



Performance of sweet pepper (*Capsicum annuum*) varieties and economics under protected and open field conditions in Uttarakhand*

AWANI KUMAR SINGH,¹ BALRAJ SINGH² and RAMWANT GUPTA³

Indian Agricultural Research Institute, New Delhi 110 012

Received: 11 January 2011; Revised accepted: 11 January 2011

Key words: Capsicum, Off-season, Polyhouse, Poly-mulching, Poly-tunnel

Sweet pepper [*Capsicum annuum* L. var. Grossum (L) Sendt] is one of the important vegetable crops which require mild climate for its growth and development. The fruits are harvested either at green mature stage or at colouring stage and is a very good source of vitamin A and C and other nutrients having great demand in big cities and other urban areas of the country and fetch very high price. Prevailing night low temperature, energy, high rainfall, hailfall, frost, waterlogging, higher relative humidity and cold wind are limiting factors for growing sweet pepper under open field conditions in hills of Uttarakhand. To make its cultivation successful, polyhouses, poly-tunnels and plastic-mulching are most suitable solutions (Chandra *et al.* 2000 and Singh *et al.* 2004 and 2010). Protected structures act as physical barrier and play a key role in integrated pest management by preventing spreading of insects, pests and viruses causing severe damage to the crop (Singh *et al.* 2003).

In addition these structures facilitate the utilization of nutrients from soil for longer duration (Singh *et al.* 2005a, 2005b, Singh 2003). Very limited information is available for growing sweet pepper through protected technology under Uttarakhand condition. Therefore, present study was conducted with an objective to evaluate technical feasibility of protected technology and suitable hybrids for obtaining maximum yield, economic gain and to minimize biotic and abiotic stresses for sweet pepper crop under prevailing conditions of Uttarakhand.

Experiments were conducted during 2007–2009 at the Research Farm and Extension Centre, Lohaghat (Champawat) of G.B.P.U.A.&T. Pantnagar (Uttarakhand) under protected and open field (unprotected) conditions. Lohaghat is located in district Champawat, at an altitude of 1 800–2 100 m sea level sloppy mountains with low snowfall during growing

season especially March to October. Two sets of factors were selected for the study, viz. varieties (five sweet pepper varieties i.e. California Wonder (an open variety), Bharat, Indum 5, US 181 and Tanvi—all hybrids and methods of cultivation (four technology viz. polyhouse, poly-tunnels, poly-mulching and open field condition). These two factors were combined to form 80 treatments with four replications during both the year. The experiment was laid out in RBD design. Seedlings of all varieties were raised under poly-tunnel conditions. Seedlings of 45 days old were transplanted at 50 cm × 30 cm spacing during second week of March in both the years. Irrigation and fertigation was provided to crop through low pressure drip irrigation system. Recommended standard agronomical package of practices were followed. Farmyard manure was applied as basal dose @ 3kg /m² in all treatment plots 20 days prior to transplanting. One-fourth amount of nitrogen and whole amount of phosphorus and potash fertilizers was applied as basal dose before transplanting in combination of 50+100+25g/m² in form of urea, SSP and potash at last preparation time of plots and remaining nitrogen was applied in three to four splits doses @ 0.5 g/litre of water. Urea was used in fertigation around root zone of plants in each plots. The data were recorded from randomly selected three tagged plants of each plot/replication. The yield attributes viz. no. of fruits/plant, fruit diameter (cm), fruit weight (kg/plant) and fruit yield (kg/m²) were recorded. Data on incidence of diseases and mortality was also recorded. The cost of cultivation (₹/m²), gross income/m², net income/m², and cost benefit ratio were calculated. The statistical analysis (ANOVA) for the above parameters of both years were carried out using random block design (RBD).

