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Impact of biodynamic preparations and *panchgavya* in organically managed cropping systems comprising legumes on soil biological health

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ABSTRACT

Biological health of soil was assessed to understand the effect of varingly managed organic cropping systems under field conditions. Twelve treatment combinations comprised two cropping systems (CS_1-Basmati rice-Chickpea-*Sesbania* green manure ;CS_2-Basmati rice-Vegetable pea-Maize (green cob & Fodder) + Green gram (residues incorporation) and six organic nutrient manangement practices- T_1: Farmyard manure + Vermicompost + Enriched Compost + Neem Cake, T_2: Biodynamic Preparations, T_3: Farmyard manure + Vermicompost + Enriched Compost + Neem Cake + *Panchgavya*, T_4: Farmyard manure + Vermicompost + Enriched Compost + Neem Cake + Biodynamic Preparations, T_5: Farmyard manure + Vermicompost + Enriched Compost + Neem Cake + Biodynamic Preparations + *Panchgavya*, T_6: Control. The highest activity of different soil enzymes *viz.*, dehydrogenase, acid, alkaline and total phosphatase; and aryl sulfatase was assessed to the tune of 1311.02 µg Tri Phenyl Formazan $24h^{-1}g^{-1}$ soil at flowering in '*spring*', 26.99 µg p-nitrophenol $h^{-1}g^{-1}$ soil, 35.19 µg p-nitrophenol $h^{-1}g^{-1}$ soil, 62.18 µg p-nitrophenol $h^{-1}g^{-1}$ soil and 77.75 µg p-nitrophenol $h^{-1}g^{-1}$ soil at harvest of '*rabi*' crop, respectively receiving the organic nutrient package through T_5. Significantly enhanced microbial population and their biomass facilitating the enhanced mineralization of nitrogen to the tune of 150.10 µg NH_4^+-N g^{-1} soil with nutrient management practices employed through T_5 was observed.

Key words: Biodynamic, Cropping systems, Microbial biomass carbon, Mineralizable nitrogen, Organic nutrient management, Panchgavya, Soil biological health, Soil enzymes.

INTRODUCTION

Soil is the most important natural resource in agriculture and it is considered as a living organism as it is diverse, full of life and energies. Sustainable agriculture is unifying concept, which considers ecological, environmental, philosophical, ethical and social impacts, balanced with cost effectiveness. Soil quality is considered to be a key element in sustainable agriculture. Organic management of agricultural soils positively influences soil properties (Tu *et al.*, 2006) since the addition of organic amendments improves soil organic matter (SOM) accumulation by increasing carbon (C) pools with a slow turnover time (Lal and Kimble, 1997).

Heavy use of chemicals in intensive agriculture has weakened the ecological base in addition to degrading the soil, water resources and quality of the food. To overcome the adverse impact of intensive cultivation scientific community and farmers are working hand in hand to develop a strong workable and compatible package of nutrient management through organic resources for various crops based on scientific facts, local conditions and economic viability.

Biodynamic techniques enhance, rejuvenate, add to and maintain soil quality in terms of biological properties. The biodynamic system places its emphasis on the use of cow-horn manure (BD 500 preparation) and horn silica (BD 501 preparation) which are claimed to enhance soil biological activity (Koepf, 1989). *Panchgavya* is another source of nutrient management in organic farming. It is a combination of five products of cow origin such as cow dung, urine, milk, curd and ghee. It contains bacteria, fungi, protein, carbohydrates, fats and some growth promoting factors.

The positive impact of biodynamic practices and '*panchgavya*' alone or in combination with various organic nutrient management practices has been found in various crops (Shwetha, 2007; Chandrakala, 2008). However, very scarce literature is available depicting the impact of biodynamic preparation and '*panchgavya*' either alone/ in combination with various other organic nutrient resources

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under different cropping systems on biological soil health. Therefore, the studies were undertaken to understand how the biodynamic preparations and '*panchgavya*' in isolation and along with various organic nutrient management practices influences the various soil biological health parameters under different cropping systems comprising legumes.

MATERIALS AND METHODS

The soil samples from 0-15 cm depth were collected at different crop growth stages *viz.*, during '*rabi*' at flowering (RF) and at harvest (RH) in 2009-10 and during '*spring*' at flowering (SF) in 2010 from the experiment initiated during *Kharif* 2009 under All India Network Project on Organic Farming at Seed Production Centre of G.B.P.U.A.&T., Pantnagar. The experiment was laid down in a split plot design with three replication with twelve treatment combinations. The detailed treatment combinations are given in Table 1.

The initial pH, EC and bulk density of the experimental site was 6.90, 0.136 dSm^{-1} and 1.25 gcm^{-3} with 1.25% organic carbon, available N, P and K 196.00, 26.24 and 141.20 Kg ha^{-1} respectively.

The soil samples were collected separately at different stages of crop growth prior to estimation of soil biological properties. The field moist samples were preserved in refrigerator at 4ºC till the soil biological properties were assessed.

