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Performance of Bell Pepper (*Capsicum annum*) Under Different Grow Bag Media in Lalitpur District, Nepal

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ABSTRACT

Promoting rooftop farming using suitable grow bag media is of utmost importance in densely populated cities like Lalitpur to sustain the human race. To assess the productivity and other economic characteristics of bell peppers, an experiment was conducted from Feb 2022 to Jun 2022 in different grow bag media on the premises of Vegetable Crop Development Centre, Khumaltar, Lalitpur. The experiment was conducted in Randomized Complete Block Design (RCBD), with four replications and five treatments with growing media: Coco peat: vermicompost (1:1), Soil: sand: FYM (Farmyard Manure) (1:1:1), Soil: Sand: FYM: Vermicompost (1.25:0.75:0.5:0.5), Soil: vermicompost (1:1), and Soil: ash: FYM (1:0.5:1) on the cultivar California Wonder. Growth parameters like plant height (47.865 cm), number of leaves (50.6), number of branches/plant (9.5), and stem diameter, and yield parameters like total fruit weight (1693.93 gm), average fruit weight (84.68 gm), number of fruits (42.75), fruit diameter (6.37 cm), and fruit length (7.22 cm) were observed during the experiment. The media consisting of T3 (Soil: Sand: FYM: Vermicompost (1.25:0.75:0.5:0.5)) proved to be statistically superior over the rest of the combinations for almost all aspects under investigation, whereas comparatively poor performance was observed in Coco peat: vermicompost (1:1) media. This study suggests that the grow bag media of Soil: Sand: FYM: vermicompost (1.25:0.75:0.5:0.5) gave the highest gross return and net return, with the highest B: C ratio (2.08) observed in the grow bag media of Soil: Sand: FYM (1:1:1).

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Introduction

Bell pepper, also known as sweet pepper/capsicum, is a fruit of a solanaceous plant Capsicum annum, and is native to Central America and northern South America (Bosland, 1996). Different cultivars of this crop have different colors ranging from yellow, orange, and green to red and purple (Howard et al., 2000). Bell pepper shares the same genera with hot chili peppers (Capsicum fluorescence) which are used as condiments due to their pungency; however, it is not pungent because of the absence of pungent chemical capsaicin and is often called a sweet pepper (Govindarajan, 1986). Bell pepper is used as a green vegetable which is a rich source of vitamin C and other important micronutrients needed for the human body (Marin et al., 2004). Bell pepper is a plant of a relatively short cropping period, and high nutrient and antioxidant content (Navarro et al., 2006). It is very popular among commercial vegetable-growing farmers because of its high demand, relatively higher price, and low-price fluctuations over the year (Boriss & Brunke, 2005).

In Nepal, capsicum is cultivated in a 1470 ha area with a production of 15301 tons and a productivity of 10.41 tons/ha (MoALD, 2020Lalitpur, being one of the districts of Kathmandu Valley, is the most densely populated area in Nepal, covering an area of 385 sq. km and a head population of 548,401. (CBS Annual Report, 2019). In Lalitpur, Capsicum is cultivated in an area of 62 ha with a production of 1190 Mt and a yield of 19.25 Mt/ha which is higher than the National average (10.41 Mt/ha) (MoALD, 2020).

Lalitpur faces a high demand for vegetables, but limitations like land fragmentation, high population density, and conversion of productive land for commercial purposes restrict local production, forcing many households to buy vegetables at a premium. People are practising terrace farming with the use of locally available materials. In rooftop farming, the choice of different grow bag media for the cultivation of vegetables is situational and complicated. Urban farmers are facing uncertainty in

the selection of potting mixture and agricultural suppliers promoting expensive grow bag mediums. The potential growing media could be coco peat: vermicompost (1:1) (Brunda SN & Devi Singh, 2023). Very few research studies were carried out in Nepal to evaluate the growth and yield parameters of bell peppers by using different growing media. Therefore, this study aimed to evaluate using locally available and inexpensive media for cost-effective and organic bell pepper production. This experiment will not only find out the productive and cost-effective combination of grow bag media but also pave the way for further studies.

