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Perminder Singh Brar
Department of Soil Science and Water Management, Dr Y S Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh, India

Rajesh Kaushal
Department of Soil Science and Water Management, Dr Y S Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh, India

Gitika Bhardwaj
Department of Soil Science and Water Management, Dr Y S Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh, India

Uday Sharma
Department of Soil Science and Water Management, Dr Y S Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh, India

Corresponding Author:
Perminder Singh Brar
Department of Soil Science and Water Management, Dr Y S Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh, India

Yield and fruit quality response of PGPR, bulky and folk liquid manures on capsicum (*Capsicum annuum* L.) in Western Himalayas of India

Perminder Singh Brar, Rajesh Kaushal, Gitika Bhardwaj and Uday Sharma

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Abstract

This paper describes the effect of PGPR, folk liquid manures (Panchagavya, Jeevamrut, Amritpani), bulky and concentrated organic manures (Vermicompost and Poultry manure) under Capsicum in mid hills of Western Himalayas during kharif season of year 2016 at research farm, Department of Soil Science and Water Management, Dr YSPUHF, Nauni, Solan, India. There were 7 treatments of the research trial and the treatment T2 (90% Recommended dose of nutrients with PGPR and liquid manures- Panchagavya, Jeevamrut, Amritpani) recorded maximum plant height (58.3 cm), plant biomass (65.87 g plant^{-1}), fruit yield (26.96 t ha^{-1} and 0.910 kg plant^{-1}), total NPK uptake (13.76, 1.79 and 13.34 kg ha^{-1}). Among soil properties maximum value of organic carbon (1.30%), macronutrient (NPK) content (441.73, 76.71 and 290.10 kg ha^{-1}), DTPA extractable cations (3.12, 2.89, 7.50 and 2.76 ppm) were obtained in treatment T2. An experimental evaluation of different treatments leads to conclusion that treatment with 90% RDN, PGPR and liquid manures was best among all treatments and it had significant effects on plant as well as soil properties.

Keywords: Bulky organic manures, concentrated organic manure, PGPR, folk liquid manure

Introduction

Capsicum or Bell pepper (*Capsicum annuum* L.) is an immensely advantageous annual vegetable crop of family Solanaceae. Fruits are non-pungent, blocky, square or triangular shaped, thick fleshed, three to four lobed, green, yellow or red in colour. They are also rich source of vitamin C, Vitamin A, edible oil, proteins, carbohydrate, fats, fibers, amino acids, fatty acids and minerals (Zou *et al.*, 2015) [31]. In India, it is cultivated over an area of about 32,150 ha with an annual production of 1.82 lakh MT (Anonymous, 2016) [5]. In Himachal Pradesh, it is cultivated over an area of about 2070 ha with an annual production of 34.13 thousand MT (Anonymous, 2016) [5]. Application of abundant doses of commercial fertilizers and pesticides has inauspicious effects on soil health as well as human health problems (Narkhede *et al.*, 2011) [19]. The minimal awareness to ecological agricultural principles affect the physico-chemical and biological properties leading to imbalance of ecology which also affect the life existed among soil, animals and human beings. Organic manures increases microbial population activity, biodiversity and also act as source of nutrients. The method of cultivation through organic farming is profit making for the farmers and useful in overcoming the ill effects from chemical farming.

Material and method

Study site

The study was conducted during the Kharif seasons of 2016 and experimental site is situated at 30º 52′ North latitude and 77º 11′ East longitude at an elevation of 1260 m above mean sea level in the research farm of the Department of Soil Science and Water Management, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (Himachal Pradesh).

Climatic and Edaphic factors

The study area falls in sub-temperate, sub-humid agro-climatic zone-II of Himachal Pradesh. The average annual rainfall of the area is about 1115 mm and about 75 per cent of it is received during the monsoon period (mid-June to mid-September). Winter rains are meagre and received during the month of January and February. May-June is the hottest and December-January is the coldest months. The soils of study area fall in Inceptisol order and sub group Eutrochrept according to Soil Taxonomy of USDA. These soils owe their origin to ferromagnesian shales and dolomitic limestone.

Table 1: Soil properties of experimental site before the start of experiment during kharif season of 2016.

