Himachal Journal of Agricultural Research 36 (1): 40-46, 2010

Performance of yellow and red capsicum hybrids in naturally ventilated polyhouse in mid hills of Western Himalaya

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Abstract

The present investigation was carried out in 24 x 10 m naturally ventilated polyhouse having fan pad system by evaluating 18 genotypes of bell pepper during April to December 2007 in Randomized Block Design having three replications with the objectives to estimate the extent of variation for various economic traits and to identify high yielding hybrids desirable for greenhouse cultivation. Observations were recorded on marketable green as well as coloured fruit yield per plant and other important horticultural and quality traits. Mean sum of squares due to genotypes were significant for all the traits except number of lobes per fruit. The study revealed that Hybrid-16 and Hybrid-10 for green fruits and Hybrid-16 and Hybrid-3 for coloured fruits exhibited high mean performance for marketable fruit yield per plan' number of marketable fruits per plant, harvest duration, fruit size and these hybrids need to be included for further evaluation in different agro-climatic zones of Himachal Pradesh under protected environment.

Key words: Capsicum hybrids, protected cultivation, red and yellow capsicum hybrids.

Introduction

Bell pepper (*Capsicum annuum* L. var. grossum Sendt.), commonly known as sweet pepper or *Shimla mirch,* is the native of Mexico with secondary centre of origin in Guatemala (Bukasov, 1930). It was introduced in India by the Britishers in the 19th century in Shimla hills. Globally, it is cultivated over an area of 17, 03,486 ha with the production and productivity of 2,60,56,900 and 15.30 tonnes including hot pepper (FAO, 2007). In India, it is cultivated over an area of 5,500ha with the production and productivity of 51,000 and 9.27 tonnes including hot pepper, respectively (FAO, 2007). It is commercially grown in Himachal Pradesh, Jammu and Kashmir, Uttrakhand, Arunachal Pradesh and Darjeeling District of West Bengal during summer months and as an autumn crop in Maharashtra, Karnataka, Tamil Nadu and Bihar. In Himachal Pradesh, it is extensively grown as cash crop (June-October) in zone I, zone II and zone III in open environment and covers an area of 2,447 ha with the production of 31,810 tonnes including hot pepper (Anonymous, 2008).

Fruits of bell pepper are generally blocky, square, thick fleshed and three to four lobed with low to mild pungency. There are several uses of bell pepper *viz.,* salad, stuffing material, cooked vegetable, pickled, or processed and appreciated worldwide for its aroma, flavour and colour. Bell pepper is rich in alkaloids (capsaicin), fatty acids, flavonoids, volatile oil and carotene. It is rich in ascorbic acid and zinc, which are vital for a strong and healthy immune system. It is rich in vitamin A, rutin (a bioflavonoid), beta-carotene, iron, calcium and potassium. It also contains magnesium, phosphorus, sulphur, B-complex vitamins, sodium and selenium (Agarwal *et al.,* 2007).

It is an important off-season egetable of western Himalayas and offers potential for boosting economy of the farmers of hilly regions. It is a warm season and chilling sensitive crop and cannot tolerate extended periods of temperature below 10^0 C. The mean growing temperature for the crop is 18–24^0 C. At present, capsicum growers in hilly regions are facing several problems in the open field cultivation like vagaries of weather *viz.,* fluctuating temperature, unprecedented rains and frequent hailstorms, which affect yield and quality of the produce thereby reducing the profit margin of the producers. Due to these, the scenario of bell pepper production in western Himalayas has been changing significantly and the protected cultivation is getting preference over open field cultivation for off-season quality production, extending availability of the quality produce, higher productivity and improved nutritional attributes of the polyhouse produce. In open environment, the growers produce green capsicum only which is not comparable in quality

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with the polyhouse produce, however, it sells at premium price in adjoining plains. Protected cultivation also offers promise for production of coloured capsicum, which is in huge demand in fast food industry and metropolitan cities, where it is sold at premium price thereby fetching lucrative returns to the growers.

Preliminary studies have revealed that capsicum can become a money spinner for hill farmers in protected environment. However, information related to performance of hybrids of bell pepper under protected environment both for green and coloured fruits is meager. In spite of economic importance of the crop in hilly regions under protected conditions, research efforts have not been made to evaluate the existing hybrids of bell pepper for the production of green or coloured fruits especially in mid hills of the sub-temperate western Himalaya. Therefore, the present study was aimed to assess the performance of red and yellow capsicum hybrids under naturally ventilated polyhouse.