The biological properties like total microbial count in soil was determined by Serial dilution technique (Wollum, 1982) using plate count agar (bacteria), Martin's Rose-Bengal streptomycin medium (for fungi) and Ken-knight and Munaier's medium (for actinomycetes) and expressed as cfu g^{-1} of oven dry soil. Soil microbial biomass carbon was estimated by chloroform fumigation and extraction technique (Jenkinson, 1988). Field moist soil (25g) was fumigated with ethanol free chloroform at 25ºC for 24 h. After removal of chloroform vapour by repeated evacuation, the soils were then extracted with 0.5M K_2SO_4. Controls were prepared by extracting soils without fumigation. $C_{mic.}$ was calculated from the differences in extractable C_{org} between the fumigated and non fumigated soil and expressed as µg g^{-1} of soil. For estimation of acid and alkaline phosphatase activity in soil modified universal buffer having pH 6.5 and 11.0, respectively and artificial substrate, p-nitrophenyl phosphate (PNP) was used. The product of acid and alkaline phosphatase activity, p-nitrophenol was detected colorimetrically at 410 çm (Tabatabai and Bremner, 1969) and expressed as µg p-nitrophenol h^{-1} g^{-1} of soil. Soil dehydrogenase activity was determined through the reduction of triphenyl tetrazolium chloride (TTC) to triphenyl formazan (TPF) as described by Casida *et al.* (1964). The moist soil (1g) was treated with 1ml of 3% TTC, and then incubated at 28ºC for 24 hr. Reduced product (TPF)was extracted with methanol, centrifuged, and the supernatent's absorbance was read at 485 ηm using spectrophotometer and expressed as µg TPF 24 h^{-1} g^{-1} optical density of soil.

Aryl sulfatase activity in soil was determined by using an artificial substrate, p-nitrophenyl sulfate (PNS). The product of aryl sulfatase activity, p-nitrophenol was detected colorimetrically at 410 ηm (Tabatabai and Bremner, 1970) and expressed as µg p-nitrophenol h^{-1} g^{-1} optical density of soil. Soil mineralizable nitrogen was determined by

TABLE 1: Details of the treatment combinations along with nutrient levels in various crops

Cropping Systems: 2

CS_1: Basmati rice-Chickpea-*Sesbania* green manure

CS_2: Basmati rice-Vegetable pea-Maize (green cob & Fodder) + Green gram (residues incorporation)

Organic/biodynamic nutrient management practices: 6

Treat. \ Crops	Vegetable pea	Chickpea	Maize+Green gram	Basmati Rice
T1	8t FYM + 8t EC + 2.12t VC + 2.65q NC/ha	8t FYM + 8t EC + 2.12t VC + 2.65q NC/ha	26.5t FYM + 26.5t EC + 2.12t VC + 1.2t NC/ha	9.28t FYM + 9.28t EC + 2.12t VC + 0.4t NC/ha
T2	BD500; BD501; CPP	BD500; BD 501; CPP	BD500; BD 501; CPP	BD500; BD 501; CPP
T3	T1 + *Panchgavya*	T1 + *Panchgavya*	T1 + *Panchgavya*	T1 + *Panchgavya*
T4	T1 + T2	T1 + T2	T1 + T2	T1 + T2
T5	T4 + *Panchgavya*	T4 + *Panchgavya*	T4 + *Panchgavya*	T4 + *Panchgavya*
T6	Control	Control	Control	Control

BD-500: Two foliar application @ 30g BD-500 in 15 litres water per acre to soil before sowing or at transplanting of crop.

BD-501: Two foliar application @ 1g BD-501 in 15 litres water per acre to soil i.e at two leaf stage and after fruit setting stage.

Cow Pat Pit (CPP): Foliar spray/seed treatment/root dipping @ 5kg CPP in 20 litre of water. Three sprays were given:- at two leaf stage, flowering and fruit setting stage.

Panchgavya: Applied @ 30ml/litre. Two sprays:- 15 days before flowering and 15 days after flowering.

incubation method at 40ºC for 7 days under aerobic conditions. Samples were extracted using 2M KCl following the method of Stanford and Smith (1972) and expressed as µg NH_4^+-N g^{-1} soil.

RESULTS AND DISCUSSION

Microbial population: Microbial population in terms of cfu of bacteria, fungi and actinomycetes per g of soil was recorded as influenced by the cropping systems, various organic nutrient management practices alone and in combination with biodynamic preparations *i.e.* BD 500, BD 501 and '*panchgavya*'. During '*rabi*', cropping systems influenced the bacterial and actinomycetes population significantly at flowering as well as harvest (Table 2 & 3). CS_1 supported the bacterial population of 1.72 x 10^7 cfu g^{-1} soil at flowering and 2.53 x 10^7 and 4.22 x 10^7 cfu g^{-1} soil at harvest of '*rabi*' crop *i.e.* chickpea and flowering of spring crop, respectively. The fungal population was higher under CS_2, although significantly higher at flowering of '*rabi*' crop i.e. greengram only (Table 4). Cropping systems-1 comprising basmati rice-chickpea-*Sesbania* green manure significantly supported the higher microbial population of 5.38 x 10^7, 7.94 x 10^7 and 10.24 x 10^7 cfu g^{-1} of soil at flowering, harvest of '*rabi*' crop and flowering of '*spring*' crop, respectively (Fig. 1). Population of bacteria, actinomycetes, fungi and total was significantly greater in the soil receiving organic nutrients and biodynamic

TABLE 2: Effect of cropping systems, organic nutrient management practices, biodynamic preparations and '*panchgavya*' on bacterial population (x10^7 cfu g^{-1} soil) during '*rabi*' and '*spring*' season

