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Impact of organic nutrients on soil health and enzyme activity in soybean (*Glycine max*) on typic Heplustepts soils in Rajasthan

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ABSTRACT

A field experiment entitled, impact of organic nutrients on soil health and enzyme activity in soybean (*Glycine max* L.) on typic Heplustepts soils in Rajasthan was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during consecutive *kharif* season of the year 2016 and 2017. The experiment was evaluated in randomized block design (RBD) with three replications. Organic manures (FYM, compost, green leaf manure and vermicompost) were incorporated in treated plots before 15 days of sowing. Variety JS-9560 of soybean was sown as per recommended package of practices. Results showed that organic carbon, available N, P, K and micronutrients, viz. Fe, Zn, Cu and Mn in soil were found maximum at harvest stage of soybean with the application of 100% vermicompost treatment. Enzyme activity dehydrogenase and phosphate activity in soil were significantly influenced through organic nutrient fertilization of 100% vermicompost treatment. Maximum net return of ₹ 60785.07 with benefit cost ratio of 2.9 was obtained with the application of 100% RDF, followed by 100% vermicompost.

Key words: Enzyme, Fertilization, Micronutrients, Net return, Organic manures, Vermicompost

In the concern of increasing food production to meet the needs of ever-increasing population of the country, green revolution was launched in the mid-sixties and that became a land mark in transformation of agriculture in India. It was estimated that consumption of chemical fertilizers increased by seven folds and pesticides by 375 times while the food production just doubled during the first 20 years of the launch of green revolution in India (Ramanathan 2006). Though excessive use of agro-chemicals for the last 50 years helped in achieving commendable progress in production, danger signals now have started coming sooner than expected. 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 (Yadav *et al.* 2016). The proper management of organic matter makes it possible to increase the efficiency of use of soil and added nutrients (Das and Singh 2014). Commonly known food legumes, secondary to cereals in production and consumption in India, are the most valuable and natural source of vitamin, proteins, minerals and calories (Umadevi and Ganesan 2007). Those legumes play an important role in Indian agriculture as they restore soil fertility by fixing atmospheric nitrogen through their nodules (Naik *et al.* 2014). Globally, soybean (*Glycine max* L.) is a number one oilseed and grain legume crop, becoming popular oil seed and pulse crop in India and occupy first place among the oil seeds (Economic Survey 2015-16). Soybean seed contains 20 % oil and 39-41 % protein (Patil *et al.* 2012). Keeping the above an experiment was carried to evaluate impact of Organic Nutrients on Soil Health and Enzyme activity in Soybean on typic Heplustepts Soils in Rajasthan during *kharif,* 2016 and 2017 at Instructional Farm, Rajasthan College of Agriculture, Udaipur.

MATERIALS AND METHODS

Treatments and agronomic practices

A field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during consecutive *kharif* season of the year 2016 and 2017. The soil of the experimental site was clay loam in texture (*Typic Haplustepts*) with 38.47, 26.46 and 34.54 % of sand, silt and clay respectively. Initially, the soil (0–15 cm depth) was with medium in organic carbon (0.56 to 0.62 %), low in available N (253 to 255 kg/ha), medium in available P (12.0 to 13.67 kg/ha) and high in available K (450 to 451 kg/ha). The soil have *p*H 8.25 to 8.21 and EC (0.82 to 0.81dS/m) and having DTPA extractable micronutrients in optimum range (Zn, Fe, Mn and Cu: 2.13 to 2.16, 2.42 to

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Table 1 Details of treatments with their symbols

Treatment	Treatment details
T_1	Control
T_2	100% RDF
T_3	100 % FYM
T_4	100% Vermicompost
T_5	100% Compost
T_6	100% Green leaf manure
T_7	50 % FYM + 50 % Vermicompost
T_8	50 % FYM + 50 % Compost
T_9	50 % FYM + 50 % Green leaf manure
T_{10}	50%Vermicompost + 50 % Compost
T_{11}	50% Vermicompost + 50 % Green leaf manure
T_{12}	50 % Compost + 50 % Green leaf manure

2.51, 9.32 to 9.67 and 1.65 to 1.70 mg/kg respectively). The experiment was conducted in randomized block design with three replications and treatment details is given Table 1.

