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Effect of nodulation and quality of soybean [*Glycine max* (L.) Merill] as influenced by biofertilizers

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Abstract
The field investigation entitled "Studies on growth, nodulation and yield of soybean [*Glycine max* (L.) Merill] as influenced by biofertilizers" was conducted on farm, Department of Agronomy, College of Agriculture, Latur. The experimental field was leveled and well drained. The soil was clayey loam in texture, low in available nitrogen, medium in available phosphorus, high in potassium and slightly alkaline in reaction. The environmental conditions prevailed during experimental period was favourable for normal growth and maturity of soybean crop. The experiment was laid out in randomized block design with three replications and variety MAUS-71 as a test crop along with eight treatments. T_1- RDF + *Rhizobium* (P), T_2- RDF + *Rhizobium* (L), T_3- RDF + *Rhizobium* (P) + PSB (P), T_4- RDF + *Rhizobium* (P) + PSB (L), T_5- RDF + *Rhizobium* (L) + PSB (P), T_6- RDF + *Rhizobium* (L) + PSB (L), T_7- Only RDF (30:60:30 NPK kg ha^{-1}) and T_8- Un-inoculated and un-fertilized (Control). The gross and net plot size of each experimental unit was 5.4m x 4.5m and 4.5m x 3.5m, respectively. Sowing was done on 05th July, 2013 by dibbling the seed. The recommended cultural practices and plant protection measures were taken. As per fertilizer treatment whole dose of fertilizer applied as basal dose at the time of sowing. Application of RDF + *Rhizobium* (L) + PSB (L) (T_6) recorded significantly higher growth, yield and quality contributing characters followed by application of RDF + *Rhizobium* (L) + PSB (P) (T_5) and RDF + *Rhizobium* (P) + PSB (L) (T_4).

Keywords: nodulation, quality, soybean, influenced, biofertilizers

Introduction
Soybean [*Glycine max.* (L.) Merill] is a leguminous crop and belongs to family leguminoaceae with sub family papilionaceae. It is originated in China and it was introduced in India in recent years. It is basically a pulse crop and gained the importance as an oilseed crop as it contains 20% cholesterol free oil. The prices of fertilizers are increasing day by day and therefore, it is necessary to reduce the cost of fertilizers by using *Rhizobium* and PSB inoculation to increase yield of legume crops. Biofertilizers are the products containing living cells of different types of microorganisms which have an ability to mobilize nutritionally important elements for non-usable to usable form through biological process. Biofertilizers cannot replace chemical fertilizers, but certainly are capable of reducing their input. Seed inoculation with effective *Rhizobium* inoculants is recommended to ensure adequate nodulation and N_2 fixation for maximum growth and yield of pulse crop. Biofertilizers do not supply nutrients directly to crop plants but have capacity to fix atmospheric nitrogen and convert insoluble phosphate into soluble form. Hence, soil microorganisms play significant role in mobilizing P for the use of plant and large fraction of soil microbial population can dissolve insoluble phosphate in soil. Use of *Rhizobium* inoculums in the establishment of legumes has been widely recognized, especially in areas where indigenous nodulation has been found to be inadequate. The benefits by the use of *Rhizobium* inoculants show that a quite good deal of money can be saved by marginal farmers by using quality tested inoculants on the farm. (Zarrin and Fayyaz, 2007). Biofertilizers being essential components of organic farming play vital role in maintaining long term soil fertility and sustainability by fixing atmospheric di-nitrogen (N=N) mobilizing fixed macro and micro nutrients or convert insoluble P in the soil into forms available to plants, thereby increases their efficiency and availability. (Mishra *et al*., 2013) [8].

