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Yield and yield contributing parameters of soybean as influenced by application of biofertilizers

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Abstract

A field experiment was conducted in the field during *Kharif* season of 2023 at Post Graduate Institute Farm, MPKV, Rahuri to investigate the “Studies on physiological responses and yield of soybean influenced by application of biofertilizers” with objectives, to study the physiological responses of soybean to the application of biofertilizer and yield influenced by the application of biofertilizers. The experiment was laid out in split plot design with three replications. There were 14 treatment combinations comprised with 7 biofertilizer treatments and two varieties *viz.*, KDS-726 and KDS-753. The results of field experiment revealed that, the variety KDS-726 had shown statistically significantly superior results than the variety KDS-753 while the biofertilizer treatment T₅ i.e. Seed inoculation of *Rhizobium* + PSB + KMB @ 25 g each kg⁻¹ + 100% RDF recorded the statistically significantly superior number of pods plant⁻¹ (56.87), seed yield plant⁻¹ (17.92 g), 100 seed weight (16.50 g), seed yield plot⁻¹ (2.82 kg), seed yield ha⁻¹ (3394.42 kg) and harvest index (50.91) whereas treatment T₆ i.e. Seed inoculation of *Rhizobium* + PSB + KMB @ 25gm each kg⁻¹ + 75% RDF recorded number of pods plant⁻¹ (53.81), 100 seed weight, (16.36 g), seed yield plant⁻¹ (16.51 g), seed yield plot⁻¹ (1.74 kg), seed yield ha⁻¹ (3224.22 kg) and harvest index (50.07) which was found statistically at par with treatment T₅.

Keywords: Soybean, biofertilizers, yield, pods, harvest index

Introduction

Soybean contributes 40 and 25% to the total oilseeds and edible oil production of the country and earns valuable foreign exchange by exporting soya meal. Current crushing capacity of soybean processing industry is about 20 million t annum⁻¹ with the annual total production of 12.0 million t soybean oil. As far as consumption pattern is concerned, 100% of soybean oil produced in the country has consumed domestically, and 8-10% of total soybean produced is consumed at homes for direct food purposes. Thirty-five percent of total soy meal produced finds its way to the domestic market.

Soybean is also called as nature's versatile crop is a rich source of proteins and oil. As Indian diet is deficient in proteins, both in quality and quantity, soybean can be considered as “Poor man's meat”. Soybean is the largest oilseed crop of the world contributing 58 per cent in total oilseed production. Soybean contains about 40-44 per cent protein, 23 per cent carbohydrates and 20 per cent cholesterol free oil. Soybean proteins are rich source of valuable amino acid, lysine (5%), 60 per cent polyunsaturated fatty acids (52.8% Linoleic acid and 7.2% Linolenic acid). Vitamins A, B, C, D, E and K are also present in soybean (Aslam *et al.*, 1995) [2].

Several synergistic factors are responsible for the good yield of the soybean crop. The wise selection of variety, good agronomic practices, and strategic coping with yield constraints can robust the soybean production that can meet the future demand of soybean crops. Among the crop management practices, judicious management of plant nutrients can increase production significantly. Plant nutrients are the essential elements that are needed for growth and reproduction and can be available naturally from soil and air and artificially by the application of organic matters and commercial fertilizers. Nutrients are the key factor for production, which has a great interaction that may gain either a positive or a negative effect on crop production depending upon the amount, dose, crop growth stage, combination, and balance. For proper growth and development of soybean crop, altogether fifteen nutrients are required.

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Bio-fertilizers can play an important role in meeting the nutrient requirement of crops through biological nitrogen fixation (BNF), solubilization of insoluble phosphorus sources (PSB), extend the nutrient absorption to zones not accessible to plant roots (VAM). Therefore, introduction of efficient strain of *Rhizobium* in the soil which is poor in nitrogen may be helpful in boosting up production and consequently more nitrogen fixation. Several bacteria belonging to genera *Pseudomonas* and *Bacillus* have the ability to solubilize inorganic phosphorus insoluble sources. Inoculation of seed with phosphate solubilizing bacteria (PSB) increases crop growth, nutrient availability, uptake and crop yield.

Materials and Methods

A field trial "Studies on Physiological responses and yield of soybean influenced by application of biofertilizers" was conducted at the Agricultural Botany Field, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri during *Kharif* season of 2023. The plot selected for the experiment had a uniform soil depth. The topography of field was uniform and leveled. The soil was medium and well drained with medium black colour.

