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EFFECT OF ORGANIC MANURES AND FOLIAR SPRAY OF WATER SOLUBLE FERTILIZERS ON MICROBIAL ACTIVITY IN A CHILLI (*CAPSICUM ANNUUM* L.) CROP GROWN IN A VERTISOL

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ABSTRACT

A field experiment was conducted during *kharif* 2013-14 and 2014-15 with different sources of organic manures along with foliar application of water soluble fertilizers to study the microbial activity in the soil at different stages of crop growth. The experiment consists of four main treatments as organics, M_1- Recommended Package of Practices (RPP)- {Recommended Dose of Fertilizers (RDF) + 25 t ha^{-1} FYM (Farm Yard Manure)}, M_2- 50 per cent N through FYM + 50 per cent inorganic N, M_3- 50 per cent N through VC(vermicompost) + 50 per cent inorganic N, M_4- 50 per cent N through FYM and VC + 50 per cent inorganic N and four sub treatments as water soluble fertilizers, S_1- KNO_3 @ 1 per cent, S_2- K_2SO_4 @ 1 per cent, S_3- 19:19:19 @ 1 per cent, S_4- KNO_3 + K_2SO_4 + 19:19:19 each @ 1 per cent along with one control (RPP + water spray) with three replications. Results showed that treatment M_3 recorded highest urease (23.98 μg NH_4-N g^{-1} day^{-1}), phosphatase (32.54 μg pNP g^{-1} hr^{-1}) and dehydrogenase (20.64 μg TPF/g/day) activity irrespective of growth stage. Substitution of organics enhanced the activity of enzymes in the soil.

INTRODUCTION

Soil micro-organisms play a key role in nutrient cycling in the soil. Microbial processes are an integral part of the functions of ecosystems connected with nutrient cycling, fertilization and organic matter transformation. Soils containing a high microbial diversity are characteristic of a healthy soil-plant relationship, whereas those with low microbial diversity are characterized as an unhealthy soil that often hardly responds to environmental changes (Tejada *et al.*, 2011). Both soil and enzyme systems are associated with organic manure management which carry out a wide range of processes that are important for soil health and fertility (Deshmukh and Urkude, 2014). Many studies (Anderson and Domsch 1989, Ross and Tate 1993) reported that microbial biomass and microbial activity are closely related with the content of organic matter that is positively influenced by organic matters such as post-harvest residues and organic manure. Microbial biomass is in positive correlation with the amount of organic matters supplied in a longer period, but it also responds to a single application of organic matter (Ocio *et al.*, 1991).

Application of organic manures is one of important practical measures to improve soil fertility. In addition to providing necessary nutrients for crops and improving soil physico-chemical properties, organic manures is able to enhance soil microbial activity of soil, such as improving activity of soil enzymes and increasing soil microbial biomass (Ren *et al.*, 1996; Sun *et al.*, 2003; Lv *et al.*, 2005). Most organic manures added into soil contain polymeric compounds and thus the decomposition of these organic matters depends on the microbial production of extracellular enzymes and their break down should occur before taking up of low molecular weight organic molecules by microbial cells. Because the growth and activity of microorganisms are sensitive functions of soil properties including nutrition, texture, pH, temperature, and water content, dynamic changes of microbial community can represent the improving effects of different types and amounts of organic materials on soil quality. If only nitrogen fertilizers are applied, the rate of organic matter mineralization increases, leading to a decrease in the content of easily decomposable organic matter in the soil that is related with a decrease in microbial biomass content (Collins *et al.*, 1992). Hence an attempt was made to increase the enzyme activity with the substitution of organic manures.