Material and Methods

The present investigation was undertaken at Experimental Farm of the Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishavavidyalaya, Palampur during the year 2007. The experimental farm is situated at 32^0 6' N latitude and 76^0 3' E longitude at an elevation of 1290.80 m above mean sea level. Severe winters and mild summers with high rainfall characterize the place. Agro climatically, the location represents the mid-hill zone of Himachal Pradesh and is characterized by humid sub-temperate climate with high rainfall (2500 mm), of which 80% is received during June to September. Due to heavy down pour, it is difficult to grow capsicum at Palampur in open field conditions after July. The experimental material for the present study comprised of 18 genotypes of capsicum including 2 standard checks, i.e Hybrid-1, Hybrid-2, Hybrid-3, Hybrid-4, Hybrid-5, Hybrid-6, Hybrid-7, Hybrid-8, Hybrid-9, Hybrid-10, Hybrid-11, Hybrid-12, Hybrid-13, Hybrid-14, Hybrid-15, Hybrid-16, Bharat F_1 hybrid (check) and California Wonder (OP check).

Eighteen genotypes comprising of 17 hybrids and 1 open pollinated variety were planted in Randomized Block Design with 3 replications in a 24 x 10 m modified naturally ventilated polyhouse having fan pad system. The crop was grown on 20 cm raised beds having 70 cm width. Besides the application of vermicompost @ 5 tonnes per hectare, the chemical fertilizers were applied as per the recommended package of practices (50 kg each of N, P, and K per hectare). Whole of vermicompost and chemical fertilizers were applied in pits before transplanting. The fertigation was given once a week by applying liquid fertilizer (19:19:19) after third week of transplanting and was stopped 15 days before final harvest. The nursery was sown on 2nd February 2007 and seedlings were transplanted on 9th April 2007. 12 plants of each genotype were planted at inter row distance of 45 cm and intra plant distance of 30 cm.

The intercultural operations, i.e., hoeing and weedings were carried out in accordance with recommended package of practices to ensure a healthy crop growth and development. Irrigation was applied through drip twice a week. The crop was trained on 4 stems through nylon twines by retaining one flower and two leaves per node. The observations were recorded on 10 competitive plants (5 for green fruits and 5 for coloured fruits) in each entry and the observations were recorded on various horticultural and quality traits (green as well as coloured fruits separately).The observations were recorded on various horticultural traits *viz* ; days to first flowering, days to first harvest, green fruits, coloured fruits, number of marketable fruits per plant at green/red stage, fruit length (cm), fruit width (cm), pericarp thickness (mm), number of lobes per fruit, average fruit weight (g) at green/red stage, marketable fruit yield (kg) per plant at green/red stage, plant height (cm) and quality traits such as ascorbic acid content (mg/100 g), capsaicin content (%), colouring matter and total carotenoids content (mg /100 g) at yellow ripe stage. The average values for each genotype in each replication for the traits studied were used for further statistical analysis. The data for the component traits excluding colouring matter and total carotenoids content were analyzed as per the model given by Panse and Sukhatme (1984).

Results and Discussion

The analysis of variance revealed that mean squares due to genotypes were significant for the traits *viz.*, days to first flowering, days to first harvest (marketable green and coloured fruits), number of fruits per plant (marketable green and coloured fruits), fruit length, fruit width, pericarp thickness, average fruit weight

(marketable green and coloured fruits), number of seeds per fruit, harvest duration (marketable green and coloured fruits), plant height and marketable fruit yield per plant (green well as coloured) (Table1).

Table 1. Analysis of variance for yield and yield attributes in capsicum

Traits	Stage	Mean sum of Squares		
		Source	Treatment	Error
		Replication		
		df 2	17	34
Days to first flowering	Green	1.851	7.678*	0.479
Days to first harvest	Green	1.555	14.039*	1.359
	Coloured	6.240	115.351*	6.613
Number of marketable fruits per plant	Green	0.279	84.492*	3.502
	Coloured	2.166	6.009*	1.303
Fruit length (cm)	Green	0.128	1.249*	0.047
Fruit width (cm)	Green	0.018	0.244*	0.028
Pericarp thickness (mm)	Green	0.058	0.520*	0.083
Number of lobes per fruit	Green	0.076	0.236	0.124
Average fruit weight (g)	Green	44.686	120.179*	8.579
	Coloured	70.367	419.70*	44.223
Number of seeds per fruit	Green	16.518	2231.561*	26.283
Harvest duration (days)	Green	12.574	933.851*	46.181
	Coloured	81.796	1054.018*	36.031
Plant height (cm)	Green	10.257	1378.686*	20.148
Ascorbic acid (mg/100 g)	Green	11.912	123.072*	4.806
Capsaicin content (%)	Green	0.000008	0.0007*	0.00002
Marketable fruit yield per plant (kg)	Green	0.003	0.398*	0.027
	Coloured	0.0465	0.187*	0.020