In the present investigation two varieties of soybean KDS-726 and KDS-753 were sown on field by applying different biofertilizer treatments. Seven treatment combinations were made as given in Table 1. There were three number of replications. Experimental design used for the plot was split plot design according to that layout of field was made.

The data collected on individual characters were subjected to the method of analysis of variance commonly applicable to the Split plot design (Panse and Sukhatme, 1985) [13].

Table 1: Different biofertilizer treatments

T ₁	: Recommended Dose of fertilizer NPK
T ₂	: Seed inoculation of <i>Rhizobium</i> @ 25 g/kg + 100% RDF.
T ₃	: Seed inoculation of PSB @ 25 g/kg + 100% RDF.
T ₄	: Seed inoculation of KMB @ 25 g/kg + 100% RDF.
T ₅	: Seed inoculation of <i>Rhizobium</i> + PSB + KMB @ 25g each/kg + 100% RDF
T ₆	: Seed inoculation of <i>Rhizobium</i> + PSB + KMB @ 25g each/kg + 75% RDF
T ₇	: Control Absolute

Table 2: Number of pods plant⁻¹ and 100 seed weight (g) as influenced by different treatments in soybean

Factors		Number of pods plant ⁻¹	100 seed weight (g)	Harvest Index (HI)
A. Main plots: Variety (V)				
V ₁	KDS-726	52.33	15.87	45.42
V ₂	KDS-753	48.89	14.52	45.16
	S.E. (m) ±	0.28	0.17	0.11
	CD at 5%	1.70	1.03	NS
B. Sub plots: Treatments (T)				
T ₁	Recommended Dose of fertilizer NPK	49.56	14.69	43.15
T ₂	Seed inoculation of <i>Rhizobium</i> @ 25g kg ⁻¹ + 100% RDF.	51.14	15.05	44.89
T ₃	Seed inoculation of PSB @ 25 gkg ⁻¹ + 100% RDF.	50.60	15.03	44.31
T ₄	Seed inoculation of KMB @ 25 gkg ⁻¹ + 100% RDF.	50.85	14.86	43.56
T ₅	Seed inoculation of <i>Rhizobium</i> + PSB + KMB @ 25g each kg ⁻¹ + 100% RDF	56.87	16.50	50.91
T ₆	Seed inoculation of <i>Rhizobium</i> + PSB + KMB @ 25g each kg ⁻¹ + 75% RDF	53.81	16.36	50.07
T ₇	Absolute Control	41.44	12.86	40.16
	S.E. (m) ±	1.79	0.48	1.77
	CD at 5%	5.21	1.41	5.16
C. Interaction (V x T)				
	S.E. (m) ±	2.53	0.68	2.50
	CD at 5%	NS	NS	NS
	General Mean	50.61	15.19	45.30

Results and Discussion

Yield and Yield contributing parameters

• Number of pods plant⁻¹

The data given in Table 2 revealed that two varieties and seed inoculation of *Rhizobium*, PSB and KMB has significant effect on number of pods of soybean. The average number of pods recorded in soybean plants were 50.61.

From the data recorded during the experiment, showed that there was statistically significant difference between numbers of pods of two varieties. The average number of pods of KDS 726 was 52.33 and it was significantly superior to that of KDS 753 (48.89).

Data presented in Table 2 revealed that number of pods plant⁻¹ in all treatments were significantly increased over treatment T₇ i.e. absolute control. Treatment T₅ i.e. seed inoculation of *Rhizobium*, PSB and KMB plus 100% RDF recorded statistically significantly superior number of pods plant⁻¹ (56.87) than rest of the treatments except treatment T₆. Whereas, treatment T₆ i.e. seed inoculation of *Rhizobium*, PSB and KMB plus 75% RDF recorded 53.81 number of pods⁻¹ and it was at par to treatment T₅. Moreover, Treatment T₂ i.e. seed inoculation of *Rhizobium* @ 25each kg⁻¹+ 100% RDF (49.56), T₃ i.e. seed inoculation of PSB @ 25 each kg⁻¹+ 100% RDF (50.60) and T₄ i.e. Seed inoculation of KMB @ 25 each kg⁻¹+ 100% RDF (50.85) were found higher number of pods than T₇ i.e. absolute control.

In general, inoculation with *Rhizobium*, PSB and KMB have significant effect on number of pods per plant. The seed inoculation of *Rhizobium*, PSB and KMB along with fertilizer dose gave significant increase as compared to effect of fertilizer dose.