MATERIALS AND METHODS

An experiment was conducted during *kharif* 2013-14 and 2014-15 in farmer's field in Dharwad district situated in the northern transitional zone of Karnataka. The soil of the experimental site was *Typic Chromustert* and soil reaction was neutral (7.44). The organic carbon content of experimental soil was 6.10 g kg^{-1}, low in available nitrogen (171 kg ha^{-1}), medium in P_2O_5 (25.8 kg ha^{-1}) and medium in K_2O (235 kg ha^{-1}) and were determined by standard procedures (Jackson, 1967). The experiment consists of four main treatments as organics, M_1- Recommended Package of Practices (RPP)- {Recommended Dose of Fertilizers (RDF) + 25 t ha^{-1} FYM}, M_2- 50 per cent N through FYM + 50 per cent inorganic N, M_3- 50 per cent N through VC + 50 per cent inorganic N, M_4- 50 per cent N through FYM and VC + 50 per cent inorganic N and four sub treatments as water soluble fertilizers, S_1- KNO_3 @ 1 per cent, S_2- K_2SO_4 @ 1 per cent, S_3- 19:19:19 @ 1 per cent, S_4- KNO_3 + K_2SO_4 + 19:19:19 each @ 1 per cent along with one control (RPP + water spray) with three replications. The design adopted was split plot. The cultivar used for the experiment was Dyvanur with a spacing of 75 x 75 cm. Foliar sprays were given on 45th DAT (Days After Transplanting) and 90th DAT except for the sub plot treatment (S_4) which received combined spray of KNO_3, K_2SO_4, 19:19:19 given at 45th DAT with 10 days interval for each spray.

Urease activity

The reaction mixture comprising of 10 g of soil, 1 ml of toluene, 10 ml of phosphate buffer (pH 6.7) and 10 ml of 10 per cent urea solution in distilled water was incubated at 30ºC for 24 hours, later 15 ml of 1 N KCl solution was added. One ml of aliquot filtrate was mixed with 2 ml of 10 per cent sodium tartarate solution and 0.5 ml of Nessler's reagent. The intensity of yellow colour developed was read in spectrophotometer after 30 minutes at 610 nm (Pancholy and Rice, 1973) against blank.

Dehydrogenase activity

To five grams of soil in a stoppered test tube, 2.5 ml of distilled water and one ml of 2, 3, 5-triphenyl tetrazolium chloride (3%) were added and incubated at 37ºC for 24 hours. The supernatant was filtered through Whatman No. 50 filter paper and the soil was washed repeatedly with methanol till the filtrate was free from red colour and the pooled filtrate was diluted to 100 ml. The colour intensity was measured at 485 nm in a spectrophotometer (Casida *et al.*, 1964).

Phosphatase activity

The reaction mixture comprising of one g of soil, 0.2 ml toluene, four ml modified universal buffer (pH 7.5) and one ml of p-nitrophenol phosphate solution were mixed and incubated at 37ºC for one hour. One ml of 0.5 M $CaCl_2$ $2H_2O$ and four ml of 0.5 M NaOH were added, swirled and filtered. The intensity of yellow colour was measured at 420 nm against the reagent blank (Evasi and Tabatabi, 1979).

RESULTS AND DISCUSSION

Urease activity

At 60 DAT, urease enzyme activity was significantly influenced by organic manures but foliar spray of water soluble fertilizers have not influenced urease activity (Table 1). Highest urease enzyme activity (23.98 μg NH_4-N/g/day) was recorded with the 50 per cent substitution of inorganic nitrogen through vermicompost, while lowest (17.13 μg NH_4-N/g/day) was recorded in the control. 50 per cent substitution of inorganic nitrogen through FYM + vermicompost and 50 per cent substitution of inorganic nitrogen through FYM alone also recorded significantly higher urease activity (23.44 and 21.74 μg NH_4-N/g/day for M_4 and M_2 respectively) than control. At 90 DAT highest enzyme activity (15.33 μg NH_4-N/g/day) was recorded with the 50 per cent substitution of inorganic nitrogen through vermicompost, while lowest (9.82 μg NH_4-N/g/day at) was recorded in the control (RPP + water spray).

This might be attributed to higher nitrogen content and faster decomposition of organic manures and release of ammoniacal N (Saha *et al.,* 2008; Meena *et al.,* 2013; Meena *et al.,* 2014). The decrease in urease activity (Maestre *et al.*, 2011) noticed with addition of inorganic nitrogen and increased urease activity was noticed with crop residues and organic manure additions (Fig.1). The carbon source applied to soils through organic manures stimulates microbial population which inturn increased the enzyme activity. Further organic carbon content is higher in the treatment that received 50 per cent organic nutrient management practice when compared to conventional method. The higher enzyme activity might be due to the fact that residue decomposition from the organic litter may have added synergizing effect on microbial activity (Tejada *et al.,* 2010).