Properties	Values
pH (soil:water ratio, 1:2)	6.91
EC (dSm^{-1})	0.64
Organic Carbon (%)	1.12
Available N (kg ha^{-1})	382.10
Available P (kg ha^{-1})	52.67
Available K (kg ha^{-1})	243.37
DTPA extractable Cu (ppm)	1.63
DTPA extractable Zn (ppm)	2.27
DTPA extractable Fe (ppm)	5.47
DTPA extractable Mn (ppm)	2.07

Treatment details

The present study aimed at evaluating the effect of organic management practices on soil properties under capsicum crop. The experiment was laid out in Randomized Block Design with seven treatments and three replications in plots of size 2.40 m× 2.25 m. The sources of nutrients were vermicompost and poultry manure (50:50 ratio of N equivalence basis), PGPR and organic liquid manures like panchagavya, jeevamrut and amritpani were also applied in according to treatments.

T_1: 100% recommended dose of nutrients (RDN)
T_2: 90% RDN along with PGPR and Folk liquid manures (5% concentration)
T_3: 80% RDN along with PGPR and Folk liquid manures (5% concentration)
T_4: 70% RDN along with PGPR and Folk liquid manures (5% concentration)
T_5: 60% RDN along with PGPR and Folk liquid manures (5% concentration)
T_6: 50% RDN along with PGPR and Folk liquid manures (5% concentration)
T_7: 40% RDN along with PGPR and Folk liquid manures (5% concentration)

Plant and Soil Sampling analysis

Plant height was measured from the ground level to the highest tip and root length was from the base up to the lowest tip of the root and results were expressed in centimeter. Plant biomass was determined by taking fresh weight as well as dry weight of the plant and biomass was expressed in grams per plant. For plant nutrient status, plant samples were collected, dried, crushed, and digested in Di-acid mixture prepared by mixing concentrated HNO_3 and $HClO_4$ in the ratio of 4:1 as laid down by Piper (1966) [22]. The total N was analyzed by the Micro-Kjeldhal's method as outlined in A.O.A.C (1980) [1]. Total Phosphorus was estimated by Vanado molybdate phosphoric yellow colour method by Jackson (1973) [13]. Potassium in the Di-acid extract was estimated on the flame photometer. For Ca, Mg, Zn, Cu, Fe and Mn the estimation was carried out on Atomic Absorption Spectrophotometer. For soil sampling, composite soil samples from the field were collected and analyzed for physico-chemical properties of soil. Soil pH and EC were determined in soil: water suspension (1:2) as described by Jackson (1973) [13]. Organic carbon was determined by the wet digestion method of Walkley and Black (1934) [29]. The available nitrogen (N) was estimated by alkaline potassium permanganate method (Subbiah and Asija, 1956) [26]. Available Phosphorus in the soil was determined by ammonium molybdate method using Olsen's extractant (Olsen *et al.*, 1954) [21]. Exchangeable potassium was extracted with neutral normal ammonium acetate (Merwin and Peach, 1951) [17] and estimated on flame photometer. For the estimation of micro nutrients, 10 g of soil samples were shaken with 20 ml of diethylenetriamine Penta acetic acid (DTPA extract) as given by Lindsay and Norvell (1978) [16]. Available Zn, Cu, Fe and Mn in the extract were determined on Atomic Absorption Spectrophotometer.

For soil microbial status, the soil was analyzed for total microbial count. 1g of soil was taken in 9 ml of sterilized water blank and the soil suspension was diluted in 10-fold series, then total microbial counts were determined by standard spread plate technique as described by Subbarao (1999) [27]. The population was expressed as colony forming units per gram of soil (cfu g^{-1} soil). Microbial biomass-C was determined by soil fumigation extraction method detailed by Vance *et al.*, 1987 [30]. In this method, 20 g of soil was fumigated with 50 ml chloroform in vacuum desiccator for 24 hours in dark and other 20 g soil sample was refrigerated, then both the samples (fumigated and un-fumigated) were extracted with 80 ml of 0.5 M K_2SO_4, for half an hour and filtered through Whatman no.1 filter paper. Then added 2 ml of 66.5mM $K_2Cr_2O_7$ and 5 ml digestion mixture containing H_2SO_4 and ortho-phosphoric acid (2:1) to 8ml filtrate and heated on hot plate at 120 ºC for 30 min. After that made the final volume to 250 ml with distilled water and 2-3 drops of ferroin indicator was added and titrated against 0.005 N Ferrous ammonium sulphates (FAS).