Materials and Methods

Experimental Site

The experiment was conducted from February 2022 to June 2022 in the office premises of the Vegetable Development Centre, Khumaltar, Lalitpur. It is located in the south-central part of Kathmandu Valley at an altitude of 1,400 meters with 27° 32' 31.0812" N latitude and 85° 20' 3.4692" E longitude. This region has a sub-tropical climate with mild summer and cold winter (DHM, 2022).

Weather Conditions During the Experiment

Weekly interval average data on different weather parameters i.e., maximum and minimum temperatures, precipitation and relative humidity recorded during the potato growing season is presented in Figure 1.

Experimental Details

The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications and 5 treatments. Each plot had 5 grow bags, and, in each grow bag, a single plant was transplanted. The size of the grow bag was 24cm* 24 cm*40 cm. California Wonder was the cultivar of bell peppers used in the experiment. It is a sturdy and wide-frame cultivar and is very suitable for rooftop gardening in growing bags. Treatment details are shown in the Table 1.

Crop Management Practices

Seedlings were grown in a tray containing Coco peat inside the greenhouses. After two weeks, seedlings were transferred into plastic bags containing coco peat and vermicompost (1:1). A solution of mancozeb (2%) was sprayed as a prophylactic measure to control fungus. They were transplanted on grow bags after 1 month. Grow bag mixes were prepared by mixing individual components of treatments in the ratio mentioned by volume. The grow bag filled 3/4 of its space. A basal dose of fertilizer i.e., 1 gram of urea, 1.25 gram of DAP and 1.25 gram of MOP was applied before transplanting. Another dose of 1 gram of urea was given at 50 DAT (Days After Transplanting) and 2% complete fertilizer at 35 DAT and 70 DAT were sprayed. The plants were sprayed with SAAF fungicide 2% by volume at 10-day intervals. We avoided using insecticide because there were no significant insect issues.

Observations

The height of the plant from ground level to the growing tip and the number of leaves were measured after 30 days of transplanting for the first time and after every 25-day interval. The number of branches capable of fruiting was measured at 55 and 85 days after transplanting. Stem diameters were measured at the final harvest stage at about 2cm from the ground level using vernier callipers from 5 sample plants and averages were calculated. Number of fruits per plot is calculated by adding all the number of fruits harvested throughout the research. The weight of a marketable fruit per plant was determined as the total weight of healthy fruit to the total no of sample plants at harvest which can be sold in the market. The fruits were harvested in 70, 77 and 84 days after transplanting. The yield components of the crop were recorded accordingly using an electronic balance. The benefit-cost analysis of different treatments was carried out by using the formula:

$$\frac{B}{C}\ \text{ratio} = \frac{\text{Gross Return}}{\text{Variable Cost}}$$

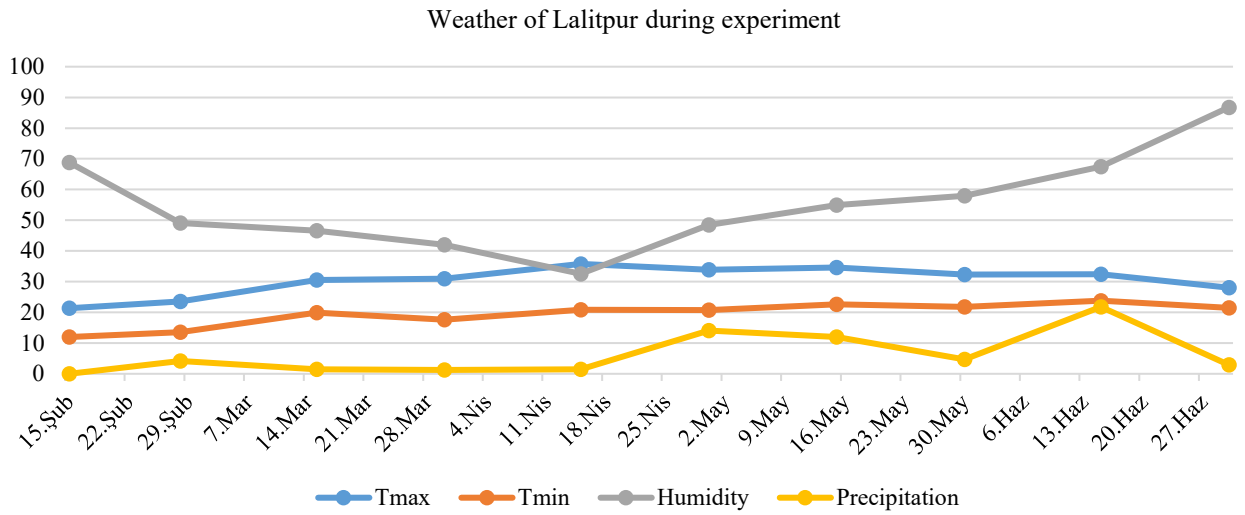

Figure 1. Weather conditions during the experiment in Lalitpur (NASA Powe, 2022). Temperatures in the figure are given in Celsius

Table 1. Treatment details

Treatment No.	Name of Treatment	Ratio	Symbol
1	Coco peat: Vermicompost	1:1	T1
2	Field soil: Sand: FYM	1:1:1	T2
3	Soil: Sand: FYM: Vermicompost	1.25:0.75:0.5:0.5	T3
4	Soil: Vermicompost	1:1	T4
5	Soil: Rice husk ash: FYM	1:0.5:1	T5

FYM: Farmyard Manure

Table 2. Effect of growing media on Plant height of bell peppers

Treatments		Plant height(cm)		
		30DAT	55DAT	80DAT
T_1	Coco peat: vermicompost (1:1)	12.14^{a}	21.65^{c}	37.1^{c}
T_2	Soil: sand: FYM (1:1:1)	11.63^{a}	27.5^{b}	43.2^{b}
T_3	Soil: sand: FYM: vermicompost (1.25:0.75:0.5:0.5)	12.30^{a}	31.4^{a}	47.87^{a}
T_4	Soil: vermicompost (1:1)	11.1^{a}	24^{c}	41.65^{b}
T_5	Soil: ash: FYM (1:0.5:1)	11.11^{a}	27.48^{b}	42.83^{b}
LSD (0.05)		1.55	2.92	3.93
C V%		8.62	7.19	11.14
Grand mean		11.65	26.41	42.53

Note: LSD, Least Significant Difference; SEm, Standard Error of mean; CV (%), Coefficient of Variation; DAT, days after transplanting. Means followed by the common letter(s) within each column are not significantly different at a 5% level of significance by the DMRT test.

Table 3. Effect of growing media on growth parameters of bell peppers

Treatments	Number of leaves			Number of branches		Stem diameter (cm)
	30 DAT	55 DAT	80 DAT	55DAT	80 DAT	80 DAT
T_1	7.25^{b}	19.54^{b}	37.4^{e}	5.85^{b}	6.5^{c}	1.05^{b}
T_2	10.45^{a}	35.15^{a}	47.35^{b}	6.4^{ab}	8.3^{b}	1.24^{a}
T_3	10.65^{a}	37^{a}	50.6^{a}	7.25^{a}	9.5^{a}	1.37^{a}
T_4	9.35^{a}	34.15^{ab}	42.35^{d}	6.8^{a}	7.8^{b}	1.19^{ab}
T_5	10.05^{a}	34.9^{a}	44.75^{c}	6.55^{ab}	8.35^{b}	1.26^{a}
LSD (0.05)	1.51	2.50	2.23	0.80	0.61	0.17
SE (+-)	0.21	0.36	0.32	0.11	0.09	0.024
C V%	10.23	7.92	9.02	7.92	4.86	9.02
Grand mean	9.55	32.15	44.49	6.57	8.09	1.23

Note: LSD, Least Significant Difference; SEm, Standard Error of mean; CV (%), Coefficient of Variation; DAT, days after transplanting. Means followed by the common letter(s) within each column are not significantly different at a 5% level of significance by the DMRT test.