Phosphatase activity

Highest phosphatase activity (32.54 μg pNP/g/hr) was recorded with 50 per cent substitution of inorganic nitrogen through vermicompost, while lowest (17.90 μg pNP/g/hr) was recorded in the control (RPP + water spray) at 60 DAT (Table 2). Highest enzyme activity (21.79 μg NH_4-N/g/day) was recorded with the 50 per cent substitution of inorganic nitrogen through vermicompost, while lowest (12. 33 ìg pNP/g/hr) was recorded in the control at 90 DAT.

The higher phosphatase activity in soil under organic substituted treatments was due to enhanced carbon content in soil that stimulated microbial multiplication leading to increased decomposition process (Fig.2). Further plant roots and their exudates stimulate enzyme activity because of their positive effect on microbial activity (Tejada *et* al., 2010).. Similar results were obtained by The highest phosphatase activity was recorded (Meena *et al.*, 2014) with 100 per cent substitution of RDN with concentrate organic manure. reported that the addition of organic substances to the soil served as a carbon source (Sriramachandrasekharan and Ravichandran 2011) that enhanced microbial biomass and phosphatase activity, showing that these enzymes are of microbiological origin (Bohem *et al.*, 2005).

Dehydrogenase activity

Highest dehydrogenase activity (20.64 μg TPF/g/day) was recorded with the 50 per cent substitution of inorganic nitrogen through vermicompost, while lowest (10.82 μg TPF/g/day) was recorded in the control (RPP + water spray) at 60 DAT. Substitution of 50 per cent inorganic nitrogen through FYM + vermicompost and 50 per cent substitution of inorganic nitrogen through FYM alone (M_2) were also recorded significantly higher enzyme activity (18.76 and 14.98 μg TPF/g/day for M_4 and M_2 respectively) than control (Table 3). At 90 DAT, the same trend was followed with respect to dehydrogenase activity. Highest activity (16.27 μg NH_4-N/g/day) was recorded with 50 per cent substitution of inorganic nitrogen through vermicompost (M_3), while lowest (8.00 μg TPF/g/day) was recorded in the control (RPP + water spray).

The higher dehydrogenase activity after addition of vermicompost might be due to increased microbial population, which is known to stimulate the dehydrogenase activity in soil (Watts *et al.*, 2010). Dehydrogenase activity was also brought about by the changes in soil organic carbon (Aon and Colaneri, 2001) as higher level of organic carbon serves as

Table 1: Urease activity ($\mu g\ NH_4$-N $g^{-1}\ day^{-1}$) in soil at different growth stages as influenced by organics and foliar spray of water soluble fertilizers

