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Influence of Different Sources of Organic Manures and Decomposers on Enzymatic Activity and Microbial Dynamics of Rhizosphere Soil of Chilli (*Capsicum annum* L.)

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A B S T R A C T

A field experiment was conducted at research and demonstration block of Research Institute on Organic Farming (RIOF), UAS, GKVK, Bengaluru during 2017-2018 to study the combined effect of different sources of organic manures, decomposers on enzymatic activity and microbial dynamics of rhizosphere soil of chilli. The experiment was laid out on Factorial Randomized Block Design with 12treatments and replicated thrice. Irrespective of decomposers treatments, application of vermicompost on N equivalent basis had recorded significantly higher chilli yield (20.47 and 23.09 t ha^{-1}) and stalk yield (5.28 and 6.15 t ha^{-1}) as compared to the application of poultry manure (19.40 and 21.85 t ha^{-1}, 5.01 and 5.83 t ha^{-1}), sheep manure (18.83 and 21.19 t ha^{-1}, 4.86 and 5.65 t ha^{-1}) and FYM (18.27 and 20.54 t ha^{-1}, 4.74 and 5.50 t ha^{-1}).Application of jeevamrutha to soil had recorded significantly higher chilli yield (18.27 and 20.54 t ha^{-1}) and stalk yield (4.74 and 5.50 t ha^{-1}) as compared to application of microbial consortia (20.17 and 22.74 t ha^{-1}, 5.21 and 6.07 t ha^{-1}) and NCOF-decomposer (16.24 and 18.20 t ha^{-1}, 4.2 and 4.88 t ha^{-1}).Application of vermicompost had recorded significantly higher bacterial population (27.15 × 10^5 and 30.29 × 10^5 CFU g^{-1} of soil, respectively) as compared to FYM (24.23 × 10^5 and 26.87 × 10^5 CFU g^{-1} of soil), poultry manure (25.73 × 10^5 and 28.63 × 10^5 CFU g^{-1} of soil)and sheep manures(24.97 × 10^5 and 27.74 × 10^5 CFU g^{-1} of soil).Application of jeevamrutha recorded significantly higher bacterial population (28.27 × 10^5 and 31.59 × 10^5 CFU g^{-1} of soil, respectively) as compared to NCOF- decomposer (21.54 and 23.73 × 10^5 CFU g^{-1} of soil, respectively). Interaction effects of these factors didn't differ significantly.

Introduction

Chilli (*Capsicum annuum* L.) is a popular vegetable crop,commonly known as bell pepper or sweet pepper or hot pepper or chilli. Chilli is grown over an area of 19.89 million hectares in the World, with a production of 33.52 million tonnes (Patel, 2017). Major chilli growing countries are India, China, Indonesia, Korea, Pakistan, Turkey and Sri Lanka in Asia. India is the world leader in chilli production followed by China and Pakistan. In India, green chilli is grown in an area of 3.66 lakh hectares with anuual production of 35.92 lakh tones and productivity of 10.2 million tones during 2018(Anon.,2018). This shows that the bulk share of chilli production is in Asian countries, though it is produced throughout the world. In India, chillies are grown in almost all the state throughout the country. Andhra Pradesh is the largest producer of chilli in India and contributes about 26 per cent to the total area followed by Maharashtra (15%), Karnataka (11%), Orissa (11%),Madhya Pradesh (7%) and other states contributing nearly 22% to the total area under Chilli. The lion's share is taken by India with 36% share in global production, followed by China (11%), Bangladesh (8%), Peru (8%) and Pakistan (6%)(Anon., 2018).

The quality of compost can be improved by using different microbial inoculants. The wastes can be co-inoculated with decomposing lingo-cellulolytic microbes and enriching free living N_2 fixers, phosphate solubilizers and Plant Growth Promoting Rhizobacteria (PGPRs). PGPRs are the microorganisms which help in promotion/ protection of plant by their association with plants. PGPRs are colonizing the root surface to survive, multiply and compete with another micro biota (Kloepper, 1994).Some examples of PGPR are like *Agrobacterium*, *Bacillus*, *Chromobacterium*, *Erwinia*, *Flavobacterium*, *Pseudomonas* and*Trichoderma* (Bhattacharyya and Jha, 2012).

