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Short communication

Effect of organic cultivation of *Capsicum annuum* L. on soil microbial properties under open-field and shade-house conditions

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ABSTRACT

Two bell pepper (*Capsicum annuum* L.) varieties, viz., California Wonder and Gangavati Local, were raised under nine completely organic nutrient sources, along with recommended package of practices, and, under completely inorganic nutrient sources. Irrespective of the variety and growing environment, there was substantial increase in total bacterial count (22.97% and 24.98%), population of fungi (20.23% and 20.23%), actinomycetes (36.89% and 36.83%) and mycorrhiza (44.63% and 29.40%) in open-field and shade-house conditions, respectively, in all the nutrient combinations where organic sources were used, compared to the inorganic treatment. All organic nutrient sources used were found to be similar in their effect on soil microbes.

Key words: Capsicum, organics, shade-house, soil microbes, dehydrogenase activity

Heavy use of chemical fertilizers, pesticides and fungicides causes health hazards and environmental pollution, apart from imparting resistance to pathogens nad insects. Thus, sustainable agriculture is the answer to tackle various issues arising from excessive dependence on synthetic chemicals. Organic farming is not merely non-chemical agriculture, but is a system for integrating interactions between soil, plant, water and soil micro-flora and fauna. Organic farming keeps soil healthy by improving biological life therein and helps sustain yields (Lampkin, 1990). It is based mainly on principles of restoration of soil organic matter in the form of humus and increasing microbial population (Pathak and Ram, 2003). Bell pepper, being a high-value crop, is subjected to indiscriminate use of fertilizers and pesticides for realizing high yields. But, information on organic cultivation of bell pepper as of now is rather scanty. Hence, the present study was undertaken with to assess the response of bell pepper to organic sources of nutrients in relation to biological status of the soil.

The experiment was carried out at Agricultural Research Station, Gangavati, during 2006 and 2007 in a fixed plot situated in the Northern dry zone of Karnataka (Zone-3) that receives rain both from South-West and North-East monsoon. This zone also falls under Tungabhadra command area. Average rainfall received here was 357.4mm and 176.4mm during the cropping seasons of 2006 and 2007, respectively. The soil of the experimental site was medium black. Composite soil samples were collected from 0-25cm depth before and after the experiment and subjected to analysis for biological properties. The experiment included main treatments as two varieties of bell pepper, viz., California Wonder and Gangavati Local. Sub-treatments were organic source of nutrients, presented in Table 1. The experiment was laid out in split-plot design, with three replications.

The experimental area was sown with sunhemp (*Crotalaria juncea*) about three months earlier to bell pepper and sunhemp was incorporated into soil 45 days before transplanting bell pepper. Sunhemp incorporation was done in all experimental plots except sub-plot treatments O_{10} and O_{11}. Subsequently, the plot area was brought to fine tilth by repeated ploughing and harrowing.

The nursery area too was ploughed, harrowed and the soil brought to a fine tilth. Beds for raising nursery seedlings for organic nutrient-source treatment were prepared by incorporating well-decomposed FYM + sand + red soil. Beds for raising seedlings for inorganic treatment were incorporated with the recommended dose of inorganic fertilizer mix along with FYM (Anontmous, 2005) before sowing bell pepper seeds. To avoid seed and soil-borne diseases, bell pepper seeds were treated with *Trichoderma viridae* prior to sowing. Roots of thirty five day old seedlings

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of bell pepper (except seedlings for O_{10} and O_{11} treatments) were dipped in a slurry containing biofertilizers, viz., *Azospirillum*, mycorrhizal and phosphorus solubilizing bacterial cultures, for ten minutes. The seedlings were transplanted to a shade-house. All the necessary care and cultural operations were followed to raise the bell pepper crop. Diseases and pests were, however, managed using products of animal or plant origin only (neem oil, NSKE 0.5%, NPV, *Pseudomonas fluorescence, Nomuruea releyi, Trichoderma viridae, Hirestela thampane and Verticillium lecani)* in the organic plots.