Treatments		2013-14					2014-15					Pooled				
		S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
M_1	60 DAT	17.57	17.13	17.62	18.28	17.65	18.89	18.77	18.46	19.15	18.82	18.23	17.95	18.04	18.72	18.23
	90 DAT	9.77	9.33	9.77	9.77	9.66	10.71	10.82	10.72	11.02	10.82	10.24	10.08	10.24	10.39	10.24
M_2	60 DAT	20.20	20.09	20.13	21.71	20.53	23.07	22.21	22.68	23.82	22.94	21.63	21.15	21.40	22.76	21.74
	90 DAT	12.07	12.00	12.00	13.63	12.43	14.38	13.32	12.82	14.53	13.76	13.22	12.66	12.41	14.08	13.09
M_3	60 DAT	22.67	22.84	23.86	24.18	23.39	24.71	24.15	24.61	24.79	24.57	23.69	23.50	24.24	24.49	23.98
	90 DAT	14.40	14.63	14.30	14.63	14.49	16.39	15.83	15.74	16.69	16.16	15.39	15.23	15.02	15.66	15.33
M_4	60 DAT	22.31	21.98	22.74	22.77	22.45	24.54	23.98	23.85	25.32	24.42	23.43	22.98	23.30	24.05	23.44
	90 DAT	14.17	13.87	13.63	13.37	13.76	15.76	14.93	14.87	15.70	15.32	14.96	14.40	14.25	14.53	14.54
Mean	60 DAT	20.69	20.51	21.09	21.74		22.80	22.28	22.40	23.27		21.75	21.39	21.75	22.50	
	90 DAT	12.60	12.46	12.43	12.85		14.31	13.73	13.54	14.48		13.45	13.09	12.98	13.67	
Control			60 DAT		90 DAT		60 DAT		90 DAT		60 DAT		90 DAT			
			16.49		9.03		17.77		10.60		17.13		9.82			
Sources			60 DAT		90 DAT		60 DAT		90 DAT		60 DAT		90 DAT			
M	S.Em+		0.34		0.36		0.35		0.47		0.33		0.39			
	CD (0.05)		1.17		1.25		1.22		1.63		1.15		1.34			
S	S.Em+		0.40		0.22		0.30		0.26		0.28		0.19			
	CD (0.05)		NS		NS		NS		NS		NS		NS			
M x S	S.Em+		0.80		0.44		0.60		0.52		0.56		0.37			
	CD (0.05)		NS		NS		NS		NS		NS		NS			
Control	S.Em+		0.73		0.49		0.61		0.60		0.56		0.46			
	CD (0.05)		2.11		1.42		1.74		1.73		1.61		1.33			

Note : M_1 – RPP; M_2 – 50% N through FYM + 50% inorganic N; M_3 – 50% N through VC + 50% inorganic N; M_4 – 50% N through FYM and VC + 50% inorganic N; S_1 – KNO_3 @ 1%; S_2 – K_2SO_4 @ 1% ; S_3 – 19:19:19 @ 1%; S_4 – KNO_3 + K_2SO_4 + 19:19:19 each @ 1%; Control – RPP with water spray; Recommended dose of P and K are common to all the treatments, DAT- Days After Transplanting; NS – Non-significant

Table 2: Phosphatase activity (μg pNP g^{-1} hr^{-1}) in soil at different growth stages as influenced by organics and foliar spray of water soluble fertilizers

Treatments		2013-14					2014-15					Pooled				
		S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
M_1	60 DAT	17.90	17.83	18.33	18.57	18.16	19.57	20.00	20.63	20.43	20.16	18.73	18.92	19.48	19.50	19.16
	90 DAT	11.70	11.73	12.23	12.47	12.03	13.83	13.97	14.50	14.53	14.21	12.77	12.85	13.37	13.50	13.12
M_2	60 DAT	21.77	22.17	22.50	23.00	22.36	24.77	25.13	24.30	25.87	25.02	23.27	23.65	23.40	24.43	23.69
	90 DAT	14.17	14.27	14.60	14.73	14.44	16.27	15.70	16.13	16.97	16.27	15.22	14.98	15.37	15.85	15.35
M_3	60 DAT	30.23	29.87	31.17	30.83	30.53	33.83	34.10	35.40	34.87	34.55	32.03	31.98	33.28	32.85	32.54
	90 DAT	20.03	19.67	20.70	20.63	20.26	23.90	22.93	23.07	23.40	23.33	21.97	21.30	21.88	22.02	21.79
M_4	60 DAT	25.60	25.47	26.20	26.13	25.85	29.40	29.43	30.57	30.33	29.93	27.50	27.45	28.38	28.23	27.89
	90 DAT	17.50	17.37	18.10	18.03	17.75	18.97	18.90	19.53	19.87	19.32	18.23	18.13	18.82	18.95	18.53
Mean	60 DAT	23.88	23.83	24.55	24.63		26.89	27.17	27.73	27.88		25.38	25.50	26.14	26.25	
	90 DAT	15.85	15.76	16.41	16.47		18.24	17.88	18.31	18.69		17.05	16.82	17.36	17.58	
Control			60 DAT		90 DAT		60 DAT		90 DAT		60 DAT		90 DAT			
			16.50		10.83		19.30		13.83		17.90		12.33			
Sources			60 DAT		90 DAT		60 DAT		90 DAT		60 DAT		90 DAT			
M	S.Em+		0.19		0.17		0.32		0.20		0.15		0.13			
	CD (0.05)		0.64		0.58		1.12		0.67		0.52		0.45			
S	S.Em+		0.25		0.23		0.44		0.32		0.26		0.22			
	CD (0.05)		NS		NS		NS		NS		NS		NS			
M x S	S.Em+		0.50		0.47		0.88		0.64		0.51		0.44			
	CD (0.05)		NS		NS		NS		NS		NS		NS			
Control	S.Em+		0.46		0.47		0.81		0.57		0.46		0.41			
	CD (0.05)		1.33		1.34		2.33		1.63		1.32		1.18			

