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Productivity of soybean (*Glycine max* L. Merril) as influenced by combined use of enriched compost and biofertilizers

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Abstract
The field investigation was carried out at Agronomy Instructional farm, Rajasthan College of Agriculture, MPUAT, Udaipur, to the evaluate influence of combined use of enriched compost and biofertilizers soybean nutrition grown under typic *Haplustepts* clay loam soil. The field comprised of 10 treatments replicated in randomized block design. The results obtained from field investigation indicated a significant improvement in various growth attributes *viz;* chlorophyll content, total number of root nodules, and effective root nodules and yield and yield attributes *viz;* number of pods plant^{-1}, number of seeds pod^{-1}, seed yield, straw yield, biological yield. The data indicates that application of enriched compost (5 t) ha^{-1} along with *Rhizobium* + PSB recorded significant higher seed yield (1652.03 kg ha^{-1}), haulm yield (2344.28 kg ha^{-1}), and biological yield (3696.30). However, enriched compost (5 t) ha^{-1} +*Rhizobium* + PSB was found statistically at par with enriched compost (4 t) ha^{-1}*Rhizobium* + PSB, enriched compost (5 t) ha^{-1}+*Rhizobium*, enriched compost (5 t) ha^{-1} + PSB. In case net return treatment enriched compost (5 t) ha^{-1} + *Rhizobium* + PSB gave highest net return (41805.9) while the highest B: C (1.83) was obtained by the application of enriched compost (4 t) ha^{-1}*Rhizobium* + PSB.

Keywords: Soybean, *Glycine max* L. Merril, influenced, combined, enriched compost, biofertilizers

Introduction
Soybean (*Glycine max* (L.) Merrill) is the 3rd most important oilseed crop after groundnut and rapeseed-mustard and it is also known as the GOLDEN BEAN of the 20th century and is native to East Asia, where it appears to have been cultivated from a wild species knows as '*Glycine soja'*, starting about 5000 year ago. It contains about 20% Oil and protein 40% with 6-7% total mineral, 5-6% crude fiber, 5% ash and 17-19%. Carbohydrates. Soybean protein contains a good amount of isoflavones which helps in preventing the heart disease. It may be a good substitute such as 'soya milk'. Soybean is highly versatile bean that can be processed in to oil, flour and milk.

Efficient management of organic and inorganic sources is a pre-requisite. For achieving continuous production of crops in an economically and ecologically sustainable manner. Organic matter forms a very important source of plant nutrients whereas organic manures are used to supply both macro and micro nutrients and sustain amount of humic substances particularly humic and fulvic acid that helps to maintain soil pH. Thus, for maintenance of the soil fertility, productivity and soil health with the FYM, enriched compost and biofertilizers cannot replace chemical fertilizers but certainly are capable of reducing their input. Seed inoculation with effective. Rhizobium inoculant is recommended to ensure additional nodulation and N2 fixation for maximum growth and yield of pulse crop.

Materials and Methods
The experiment was conducted at Instructional Farm, Agronomy, Rajasthan College of Agriculture, Udaipur (Rajasthan) in *kharif* 2018on sandy clay loam soil which is slightly alkaline in nature comprised of 10 treatments, only RDF, Enriched compost (3 t) ha^{-1}+ *Rhizobium*, Enriched compost (3 t) ha^{-1} + PSB, Enriched compost (3 t) ha^{-1} + *Rhizobium* + PSB, Enriched compost (4 t) ha^{-1}+ *Rhizobium*, Enriched compost (4 t) ha^{-1} + PSB, Enriched compost (4 t) ha^{-1} + *Rhizobium* + PSB, Enriched compost (5 t) ha^{-1}+ *Rhizobium*, Enriched Compost (5 t) ha^{-1} + PSB and Enriched compost (t) ha^{-1} + *Rhizobium* + PSB.

These treatments were evaluated under randomized block design (RBD) with three replications. Soybean cultivar (JS - 9560) was taken as test crop. The enriched compost was prepared as method followed by Biswas and Narayanasamy. The enriched compost contains N (0.75 %), P_2O_5 (2.03 %) and K_2O (0.67 %).

Results and Discussion

Growth and growth attributes

According to data given in Table 1 there was a significant increase in various growth attributes *viz;* chlorophyll content, total number of root nodules, and effective root nodules and with the application of different doses of enriched compost and bio-fertilizer inoculation as compared to control.

The optimum results were obtained with application of enriched compost (5 t) ha^{-1} +*Rhizobium* + PSB (T_{10}) which is found at par with treatment T_7, T_8 and T_9 indicating soybean respond well on application of enriched compost along with bio-inoculants which could be understood by an increase in chlorophyll content, total root nodule and effective number of nodules. Inoculation of soybean seed with nitrogen fixing bacteria enhances the nitrogen content in plant. There is positive relationship between chlorophyll content and nitrogen content in plant leaf (Fritschi and Ray, 2007; Kumawat *et al.*, 2000; Hoque *et al*., 1999) [4]. Chlorophyll and carotenoids content in soybean seed were positively influenced by organic manures (Lakshmisha *et al.*, 2012) [6] the increase in nodulation might be due to synergistic effect of the two types of microorganisms for biological nitrogen fixation as against their individual application. Results of the similar kind have also been reported by (Rudresh *et al.*, 2005) [12]. Phosphorous deficiency has been shown to affect symbiosis by decreasing the supply of photo synthates to the nodule, which reduces the rate of bacterial growth and the total population of legume nodulating microorganisms (Moreira *et al*., 2010) [8]. It is also due to the fact that phosphate solubilizing bacteria by virtue of their property of producing organic acids solubilize insoluble or fixed form of phosphorus in the rhizosphere and makes it available to the growing plants, which promotes root development in plants and these findings are in agreement with the findings of Tagore*et al*., 2013.It might be due to the positive effect of PSM inoculation on the nodules, which increases the supply of N to the crop plants and ultimately grow thand yield of the legumes (Ditta *et al.,* 2018) [2].

