Vegetable Science (2011) 38(1) : 30-34

Identifying superior quality F_1 tomato hybrids for year round production under low cost plastic greenhouses in North-West Himalayas

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Received : Oct 2009 / Accepted : Dec 2010

Abstracts Tomato is an important crop of hilly regions in India and fetches off season prices to farmers when grown during rainy season in Himachal Pradesh. However, the production remains in scarcity during March-June and October- December due to environmental hazards. The only alternative is to make use of low cost plastic greenhouses for tomato production during these periods so that year round and off-season supply to the market in the plains is regulated. Keeping this in view, an experiment was conducted to evaluate and identify the superior and most promising F1 hybrids in respect of productivity and quality of the produce in a low cost plastic greenhouse. The study was carried out on 16 tomato hybrids in relation to earliness, yield and quality. Out of 16 hybrids, Naveen $2K^+$ recorded the maximum fruit yield/plant (3.23 and 3.81 kg) and fruit yield/m^2 (12.92 and 15.24 kg) followed by Amisha and Rakshak. Naveen $2K^+$ also recorded maximum fruit weight (73.33 and 74.17 g), and harvest duration (73.33 and 74.67 days) during both the years. A cherry tomato hybrid BSS-366 was earliest in marketable maturity (78.67 and 79days) and recorded the maximum number of flowers/ cluster, number of fruits/ cluster, number of flower clusters/ plant, number of fruits/ plant, total soluble solids, ascorbic acid and lycopene content. Rakshak exhibited maximum value of pericarp thickness and shelf life.

Keywords : Hybrids, tomato, greenhouse

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Introduction

The tomato is an important vegetable throughout the world and is found on the markets in most cities of the world. It is also one of the most promising crop for intensive cultivation practices (Saglam and Yazgan, 2000). The cultivation of tomato is done under open field conditions in the mid hill region of Himachal Pradesh and the growth of tomato is influenced by many production constraints including various foliar and fruit diseases which affect the production and quality of tomato especially during rainy season. Moreover, year round production of the tomato in the mid hills is also not possible since it can not be grown during winters in open. Therefore production under protected conditions is an alternative for obtaining increased yield of tomato with superior quality of produce and efficient resource management. Protected cultivation also enables vegetable growers to realize greater returns per unit area and also offers other benefits like early harvest, longer harvest duration, reduced or no leaching of fertilizers and eco friendly management of pests, weeds and diseases. Identification of suitable cultivar is the most important aspect of protected cultivation because of higher cost of production as compare to the open field. Generally indeterminate cultivars are considered good for raising tomatoes inside the polyhouses.

Materials and Methods

The experiment was carried out for two years at vegetable research farm of the Department of Vegetable Science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during July to December, 2006 and February to June, 2007. Hybrids obtained from different seed sources were Rakshak, Tolstoi, Sartaj and BSS-366 from Beejo Sheetal; Rakshita and Naveen $2K^+$ from IAHS Pvt. Ltd.; Amisha and Yash from Centuary seeds Pvt. Ltd.; Vibhuti from Suttind Seeds Pvt. Ltd.; Snehlata from Unicorn Seeds Ltd.; Avtar from Nunhemps India Pvt. Ltd.; US-285 from US Agri Seeds; Surya from

Seminis; Atul from Shubh Labh Services Ltd. and Solan Garima and Solan Sindhur from UHF, Nauni, Solan.

The seedlings were transplanted at a spacing of 90 X 30 cm between rows and plants respectively. Eighteen plants were accommodated in each treatment and grown over a uniform growing media comprising of soil, farmyard manure and sand (2:1:1). The experimental design was randomized block design with three replications. Two stem system of training was followed and data were recorded on days to first flowering, days to marketable maturity, Number of flower clusters/plant, number of flowers/cluster, number of fruits/cluster, fruit set (%), Number of fruits/plant, average fruit weight (g), fruit yield (Kg/plant), fruit yield (Kg/m^2), pericarp thickness (mm), harvest duration (Days), shelf life (Days), total soluble solids (^{0}B), Titrable acidity (%), Ascorbic acid (mg/100g) and lycopene content (mg/100g) during both the years.

