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PERFORMANCE OF SOYBEAN (*GLYCINE MAX* L.) UNDER ORGANIC PRODUCTION SYSTEM

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ABSTRACT
A field experiment was conducted during *kharif* seasons of 2013, 2014, 2015 and 2016 at Zonal Agricultural Research Station, V. C. Farm, Mandya to evaluate the performance of soybean (*Glycine max* L.) under organic production system. The experiment consists of eleven treatments replicated thrice in RCBD design. Among the various treatments, application of 100% N equivalent compost + recommended FYM (10 t/ha) + beejamrutha (seed treatment) + jeevamrutha (500 liter/ha) recorded significantly higher seed yield during all the years of experimentation (1174, 1173, 1258 and 1325 kg/ha, respectively) and also in their pooled data (1233 kg/ha). This increased yield was attributed to more availability of nitrogen (289.3 kg/ha), phosphorus (35.85 kg/ha) and potassium (185.6 kg/ha) in the soil compared to other treatments. Soil chemical properties, *viz*. soil pH, organic carbon content and electric conductivity, were not influenced by application of the organic manures. However, there was an improvement in the soil chemical properties compared to initial soil data.

INTRODUCTION

Soybean (*Glycine max* L.) popular as golden bean has become the miracle crop of 21st century. It serves the dual purpose for being grown both as an oilseed crop and pulse crop as well (Thakare *et al.,* 2006). In India, it is cultivated in 9.60 million ha with the annual production of 12.74 million tonnes. Madhya Pradesh contributes nearly 5.56 mha area with the production of 6.68 mt (Anonymous, 2012). Conventional agriculture has made an adverse impact on soil and plant health. So, as to prevent soil deterioration due to use of conventional agricultural practices and to meet demand of increased food production it has become necessary to make use of organic manures. Utilizing cheap and local inputs with zero utilization of chemicals in any form like fertilizer, herbicide, pesticide has become the simple principle of organic farming. The many benefits associated with organic farming practices have renewed interest in adoption of the same among farming community and this has started gaining momentum in all crops (Reshma *et al*., 2018).

Apart from using conventional farm based products, there is an increasing demand for organic liquid formulations like jeevamrutha and beejamrutha which help in quick build up of soil fertility through enhanced activity of soil microflora and fauna. Role of foliar application of jeevamrutha in production of many plantation crops had been well documented in India (Selvaraj, 2003). Despite many advantages with organic liquid formulations they have not been exploited extensively in crop production and more so in cowpea crop. Keeping these facts in view, field study was planned with an objective to study the growth and yield of soybean as influenced by organic manures along with jeevamrutha and beejamrutha. Organic farming gives major emphasis on recovery and maintenance of soil fertility and for sustainable yield. Organic farming helps to improve the physical, chemical and biological properties of soil and maintains the ecological balance as well as productivity of life supporting systems for the future generations. Organic manures in agriculture add much needed organic and mineral matter. Organic systems rely on management of organic matter to enhance the soil fertility and productivity (Naik *et al*., 2014).

Soybean being a high protein and energy crop and its productivity is often limited by the low availability of essential nutrients or imbalanced nutrition forming one of the important constraints to soybean productivity in India. So, a balanced nutrients application is must to harness the productivity of the crops. Hence the investigation carried out with an objective to study the Performance of Soybean under organic production system.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* season of 2013, 2014, 2015 and 2016 at Zonal Agricultural Research Station, V. C. Farm, Mandya (12º34.3′ N latitude, 76º49.8′E longitude and at an elevation of 697 m above mean sea level). The soil of experimental site was red sandy loam in texture having a pH of 7.80 and maximum sand content (76.0%) with bulk density of 1.36 g/cc. The initial soil analysis indicated that it was low in organic carbon (0.32%), available nitrogen (alkaline $KMNO_4$ oxidizable-N as per Subbaiah and Asija,