Application of organic manures and inorganic fertilizers

Organic manures (FYM, vermicompost, green leaf manure and compost) were thoroughly mixed and applied as per allocation of treatments in plots before 15 days of sowing) prior to soybean sowing. The application of recommended doses of fertilizers (RDF: 20 kg N, 40 kg P_2O_5 and 30 kg K_2O ha^{-1}) for soybean were given as basal application at the time of sowing. The composition of organic manures is given in the Table 2.

Soil sampling, processing and analysis

Soil samples were collected at the harvest of soybean crop from 0–15 cm depth at three randomly selected spots in each replication and composite samples were prepared. Collected soil was gently ground, well mixed and sieved through 2 mm mesh and utilized for laboratory analysis for chemical and biological properties. The field moist soil samples were collected for microbiological study and stored at 4°C until further analysis. Soil chemical parameters were determined by following standard methods outlined by (Jackson 1967). The soil *p*H and EC were determined (1:2 soil: water suspension) on potentiometer. The available N, P, and K and soil organic C were estimated from soil samples. Following standard methods soil microbial enzyme activities, viz. alkaline phosphatase (Tabatabai and Bremner 1969) and soil dehydrogenase activity (Casida *et al.* 1964) were measured.

Table 2 Nutrient composition of the organic manures used in the experiment

Manure	N (%)	P_2O_5 (%)	K_2O (%)
FYM	0.50	0.26	0.49
Vermicompost	2.25	0.95	1.00
Compost	1.1	0.71	0.62
Green manure	1.45	0.58	1.02

Economics

In order to evaluate the economic feasibility of different treatments, the economics of each treatment was worked out in terms of net returns (₹ ha^{-1}) and the benefit: cost (B:C) ratio.

Net returns (₹ ha^{-1})

To evaluate profitability of different treatments, economics was worked out by calculating net returns (₹ ha^{-1}) by subtracting cost of treatment and cost of cultivation from gross income obtained. Cost of cultivation and net profit were calculated on the basis of prevailing prices of produce, inputs and labour rates used.

Benefit cost ratio

Benefit: cost was calculated by dividing gross return by cost of cultivation for each treatment in order to evaluate economic viability of treatments.

$$\text{Benefit-cost ratio} = \frac{\text{Gross return (₹ ha}^{-1}\text{)}}{\text{Total cost incurred (₹ ha}^{-1}\text{)}}$$

Statistical analysis

The experimental data were statistically analyzed for analysis of variance through the procedure appropriate to the experiment laid out as described by (Panse and Sukhatme 1985). Interpretation of results was based on ‘F’ test. The comparison among means was made by calculating critical difference (CD) at 5% level of significance.

RESULTS AND DISCUSSION

Bulk density and organic carbon

Data revealed (Table 3) that nutrient management practices decreased bulk density and increased organic carbon content in soil during both the individual years and in pooled data for two years. The minimum bulk density (1.30, 1.28 and 1.29 Mg m^{-3}**)** and highest organic carbon (0.91, 0.93 and 0.92%) at 0-15 cm depth were recorded under the 100% vermicompost (T_4) over rest of the treatments during both the years and on pooled basis.

It might be due to addition of organic nutrient source have created environment conductive for formation of humic acid, stimulated the activity of soil microorganism and direct addition, biological immobilization and continuous mineralization of FYM and vermicompost on surface soil layer resulting in an increase in the organic carbon content and decrease bulk density of the soil. The result of the present investigation is harmony with the findings of Aher *et al.* (2015).

Nutrient availability (N, P, K, Fe, Zn, Cu and Mn) in soil after harvest

Results pertaining to available nutrient status of soil as

Table 3 Effect of organic sources of nutrients on organic carbon and bulk density

Treatment	OC (%)			BD (Mg m^3)		
	2016	2017	Pooled	2016	2017	Pooled
T_1 = Control	0.54	0.54	0.54	1.42	1.41	1.42
T_2 = 100% RDF	0.64	0.62	0.63	1.40	1.40	1.40
T_3 =100% FYM	0.69	0.69	0.69	1.40	1.38	1.39
T_4 = 100% vermicompost	0.91	0.93	0.92	1.30	1.28	1.29
T_5 =100% compost	0.75	0.75	0.75	1.37	1.36	1.37
T_6 = 100% green leaf manure	0.64	0.66	0.65	1.40	1.40	1.40
T_7 = 50% FYM + 50% vermicompost	0.87	0.90	0.89	1.34	1.34	1.34
T_8 = 50% FYM + 50% compost	0.74	0.75	0.75	1.40	1.40	1.40
T_9 = 50% FYM + 50% green leaf manure	0.74	0.75	0.75	1.38	1.38	1.38
T_{10} =50% vermicompost + 50% compost	0.87	0.90	0.89	1.34	1.34	1.34
T_{11} = 50% vermicompost + 50% green leaf manure	0.76	0.76	0.76	1.36	1.36	1.36
T_{12} = 50% compost + 50% green leaf manure	0.75	0.75	0.75	1.37	1.36	1.37
SEm±	0.01	0.01	0.01	0.049	0.031	0.029
CD (P = 0.05)	0.04	0.03	0.02	NS	NS	0.082

