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Effect of organic growing media and crop geometry on growth and yield of *capsicum* var. California wonder under protected condition in North West Himalayas

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Abstract An experiment was conducted inside polyhouse during 2008 and 2009 to study the effect of organic growing media and plant spacing on growth and yield of capsicum variety California Wonder in the mid hills of north western Himalayas. The media consisting of Soil : Sand : FYM : Vermicompost (1 : 1 : 0.5 : 0.5) proved to be statistically superior over rest of the combinations for almost all the aspects under investigation. All the attributes were better or at par when the depth of the media was kept at lesser depth (15cm) and the plants at wider spacing (50x50cm). Therefore it can be inferred that incorporation of vermicompost and FYM led to the better soil properties and nutrient supply to plants, whereas appropriate crop geometry created suitable micro environment for proper plant competition. Better performance of the plants in lesser depth of media in turn made the cultivation economical for the growers.

Keywords: Crop geometry, Capsicum, Protected cultivars, growing meter

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Introduction

Capsicum is one of the important commercial vegetable of mid hills of Himalayas that gives maximum profit to the farmers during early and off-seasons when grown in greenhouses. It also has great potential for export (Singh, *et. al.*, 2005). "California Wonder", is the most commonly grown variety in the region. Despite its economic importance, growers are not in a position to produce good quality capsicum due to adverse climatic condition under open fields. Hence, to increase productivity of good quality produce and for production during off-season, there is need to cultivate capsicum under protected structures such as poly houses.

The consistent and discriminate use of inorganic fertilizers have caused serious damage to soil health, ecology and caused decline in vitamin and mineral content of fresh fruits and vegetables. The addition of farm organic wastes, manures and vermicompost etc. are extremely important to maintain the fertility and productivity of the agricultural system. Organically grown greenhouse crops in general, have higher nutrient demands than field grown crops and therefore, in order to optimize production it is essential to focus on the growing media studies. Use of bio fertilizers in vegetables enables the production of superior quality produce devoid of toxic residues. Since capsicum is mostly consumed fresh or only partially cooked, it should be free from the residual effects of chemical fertilizers. Moreover organically grown crops are preferred for their flavour, taste, nutritive value and extended shelf life. Hence, the present study was undertaken with respect to organic growing media and crop geometry of capsicum under protected condition in order to maximize yields and subsequently the profits gained by the producers.

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Materials and methods

The experiment was conducted at the experimental farm of Vivekananda Institute of Hill Agriculture (Indian Council of Agricultural Research) located at Hawalbagh ($29^{0}36'$ N, $79^{0}40'$ E and 1250 m amsl), Almora, Uttarakhand India. Planting of capsicum (*Capsicum annum* L.) var. "California Wonder" was done in split plot design (SPD) with three replications during the summer season of 2008 and 2009 inside a semi automatic polyhouse. The different growing media were allotted randomly to the main plots while the planting geometry to the sub-plots. All the standard recommended cultural practices were followed to raise a successful crop during the course of investigation. Treatment details along with symbols are depicted in Table-1

Data for growth and yield attributes were recorded on five randomly chosen plants in each treatment. Then the average was calculated. All the growth characters such as average plant height, diameter of main shoot, number of shoots and leaves per plant, leaf area and chlorophyll content index of leaves were recorded thrice at 30, 60 and 90 days respectively, after transplanting. The cumulative value of the yield per plant and per hectare was taken as and when the pickings progressed.

The data was subjected to analysis of variance with SPSS. When the *F* test was significant, means were separated by Duncan's Multiple Range Test (P=0.05).

Results and discussion

Growth parameters: The data in general revealed that the organic media consisting both of vermicompost and FYM incorporated upto 30cm depth recorded the maximum growth among all the treatments Perusal of the Table 2 showed that the plant height and diameter of the main shoot was significantly highest in M_4 over the control (M_5) consisting only of inorganic fertilizers during both the years of experimentation. In most of the cases it was statistically superior to the solely FYM based media (M_1 and M_2) also. The same media upto 15cm depth (M_3) performed closely behind it and gave the second best results and many times was statistically at par to the highest readings. Combination of FYM and vermicompost in M_4 and M_3 showed a tendency to produce more number of shoots per plant (Table 2) as compared to the media containing only FYM (M_1 & M_2) and control during both 2008 and 2009. Once again a similar trend was followed for number of leaves per plant, leaf area and chlorophyll content index during both the years. Here also M_4 and M_3 proved to be statistically superior over control and $M_{1.}$ (Table 3) These results are in accordance to the studies of Yadav and Vijayakumari,(2003) They had inferred that vermicompost alone and admixed with FYM, green manure, neem cake and N : P : K were found to be effective in improving various biometric parameters. Organic wastes can be broken down and fragmented rapidly by earthworm, resulting in a stable nontoxic material with appropriative structure which has potentially high economic value as a soil conditioner for plant growth. (Hala et al.,2003) Bio-fertilizers have a property of good water holding capacity and are also able to drain excess water to come to field capacity which creates congenial root environment. Considering the results, it is noticed that growth characters of capsicum were increased with application of vermicompost treatments. These results may be attributed to the role of macro and micro-nutrients, as well as the improved soil conditions due to vermicompost application, which conduced to stimulate metabolic processes and encourage growth, synthesis and accumulation of more metabolites in plant tissues. Several investigators mentioned similar results on different plants such as Kumar and Kohli (2005) in capsicum, Natarajan (2005) in tomato, Bairwa *et al* (2009) in Okra.

