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Effect of organic nutrient sources on growth, yield and quality of bell pepper (*Capsicum annuum* L.) under mid hill condition of Himachal Pradesh

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Abstract
The experiment was laid out in Randomized Complete Block Design (RCBD) Factorial with three replications comprising of ten treatment combinations of organic manure and liquid manure. The study revealed that application of Vermicompost @ 7 t/ha along with Jeevamrut (Drenching @ 5 % + Foliar spray @ 3 %) significantly influenced growth and yield attributes of bell pepper and recorded (82.4) per cent increase in yield over control along with less incidence of insect pest and diseases. However FYM @10 t/ha + VC 3.5 t/ha + Jeevamrut (Drenching @ 5 % + Foliar spray @ 3 %) recorded highest TSS (^{0}B) and ascorbic acid content (mg/100g). Hence, application of Vermicompost along with Jeevamrut for getting better growth, high yield, and least insect pest and diseases incidence can be recommended for commercial cultivation in mid Hill condition of Himachal Pradesh.

Keywords: FYM, vermicompost, jeevamrut, growth, yield and quality

1. Introduction
Bell pepper (*Capsicum annuum* L. var. grossum Sendt.) belongs to family Solanaceae, chromosome number 2n = 24, commonly known as sweet pepper, capsicum and Shimla mirch. It is native of Mexico with secondary centre of origin in Guatemala (Bukasov, 1930) [5]. It was first introduced by British in 19th century in Shimla hills of India (Singh *et al*., 1993) [18]. Bell pepper is grown as autumn-winter crop in the plains and summer crop in the hilly areas of India. It is a warm season crop but grows well in mild climate. It is vulnerable to frost, a temperature ranging from 26-28 ºC during daytime and 16- 18 ºC at night is ideal for its growth and development. It can't withstand extreme temperatures, below 15 ºC and above 30 ºC significantly reduce growth and fruit set. High relative humidity is good for growth and development, fruit set and yield; however this condition is favourable for the development of foliar and fruit diseases (Hazra *et al*., 2011) [9]. Organic manure can be used as alternate practice to inorganic fertilizers (Naeem *et al*., 2006) [13] for the improvement of soil properties as well as microbial load (Suresh *et al*., 2004) [20]. Organic manure has a significant potential to promote plant growth as a provenance of all essential macro and micronutrients in their available forms during decomposition (Nweke *et al*., 2013) [15] and soil physical and chemical properties are enhanced (Chaterjee *et al*., 2005) [7]. So, growth, yield and quality of crop as well as soil quality are improved by the application of manures. The present global scenario strongly emphasizes the need to follow nature-friendly agricultural operations for sustainable food production. The expenditures of inorganic fertilizers is increasing exceedingly to a range that it becomes unavailable for the reach of small and borderline farmers. The Jeevamrut and organic manure are environmentally safe organic amendment made from the products of cow. The application of organic manure as well as liquid manure such as Jeevamrut results in significantly higher growth, yield and quality of crops (Gore and Sreenivasa, 2011) [8]. It is very essential to adopt sustainable agricultural practices through organic resources for different crops based on scientific facts. Keeping this factor in mind the present study was planned to produce healthy organic crop of bell pepper by using various inputs of biological origin and their effect on growth, yield and quality of the bell pepper crop.

2. Materials and methods
The present study was carried out at Vegetable Research Farm of the Department of Vegetable Science, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan HP from April to September, 2016. The experiment was laid out in Randomized Complete Block Design (RCBD) Factorial with three replications comprising of ten treatment combination of manure and liquid manure, the details treatment combination is given in Table.1. The seeds of bell pepper cv. Solan Bharpur were sown in the nursery beds on 5th March, 2016 and the seedlings were transplanted on 26th April, 2016. The plot size was 2.40 m x 2.25 m and a spacing of 60 cm X 45 cm was followed.The analysis of the soil was done before planting and it was found that soil was rich in organic matter and having pH, EC and OC values of 7.2, 0.431dSm^{-1} and 1.38 per cent, respectively. The available N, P and K content was recorded to be 395.14, 58.24 and 263.2 kg/ha, respectively.