All organic manures are decomposed organic matter obtained by the action of microbial population in a warm and moist aerobic environment using cow dung, cow urine and other waste materials available from backyard cattle (Ramprasad *et al.,* 2009). Usage of decomposers such as jeevamrutha, microbial consortia and NCOF- decomposer results in increased growth and yield of crops and improve the soil physico-chemical and biological properties. They contain micro and macro nutrients, many vitamins, essential amino acids, beneficial microorganisms and growth promoting substances *viz.*, IAA, GA (Devakumar *et al.*, 2008 and Tharmaraj *et al.*, 2011). Jeevamrutha are eco-friendly organic preparations made from cow products. The products from cow have the ability to bring the flow of cosmic energy which in turn can revitalize the growth process (Natarajan, 2002). Use of farm yard manure (FYM) and liquid organic formulations like panchagavya and jeevamrutha are potential sources of organic nutrients. Hence, the present investigation was conducted to study the combined effect of vermicompost, FYM, poultry manure, sheep manure and jeevamrutha on growth, yield, enzymatic activity and microbial dynamics of chilli.

Materials and Methods

A field experiment was conducted at research and demonstration block of Research Institute on Organic Farming, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru which is situated in Eastern dry zone of Karnataka at a latitude of 12^o 58′ North, longitude of 75^o 35′ East and at an altitude of 930 m above mean sea level. The experiment was conducted to study the combined effect of different sources of organic manure, jeevamrutha and decomposers on growth and yield of chilli during *kharif* - 2017 and 2018 under irrigated condition. The experiment was laid out on factorial Randomized Block Design with 12 treatments replicated thrice. The treatment are T_1:FYM x Jeevamrutha, T_2: FYM x Microbial consortia, T_3: FYM x Decomposer, T_4:Vermicompost x Jeevamrutha,

T_5:Vermicompost x Microbial consortia, T_6:Vermicompost x Decomposer, T_7: Poultry manure x Jeevamrutha, T_8: Poultry manure x Microbial consortia, T_9: Poultry manure x Decomposer, T_{10}: Sheep manure x Jeevamrutha, T_{11}: Sheep manure x Microbial consortia and T_{12}:Sheep manure x Decomposer. Recommended dose of nutrients for chilli is 150:75:75 N:P_2O_5:K_2O kg ha^{-1} and nutrients were supplied through FYM, vermicompost, poultry manures and sheep manures on the basis of nitrogen equivalent. Treatment combinations consisted of four different organic sources (M_1: FYM, M_2: Vermicompost, M_3: Poultry Manure and M_4: Sheep manures-100 % N equivalent basis), three decomposers (J: Jeevamrutha, C:Microbial consortia and N: decomposer developed by NCOF). Different sources of organic manure were incorporated into the soil, three weeks prior to planting. Application of jeevamrutha at 2000 l ha^{-1}, microbial consortia and NCOF- decomposer were applied at the time of planting and at different growth stages. Soil of the experimental site was red sandy loam with a pH of 6.93**,** EC (0.27 dSm^{-1}), low in organic carbon (0.44 %) and medium in available nitrogen (292 kg ha^{-1}), P_2O_5 (27 kg ha^{-1}) and K_2O (241 kg ha^{-1}). Experimental data collected was subjected to statistical analysis by adopting Fisher's method of analysis of variance (ANOVA) as outlined in Gomez and Gomez (1984). Critical difference (CD) values were calculated whenever the "F" test was significant at 5 per cent level.

Results and Discussion

Effect of different sources of organic manures and decomposers on yield of chilli

Green chilli yield varied significantly due to application of different sources *i.e.*, FYM, vermicompost, poultry manure and sheep manure during *Kharif*, 2017 and 2018 seasons. Significantly higher green chilli yield (20.47 and 23.09 t ha^{-1}) was recorded with the application of vermicompost it was 10.74 and 11.04 per cent higher yield over the application of FYM. Whereas, the application of vermicompost recorded 5.23 and 5.37 per cent higher yield over application of poultry manure (Table 1). Among the decomposers, significantly higher green chilli yield (21.31 and 24.06 t ha^{-1}) was recorded with the application of jeevamrutha at 2000 l ha^{-1} as compared to microbial consortia (20.17 and 22.74 t ha^{-}1) and decomposer (16.24 and 18.20 t ha^{-1}) and it was 23.79 and 24.35 per cent increase in yield with application of jeevamrutha during both the seasons (Table 1). These results are in conformity with the findings of Vishwajith *et al.,* (2018) in okra, ReshmaSutar *et al.,* (2018) in cowpea, Naveena (2017) in ragi, RekhaGonal (2017) in baby corn, BasavarajKumbar *et al.,* (2017) in french bean. The increase in yield might be due to significant increase in yield parameters such as higher number of fruits, fruit length and fruit weight. These results are in line with Somasundaram (2003) in maize-sunflower-greengram system, Boomiraj (2003) in bhendi and Yadav and Lourduraj (2006) in rice.