Results and Discussion

Significant differences were observed among hybrids used in the study when grown in the low cost plastic greenhouses. The performance of different hybrids in an uniform growing media has been given in the tables 1, 2, 3 and 4 US-285 was earlest (28.00 and 29.33 days) to reach the first flowering followed by Rakshak (28.67 and 30.33 days), Solan Garima (29.67 and 30.67 days), Surya (31.00 and 31.33 days) and Sartaj (30.00 and 31.67 days) while, Vibhuti took maximum number of days (40.33 days) to first flowering. BSS-366 recorded 78.67 and 79 days respectively during both the years to reach the first marketable maturity followed by US-285 (83.33 and 83.67 days). This finding was in close line with Khalid *et al.* (2002) who reported the range of 30-35 days for days to first flowering in tomato production under protected condition. Khalid *et al.* (2002) also observed significant variation in days to marketable maturity in different cultivars of tomato.

Maximum number of flowers per cluster (11.18 and 11.42) and flower clusters/plant (16.67 and 17.67) was observed in BSS-366 which was significantly higher than all other genotypes. However, minimum number of flowers per cluster (4.10 and 4.38) and flower clusters/plant (9.00 and 9.67) was recorded in Avtar and Sartaj respectively during both the years. BSS-366 a cherry type tomato also recorded maximum average number of fruits per cluster (9.53 and 10.12) and fruits per plant (160 and 169) which was statistically superior to all other hybrids during both years. Minimum average number of fruits per cluster (3.00 and 3.43) was found in Avtar during both the years and minimum number of fruits (25.33) was recorded in Avtar during the first year and during second year, it was recorded in Surya (36). Farooq *et al.* (2006) also reported the significant difference for number of fruits per plant in the evaluation of five tomato hybrids under plastic tunnel. Pant *et al.* (2002) reported highest number of fruits/plant (139) in cultivar DARL304 in hydroponic system of growing

Table 1: Effect of uniform growing media and fertilization on yield and yield attributing characters of tomato in low cost plastic greenhouse during 2006

Hybrids	Days to first flowering	Days to marketable maturity	No of flowers/ cluster	No of fruits/ cluster	No of flower clusters/ plant	No. of fruits/ plant	Fruit set (%)	Average fruit weight	Fruit yield Kg/ plant	Fruit yield Kg/ m^2	Harvest duration (Days)
Rakshak	28.67	88.33	5.88	4.80	10	43.67	82.25	60.67	2.57	10.28	57.67
Rakshita	35.33	98.00	5.58	4.22	10.33	39.33	75.48	58.67	2.17	8.68	68.33
Amisha	30.67	100.33	5.97	5.15	12.00	52.03	85.99	58.33	3.07	12.28	71.67
Tolstoi	31.33	85.00	6.22	4.72	10.33	43.67	76.77	48.17	2.17	8.68	56.33
Solan Garima	29.67	88.33	4.87	3.72	10.67	34.33	76.09	57.33	1.95	7.80	58.33
Naveen 2 K^+	34.67	98.67	5.85	4.62	11.50	44.00	80.67	73.33	3.23	12.92	73.33
Sartaj	30.00	85.67	5.63	4.75	9.00	35.33	84.32	51.50	1.81	7.24	59.67
Vibhuti	37.67	90.33	5.03	4.10	9.33	36.00	84.50	58.50	2.07	8.28	58.00
Snehlata	33.67	85.00	5.55	4.00	10.67	36.00	72.92	55.17	2.05	8.20	57.67
Solan Sindhur	31.67	87.67	5.02	3.77	10.67	33.33	75.93	63.67	2.05	8.20	58.33
SH-7711 (Avtar)	35.67	98.33	4.10	3.00	10.83	25.33	72.84	51.00	1.36	5.44	65.33
BSS-366	37.33	78.67	11.18	9.53	16.67	160.0	86.21	5.15	0.83	3.32	54.33
Yash	31.37	83.67	4.92	4.00	11.00	37.67	80.91	54.67	2.00	8.00	54.67
US-285	28.00	83.33	4.89	4.14	10.67	39.00	84.83	44.00	1.71	6.84	51.00
Surya	31.00	85.33	4.19	3.12	10.67	30.33	74.48	64.33	1.90	7.60	57.33
Atul	35.67	98.67	4.66	3.45	10.00	29.33	74.36	51.00	1.58	6.32	68.67
Mean	32.61	89.71	5.60	4.44	10.90	45.67	79.28	53.47	2.07	8.28	60.67
SE(m)	1.24	2.03	0.48	0.37	0.54	1.71	3.13	1.43	0.45	0.87	1.61
$CD_{(0.05)}$	3.59	5.85	1.26	1.06	2.24	4.94	9.01	4.12	1.31	2.51	4.63