Table 1: Details of treatments used in the study

Treat. No.	Treat. Code	Treatments
T_1	M_0L_0	No organic manure + No liquid manure (Control)
T_2	M_1 L_0	FYM @ 20 t/ha + No liquid manure
T_3	M_2 L_0	Vermicompost @ 7 t/ha + No liquid manure
T_4	M_3 L_0	FYM @ 10 t/ha + VC 3.5 t/ha + No liquid manure
T_5	M_4 L_0	FYM @15 t/ha + VC 1.75 t/ha + No liquid manure
T_6	M_0L_1	No organic manure + Jeevamrut (Drenching + Foliar Spray)
T_7	M_1 L_1	FYM @20 t/ha. + Jeevamrut (Drenching + Foliar Spray)
T_8	M_2 L_1	Vermicompost @ 7 t/ha. + Jeevamrut (Drenching + Foliar Spray)
T_9	M_3 L_1	FYM @10 t/ha + + VC 3.5 t/ha + Jeevamrut (Drenching + Foliar Spray)
T_{10}	M_4 L_1	FYM @ 15 t/ha + VC 1.75 t/ha + Jeevamrut (Drenching + Foliar Spray)

2.1 Application of organics

The entire FYM and Vermicompost as per treatment combination per plot were applied evenly by mixing with soil before transplanting of bell pepper seedlings and liquid manure was applied as 3 drenching with Jeevamrut @ 5 per cent at 15 days interval started at the time of transplanting + 2 Foliar Spray of Jeevamrut @ 3 per cent at 15 days interval started after 45 days of transplanting.

3. Result and discussion

3.1 Growth characters

An examination of Table. 2, indicated that the effect of manure, liquid manure and their interactions on leaf area were significant. Application of vermicompost significantly influenced all growth characters among various levels of manure. Significantly more plant height (65.13 cm), number of branches per plant (2.93) and leaf area (84.05 cm^2) were recorded with application of vermicompost and minimum growth characters were registered in M_0. Growth characters were also significantly enhanced with application of Jeevamrut (L_1) and recorded maximum plant height (64.83 cm), number of branches per plant (2.85) and leaf area (83.17 cm^2) as compared to L_0.

The data on different treatment combination divulged that maximum plant height (66.00 cm), number of branches per plant (3.20) and leaf area (85.39 cm^2) were observed in M_2L_1 and were minimum in M_0L_0. The application of vermicompost and Jeevamrut may have attributed to the faster enhancement of vegetative growth and storing sufficient reserved food materials for enhanced growth. It might also be due to huge amount of beneficial microbes present in vermicompost and jeevamrut which may have helped in decomposition of organic matter and releasing of available nutrients for easy uptake and utilization by plants from the soil treated with them resulting in better growth and development. These findings are in agreement with (Arancon *et al*., 2003) [4], (Arancon *et al*., 2005) [3], (Joshi and Pal Vig, 2010) [10], (Huerta *et al*., 2010) and (Adhikari *et al*., 2016) [1]. (Ramesh *et al*., 2015) [17] reported similar result in tomato.

3.2 Yield and quality characters

Data recorded on yield and quality characters have been depicted in Table. 2, 3 respectively. An examination of the data showed significant differences among various levels of organic manure and liquid manure as well as their interactions. Vermicompost treated plots produced significantly more number of fruits per plant (27.00), average fruit weight (56.43 g), fruit yield (21.77 kg/plot) and fruit yield (322.47 q/ha) while higher ascorbic acid content (178.67 mg/100 g) in M_3 and higher value of TSS (5.47 ^{0}B) were recorded in M_4 and minimum yield and quality characters were recorded when manure was not applied. Levels of liquid manure revealed that Jeevamrut (L_1) produced more number of fruits per plant (25.75), average fruit weight (54.43 g), fruit yield (20.20 kg/plot), fruit yield (299.26 q/ha), TSS value (5.83 ^{0}B) and ascorbic acid content (172.27 mg/100 g) as compare to L_0 (no liquid manure).