Table 1: Treatment details of the experiment along with symbols

Treatment No.	Growing media (M)	Plant spacing (S)	Symbol
1.	Soil : sand : FYM (1:1:1) (upto 15cm depth)	50 x 30cm	M_1 S_1
2.	Soil : sand : FYM (1:1:1) (upto 15cm depth)	50 x 50cm	M_1 S_2
3.	Soil : sand : FYM (1:1:1) (upto 30cm depth)	50 x 30cm	M_2 S_1
4.	Soil : sand : FYM (1:1:1) (upto 30cm depth)	50 x 50cm	M_2S_2
5.	Soil : sand : FYM : Vermicompost (1:1:0.5:0.5) (upto 15cm depth)	50 x 30cm	M_3 S_1
6.	Soil : sand : FYM :Vermicompost (1:1:0.5:0.5) (upto 15cm depth)	50 x 50cm	M_3 S_2
7.	Soil : sand : FYM : Vermi-compost (1:1:0.5:0.5) (upto 30 cm depth)	50 x 30cm	M_4 S_1
8.	Soil : sand : FYM : Vermi-compost (1:1:0.5:0.5) (upto 30cm depth)	50 x 50cm	M_4S_2
9.	Control	50 x 30cm	M_5 S_1
10.	Control	50 x 50cm	M_5 S_2

Table 2: Effect of organic growing media and plant spacing on plant height, diameter of main shoot and number of shoots per plant

Treat-ment	2008									2009								
	Plants height (cm)			Diameter of main shoot (cm)			Shoots per plant (no.)			Plants height (cm)			Diameter of main shoot (cm)			Shoots per plant (no.)		
	Days after transplanting																	
	30	60	90	30	60	90	30	60	90	30	60	90	30	60	90	30	60	90
Growing Media																		
M_1	42.48a	73.24ab	106.00b	0.92ab	1.39a	1.51ab	5.83	11.67	15.47a	51.09a	77.21a	103.86ab	0.92a	1.11ab	1.26a	6.00	10.50b	14.03
M_2	42.67a	73.81ab	107.05bc	0.93ab	1.42ab	1.51ab	6.03	11.73	15.60a	51.17a	79.92a	108.07bc	0.93a	1.16ab	1.28a	7.15	10.90b	14.13
M_3	44.08b	75.35bc	109.98cd	0.97b	1.47bc	1.52b	6.37	12.03	16.17	52.62ab	86.76b	115.92cd	1.02b	1.17ab	1.35b	7.38	11.43c	14.80
M_4	44.51b	76.88c	112.19d	0.97b	1.52c	1.53b	6.20	12.40	16.37	54.00b	88.89b	119.84d	1.00b	1.19b	1.39b	7.73	12.13d	15.27
M_5	42.10a	72.75a	102.41a	0.88a	1.38a	1.44a	5.35	10.63	15.17	48.90a	75.39a	98.18a	0.87a	1.08a	1.24a	5.50	8.67a	12.73
LSD (P=0.05)	1.35	2.38	3.32	0.07	0.06	0.08	0.3	0.52	0.73	4.90	4.96	8.55	0.07	0.10	0.06	0.44	0.63	1.24
Spacing																		
S_1	43.41a	75.00a	108.19a	0.92a	1.40a	1.47a	5.81	11.44	15.57	52 .00a	82.14a	110.15a	0.93a	1.11a	1.29a	6.65	10.47a	13.93
S_2	42.93a	73.79a	106.84a	0.95a	1.48b	1.53a	6.11	11.95	15.93	51.11a	81.14a	108.20a	0.96a	1.17b	1.32a	6.84	10.99b	14.45
LSD (P=0.05)	1.70	1.68	2.24	0.06	0.04	0.08	0.1	0.31	0.50	2.61	2.97	2.94	0.09	0.05	0.04	0.22	0.51	0.43

Table 3: Effect of organic growing media and plant spacing on number of leaves per plant, leaf area per plant and chlorophyll content index of plants.