Materials and Methods

The experiment was conducted during *kharif* season of 2013-14 on the Farm, of Department of Agronomy, College of Agriculture, Latur. The topography of experimental field was uniform and leveled. Geographically Latur is situated between 18°05' to 18°75' North latitude and between 76°25' to 77°25' East longitude. Its height from mean sea level is about 633.85 m and has sub-tropical climate. The mean annual precipitation was about 734 mm. Most of the monsoon rains (72 per cent) received from June to September. The total rainfall received during crop growth season was 817.3 mm and distributed over 62 rainy days during the course of experimentation. The present experiment was laid out by using Randomized Block Design with three replications. The treatments were consisting of *Rhizobium* and PSB with both solid and liquid forms constituting eight treatments, Randomized Block Design (RBD), Replication three, Treatments, T_1- RDF + *Rhizobium* (Powder form), T_2-RDF + *Rhizobium* (Liquid form), T_3- RDF + *Rhizobium* (Powder form) + PSB (Powder form), T_4- RDF + *Rhizobium* (Powder form) + PSB (Liquid form), T_5- RDF + *Rhizobium* (Liquid form) + PSB (Powder form), T_6- RDF + *Rhizobium* (Liquid form) + PSB (Liquid form), T_7- RDF (30:60:30 NPK kg ha^{-1}), T_8-Un-inoculated and un-fertilized (Control). Soybean (MAUS-71) the variety is recommended for the Maharashtra under rainfed conditions. Sowing was done on 5th July, 2013 by dibbling two to three seeds at each hill at a recommended spacing of 45cm x 5cm. Biometric observations, sampling technique five plants from each net plot were randomly. Pre-harvest studies, Plant height (cm), Number of functional leaves plant^{-1}, Leaf area plant^{-1} (dm^2), Number of branches, Number of pods, Dry matter accumulation, Post-harvest studies, Seed yield plant^{-1} (g), Seed index (g), Pod yield plant^{-1} (g), Number of seeds plant^{-1}, Yield, Seed yield plot^{-1}, Straw yield plot^{-1}, Harvest index (%), Economics, Gross monetary returns (Rs ha^{-1}), Cost of cultivation (Rs ha^{-1}), Net monetary returns (Rs ha^{-1}), Benefit: cost ratio.

Results

Data on mean number of nodules per plant as influenced by various treatments is presented in (Table 1). The mean number of nodules per plant was found to be increased up to 60 DAS which was functional and thereafter it was declines and get non-functional. The mean number of nodules was recorded at 30, 45, 60, 75 DAS and at harvest was 25.04, 29.04, 39.54, 27.04 and 15.50 respectively. At 30 DAS, maximum number of nodules per plant was observed with the application of RDF + *Rhizobium* (L) + PSB (L) (T_6) which was at par with RDF + *Rhizobium* (L) + PSB (P) (T_5) and was significantly superior over rest of the treatments. At 45, 60 and 75 DAS maximum number of nodules per plant was observed with the application of RDF + *Rhizobium* (L) + PSB (L) (T_6) which was significantly superior over rest of the treatments. Maximum number of nodules per plant was observed with the application of RDF + *Rhizobium* (L) + PSB (L) (T_6) which was at par with RDF + *Rhizobium* (L) + PSB (P) (T_5) and was significantly superior over rest of the treatments. The maximum number of nodules plant^{-1} was observed with the application of RDF + *Rhizobium* (L) + PSB (L) (T_6) (60.67). Gupta and Seema Sahu, (2012) [4] also reported similar results.

Protein content (%) and protein yield (kg ha^{-1})

Protein content (%): Data on protein content (%) of soybean as influenced by different treatments along with statistical inference are presented in Table No. 2. Data revealed that, the protein content (%) was statistically found to be non-significant. Application of RDF + *Rhizobium* (L) + PSB (L) (T_6) recorded higher protein content than control treatment (T_8). The mean protein content of soybean was recorded 40.09%.

Table 1: Mean number of nodules plant^{-1} of soybean as influenced by various treatments at different crop growth stages

Treatments	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
T_1- RDF + *Rhizobium* (P)	22.67	24.67	33.33	23.33	13.67
T_2- RDF + *Rhizobium* (L)	25.33	29.33	36.00	28.00	15.67
T_3- RDF + *Rhizobium* (P) + PSB (P)	26.00	30.67	37.33	29.33	16.67
T_4- RDF + *Rhizobium* (P) + PSB (L)	26.33	31.33	39.67	28.67	17.33
T_5- RDF + *Rhizobium* (L) + PSB (P)	30.67	34.00	51.33	32.33	17.67
T_6- RDF + *Rhizobium* (L) + PSB (L)	35.00	42.67	60.67	38.00	21.67
T_7- RDF (30:60:30 NPK kg ha^{-1})	18.00	20.33	29.33	19.33	12.33
T_8- Control	16.33	19.33	28.67	17.33	9.00
SE ±	1.60	1.73	2.78	1.54	1.42
C.D. at 5%	4.80	5.20	8.33	4.62	4.25
General Mean	25.04	29.04	39.54	27.04	15.50