Increase in yield parameters might be due to higher total dry matter accumulation (TDMA). Higher TDMA might be due to higher plant height which resulted in more number of branches and more leaf area. Significantly higher dry matter production was recorded with the application of jeevamrutha throughout the crop growth period possibly due to the continuous supply of nutrients and plant growth promoting substances available in jeevamrutha. This is in conformity with Sreenivasa *et al.,* (2009) and Nileema Gore and Sreenivasa (2011) who have also reported higher plant height, root length, dry matter production, number of fruits per plant and fruit weight of tomato with the application of jeevamrutha. Lower chilli yield (16.24 and

18.20 t ha^{-1}) was recorded during *kharif*, 2017 and *kharif*, 2018 with decomposer application (Table 1). The possible reasons might be due to higher nutrient content and beneficial microbes such as bacterial, fungi, N- fixers, P-solubilizers and actinomycetes present in jeevamrutha might have resulted in higher growth and yield of crop. The increased yield was also might be due to sink potential as indicated due to better availability of nutrients and moisture, which helped in production of more photosynthates and its translocation to fruits during their peak stage of crop growth. This might have fulfilled the crop nutrient demand and enhanced yield (Sreenivasa *et al.*, 2009). Application of organic matter to the soil improves the rhizosphere properties to a greater extent. This would favour the growth and multiplication of soil flora and fauna (Devakumar *et al.*, 2014). The organic manures have the capacity to fulfill the nutrient demand of the crops adequately and promote the activity of beneficial micro and macro flora in the soil (Mohan Singh, 2003). This might have helped in greater availability of nutrients in the rhizosphere soil and enhanced the uptake of nitrogen, total phosphorus and total potassium during 2017 and 2018, respectively. Presence of higher amount of organic substances in the rhizosphere soil possibly provided favourable environment and substrate availability to the beneficial soil microorganisms. Similar results were also observed by Mohammad and Farzaneh (2019) reported that higher nutrient uptake of total nitrogen, phosphorus and potassium was observed in mungbean crop with the application of vermicompost 10 t ha^{-1} as compared to FYM and control.

Interaction effect ofdifferent sources of organic manures and decomposer on growth and yield of chilli

Interaction effect among different sources of organic manure and decomposers was found to be observed. Numerically higher and lower fruit yield (22.30 and 14.85 t ha^{-1}) and stalk yield (5.75 and 3.87 t ha^{-1}) were observed in the treatment combined application of vermicompost and jeevamrutha and FYM and decomposers respectively.

From this study it can be concluded that application of different organic manures (FYM, vermicompost, poultry manure and sheep manure) and decomposers (jeevamrutha microbial consortia and decomposer) are beneficial in improving growth and yield of chilli by providing better availability of nutrients, improved microbial activity and availability of growth promoting substances.

Effect of different organic manures, jeevamrutha and decomposers on soil microbial population

The increase in microbial population is a key indicator of soil fertility and soil health. Microbial communities are important for the functioning of the ecosystem, both in relation to direct interactions with plants and with regard to nutrient and organic matter cycling. They are involved in the fundamental activities that ensure the stability and productivity of both agricultural systems and natural ecosystems. Increase in population results in increased soil microbial biomass, a temporary reservoir of labile nutrients. Further, increase in various other biological activities such as enzyme activities, mineralization capabilities, rate of nitrification, microbial diversity *etc*., will have influence on soil fertility. These biological parameters can also be used as effective indicators for assessing long-term soil and crop management effects on soil quality.