The interactions of both factors revealed that maximum number of fruits per plant (29.13), average fruit weight (59.33 g), fruit yield (24.73 kg/plot), fruit yield (366.42 q/ha), was observed in M_2L_1. However, TSS value (6.20 ^{0}B) and ascorbic acid content (181.33 mg/100 g) were highest in M_3L_1 and they were minimum in M_0L_0. It may be due to the direct effect of vermicompost application on plant growth, which provides a source of plant macro and micronutrients. Although some of these nutrients are present in inorganic forms and are readily available to plants, most are released gradually through mineralization of the organic matter, thus comprising a gradual-release fertilizer that contributes the plant with a dynamic and stable source of nutrients.These results are also supported by findings of (Kumar, 2016) [11], (Arancon *et al*., 2003) [4], (Arancon *et al*., 2005) [3], (Natesh *et al*., 2005) [14] and (Ramesh *et al*., 2015) [17]. (Pal *et al*., 2015) [16] and (Meena *et al*., 2014) [12] also reported maximum ascorbic acid content and TSS from application of vermicompost in tomato.

Table 2: Effect of organic nutrient sources on growth, yield and yield contributing traits

Particular	Plant height (cm)	Number of branches per plant	Leaf area (cm^2)	Number of fruits per plant	Fruit weight (g)	Fruit yield kg/plot	Fruit yield (q/ha)
Organic manure							
M_0	60.37	2.20	78.49	20.63	45.27	15.13	224.15
M_1	63.77	2.77	82.13	25.23	55.00	19.98	296.05
M_2	65.13	2.93	84.05	27.00	56.43	21.77	322.47
M_3	64.50	2.67	83.22	24.87	52.37	19.22	284.69
M_4	62.63	2.60	82.46	24.37	50.13	18.17	269.14
$CD_{0.05}$ (M)	0.54	0.15	0.58	0.64	1.30	0.41	6.04
Liquid Manure							
L_0	61.73	2.41	80.97	23.09	49.25	17.51	259.34
L_1	64.83	2.85	83.17	25.75	54.43	20.20	299.26
$CD_{0.05}$ (L)	0.34	0.09	0.37	0.41	0.82	0.26	3.82
Interaction (M×L)							
M_0L_0	57.60	2.13	77.96	18.67	42.47	13.56	200.89
M_0L_1	63.13	2.27	79.02	22.60	48.07	16.70	247.41
M_1L_0	62.53	2.53	81.99	24.40	53.47	18.70	277.04
M_1L_1	65.00	3.00	82.27	26.07	56.53	21.27	315.06
M_2L_0	64.27	2.67	82.71	24.87	53.53	18.80	278.52
M_2L_1	66.00	3.20	85.39	29.13	59.33	24.73	366.42
M_3L_0	63.13	2.40	81.76	24.13	48.80	18.57	275.06
M_3L_1	65.87	2.93	84.67	25.60	55.93	19.87	294.32
M_4L_0	61.13	2.33	80.41	23.40	48.00	17.90	265.19
M_4L_1	64.13	2.87	84.51	25.33	52.27	18.43	273.09
$CD_{0.05}$ (M×L)	0.77	0.21	0.82	0.91	1.84	0.58	8.54

Table 3: Effect of organic nutrient sources on quality and insect pest and diseases

