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Performance of carrier based and liquid bio-inoculants in Soybean (*Glycine max* (L.) Merill)

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Abstract: *A field experiment was conducted at experimental farm, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in Maharashtra during the rainy (kharif) season of 2014-15 to study the comparative performance of carrier based and liquid bio-inoculants in soybean. Results revealed that the application of liquid based Rhizobium + PSB (100+100 ml each 10 kg^{-1} seed) +Recommended Dose of Fertilizers (T_{10}) treatment was found productive and profitable as compared to all other treatments, except the application of Rhizobium + PSB (LB) (50+50 ml each 10 kg^{-1} seed)+T_1 (T_9) and Rhizobium + PSB (CB) (250g each 10kg^{-1} seed) +T_1 (T_4) treatments.*

Key words: *Soybean, Carrier based inoculants (CB), Liquid based inoculants (LB), Yield and Economics .*

INTRODUCTION

Soybean (*Glycine max (L) Merill)* is one of the most important oilseed as well as pulse crop in the world. It is known as the Golden bean of the 21st century. Soybean is one of the most important crop worldwide and soybean seeds are important as protein meal and vegetable oil. It has been established as an industrially vital and economically viable oilseed crop in many areas of India. It is emerging as a leading oilseed crop in India due to its higher yield potential and as a substitute for low yielding crops in *Kharif*.

Soybean being a legume crop builds up the soil fertility by fixing large amounts of atmospheric nitrogen through the root nodules, and also through leaf fall on the ground at maturity. It is grown on area of 12.03 million ha in India with total production of 12.98 million tonnes and average productivity 1079 kg ha^{-1} (Anonymous, 2013).

The most prominent and contributing function of biofertilizer is sustainable reduction in environmental pollution and improvement in agro-ecological soundness. Biofertilizers are affordable to farmers because of low costs and they are very significant in making available nutrients like nitrogen and phosphorus to the crop plants. (Pandy and Pandey, 1995).

Liquid bio-fertilizers that are likely to reduce the consumption of nitrogenous fertilizers by as much as 50 per cent. Also, unlike the earlier method of producing bio-fertilizers carriers like lignite powder, these liquid bio-fertilizers have a longer shelf-life and have lesser chances of contamination. Liquid bio-fertilizers will cut down the costs tremendously. In view of the above consideration, the present investigation conducted.

MATERIALS AND METHODS

The field experiment on soybean (*Glycine max (L) Merill)* was conducted during *kharif* season of 2014-15 at experimental farm, Department of Agronomy, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experiment was laid out in Randomized Block Design consisted of ten treatments replicated in three times. The treatments were as T_1- RDF alone, T_2-*Rhizobium* inoculation (CB) (250g 10kg^{-1} seed) +T_1, T_3- PSB inoculation (CB) (250g 10kg^{-1} seed) +T_1, T_4- *Rhizobium* + PSB (CB) (250g each 10kg^{-1} seed) +T_1, T_5- *Rhizobium* (LB) (50 ml 10 kg^{-1} seed) +T_1, T_6- *Rhizobium* (LB) (100 ml 10 kg^{-1} seed) +T_1, T_7- PSB (LB) (50 ml 10 kg^{-1} seed) +T_1, T_8- PSB (LB) (100 ml 10 kg^{-1} seed) +T_1, T_9- *Rhizobium* +PSB (LB) (50 + 50 ml each 10 kg^{-1} seed) + T_1, T_{10}-*Rhizobium* + PSB (LB) (100 + 100ml each 10 kg^{-1}seed) + T_1.

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Table 1
Seed yield, Straw yield, Biological yield and harvest index of soybean as influenced by various treatments.

Treatment	*Seed yield (kg ha^{1})*	*Straw yield (kg ha^{-1})*	*Biological yield (kg ha^{-1})*	*HarvestIndex (%)*
T_1– RDF alone	1236	2093	3329	37.12
T_2– *Rhizobium* inoculation (CB) (250g 10kg^{-1} seed) + T_1	1343	2150	3493	38.44
T_3–PSB inoculation (CB) (250g 10kg^{-1} seed) + T_1	1318	2121	3439	38.32
T_4–*Rhizobium* + PSB (CB) (250g each 10kg^{-1} seed) + T_1	1533	2283	3816	40.17
T_5–*Rhizobium* (LB) (50 ml 10 kg^{-1} seed) + T_1	1468	2216	3684	39.84
T_6– *Rhizobium* (LB) (100 ml 10 kg^{-1} seed) + T_1	1488	2220	3708	40.12
T_7–PSB (LB) (50 ml 10 kg^{-1} seed) + T_1	1430	2206	3636	39.32
T_8–PSB (LB) (100 ml 10 kg^{-1} seed) + T_1	1442	2213	3655	39.45
T_9–*Rhizobium* + PSB (LB) (50+50 ml each 10 kg^{-1} seed) + T_1	1590	2341	3931	40.44
T_{10}–*Rhizobium* + PSB (LB) (100+100ml each 10 kg^{-1}seed) + T_1	1640	2413	4053	40.46
SE±	49.09	62.38	97.55	–
CD at 5%	145.87	185.35	289.87	–

Seeds were inoculated with carrier based or liquid based inoculants such as *Bradyrhizobium japonicum* and PSB as per treatments by seed treatment before sowing. The recommended dose of chemical fertilizers was applied @ 30:60:30 N, P_2O_5 and K_2O kg ha^{-1} through urea, single super phosphate and muriate of potash. The crop was sown on 14 July 2014 and harvested on17 July 2014.

