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Quality and economics of mungbean [*Vigna radiata* (L.) Wilczek] as influenced by application of PROM and microbial inoculants

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Abstract
A field trial was conducted at agronomy farm, S.K.N. Agriculture University, Jobner during kharif season of 2019 to study the effect of PROM and microbial inoculants on Mungbean. The experiment comprised of 12 treatments involving control, PROM, PSB, VAM, Pseudomonas fluorescens (PF) and their respective combinations which was laid out in randomized block design with three replications. Results revealed that the magnitude of protein content was increased under combined application of PROM + PSB + VAM + PF (T_{12}) as compared to other combinations and control, but it was at par with PROM + PSB + VAM (T_9). T_{12} treatment recorded higher protein content and protein yield remained at par on treatment (T_9). Treatment PROM + PSB + VAM + PF (T_{12}) fetched the highest net returns in comparison to PSB, PROM, VAM, PF alone and control, respectively. However, it was found at par with PROM + PSB + VAM (T_9).

Keywords: Protein content, PROM, VAM, mungbean

Introduction

Mung bean (*Vigna radiata* L.) commonly known as green gram is an ancient and well-known pulse crop that belongs to family Papilionoideae and originated from South East Asia (Mogotsi, 2006). It is a short duration pulse crop of kharif season which can be grown as compensational crop between Rabi and kharif seasons. On the other hand, the same source indicated that mung bean fixes atmospheric N_2 and enriches the soil with N nutrient for the growth of succeeding crops. Moreover, the crop can be successfully grown on marginal lands where other crops perform poorly and most suitable for green manure use (Dainavizadeh & Mehranzadeh, 2013). The germinated seeds of greengram enclose surprising quantity of ascorbic acid (Vitamin C), riboflavin and Thiamine (Dhakal *et al*., 2016). In legumes nitrogen requirement is less as compared to phosphorus because major portion is supplied through nitrogen fixation. Therefore phosphorus is the key nutrient for increasing productivity of pulses in general and green gram in particular. Phosphorus is the major essential element required by the crop. Phosphorus stimulates early root development, enhances the availability of Rhizobia and increases the formation of root nodules thereby fixing more atmospheric nitrogen. In order to meet this phosphorus requirement and to promote crop production, the use of high inputs of chemicals in the soil in the form of fertilizers along with intensive irrigation practices, helped to achieve the target to a certain stage. However, the decrease in crop yield took place despite the application of fertilizer. The toxic chemicals influence the life of beneficial soil microorganisms, which are indeed responsible for maintaining soil fertility. Moreover, groundwater, air, and human and animal health have also been adversely affected by excessive use of these chemicals directly and indirectly. Therefore, preserving the health of the soil is very essential. The avoidance of chemical fertilizers and the use of natural fertilizers such as bio-fertilizers, vermicompost, green manure and biopesticides, as well as the nourishing of the soil and the environment, can be a sustainable approach to crop productivity.

Phosphate Rich Organic Manure (PROM) is a type of fertilizer used as an alternative to diammonium phosphate and single super phosphate. It is produced by co-composting high-grade (32% P_2O_5 +/- 2%) rock phosphate in very fine size (say 80% finer than 54 microns). The finer the rock phosphate, the better is the agronomic efficiency of Phosphate rich organic manure. Microorganisms are crucial in the natural phosphorus cycle. The use of phosphate solubilizing bacteria (PSB) as bio-fertilizers for agriculture enhancement has been a subject of study for years. PSBs apply various approaches to make phosphorus accessible for plants to absorb. These include lowering soil PH, chelation, and mineralization. The principal mechanism for solubilization of soil P is lowering of soil pH by microbial production of organic acids or the release of protons (Kumar *et al*., 2018) [7]. Strong positive correlation has been reported between solubilization index and organic acids produced (Alam *et al*., 2002). Symbiotic relationship between plant roots and certain soil fungi e.g. Vesicular Arbuscular Mycorrhiza (VAM) contributes a significant role in P cycling and uptake of P by plants (Biswas *et al*., 2001). Through symbiotic linking with plant roots, VAM helps in mobilization of Phosphorus. These fungi can save P – fertilizer by 25 – 30 per cent (Somani *et al*., 1990). Certain phosphate solubilizing bacteria acts as Plant Growth Promoting Rhizobacteria (PGPR) i.e. one of the classes of beneficial bacteria residing in the rhizosphere (Kloepper *et al*., 1989). Pseudomonas fluorescens (PF) is a gram-negative bacterium that colonizes roots of agricultural crops; provide essential services to the agro-ecosystem as they encourage plant growth and health by overpowering soil-borne diseases, by stimulating plant immune defences, and by improving nutrient accessibility in soil. Pseudomonas fluorescens has capacity to mobilize inorganic phosphate in agricultural soils (Browne *et al*., 2009). It solubilizes about 30 per cent of soil phosphorus.