NM \ CS	Rabi						Spring		
	At flowering			At harvest			At flowering		
	CS-1	CS-2	Mean	CS-1	CS-2	Mean	CS-1	CS-2	Mean
T1:FYM+VC+ EC + NC	1.73	1.19	1.46	2.59	1.36	1.98	4.59	4.24	4.42
T2: BD	1.70	1.16	1.43	2.58	1.34	1.96	4.22	4.20	4.21
T3: T1 + *Panchgavya*	1.75	1.21	1.48	2.64	1.37	2.01	4.61	4.52	4.57
T4 : T1 + T2	1.76	1.24	1.50	2.85	1.38	2.12	4.62	4.58	4.60
T5 : T4 + *Panchgavya*	1.78	1.26	1.52	2.87	1.40	2.14	4.73	4.73	4.73
T6 : Control (Green manure/ Green gram residue only)	1.59	1.05	1.32	1.64	1.15	1.40	2.54	2.04	2.29
Average	1.72	1.19		2.53	1.33		4.22	4.05	
	CS	NM	CS × NM	CS	NM	CS × NM	CS	NM	CS × NM
C.D≤0.05	0.39	0.11	NS	0.27	0.39	NS	NS	0.69	NS

TABLE 3: Effect of cropping systems, organic nutrient management practices, biodynamic preparations and '*panchgavya*' on actinomycetes population (x10^7 cfu g^{-1} soil) during '*rabi*' and '*spring*' season

NM \ CS	Rabi						Spring		
	At flowering			At harvest			At flowering		
	CS-1	CS-2	Mean	CS-1	CS-2	Mean	CS-1	CS-2	Mean
T1:FYM+VC+ EC + NC	3.37	2.69	3.03	5.42	2.67	4.05	6.08	5.26	5.67
T2: BD	3.35	2.64	3.00	5.40	2.65	4.03	6.01	5.19	5.60
T3: T1 + *Panchgavya*	3.48	2.70	3.09	5.46	2.72	4.09	6.14	5.33	5.74
T4 : T1 + T2	3.82	2.72	3.27	5.49	2.73	4.11	6.16	5.60	5.88
T5 : T4 + *Panchgavya*	3.83	2.75	3.29	5.57	2.74	4.16	6.18	5.64	5.91
T6 : Control (Green manure/ Green gram residue only)	3.28	2.39	2.84	4.11	2.56	3.34	4.63	3.39	4.01
Average	3.52	2.65		5.24	2.68		5.87	5.07	
	CS	NM	CS × NM	CS	NM	CS × NM	CS	NM	CS × NM
C.D≤0.05	0.12	0.29	NS	1.18	0.41	0.58	NS	0.52	NS

TABLE 4 : Effect of cropping systems, organic nutrient management practices, biodynamic preparations and '*panchgavya*' on fungal population (x10^6 cfu g^{-1} soil) during *'rabi'* and '*spring*' season

CS / NM	Rabi						Spring		
	At flowering			At harvest			At flowering		
	CS-1	CS-2	Mean	CS-1	CS-2	Mean	CS-1	CS-2	Mean
T1:FYM+VC+ EC + NC	1.47	1.89	1.68	1.81	1.83	1.82	1.54	1.64	1.59
T2: BD	1.45	1.88	1.67	1.79	1.78	1.79	1.51	1.60	1.56
T3: T1 + *Panchgavya*	1.48	1.91	1.70	1.82	1.85	1.84	1.57	1.63	1.60
T4 : T1 + T2	1.50	1.96	1.73	1.88	1.87	1.88	1.58	1.66	1.62
T5 : T4 + *Panchgavya*	1.51	2.00	1.76	1.92	1.89	1.91	1.60	1.67	1.64
T6 : Control (Green manure/ Green gram residue only)	1.10	1.09	1.10	1.02	1.41	1.22	1.15	1.22	1.19
Average	1.42	1.79		1.71	1.77		1.49	1.57	
	CS	NM	CS × NM	CS	NM	CS × NM	CS	NM	CS × NM
C.D≤0.05	0.29	0.11	0.15	NS	0.21	0.30	NS	0.13	NS

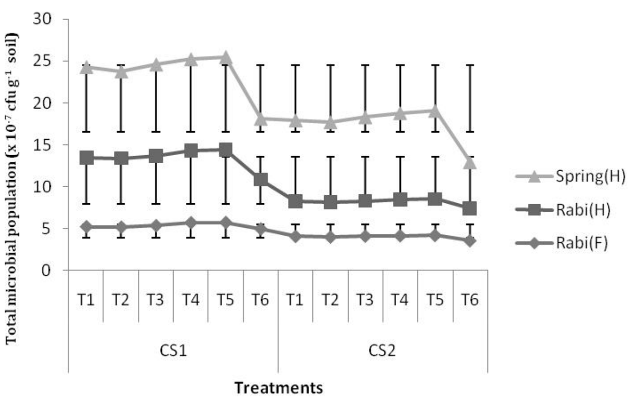

FIG 1: Effect of cropping systems, organic nutrient management practices, biodynamic preparations and '*panchgavya*' on total microbial population during '*rabi*' and *'spring'* season

preparations. Application of FYM, EC, NC, VC, biodynamic prepararations and '*panchgavya'* (T_5) supported the higher population of bacteria, actinomycetes and fungi at all stages of '*rabi'* and '*spring'* season crops. The highest total microbial population under T_5 was 4.98 x 10^7, 6.48 x 10^7 and 10.81 x 10^7 cfu g^{-1} soil at flowering, harvest of '*rabi'* crops and flowering of '*spring'* crop, respectively (Fig. 1). The data on fungi, actinomycetes, bacteria and total microbial count indicate that incorporation of organic manures provided a condusive environment for microbial proliferation due to increased organic C, mineral N and total N content of soils. The greater biomass C and N flush values, measure of microbial population, in amended soils were recorded (Dinesh *et al.*, 2000).

