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Studies on growth, yield 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 5.4 m x 4.5 m and 4.5 m x 3.5 m, 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: *Glycine max* L. 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) [5]. 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) [3].

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 45 cm x 5 cm. 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.

Table 1: Pod yield (g) plant^{-1}, seed yield (g) plant^{-1}, number of seeds plant^{-1} and seed index (g) of soybean as influenced by various treatments

Treatments	Pod yield plant^{-1} (g)	Seed yield (g) plant^{-1}	No. of seeds plant^{-1}	Seed index (g)
T_1- RDF + *Rhizobium* (P)	8.49	5.13	49.13	11.85
T_2- RDF + *Rhizobium* (L)	8.54	5.17	52.43	11.90
T_3- RDF + *Rhizobium* (P) + PSB (P)	8.85	5.48	56.65	11.96
T_4- RDF + *Rhizobium* (P) + PSB (L)	9.06	5.69	59.39	12.05
T_5- RDF + *Rhizobium* (L) + PSB (P)	9.24	5.88	61.11	12.14
T_6- RDF + *Rhizobium* (L) + PSB (L)	9.57	6.20	64.54	12.17
T_7- RDF (30:60:30 NPK kg ha^{-1})	7.96	4.60	47.73	11.78
T_8- Control	7.33	3.96	46.07	11.72
SE +	0.43	0.43	3.16	0.11
C.D. at 5%	1.29	1.29	9.47	NS
General Mean	8.63	5.27	54.63	11.95

Data presented (Table 1) revealed that, the pod yield per plant differed significantly due to different treatments. An application of RDF + *Rhizobium* (L) + PSB (L) (T_6) produced maximum pod yield per plant (9.57 g) which was at par with RDF + Rhizobium (P) (T_1), RDF + Rhizobium (L) (T_2), 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. More pod yield due to different treatments may be due to more growth and photosynthesis which resulted in better filling of pod hence more pod yield (g) plant^{-1} was obtained. Similar kind of results was reported by Oad *et al*., (2002) [4]. Lowest pod yield was recorded in control treatment (T_8) and it was significantly inferior to all other treatments. Due to application of different treatments might have also provided more nitrogen resulting in increased number of grains and higher uptake of nutrients by the plant consequently might have increased yield contributing characters. Similar kind of results was reported by Oad *et al*., (2002) [4]. An application of RDF + *Rhizobium* (L) + PSB (L) (T_6) produced maximum seed yield per plant (6.20 g) which was at par with RDF + *Rhizobium* (P) (T_1), RDF + *Rhizobium* (L) (T_2), 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. This might because of the cumulative effect in increasing growth contributing characters which have been clearly exhibited on the final produce i.e. seed and straw yield ha^{-1}. Similar kind of results was reported by Ingle *et al.*, (2001) [1]. Lowest seed yield was recorded when RDF and biofertilizers were not applied and it was significantly inferior over all other treatments. Straw yield kg ha^{-1} as influenced by different treatments was found to be significant. The application of RDF + *Rhizobium* (L) + PSB (L) (T_6) recorded significantly higher mean straw yield (3125 kg ha^{-1}) followed by the application of RDF + *Rhizobium* (L) + PSB (P) (T_5) (3045 kg ha^{-1}). Similar kind of results was reported by Menaria *et al.*, (2003) [2].

Table 2: Seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) of soybean as influenced by various treatments

Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T_1- RDF + *Rhizobium* (P)	2179	2866	5045	43.20
T_2- RDF + *Rhizobium* (L)	2196	2850	5046	43.51
T_3- RDF + *Rhizobium* (P) + PSB (P)	2330	2959	5289	44.06
T_4- RDF + *Rhizobium* (P) + PSB (L)	2419	3045	5464	44.27
T_5- RDF + *Rhizobium* (L) + PSB (P)	2501	3045	5546	45.09
T_6- RDF + *Rhizobium* (L) + PSB (L)	2634	3125	5759	45.73
T_7- RDF (30:60:30 NPK kg ha^{-1})	1954	2658	4612	42.37
T_8- Control	1682	2469	4151	41.59
SE +	126.1	114.9	170.1	-
C.D. at 5%	378.1	344.5	509.9	-
General Mean	2237	2877	5114	44.73

Data (Table 2) revealed that application of RDF + *Rhizobium* (L) + PSB (L) (T_6) to soybean crop resulted in higher seed yield (2634 kg ha^{-1}) and 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) which was significantly superior over rest of the treatments. application of RDF + *Rhizobium* (L) + PSB (L) (T_6) to soybean crop resulted in higher straw yield (3125 kg ha^{-1}) and which was at par with RDF + *Rhizobium* (P) (T_1), RDF + *Rhizobium* (L) (T_2), RDF + *Rhizobium* (P) + PSB (P) (T_3), RDF + *Rhizobium* (P) + PSB (L) (T_4) and RDF + *Rhizobium* (L) + PSB (P) (T_5) and which was significantly superior over rest of the treatments. Lowest number of seeds was recorded in control treatment (T_8) and it was significantly inferior over all other treatments. Numerically higher seed index was recorded with RDF + *Rhizobium* (L) + PSB (L) (12.17g) but statistically it was non-significant. Similar kind of results was reported by Menaria *et al.*, (2003) [2]. The biological yield was significantly higher under the 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). The lowest biological yield was recorded under control treatment (T_8), (4151 kg ha^{-1}). the highest harvest index was observed in treatment RDF + *Rhizobium* (L) + PSB (L) (45.73%) and in control treatment (T_8) recorded the lowest harvest index (41.59%).

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