The dehydrogenase enzyme estimation was carried out by method given by Casida *et al.*, (1964). 1 g of soil was incubated for 12 hours with 1 ml of 3% TTC (Triphenyltetrazolium chloride) and 0.5 ml of 1% glucose. After incubation 10 ml of methanol was added. Then the test tube was shaken and allowed to stand in dark for 24 hours. Supernatant was withdrawn and colour intensity was measured using blue filter at 400 nm wavelength. The amount of formazan formed from standard curve prepared from TPF (Triphenylformazan) was in the range of 0.04 to 0.5 mg 10 ml^{-1}. The results were expressed in the terms of TPF per hour per gram of soil (mg TPF $h^{-1}g^{-1}$soil). The phosphatase enzyme estimation was carried out by method given by Tabatabai and Bremner (1969). One gram of soil taken in test tube was incubated with 1ml of 5mM buffered sodium p-nitrophenyl phosphate in acetate buffer (pH 5.2) and 0.3ml toluene at 37 ºC for 1 hour. Determination of p-nitrophenol involved the colorimetric analysis of the extract obtained by treating the incubated soil sample with 4 ml water, 10 ml of 0.5 M NaOH and by filtering it through Whatman no. 42 filter paper, The suspension obtained by shaking the mixture for 1 minute and absorbance of yellow color of p-nitrophenol released was determined spectrophotometrically at 420 nm wavelength. The standard curve was prepared by p-nitrophenol (10-100 ppm). The result was expressed as µ mole of p-nitrophenol per gram soil per hour (µmole p-nitrophenol $h^{-1}g^{-1}$soil). The Urease enzyme estimation was carried out by 10 g of dry and sieved soil was incubated for 15 minutes with 15 ml of toluene. Add 10 ml of urea solution and 20 ml of citrate buffer. Mix and incubate for three hours at 37°C. Then dilute to 100 ml with water, mix and filter. Pipette out 1 ml of filtrate, add 9 ml of water, 4 ml phenate solution and 3 ml of sodium hypochlorite solution. Mix and allow standing for 20 minutes until the maximum color is obtained. Dilute to 50 ml with water mix well and read the transmittance or absorbance at 630 mm against the blank. The standard curve was prepared from ammonium sulphate solution (10 µg N ml^{-1}). Results are expressed as mg NH^{4+} g^{-1} soil to get Urease number. Multiply Urease number by 0.32 to obtain Urease units (Hoffman, 1965).

Results and Discussions

Plant growth parameters

The perusal of data presented in Table 2 indicates that different organic amendments like amritpani, jeevamrut, poultry manure, vermicompost and FYM had significantly influence the plant height, root length, plant biomass, number of fruits per plant, fruit yield (per hectare and per plant). Plant subjected to 90% Recommended dose of nutrients (RDN) along with PGPR inoculation and liquid organic inputs exhibited maximum increase in plant height (58.3 cm) of capsicum, significantly higher plant biomass (65.87 g plant^{-1}), highest (16.54) number of fruits, maximum (26.96 t ha^{-1}) fruit yield was recorded with 0.910 kg fruit yield per plant. These results are in line with those of Dwivedi *et al*., (2014) [12] who studied the effect of organic amendments like amritpani, jeevamrut, poultry manure, vermicompost and FYM in Cape gooseberry (*Physalis peruviana* L.) and recorded significant increase in plant height by the application of these organic amendments. Aniekwe and Nwokwu (2013) [4] recorded significantly higher number of fruits by the application of farm yard manure and vermicompost in Watermelon. The highest yield by the application of PGPR + 90% RDN + liquid organic input might be attributed due to increased plant growth parameter particularly height and branching and more number of fruits per plant. The effect of application of bulky manures and liquid organic inputs on root length revealed that maximum (15.3 cm) root length was recorded in T_3 with 80% RDN + PGPR + organic liquid inputs and the minimum (10.3 cm) root length was revealed in T_7 i.e. 40% RDN + PGPR + liquid organic inputs. However, T_1 (100% RDN) and T_4 (70% RDN + PGPR + organic liquid inputs) was statistically at par with root length of 12.6 cm and 12.8 cm, respectively. The increase in root length with increase in doses of N and organic inputs in capsicum has already been reported by Amirthalingam (1988) [3] who reported that with increasing in dose of nitrogen through chemical fertilizers + liquid manures, root length in capsicum crop increases.