Maximum crop duration (270 days) was recorded in sweet pepper under polyhouse conditions along with maximum fruit diameter (6.91 cm), maximum no. of fruits/plant (47), highest individual fruit weight (62.17 g), average fruits weight (2.91 kg/plant), yield (17.48 kg/m²), gross returns (₹ 349.68/m²), net returns (₹ 281.45 /m²) and cost : benefit ratio 1.0: 5.5 in all five varieties, followed by

*Short note

¹ Senior Scientist, ²Principal Scientist and Incharge (e mail: drbsingh@yahoo.co.in), Centre for Protected Cultivation Technology;

³Post Doctoral Fellow (e mail: ramwantgupta@yahoo.com), Division of Seed Science and Technology

poly-tunnel and plastic-mulching treatments. The above observations were recorded minimum under open field condition (Table 1). Plants grown in polyhouse experienced minimum incidence of bacterial wilt (3.08%) and blossom end-rot in fruits (4.32%) whereas it was maximum in open field condition 75% and 16% respectively during the study (Table 1). The higher fruit yield, better economics and minimum disease and mortality was recorded under polyhouses, due to its protective ability against major abiotic stresses, which reduces the effect of the excess rainfall, water logging, and provide controlled environment (3–4°C higher temperature than open field condition) to the crop (Singh *et al.* 2003 and Singh *et al.* 2010). The hybrid *Tanvi*

produced maximum fruit diameter, no. of fruits/plant, individual fruits weight, weight of fruits, yield, gross income, net income and cost : benefit ratio in both open and protected condition. Sweet pepper hybrids US-181 and Indum 5 also produced similar pattern of result in both the conditions (Table 1). Based on the present results these three varieties can be recommended for growing in up lands of Uttarakhand under both protected and open field conditions more specifically during rainy season. The average crop duration of 200 days, fruit diameter (5.14 cm), no. of fruits/plant (42.0), individual fruit weight (49.85g), fruits yield kg/plant (2.12 kg), yield kg/m² (12.75 kg), gross return (₹ 211.81/m²), net returns (₹ 158.16/m²), and B:C ratio(1.0: 3.81) and

Table 1 Combined response of sweet pepper under different protected and open field condition

Pooled data during 2007–09												
Observations/ characters												
Sweet pepper variety	Total crop period (days)	Fruit diameter (cm)	No. of fruits/plant	Individual fruit weight (g)	Weight of fruits/m ² (kg)	Yield (kg/m ²)	Incidence of bacterial wilt (%)	Incidence of blossom-end rot in fruits (%)	Cost of cultivation (₹/m ²)	Gross income (₹/m ²)	Net returns (₹/m ²)	BCR
<i>Polyhouse technology</i>												
California Wonder	270	5.60	40	56.70	2.26	13.56	5.10	6.50	65.50	271.20	205.70	4.14
Bharat	270	6.50	46	60.80	2.76	16.56	3.10	3.70	68.50	331.20	262.70	4.83
US 181	270	7.50	50	65.30	3.26	19.56	2.10	3.30	69.50	391.20	321.75	5.62
Indum 5	270	7.45	48	62.20	2.98	17.88	3.00	4.50	67.20	357.60	290.39	5.32
Tanvi	270	7.50	51	65.85	3.31	19.86	2.10	3.60	70.50	397.20	326.70	5.63
CD (P=0.05)	NS	0.75	10.05	1.31	0.92	1.12	1.0	1.32				
<i>Poly-tunnel technology</i>												
California Wonder	180	3.80	32	40.50	1.29	7.74	17.50	8.00	45.50	123.84	78.34	2.72
Bharat	180	4.20	40	45.80	1.82	10.92	16.50	6.50	48.50	174.72	126.22	3.60
US 181	180	4.60	43	46.50	1.99	11.94	16.20	4.50	49.30	190.04	140.74	3.87
Indum 5	180	4.80	45	47.20	2.12	12.72	15.50	5.50	50.20	203.52	152.22	4.05
Tanvi	180	5.10	46	48.50	2.23	13.38	15.80	6.50	52.20	214.08	161.88	4.10
CD (P=0.05)	NS	0.68	1.07	1.30	0.83	1.08	1.32	1.41				
<i>Poly-mulching technology</i>												
California Wonder	150	3.60	30	38.70	1.16	6.96	50.50	15.50	41.80	97.44	55.64	2.33
Bharat	150	3.90	35	40.30	1.41	8.46	45.30	10.50	42.50	118.44	75.94	2.80
US 181	150	4.20	38	42.50	1.61	9.66	42.50	8.70	43.30	135.24	91.94	3.12
Indum 5	150	4.15	41	43.50	1.78	10.70	42.80	7.50	44.50	149.80	105.30	3.37
Tanvi	150	4.30	43	43.70	1.90	11.40	40.50	9.20	45.60	159.60	114.00	3.50
CD (P=0.05)	NS	0.56	1.10	1.28	0.62	1.13	1.21	1.39				
<i>Un-protected/open technology</i>												
California Wonder	100	2.50	25	36.50	0.55	3.30	80.50	20.50	28.50	39.60	11.10	1.38
Bharat	110	2.75	30	39.20	0.75	4.50	70.50	18.50	32.30	54.00	21.69	1.67
US 181	120	3.2	33	40.50	1.12	6.72	65.50	15.60	34.70	80.64	45.49	2.32
Indum 5	125	3.30	36	42.30	1.20	7.20	68.50	14.50	35.40	86.40	50.99	2.44
Tanvi	130	3.50	39	42.20	1.30	7.80	58.40	16.50	36.50	93.60	57.10	2.56
CD (P=0.05)	1.23	0.70	1.22	1.31	0.63	1.15	1.23	1.41				

