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Effect of fertility levels and bio-fertilizers on productivity of mungbean [*Vigna radiata* (L.) Wilczek]

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Abstract
A field experiment was conducted at Agronomy farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur (Rajasthan) during *kharif*, 2022 on loamy sand soil with objective to study the response of mungbean to varying fertility levels and bio-fertilizers. The sixteen treatment combinations consisting of four each of fertility levels (Control, 50, 75 and 100% RDF) and bio-fertilizers (Control, Rhizobium, PSB and Rhizobium + PSB) were tested in randomized block design with three replications. Application of rhizobium and PSB was significantly increased the number of pods/plant, seeds/pod, test weight, seed (1053 kg/ha), straw (2054 kg/ha) and biological yield (3106 kg/ha) were also obtained under rhizobium and PSB that were 20.20, 15.78 and 17.25 percent more than over control, respectively and net returns (Rs 53772/ha) and B:C ratio (2.73) over control and rhizobium alone.

Keywords: Rhizobium, PSB, Pods, Bio fertilizers, net return

Introduction
Pulses, also known as grain legumes, are next to cereals in terms of agriculture importance and have been considered best option for diversification and intensification of agriculture across the globe because of their intrinsic value such as nitrogen fixing ability (15-35 kg/ha), high protein content and ability to thrive well in less endowed environments. In India, mungbean is grown on 5.13 million hectares area with total production of 3.17 million tonnes and an average productivity of 570 kg/ha (Anonymous, 2022-23a) [1]. The important mungbean growing states are Rajasthan, Madhya Pradesh, Uttar Pradesh, Punjab, Haryana, Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. Among states, Rajasthan occupied first position in total mungbean production of India, which produces 1.6 million tonnes from 2.62 million hectares with an average productivity of 545 kg/ha (Anonymous, 2022-23b) [2]. It is mostly grown in arid and semi-arid districts of Rajasthan including Nagaur, Jodhpur, Jaipur, Ajmer, Pali, Jalore, Sriganganagar, Tonk, Churu, Barmer and Bikaner. Biofertilizers, a component of integrated nutrient management are considered to be cost effective, eco-friendly and renewable source of non-bulky, plant nutrient supplementing component in sustainable agriculture. Their role assumes a special significance in present context of very high costs of chemical fertilizers. Use of biofertilizers can have a greater importance in increasing fertilizer use efficiency. Indian soils are of low to medium status for available nitrogen and available phosphorus. 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. The alliance of *Rhizobium* and pulse crops enables in enhancing fertility of soil and is a worth effective approach of nitrogen fertilization in legumes. Most of the soils of Rajasthan are low in available phosphorus and organic matter. Seeds of pulses when inoculated with phosphate solubilizing bacteria they secret acidic substances and solubilize the unavailable soil phosphorus. The inoculation with phosphate solubilizing bacteria may increase yield of crops by 10-30 percent (Tilak and Annapurna, 1993) [13].

Methods and Materials

A field experiment entitled "Effect of Fertility Levels and Bio-fertilizers on Productivity of Mungbean [*Vigna radiata* (L.) Wilczek]" was carried out during kharif season of 2022 at Research farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur. Geographically, the study area is located at 75º48'84" E longitude and 26º82'47" N latitude and this region falls under agro-climatic zone III A (Semi-arid Eastern Plain Zone) of Rajasthan. Experimental soil was sandy loamy in texture, low in organic carbon (0.23%) and available nitrogen (125.73 kg N/ha), medium in available phosphorus (17.92 kg P_2O_5/ha) and available potassium (151.76 kg K_2O/ha). The soil was non saline with a pH value of 8.25. Prior to sowing, the mungbean seeds were treated with liquid bio-fertilizers [N-Fixer (Rhizobium), P-Fixer (PSB) and N + P-Fixer (Rhizobium+ PSB)] at the rate of 5 ml/kg seed as per treatment. After treating the seed with liquid bio-fertilizers, it was dried in shade and used for sowing. Experimental data recorded in various parameters were statistically analyzed with the help of Fisher's analysis of variance technique (Panse and Sukhatme, 1985) [8].