Table 2: Effect of PGPR, Bulky and folk liquid manures on various plant growth parameters

Treatments	Plant Height (cm)	Root Length (cm)	Plant Biomass (g plant^{-1})	No. of fruits per plant	Fruit yield per plant (kg)	Fruit yield (t ha^{-1})
T1	46.5	12.6	57.92	13.25	0.649	19.23
T2	58.3	14.1	65.87	16.54	0.910	26.96
T3	51.0	15.3	63.57	14.19	0.738	21.87
T4	45.7	12.8	58.10	13.62	0.667	19.77
T5	43.4	11.8	55.23	11.01	0.495	14.68
T6	43.0	10.6	51.33	10.14	0.416	12.32
T7	39.9	10.3	50.77	9.08	0.336	9.95
Mean	46.8	12.5	57.54	12.55	0.602	17.83
CD (0.05)	3.70	1.11	3.56	2.11	0.11	3.40

Plant nutrient content

Total NPK content in shoot

The data presented in Table 3 revealed that total NPK content in shoot was significantly influenced by different treatments. Results showed that the effect of different treatments was significant and highest (5.46%) total nitrogen, (0.66%) total phosphorous content, total potassium (6.21%) was recorded for treatment T_2 (90% RDN along with PGPR and liquid organic input). Our results are in line with those of Ravimycin (2016) [23], who also reported increase in nutrient content of coriander plants by the application of vermicompost and farm yard manure.

Total NPK content in root

The data presented in Table 3 indicated that total nitrogen content in root which was influenced significantly by different organic amendments. The effect of different organic inputs was significant with highest (4.02%) total nitrogen, and higher (0.57%) total phosphorous content, highest (3.43%) total potassium content in root, observed under treatment T_2 (90% RDN + PGPR + panchagavya + jeevamrut + amritpani). These results are in accordance with the results obtained by Mia *et al.*, (2010) [18] who worked on banana plants and concluded that PGPR inoculation greatly increased NPK concentration in roots.

Total NPK content in fruit

The data presented in Table 3 indicated that total nitrogen content in fruit which was influenced significantly by different organic amendments. The effect of different organic inputs was significant with highest (4.61%) total nitrogen, and higher (0.60%) total phosphorous content, highest (4.02%) total potassium content in fruit, observed under treatment T_2 (90% RDN + PGPR + panchagavya + jeevamrut + amritpani). These results are in accordance with the studies carried out by Weber *et al.*, (2007) [30] who concluded that compost application significantly increases NPK content in plant and also affect soil properties.

Table 3: Effect of PGPR, Bulky and folk liquid manures on various plant nutrient content and plant uptake

Treatments	Shoot (%)			Root (%)			Fruit (%)			Uptake (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K	N	P	K
T1	4.16	0.55	5.83	3.72	0.55	3.37	4.20	0.50	3.76	10.37	1.38	11.12
T2	5.46	0.66	6.21	4.02	0.57	3.43	4.61	0.60	4.02	13.76	1.79	13.34
T3	4.38	0.62	5.98	3.88	0.56	3.38	4.55	0.54	3.88	12.06	1.62	12.46
T4	4.17	0.56	5.87	3.76	0.55	3.37	4.23	0.52	3.76	10.47	1.40	11.19
T5	3.74	0.48	5.82	3.68	0.46	3.30	4.12	0.39	3.68	9.44	1.09	10.46
T6	3.50	0.45	5.68	3.60	0.43	2.84	3.99	0.34	3.60	8.43	0.93	9.22
T7	3.27	0.32	4.85	3.27	0.28	2.25	3.92	0.30	3.27	7.87	0.68	7.81
Mean	4.10	0.52	5.75	3.71	0.49	3.14	4.23	0.46	3.71	10.34	1.27	10.80
CD (0.05)	0.20	0.04	0.21	0.13	0.10	0.19	0.22	0.10	0.14	0.58	0.14	0.64