(1956) (225kg/ha), medium in phosphorus (0.5 M $NaHCO_3$ extractable P as per Olsen *et al*. (1954) (18.2 kg/ha) and potassium (Neutral ammonium acetate extractable K as per Toth and Prince (1949) (133 kg/ha). The experiment consisted of 11 treatments *viz.*, T_1: 75% N equivalent compost, T_2: 100% N equivalent compost, T_3: 125% N equivalent compost, T_4: 100 % N equivalent compost + FYM @ 10 t/ha, T_5: 75% N equivalent compost + beejamrutha, T_6: 100 % N equivalent compost +beejamrutha, T_7: 125 % N equivalent compost + beejamrutha, T_8: 75 % N equivalent compost + beejamrutha + jeevamrutha @ 500 liter/ha, T_9: 100 % N equivalent compost + beejamrutha + jeevamrutha @ 500 liter/ha, T_{10}: 125 % N equivalent compost + beejamrutha + jeevamrutha @ 500 liter/ha and T_{11}: 100 % N equivalent compost + FYM @ 10 t/ha + beejamrutha + jeevamrutha @ 500 liter/ha were tested in three replication and RCBD design. The recommended dose of nutrients is 30:80:37.5kg NPK/ha.

The Soybean variety 'JS 335' was sown with a spacing of 45 cm x 10 cm using a seed rate of 62.5 kg/ha. The seeds were soaked with beejamrutha over night and then dried under shade before sowing. The manures were supplied in the form of compost (prepared by using cattle shed waste) and vermicompost (prepared by using cattle shed waste and crop residues). The liquid organic formulations beejamrutha and jeevamrutha were prepared by following procedures given by Palekar (2006). Beejamrutha was prepared by soaking 5 Kg of local cow dung in 20 litres of water and 50 g of lime in one litre water overnight. Next day morning squeeze cow dung into the lime soaked water and 10 liters of local cow urine was added to this by stirring thoroughly and adding lime solution and mix well. Jeevamrutha was prepared by mixing 10 kg of cow dung, 10 litre of cow urine, 2 kg of local jaggery, 2 kg of flour and hand full of soil collected from farm. All these were put in 200 litre capacity plastic drum and mixed thoroughly and volume was made up to 200 litre. The mixture was stirred well in clock wise direction and kept in shade covered with wet jute bag. The solution was regularly stirred clockwise in the morning, afternoon and in the evening continuously for 10 days and it was used for soil application. Jeevamrutha was applied when the soil was wet near the root zone of the crop as per the treatments. The nutrient content of FYM was 0.5%N, 0.2%P and 0.5%K, compost was 0.58%N, 0.32%P and 0.52%K and vermicompost was 1.13%N, 0.678%P and 1.13%K. The recommended dose of the FYM and compost were applied as basal dose 20 days before sowing. After 30 days after sowing, vermicompost was applied as top dress @ 1250 kg/ha and Jeevamrutha was sprayed after 30 days after sowing @ 500 lt/ha. Standard package of practices were adopted. Growth, yield parameters and yield were measured and estimated using standard procedures.

The data collected from the experiment at different growth stages were subjected to statistical analysis as suggested by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was P= 0.05. Critical difference values were calculated wherever 'F' test was significant.

RESULTS AND DISCUSSION

Effect on growth parameters

The higher plant height and number of branches per plant

Table 1: Influence of organic manures on growth and yield parameter of soybean.