Materials and Methods

An attempt was made to study the effect of PROM and Microbial Inoculants on growth and yield of mungbean. Field experiment was conducted during kharif season of 2019 at agronomy Farm, SKN Agriculture University, Jobner (Rajasthan). The soil was loamy sand with pH 8.2, available N 128.0 kg/ha (Subbiah and Asija, 1956), P 16.63 kg/ha (Olsen *et al*., 1954), K 154.1 kg/ha (Jackson, 1967) and 0.15% organic carbon (Jackson, 1973). The twelve treatments comprised of control, PROM, PSB, VAM, Pseudomonas fluorescens (PF) and their respective combinations were laid out in Randomized Block Design with three replications. PROM (10.4% P_2O_5) applied as basal equivalent to 40 kg P_2O_5/ha and was incorporated well into the soil at the time of sowing as per treatments. Mungbean seed was inoculated with liquid PSB culture i.e. Bacillus megatherium @2 ml/kg seed and with PGPR Pseudomonas fluorescens (PF) @10 ml/kg seed as per routine procedure 2-3 hours before sowing as per treatments. The soil based VAM (Trichoderma viride) containing hyphae, spores and sporacarp was incorporated into soil in crop rows at the time of sowing @5 kg/ha VAM was mixed with 8-10 kg vermi-compost as per treatment and thoroughly mixed manually in the treated plots. Seeds of the mungbean variety, IPM-02-3 were sown on 10th July, 2019 in rows spaced at 30 cm apart at the depth of 4-5 cm with the help of ‘kera’ method using a seed rate of 16 kg/ha. Prior to sowing, the seed was treated with Rhizobium culture, uniformly under all the treatments. The experimental data recorded for quality and economics were subjected to statistical analysis in accordance with the “Analysis of Variance” technique suggested by (Fisher, 1950). Appropriate standard error for each of the factor was worked out. Significance of differences among treatment effects was tested by “F” test. Critical difference (CD) was worked out, wherever the difference was found significant at 5.0 or 1.0 per cent level of significance.

Results and Discussion

Protein content and protein yield

Protein content in mungbean grain was also improved significantly due to application of PROM and microbial inoculants (Table 1). Among all the treatments, PROM + PSB + VAM + PF observed significantly higher protein content (25.0 per cent) in grain and registered 13.1, 16.8, 19.6, 20.1 and 24.3 per cent more protein content than PROM, PSB, VAM, PF and control, respectively. It was accompanied in the order of T_9 (24.7%), T_{10} (24.1%), T_6 (23.3%), T_{11} (22.7%), T_7 (22.2%) and T_2 (22.1%) treatments. Same trend was followed in protein yield. The primary component of amino acids which constitute the basis of protein is N and consequently higher N content in grain is directly responsible for higher protein. These results are in close agreement with those of Kumawat *et al*. (2009) [9], Singh *et al*. (2015) [10] and Kumar and Yadav (2018) [7] in mungbean.

Table 1: Effect of PROM and microbial inoculants on protein content and yield in mungbean

Treatments	Protein content (%)	Protein yield (kg/ha)
T_1 – Control	20.1	125.424
T_2 – PROM	22.1	183.43
T_3 – PSB	21.4	161.356
T_4 – VAM	20.9	145.673
T_5 – Pseudomonas fluorescens (PF)	20.8	142.064
T_6 – PROM + PSB	23.3	228.107
T_7 – PROM + VAM	22.2	203.796
T_8 – PROM + PF	21.9	194.253
T_9 – PROM + PSB + VAM	24.7	266.019
T_{10} – PROM + PSB + PF	24.1	255.46
T_{11} – PROM + VAM + PF	22.7	227.454
T_{12} – PROM + PSB + VAM + PF	25	279.75
SEm+	0.7	0.56
CD (p = 0.05)	1.45	35.9

Table 2: Effect of PROM and microbial inoculants on net returns and B: C ratio in mungbean

Treatments	Net returns (Rs/ha)	B:C ratio
T_1 – Control	24791	1.24
T_2 – PROM	30505	1.04

