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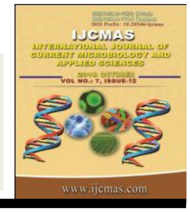

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Influence of Selected Organic Manures on Soil Health and Yield Sustainability of Western Himalaya Vegetable Production Systems

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ABSTRACT

A field study from 2009 to 2013 was carried out to investigate the effect of organic manure including panchagavya and biodynamic spray on commonly used tomato-coriander-pea and cauliflower-cauliflower-peacropping system in Western Himalaya. The results revealed that cropping systems differ significantly in terms of soil microbial properties. The tomato-coriander-pea crop sequence recorded higher soil carbon biomass and population of soil bacteria, fungi and actinomycetes as compared to cauliflower-cauliflower-pea crop sequence. The tomato-coriander-pea had enhanced activity of phosphatase enzyme in soil. Soil pH and availability of micronutrients was not influenced under cropping systems, however, organic carbon and availability of major nutrients was significantly improved in tomato-coriander-pea sequence than cauliflower-cauliflower-pea. The highest productivity and net returns were observed for tomato-coriander-pea as compared to cauliflower-cauliflower-pea sequence. Different nutrient sources significantly influenced measured soil and plant parameters except soil pH. The maximum increase in organic carbon, soil carbon biomass, bacteria, fungi, actinomycetes and phosphatase enzyme, availability of major and micronutrients, yield and net returns were observed with farmyard manure application followed by biodynamic and panchagavaya spray as compared to control.

Introduction

Growing awareness of health and environmental issues in agriculture has demanded production of organic food, which is emerging as an attractive source of rural income generation (Bhattacharya and Chakraborty, 2005). The green revolution in India brought about a spectacular increase in agricultural production with introduction of high yielding varieties of crops, extension of irrigated areas, use of chemical fertilizers and pesticides and enhancing of cropping intensity which made the country self -sufficient in food production. However, during green revolution process, the use of organic manures, which was hitherto the main practice in Indian agriculture, diminished considerably (Gupta *et al.*, 2005). The harmful effects of chemical based farming such as accumulation of excessive amount of nitrate in the water, occurrence of a sharp decline in the ground water level and its contamination with heavy metals, deposition of phosphate along with nitrate in the aquatic ecosystems, presence of pesticidal residues in various food stuffs, caused a number of problems in human beings, animals and plants. Rise in resistance of pests to chemical pesticides, occurrence of multi-nutrient deficiencies in soils, thereby resulting into an overall decline in their production capacity under intensive fertilizer use are the other deleterious effects created by the green revolution process. The addition of organic nutrients to soil could be a promising technology for reducing the usage of synthetic fertilizers (Karthigeyanm and Alagesan, 2011). Therefore, this study was carried out to assess the effect of organic manures including foliar spray of panchagavya and biodynamic on the yield and soil properties of two commonly used vegetable production systems in Western Himalaya.