Table 2: Effect of uniform growing media and fertilization on quality characters of tomato in low cost plastic greenhouse during 2006

Hybrids	Pericarp thickness (mm)	Shelf Life (Days)	Total Soluble Solids (^{0}B)	Ascorbic Acid (mg/100)	Lycopene content (mg/100g)
Rakshak	6.55	13.67	4.66	21.33	2.35
Rakshita	5.78	11.00	4.32	23.67	2.97
Amisha	6.02	12.33	4.72	24.33	3.14
Tolstoi	4.64	10.67	3.84	21.67	2.56
Solan Garima	4.25	9.67	4.72	20.16	2.34
Naveen 2 K^+	6.32	13.33	4.85	23.67	2.98
Sartaj	5.78	11.67	3.35	22.33	2.37
Vibhuti	5.22	9.33	4.12	17.29	2.05
Snehlata	4.87	8.67	4.43	22.43	2.23
Solan Sindhur	4.94	10.00	4.69	23.67	2.85
SH-7711 (Avtar)	4.49	8.33	4.82	26.21	2.73
BSS-366	2.49	5.67	5.43	28.39	3.19
Yash	4.52	8.33	4.53	23.56	2.37
US-285	5.64	11.00	4.97	22.67	2.43
Surya	4.89	9.67	4.56	18.36	2.97
Atul	4.83	11.33	4.45	20.33	2.39
Mean	5.08	10.29	4.57	22.50	2.65
SE(m)	0.30	0.59	0.26	0.93	0.13
$CD_{(0.05)}$	0.88	1.71	0.75	2.67	0.39

Table 3: Effect of uniform growing media and fertilization on yield and yield attributing characters of tomato in low cost plastic greenhouse during 2007

Hybrids	Days to first flowering	Days to marketable maturity	No of flowers/ cluster	No of fruits/ cluster	No of flower clusters/ plant	No. of fruits/ plant	Fruit set (%)	Average fruit weight	Fruit yield Kg/ plant	Fruit yield Kg/ m^2	Harvest duration (Days)
Rakshak	30.33	92.00	6.20	5.61	11	54	90.26	60.83	3.28	13.12	59.33
Rakshita	38.67	103.67	5.80	4.74	11.5	49.33	81.94	61.67	3.08	12.32	72.00
Amisha	33	99.00	6.59	5.69	13.17	61	86.12	62.33	3.56	14.24	74.00
Tolstoi	34	87.33	6.47	5.42	11.33	54	83.09	50.00	2.77	11.08	59.67
Solan Garima	30.67	92.33	5.04	4.19	11.33	39.67	82.75	60.33	2.41	9.64	62.67
Naveen 2 K^+	36.67	96.67	6.11	4.84	12.17	51.33	78.71	74.17	3.81	15.24	74.67
Sartaj	31.67	88.00	5.99	5.15	9.67	46	85.56	52.50	2.41	9.64	60.00
Vibhuti	40.33	92.33	5.25	4.66	9.83	42	88.75	61.67	2.58	10.32	61.00
Snehlata	35.67	85.33	5.83	4.33	11.67	43	73.89	58.33	2.62	10.48	60.33
Solan Sindhur	34	90.00	5.17	4.22	11.33	42.33	81.50	67.50	2.78	11.12	62.00
SH-7711 (Avtar)	39.33	101.67	4.38	3.43	11.83	36.33	78.09	53.33	2.02	8.08	69.33
BSS-366	39.33	79.00	11.42	10.12	17.67	169	89.27	5.17	0.87	3.48	56.67
Yash	34	85.33	5.11	4.51	11.67	45.17	88.01	57.50	2.13	8.52	56.00
US-285	29.33	83.67	5.30	4.69	11.50	49	88.54	45.83	2.25	9.00	54.67
Surya	31.33	86.00	4.41	3.61	11.17	36	82.04	66.83	2.39	9.56	58.00
Atul	39.67	102.33	4.91	4.00	10.83	40.67	81.52	52.83	2.20	8.8	73.33
Mean	34.87	91.54	5.87	4.95	11.73	53.68	83.75	55.68	2.66	10.64	63.35
SE(m)	1.31	2.09	0.38	0.41	0.95	1.64	3.84	1.57	0.49	1.92	1.55
$CD_{(0.05)}$	3.79	6.05	1.09	1.18	2.75	4.74	11.07	4.51	1.42	5.54	4.47