affected by application of inorganic or organic manure are presented in this section. Soil samples were collected plot wise from different treatments at one depths, *i.e.* 0-15 cm from the field after harvest of soybean crop.

Available nitrogen, phosphorus and potassium

Data presented in (Table 4 and 5) indicate that the available nitrogen, phosphorus and potassium in soil varies among the treatments. However at harvest, the highest available nitrogen (475.35, 468.73 and 472.04 kg ha^{-1}) phosphorus (30.42, 30.56 and 30.49 kg ha^{-1}) and potassium (596.24, 595.00 and 595.62 kg ha^{-1}) was recorded under application of 100% vermicompost (T_4) which was followed by other organic treatments during both the years and pooled basis compared to 100 % RDF. Pooled data for two years indicate that the application of 100% vermicompost (T_4) treatment significantly improved nitrogen, phosphorus and potassium status of soil in order of 85.15, 92.60 and 7.19% respectively as compared to RDF (T_2). Organic manures meet the nutrient requirement of crops with greater nutrient use efficiency and also correct the deficiency of nutrients as and when noticed under organic production system (Shwetha 2009).

Available zinc, manganese, copper and iron

It was observed (Table 5, 6 and 7) that available Zn,

Table 4 Effect of organic sources of nutrients on available nutrient after harvest of soybean

Treatment	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})		
	2016	2017	Pooled	2016	2017	Pooled
T_1 = Control	247.50	248.68	248.09	13.56	13.70	13.63
T_2 = 100% RDF	254.36	255.53	254.95	15.76	15.90	15.83
T_3 =100% FYM	281.55	279.33	280.44	22.86	23.00	22.93
T_4 = 100% vermicompost	475.35	468.73	472.04	30.42	30.56	30.49
T_5 =100% compost	310.45	306.53	308.49	23.86	24.00	23.93
T_6 = 100% green leaf manure	270.30	269.41	269.85	15.98	16.12	16.05
T_7 = 50% FYM + 50% vermicompost	404.35	405.52	404.94	26.98	27.12	27.05
T_8 = 50% FYM + 50% compost	342.42	343.59	343.01	25.82	25.96	25.89
T_9 = 50% FYM + 50% green leaf manure	339.74	340.91	340.33	24.64	24.78	24.71
T_{10} =50% vermicompost + 50% compost	406.21	404.49	405.35	30.24	30.38	30.31
T_{11} = 50% vermicompost + 50% green leaf manure	371.06	370.41	370.74	26.88	27.02	26.95
T_{12} = 50% compost + 50% green leaf manure	343.24	344.41	343.83	24.68	24.82	24.75
SEm±	8.164	8.732	5.977	0.783	0.530	0.473
CD (P = 0.05)	23.945	25.611	17.036	2.297	1.554	1.348

Table 5 Effect of organic sources of nutrients on available nutrient after harvest of soybean

Treatment	Potassium (kg ha^{-1})			Zinc (mg kg^{1})		
	2016	2017	Pooled	2016	2017	Pooled
T_1 = Control	448.62	447.41	448.02	2.02	1.95	1.99
T_2 = 100% RDF	556.27	555.06	555.67	2.18	2.11	2.15
T_3 =100% FYM	562.25	561.05	561.65	2.42	2.35	2.39
T_4 = 100% vermicompost	596.24	595.00	595.62	3.66	3.59	3.63
T_5 =100% compost	576.25	575.05	575.65	2.44	2.37	2.41
T_6 = 100% green leaf manure	553.36	552.15	552.76	2.40	2.33	2.37
T_7 = 50% FYM + 50% vermicompost	594.56	593.35	593.96	3.48	3.41	3.45
T_8 = 50% FYM + 50% compost	584.26	583.05	583.66	2.72	2.65	2.69
T_9 = 50% FYM + 50% green leaf manure	478.85	477.64	478.25	2.48	2.41	2.45
T_{10} =50% vermicompost + 50% compost	494.86	493.65	494.26	3.62	3.55	3.59
T_{11} = 50% vermicompost + 50% green leaf manure	486.56	485.35	485.96	2.42	3.35	2.89
T_{12} = 50% Compost + 50% Green Leaf Manure	580.24	579.03	579.64	2.52	2.45	2.49
SEm±	10.816	12.298	8.189	0.037	0.053	0.033
CD (P = 0.05)	33.51	25.42	20.44	0.110	0.156	0.093