Statistical Analysis

The data recorded on different parameters from the field and laboratory were first tabulated in Microsoft Excel (MS- Excel), and then Analysis of Variance (ANOVA) for all data was computed using the R-STUDIO computer software package. All the analyzed data were subjected to Duncan's Multiple Range Test (DMRT) for mean comparison at a 5% level of significance.

Results and Discussions

Effect of Growing Media on Growth Parameters of Bell Peppers

The use of different types of grow bag media showed a significant effect on the growth characteristics of bell peppers. Initially (30DAT), the performance of all the treatments was statistically similar. Later, significantly the highest plant height (47.865 cm) (Table 2), highest number of leaves (50.6) and the highest number of branches/ plants (9.5) were observed in T_3 (Soil: sand: FYM: vermicompost (1.25:0.75:0.5:0.5)) (Table 3). In most of the cases, the performance of plants in T_2, T_5 and T_4 was statistically similar, whereas T_1 showed the poorest performance on all dates. No significant difference was found in Stem diameter in all treatment combinations. The highest (1.37) and smallest (1.045 cm) stem diameter was recorded in the T_3 and T_1 respectively.

On average well-decomposed farmyard manure contains 0.5 percent N, 0.2 percent P_2O_5, and 0.5 percent K_2O (Shinde, 1992). Vermicomposting causes a considerable increase in available phosphorus, exchangeable potassium, calcium, and nitrogen (Nath, Singh, & Singh, 2009). Vermicompost contains high levels of readily available macro- and micronutrients, organic acids, and active microbial populations (Roy, Srivastava, Kumar, & Singh, 2010). Sand is an excellent medium for drainage and aeration since it warms and cools rapidly (Gungor & Yildirim, 2013). The maximum plant height observed in the treatment combination of Soil: sand: FYM: Vermicompost may have resulted from improved aeration, water retention, and nutrient availability in the growing media, which enhance plant vegetative growth, especially nitrogen and phosphorous, by promoting cell division and elongation (Gopinath et al., 2008). This result agrees with the findings of Kumar and Kohli (2005) in capsicum.

Coco peat has a very high water-holding capacity which causes poor aeration in the root zone (Hebbar, et al., 2011). Depending on the handling and processing technique, the physical properties of coco peat can easily affect the air

capacity and water retention. (Abad, Noguera, Puchades, Maquieira, & Noguera, 2002). The most suitable soil to grow capsicum is well-drained sandy loam soils with good percolation (Hebbar, et al., 2011). Waterlogging should not occur on the growing site because water stagnation harms the crop (Denzongpa & Sharma, 2013). Therefore, the poor performance of T_1 might be the water retention capacity of coco peat as waterlogging is detrimental to plants.

Effect of Growing Media on Yield Parameters of Bell Peppers

It is evident from Table 3 that the yield characteristics of bell peppers showed significant differences among different treatments of growing media. Total fruit weight per plot was recorded as the highest in the second harvest in all five treatments. In the second harvest, the highest total fruit weight was found in T_3, which was 1693.93gm and it was followed by T_4, T_2 and T_5 (Table 4). The lowest total fruit weight per plot of 891.36g was observed in the control treatment of Coco peat: vermicompost (1:1) (Table 4). Similar result was recorded in the first and third harvests. In the case of average fruit weight per plot, no significant difference was observed in all treatment combinations. The highest (84.68g) and the smallest (73.02g) average fruit weight per plot was recorded in the T_3 and T_1 respectively (Table 4). Similarly, the total number of fruits per plot was highest in T_3 (42.75) and T_5 showed the least number of fruits (26). Significant difference among the various treatment combinations was recorded in fruit diameter. T_3 (6.37 cm) showed superior performance, which was followed by T_2, T_4, T_5 and T_1. No significant difference was observed in fruit length in all treatment combinations. The highest fruit length was recorded in T_3 (7.22 cm) which was statistically similar to T_2, T_4, T_5 and T_1. This result agrees with the findings of Roy et.al, (2010) Llaven et al. (2008) and Uma Maheshwari and Haripriya (2007), where FYM and vermicompost-based growing media showed better yield traits.