Application of vermicompost and jeevamrutha have significantly influenced the bacteria, fungi, actinomycetes and P- solubilizer population in the soil at all stages of crop growth. In the present investigation, application of vermicompost through N equivalent recorded significantly higher bacteria (27.15 and 30.29 × 10^5 CFU g^{-1} soil), actinomycetes (23.36 and 25.71 × 10^3 CFU g^{-1} soil) and fungi (16.94 and 19.61 × 10^4 CFU g^{-1} soil) and P- solubilizer (32.43 and 34.53 × 10^5 CFU g^{-1} soil) population during both the seasons and it was followed by application of poultry manure through N equivalent and lower population was with FYM application (Table 2 and 3). This might be due to the decomposition of organic matter. The work of breaking down of organic material is done is done by bacteria and fungi of many kinds and takes place in the several stages, various intermediate products being formed before the final substance nitrate. These results are in the line with KulvinderKaur *et al.*, (2005), Boraiah *et al.*, (2017) and Siddappa, (2015). Further, these microorganisms solubilize the nutrients and made available for the uptake of nutrients. These results are in conformity with Lavanya *et al.*, (2016) and they opined that maximum population of general bacteria, fungi, actinomycetes, *Pseudomonas* and PSB were observed in the soil treated with jeevamrutha at 1000 l ha^{-1} and 7.5 per cent panchagavya in field bean when compared to without jeevamrutha and panchagavya treated soil. This might be due to the fact that jeevamrutha serves as a good source of beneficial microorganisms and it is in conformity with the findings of Devakumae *et al.*, (2014) Kiran (2014) in chickpea, Siddappa (2015) in fieldbean and Madhukumar (2015) in chilli who have also reported the higher beneficial microbial population and the beneficial effect of jeevamrutha in enhancing the microbial load in the rhizosphere region. Further, Devakumar *et al.*, (2008) have also reported that maximum microbial population was observed between 9th and 12th day after preparation of jeevamrutha. This might have enhanced the decomposition process in the soil which might have resulted in relatively quick release of nutrients from compost than without the application of jeevamrutha.

Application of jeevamrutha at 2000 l ha^{-1} recorded significantly higher microbial population in soil *viz.*, bacteria (28.27 and 31.59 × 10^5 CFU g^{-1} soil), actinomycetes (24.32 and 26.82 × 10^3 CFU g^{-1} soil), fungi (17.63 and 20.46 × 10^4 CFU g^{-1} soil) and PSB (33.76 and 34.83 × 10^5 CFU g^{-1} soil during both the seasons, respectively) as compared to application of microbial consortia and NCOF-decomposer (2 and 3). This might be due to enhanced effect of jeevamrutha on soil micro flora as compared to individual applications and also jeevamrutha and panchagavya had supported the multiplication of different beneficial microbes. These results are in consonance with the findings of Lavanya *et al.*, (2016), ReshmaSutar *et al.*, (2017) and Boraiah *et al.*, (2017). Similarly, jeevamrutha and panchagavya contains enormous amount of microbial load which multiplies in the soil and acts as a tonic to enhance the microbial activity in the soil (Devakumar *et al.*, 2008 and Patel *et al.*, 2014). According to Devakumar *et al.*, (2014), use of handful of soil for jeevamrutha preparation serves as source of initial inoculum of bacteria, fungi, actinomycetes, N- fixers and P- solubilizers.

Hence, more number of beneficial microorganisms were found in organic liquid manure formulations. This might have helped in increasing the microorganisms with the application of jeevamrutha.

Among the different treatment combinations, application of vermicompost and jeevamrutha at 2000 l ha^{-1} recorded higher microbial population *viz.*, bacteria (29.58 and 33.12 × 10^5 CFU g^{-1} of soil), actinomycetes (25.45 and 28.12 × 10^3 CFU g^{-1} of soil), fungi (18.45 and 21.45 × 10^4 CFU g^{-1} of soil) and PSB (35.33 and 37.43 × 10^5 CFU g^{-1} of soil) as compared to individual application. This might be due to the beneficial effect of organic material which serves as a source of carbon and energy for soil microorganisms in addition to the liquid manures which contains enormous amount of microbial load which multiplies in the soil and acts as a tonic to enhance the microbial activity in the soil (KulvinderKaur *et al.*, 2005, Siddappa *et al.*, 2017, Latha *et al.*, 2016 and Boraiah *et al.*, 2017).

Table.1 Green chilli yield and stalk yield of chilli as influenced by application of organic manures, jeevamrutha and decomposers during *kharif 2017* and 2018