Total uptake

An inquisition of data presented in Table 3 indicate that total uptake by plant is influenced significantly by different treatment with maximum value of total nitrogen (13.76 kg ha^{-1}), phosphorous (1.79 kg ha^{-1}) and potassium (13.34 kg ha^{-1}) uptake was recorded in treatment T_2 (90% RDN + panchagavya + jeevamrut + amritpani). The uptake of NPK in treatment T_2 increased by 31, 30 and 21%, respectively over 100% RDN. The lowest value of total uptake of nitrogen (7.87 kg ha^{-1}), phosphorous (0.68 kg ha^{-1}) and potassium (7.81 kg ha^{-1}) was recorded in treatment T_7 (40% RDN + panchagavya + jeevamrut + amritpani). The findings are in conformity with those of Turan *et al.*, (2010) [27] as they also reported significant increase in macro and micro-nutrient uptake by the application of PGPR.

Soil properties

None of the tried treatment has significant effect on pH and EC as shown in Table 4. The pH and EC values ranged from 6.92 to 7.59 & 0.53 dS m^{-1} to 0.80 dS m^{-1} respectively. These results on soil pH and EC are in accordance with the studies carried out by Badhulkar *et al.*, (2000), Selvi *et al.*, (2004) and Bajpai *et al.*, (2006) [7, 24, 8] clearly revealed that only long term experimentation may bring changes in some of the physico-chemical properties of soil. However significantly higher (1.30%) organic carbon was recorded in T_2 and lower (1.05%) was recorded in T_7 (40% RDN through vermicompost and poultry manure + PGPR + liquid organic inputs). Das and Singh (2014) [11] recorded that combined application of organic inputs such as farm yard manure (FYM), cereal compost, and legume compost and with PGPR has increase significantly organic carbon of soil as compare to the application of RDN individually. Also significant higher (441.73 kg ha^{-1}) value of available nitrogen was recorded under treatment T_2 having 90% RDN with PGPR and also liquid organic inputs (panchagavya, jeevamrut and amritpani) followed by treatment T_3 [80% RDN along with PGPR and liquid (panchagavya, jeevamrut and amritpani) inputs], However, treatment T_1 (100% RDN) was statistically at par with treatment T_4 (70% RDN along with PGPR and liquid (panchagavya, jeevamrut and amritpani) inputs). The increase in available N might be ascribed to organic manures i.e. vermicompost and poultry manure, which contain higher amount of nutrient. The results are in conformity with those of Boateng *et al.*, (2006) [10] who also recorded over 53% increase in available N by the application of poultry manure in maize. It was also found that significantly higher (76.71 kg ha^{-1}) content of available phosphorous was recorded in treatment T_2 and the minimum (55.07 kg ha^{-1}) amount of available phosphorous was recorded under treatment T_6 [50% RDN along with PGPR and liquid manures (panchagavya, jeevamrut and amritpani) inputs]. The present results are in accordance with the findings of Singh and SubbaRao (1979) who found that bio-fertilizers (*Azospirillum brasilense* with *Rhizobium japonicum)* increased the available phosphorous content in soil of soybean. Significantly higher (290.10 kg ha^{-1}) value of available potassium was recorded in treatment T_2 containing 90% RDN along with PGPR and Liquid inputs (panchagavya, jeevamrut and amritpani) as compared to T_1 (100% RDN) with 276.97 kg ha^{-1}, followed by treatment T_3 (281.48 kg ha^{-1}) containing application of 80% RDN along with PGPR and liquid organic inputs (panchagavya, jeevamrut and amritpani). The lowest available potassium was recorded under treatment T_7 (262.03 kg ha^{-1}) having 40% RDN along with PGPR and liquid organic inputs (panchagavya, jeevamrut and amritpani). These results are also in confirmation to the findings of Aziz *et al.*, (2010) [6] who reported that organic manure (farm yard manure) application significantly increases the soil available potassium content in soil. The significant effect of application of microbial inoculation and organic inputs on pooled analysis data of available micronutrients cations presented in Table 4 revealed that maximum Zn, Cu, Fe, Mn *viz.* 3.12 ppm, 2.89 ppm, 7.50 ppm, 2.76 ppm available micronutrients cations were recorded in T_2 with 90% RDN + PGPR + organic liquid manures and minimum (Zn, Cu, Fe, Mn *viz.* 1.29 ppm, 1.20 ppm, 4.74 ppm, 1.18 ppm) available micronutrient cations were obtained in T_7 i.e. 40% RDN + PGPR + organic liquid inputs. The present findings are further corroborated by findings of Jain *et al.*, (2014) [14] that application of panchagavya had significant effect on available micronutrients in different plant seedlings.