tomatoes.

Similarly, significant variation was observed in fruit set percentage. Maximum fruit set was recorded in BSS-366 (86.21%) during year 2006 and Rakshak in year 2007. Minimum fruit set (72.84 and 73.89%) was found in Avtar and Snehlata during first and second year respectively. Hazarika and Phookan (2005) also reported the variation in fruit set percentage. Naveen 2K^+ recorded highest fruit weight (73.33 and 74.17 g) and was statistically superior to all other genotypes during both the years whereas, minimum fruit weight was found in

Table 4: Effect of uniform growing media and fertilization on quality characters of tomato in low cost plastic polyhouse during 2007

Hybrids	Pericarp thickness (mm)	Shelf Life (Days)	Total Soluble Solids (^{0}B)	Ascorbic Acid (mg/100)	Lycopene content (mg/100g)
Rakshak	6.71	15.33	4.70	18.97	2.41
Rakshita	5.97	12.33	4.27	21.66	3.07
Amisha	6.12	14.33	4.87	21.92	3.17
Tolstoi	4.63	11	3.47	20.12	2.39
Solan Garima	4.16	9.33	4.63	18.07	2.41
Naveen 2 K^+	6.12	14	4.93	20.64	3.06
Sartaj	5.80	12	3.23	20.63	2.39
Vibhuti	5.48	9.67	4.00	15.64	2.02
Snehlata	4.93	8	4.50	20.89	2.28
Solan Sindhur	5.02	8.67	4.60	21.40	2.97
SH-7711 (Avtar)	4.67	7.33	4.78	24.39	2.89
BSS-366	2.51	5	5.37	32.43	3.24
Yash	4.54	9	4.50	20.76	2.49
US-285	5.59	12	5.00	20.77	2.55
Surya	4.92	8.33	4.67	17.70	3.03
Atul	4.99	12	4.50	18.46	2.45
Mean	5.13	10.52	4.54	20.88	2.68
SE(m)	0.26	0.66	0.22	0.89	0.15
SE(d)	0.36	0.93	0.32	1.27	0.21
$CD_{(0.05)}$	0.74	1.89	0.64	2.59	0.42

BSS-366 (5.15 and 5.17 g) during both the years. Vooren *et al.* (1986) reported that higher or lower fruit weight in tomato may be ascribed to the varietal characterstics. Comparison of data recorded on yield per plant showed that the hybrid Naveen 2K^+ recorded highest yield/plant (3.23 and 3.81 kg) followed by Amisha (3.07 and 3.56 kg). Minimum yield per plant was found in BSS-366 (0.83 and 0.87 kg) during both the years. Pant *et al.* (2002) reported highest yield of 7.6 kg/plant in cultivar DARL304 in hydroponic system. Similarly, the promising variety Naveen 2K^+ recorded maximum fruit yield/ m^2 (12.92 and 17.2 kg) followed by Amisha (10.83 and 16.48 kg) and minimum yield kg/m^2 (3.32 and 3.48) was observed in BSS-366. Khalid *et al.* (2002) has also recorded highest fruit yield of 20.4 kg/m^2 in cultivar Torquessa and 12.34 kg/m^2 in cultivar Jacinta. Farooq *et al.* (2006) also reported highest fruit yield of 13.16 kg/m^2 in cultivar Mamotoroyork and 9.44 kg/m^2 in cultivar Chinese hybrid.