Manures	Green chilli yield (t ha^{-1})							
	2017				2018			
	Decomposers				Decomposers			
	J	C	N	Mean	J	C	N	Mean
FYM	20.66	19.30	14.85	**18.27**	23.30	21.73	16.59	**20.54**
VC	22.30	20.61	18.51	**20.47**	25.20	23.24	20.81	**23.09**
PM	21.38	20.59	16.22	**19.40**	24.14	23.23	18.17	**21.85**
SM	20.90	20.19	15.39	**18.83**	23.59	22.76	17.21	**21.19**
Mean	**21.31**	**20.17**	**16.24**		**24.06**	**22.74**	**18.20**	
	S.Em ±		**CD (P = 0.05)**		**S.Em ±**		**CD (P = 0.05)**	
M	0.510		1.496		0.596		1.749	
D	0.442		1.295		0.516		1.514	
M x D	0.883		NS		1.033		NS	
Manures	**Stalk yield (t ha^{-1})**							
	2017				2018			
	Decomposers				Decomposers			
	J	C	N	Mean	J	C	N	Mean
FYM	5.34	4.99	3.87	**4.74**	6.22	5.81	4.48	**5.50**
VC	5.75	5.32	4.78	**5.28**	6.71	6.20	5.56	**6.15**
PM	5.52	5.31	4.20	**5.01**	6.43	6.19	4.86	**5.83**
SM	5.39	5.21	3.98	**4.86**	6.29	6.07	4.61	**5.65**
Mean	**5.50**	**5.21**	**4.21**		**6.41**	**6.07**	**4.88**	
	S.Em ±		**CD (P = 0.05)**		**S.Em ±**		**CD (P = 0.05)**	
M	0.132		0.386		0.159		0.467	
D	0.114		0.335		0.138		0.404	
M x D	0.228		NS		0.276		NS	

CD at 5 % **NS** - Non-significant **DAT**- Days after Transplanting **M** - Manures
RDF: 125:75:63 kg $N:P_2O_5:K_2O$ ha^{-1} for N equivalent FYM application **D** - Decomposers
FYM - Farm yard manure **VC –** Vermicompost **PM** - Poultry manure **SM** - Sheep manure
J – Jeevamrutha **C** - Microbial Consortia **N -** Decomposer from NCOF

Table.2 Soil microbial population of chilli at harvest of as influenced by application of organic manures, jeevamrutha and decomposers during *kharif 2017*

Manures	Microbial population							
	Bacteria (No. × 10^5 CFU g^{-1} of soil)				Actinomycetes (No. × 10^3 CFU g^{-1} of soil)			
	Decomposers				Decomposers			
	J	C	N	Mean	J	C	N	Mean
FYM	27.40	25.60	19.70	**24.23**	23.58	22.03	16.95	**20.85**
VC	29.58	27.33	24.55	**27.15**	25.45	23.52	21.12	**23.36**
PM	28.36	27.32	21.52	**25.73**	24.40	23.50	18.51	**22.14**
SM	27.73	26.78	20.41	**24.97**	23.86	23.04	17.56	**21.49**
Mean	**28.27**	**26.76**	**21.54**		**24.32**	**23.02**	**18.53**	
	S.Em ±		**CD (P = 0.05)**		**S.Em ±**		**CD (P = 0.05)**	
M	0.676		1.984		0.582		1.707	
D	0.586		1.718		0.504		1.478	
M x D	1.172		NS		1.008		NS	
Manures	**Microbial population**							
	Fungi (No. × 10^4 CFU g^{-1} of soil)				**PSB (No. × 10^5 CFU g^{-1} of soil)**			
	Decomposers				**Decomposers**			
	J	**C**	**N**	**Mean**	**J**	**C**	**N**	**Mean**
FYM	17.09	15.97	12.28	**15.11**	32.73	30.58	23.52	**28.94**
VC	18.45	17.05	15.31	**16.94**	35.33	32.65	29.32	**32.43**
PM	17.69	17.04	13.42	**16.05**	33.88	32.63	25.70	**30.73**
SM	17.29	16.70	12.73	**15.58**	33.12	31.99	24.38	**29.83**
Mean	**17.63**	**16.69**	**13.44**		**33.76**	**31.96**	**25.73**	
	S.Em ±		**CD (P = 0.05)**		**S.Em ±**		**CD (P = 0.05)**	
M	0.422		1.237		0.808		2.370	
D	0.365		1.072		0.700		2.052	
M x D	0.731		NS		1.399		NS	

CD at 5 % **NS** - Non-Significant **DAT**- Days After Transplanting **M -** Manures
RDF: 125:75:63 kg N:P_2O_5:K_2O ha^{-1} for N equivalent FYM application **D** - Decomposers
FYM - Farm yard manure **VC –** Vermicompost **PM** - Poultry manure
SM - Sheep manure **J** – Jeevamrutha **C** - Microbial Consortia
N - Decomposer from NCOF

Table.3 Soil microbial population of chili at harvest as influenced by application of organic manures, jeevamrutha and decomposers during *kharif* 2018