Recommended plant protection measures were followed for control of pests and diseases. For recording biometric observations five plants were randomly selected from the net plot. The seed and straw yields were recorded from net plot area at physiological maturity of the crop.

RESULTS AND DISCUSSION

Yield Studies

The data on seed, straw and biological yield of soybean was influenced significantly due to various treatments of application of carrier based and liquid bio-inoculants. Application of *Rhizobium* + PSB (LB) (100+100 ml each 10 kg^{-1} seed) + T_1 (T_{10}) produced significantly higher seed yield over rest of the treatments and which was found to be at par with application of *Rhizobium* + PSB (LB) (50 + 50 ml each 10 kg^{-1} seed) + T_1 (T_9) and *Rhizobium* + PSB (CB) (250g each 10kg^{-1} seed) + T_1 (T_4) treatments. Increase in seed yield was due to higher yield attributes recorded with the application of two bacterial inoculants i.e. *Bradyrhizobium japonicum* and PSB (*Bacillus megaterium*) + RDF as compared to rest of treatments. Similar finding reported by Tran Thi Ngoc Son *et al*. (2007) and Singaravel *et al.* (2008).

Significantly more straw yield was recorded by application of *Rhizobium* + PSB (LB) (100 + 100 ml each 10 kg^{-1} seed) + T_1 (T_{10}) and which was at par with *Rhizobium* + PSB (LB) (50 + 50 ml each 10 kg^{-1} seed) + T_1 (T_9) and *Rhizobium* + PSB (CB) (250g each 10kg^{-1} seed) + T_1 (T_4) treatments. This might be due to better growth contributing characters recorded with application of two bacterial inoculants i.e. *Bradyrhizobium japonicum* and PSB (*Bacillus megaterium*) + RDF as compared to rest of treatments. The results are in line with those reported by Pratibha Sahai and Ramesh Chandra (2011) and Gupta (2005). Similar trend was found in case of biological yield also.

ECONOMICS

The gross and net monetary returns were significantly influenced due to various treatments. Application of *Rhizobium* + PSB (LB) (100 + 100 ml each 10 kg^{-1} seed) + T_1 (T_{10}) produced the maximum gross monetary returns which was significantly more than rest of the treatments except with the application of *Rhizobium* + PSB (LB) (50 + 50 ml each 10 kg^{-1} seed) + T_1 (T_9) and application of *Rhizobium* + PSB (CB) (250g each 10kg^{-1} seed) + T_1 (T_4). This might be due to higher seed yield and straw yield recorded with these treatments.. Similar finding were reported by Patil *et al*. (2009) and Mohite *et al*. (2011).

Net monetary returns was observed maximum with the application of *Rhizobium* + PSB (LB) (100+100 ml each 10 kg^{-1} seed) + T_1 (T_{10}), but it was at par with the application of *Rhizobium* + PSB (LB) (50 + 50 ml each 10 kg^{-1} seed) + T_1 (T_9) and *Rhizobium* + PSB (CB) (250g each 10kg^{-1} seed) + T_1 (T_4). It was mainly influenced by yield levels and cost of cultivation. The results were in confirmation with Dhage *et al*. (2008) and Tomar *et al*. (2011). Similar kind of results were recorded in case of B:C ratio also.

Table 2
Economics of soybean as influenced by various treatments.

Treatment	*Gross monetary returns (Rs ha^{-1})*	*Cost of cultivation (Rs ha^{-1})*	*Net monetary returns (Rs ha^{-1})*	*B:C ratio*
T_1 – RDF alone	32705	22883	9822	1.42
T_2 –*Rhizobium* inoculation (CB) (250g 10kg^{-1} seed) + T_1	35464	22995	12469	1.54
T_3 –PSB inoculation (CB) (250g 10kg^{-1} seed) + T_1	34810	22995	11815	1.51
T_4 –*Rhizobium* + PSB (CB) (250g each 10kg^{-1} seed) + T_1	40386	23108	17278	1.74
T_5 –*Rhizobium* (LB) (50 ml 10 kg^{-1} seed) + T_1	38555	23023	15532	1.67
T_6 –*Rhizobium* (LB) (100 ml 10 kg^{-1} seed) + T_1	39211	23164	16047	1.69
T_7 –PSB (LB) (50 ml 10 kg^{-1} seed) + T_1	37711	23023	14668	1.63
T_8 –PSB (LB) (100 ml 10 kg^{-1} seed) + T_1	38202	23164	15038	1.64
T_9 –*Rhizobium* + PSB (LB) (50+50 ml each 10 kg^{-1} seed) + T_1	41874	23164	18710	1.80
T_{10} –*Rhizobium* + PSB (LB) (100+100ml each 10 kg^{-1}seed) + T_1	43190	23445	19745	1.84
SE ±	1320	–	1221	–
CD at 5%	3924	–	3628	–
G. Mean	38211	–	15114	1.64

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