Note : M_1 – RPP M_2 – 50% N through FYM + 50% inorganic N; M_3 – 50% N through VC + 50% inorganic N; M_4 – 50% N through FYM and VC + 50% inorganic N; S_1 – KNO_3 @ 1%; S_2 – K_2SO_4 @ 1%; S_3 – 19:19:19 @ 1%; S_4 – KNO_3, K_2SO_4 + 19:19:19 each @ 1% ; Control – RPP with water spray ; Recommended dose of P and K are common to all the treatments, DAT- Days After Transplanting; NS – Non-significant

Table 3: Dehydrogenase activity (μg TPF/g/day) in soil at different growth stages as influenced by organics and foliar spray of water soluble fertilizers

Treatments		2013-14					2014-15					Pooled				
		S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
M_1	60 DAT	12.00	12.20	11.87	11.77	11.96	13.13	12.67	12.83	12.97	12.90	12.57	12.43	12.35	12.37	12.43
	90 DAT	7.33	7.17	7.50	7.43	7.36	8.67	8.27	9.00	9.13	8.77	8.00	7.72	8.25	8.28	8.06
M_2	60 DAT	14.33	14.10	14.67	14.73	14.46	15.37	15.20	15.77	15.71	15.51	14.85	14.65	15.22	15.22	14.98
	90 DAT	9.43	9.40	9.77	9.83	9.61	11.23	10.83	11.67	12.50	11.56	10.33	10.12	10.72	11.17	10.58
M_3	60 DAT	19.83	19.73	19.90	20.07	19.88	20.63	20.55	22.10	22.30	21.40	20.23	20.14	21.00	21.18	20.64
	90 DAT	14.77	14.63	14.97	14.93	14.83	17.63	17.33	17.80	18.10	17.72	16.20	15.98	16.38	16.52	16.27
M_4	60 DAT	18.20	18.10	18.53	18.53	18.34	19.37	18.80	19.23	19.33	19.18	18.78	18.45	18.88	18.93	18.76
	90 DAT	13.37	13.30	13.70	13.73	13.53	14.60	13.93	14.23	14.63	14.35	13.98	13.62	13.97	14.18	13.94
Mean	60 DAT	16.09	16.03	16.24	16.28		17.13	16.80	17.48	17.58		16.61	16.42	16.86	16.93	
	90 DAT	11.23	11.13	11.48	11.48		13.03	12.59	13.18	13.59		12.13	11.86	12.33	12.54	
Control		60 DAT		90 DAT		60 DAT		90 DAT		60 DAT		90 DAT				
		9.77		7.30		11.87		8.70		10.82		8.00				
Sources		60 DAT		90 DAT		60 DAT		90 DAT		60 DAT		90 DAT				
M	S.Em+	0.39		0.21		0.35		0.47		0.31		0.24				
	CD (0.05)	1.36		0.74		1.21		1.63		1.06		0.82				
S	S.Em+	0.13		0.12		0.39		0.36		0.21		0.19				
	CD (0.05)	NS		NS		NS		NS		NS		NS				
M x S	S.Em+	0.26		0.23		0.78		0.71		0.43		0.37				
	CD (0.05)	NS		NS		NS		NS		NS		NS				
Control	S.Em+	0.41		0.26		0.69		0.74		0.44		0.38				
	CD (0.05)	1.19		0.74		1.97		2.13		1.26		1.11				