Treatments	Plant height (cm)				No. of Branches				No. of pods per plant			
	2013	2014	2015	2016	Pooled	2013	2014	2015	2016	Pooled	2013	2014	2015	2016	Pooled
T_1	24.1	26.5	26.9	28.4	26.5	6.6	6.7	6.8	6.7	6.7	17.3	20.3	20.9	23.5	20.5
T_2	25.3	24.6	25.5	26.3	25.4	7.1	7.4	7.5	8.5	7.6	18.6	17.6	18.6	20.9	18.9
T_3	25.1	24.9	26.3	29.5	26.5	6.9	7	7.2	8.3	7.4	17.9	18.3	20.3	24.6	20.3
T_4	32.1	28.7	32.1	35.6	32.1	8.1	7.5	7.8	8.9	8.1	22.3	21.7	23.6	25.2	23.2
T_5	26.8	25.2	26.6	29.3	27	7.2	6.9	7.1	7.5	7.2	20	21.7	24	26.8	23.1
T_6	28.5	27.6	30.2	34.2	30.1	7.8	7.8	8	9.2	8.2	21	20.1	23.7	25.7	22.6
T_7	27.3	25.7	28.7	30.9	28.1	7.8	7.7	8	9.7	8.3	20.6	21.4	22.9	26.3	22.8
T_8	29.4	26.7	27	29.6	28.2	7.9	7.4	7.8	8.6	7.9	21.8	21.1	22.4	25.6	22.7
T_9	30.6	26.9	27.8	30.7	29	8	7.9	8.1	9.8	8.5	21.6	21.7	23.7	27.8	23.7
T_{10}	33.4	29.6	32.6	35.6	32.8	8.2	7.8	8.2	10.2	8.6	23.2	22.5	24.5	28.4	24.7
T_{11}	34.2	32.2	34.6	37.4	34.6	8.8	8	8.9	11.2	9.2	24	22.9	23.7	29.1	24.9
S.Em.±	0.5	1	0.85	0.78	0.8	0.2	0.2	0.23	0.25	0.2	0.5	0.6	0.6	0.67	0.6
CD @ 5%	1.4	2.9	2.48	2.31	2.3	0.5	0.6	0.64	0.75	0.6	1.4	1.8	1.8	2	1.8

Table 2: Influence of organic manures on yield and economics of soybean.

Treatments	Seed yield(kg/ha)					Haulm Yield (kg/ha)				Pooled data of 4 years			
	2013	2014	2015	2016	Pooled	2013	2014	2015	2016	Pooled	COC (x 10^3 Rs./ha)	Net Returns (x 10^3 Rs./ha)	B:C ratio
T_1	620	639	640	720.5	655	840	946	1012	1236	1009	25.1	3.6	1.14
T_2	652	657	662	700.5	668	930	753	852.3	896.3	858	26.6	2.6	1.1
T_3	632	821	837	896	797	881	996	1105	1358	1085	28.1	6.8	1.24
T_4	1015	933	1089	1124	1040	1385	1325	1465	1718	1473	35.6	9.9	1.28
T_5	680	622	678	785	691	1010	802	915	1002	932	25.6	4.6	1.18
T_6	810	681	724	796	753	1238	822	925	1120	1026	27.1	5.8	1.22
T_7	780	696	732	758	742	1129	1100	1354	1785	1342	28.6	3.9	1.14
T_8	861	696	740	801	775	1374	1016	1254	1695	1335	26.6	7.3	1.27
T_9	1021	1098	1156	1018	1073	1547	1352	1520	1741	1540	28.1	18.8	1.67
T_{10}	1165	941	1195	1235	1134	1590	1409	1569	1945	1628	29.6	20	1.68
T_{11}	1174	1173	1258	1325	1233	1623	1519	1658	1995	1699	37.1	16.8	1.45
S.Em. ±	14	17	16.8	23.5	17.8	22	26	25.8	32.5	26.6	-	-	-
CD @ 5%	41	49	50.52	70.1	52.7	64	77	77.8	96.8	78.9	-	-	-

(34.6 cm and 9.2, respectively in their pooled data) was recorded under application of 100% N equivalent compost + recommended FYM + Beejamrutha + Jeevamrutha as compared to other organic treatments (Table 1). This was closely followed by 125% N equivalent compost + Beejamrutha + Jeevamrutha (32.8 cm and 8.6, respectively in their pooled data) and 100% N equivalent compost + Beejamrutha + Jeevamrutha (29.0 cm and 8.5, respectively in their pooled data). This increase in plant height and number of branches per plant may be due to higher dry matter production and its distribution to vegetative part and these higher growth parameters was mainly attributed to higher N availability throughout the crop growth period because of slow decomposition of organic matter and higher rhizobium nodules in the root. The similar increase in soybean growth parameters due to application of organics was reported by Jaybhay *et al.* (2015). Increase in growth attributes due to jeevamrutha application might be attributed to solubilisation of nutrients in soil and absorption of nutrients and moisture in the same line as reported by Yogananda *et al.* (2015), Jidhu Vaishnavi and Jayakumar (2016) and Siddappa *et al.* (2016).