Protein yield (kg ha^{-1})

Data presented (Table 2) on protein yield (kg ha^{-1}) as influenced by various treatments are presented in Table 2. Protein yield (kg ha^{-1}) of soybean was recorded maximum (1067.9 kg ha^{-1}) by RDF + *Rhizobium* (L) + PSB (L) (T_6) which was at par with RDF + *Rhizobium* (P) + PSB (P) (T_3), RDF + *Rhizobium* (P) + PSB (L) (T_4) and RDF + *Rhizobium* (L) + PSB (P) (T_5) and was significantly superior over rest of the treatments. The mean protein yield of soybean was recorded 897.8 kg ha^{-1}.

Oil content (%) and oil yield (kg ha^{-1})

Oil content (%)

Data presented (Table 2) on oil content (%) as influenced by various treatments are presented in Table 2. Data on oil content was found to be statistically non-significant. Application of RDF + *Rhizobium* (L) + PSB (L) (T_6) recorded higher oil content than control treatment (T_8). The mean oil content of soybean was recorded 20.57%.

Table 2: Protein content (%), protein yield (kg ha^{-1}), oil content (%) and oil yield (kg ha^{-1}) as influenced by different treatments

Treatments	Protein content (%)	Protein yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
T_1- RDF + *Rhizobium* (P)	39.99	871.5	20.41	445.53
T_2- RDF + *Rhizobium* (L)	40.11	880.6	20.47	449.47
T_3- RDF + *Rhizobium* (P) + PSB (P)	40.30	939.1	20.64	480.27
T_4- RDF + *Rhizobium* (P) + PSB (L)	40.37	976.3	20.87	505.11
T_5- RDF + *Rhizobium* (L) + PSB (P)	40.40	1009.7	21.02	521.57
T_6- RDF + *Rhizobium* (L) + PSB (L)	40.54	1067.9	21.10	557.26
T_7- RDF (30:60:30 NPK kg ha^{-1})	39.64	774.4	20.11	392.20
T_8- Control	39.41	662.7	19.95	335.59
SE $\pm$	0.31	52.17	0.57	28.19
C.D. at 5%	NS	156.39	NS	84.52
General Mean	40.09	897.8	20.57	460.87

Oil yield (kg ha^{-1})

Data presented (Table 2) on oil yield (kg ha^{-1}) as influenced by various treatments are presented in Table 2. Oil yield (kg ha^{-1}) of soybean was recorded maximum at treatment RDF + *Rhizobium* (L) + PSB (L) (T_6) which was found to be at par with RDF + *Rhizobium* (P) + PSB (P) (T_3), RDF + *Rhizobium* (P) + PSB (L) (T_4) and RDF + *Rhizobium* (L) + PSB (P) (T_5) and was significantly superior over rest of the treatments. The mean oil yield of soybean was recorded 460.87 kg ha^{-1}. The effect of different treatments on mean protein content (%) was found to be non-significant whereas, mean protein yield (kg ha^{-1}) was found to be statistically significant. The application of RDF + *Rhizobium* (L) + PSB (L) (T_6) recorded higher mean protein content and mean protein yield (40.54% and 1067.9 kg ha^{-1}). Statistically similar results were recorded by Iraj Zarei *et al*., (2012) [5]. The mean oil content (%) was not influenced significantly with the application of different treatments. While, mean oil yield (kg ha^{-1}) was found to be statistically significant with application of different treatments. With the application of RDF + *Rhizobium* (L) + PSB (L) (T_6) the highest value of mean oil content was (21.10%) whereas, it also recorded significantly higher mean oil yield (557.26 kg ha^{-1}). Statistically similar results were recorded by Mekki and Ahmed, (2005) [7].

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