Materials and Methods

A field experiment was conducted from 2009 – 2013 to investigate the effect of organic manure including panchagvya and biodynamic spray on vegetable yield, economic, mineral concentration and soil properties. The experiment was situated at the experimental farm of the Himachal Pradesh Agricultural University, Hill Agricultural Research and Extension Centre near Kullu-Manali, India (31.8^{O}N latitude, 77^{O}E longitude at an altitude of 1090m above sea level, where annual rainfall varies from 1000-1200 mm). The experiment consisted of two cropping systems [CS_1=Tomato (*Lycopersicon esculentum* var. *commune*) - coriander (*Coriandrum sativum* L.*)* -pea (*Pisum sativum* var. *arvense*) and $CS_{2=}$cauliflower (*Brassica oleracea*var. *brotytis*) –cauliflower (*Brassica oleracea* var. *brotytis*)-pea (*Pisum sativum* var. *arvense*)] and five nutrient sources [NS_1=rockphosphate enriched FYM + vermicompost (1:1); NS_2=farmyard manure + BD 501 spray; NS_3= NS_1 + panchagavya spray; NS_4= NS_2 +panchagavya spray and NS_5-control]. The cropping systems were placed in main plots and nutrient sources in sub plots in a split plot design with three replications. The experimental soils had initial pH 5.5; organic carbon 0.45%; bulk density 1.62 g/cc. They contained N146 Kg/ha, P_2O_5 43 Kg/ha and K_2O 121 Kg/ha. Micronutrient Fe, Mn, Zn and Cu were 30, 1.03, 1.20 and 0.12 ppm, respectively. Crops were transplanted/ sown in a fixed plot of 54 m^2 following recommended package of practices. The irrigation was given as per requirement. The weeds were managed manually. The bio-pesticides (*Trichoderma viride* and *Pseudomonas fluorescence*) and bio-insecticide (Azardarachtin @ 0.15% EC) were used for plant protection purposes. The FYM used in the study contained 2.35% N, 0.27% P, 2.39% K and vermicompost contained 1.68% N, 0.20% P, and 1.28% K and was applied as per treatment equivalent to recommended fertilizer doses at the time of field preparation. Panchagavya, an organic formulation, was prepared with 5 kg cow dung, 1 kg clarified butter, 5 L cow urine, 3 L curd, 3 L milk, and 5 L water. These materials were mixed together and stirred daily for 15 days. A dilution of 1:10was used for spraying on crops at 15 days interval starting just after appearance of flowering. Biodynamic 501 sourced Eco-Agricultural Research Foundation; Mysore, India was sprayed @ 2.5 g/ 40 L of water as a fine mist on the plant foliage before sunrise as per bio dynamic calendar on a moon opposite Saturn day. Composite soil samples (0-15 cm) collected after every crop cycle were analyzed for some soil chemical and physical properties. Soil microbiological properties were determined initially and after four crop cycles. The soil organic carbon was determined by wet oxidation method (Walkley and Black, 1934); available N by alkaline permanganate method (Subbiah and Asija, 1956); available phosphorus by Olsen's method (Olsen *et al.*, 1954); available potassium by flame photometer (Jackson, 1973) and soil bulk density using method of Singh (1980). The enumeration of total bacteria, fungi, actinomycetes in fresh rhizosphere soil samples was carried out by following serial dilution plate count technique using nutrient agar for bacteria, Martin's Rose Bengal agar for fungi (Martin, 1950), Kuster's agar (Kusterand Williams, 1964) for actinomycetes. Alkaline phosphatase activity was measured by estimating concentration of P- nitro phenol a hydrolyzed product of substrate P-nitro phenyl phosphate (PNP). The yield of whole cropping system was determined by summing up yield data of three crops and expressed as q/ha. The economics was calculated on the prevailing market prices. The cost of the output was increased by 25%, considering higher value of organic produce. The data were subjected to ANOVA for a split plot design and means were compared using significant difference at 5% probability using CPCS-1 data analysis package.

Results and Discussion

The cropping systems differ significantly for variables like yield, net returns and benefit cost ratio (Table 1). Tomato-coriander-pea cropping system (CS_1) recorded 17 %, 87% and 70% increment for yield, net returns and B:C, respectively, over cauliflower-cauliflower-pea system (CS_2). Crop rotation have a major impact on increasing soil structural stability, nutrient use efficiency, crop water use efficiency and soil organic matter levels, providing better weed control, and disrupting insect and disease life cycles (Carter *et al.,* 2002, Carter *et al.,* 2003), which may further improve soil productivity an crop yield (Galantini *et al.,* 2000; Miglierina *et al.,* 2000; Varvel, 2000; Kelley *et al.,* 2003). The finding is also supported by Keith (2006) who found crop rotations as key strategies to build the soil, manage pests, and increase yields and profit. The application FYM followed by biodynamic and panchgavaya spray (NS_4) recorded highest yield, net returns and B: C as compared to other nutrient sources. Shekara *et al.,* (2010) suggested that increased growth due to addition of various organic manures could be attributed to adequate supply of nutrients, higher uptake and recovery of applied nutrients, which in turn, must have improved synthesis and translocation of metabolites to various reproductive structures of the plant. The beneficial effect of a mix of farmyard manure and biodynamic on lettuce and Indian spices have already been documented by Bacchus (2010).