Treat-ment	2008									2009								
	Leaves per plant (no.)			Leaf area per plant (cm^2)			Chlorophyll content index of leaves			Leaves per plant (no.)			Leaf area per plant (cm^2)			Chlorophyll content index of leaves		
	Days after transplanting																	
	30	60	90	30	60	90	30	60	90	30	60	90	30	60	90	30	60	90
Growing Media																		
M_1	80.07a	147.20a	160.27a	56.07ab	72.16ab	69.80a	58.99a	78.11b	70.45a	77.75ab	105.45a	47.85ab	63.13	74.02a	71.64a	60.14a	83.84	80.26ab
M_2	80.48a	158.50b	165.30a	60.55bc	73.71b	75.42ab	59.38a	76.76b	74.26a	81.40b	116.30b	57.63bc	67.47	75.43a	75.73	62.12a	84.62	81.60ab
M_3	87.70b	161.20b	166.43	63.56cd	74.75b	79.12bc	67.56b	85.64c	79.92b	88.35c	124.70c	61.37c	72.08	83.96b	80.76	68.86	85.91	84.07b
M_4	88.98	166.03c	169.80	66.16d	80.93c	82.87c	69.94b	79.89b	81.26c	91.60c	135.67c	68.20c	74.64	86.70b	85.54	70.78	86.26	83.46b
M_5	74.75	142.43a	150.27	56.22a	68.99a	72.21ab	56.59a	69.81a	69.80a	74.20a	106.23a	37.33a	59.51	73.73a	69.73a	57.84a	76.85	77.97a
LSD (P=0.05)	8.38	7.27	16.01	5.05	4.08	8.30	7.46	6.03	6.28	5.87	8.29	1.61	3.86	7.24	2.52	5.56	4.67	5.90
Spacing																		
S_1	83.20	156.44	163.97	58.86a	72.32a	73.45a	60.82a	75.71a	72.48a	83.74	119.99	156.54	65.91	76.55a	76.81a	61.29a	79.49a	79.25a
S_2	81.67	153.71	160.85	62.16b	75.89b	78.31b	64.17a	80.37b	77.80b	81.58	115.35	152.41	68.82	81.00b	76.54a	66.20	87.50	83.69
LSD (P=0.05)	3.55	4.71	7.06	1.95	1.65	3.36	4.27	4.89	5.29	4.49	7.08	4.85	2.12	3.17	1.45	3.0	2.62	3.81

Spacing is a nonmonetary input but it plays a vital role in plant growth and yield by changing the magnitude of competition. Wider spacing enhanced most of the growth parameters in the experiment but the difference was significantly higher only for number of shoots and leaf area per plant (Tables 2 and 3) These results are in agreement of studies conducted by Abu Baker (2008). The increase in plant population also caused significant decline in the chlorophyll index of the plant. However, the reduction of leaf chlorophyll content could be explained partially by the effects of shading of the lower canopy, causing poor canopy interception of the photosynthetically active radiation (Brahim *et al.*, 1998). At the wider spacing, the area for the development of a single plant is larger and so are the possibilities for more lush growth and the development of fruitful branches. In high densities, plants compete with each other for nutrients, water and light and therefore develop poorly (Maynard and Scott, 1998). There was no significant effect of the interaction of growing media and spacing on any of the growth parameters.

Yield: It is evident from Table 4 that the yield per plant increased significantly with the incorporation of vermicompost and FYM together in M_3 and M_4 media.

Table 4: Effect of growing media and spacing on yield of capsicum var. California Wonder

Treatment	2008		2009	
	Yield per plant (kg)	Yield per ha (q)	Yield per plant (kg)	Yield per ha (q)
Growing Media				
M_1	1.00^{b}	464.80^{b}	0.99^{a}	459.17^{bc}
M_2	0.98^{b}	460.56^{b}	0.92^{a}	428.00^{ab}
M_3	1.20^{c}	558.50^{c}	1.18^{b}	547.77^{d}
M_4	0.97^{b}	448.35^{b}	1.05^{a}	488.90^{c}
M_5	0.76^{a}	360.81^{a}	0.97^{a}	406.50^{a}
LSD (*P*=0.05)	0.13	60.32	0.13	45.67
Spacing				
S_1	0.82^{a}	458.02^{a}	0.82^{a}	457.98^{a}
S_2	1.15^{b}	459.19^{a}	1.22^{a}	474.16^{a}
LSD (*P*=0.05)	0.08	36.49	0.07	25.83

Means followed by the same letter in each column are not significantly different.