Manures	Microbial population							
	Bacteria (No. × 10^5 CFU g^{-1} of soil)				Actinomycetes (No. × 10^3 CFU g^{-1} of soil)			
	Decomposers				Decomposers			
	J	C	N	Mean	J	C	N	Mean
FYM	30.58	28.47	21.58	**26.87**	25.96	24.17	18.32	**22.82**
VC	33.12	30.50	27.24	**30.29**	28.12	25.89	23.13	**25.71**
PM	31.70	30.48	23.70	**28.63**	26.91	25.88	20.12	**24.30**
SM	30.96	29.85	22.41	**27.74**	26.28	25.35	19.03	**23.55**
Mean	**31.59**	**29.82**	**23.73**		**26.82**	**25.32**	**20.15**	
	S.Em ±		**CD (P = 0.05)**		**S.Em ±**		**CD (P = 0.05)**	
M	0.781		2.291		0.663		1.945	
D	0.676		1.984		0.574		1.684	
M x D	1.353		NS		1.149		NS	
Manures	**Microbial population**							
	Fungi (No. × 10^4 CFU g^{-1} of soil)				**PSB (No. × 10^5 CFU g^{-1} of soil)**			
	Decomposers				**Decomposers**			
	J	**C**	**N**	**Mean**	**J**	**C**	**N**	**Mean**
FYM	19.80	18.44	13.97	**17.41**	34.83	32.68	25.62	**31.04**
VC	21.45	19.75	17.64	**19.61**	37.43	34.75	31.42	**34.53**
PM	20.53	19.74	15.35	**18.54**	35.98	34.73	27.80	**32.84**
SM	20.05	19.33	14.51	**17.97**	35.22	34.09	26.48	**31.93**
Mean	**20.46**	**19.32**	**15.37**		**34.83**	**32.68**	**25.62**	**31.04**
	S.Em ±		**CD (P = 0.05)**		**S.Em ±**		**CD (P = 0.05)**	
M	0.506		1.483		0.808		2.370	
D	0.438		1.285		0.700		2.052	
M x D	0.876		NS		1.399		NS	

CD at 5 % **NS** - Non-Significant **DAT**- Days After Transplanting **M -** Manures
RDF: 125:75:63 kg $N:P_2O_5:K_2O$ ha^{-1} for N equivalent FYM application **D** - Decomposers
FYM - Farm yard manure **VC –** Vermicompost **PM** - Poultry manure **SM** - Sheep manure
J – Jeevamrutha **C** - Microbial Consortia **N -** Decomposer from NCOF

Table.4 Enzyme activity of soil at active flowering stage of chilli as influenced by application of organic manures, jeevamrutha and decomposers during *kharif 2017*

Manures	Enzyme activities							
	Dehydrogenase activity (µg TPF formed g^{-1} of soil day^{-1})				Acid phosphatase activity (µg PNP formed g^{-1} of soil $hour^{-1}$)			
	Decomposers				Decomposers			
	J	C	N	Mean	J	C	N	Mean
FYM	54.19	50.63	38.95	**47.92**	31.67	29.64	22.99	**28.10**
VC	58.50	54.06	48.55	**53.70**	34.12	31.55	28.37	**31.35**
PM	56.09	54.03	42.55	**50.89**	32.73	31.54	24.91	**29.72**
SM	54.84	52.97	40.37	**49.39**	32.00	30.92	23.64	**28.86**
Mean	**55.91**	**52.92**	**42.60**		**32.63**	**30.91**	**24.98**	
	S.Em ±		CD (P = 0.05)		S.Em ±		CD (P = 0.05)	
M	1.338		3.924		0.782		2.293	
D	1.159		3.398		0.677		1.986	
M x D	2.317		NS		1.354		NS	
Manures	**Enzyme activities**							
	Alkaline phosphatase activity (µg PNP formed g^{-1} of soil $hour^{-1}$)				**Urease activity (µg NH_4-N formed g^{-1} of soil $hour^{-1}$)**			
	Decomposers				**Decomposers**			
	J	**C**	**N**	**Mean**	**J**	**C**	**N**	**Mean**
FYM	21.89	20.48	15.89	**19.42**	6.02	5.63	4.33	**5.32**
VC	23.58	21.81	19.61	**21.66**	6.50	6.01	5.39	**5.97**
PM	22.62	21.79	17.21	**20.54**	6.23	6.00	4.73	**5.65**
SM	22.12	21.37	16.34	**19.94**	6.09	5.89	4.49	**5.49**
Mean	**22.55**	**21.36**	**17.26**		**6.21**	**5.88**	**4.73**	
	S.Em ±		CD (P = 0.05)		S.Em ±		CD (P = 0.05)	
M	0.540		1.585		0.149		0.436	
D	0.468		1.373		0.129		0.378	
M x D	0.936		NS		0.257		NS	