Effect on yield and yield parameters

The application of different source of organic had non-significant influence on yield attributing parameters *viz.*, number of seeds/plant and 1000 seed weight (Table 2). However, the number of pods/plant was influenced significantly. Application of 100% N equivalent compost + recommended FYM + Beejamrutha + Jeevamrutha recorded significantly higher number of pods/plant (24.9 in their pooled data) compared to other treatments. This was closely followed by 125% N equivalent compost + Beejamrutha + Jeevamrutha (24.7 in their pooled data) and 100% N equivalent compost + Beejamrutha + Jeevamrutha (23.7 in their pooled data). This increased pod numbers was mainly attributed to diversion of more photosynthates to reproductive parts. Similar increase in soybean yield parameters due to application of FYM and Vermicompost was also reported by Moghadam (2014). The results of the experiment indicated that, the seed and haulm yield of soybean varied significantly among different levels and sources of organic manures (Table 2). The seed yield and haulm yield were significantly higher with application of 100% N equivalent compost + recommended FYM + Beejamrutha + Jeevamrutha (1233 and 1699 kg/ha, respectively in their pooled data) compared to other source of organics. This was followed by 125% N equivalent compost + Beejamrutha + Jeevamrutha (1134 and 1628 kg/ha, respectively in their pooled data) and 100% N equivalent compost + Beejamrutha + Jeevamrutha (1073 and 1540 kg/ha, respectively in their pooled data). This was mainly due to the fact that apart from source of nutrient, application of organic manures improved the soil physico-chemical properties of soil that resulted in better root system with increased absorption of moisture and nutrient from the deeper layers which in turn enhanced the growth and yield attributing parameters of soybean and finally grain and halum yield. These results are in line with the earlier findings of Reshmi *et al.* 2018, Palekar (2006) and Arun Kumar *et al.* (2014). This might be result of reduced supply of nutrients at the later stages of crop growth which in legumes, usually result in pod shedding before maturity due to lesser supply of photosynthetes towards the pod because of drying and

Table 3: Influence of organic manures on soil chemical properties after the harvest of fourth crop.

Treatment	pH	EC (dSm^{-1})	OC (%)	Soil available nutrients (kg/ha)			Nutrient uptake (kg/ha)		
				N	P_2O_5	K_2O	N	P	K
T_1	7.62	0.328	0.412	240.2	22.36	142.6	100.7	17.6	62.8
T_2	7.3	0.35	0.421	245.6	25.95	162.3	112.3	18.4	65.9
T_3	7.24	0.35	0.423	252.3	33.85	158.7	122.7	20.1	71.8
T_4	6.79	0.345	0.426	290.6	32.56	160.9	106.8	18.4	78.5
T_5	7.8	0.329	0.42	253.6	23.58	142.3	116.8	20.56	71.7
T_6	7.42	0.343	0.429	262.3	27.85	160.2	124.4	21.04	78.4
T_7	7.18	0.355	0.428	284.5	35.69	165.3	116.9	22.23	81.7
T_8	7.1	0.33	0.43	256.9	28.45	142.5	132.5	22.43	85.7
T_9	7.13	0.35	0.435	255.6	26.98	168.9	136.7	24.5	90.4
T_{10}	7.02	0.36	0.462	285.6	33.56	170.5	142.4	25.9	93.9
T_{11}	6.78	0.37	0.383	289.3	35.85	185.6	143.4	26.3	97.4
S.Em. ±	0.31	0.018	0.06	11.12	0.52	3.45	4.48	0.89	5.02
CD (P=0.05)	NS	NS	NS	33.56	1.52	10.31	13.45	2.66	15.05

Initial values: pH: 7.80 EC: 0.305 dSm^{-1} OC: 0.32% N: 225 kg/ha, P_2O_5: 18.2 kg/ha K_2O: 133 kg/ha