Table 1. Organic and inorganic sources of nutrients used

O_1 Basal dose of 100% N equivalent (150 kg/ha) through FYM 50% (75 kg/ha) and Vermicompost 50% (75 kg/ha)
O_2 Basal dose of 100% N equivalent (150 kg/ha) through FYM 50% (75 kg/ha) and Vermicompost 25% (37.5 kg/ha) as basal and top dressing after 45 DAT with 25% Vermicompost (37.5 kg/ha)
O_3 Basal dose of 150% N equivalent (225 kg/ha) through FYM 50% (112.5 kg/ha) and Vermicompost 50% (112.5 kg/ha)
O_4 Basal dose of 150% N equivalent (225 kg/ha) through FYM 50% (112.5 kg/ha) and Vermicompost 25% (56.25 kg/ha) as basal and top dressing after 45 DAT with 25% Vermicompost (56.25 kg/ha)
O_5 Basal dose of 100% N equivalent (150 kg/ha) through FYM 50% (75 kg/ha) and poultry manure 50% (75 kg/ha)
O_6 Basal dose of 100% N equivalent (150 kg/ha) through FYM 50% (75 kg/ha) and poultry manure 25% (37.5 kg/ha) and top dressing after 45 DAT with 25% poultry manure (37.5 kg/ha)
O_7 Basal dose of 150% N equivalent (225 kg/ha) through FYM 50% (112.5 kg/ha) and poultry manure 50% (112.5 kg/ha)
O_8 Basal dose of 150% N equivalent (225 kg/ha) through FYM 50% (112.5 kg/ha) and poultry manure 25% (56.25 kg/ha) as basal and top dressing after 45 DAT with 25% poultry manure (56.25 kg/ha)
O_9 Basal dose of 150 kg N equivalent through FYM, in addition to 25 t/ha recommended FYM
O_{10} NPK 150:75:50 kg/ha inorganic fertilizer source and 25 t/ha FYM as per recommended package (Control 1)
O_{11} NPK 150:75:50 kg/ha inorganic fertilizer source only (Control 2)

Varieties used: V1= California Wonder, V2= Gangavathi Local

Ten grams of soil samples were diluted serially, using sterile distilled water, to 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} strengths. Aliquots of the one ml of appropriate dilution were plated. Total bacteria present were enumerated by growth on nutrient agar, fungi on Martins Rose Bengal agar and actinomycetes on Kusters agar medium. Plates were incubated at room temperature and counts were made at three days for bacteria, at five days for fungi and at seven days for actinomycets. Mycorrhizal spores from soil samples were isolated by wetsieving and decanting (Gerdemann and Nicolson, 1963). Dehydrogenase activity in soil was assayed by the method of Cassida *et al* (1969). Data generated from the experiments were statistically analyzed and interpreted, following Fisher's method of Analysis of Variance, as suggested by Panse and Sukhatme (1967).

Data in Tables 2 and 3 reveal a substantial increase in total bacterial count (22.97% and 24.98%), total fungal count (20.23% and 20.23%) and total actinomycetan count (36.89% and 36.83%) in the experiment site after bell pepper cropping, in open and shade-house conditions, respectively, compared to the initial value. Bell pepper varieties did not

Table 2. Effect of nutrient source on total populations of bacteria, fungi and actinomycetes in bell pepper varieties grown under open-field conditions (pooled data)

Nutrient source	Total bacterial count (CFuX10^6/g)			Total fungal count(CFuX10^4/g)			Total actinomycetes count (CFuX10^4/g)		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
O_1	54.10	55.12	54.61	24.17	26.00	25.09	30.06	29.41	29.73
O_2	55.81	52.57	54.19	23.18	23.91	23.55	30.99	29.63	30.31
O_3	52.85	53.78	53.31	25.19	24.67	24.93	29.25	28.39	28.82
O_4	53.04	54.56	53.80	24.14	25.41	24.78	31.77	31.79	31.78
O_5	52.55	50.87	51.71	25.14	25.02	25.08	30.01	31.18	30.59
O_6	52.86	50.85	51.85	25.69	24.81	25.25	30.39	30.38	30.38
O_7	52.27	50.6	51.43	22.63	24.19	23.41	27.00	29.16	28.08
O_8	53.88	54.25	54.06	23.11	24.18	23.65	27.36	29.33	28.34
O_9	53.78	50.12	51.95	24.37	25.15	24.76	28.85	30.37	29.61
O_{10}	41.26	40.32	40.79	20.44	20.53	20.49	19.63	18.94	19.28
O_{11}	34.31	36.31	35.31	16.28	17.21	16.75	16.76	15.35	16.05
Mean	50.61	49.94	50.27	23.122	23.73	23.43	27.46	27.63	27.54
Initial Value		38.72		18.69			17.38		
% increase over IV		22.97		20.23			36.89		
	CD (*P=0.01)*	SEm±		CD (*P=0.01*)	SEm±		CD at (*P=0.01*)	SEm±	
Variety (A)	NS	0.6638		NS	0.5973		NS	0.3264	
Nutrient source (B)	6.09	1.6724		3.15	0.8635		3.79	1.0421	
AxB	8.62	2.3651		4.45	1.2212		5.36	1.4737	
AxB	7.43			5.36			4.25		