Particular	TSS (^{0}B)	Ascorbic acid (mg/100 g)	Incidence of fruit borer (%)	Incidence of fruit rot (%)	Incidence of leaf curl virus (%)
Organic manure					
M_0	4.70	148.67	5.72 (2.58)	12.41 (3.62)	10.00 (3.29)
M_1	5.05	173.33	4.01 (2.24)	9.04 (3.14)	5.00 (2.35)
M_2	5.15	171.33	3.35 (2.03)	8.67 (3.00)	2.50 (1.73)
M_3	5.10	178.67	3.91 (2.19)	11.53 (3.53)	3.33 (1.97)
M_4	5.47	175.33	3.85 (2.20)	11.64 (3.55)	5.00 (2.35)
$CD_{0.05}$ (M)	0.12	1.31	0.12	0.11	0.55
Liquid Manure					
L_0	4.36	166.67	4.86 (2.41)	12.91 (3.72)	5.33 (2.43)
L_1	5.83	172.27	3.48 (2.09)	8.41 (3.02)	5.00 (2.24)
$CD_{0.05}$ (L)	0.08	0.83	0.07	0.18	NS
Interaction (M×L)					
M_0L_0	4.00	142.67	6.85 (2.80)	16.33 (4.16)	8.33 (3.03)
M_0L_1	5.40	154.67	4.58 (2.36)	8.48 (3.08)	11.67 (3.54)
M_1L_0	4.50	172.00	3.69 (2.16)	11.71 (3.56)	6.67 (2.74)
M_1L_1	5.60	174.67	4.34 (2.31)	6.38 (2.71)	3.33 (1.97)
M_2L_0	4.50	169.33	5.23 (2.49)	13.54 (3.81)	3.33 (1.97)
M_2L_1	5.80	173.33	1.48 (1.57)	3.79 (2.18)	1.67 (1.48)
M_3L_0	4.00	176.00	3.87 (2.20)	10.13 (3.33)	3.33 (1.97)
M_3L_1	6.20	181.33	3.94 (2.18)	12.93 (3.73)	3.33 (1.97)
M_4L_0	4.80	173.33	4.66 (2.38)	12.82 (3.72)	5.00 (2.45)
M_4L_1	6.13	177.33	3.04 (2.01)	10.45 (3.38)	5.00 (2.26)
$CD_{0.05}$ (M×L)	0.17	1.86	0.16	0.25	NS

3.3. Incidence of insect pest and diseases

Observations recorded on incidence of insect pest and diseases have been presented in Table. 3, revealed significant differences among different levels of organic manure and liquid manure as well as their interactions. It is evident that application of vermicompost (M_2) recorded lower incidence of fruit borer (3.35 %), fruit rot (8.67 %) and leaf curl virus (2.50 %) and maximum incidences were observed when no manure (M_0) was applied.

The plots treated with Jeevamrut (L_1) helped in reducing incidence of fruit borer % and recorded (3.48 %), fruit rot (9.02 %). However the effect of Jeevamrut was found non-significant on incidence of leaf curl virus and maximum were recorded in L_0 (No liquid manure). The interactions of both the factors showed lowest incidence of fruit borer (1.48 %) and fruit rot (3.79 %) in M_2L_1 whereas the interaction of both

manures was also found non-significant on incidence of leaf curl virus and maximum was recorded in M_0L_0.

This may be due to active and rapid multiplication of bacteria especially in rhizosphere, which creates favourable conditions for N-fixation at higher rate and availability of unavailable nutrients, hormone excretion and supply of antibacterial and antifungal substances with the application of vermicompost and Jeevamrut. Vermicompost been scientifically proved as 'miracle growth promoter & also plant protector' from pests and diseases. These findings are in accordance with (Sinha *et al*., 2010) [19] and (Kumar, 2016) [11]. (Am-Euras, 2009) reported vermicompost as a miracle of plant protector from pests and diseases. (Chadha *et al*., 2012) [6] reported efficiency of Jeevamrut against various plant pathogens.

4. Conclusion

From the present studies, it was concluded that among different levels of manure, vermicompost performed best for most of the yield and yield contributing traits with minimum insect pest and diseases incidence. In levels of liquid manure application of Jeevamrut performed best for most of the yield and yield contributing traits as well as least incidence of insect pest and diseases. The interaction effect of manure and liquid manure shown best result from combined application of Vermicompost + Jeevamrut for most of the yield, yield contributing traits as well as least incidence of insect pest and diseases. Therefore, on the basis of results obtained in present studies, application of Vermicompost @ 7 t/ha along with Jeevamrut (Drenching @ 5 % + Foliar spray @ 3 %) for better growth, high yield, least insect pest and diseases incidence can be recommended for commercial cultivation.

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