Treatment containing sand and vermicompost might provide an ideal condition for the growth and development of capsicum fruit as sandy loam soil with better aeration is good for capsicum. Pepper plants thrive on more nitrogen than other crops, resulting in increased flower and fruit production (Haifa Group). When the soil lacks sufficient phosphorus, pepper plants will suffer stunted growth, with shorter and weaker branches, fewer flower buds forming, and ultimately, a decrease in overall fruit production (Haifa Group). A similar result was observed by Chewaka, Mohammed, & Kassa (2022), where potting media containing Compost + FYM + Topsoil showed superior performances.

Marketable and non-marketable Fruit Weight Per Plot

Different treatments had different effects on the marketable and non-marketable weight of fruits per plot. At the time of the second harvest, the highest marketable weight per plot (1615.25 g) was found in the grow bag containing Soil: Sand: FYM: vermicompost (T_3) and the lowest marketable weight per plot (809.45 g) was recorded in Coco peat and vermicompost (T_1) (Table 5). A similar trend was observed in the third harvest. The weight of non-marketable fruit per plot was highest (128.68g) in T_5, while it was found lowest (78.68 g) in T_3. However, the weight of non-marketable fruit per plot was highest (233.58g) in T_1 and the lowest in T_3 at the time of the third harvest.

Table 4. Effect of growing media on yield parameters of bell peppers

Trt	Total fruit weight per plot (g)			Average fruit weight (g)					
	1st hrv	2nd hrv	3rd hrv	1st hrv	2nd hrv	3rd hrv	FN	FD	FL
T_1	224.53^{d}	891.36^{c}	610.18^{b}	70.38^{c}	73.02^{c}	60.60^{b}	25.5^{d}	4.27^{d}	5.17^{c}
T_2	503.56^{b}	1350.07^{b}	882.43^{a}	77.29^{bc}	79.16^{abc}	69.52^{a}	36.25^{b}	6.07^{b}	6.48^{ab}
T_3	786.25^{a}	1693.92^{a}	991.78^{a}	85.23^{a}	84.68^{a}	73.63^{a}	42.75^{a}	6.37^{a}	7.22^{a}
T_4	530.56^{b}	1266.8^{b}	611.25^{b}	81.63^{ab}	80.22^{ab}	69.67^{a}	31^{bc}	6.015^{c}	6.28^{b}
T_5	343.9^{c}	985.22^{c}	572.56^{b}	72.13^{c}	74.03^{bc}	70.58^{a}	26^{d}	5.325^{d}	5.48^{bc}
LSD (0.05)	105.06	186.72	136.58	7.14	6.62	6.93	4.13	0.31	0.67
SE (+-)	15.24	27.09	19.82	1.04	0.96	1.01	0.599	0.60	0.43
CV%	14.27	9.79	12.08	6.00	5.49	6.54	8.30	8.30	7.68
Grand mean	477.8	1237.5	733.6	77.33	78.22	68.80	32.30	5.61	6.57

Note: LSD, Least Significant Difference; SEm, Standard Error of mean; CV (%), Coefficient of Variation; DAT, days after transplanting. Means followed by the common letter(s) within each column are not significantly different at a 5% level of significance by the DMRT test.

Table 5. Effect of growing media on marketable and non-marketable fruit weight of bell peppers.