Observed increase in number of pods per plant by application of *Rhizobium* and PSB on French bean. Whereas similar results have been given by Heisnam *et al.*, (2017) [7], Sharma *et al.*, (2017) [16], Raut *et al.*, (2018) [15], Thakur *et al.*, (2018) [18], Katiyar *et al.*, (2020) [11].

The interaction effect between different varieties and biofertilizer treatments were found non-significant in respect of number of pods plant⁻¹.

• 100 Seed Weight (g)

The 100 seed weight of soybean showed significant variation among the various treatments in this experiment. Data given in Table 2 shows that the average 100 seed weight soybean was 15.19 g.

The experiment had showed significance difference between two varieties. 100 seed weight obtained was 15.87 g in KDS 726 whereas the 14.52 g was in KDS 753. This might be due to genetic characters of the variety, KDS 726 is a bold seeded variety.

The data presented in Table 11 and Figure 4 revealed that, seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg⁻¹ + 100% RDF had significant effect on 100 seed weight of soybean. Treatment T₅ seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg⁻¹ + 100% RDF recorded statistically significantly superior 100 seed weight (16.50 g) than rest of the treatments except treatment T₆. Whereas, treatment T₆ i.e. Seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg⁻¹ + 75% RDF was found at par to T₅ (16.36 g). Moreover, Treatment T₂ i.e. Seed inoculation of *Rhizobium* @ 25g kg⁻¹ + 100% RDF (15.05 g), T₃ i.e. seed inoculation of PSB @ 25 g kg⁻¹ + 100% RDF. (15.03 g) and T₄ i.e. Seed inoculation of KMB @ 25 g kg⁻¹ + 100% RDF. (14.86 g) were also found significant over T₇ i.e. absolute control, which recorded lowest 100 seed weight (12.86 g).

In general, it was observed that, inoculation of *Rhizobium*, PSB and KMB has significant effect on 100 seed weight of soybean. The seed inoculation along with fertilizer dose recorded significant higher seed weight as compared to absolute control.

The results are in agreement with findings of Ramana *et al.*, (2011) [14], Hassan *et al.*, (2017) [6] who were observed inoculation of PSB significantly increased the 100 seed weight of different legume crop.

The interaction effect between different varieties and biofertilizer treatments were found non-significant in respect of 100 seed weight.

• Harvest Index (HI): The harvest index of soybean as

influenced significantly due to different treatments is presented in Table 2. From the experiment the mean harvest index was found 45.30%. The comparison between two varieties of soybean in respect of harvest index were found non-significant.

The harvest index was influenced significantly due to different biofertilizer treatments. The harvest index was statistically significantly superior in treatment T₅ i.e. seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg⁻¹ + 100% RDF (50.91%) than rest of the treatments except treatment T₆. Treatment T₆ i.e. seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg⁻¹ + 75% RDF recorded the harvest index of 50.07%, which was at par with treatment T₅. The lowest harvest index was observed in absolute control (T₇) (40.16%).

The highest harvest index was recorded in treatment T₅ and then in treatment T₆, it might be due to the nutrients were available to plant for its complete life cycle. PSB solubilizes phosphate which increased its availability to plant that ultimately leads to better harvest index. The results are in agreement with Dhakal *et al.* (2015) [3]. The similar results were reported by Gautam *et al.*, (2017) [4].

The interaction effect between different varieties and biofertilizer treatments were found non-significant in respect of harvest index.

• Seed Yield (g plant⁻¹), Seed Yield (kg plot⁻¹) and Seed Yield (kg ha⁻¹)

The data presented in Table 3 revealed that the yield of two varieties and seed inoculation of *Rhizobium*, PSB and KMB has significant effect on seed yield per hectare of soybean. The average seed yield obtained per plant was 14.52 g. The average seed yield obtained of soybean per plot was 2.31 Kg. and per hectare was 2801.66 Kg.

The results obtained from the following experiment showed that the per plant seed yield obtained in variety KDS 726 (15.56 g) was statistically significantly superior to the variety KDS 753 (13.48 g).

