P_2O_5	15828	47089	31261	1.98

improved starch accumulation and facilitate its translocation towards reproductive parts (nearest sink) of the plants, thereby, leading to positively influence the pod and seed formation. Similar findings were also reported earlier by many workers (Nadeem *et al*., 2004; Sepat, 2005; Kumawat, 2006). The maximum seed yield (453 kg ha^{-1}) was also noted under *Rhizobium* + PSB + 30 kg ha^{-1} P (Table 1). An increase in 100-seed weight, number of pods $plant^{-1}$ and number of seeds pod^{-1} under this treatment resulted in superior seed yield over the others. This might be due to the surplus assimilation of carbohydrates in the leaves, and during their senescence, it would get translocated into seeds, which finally boosted the seed yield. These results corroborated the findings of Sepat (2005) and Kumawat (2006). The significantly highest haulm yield (1026 kg ha^{-1}) was noted with the application of 30 kg ha^{-1} phosphorus and seed treatment by *Rhizobium* + PSB (Table 1). This was because of the increased development and growth of crop plants to improved nutritional status of rhizosphere created by microorganisms. These findings were also reported earlier in mothbean (Ram and Dixit, 2001; Patel *et al*., 2004) and chickpea (Kumar and Sharma, 2005). Phosphorus plays an important role in the formation of phosphatic bonds such as ADP and ATP for accomplishing the energy needs of plants, and also acts as an important constituent of phospholipids and nucleoprotein (Singh *et al.,* 2017). It is a crucial element for proliferation of root nodules hence improves biological yield. Significantly highest harvest index (30.62%) was also observed in application of 30 kg ha^{-1} phosphorus and seed treatment by *Rhizobium* + PSB; whereas, lowest harvest index (16.87%) was recorded in seed inoculation by *Rhizobium* and application of 20 kg ha^{-1} P. Further, maximum net return (₹ 34565 ha^{-1}) and B:C (2.33) was found in application of 30 kg ha^{-1} phosphorus and seed treatment by *Rhizobium* + PSB.

Based on the above results, it may be concluded that the application of phosphorus at 30 kg ha^{-1} and seed inoculation by *Rhizobium* + PSB is beneficial in increasing yield attributes, yield and harvest index. This treatment was also proved to be beneficial in fetching higher economic returns per rupee invested.

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