Treatments	Second Harvest		Third Harvest	
	Marketable fruit weight per plot(g)	Non-marketable fruit weight per plot(g)	Marketable fruit weight per plot(g)	Non-marketable fruit weight per plot(g)
T_1	809.45^{d}	81.93^{c}	376.6^{e}	233.58^{a}
T_2	1257.35^{b}	92.73^{b}	673.4^{b}	209.03^{b}
T_3	1615.25^{a}	78.68^{d}	876.78^{a}	115^{d}
T_4	1178.63^{b}	88.18^{bc}	482.58^{c}	128.68^{d}
T_5	856.54^{d}	128.68^{a}	419.13^{d}	153.43^{c}
SE (+-)	1.45	0.96	1.24	0.89
CV%	11.2	14.09	9.5	10
Grand mean	1143.44	94.03	565.70	167.94

Note: LSD, Least Significant Difference; SEm, Standard Error of mean; CV (%), Coefficient of Variation; DAT, days after transplanting. Means followed by the common letter(s) within each column are not significantly different at a 5% level of significance by the DMRT test.

Table 6. Effect of different grow bag media on the performance of bell pepper: economic analysis

Treatments	Total cost of production (NRs/ plot)	Net return (NRs/ plot)	Gross return (NRs/ plot)	B: C ratio
Coco peat: vermicompost (1:1)	650.12	-71.12^{e}	579.00^{c}	0.89^{e}
Soil: sand: FYM (1:1:1)	368.23	398.07^{ab}	766.30^{b}	2.08^{a}
Soil: sand: FYM: vermicompost (1.25:0.75:0.5:0.5)	479.76	432.24^{a}	912.00^{a}	1.90^{ab}
Soil: vermicompost (1:1)	512.97	98.2^{c}	611.17^{bc}	1.19^{c}
Soil: ash: FYM (1:0.5:1)	415.12	36.11^{d}	451.23^{d}	1.08^{cd}
SE (+-)		0.97	1.23	0.65
C V%		8.43	9.34	7.65

Note: LSD, Least Significant Difference; SEm, Standard Error of mean; CV (%), Coefficient of Variation; DAT, days after transplanting. Means followed by the common letter(s) within each column are not significantly different at a 5% level of significance by the DMRT test

Economies of Bell Pepper Production Effective Tiller Per m^2

The use of different grow bag media had a profound effect on the cost of production, net return per plot, gross return per plot, and Benefit: Cost ratio. The total cost of production per plot was highest (650.12 rupees) in the control treatment of Coco peat: vermicompost (1:1) whereas it was found to be lowest (368.23 rupees) in the conventional potting mix i.e., Soil: sand: FYM (1:1:1) (Table 6). The gross return was highest (912 rupees) in the treatment with soil, sand, FYM, and vermicompost in the ratio of 1.25:0.75:0.5:0.5 whereas the gross return was found the lowest (451.23 rupees) in the treatment of Soil: ash: FYM (1:0.5:1) (Table 6). The benefit: cost ratio was highest (2.08) on the treatment containing soil, sand, and FYM on the ratio of 1:1:1 which was followed by Soil: sand: FYM: vermicompost (1.25:0.75:0.5:0.5). The B: C ratio was lowest and less than zero (0.89) on the mixture of cocopeat and vermicompost in the ratio of 1:1 (Table 6). It can be explained by the higher cost of both the raw materials.

Conclusions

The use of different grow bag media had a profound effect on growth, yield, and economic traits of the 'California Wonder' cultivar of bell pepper. The grow bag mix containing soil, sand, FYM and vermicompost in the ratio of 1.25:0.75:0.5:0.5 increased growth traits such as plant height, number of leaves and stem diameter; and yield attributing traits namely the number of branches, total fruit weight, average fruit weight and marketable fruit weight in capsicum. The gross return was the highest in the same treatment while net return and B: C were observed the highest in the treatment with the grow bag containing a mixture of soil: sand: FYM (1:1:1). Therefore, the use of the grow bag mix containing soil, sand, FYM and vermicompost in the ratio of 1.25:0.75:0.5:0.5 is beneficial to get the highest production bell pepper in Lalitpur district.

Declarations

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