Table 6 Effect of organic sources of nutrients on available nutrient after harvest of soybean

Treatment	Manganese (mg kg^{1})			Iron (mg kg^{1})		
	2016	2017	Pooled	2016	2017	Pooled
T_1 = Control	9.02	9.00	9.01	2.62	2.60	2.61
T_2 = 100% RDF	9.46	9.34	9.40	2.69	2.62	2.66
T_3 =100% FYM	9.64	9.55	9.59	2.98	2.88	2.93
T_4 = 100% vermicompost	13.52	13.36	13.44	3.72	3.66	3.69
T_5 =100% vompost	9.72	9.67	9.70	2.98	2.96	2.97
T_6 = 100% green leaf manure	9.53	9.36	9.44	2.89	2.82	2.86
T_7 = 50% FYM + 50% vermicompost	12.97	12.49	12.73	3.48	3.38	3.43
T_8 = 50% FYM + 50% compost	11.22	10.88	11.05	3.28	3.24	3.26
T_9 = 50% FYM + 50% green leaf manure	9.81	9.70	9.75	3.08	2.95	3.02
T_{10} =50% vermicompost + 50% compost	13.08	12.65	12.86	3.56	3.48	3.52
T_{11} = 50% vermicompost + 50% green leaf manure	11.14	10.78	10.96	3.32	3.26	3.29
T_{12} = 50% compost + 50% green leaf manure	10.26	10.14	10.20	3.16	3.08	3.12
SEm±	0.181	0.200	0.135	0.088	0.061	0.053
CD (P = 0.05)	0.531	0.586	0.384	0.257	0.179	0.152

Mn, Cu and Fe in soil varies among the treatments. Results indicate that the highest available zinc (3.66, 3.59 and 3.63 mg kg^{-1}), manganese (13.52, 13.36 and 13.44 mg kg^{-1}), copper (2.52, 2.48 and 2.50 mg kg^{-1}) and iron (3.72, 3.66 and 3.69 mg kg^{-1}) were recorded in the treatment 100% vermicompost (T_4) which was followed by other organic treatments during both the years and pooled basis. The availability of micronutrient cations (Zn, Cu, Fe and Mn) increases as the organic matter provides chelating agent for complexation of these micronutrients. The results of present study are in agreement with those reported by Chaturvedi *et al.* (2012).

Enzymatic activity

Dehydrogenase activity: The highest dehydrogenase activity (12.40, 12.52 and 12.46 µgTPFg^{-1} soil) was observed with treatment receiving the 100% vermicompost (T_4) and which was followed by the 50% FYM +50% vermicompost (T_7) and 50% vermicompost + 50% green leaf manure (T_{11}). The lowest dehydrogenase activity (8.90, 9.12 and 9.01 µg TPFg^{-1} soil) in the soil was found in control treatment (T_1) at harvesting stage of the soybean crop. On pooled basis, the

Table 7 Effect of organic sources of nutrients on available nutrient after harvest of soybean

Treatment	Copper (mg kg^{1})		
	2016	2017	Pooled
T_1 = Control	1.60	1.58	1.59
T_2 = 100% RDF	1.61	1.61	1.61
T_3 =100% FYM	1.78	1.72	1.75
T_4 = 100% vermicompost	2.52	2.48	2.50
T_5 =100% compost	1.89	1.82	1.86
T_6 = 100% green leaf manure	1.72	1.68	1.70
T_7 = 50% FYM + 50% vermicompost	2.32	2.28	2.30
T_8 = 50% FYM + 50% compost	2.18	2.18	2.18
T_9 = 50% FYM + 50% green leaf manure	1.92	1.89	1.91
T_{10} =50% vermicompost + 50% compost	2.46	2.44	2.45
T_{11} = 50% vermicompost + 50% green leaf manure	2.22	2.20	2.21
T_{12} = 50% compost + 50% green leaf manure	2.12	2.05	2.09
SEm±	0.046	0.047	0.033
CD (P = 0.05)	0.134	0.137	0.093

treatment 100% vermicompost (T_4) significantly increase 32.49 % dehydrogenase activity in the soil as compared to RDF (Table 8).