Table 2 Effect of different protected and open condition on sweet pepper

Pooled data during 2007–09												
Cultivation method	Observations											
	Total crop period (days)	Fruit diameter (cm)	No. of fruits/plant	Individual fruit weight (g)	Weight of fruits/m ² (kg)	Yield (kg/m ²)	Incidence of bacterial wilt (%)	Incidence of blossom-end rot in fruits (%)	Cost of cultivation Rs./m ²	Gross income (₹/m ²)	Net returns (₹/m ²)	BCR
<i>Protected condition</i>												
Polyhouse	270	6.90	47	62.16	2.91	17.48	3.40	4.32	68.24	322.08	253.84	4.72
Poly-tunnels	180	4.49	41	45.64	1.89	11.34	16.32	6.60	49.16	181.24	132.08	3.68
Poly-mulching	150	4.03	37	41.74	1.57	9.43	44.32	7.18	43.54	132.10	88.56	3.03
Mean	200	5.14	42	49.85	2.12	12.75	21.34	6.03	53.65	211.81	158.16	3.81
<i>Open field condition</i>												
CD (<i>P</i> =0.05)	28.53	0.89	2.33	0.75	0.49	2.17	12.63	1.43				

minimum disease incidence of bacterial wilt (21.34%) and blossom end rot in fruits (6.03%) were found higher under protected technology followed by open condition (117 days), (3.05 cm), (33), (40.20g), (0.98 kg/plant), (0.90 kg/m²), (₹ 70.85/m²), (₹ 37.37/m²), (2.12), (68.70%) and (17.10%) respectively during all the years (Table 2). The higher loss of yield and economic was calculated in open field condition among all varieties of sweet pepper as compared to different protected conditions (Tables 1, 2). This is because of open field not protected against heavy rainfall, hail fall, cold wind and high humidity. The open field condition also promotes disease, i.e. bacterial wilt in plant and fruits (Singh *et al.* 2003, 2005b). The higher yield in polyhouse, polytunnel and polymulching technologies might also be due to improved climate in these conditions. In polyhouse the temperature was found to be 3–4°C higher than open condition, whereas in polytunnel the temperature was found to be 1–2°C higher than polyhouse. In polymulching the soil temperature was found to be 1–2°C higher than open field condition.

SUMMARY

Protected technology enhanced crop duration, (270 days) in polyhouse, (180 days) in poly tunnel, (150 days) in poly-mulching as compare to (117 days) in open field condition. highest number of fruit weight (2.91 kg/plant) and yield (17.48 kg/m²) were achieved in polyhouse, followed by poly-tunnel (1.89 kg/plant, 11.34 kg m²), poly-mulching (1.57 kg/plant, 9.43 kg/m²) and open field condition (0.98 kg/plant, 5.90 kg/m²), respectively. Different protected technologies exhibited greater net return (₹ 253.84 /m² in polyhouse, ₹ 132.08 /m² in poly-tunnel, ₹ 88.56 /m² in poly-mulching, ₹ 37.37/m² in open) and B:C ratio (1.0: 4.72) in

polyhouse, (1.0: 3.68) in poly-tunnel, (1.0: 3.03) in poly-mulching was achieved while it was lowest in open field condition (1.0:2.12). Minimum bacterial wilt (3.40%) and blossom end-rot of fruit (4.32%) was observed under polyhouse condition, while it was maximum in open field condition (68.7 and 17.10%) respectively. It is concluded that protected features considerably enhance production of sweet pepper as compared to open fields, particularly during rainy and off-season in Uttarakhand.

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