Inoculation of seed with *Rhizobium* might have resulted in greater fixation of atmosphere nitrogen in soil for use by the plants and consequently resulting in to higher plant growth, which in term resulted in to higher production of assimilates and their partitioning to different reproductive structures such as the result of increased plant growth in terms of total and effective root nodules due to overall better nutritional environments in the rhizosphere. Regar *et al.,* 2018; Chattopadhyay and Dutta, 2003; Vikram and Hamzeh zarghani, 2008) [18]. It might also be due the organic material served as a better source of carbon and nutrients for the microbes (indigenous and inoculated) as well as for the crop plants, and source of continuous supply of essential nutrients to the crop plants, and ultimately led to improve the growth and yield (Verma *et al.,* 2013) [17].

The increase in nodulation with manure may be linked to its impacts on availability of other nutrients, on moisture supply or on better soil structure creating a more favourable environment for nodulation (Rurangwa *et al*., 2018) [13].

Yield and yield attributes

The results revealed that fertilization of soybean crop with enriched compost and biofertilizers most effectively enhanced various yield & yield parameters *viz.* number of pods per plant, number of seeds pod^{-1}, seed yield, straw yield and biological yield (Table 2).The best result on seed yield (1652.03 kg ha^{-1}) was obtained with application of enriched compost (5 t) ha^{-1} + *Rhizobium* + PSB (T_7).This indicate that soybean responds well to integrated application of enriched compost and biofertilizer which greater yield response of soybean in this region is might due to greater phosphorus availability in which this region in medium in availability as aforesaid. It might also be due to PSB might have solubilized phosphorus from RP by excreting organic acids, *i.e.* citric and gluconic acids and chelating materials in the immediate vicinity of rhizosphere. The greater P availability is through involvement of phosphorus solubilizing microorganism from rock phosphate is also reported in of soybean (Lan *et al*., 2016; Trabelsi *et al*., 2017; Muda *et al.,* 2013).These results in agreement with result recorded with the graded enhancement of phosphorus application recorded significant increase in growth and yield parameters (Rana *et al.*, 2013) [9-10]. Application of organic source of nutrition coupled with biofertilizers increased biomass production of the black gram crop. This may also be attributed to organic manure and biofertilizer on microbial and root proliferation on soil which caused solubilizing effect on native phosphorus and other nutrients (Shekhawat *et al.,* 2017). A positive correlation exists between the number of nodules and soybean grain yield of soybean (Suryantini, 2014) [14]. Seed inoculation with *Rhizobium* enhance release of the native P from the soil and concentration of phosphorus increased in soil solution which helped in early root growth and nodules which associated with higher yield of soybean. (Regar *et al*., 2018) [11].

Table 1: Effect of enriched compost and bio-fertilizers on growth attributes of soybean.

Treatments	Chlorophyll content (mg g^{-1}) at 45 DAS	LAI at 45 DAS	Root nodules at 45 DAS	
			Total	Effective
Control	2.71	2.40	20.44	15.27
Enriched compost (3 t) + *Rhizobium*	2.98	2.46	23.59	18.48
Enriched compost (3 t) + PSB	2.94	2.51	23.85	18.20
Enriched compost (3 t) + *Rhizobium* +PSB	3.17	2.53	26.89	20.90
Enriched compost (4 t) + *Rhizobium*	3.36	2.58	30.86	23.00
Enriched compost (4 t) + PSB	3.36	2.58	30.92	22.79
Enriched compost (4 t) + *Rhizobium* +PSB	3.57	2.72	35.01	25.34
Enriched compost (5 t) + *Rhizobium*	3.67	2.69	35.60	26.25
Enriched compost (5 t) + PSB	3.66	2.65	36.87	25.99
Enriched compost (5 t) + *Rhizobium* + PSB	3.70	2.73	37.65	26.56
SE m ±	0.06	0.07	0.95	0.68
CD (P=0.05)	0.18	NS	2.81	2.01

Table 2: Effect of enriched compost and bio-fertilizers on yield attributes of soybean

Treatments	No. of pods per plant	No. of seeds per pod	Test weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Control	11.74	1.86	103.63	879.54	1456.78	2336.33	37.12
Enriched compost (3 t) + *Rhizobium*	14.00	2.14	105.47	1019.41	1706.53	2725.94	37.34
Enriched compost (3 t) + PSB	14.18	2.16	105.49	1031.00	1692.04	2723.03	37.98
Enriched compost (3 t) + *Rhizobium* +PSB	17.23	2.43	107.03	1229.47	1897.53	3127.00	39.09
Enriched compost (4 t) + *Rhizobium*	20.21	2.75	107.01	1360.29	2103.01	3463.30	39.36
Enriched compost (4 t) + PSB	20.39	2.77	107.13	1373.31	2086.93	3460.24	39.77
Enriched compost (4 t) + *Rhizobium* +PSB	22.93	3.16	107.55	1569.49	2296.77	3866.26	40.65
Enriched compost (5 t) + *Rhizobium*	24.54	3.21	108.05	1604.54	2337.19	3941.73	40.77
Enriched compost (5 t) + PSB	24.74	3.24	108.12	1619.13	2326.41	3945.53	41.11
Enriched compost (5 t) + *Rhizobium* + PSB	25.02	3.39	109.26	1652.03	2344.28	3996.30	41.34
SE m ±	0.74	0.09	0.84	41.14	60.64	82.05	1.03
CD (P=0.05)	2.21	0.26	NS	122.24	180.18	243.79	3.05

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