NS = Non-significant; V1= California Wonder; V2= Gangavathi Local

Table 3. Effect of nutrient source on total bacterial count, fungal count and actinomycetan count in bell pepper varieties grown under shade-house conditions (pooled data)

Nutrient source	Total bacterial count (CFuX10^6/g)			Total fungal count (CFuX10^4/g)			Total actinomycetes count (CFuX10^4/g)		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
O_1	40.33	42.33	41.33	17.53	18.57	18.05	23.6	22.27	22.93
O_2	40.67	41.37	41.02	16.33	16.97	16.65	20.53	22.23	21.38
O_3	41.40	41.46	41.43	18.10	18.53	18.31	23.00	22.53	22.76
O_4	41.00	41.30	41.15	18.47	17.63	18.05	22.13	24.77	23.45
O_5	42.53	39.40	40.96	17.07	18.30	17.68	24.67	21.63	23.15
O_6	37.93	38.76	38.34	17.13	16.93	17.03	20.50	20.40	20.45
O_7	39.53	39.70	39.61	16.80	17.10	16.95	22.50	21.06	21.78
O_8	40.10	40.73	40.41	16.13	16.23	16.18	19.90	22.60	21.25
O_9	41.50	43.63	42.56	18.23	17.50	17.86	24.90	26.43	25.66
O_{10}	29.33	29.53	29.43	15.17	15.07	15.12	17.27	18.00	17.63
O_{11}	28.47	27.53	28.00	14.17	14.40	14.28	14.33	13.83	14.08
Mean	38.43	38.70	38.56	16.83	17.02	16.92	21.21	21.43	21.32
Initial Value	29.30	14.98	15.58						
% increase over IV	24.98	20.23	36.83						
	CD (*P=0.01*)	SEm±		CD (*P=0.01*)	SEm±		CD (*P=0.01*)	SEm±	
Variety (A)	NS	0.720		NS	0.222		NS	0.393	
Nutrient sources (B)	6.36	1.748		NS	1.126		3.88	1.065	
A × B	9.00	2.473		NS	1.593		5.48	1.507	
A × B	7.88			NS			4.58		

NS = Non-significant; V1= California Wonder; V2= Gangavathi Local

significantly influence microbial count. Organic treatments showed significant increase in microbial count over inorganic treatments. However, the of various organic treatments were found to be at par for microbial count.

There was substantial increase in total mycorrhizal count (44.63% and 29.40%) and dehydrogenase activity (30.72% and 8.87%) in the open and shade-house conditions, respectively, in organic treatments over the initial value (Tables 4 and 5). Results indicated that organic sources of nutrients significantly influenced soil mycorrhizal count as well as dehydrogenase activity compared to inorganic sources. However, there was no significant difference among organic sources of nutrients.

Vermicompost and poultry manure are known to contain higher amounts of growth substances, vitamins and enzymes. This increased the bacterial population and root biomass, resulting in elevated amounts of exudates which, in turn, increased bacterial multiplication in the rhizosphere region. Present results are in agreement with those of Chitesh (2005) and Nandani (2006). Microbial count was higher in the treatments O_1 to O_8 compared to other treatments involving chemical fertilizers.