T_3 – PSB	33988	1.70
T_4 – VAM	29498	1.42
T_5 – Pseudomonas fluorescens (PF)	29123	1.45
T_6 – PROM + PSB	41381	1.41
T_7 – PROM + VAM	36249	1.21
T_8 – PROM + PF	34686	1.18
T_9 – PROM + PSB + VAM	48078	1.60
T_{10} – PROM + PSB + PF	47170	1.61
T_{11} – PROM + VAM + PF	42270	1.41
T_{12} – PROM + PSB + VAM + PF	50920	1.69
SEm+	1716	0.06
CD (p = 0.05)	3559	0.12

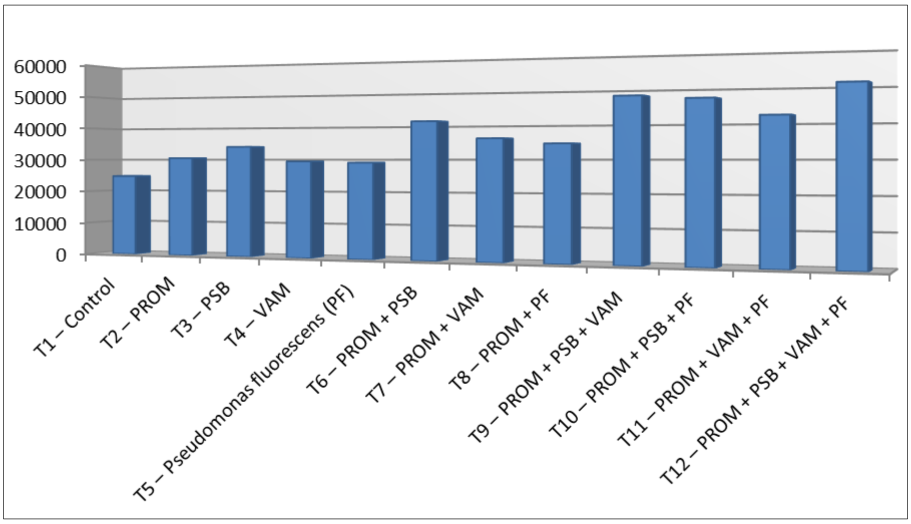

Fig 1: Effect of PROM and microbial inoculants on net returns in mungbean

Economics

Net returns

It is obvious from data presented in table 2 and fig. 1 that all the treatments of PROM and microbial inoculants varied widely in influencing the net returns in mungbean. Application of PROM, VAM, PSB and PF, alone provided the net returns of Rs 30505, 29498, 33988 and 29123/ha indicating an increase of 23.0, 18.9, 37.1 and 17.5 per cent over control, respectively. The combined application of PROM and microbial inoculants was found more remunerative than application of these alone. Results showed that the treatment PROM + PSB + VAM + PF (T_{12}) was found the most remunerative among all the treatments. It fetched the maximum net returns of ` 50920/ha, thereby increasing the net returns by a huge margin of 7.9, 20.5, 23.1, 40.5, 46.8, 49.8, 66.9, 72.6, 74.8 and 105.4 per cent, respectively over T_{10}, T_{11}, T_6, T_7, T_8, T_3, T_2, T_4, T_5 and control, respectively. Application of PROM + PSB + VAM and PROM + PSB + PF also provided the additional net returns of ` 23287 and 22379/ha in comparison to control, and thus were noted to be the next superior and equally remunerative treatments. These were accompanied by T_{11}, T_6, T_7 and T_8 wherein increase in net returns over control was observed up to 70.5, 66.9, 46.2 and 39.9 per cent over control, respectively.

B:C ratio

Perusal of data also showed that use of the treatments involving PROM and microbial inoculants significantly enhanced the B: C ratio in mungbean over control (Table 4.15). The highest B: C ratio (1.70) was recorded under PSB treatment indicating an increase of 37.1 per cent over control. Treatment PROM + PSB + VAM + PF, PROM + PSB + PF and PROM + PSB+ VAM also increased the B: C ratio by 36.3, 29.8 and 29.0 per cent in comparison to control and thus proved to be the next better treatments. However, these were found at par among themselves. These were accompanied in the order of T_5 (1.45), T_4 (1.42), T_{11} (1.41) and T_6 (1.41) in regard of improving B: C ratio. On the other hand, use of PROM alone, witnessed the minimum value (1.04) of B: C ratio. As net return is calculated by multiplying grain and straw yields by their sale prices and subtracting the cost of cultivation including treatment cost, it seems to be directly associated with significantly higher grain and straw yields obtained under these superior treatments as well as comparatively lower additional cost of cultivation over control in comparison to added output.

Conclusion

Based on the results of one year experimentation, it may be concluded that application of PROM + PSB + VAM + PF was found the most superior treatment combination for obtaining higher quality and profitability in mungbean.

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