Cropping systems and nutrient sources did not change soil pH (Table 2). These finding corroborates with the findings of Dhull *et al.,* (2005), who reported similar effect of crop rotations on soil reaction. The soil organic carbon and availability of N, P, K in soil was significantly influenced due to cropping systems and organic amendments. The maximum values of N, P, K was in CS_1 and NS_2 (Table 2). The soil organic carbon significantly changed in cropping systems and nutrient sources. Long-term field studies suggest that enhanced crop rotation complexity produces long term increases in soil organic carbon (West and Post, 2002).

The earlier workers (Karlen *et al.,* 1994) have also reported increased soil organic carbon under cropping systems and attributed it to length of cropping system and loss of organic matter from tillage operation. Long-term manure applications increase soil organic carbon through the addition of organic matter (OM) in the manure and through increased OM return in crop residues due to increased crop production (Whalen and Chang, 2002). The earlier study (Clark *et al.,* 1994) also demonstrated increase in organic matter in a long term cropping sequences. Karlen *et al.,* (1994) observed improvement in soil organic matter in cropping systems and attributed it to factors like length of cropping system and loss of organic matter from tillage operation.

Table.1 Effect of treatments on yield and profit

Treatment	Yield (q ha^{-1})	Net returns (Rs.ha^{-1})	B:C
Cropping system(CS)			
CS_1 = T-Co-P	21.7	178821	1.98
CS_2 = C - C-P	17.8	95371	1.16
CD (P = 0.05)	1.1	4844	0.16
Nutrient Source (NS)			
NS_1 = RP enriched FYM+VC(1:1)	26.3	174614	2.01
NS_2 = FYM *fb* BD	26.6	176050	2.10
NS_3 = NS_1 *fb* Panchagavya	26.7	165374	1.67
NS_4 = NS_2 *fb* Panchagavya	28.4	188886	2.35
NS_5 = Control	8.5	32879	0.50
CD (P = 0.05)	1.5	7584	0.14

T=tomato; C=cauliflower; Co=coriander; P=pea; fb=followed by

Table.2 Effect of treatments on soil pH, OC (%), major nutrients (kg ha^{-1}) and Micronutrients (mg^{-1} kg)

Treatment	pH	OC	N	P_2O_5	K_2O	Fe	Mn	Zn	Cu
Cropping system(CS)									
CS_1 = T-Co-P	5.7	0.79	191.6	58.9	187.2	52.0	30.8	2.4	2.0
CS_2 = C - C-P	5.7	0.84	177.0	56.3	172.2	51.1	31.5	2.4	2.0
CD (P = 0.05)	NS	0.01	0.34	0.48	0.46	NS	NS	NS	NS
Nutrient Sources (NS)									
NS_1 = RP enriched FYM+VC(1:1)	5.7	0.95	199.7	70.1	202.8	62.4	34.5	2.9	2.5
NS_2 = FYM *fb* BD	5.8	0.91	191.8	65.4	193.2	56.7	35.0	2.7	2.4
NS_3 = NS_1 *fb* Panchagavya	5.7	0.92	208.8	63.4	191.1	55.4	34.7	2.5	2.4
NS_4 = NS_2 *fb* Panchagavya	5.7	0.97	219.9	69.9	200.8	60.3	38.1	2.9	2.6
NS_5 = Control	5.6	0.56	133.8	32.5	135.4	33.9	19.7	1.0	0.9
CD (P = 0.05)	NS	0.04	8.95	3.49	5.95	1.35	2.00	0.12	0.09