Table 4: Effect of PGPR, Bulky and folk liquid manures on available macro and micronutrients

Treatments	pH	EC (dS m^{-1})	Organic Carbon (%)	Macronutrient (kg ha^{-1})			Micronutrient (ppm)			
				N	P	K	Zn	Cu	Fe	Mn
T1	6.92	0.72	1.21	416.06	70.03	276.97	2.37	2.38	5.22	1.83
T2	7.03	0.65	1.30	441.73	76.71	290.10	3.12	2.89	7.50	2.76
T3	7.59	0.57	1.26	427.44	72.42	281.48	2.76	2.70	5.94	2.13
T4	6.57	0.78	1.18	416.79	69.23	275.75	2.38	2.44	5.24	1.82
T5	7.10	0.53	1.16	392.78	66.47	273.71	1.76	1.49	5.15	1.74
T6	7.07	0.57	1.10	377.80	55.07	268.50	1.42	1.23	5.11	1.25
T7	7.01	0.80	1.05	366.59	63.89	262.03	1.29	1.20	4.74	1.18
Mean	7.04	0.66	1.18	405.60	67.69	275.51	2.16	2.05	5.56	1.82
CD $_{(0.05)}$	NS	NS	0.03	5.08	5.81	7.46	0.36	0.73	0.94	0.5

Soil microbiological properties

Microbial count

The data embodied in Table 5 revealed that the viable microbial count significantly influenced by different tried treatments. The maximum microbial count (146.67×10^5 cfu g^{-1} soil) was recorded in treatment T_2 [PGPR along with 90% RDN through bulky organic inputs (vermicompost and poultry manure) along with liquid organic (panchagavya, jeevamrut and amritpani) inputs]. The lowest colony forming units (105×10^5 cfu g^{-1} soil) were recorded in T_6 treatment i.e. 50% RDN along with PGPR and liquid organic inputs. These results are on line with the findings of Jain *et al.*, (2014) [14] who tried different combinations of panchagavya + vermicompost + FYM and noted that application of these manures increase microbial activity as well as microbial counts as compare to control.

Microbial biomass-C

Similarly highest (58.37 µg g^{-1} soil) microbial biomass-C was recorded in T_2 (90% RDN through vermicompost and poultry manure along with PGPR inoculation and liquid organic inputs) as given in Table 5. The other treatment combinations T_1 (100% RDN through vermicompost and poultry manure) and T_4 (70% RDN through vermicompost and poultry manure along with PGPR inoculation and liquid organic inputs) were statistically at par. The increase in Microbial biomass-C may be ascribed to increase in number of microbes under T_2. Similar findings are presented by Beckman (1973); Udoh *et al.*, (2005) [9, 28].