Overall interaction effect of CS x NM practices on individual group of microbes was non-significant although, it was supporting under respective CS x NM interactions when compared with control. However, the interaction effect between CS x NM resulted in significantly greater total microbial population during both the seasons. At all the stages CS_1 x T_5 supported the highest microbial population of 5.76 x 10^7, 8.63 x 10^7 and 11.07 x 10^7 cfu g^{-1} soil at RF, RH and SF stages, respectively (Fig. 1). The significant increase in microbial population in the presence of organic amendments could be ascribed to the availability of the more substrate carbon. The results are corroborated with that of Goyal, *et al.* (1992), Hasebe, *et al.* (1985). Incorporation of organic sources as nutrients resulted in elevated soil microbial population in comparison to inorganic and no fertilizer application in basmati rice.

Microbial biomass carbon: Microbial biomass carbon is a good indicator of microbially available C. It is the most active and dynamic pool of the soil organic matter, functions as soil transient nutrient's sink. In our experiment, among two cropping systems the highest microbial biomass carbon to the tune of 319.44 µg g^{-1} soil was supported under CS_1 at flowering of *'spring'* crop (Table 5). Among the different treatment combinations the T_5 supported the highest soil MBC (281.91 µg g^{-1} soil) during '*rabi'* at harvest and 325.34 µg g^{-1} soil during *'spring'* which was 32 and 44 per cent higher compared to respective control (T_6).

Highest amount of microbial biomass carbon 292.57, 285.49 and 395.02 µg g^{-1} soil was synthesized due to interaction effect of CS_2 and CS_1 in combination with T_5 organic NM practices, during RF, RH and SF stages, respectively. However, overall the lowest soil microbial

TABLE 5: Effect of cropping systems, organic nutrient management practices, biodynamic preparations and '*panchgavya*' on microbial biomass carbon (μg g^{-1} soil) during '*rabi*' and '*spring*' season

CS / NM	Rabi						Spring		
	At flowering			At harvest			At flowering		
	CS-1	CS-2	Mean	CS-1	CS-2	Mean	CS-1	CS-2	Mean
T1:FYM+VC+ EC + NC	221.65	245.49	233.57	276.73	279.65	278.19	285.54	251.49	268.52
T2: BD	221.41	244.91	233.16	271.33	269.33	270.33	284.59	249.41	267.00
T3: T1 + *Panchgavya*	232.57	248.85	240.71	276.93	280.41	278.67	321.98	252.57	287.28
T4 : T1 + T2	258.41	284.25	271.33	277.65	281.33	279.49	384.02	253.57	318.80
T5 : T4 + *Panchgavya*	269.65	292.57	281.11	278.33	285.49	281.91	395.02	255.65	325.34
T6 : Control (Green manure/ Green gram residue only)	206.73	219.65	213.19	206.73	206.73	206.73	245.49	206.73	226.11
Average	235.07	255.95		264.62	267.16		319.44	244.90	
	CS	NM	CS × NM	CS	NM	CS × NM	CS	NM	CS × NM
C.D≤0.05	NS	24.16	NS	NS	25.01	NS	55.52	29.65	41.95

biomass carbon of 206.73 μg g^{-1} soil was estimated in CS_1 /CS_2 x T_6 at RF, RH and SF stages, respectively (Table 5). Organic NM practices consisting of biodynamic preparations and '*panchgavya*' application, as additional organic components, had supported the greater microbial population contributing to the enhanced soil microbial biomass carbon (Table 5). The microbial biomass carbon which constitutes the active fraction of soil organic matter (Paul and Voroney, 1984) also improved under the nutrient management practices consisting of organics (Table 5). This could be due to swift in oxidation of organic matter caused due to the elevated levels of microorganisms, residual effect of green manures and better plant root growth (Katyal *et al.*, 2003; Kumar and Yadav, 2003). Bolton *et al.* (1985) reported increased in soil microbial biomass due to organic fertilizers in comparison to inorganic ones.

Dehydrogenase: Dehydrogenase activity, an indicator of microbiological activity involved in oxidative phosphorylation, was found to be higher under CS_2 during '*rabi*' whereas during '*spring*' CS_1 supported the higher activity. During both the seasons, the various organic sources along with biodynamic preparations and '*panchgavya*' (T_5) supported the highest dehydrogenase activity to the tune of 1276.97, 1247.17 and 1311.02 μg TPF 24 h^{-1} g^{-1} of soil where the lowest of 925.12, 886.98 and 908.15 μg TPF 24 h^{-1} g^{-1} of soil under control (T_6) at RF, RH and SF stages, respectively (Table 6). The interaction between CS_1 x T_5 and CS_2 x T_5 and CS_1 x T_5 at '*rabi*' flowering, '*rabi*' harvest and '*spring*' flowering facilitated the highest dehydrogenase activity to the tune of 1284.09, 1252.87 and 1312.79 μg TPF 24h^{-1} g^{-1} of soil, respectively. However, the lowest amount of 895.69, 831.44 and 891.65 μg TPF 24h^{-1} g^{-1} soil was recorded under CS_1 and CS_2 along with T_6 at RF, RH and SF stages, respectively (Table 6). The variation during season could be ascribed to soil water content and temperature variations during the seasons. Brzezinska *et al.* (1998) reported that soil water content and temperature influence the dehydrogenase activity by affecting the soil oxidation and reduction status. The enhanced dehydrogenase activity due to amendment of organic nutrient sources can be explained as the organic manure/matter serve as food *i.e.* C and N source for microbes enabling increase in population and overall dehydrogenase activity. The results are in agreement with the findings of Yadav and Mowade (2004), Shwetha (2007) and Goldstein *et al.* (1999). Further enhancement of dehydrogenase activity due to biodynamic preparations and '*panchgavya*' in association with organic nutrient could be due to higher microbial population in these preparations and their stimulatory effect on native microbes. An application of biodynamic compost may supply an additional source of labile carbon and other nutrients to soil for microbial growth and activity (Carpenter-Boggs *et al.*, 2000).