*Significant at P = 0.05

However, the analysis of variance revealed non-significant differences for number of lobes per fruit. On the basis of estimates of mean values with respect to characters of horticultural importance, the Hybrid-16(2.80 kg) produced the highest marketable yield per plant followed by Hybrid-10 (2.12 kg), Hybrid-8(1.98 kg) and Hybrid-3 (1.91 kg), whereas the highest marketable coloured fruit yield was produced by Hybrid-16 (1.85 kg) followed by Hybrid-3 (1.39 kg), Hybrid-8 (1.35 kg) and Hybrid-14 (1.28 kg)(Table 2). This might be attributed to better manifestation of various yield contributing traits such as number of marketable green and coloured fruits, harvest duration, average fruit weight, etc. These results are in agreement with the findings of earlier researchers (Singh *et al.*, 2004; Jovichich *et al.*, 2005; Munshi and Kumar, 2005; Pandey *et al.*, 2005; Singh and Kumar, 2006; Gunadi *et al.*, 2007).

For number of marketable fruits, wide range of variability existed in the material under study. The highest number of marketable green fruits per plant was produced by Hybrid-16 (40.33), followed by Hybrid-10 (31.66), Hybrid-3 (30.00), Hybrid-2 and California Wonder (27.33) whereas highest marketable coloured fruits were produced by Hybrid-16 (13.66) followed by Hybrid-3 (12.00) and Hybrid-9 (11.66). Sufficient genetic variability for this trait has also been reported by earlier workers (Sharma *et al.*, 2004; Pandey *et al.*, 2005; Hutton and Handely, 2007).

Taller plants are preferred for greenhouse cultivation. In this study, the tallest plants (green crop) were observed in Hybrid-3 (173.98 cm) followed by Hybrid-14 (126.65 cm), Hybrid-2 (126.31cm) and Hybrid-10 (118.63 cm) and most of these hybrids produced high marketable fruit yield per plant (Table 3). Higher fruit yield in taller plants could be attributed to the production of more number of flowers. The results are in agreement with the findings of Pandey *et al.*, (2005).

Prolonged harvest duration is an important feature of the hybrids, which are grown under greenhouse conditions. In this study, the hybrids having longer harvest duration, in general, produced higher fruit yield per plant. Longest harvest duration for marketable green fruits was observed in Hybrid-16 and Hybrid-10 (185.00 days), followed by Hybrid-13 (184.00 days), Hybrid-4 (183.00 days) and hybrid check Bharat (181.00 days) and these were statistically at par

with each other. However, the longest harvest duration for marketable coloured fruits was recorded in Hybrid-4 (155.00 days) followed by Hybrid-14 (148.66 days) and Hybrid-16 (147.00 days) (Table 3). The longer harvest duration of marketable fruits at green stage than coloured fruits is attributed to early and frequent harvest of the green fruits, which continued up to December month. Moreover, cloudy weather during July to September and low temperature after 20th October might have been unfavourable for proper colour development in red and yellow fruited hybrids, which ultimately resulted in lesser number of coloured marketable fruits per plant as well as yield. In bell pepper, medium sized fruits are preferred over large sized fruits. Hybrid-3 (9.43 cm) followed by hybrid check Bharat (8.63 cm) and Hybrid-14 (7.88 cm) produced longest green fruits, whereas, the Hybrid-14 (6.56 cm) recorded the maximum fruit width followed by Hybrid-15 (6.43 cm). Fruit width is a desirable character for getting blocky fruits. Sufficient genetic variability for these two traits has been observed in the experimental material, which corroborates the findings of Chang (1977), Elangovan *et al.*, (1981), Joshi and Singh (1983), Valsikova and Belko (2004) and Pandey *et al.* (2005). Bell pepper fruits with thicker pericarp not only withstand long distance transportation, but also have invariably longer shelf life. Pericarp thickness was highest in Hybrid-16 (6.60 mm) and Hybrid-5 (6.46 mm) and these were statistically at par with each other. These two hybrids offer promise for long distance transportation. Valsikova and Belko (2004) have also observed significant variation for flesh thickness among capsicum genotypes, which supports the present findings. Average fruit weight was highest in Bharat hybrid check (82.42 g) followed by Hybrid-8 (79.34 g) and Hybrid-11 (74.38 g) for green fruits, whereas, for marketable coloured fruits, the Hybrid-16 produced maximum fruit weight (135.38 g) followed by Hybrid-3 (119.36 g) and Hybrid-8 (119.12 g). Wide range of variability (82.23 to135.38 g) was observed for this trait, which is in conformity with the findings of Hutton and Handley (2007).