CD at 5 % **NS** - Non-Significant **DAT**- Days After Transplanting **M -** Manures
RDF: 125:75:63 kg N:P_2O_5:K_2O ha^{-1} for N equivalent FYM application **D** - Decomposers
FYM - Farm yard manure **VC –** Vermicompost **PM** - Poultry manure **SM** - Sheep manure
J – Jeevamrutha **C** - Microbial Consortia **N -** Decomposer from NCOF

Table.5 Enzyme activity of soil at active flowering stage of chilli as influenced by application of organic manures, jeevamrutha and decomposers during *kharif* 2018

Manures	Enzyme activities							
	Dehydrogenase activity (µg TPF formed g^{-1} of soil day^{-1})				Acid phosphatase activity (µg PNP formed g^{-1} of soil $hour^{-1}$)			
	Decomposers				Decomposers			
	J	**C**	**N**	**Mean**	**J**	**C**	**N**	**Mean**
FYM	57.38	53.43	40.49	**50.43**	34.72	32.45	25.01	**30.73**
VC	62.15	57.23	51.12	**56.83**	37.47	34.60	31.03	**34.37**
PM	59.48	57.19	44.48	**53.72**	35.91	34.58	27.16	**32.55**
SM	58.09	56.02	42.05	**52.05**	35.10	33.89	25.74	**31.58**
Mean	**59.28**	**55.97**	**44.53**		**35.80**	**33.88**	**27.24**	
	S.Em ±		**CD (P = 0.05)**		**S.Em ±**		**CD (P = 0.05)**	
M	1.466		4.298		0.889		2.607	
D	1.269		3.722		0.770		2.258	
M x D	2.538		NS		1.540		NS	
Manures	**Enzyme activity**							
	Alkaline phosphatase activity (µg PNP formed g^{-1} of soil $hour^{-1}$)				Urease activity (µg NH_4-N formed g^{-1} of soil $hour^{-1}$)			
	Decomposers				Decomposers			
	J	**C**	**N**	**Mean**	**J**	**C**	**N**	**Mean**
FYM	24.64	23.23	18.64	**22.17**	6.98	6.50	4.93	**6.13**
VC	26.33	24.56	22.36	**24.42**	7.56	6.96	6.22	**6.91**
PM	25.37	24.54	19.96	**23.29**	7.24	6.96	5.41	**6.53**
SM	24.87	24.12	19.09	**22.69**	7.07	6.81	5.12	**6.33**
Mean	**25.30**	**24.11**	**20.01**		**7.21**	**6.81**	**5.42**	
	S.Em ±		**CD (P = 0.05)**		**S.Em ±**		**CD (P = 0.05)**	
M	0.540		1.585		0.178		0.523	
D	0.468		1.373		0.154		0.453	
M x D	0.936		NS		0.309		NS	

CD at 5 % **NS** - Non-Significant **DAT**- Days After Transplanting **M** - Manures
RDF: 125:75:63 kg $N:P_2O_5:K_2O$ ha^{-1} for N equivalent FYM application **D** - Decomposers
FYM - Farm yard manure **VC –** Vermicompost **PM** - Poultry manure **SM** - Sheep manure
J – Jeevamrutha **C** - Microbial Consortia **N -** Decomposer from NCOF

Effect of different organic manures, jeevamrutha and decomposers on soil enzymatic activity

Dehydrogenase is an extra cellular enzyme in the soil and considered to play an important role in the initial stage of oxidation of soil organic matter by transferring hydrogen or electron from substrates to acceptors indicates the microbial activity in the soil. Measurement of dehydrogenase represents immediate metabolic activities of soil microorganism at the time of the test. Soil dehydrogenase activity is an oxidative degradation process *i.e.,* dehydrogenation of organic matter by transferring hydrogen and electrons from substrate to acceptors. Dehydrogenase enzymes play a significant role in the biological oxidation of soil organic matter. Dehydrogenase activity thus serves as an indicator of the microbiological redox systems and may be considered a good measure of microbial oxidative activities in soils (Casida *et al.*, 1964).