Alkaline phosphatase activity: Amongst nutrient management practices, application of 100% vermicompost (T_4) registered highest (Table 8) alkaline phosphatase activity in soil (12.49, 12.57, 12.53 µg g^{-1} ha^{-1}) which was followed by the 50% vermicompost + 50% compost (T_{10}). The minimum alkaline phosphatase activity (9.14, 9.18, 9.16 µg g^{-1} h^{-1}) in soil was found in control (T_1) treatment during both the years of experiment and pooled basis. Pooled data for two years indicate that alkaline phosphatase activity in soybean crop fertilized with 100% vermicompost (T_4) significantly increase 31.89 % alkaline phosphatase activity in the soil as compared to RDF.

The lower activity of soil enzyme activity in recommended dose of fertilizers as compared to other treatments with manures may be attributed to the lack of sufficient substrate, *i.e.* organic carbon which acts as energy source for proliferating microbial population. Similar results were also reported by Aher *et al. (*2015).

Net return

Data indicate (Table 9 and Fig 1) that soybean crop fertilized with 100% RDF (T_2) found maximum net return of ₹ 58201.41, ₹ 63368.73 and ₹ 60785.07 ha^{-1} over followed by application of 100% vermicompost (T_4), however, both these nutrient management practices to soybean crop significantly enhanced net return over rest of the treatments during the year of experimentation. The minimum net return was recorded with control treatment obtaining ₹ 20251.36, ₹ 22976.87 and ₹ 21614.11 ha^{-1} (T_1).

B:C ratio

Under nutrient management practices, soybean crop nutrient supplied through 100% RDF (T_2) recorded highest B:C ratio 2.82, 3.07 and 2.95 in 2016-17, 2017-18 and pooled basis respectively over control which is followed by the application of 100% vermicompost (T_4) and both these nutrient management practices in soybean significantly improved BC ratio over rest of treatments during both years (2016-17 and 2017-18) and pooled respectively (Table

Table 8 Effect of organic sources of nutrients on enzyme activity

Treatment	Dehydrogenase (µgTPFg^{-1} soil)			Alkaline phosphatase (µg g^{-1} ha^{-1})		
	2016	2017	Pooled	2016	2017	Pooled
T_1 = Control	8.90	9.12	9.01	9.14	9.18	9.16
T_2 = 100% RDF	9.40	9.49	9.45	9.47	9.53	9.50
T_3 =100% FYM	9.76	9.87	9.81	9.83	9.89	9.86
T_4 = 100% vermicompost	12.40	12.52	12.46	12.49	12.57	12.53
T_5 =100% compost	9.96	10.06	10.01	10.03	10.09	10.06
T_6 = 100% green leaf manure	9.66	9.76	9.71	9.80	9.79	9.79
T_7 = 50% FYM + 50% vermicompost	11.48	11.59	11.54	11.75	11.63	11.69
T_8 = 50% FYM + 50% compost	10.95	11.06	11.00	11.21	11.10	11.16
T_9 = 50% FYM + 50% green leaf manure	10.15	10.25	10.20	10.27	10.29	10.28
T_{10} =50% vermicompost + 50% compost	11.85	11.97	11.91	12.06	12.01	12.03
T_{11} = 50% vermicompost + 50% green leaf manure	11.17	11.28	11.22	11.34	11.32	11.33
T_{12} = 50% compost + 50% green leaf manure	10.78	10.91	10.84	10.86	10.93	10.90
SEm±	0.193	0.211	0.143	0.174	0.190	0.129
CD (P = 0.05)	0.565	0.619	0.407	0.511	0.559	0.368