Open pollinated check California Wonder was earliest in flowering and took 29.33 days for first flowering. The findings revealed that California Wonder can be used as one of the parents for developing early maturing varieties and hybrids in capsicum. Hybrid-3 and Hybrid-9 (58.00 days) and Hybrid-16 (91.66 days) took minimum days for first harvest for green marketable fruits and marketable coloured fruits, respectively. Less variation was observed for marketable green fruit harvest (58.00 to 65.00 days) as well as marketable coloured fruit harvest (91.66 days to 110.33 days).

Hybrids having lesser number of seeds are preferred by the consumers. In present study, the number of seeds in different hybrids including OP check ranged from 62.33 to 152.66. Highest yielding hybrids Hybrid-16 and Hybrid-10 had moderate number of seeds per fruit and offered promise. Wide range of variation has been observed for this trait, which corroborate the findings of Shrestha (2003). Ascorbic acid content was highest in fruits of California Wonder (122.23 mg/100 g) followed by Hybrid-5 (119.93 mg/100 g) and Hybrid-1 (118.74 mg/100 g), whereas, lower values for capsaicin were observed in the hybrids, which varied from 0.056 to 0.112 per cent. In fact, low capsaicin and high ascorbic acid are desirable biochemical attributes in bell pepper. Hybrid-5, Hybrid-8 and Hybrid-3 appear promising for high ascorbic acid and low capsaicin content (Table 3). These findings are also in close conformity with Valsikova and Belko (2004).

The study revealed that Hybrid-16 produced highest green and coloured marketable fruit yield per plant (2.80 and 1.85 kg, respectively) followed by Hybrid-10 (2.12 kg) for green marketable fruit yield per plant and Hybrid-3 (1.39 kg) for coloured marketable fruit yield per plant. These hybrids appeared promising with respect to number of marketable fruit yield per plant, fruit length, harvest duration and fruit width. These hybrids can be grown in medium tech naturally ventilated polyhouses after multi-location testing for continuous supply of green and coloured fruits to the adjoining plain markets.

Table 2. Mean performance of green capsicum yield, horticultural and quality traits

Genotypes/ Traits	Days to first flowering	Days to first harvest	Number of marketable fruits per plant	Fruit length (cm)	Fruit width (cm)	Pericarp thickness (mm)	Number of lobes per fruit	Average fruit weight (g)	Number of seeds per fruit	Harvest duration (days)	Plant height (cm)	Ascorbic acid (mg/100 g)	Capsaicin content (%)	Marketable fruit yield per plant (kg)
Hybrid-1	34.66	60.0	25.66	6.71	5.45	4.63	4.11	64.78	83.00	141.3	114.2	118.74	0.087	1.66
Hybrid-2	34.66	64.6	27.33	7.33	6.16	6.11	3.77	60.11	144.33	154.0	126.3	101.63	0.093	1.64
Hybrid-3	34.00	58.0	30.00	9.43	6.38	5.73	3.33	63.65	152.66	177.6	173.9	118.62	0.076	1.91
Hybrid-4	33.33	59.6	22.00	7.46	6.40	6.03	4.00	69.57	117.00	183.0	110.4	107.27	0.086	1.52
Hybrid-5	33.66	61.6	27.00	7.55	6.05	6.46	3.55	69.76	125.00	179.6	114.8	119.93	0.065	1.88
Hybrid-6	32.66	59.3	25.66	7.20	6.01	6.10	3.88	68.75	110.66	171.6	119.0	104.92	0.112	1.76
Hybrid-7	35.00	62.0	24.00	7.53	5.71	6.18	4.00	56.61	82.33	144.3	75.48	118.78	0.110	1.36
Hybrid-8	35.00	62.6	25.00	6.90	6.10	6.31	4.00	79.34	139.33	155.3	96.46	117.23	0.062	1.98
Hybrid-9	32.00	58.0	25.66	7.73	6.20	6.36	3.77	65.21	83.66	177.0	108.7	106.55	0.087	1.67
Hybrid-10	34.33	60.3	31.66	7.46	6.08	6.28	3.55	66.89	92.66	185.0	118.6	117.38	0.108	2.12
Hybrid-11	35.33	63.6	15.66	7.13	5.96	6.15	3.78	74.38	62.33	167.0	119.1	114.96	0.056	1.16
Hybrid- 12	34.66	64.0	20.66	7.10	5.91	6.15	3.89	66.12	86.66	125.0	115.5	107.00	0.068	1.37
Hybrid-13	36.66	65.0	26.66	6.93	6.05	5.91	4.33	66.70	142.00	184.0	94.26	109.02	0.086	1.78
Hybrid-14	34.00	60.0	25.33	7.88	6.56	6.08	4.00	71.24	119.66	174.3	126.6	107.85	0.071	1.80
Hybrid-15	35.66	62.6	19.33	7.68	6.43	6.10	3.33	68.03	132.33	155.0	74.28	107.89	0.075	1.31
Hybrid-16	34.66	62.3	40.33	7.85	6.28	6.60	3.89	69.48	97.66	185.0	112.7	105.10	0.086	2.80
Bharat (Hybrid check)	34.00	59.6	21.33	8.63	6.40	5.78	4.11	82.42	149.00	181.0	107.5	113.59	0.088	1.75
California Wonder (OP check)	29.33	60.3	27.33	7.30	6.15	6.05	3.44	60.97	121.33	166.0	118.5	122.33	0.084	1.66
Range	29.33-36.66	58.0-65.0	15.66-40.33	6.7-9.43	5.45-6.56	4.63-6.60	3.33-4.33	56.61 - 82.42	62.33-152.66	125.0 - 185.0	74.28 - 173.9	101.63 - 122.33	0.056-0.112	1.16-2.80
General mean ± SE(m)	34.09 ±0.388	61.3± 0.65	25.59 ±1.050	7.54 ± 0.12	6.13 ± 0.09	6.06 ±0.162	3.82	68.00 ±1.643	113.42 ±2.876	167.1 ±3.81	112.6 ±2.52	112.15 ±1.230	0.08± 0.002	1.73 ±0.092
SE (d)	0.565	0.95	1.528	0.18	0.14	0.236	--	2.391	4.185	5.548	3.665	1.790	0.003	0.134
CD (P=0.05)	1.148	1.93	3.105	0.36	0.28	0.480	--	4.860	8.506	11.27	7.448	3.638	0.007	0.272
CV (%)	2.030	1.90	7.312	2.88	2.74	4.776	--	4.307	4.519	4.065	3.986	1.954	5.472	9.485