Treatments O_1 to O_8 had higher dehydrogenase activity (2.62 to 2.97µl hydrogen evolved) compared to the inorganic nutrient source treatment O_{11} (2.15µl hydrogen

Table 4. Effect of nutrient source on total mycorrhizal count and dehydrogenase activity in soil after cropping season in bell pepper varieties grown under open-field conditions (pooled data)

Nutrient source	Total mycorrhizal count (No. of spores/100 g)			Dehydrogenase activity (µg TPF /g soil/24 hrs)		
	V_1	V_2	Mean	V_1	V_2	Mean
O_1	135.45	133.85	134.65	4.04	3.80	3.92
O_2	129.58	130.28	129.93	3.64	3.69	3.66
O_3	128.29	130.14	129.22	3.79	3.74	3.76
O_4	132.86	130.50	131.68	3.80	3.63	3.71
O_5	129.59	131.96	130.78	4.08	3.81	3.94
O_6	127.66	130.37	129.02	3.79	3.73	3.76
O_7	133.67	133.69	133.68	3.76	3.68	3.72
O_8	137.21	133.04	135.13	3.71	3.72	3.71
O_9	130.86	131.35	131.11	3.94	3.78	3.86
O_{10}	108.67	109.74	109.21	3.00	2.89	2.94
O_{11}	82.24	80.87	81.555	2.40	2.35	2.37
Mean	125.10	125.07	125.09	3.63	3.52	3.58
Initial Value		88.31			2.48	
% increase over IV		44.63			30.72	
	CD (*P=0.01*)	SEm±		CD (*P=0.01*)	SEm±	
Variety (A)	NS	0.8672		NS	0.0089	
Nutrient sources (B)	10.76	2.9554		0.19	0.0548	
AxB	15.23	4.1796		0.28	0.0775	
AxB	11.19					

NS = Non-significant
V1= California Wonder
V2= Gangavathi Local

Table 5. Effect of nutrient source on total mycorrhizal count and dehydrogenase activity in soil after cropping season in bell pepper varieties grown under shade-house conditions (pooled data)

Nutrient source	Total Mycorrhizal count (No. of spores/100 g)			Dehydrogenase activity (µg TPF /g soil/24 hrs)		
	V_1	V_2	Mean	V_1	V_2	Mean
O_1	99.33	105.33	102.33	2.97	2.97	2.97
O_2	101.33	106.00	103.66	2.68	2.67	2.67
O_3	102.66	102.33	102.49	2.63	2.65	2.64
O_4	105.33	106.00	105.66	2.61	2.63	2.62
O_5	97.33	93.33	95.33	3.08	3.03	3.05
O_6	93.66	95.66	94.66	2.74	2.67	2.70
O_7	95.33	92.66	93.99	2.77	2.70	2.73
O_8	100.00	87.00	93.50	2.84	2.75	2.79
O_9	110.00	105.66	107.83	2.95	2.79	2.87
O_{10}	63.33	53.66	58.49	2.37	2.24	2.30
O_{11}	44.66	41.33	42.99	2.14	2.17	2.15
Mean	92.08	89.90	90.99	2.51	2.46	2.48
Initial Value	50.38	2.26				
% increase over IV	29.40	8.87				
	CD (*P=0.01*)	SEm±		CD (*P=0.01*)	SEm±	
Variety (A)	NS	1.896		NS	0.026	
Nutrient sources (B)	14.72	4.056		0.24	0.065	
A × B	20.89	5.736		0.33	0.092	
A × B	19.45			0.29		

NS = Non-significant
V1= California Wonder
V2= Gangavathi Local

evolved). Higher enzyme activity in these treatments may be attributed to higher soil microbial population which was probably due to more substrates being available in the form of FYM, Vermicompost and poultry manure.

Soil organic matter plays an important role in protecting soil enzymes which become immobile in the three dimensional network of clay and humus complex (Tabatabai, 1994). This reflects greater biological activity in the plot receiving these substrates and stabilization of extra-cellular enzymes with humic substances (Burns, 1982 and Colvan *et al*, 2001). These results of the experiment are also in conformity with findings of Gunadi *et al* (1999), Masciandaro *et al* (2000), Chitesh (2005) and Nandani (2006).

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