Phosphatase: Phosphatase is an enzyme which hydrolyses the organic P compounds and transform into inorganic P *i.e.* plant available-P. As such the cropping systems did not influence the acid as well as alkaline phosphatase activity significantly except acid phosphatase activity at harvest of '*rabi*' crop (Table 7 & 8). CS_2 supported the significantly higher acid phosphatase activity (24.19 μg *p*-nitrophenol h^{-1} g^{-1} soil)

TABLE 6: Dehydrogenase activity (µg TPF 24 h^{-1} g^{-1} soil) as influenced by cropping systems, organic nutrient management practices, biodynamic preparations and '*panchgavya*' during '*rabi*' and '*spring*' season

NM \ CS	Rabi						Spring		
	At flowering			At harvest			At flowering		
	CS-1	CS-2	Mean	CS-1	CS-2	Mean	CS-1	CS-2	Mean
T1:FYM+VC+ EC + NC	1122.45	1113.64	1118.04	1093.39	1080.46	1086.93	1107.31	1106.10	1106.70
T2: BD	1224.49	1238.64	1231.56	1184.51	1183.91	1184.21	1289.95	1241.54	1265.75
T3: T1 + *Panchgavya*	1167.80	1181.82	1174.81	1161.73	1172.41	1167.07	1255.71	1218.96	1237.34
T4: T1 + T2	1235.83	1261.36	1248.60	1230.07	1241.38	1235.72	1301.37	1275.40	1288.38
T5: T4 + *Panchgavya*	1269.84	1284.09	1276.97	1241.46	1252.87	1247.17	1312.79	1309.26	1311.02
T6: Control (Green manure/ Green gram residue only)	895.69	954.55	925.12	831.44	942.53	886.98	924.66	891.65	908.15
Average	1152.68	1172.35		1123.77	1145.59		1198.63	1173.82	
	CS	NM	CS × NM	CS	NM	CS × NM	CS	NM	CS × NM
C.D≤0.05	NS	130.63	NS	NS	194.55	NS	NS	87.57	NS

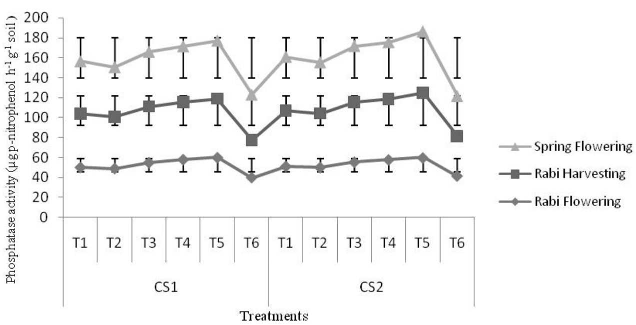

FIG 2: Phosphatase activity (µg PNP h^{-1} g^{-1} soil) as influenced by cropping systems, organic nutrient management practices, biodynamic preparations and '*panchgavya*' during '*rabi*' and '*spring*' season

at harvest of '*rabi'* crop. Biodynamic preparations and '*panchgavya'* along with the various organic nutrient sources had a significant impact on phosphatase activity (Fig. 2). Use of organic nutrient sources *viz.*, FYM, VC, EC, NC along with the biodynamic preparations and '*panchgavya'* (T_5) supported the acid, alkaline and total phosphatase activity throughout the cropping cycle. Among the various stages, the highest acid, alkaline and total phosphatase activity (26.99, 35.19 and 62.15 µg *p*-nitrophenol h^{-1} g^{-1} soil) was recorded at harvest of '*rabi'* crop. Similar results depicting enhanced phosphatase activity in the presence of organic nutrient sources were recorded (Rao *et al.,* 2007). The above results are in close agreement with the fact that enzyme activities can be increased after the addition of energy sources (Nannipieri *et al.,* 1983).

However, the lowest phosphatase activity to the tune of 39.77, 37.71 and 39.93 µg *p*-nitrophenol h^{-1} g^{-1} soil was recorded with CS_1 /CS_2 × T_6 interaction at RF, RH and SF stages, respectively (Fig. 2). The decrease in phosphatase activity at flowering of '*spring'* as well as at flowering of '*rabi'* crops (Table 7 & 8), may be related to the reduced carbon status, decline in the number of microorganisms which bind the soil colloids and humic substances (Nannipieri *et al.,* 1990).

Arylsulfatase: Arylsulfatase is believed to be partly responsible for S cycling in soils. Cropping systems significantly influenced the aryl sulfatase activity at flowering of '*spring'* crop (Table 9). CS_1 supported the higher aryl sulfatase activity to the tune of 72.26 µg PNP released h^{-1} g^{-1} soil over the CS_2. Among the various organic NM practices, T_5 comprising the organic nutrient management, biodynamic preparations and '*panchgavya'* supported the highest aryl sulfatase activity (77.75, 70.51 and 70.32 µg PNP h^{-1} g^{-1} soil) throughout the crop growth during both the seasons *i.e.* RF, RH and SF stages, respectively. Direct contribution of enzymes by the organic nutrient sources themselves, might also be responsible for greater soil enzyme activity (Dinesh *et al.*, 1998). The lowest aryl sulphatase activity to the tune of 59.44, 57.89 and 62.38 µg PNP h^{-1} g^{-1} soil was measured under T_6 at RF, RH and SF stages, respectively (Table 9).