T_1 – 75% N equivalent compost, **T_2** - 100% N equivalent compost, **T_3** – 125% N equivalent compost, **T_4** – 100 % N equivalent compost + Recommended FYM, **T_5** - 75% N equivalent compost + Beejamrutha, **T_6** – 100 % N equivalent compost + Beejamrutha, **T_7** - 125 % N equivalent compost + Beejamrutha, **T_8** - 75 % N equivalent compost + Beejamrutha + Jeevamrutha, **T_9** - 100 % N equivalent compost + Beejamrutha + Jeevamrutha, **T_{10}** - 125 % N equivalent compost + Beejamrutha + Jeevamrutha and **T_{11}** - 100 % N equivalent compost + Recommended FYM + Beejamrutha + Jeevamrutha

senescence of leaves. Similar, results were obtained in greengram by Rajkhowa *et al*. (2000) who have recorded higher number of seeds per pod, with combined application of FYM and RDF.

Effect on economics

The application of 125% N equivalent compost + beejamrutha + jeevamrutha @ 500 liter/ha found superior in obtaining higher net returns (20,000 Rs./ha) and B:C ratio (1.68) as compared to other treatments (Table 2). It was followed by application of 100% N equivalent compost + beejamrutha + jeevamrutha @ 500 liter/ha (Rs. 18,800 and 1.67, respectively). This increased net return and B:C ratio was mainly due to reduced cost of cultivation and increased grain yield. While, the highest cost of production was recorded in application of 100% N equivalent compost + FYM @ 10 t/ha + beejamrutha + jeevamrutha @ 500 liter/ha (Rs. 37,100). Hence, even though this treatment recorded highest seed yield but economically not viable. These results are in line with McBride and Catherine Greene (2009). The application of jeevmrutha, increased the activity of microbes there by solubalisation and uptake of nutrients were enhanced. This synchronized the growth of soybean and sustained the productivity.

Effect on soil physico-chemical properties

The analysis of soil physico-chemical properties *viz.*, pH, EC and %OC were not influenced significantly at the end of the fourth crop cycle (Table 3). However, these parameters were enhanced greatly as compared to initial soil test values. In the present investigation, there was a significant difference among the different sources of nutrient with respect to soil available nutrients. Application of 100% N equivalent compost + FYM 10 t/ha + Beejamrutha + Jeevamrutha registered significantly higher amount of soil available nutrients (289.3, 35.85 and 185.6 kg N, P_2O_5 and K_2O/ha, respectively) and in 125% N equivalent compost + Beejamrutha + Jeevamrutha (285.6, 33.56 and 170.5 kg N, P_2O_5 and K_2O/ha, respectively). This was due to build up of more amount of organic carbon in the soil and which in turn enhanced the nutrient supplying capacity of the soil due to build up of more and more soil micro-organisms. Organic manures were indirectly improving the physical, chemical and biological properties of soils reported by Palaniappan, and Siddeswaran, (1994) and Neha chaudhary *et al*. (2016).

The uptake of major nutrients were significantly higher in application of 100 % N equivalent compost + FYM @ 10 t/ha + beejamrutha + jeevamrutha @ 500 liter/ha (143.4, 26.3 and 97.4 kg NPK/ha) as compared to other treatments. However, it was on par with 125 % N equivalent compost + beejamrutha + jeevamrutha @ 500 liter/ha (142.4, 25.9 and 92.9 kg NPK/ha) and 100 % N equivalent compost + beejamrutha + jeevamrutha @ 500 liter/ha (136.7, 24.5 and 90.4 kg NPK/ha). These results are in line with earlier findings of Kiran *et al*. (2015), Arun Kumar *et al*. (2014) and Neha chaudhary *et al*. (2016).

Combined application of 100% N equivalent compost + beejamrutha + jeevamrutha @ 500 liter/ha resulted in better growth attributes and contributed for improved fertility status of soil. It has resulted in 47 percent increased grain yield.

As compared to application of 75% N equivalent compost. Hence, these liquid formulations are efficient organic substitutes and they can be applied along with organic manures in an integrated approach for obtaining higher crop yield besides improving the nutrient status of the soil.

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