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Table 3. Mean performance of coloured capsicum for yield, horticultural and quality traits

Genotypes/ Traits	Days to first harvest	Harvest duration (days)	Number of marketable fruits per plant	Marketable fruit yield per plant (kg)	Average fruit weight (g)	Colouring matter (ASTA Units)	Total carotenoids content (mg/100 g)
Hybrid-1	95.00	103.00	9.33	1.03	110.00	98.70	--
Hybrid-2	104.33	121.66	11.00	1.10	100.33	--	2.15
Hybrid-3	97.33	134.00	11.66	1.39	119.36	104.10	--
Hybrid-4	93.66	155.00	9.33	1.01	109.63	97.80	--
Hybrid-5	101.33	139.00	9.66	0.98	101.11	101.66	--
Hybrid-6	110.00	130.33	9.00	0.97	107.36	88.46	--
Hybrid-7	100.66	96.00	9.00	0.98	109.30	116.30	--
Hybrid-8	109.33	124.00	11.33	1.35	119.12	94.76	--
Hybrid-9	106.33	122.00	11.66	1.09	93.82	108.93	--
Hybrid-10	102.00	127.66	12.00	1.26	105.32	--	2.76
Hybrid-11	103.66	102.33	8.00	0.80	100.19	--	2.90
Hybrid-12	110.33	84.33	10.00	0.82	82.23	--	2.50
Hybrid-13	110.33	133.66	10.33	1.09	105.59	101.60	--
Hybrid-14	93.66	148.66	11.33	1.28	113.06	--	4.26
Hybrid-15	95.33	119.00	9.66	0.99	102.76	111.73	--
Hybrid-16	91.66	147.00	13.66	1.85	135.38	102.80	--
Bharat (hybrid check)	101.00	131.66	11.00	1.01	92.22	104.86	--
California Wonder (OP check)	98.33	130.66	9.00	0.88	97.65	105.83	--
Range	91.66-110.33	84.33-155.00	8.00-13.66	0.80-1.85	82.23-135.38	94.76-116.30	2.15-4.26
General mean ± SE(m)	101.35 ± 1.442	125.01 ± 3.36	10.38 ± 0.640	1.10 ± 0.079	105.80 ± 3.731	102.88	2.91
SE (d)	2.099	4.901	0.932	0.116	5.429	--	--
CD (P= 0.05)	4.267	9.960	1.894	0.236	11.034	--	--
CV (%)	2.537	4.801	10.991	12.872	6.285	--	--

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