Table 3: Seed yield (g plant⁻¹), Seed yield (kg plot⁻¹) and Seed yield (kg ha⁻¹) as influenced by different treatments in soybean

Factors		Seed yield per plant (g plant ⁻¹)	Seed yield per plot (kg plot ⁻¹)	Seed yield per ha (kg ha ⁻¹)
A. Main plots: Variety (V)				
V ₁	KDS-726	15.56	2.41	2924.40
V ₂	KDS-753	13.48	2.21	2678.51
	S.E. (m) ±	0.31	0.02	16.01
	CD at 5%	1.88	0.13	97.41
B. Sub plots: Treatments (T)				
T ₁	Recommended Dose of fertilizer NPK	12.44	2.05	2488.45
T ₂	Seed inoculation of <i>Rhizobium</i> @ 25g kg ⁻¹ + 100% RDF.	14.66	2.50	3015.38
T ₃	Seed inoculation of PSB @ 25 g kg ⁻¹ + 100% RDF.	14.48	2.43	2945.94
T ₄	Seed inoculation of KMB @ 25 g kg ⁻¹ + 100% RDF.	13.76	2.23	2747.82
T ₅	Seed inoculation of <i>Rhizobium</i> + PSB + KMB @ 25g each kg ⁻¹ + 100% RDF	17.92	2.82	3394.42
T ₆	Seed inoculation of <i>Rhizobium</i> + PSB + KMB @ 25g each kg ⁻¹ + 75% RDF	16.51	2.66	3224.22
T ₇	Absolute Control	11.86	1.48	1795.36
	S.E. (m) ±	0.61	0.10	124.32
	CD at 5%	1.79	0.30	362.87
C. Interaction (V x T)				
	S.E. (m) ±	0.87	0.14	175.82
	CD at 5%	NS	NS	NS
	General Mean	14.52	2.31	2801.66

From the data it is revealed that, there was significant difference between yields of two varieties. The KDS 726 recorded significantly superior seed yield 2.41 Kg plot⁻¹ and

2924.40 Kg ha⁻¹ over KDS 753 (2.21 Kg plot⁻¹ and 2678.51 Kg ha⁻¹).

The yield of KDS 726 was higher might be due its more vigorous growth, high vegetative growth and also due to its genetic characters. Jadhav *et al.*, (2021) ^[9] showed that KDS 726 gives better yield as compare to KDS 753, so these results resemble with them.

The seed yield recorded per plant was statistically significantly superior (17.92 g) in treatment (T₅) seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg⁻¹ + 100% RDF than rest of the treatments except treatment T₆. Treatment T₆, seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg⁻¹ + 75% RDF recorded 16.51 g yield plant⁻¹ which was found at par with Treatment T₅. The lowest per plant seed yield was recorded in treatment T₇ that is absolute control (11.86).

The treatment T₅ i.e. Seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg⁻¹ + 100% RDF recorded statistically significantly superior seed yield (2.82 kg plot⁻¹) and (3394.42 kg ha⁻¹) among the other treatment except treatment T₆. Treatment T₆ i.e. Seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg⁻¹ + 75% RDF recorded seed yield of 2.66 kg plot⁻¹ and 3224.22 kg ha⁻¹ which was found at par to treatment T₅. The treatment absolute control (T₇) had given lowest yield (1.48 kg plot⁻¹ or 1795.36 ha⁻¹ yield).

The higher number pods, greater pod length, 100 seed weight and green pod yield of French bean in the treatment receiving recommended dose of fertilizer alone inoculation of *Rhizobium*, PSB and KMB might be due to increased availability of nutrients during growth stages of crop, better nodulation under the influence of inoculation resulting in better growth and development. This is could be attributed to the conjunctive use of fertilizer and biofertilizer which might have resulted in greater nutrient availability in the *rhizosphere* and higher microbial activity (Meena *et al.*, 2018) ^[12].

The results are in agreement with the findings of Shete *et al.*, (2019) ^[17] who reported that, inoculation of consortium of *Rhizobium*, PSB and KMB with 75% RDF significantly enhanced the yield of green gram. Similar results have also been reported by Ghadge and Murumkar (2020) ^[5] in soybean crop. Ahmed *et al.*, (2016) ^[1], Yoseph and Shanko (2017) ^[19], Ramana *et al.*, (2011) ^[14], Iqbal *et al.*, (2016) ^[8], Kachave *et al.*, (2018) ^[10], who observed increase in yield of legume crops due to inoculation *Rhizobium*, PSB and KMB as single or in combination.

The interaction effect between different varieties and biofertilizer treatments were found non-significant in respect of seed yield.

Conclusion

- The variety KDS 726 had shown better performance in in yield and yield contributing characters as compare to the variety KDS-753.
- Although treatment T₅ i.e., seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg⁻¹ + 100% RDF brought significant improvement in yield, whereas seed inoculation of *Rhizobium* + PSB + KMB @ 25gm each kg⁻¹ + 75% RDF is also found at par with it.

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