Table 9 Effect of organic sources of nutrients on economics

Treatment	Net return (₹ ha^{-1})			B:C ratio		
	2016	2017	Pooled	2016	2017	Pooled
T_1 = Control	20251	22976	21614	1.13	1.28	1.21
T_2 = 100% RDF	58201	63368	60785	2.82	3.07	2.95
T_3 =100% FYM	38131	42265	40198	1.62	1.80	1.71
T_4 = 100% vermicompost	49198	54141	51670	1.90	2.09	2.00
T_5 =100% compost	31245	35381	33313	1.03	1.16	1.10
T_6 = 100% green leaf manure	28984	33034	31009	0.93	1.06	0.99
T_7 = 50% FYM + 50% vermicompost	42187	46628	44407	1.71	1.89	1.80
T_8 = 50% FYM + 50% compost	37177	41469	39323	1.38	1.54	1.46
T_9 = 50% FYM + 50% green leaf manure	35866	40097	37981	1.31	1.47	1.39
T_{10} =50% vermicompost + 50% compost	39506	43858	41682	1.40	1.56	1.48
T_{11} = 50% vermicompost + 50% green leaf manure	47150	51922	49536	1.89	2.08	1.99
T_{12} = 50% Compost + 50% green leaf manure	33300	37587	35444	1.08	1.22	1.15
SEm±	1274.791	1481.080	977.073	0.044	0.057	0.036
CD (P = 0.05)	3738.833	4343.859	2784.816	0.129	0.168	0.103

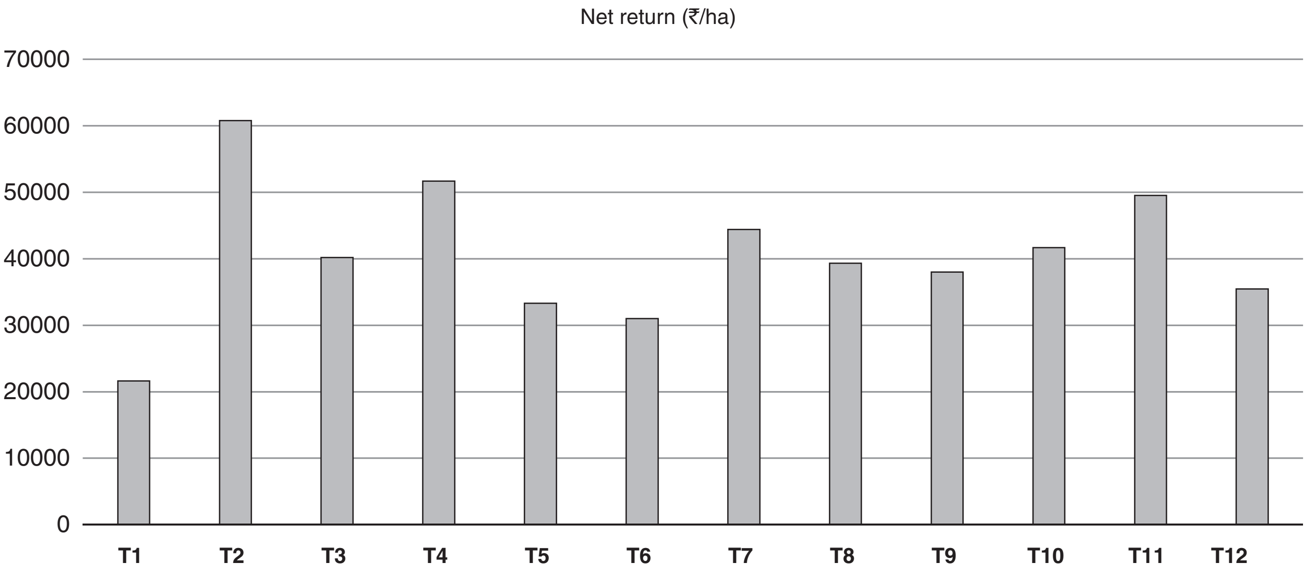

Fig 1 Effect of INM on net returns of soybean.

9). The minimum B:C ratio (1.13, 1.28 and 1.21) was recorded with control (T_1) during both years and pooled basis. This trend in economic return is mainly due to the higher cost and treatment effect on the seed and haulm yield of soybean. Similar findings were given by (Potkile *et al.* 2017).

Conclusion

On the basis of the result from present investigation conducted during *kharif* seasons of 2016 and 2017, it is concluded that application of 100% vermicompost gave higher soil organic carbon, available nitrogen, phosphorus, potassium and micronutrient compared to 100% RDF. The high BC ratio was obtained in 100% RDF as compared to 100% vermicompost because of high cost of vermicompost if we prepared organic manure at own farm then the BC ratio of 100% vermicompost may be at par with 100% RDF. Further results showed that the enzymatic activity were found maximum with application of 100% vermicompost which is followed by 50% vermicompost + 50% green leaf manure. The application of chemical fertilizers could not sustain the soil fertility and soil health. Thus, organic nutrient management improved soil health and effective for sustainability.

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