Table 5: Effect of PGPR, Bulky and folk liquid manures on various soil microbiological properties

Treatment	Microbial Count ($\times 10^5$ cfu g^{-1} soil)	Microbial Biomass (µg g^{-1} soil)	Dehydrogenase (mg TPF h^{-1} g^{-1} soil)	Urease (mg NH^{4+} g^{-1} soil)	Phosphatase (µmole PNP h^{-1} g^{-1} soil)
T1	129.00	47.43	4.17	0.22	25.25
T2	146.67	58.37	4.79	0.29	29.39
T3	135.67	53.03	4.44	0.25	27.72
T4	130.00	47.97	4.15	0.21	25.40
T5	120.00	38.87	3.81	0.20	23.40
T6	105.00	24.00	3.34	0.16	22.12
T7	115.33	30.27	2.82	0.18	19.07
Mean	125.95	42.85	3.93	0.21	24.62
CD $_{(0.05)}$	5.75	6.43	1.06	0.04	1.37

Soil Enzymes

The different treatment during both also influenced dehydrogenase activity in soil. The maximum (4.79 mg TPF h^{-1} g^{-1} soil) value of dehydrogenase was observed in treatment T_2 i.e. 90% RDN + panchagavya + jeevamrut + amritpani followed by Treatment T_3 (4.44 mg TPF h^{-1} g^{-1} soil) with 80% RDN + panchagavya + jeevamrut + amritpani, the treatment T_1 (4.17 mg TPF h^{-1} g^{-1} soil) with 100% RDN was statistically at par with treatment T_4 (4.15 mg TPFh^{-1} g^{-1} soil) having 70% RDN + panchagavya + jeevamrut + amritpani. The results are further in line with those of (Kohler *et al.*, 2007) [15] who also revealed increase in dehydrogenase in rhizospheric soil of lettuce by application of PGPR, alone or in consortium. The phosphatase activity influenced significantly by application of organic amendments differently. Significantly higher (29.39 µmole PNP h^{-1} g^{-1} soil) value of phosphatase was observed in treatment T_2 i.e. 90% RDN + panchagavya + jeevamrut + amritpani and. Treatment T_1 (25.25 µmole PNP h^{-1} g^{-1} soil) with 100% RDN was statistically at par with treatment T_4 (25.40 µmole PNP h^{-1} g^{-1} soil) having 70% RDN + panchagavya + jeevamrut + amritpani and lowest (19.07 µmole PNP h^{-1} g^{-1} soil) value of phosphatase enzyme was noted in treatment T_7 having 40% RDN + panchagavya + jeevamrut + amritpani. The results are supported by the findings of Kohler *et al.*, (2007) [15] which stated that increase in phosphatase activity near the rhizospheric soil of lettuce is due to the application of PGPR, alone or in consortium. The data pertaining to urease enzyme activity as influenced by different treatments enumerated in Table 5. It was found that significant higher (0.29 mg $NH^{4+}g^{-1}$ soil) value of urease enzyme activity were recorded in treatment T_2 containing 90% RDN along with PGPR and Liquid inputs (panchagavya, jeevamrut and amritpani). 100% RDN containing treatment T_1 (0.22 mg NH^{4+} g^{-1} soil) and treatment T_4 (0.21 mg NH^{4+} g^{-1} soil) containing 70% RDN along with PGPR and liquid organic inputs (panchagavya, jeevamrut and amritpani) were statistically at par. Lowest (0.16 mg NH^{4+} g^{-1} soil) value of urease enzyme activity was recorded in treatment T_6 with application of 50% RDN along with PGPR and Liquid organic inputs (panchagavya, jeevamrut and amritpani). The highest activity of urease enzyme was revealed in treatment T_2 might be due to application of poultry manure, vermicompost along with PGPR and organic input i.e. panchagavya, jeevamrut and amritpani. The results are in confirmation with the findings of Albiach *et al.*, (2000) [2] and Nayak *et al.*, (2007) [20] who also stated that the activity of urease as well as dehydrogenase and phosphatase enzymes in soil are influenced due to the long term application of organic inputs and compost in soil.

Conclusions

From the present investigations, it was concluded that the application of 90% RDN by Vermicompost and Poultry Manure along with liquid organic formulations i.e. Panchagavya, Jeevamrut and Amritpani and dipping of seedlings in liquid bio-fertilizer before transplanting significantly improved soil organic carbon, available macro and micronutrients, microbial count, microbial biomass, soil enzymes. Therefore the developed nutrient module may be recommended after conducting multi-locational trials for enhanced productivity of capsicum and sustaining soil health.

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