Phosphatase activity is essential for conversion of organic substrates containing phosphorus into inorganic form through hydrolysis in the soil phosphatase being an important enzyme in soil is an oxidoreductase which plays a key role in P cycle of the environment (Eivazi and Tabatabai, 1977). Urease activity is directly related to type of vegetation and quality of incorporated organic materials and with fluctuation in nutrient levels due to associated changes in population of urolytic microbes in the soil. Urease is a hydrolase enzyme responsible for hydrolytic conversion of substrate, urea into CO_2 and NH_3. Urease enzyme assay is important in understanding mineralization of N element and its response to the application of organic fertilizers. Land use system, tillage and soil management systems particularly its relations up to the agriculture practices has led to extensive research investigation in the last 3 decades (Pancholy and Rice, 1973).

In the present investigation, application of vermicompost through N equivalent recorded significantly higher enzyme activity *i.e.*, dehydrogenase activity (53.70 and 56.83 µg TPF formed g^{-1} soil day^{-1}), acid phosphatase activity (31.35 and 34.37 µg PNP formed g^{-1} soil $hour^{-1}$), alkaline phosphatase activity (21.66 and 24.42 µg PNP formed g^{-1} soil $hour^{-1}$) and urease activity (5.97 and 6.91 g NH_4-N formed g^{-1} soil $hour^{-1}$) as compared to FYM, poultry manure and sheep manure application during both the years (Table 4 and 5). These results are in conformity with finding of Clarholms (1993), Harrison (1982) and Tarafdar and Chhonkar (1978). Generally, soil enzyme activities are related to the soil organic matter content which might be improved due to inclusion of organic manure (Frankenberger and Dick, 1983). According to Ladd and Paul (1973) increase in dehydrogenase activity with increasing organic matter content and microbial population of the soil. Correlation with C: N ratio of organic manures when C: N is wide *i.e.* higher oxidizable carbon leading to proliferation of microorganisms and higher activity *i.e.* why manure having lesser decomposition would have more microbial activity.

In the present study the value of acid and alkaline phosphatase activity in treatment consists of FYM were found significant. The results of the present study support the view of Manna and Ganguly (1998) who reported phosphatase activity can be improved by the addition of organic manures in combination with inorganic fertilizer. Therefore it can be inferred that significant increase in activities of dehydrogenases and phosphatases indicates that application of sources of organic manures such as enriched vermicompost enhanced build-up of microbial biomass and also maintained higher enzymatic activities.

Application of jeevamrutha at 2000 l ha^{-1} recorded significantly higher microbial activity *viz*., dehydrogenase activity (55.91 and 59.28 µg TPF formed g^{-1} soil day^{-1}), acid phosphatase activity (32.63 and 35.80 µg PNP formed g^{-1} soil $hour^{-1}$), alkaline phosphatase activity (22.25 and 25.30 µg PNP formed g^{-1} soil $hour^{-1}$) and urease activity (6.21 and 7.21 µg NH_4-N formed g^{-1} soil $hour^{-1}$) as compared to decomoser application during both the seasons, respectively. This might be due to quick buildupof soil microflora and fauna due to the application of jeevamruthawhich has consequently increased the enzymatic activity and helped in mineralization, solubilizationof native and applied nutrients and making them available in the soil for plant uptake.This can be attributed to increased availability of nutrients like NPK and micronutrients due to enzymatic activity in soil *viz*., urease, dehydrogenase, phosphatase mediated by soil microorganisms. Such increased plant nutrient availability in soil due to enzyme activity by microorganisms was also earlier reported by Boomiraj and Christopar (2007). Among the different treatment combinations, application of vermicompost and jeevamrutha at 2000 l ha^{-1} recorded higher microbial activity *viz*., dehydrogenase activity (58.50 and 62.15 µg TPF formed g^{-1} of soil day^{-1}), acid phosphatase activity (34.12 and 37.47 µg PNP formed g^{-1} of soil $hour^{-1}$), alkaline phosphatase activity (23.58 and 26.33 µg PNP formed g^{-1} of soil $hour^{-1}$) and urease activity (6.50 and 7.56 µg NH_4-N formed g^{-1} of soil $hour^{-1}$) as compared to other treatment combinations. The urease, phosphatase and dehydrogenase activities were higher in wheat crop grown well with the application with recommended dose of N through vermicompost. Thus the results of the present study are in conformity with the Meena *et al.,* (2013) who reported soil enzymes and microbial populations (bacteria, fungi and actinomycetes) were higher due to organic manure application, but their levels and activities were not reflected in wheat crop under alluvial soils.

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