Note : M_1 – RPP; M_2 – 50% N through FYM + 50% inorganic N; M_3 – 50% N through VC + 50% inorganic N; M_4 – 50% N through FYM and VC + 50% inorganic N; S_1 – KNO_3 @ 1%; S_2 – K_2SO_4 @ 1%; S_3 – 19:19:19 @ 1%; S_4 – KNO_3 + K_2SO_4 + 19:19:19 each @ 1%; Control – RPP with water spray ; Recommended dose of P and K are common to all the treatments, DAT- Days After Transplanting; NS – Non-significant

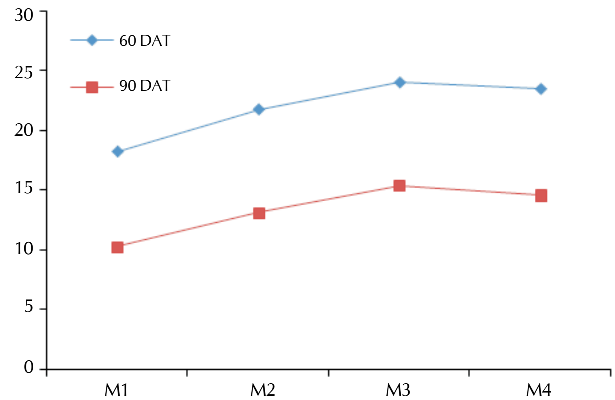

Figure 1: Urease activity (µg NH_4-N g^{-1} day^{-1}) in soil at 60 and 90 DAT as influenced by organics

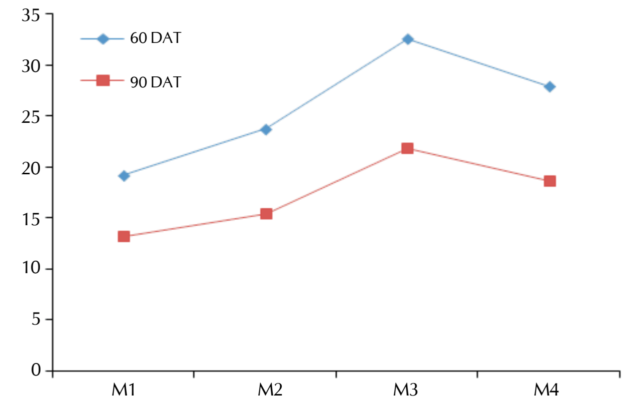

Figure 2: Phosphatase activity (µg pNP g^{-1} hr^{-1}) in soil at 60 and 90 DAT as influenced by organics

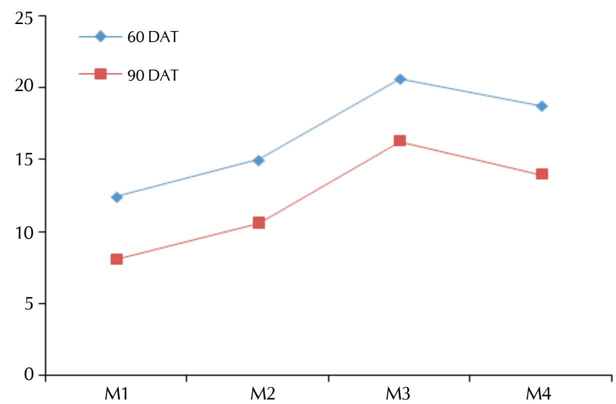

Figure 3: Dehydrogenase activity (µg TPF/g/day) in soil at 60 and 90 DAT as influenced by organics

source of energy that stimulated microbial activity (Fig.3). Higher dehydrogenase enzyme activity in soil due to application of vermicompost obtained from cow dung continuously for three years (Tejada *et al.,* 2011).

Soil microbial biomass has been suggested to be a sensitive indicator of changes in total soil organic matter given that it more readily responds to alterations in plant vegetation or land use. The biological component of the soil is responsible for soil humus formation, cycling of nutrients and building soil structure along with many other functions. Knowledge about soil microorganisms and soil biological processes may improve the scientific basis of management decisions.

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