The interaction effect of CS x NM practices did not influence the aryl sulfatase activity significantly at '*rabi'* flowering and '*rabi'* harvest. However, at flowering of '*spring'* crop interaction effect was significant. The highest extent of soil aryl sulfatase activity of 78.55, 71.18 and 76.06 µg PNP h^{-1} g^{-1} soil at RF, RH and SF stages, respectively was recorded due to interaction between CS_1 x T_5 whereas, the lowest to the tune of 58.57, 57.20 and 58.70 µg PNP h^{-1} g^{-1} soil was measured under CS_2 x T_6 at various stages

TABLE 7: Acid phosphatase activity (µg PNP h^{-1} g^{-1} soil) as influenced by cropping systems, organic nutrient management practices, biodynamic preparations and '*panchgavya*' during '*rabi*' and '*spring*' season

NM \ CS	Rabi						Spring		
	At flowering			At harvest			At flowering		
	CS-1	CS-2	Mean	CS-1	CS-2	Mean	CS-1	CS-2	Mean
T1:FYM+VC+ EC + NC	19.01	19.21	19.11	22.01	23.52	22.77	22.74	20.11	21.43
T2: BD	18.90	19.02	18.96	21.22	22.65	21.94	22.01	19.01	20.51
T3: T1 + *Panchgavya*	22.87	23.43	23.15	24.10	26.45	25.28	24.07	21.56	22.82
T4 : T1 + T2	24.69	24.89	24.79	24.56	26.55	25.56	25.07	22.10	23.59
T5 : T4 + *Panchgavya*	25.93	26.01	25.97	25.66	28.31	26.99	28.82	23.65	26.24
T6 : Control (Green manure/ Green gram residue only)	15.29	16.63	15.96	14.88	17.36	16.12	16.43	16.11	16.27
Average	22.65	23.43		22.04	24.19		23.19	20.42	
	CS	NM	CS × NM	CS	NM	CS × NM	CS	NM	CS × NM
C.D≤0.05	NS	4.41	NS	0.73	3.53	NS	NS	3.14	NS

TABLE 8: Alkaline phosphatase activity (µg PNP h^{-1} g^{-1} soil) as influenced by cropping systems and organic nutrient management practices, biodynamic preparations and '*panchgavya*' during '*rabi*' and '*spring*' season

NM \ CS	Rabi						Spring		
	At flowering			At harvest			At flowering		
	CS-1	CS-2	Mean	CS-1	CS-2	Mean	CS-1	CS-2	Mean
T1:FYM+VC+ EC + NC	31.24	31.93	31.59	31.92	32.44	32.18	31.95	32.17	32.06
T2: BD	30.13	31.03	30.58	30.55	31.71	31.13	30.68	30.30	30.49
T3: T1 + *Panchgavya*	32.23	32.10	32.17	32.09	33.85	32.97	32.92	32.93	32.93
T4 : T1 + T2	33.47	33.02	33.25	32.86	34.16	33.51	33.68	33.23	33.46
T5 : T4 + *Panchgavya*	34.27	33.85	34.06	33.40	36.98	35.19	33.99	34.75	34.37
T6 : Control (Green manure/ Green gram residue only)	24.48	24.69	24.59	22.83	22.83	22.83	29.33	23.66	26.50
Average	30.97	31.10		30.61	32.00		32.09	31.17	
	CS	NM	CS × NM	CS	NM	CS × NM	CS	NM	CS × NM
C.D≤0.05	NS	4.24	NS	NS	4.06	NS	NS	1.52	NS

(Table 9). Significant correlations between soil organic carbon and phosphatase activity were reported by Degens (1997).

Potentially mineralizable nitrogen: Nitrification is a key process in agricultural and natural ecosystems and plays an important role in the global N cycle. The cropping system, CS_1 had the highest amount of potentially mineralizable nitrogen of 115.99 and 138.01 µg NH_4^+-N g^{-1} soil at harvest of '*rabi'* and at flowering of '*spring'* season respectively. Various organic nutrient management practices employed had significant impact on potentially mineralizable nitrogen in soil at all the stages during both the seasons (Table 10). The results of present investigation are corroborated with the findings of Jagtap *et al.* (2007). At flowering of '*spring*' T_5 treatment *i.e.* combination of all the organic nutrient sources ; biodynamic preparations and '*panchgavya'* favoured the highest amount of potentially mineralizable nitrogen content (150.10 µg NH_4^+-N g^{-1} soil) over other combinations and control *i.e.* T_6. The elevated levels of potentially mineralizable nitrogen at flowering stage were attributed to the higher microbial population and in turn speedy mineralization of added organic matter through green manuring crop as well as various organic nutrient amendments. Interaction between the cropping systems and organic NM practices were significant only at flowering of '*spring*'. CS_2 x T_5 at RF and CS_1 x T_5 at RH and SF stage resulted in highest level of potentially mineralizable nitrogen to the tune of 126.50, 122.85 and 159.55 µg NH_4^+-N g^{-1} soil, respectively. The higher amount of NH_4^+-N was released in an incubation study wherein nutrients were applied along with FYM and biodynamic preparations (Goldstein, *et al.*, 1999; Carpenter-Boggs *et al.*, 2000).