Results and Discussion

Fertility levels

Application of successive fertility levels up to 75% RDF significantly increased the yield attributes *viz*., number of pods per plant, seeds per pod, test weight and seed and straw yield of mungbean over control and 50% RDF. The overall improvement in vigour and crop growth might be due to optimum availability of nutrients throughout the growth period which resulted in enhanced root and shoot development. Thus optimum fertilization stimulated better flowering, seed setting and increased values of yield attributes of mungbean. Increases in straw yield, higher test weight and various growth characters also justify that an increased supply of N and P to its optimum fertility level i.e. 75% RDF was available which resulted in greater production of grain and dry weight and contributed to greater yield. Decreasing trend with lower fertility levels further support the statement. Significant improvement in seed yield due to application of N and P was also reported by Manoj *et al*. (2014) [7] and Singh *et al.* (2017) [12]. The biological yield is a function of seed and straw yields. Thus, significant increase in biological yield with the application of N and P could be ascribed due to increased seed and straw yield (Choudhary *et al*. 2017) [5]. Biological yield increased in same proportion as that of seed yield, hence harvest index remained unchanged due to varying levels of fertility. Rathore *et al*. (2010) [9] and Kumawat *et al.* (2013) [6] who reported significant increase in yield attributes and yield of different pulse crops. Net returns recorded under 75% RDF were significantly higher as compared to control and 50% RDF. The cost involved under this treatment was comparatively lower than its additional income, which led to more returns. These results are also supported with the findings of Kumawat *et al*. (2013) [6] and Singh *et al*. (2015) [11].

Biofertilizers

A significant increase in number of pods per plant, seeds per pod, test weight and seed and straw yield was observed due to seed inoculation with dual application of Rhizobium + PSB as compared to Rhizobium alone and no inoculation. Inoculation of seed with Rhizobium as already explained, might have resulted in higher production of assimilates and their partitioning to different reproductive parts such as number of pods per plant, seed per pod and test weight and ultimately the seed yield increased over no inoculation. PSB helped in solubilisation of insoluble phosphorus, providing hormones and other growth factors and transfer of the immobilized soil phosphorus into available form through which phosphorus became easily available to crop. Greater root expansion under increased availability of phosphorus might have resulted in greater uptake of other nutrients especially micronutrient and secondary nutrients that enhanced photosynthates and their partitioning between vegetative and reproductive organs which ultimately improved the yield attributes and finally the seed yield. The increased straw yield might be due to increased plant growth in terms of dry matter production and number of branches per plant. The stimulatory effects of bio-fertilizers used are in accordance with the results obtained by Selvakumar *et al*. (2012) [10] and Bhavya *et al.* (2017) [4]. Highest net returns recorded under Rhizobium + PSB were significantly higher as compared to no inoculation and seed inoculation with Rhizobium alone. The cost involved under the above treatment was comparatively lower than its additional income, which led to more returns and B : C ratio. Kumawat *et al*. (2013) [6] and Singh *et al*. (2015) [11] were also of the same opinion.

Table 1: Effect of fertility levels and bio-fertilizers on yield attributes

Treatments	No. of pods/ plant	No. of seeds/pod	Test weight (g)
Fertility levels			
Control	12.26	5.88	34.88
50% RDF	17.23	7.05	36.05
75% RDF	19.65	7.61	37.61
100% RDF	20.39	8.08	39.08
SEm±	0.48	0.34	0.34
CD (P=0.05)	1.37	0.99	0.99
Bio-fertilizers			
Control	13.28	5.74	35.48
Rhizobium	16.40	6.92	36.67
PSB	18.87	7.51	37.15
Rhizobium + PSB	20.97	8.46	38.18
SEm±	0.48	0.34	0.66
CD (P=0.05)	1.37	0.99	1.90

Table 2: Effect of fertility levels and bio-fertilizers on yield and harvest index

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest Index (%)
Fertility levels				
Control	713	1579	2293	31.15
50% RDF	904	2105	3010	31.54
75% RDF	986	2386	3372	30.15
100% RDF	1017	2444	3462	29.65
SEm±	21	59	74	0.54
CD (P=0.05)	61	171	215	NS
Bio-fertilizers				
Control	768	1737	2505	31.84
Rhizobium	901	2111	3012	30.72
PSB	968	2311	3279	30.34
Rhizobium + PSB	984	2356	3340	29.58
SEm±	21	59	74	0.54
CD (P=0.05)	61	171	215	NS

Table 3: Effect of fertility levels and bio-fertilizers on net returns and B:C ratio

Treatments	Net returns	B:C ratio
Fertility levels		
Control	33463	1.81
50% RDF	45081	2.31
75% RDF	52044	2.60
100% RDF	55893	2.72
SEm±	1250	0.06
CD (P=0.05)	3610	0.17
Bio-fertilizers		
Control	35162	1.79
Rhizobium	46242	2.34
PSB	50530	2.56
Rhizobium + PSB	54547	2.76
SEm±	1250	0.06
CD (P=0.05)	3610	0.17

Conclusion

Application of 75% RDF proved superior and equally effective as 100% RDF, since this treatment brought significantly higher seed yield (1028 kg/ha) net returns (Rs 51636) and B:C ratio (2.58) from mungbean. Dual inoculation with Rhizobium + PSB fetched highest seed yield (1053 kg/ha), net returns (Rs 53772) and B:C ratio (2.73) from mungbean compared to sole inoculation with either N-fixer or P-fixer.

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