Among quality characters, maximum pericarp thickness (6.55 and 6.71 mm) was recorded in Rakshak followed by Naveen 2K^+ (6.32 and 6.12 mm). Minimum pericarp thickness (2.49 and 2.51 mm) was exhibited by BSS-366, which was also statistically lower than all other genotypes during both the years. Kumari *et al.* (1998) also reported variation in pericarp thickness among different cultivars.

Similarly, significant differences among the hybrids were observed for harvest duration. Maximum harvest duration of 73.33 and 74.67 days was exhibited by Naveen 2 K^+ followed by Amisha (71.67 and 74) and Atul (68.67 and 73.33) whereas, the hybrid US-285 recorded the minimum harvest duration of 51.00 days and 54.67 days during both the years. Maximum shelf life of 13.67 and 15.33 days was recorded by hybrid Rakshak followed by Amisha (12.33 and 14.33 days) and Naveen 2K^+ (13.33 and 14 days) during both the years.

The total soluble solids content signifies the amount of sugar present in fruit juice. Hence, a high soluble solid content is desirable for processed product like juice, ketchup, sauce and puree. The data obtained on average total soluble solids showed highly significant differences among the hybrids studied during both the years. The mean value for genotypes revealed maximum total soluble solids (5.43 and 5.37 ^{0}B) in BSS-366 followed by US-285 (4.97 and 5.00 ^{0}B) Amisha (4.72 and 4.87 ^{0}B) and Naveen 2K^+ (4.85 and 4.90 ^{0}B). Sartaj (3.35 and 3.23 ^{0}B) recorded the minimum average total soluble solids during both the year. Similar results have also been reported by Inden and Torres (2004).

The mean performance of the different hybrids showed maximum ascorbic acid in BSS-366 (28.39 and 32.43 mg/100g), which was statistically at par with Avtar during the year 2006. Vibhuti recorded minimum ascorbic acid (17.29 and 15.64 mg/100g) during both

the years. Phookan *et al.* (1996) obtained immense variation in tomato cultivars for ascorbic acid content. Maximum lycopene content was also observed in BSS-366 (3.19 and 3.24 mg/100g) and Vibhuti recorded minimum lycopene content (2.05 and 2.02 mg/100g) during both the years. This was in close line with Slimestad and Virehuel (2005) who reported the variation in lycopene content from 1.6 to 5.6 mg/100g of fruit.

सारांश

टमाटर हिमाचल प्रदेश व भारत वर्ष के अन्य पर्वतीय क्षेत्रों की एक मुख्य सब्जी फसल है जिसका उत्पादन बेमौसमी सब्जी उत्पाद के लिए किया जाता है। परन्तु इन पर्वतीय क्षेत्रो में अक्तूबर से मार्च तक बाहरी जलवायु में टमाटर की खेती सम्भव नही है। जिससे कि इसका वर्ष भर उत्पादन नहीं हो पा रहा है। परन्तु ठण्डी जलवायु वाले क्षेत्रों में आजकल टमाटर का उत्पादन कम लागत वाले हरित गृह में किया जा सकता है। परन्तु इसके लिए अधिक पैदावार व उत्तम गुणवता वाली संकर किस्मों का चुनाव अति आवश्यक है ताकि टमाटर को विश्व सतरीय मण्डियों में अच्छे दामों पर बेचा जा सके। बागवानी व वानिकी विश्वविद्यालय के सब्जी विज्ञान विभाग में टमाटर का हरित ग ह में फरवरी से जून व अक्तूबर से जनवरी के समय के लिए लगभग 16 संकर किस्मों पर अनुसंधान (2006–2007) में किया गया और इस अनुसंधान के परिणाम के अनुसार नवीन 2000 ने सबसे अधिक पैदावार 17.92 व 15.24 किलोग्राम मी.^{2} दी। अमीश व रक्षक क्रमशः दूसरे व तीसरे स्थान पर रहे। नवीन 2000 में सबसे अधिक फल भार 73.33 ग्राम व 74.17 ग्राम व लम्बी अवधि के लिए तुड़ान 73.33 व 74.67 दिन भी दोनों वर्षों में पाया गया।

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