Yield: Various organic and biodynamic nutrient management practices improved the yield of chickpea, vegetable pea, green gram and maize cobs. Highest yield to the tune of 1458 kg ha^{-1} of chickpea (CS_1), 5250 kg ha^{-1} of vegetable pea green pods (CS_2) during '*rabi*' and 8740 + 2476 kg ha^{-1} of '*spring*' crops (maize cobs + green gram; CS_2) was recorded under T_5 comprising the organic nutrient management, biodynamic preparations and '*panchgavya*' (Table 11).

TABLE 9: Effect of cropping systems, organic nutrient management practices, biodynamic preparations and '*panchgavya*' on aryl sulfatase (µg PNP h^{-1} g^{-1} soil) during '*rabi*' and '*spring*' season

NM \ CS	Rabi						Spring		
	At flowering			At harvest			At flowering		
	CS-1	CS-2	Mean	CS-1	CS-2	Mean	CS-1	CS-2	Mean
T1:FYM+VC+ EC + NC	70.80	74.31	72.56	69.05	68.43	68.74	70.80	63.18	66.99
T2: BD	70.05	73.92	71.99	68.55	67.95	68.25	70.02	62.20	66.11
T3: T1 + *Panchgavya*	76.93	74.80	75.87	70.43	68.99	69.71	75.06	63.32	69.19
T4 : T1 + T2	77.80	74.86	76.33	70.80	69.45	70.13	75.55	64.53	70.04
T5 : T4 + *Panchgavya*	78.55	76.94	77.75	71.18	69.83	70.51	76.06	64.57	70.32
T6 : Control (Green manure/ Green gram residue only)	60.31	58.57	59.44	58.57	57.20	57.89	66.05	58.70	62.38
Average	72.41	72.23		68.10	66.98		72.26	62.75	
C.D≤0.05	CS	NM	CS × NM	CS	NM	CS × NM	CS	NM	CS × NM
	NS	8.25	NS	NS	10.02	NS	7.60	NS	12.72

TABLE 10: Potentially mineralizable nitrogen (µg NH_4^+-N g^{-1} soil) as influenced by various cropping systems, organic nutrient management practices, biodynamic preparations and '*panchgavya*' during '*rabi*' and '*spring*' season

NM \ CS	Rabi						Spring		
	At flowering			At harvest			At flowering		
	CS-1	CS-2	Mean	CS-1	CS-2	Mean	CS-1	CS-2	Mean
T1:FYM+VC+ EC + NC	119.32	109.41	114.37	119.59	111.36	115.48	143.18	127.27	135.23
T2: BD	111.36	100.45	105.91	117.50	106.45	111.98	135.23	111.36	123.30
T3: T1 + *Panchgavya*	119.45	112.64	116.05	119.80	116.50	118.15	143.50	128.56	136.03
T4 : T1 + T2	120.27	121.18	120.73	120.77	119.41	120.09	151.14	135.23	143.19
T5 : T4 + *Panchgavya*	121.50	126.50	124.00	122.85	122.55	122.70	159.55	140.64	150.10
T6 : Control (Green manure/ Green gram residue only)	79.55	95.45	87.50	95.45	71.59	83.52	95.45	87.50	91.48
Average	111.91	110.94		115.99	107.98		138.01	121.76	
C.D≤0.05	CS	NM	CS × NM	CS	NM	CS × NM	CS	NM	CS × NM
	NS	8.52	12.05	NS	9.04	NS	7.39	8.72	NS

CS: Cropping system; NM: Nutreint management practices

TABLE 11: Yield (kg ha^{-1}) as influenced by various cropping systems, organic nutrient management practices, biodynamic preparations and '*panchgavya*' during '*rabi*' and '*spring*' season

NM \ CS	Rabi		Spring	
	At Havest			
	CS-1 (C. pea)	CS-2 (V. pea green pods)	CS-2 (Maize cobs)	CS-2 (G. Gram)
T1:FYM+VC+EC + NC	1441	5062	8560	2429
T2: BD	1163	4610	6670	1813
T3: T1 + *Panchgavya*	1228	5030	8660	2454
T4 : T1 + T2	1212	4915	8570	2432
T5 : T4 + *Panchgavya*	1458	5250	8740	2476
T6 : Control (Green manure/ Green gram residue only)	1080	3911	6580	1790
Average	1263.67	4796.33	7963.33	2332.33
C.D≤0.05	131	433.1	4.60	98.7

CS: Cropping system; NM: Nutreint management practices

CONCLUSION

The soil biological parameters analyzed indicated vast differences between soils that received biodynamic spray and '*panchgavya*' application than those that had not. Nutrient supply through organic nutrient sources along with biodynamic preparations and '*panchgavya*' under T_5, alone and in combination, with cropping system CS_1 (Basmati rice-Chickpea-*Sesbania* green manure) have a potential of improving the soil quality in terms of biological health. To have a lucid picture regarding the impact of organic nutrient management practices in combination with biodynamic preparations and '*panchgavya*' and cropping systems on soil quality, further research is warranted on various physical, chemical and biological indices of soil health over an extended period.

REFERENCES

Bolton, H. Jr.; Elliott, L.F. and Papendick, R.I. (1985). Soil microbial biomass and selected soil enzyme activities : effect of fertilization and cropping practices. *Soil Biol. Biochem.*, **17:** 297-302.

Brzezinska, M.; Stepniewska, Z. and Stepniewska, W. (1998). Soil oxygen status and dehydrogenase activity. *Soil Biol. Biochem.*, **30:** 1783-1790.

Carpenter-Boggs, L.; Kennedy, A.C., and Reganold, J.P. (2000). Organic and Biodynamic. Effects on soil biology. *Soil Sci. Soc. Amer. J.* **64:** 1651-1659.