T=tomato; C=cauliflower; Co=coriander; P=pea; fb=followed by

Table.3 Effect of treatments on soil biological properties

Treatment	Carbon biomass	Bacteria	Fungi	Actinomycetes	Phosphatase
Cropping system(CS)					
CS_1 = T-Co-P	27.9	7.6	5.4	8.3	15.3
CS_2 = C - C-P	13.4	6.2	4.4	6.3	12.7
CD (P = 0.05)	10.3	0.01	0.006	1.1	1.8
Nutrient Source (NS)					
NS_1 = RP enriched FYM+VC(1:1)	23.4	7.9	4.6	6.4	12.3
NS_2 = FYM *fb* BD	27.0	8.2	4.7	6.4	13.1
NS_3 = NS_1 *fb*Panchagavya	24.9	8.0	4.3	6.0	13.4
NS_4 = NS_2 *fb*Panchagavya	36.6	9.3	5.4	6.9	14.8
NS_5 = Control	3.37	6.0	3.4	5.3	9.6
CD (P = 0.05)	4.7	0.002	0.003	0.004	0.010

T=tomato; C=cauliflower; Co=coriander; P=pea; fb=followed by
Carbon biomass=micro gram/g soil; bacteria= 10^6cfu g^{-1} soil; actenomycetes=10^5cfu g^{-1} soil; fungi =10^5cfu g^{-1} soil; phosphatase enzyme=micro gram p-nitrophenol g/soil

Production of appreciable quantities of carbonic acids during decomposition of organic matter mineralizes the complex organic substances, which in turn would contribute to N pool. An increase in available N by application of vermicompost and FYM was also reported by Phule (1993) and Pawar (1996).

The increase in available nitrogen due to organic matter application is also attributable to the greater multiplication of soil microbes caused by the addition of organic materials which mineralize organically bound N to inorganic form (Bellakki and Badanur, 1997). Tandon (1987) attributed the increase in available phosphorus with FYM application to the contribution of P by the organics to the soil available pool and coating of organic material on sesquioxides which reduces the phosphate fixing capacity of soil. Similar observations were also reported by Bharadwaj and Omanwar (1994). The increase in available potassium in soils of organic farms could be attributed to the direct addition of potassium to the available pool of the soil from FYM and vermicompost. The beneficial effect of FYM on the available potassium might be also ascribed to the reduction of potassium fixation (Tandon, 1988). Similar observations of increase in available potassium due to addition of organic manures were made by Grewal *et al.*, (1981) and Bharadwaj and Omanwar (1994).

A significant increase in availability of soil micronutrients was observed among cropping systems (Table 2). The observed non-significant effect of cropping systems on soil micronutrients could be explained on the ground that vegetables grown in the present study were heavy feeder and nutrients availability might have exceeded crop removal. The soil micronutrients (Fe, Mn, Zn and Cu) were strongly influenced due organic manure treatments. In general, the maximum improvement was in NS_2. However, their content among different nutrient sources (NS_1 to NS_4) did not vary significantly but all the nutrient sources were superior to control (NS_5). Sharma *et al.*, (2000) attributed the increase in micronutrients in soils with addition of organics to the enhanced microbial activity and consequent release of complex organic substances (chelating agents) besides addition of these nutrients to the available pool on decomposition of organics.

The population of soil bacteria, fungi, actinomycetes and enzyme activity was significantly affected due to cropping systems and nutrient sources (Table 3). The maximum values of soil carbon biomass, bacteria, fungi, actinomycetes, phosphatase enzyme were recorded for tomato-coriander-pea in comparison to cauliflower-cauliflower-pea cropping system. The accumulation of organic carbon in cropping system might have increased soil micro flora and enzyme activity in soil. The soil microbial properties were also strongly influenced due to organic manure treatments and the highest value of all measured variables was recorded in NS_2.This is in accordance with Chauhan *et al.,* (2011), who found improvement in soil microbial properties with the application farmyard manure and compost that might be due to cumulative effect of organic manures in increasing organic carbon content of soil which acted as carbon and energy source for microbes and fermented organics in quick build- up of micro flora and fauna (Yadav and Mowade, 2004).

The results indicated that yield and improved soil health could be obtained in organic vegetable production systems using organic manure and spray of biodynamic and panchagavaya. A combine application of farmyard manure + BD 501spray could be recommended for tomato-cauliflower-pea cropping system in the Western Himalaya and the regions elsewhere having similar soil and climate conditions.

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