The media consisting of FYM alone also performed better than control. M_3 recorded the highest yield over rest of the treatments whereas control gave the poorest yield during both the years. In M_4 yield was statistically superior over M_2 and control during 2009. The treatments combining both vermicompost and FYM showed highest yields, while the yields of treatments using solely FYM were also comparable but were significantly lesser than the former. Both performed significantly better than the control. This result is in agreement of the findings of Llaven et al. (2008) in bell pepper, Uma Maheshwari and Haripriya (2007) in hot pepper. The vermicompost based M_3 and M_4 media again proved to be better to others as it produced maximum yields followed by that was FYM based M_1 and M_2 growing media. Even M_1 and M_4 were superior to control but the difference was significant only during 2009 (Table 4).

Wider spacing produced significantly more yield per plant during both the years. Although spacing induced differences in yield per hectare, but in the present study they were insignificant. The wider spacing leads to more growing area and better competition among plants and subsequently better growth which in turn had a positive effect on yield per plant and per hectare. Similar results were recorded by Mantur *et al.* (2005), A significant interaction between both the factors was recorded for yield per plant. M_2S_2, M_3S_2 and M_4S_2 were higher to M_2S_1, M_3S_1 and M_4S_1 respectively during both the years. During 2009, in addition to these, M_1S_2 and M_5S_2 were also higher to M_1S_1 and M_5S_1 respectively. The interaction of the growing media with vermicompost and wider spacing proved to be superior over the other media with lesser spacing as increased fruiting leads to increased yields.

The comparison between 15cm and 30cm depth of media revealed that although the more depth of media in M_2 and M_4 enhanced the growth characters, the yield per plant and per hectare was higher at the lower depths. It may be due to the fact that availability of more nutrients enhances the growth and development of plants (Hussein *et al*, 1984). On the other hand, the excess vegetative growth led to delayed flowering and fruiting resulting in lesser yields at higher depth of media. More over pepper has a strong taproot which is usually injured during transplanting. For the remainder of the life the taproot at the base of the stem gives rise to numerous, profusely branched laterals that grow more horizontally than vertically on transplanting , It means capsicum derives more nutrients from the surface soil so the lesser depth will prevent over use of media providing economical advantages in cultivation of capsicum in organic media. This is in agreement to studies conducted by Sirin and Sevgican, (1997). Also, the the shallow taproot system of these plants may have prevented the absorption of water and nutrients at deeper soil profiles (Brahim *et al.*, 1998).

The results of this investigation showed that the organic growing media consisting Soil : Sand : FYM : Vermicompost in a ratio of 1 : 1 : 0.5 : 0.5 up to a depth of 15 cm and at a plant spacing of 50 x 50 cm gave highest yield of capsicum var. California Wonder. It can be attributed to the better soil structure created by organic growing media, both physically and biologically, along with constant and steady nutrient supply to the plants. Apart from this, the proper spacing led to the healthy competition amongst the plants giving superior results. Furthermore, the better performance of plants in lesser depth of media makes the cultivation of capsicum in greenhouses less tedious and more economical as well.

सारांश

वर्ष 2008 एवं 2009 में उत्तर पश्चिमी हिमालय के मध्य पर्वतीय क्षेत्र में पॉलीहाउस में शिमला मिर्च की पौध बढ़त एवं उपज पर विभिन्न कार्बनिक वृद्धि माध्यमों एवं पौध ज्यामिती के प्रभाव का अध्ययन किया गया। इसके परिणाम स्वरूप यह पाया गया कि मृदाः बालूः गोबर की खादः वर्मी कम्पोस्ट (1:1:0.5:0.5) युक्त माध्यम सभी वृद्धि कारकों एवं उपज के लिए बेहतर सिद्ध हुई। परिणामों से यह भी संकेत मिलता है कि जब इस माध्यम का उपयोग कम गहराई (15 से.मी.) तक एवं पौधे से पौधे की दूरी अधिक (50 x 50 से.मी.) रखी गई तब भी उपरोक्त सभी अध्ययनरत कारकों पर बेहतर यह लगभग समान असर पाया गया। अतः यह स्पष्ट होता है कि वर्मीकम्पोस्ट एवं गोबर की खादों के उपयोग से मृदा की गुणवत्ता बढती है तथा उपयुक्त पौध ज्यामिती से पौधों को बढ़त हेतु सही सूक्ष्म वातावरण मिलता है। साथ ही कम गहराई तक वृद्धि माध्यम की आवश्यकता से खेती पर लागत कम हो जाती है।

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