Casida, L.E. Jr.; Klein, D.A. and Santoro, T. (1964). Soil dehydrogenase activity. *Soil Sci.*, **98:** 371-376.

Chandrakala, M. (2008). Effect of FYM and fermented liquid manure on yield and quality of chilli (*Capsicum annuum* L.). M.Sc. *(Agricul. Chem.).* University of Agricultural Sciences, Dharwad.

Degens, B.P. (1997). Macro-aggregation on soil by biological bonding and binding mechanisms and the factor affecting these: a review. *Australian J. Soil Res.* **35:** 431-459.

Dinesh, R. ; Dubey, R. P.; Ganeshamurthy, A. N. and Shyam Prasad, G. (2000). Organic manuring in rice-based cropping system: Effects on soil microbial biomass and selected enzyme activities. *Current Sci.* **79:** 1716-1719.

Dinesh, R.; Dubey, R. P. and Shyam Prasad, G. (1998). Soil microbial biomass and enzyme activities as influenced by organic manure incorporation into soils of a rice-rice system. *J. Agron. and Crop Sci.* **181:** 173-178.

Goldstein, W.; Barber W., Carpenter-Boggs, L.; Dalsoren, D. and Koopmans, C. (1999). Comparisons of Conventional, Organic, and Biodynamic Methods. *Michael Fields Agricultural Institute.* W2493 County Road ES, East Troy, WI 53121.

Goyal, S.; Mishra, M.M.; Hooda, I.S. and Singh, R. (1992). Organic matter microbial biomass relationships in field experiments under tropical conditions: Effects of inorganic fertilization and organic amendments. *Soil Biol. Biochem.*, **24:** 1081-1084.

Hasebe, A.; Kanazava, S. and Takai, Y. (1985). Microbial biomass in paddy soil II. Microbial biomass C measured by Jenkinson's fumigation method. *Soil Science and Plant Nutrition*, **31:** 349-359.

Jagtap, P.B.; Patil, J.D.; Nimbalkar, C.A. and Kadlag, A.D. (2007). Influence of integrated nutrient management on soil properties and release of nutrients in a saline-sodic soil. *J. Indian Soc. Soil Sci.,* **55**(2): 147-156.

Jenkinson, D.S. (1988). Determination of microbial biomass and nitrogen in soil. *In: Advances in Nitrogen Cycling in Agricultural Ecosystems* (Wilsom, J.R. ed). Willingford, Oxon., U.K:CAB International, pp. 368-386.

Katyal, V.; Gangwar, K.S. and Gangwar, B. (2003). Long-term effect of fertilizer use on yield sustainability and soil fertility in rice-wheat system in subtropical India. *Fert. News,* **48**(7): 43-46.

Koepf, H.H. (1989). The Biodynamic Farm: Agriculture in the Service of the Earth and Humanity. Anthroposophic Press, Hudson, New York. pp. 248.

Kumar, A. and Yadav, D.S. (2003). Long-term nutrient management for sustainability in rice-wheat cropping system. *Fert. News,* **48**(8): 27-34.

Lal, R. and Kimble, J.M. (1997). Conservation tillage for carbon sequestration. *Nutr. Cycl. Agroecosyst*. 49: 243-253.

Nannipieri, P. Muccini, L. and Ciardi, C. (1983). Microbial biomass and enzyme activities: production and persistence. *Soil Biology and Biochemistry* **15:6:** 679-685.

Nannipieri, P.; Greg, S. and Ceccanti, B. (1990). Ecological significance of the biological activity in soil. In: *Soil Biochemistry* Vol. 6 (J.M. Bollag and G. Stotzky, Eds.), Marcel Dekker, New York, pp. 293-355.

Paul, E.A. and Voroney, R.P. (1984). Field interpretation of microbial biomass activity measurements. In: *Current Perspectives in Microbial Ecology* (M.L. Klug and C.A. Reddy, eds). American Society for Microbiology, Washington Pp. 509-514.

Rao, M.B.; Gunapalan, N. and Reddy, B.K. 2007. In: Dynamics of soil microbial biomass and activity in conventional and organic farming systems N. *Soil Biol. Biochem.* (In Press).

Shwetha, B.N. (2007). Effect of nutrient management through organics in soybean wheat cropping system. *M.Sc. (Agri.) Thesis*, Univ. Agric. Sci., Dharwad.

Stanford, G. and Smith, S.J. (1972). Nitrogen mineralization potentials of soils. *Soil Sci. Soc. America Proc*., **36:** 465-472.

Tabatabai, M.A. and Bremner, J.M. (1969). Use of p-nitrophenyl phosphate for assay of soil phosphatase activity. *Soil Biol. Biochem*., **1:** 301-307.

Tabatabai, M.A. and Bremner, J.M. (1970). Arylsulphatase activity in soils. *Soil Sci .Soc. Am.Proc*., **34:** 225-229.

Tu, C.; Ristaino, J.B. and Hu, S. (2006). Soil microbial biomass and activity in organic tomato farming systems: Effects of organic inputs and straw mulching. *Soil Bio. Biochem.* **38:**247-255.

Wollum, A.G. (1982). Cultural methods for soil microrganisms. In: *Methods of soil Analysis* , Part 2. Chemical and Microbiological Properties (Page , A.K.; Millar , R.H. and Keeney, D.R. eds.). *Agronomy Monograph No. 9, ASA-SSSA* Publisher, Madison, Wisconsin, USA. pp. 781-814.

Yadav, A. K. and Mowade, S. M. (2004). Organic manures and compost. In: Organic farming -A ray of hope for Indian farmer.