

Growth, yield and fruit quality of strawberry under protected cultivation in South Kashmir

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Abstract: Field experiments were conducted at Krishi Vigyan Kendra, Pulwama, Jammu and Kashmir at an altitude of 1601 m amsl to identify the suitable strawberry cultivars for higher production of good quality fruits. Eight strawberry cultivars were evaluated for two consecutive years (2008-09 and 2009-10) under polyhouse conditions. Maximum plant spread (27.43 cm) along with maximum number of runners (8.54) was produced by 'Chandler'. 'Tioga' produced first flower in 97 days after planting, while runners of 'Chandler' (56.79) flowered for maximum number of days. 'Chandler' produced maximum number of flowers per plant (27.23) and set maximum berries (86.01%), however final yield of berries was more in 'Tioga' which recorded maximum yield per plot (2.26 kg), closely followed by 'Chandler' (2.19 kg). Berry weight (12.24 g) and berry size (5.10 cm length and 4.73 cm) was maximum in 'Tioga'. 'Catskill' registered maximum for all the biochemical characters, closely followed by 'Tioga'. Overall, 'Chandler', 'Catskill' and 'Tioga' performed well under polyhouse conditions in Kashmir Valley.

1. Introduction

Strawberry (*Fragaria x annanasa* Dutch) has been grown commercially in various parts of the world for many years but in India it was only introduced in the early 1960's (Sharma and Sharma, 2004) and it has now acclimatized well in different parts of India. This is essentially a temperate fruit crop hence its expansion in the Kashmir valley has been gaining popularity in the last decade. It is not only consumed as fresh fruit but is also used in processed foods such as jam, ice cream, biscuits and so on. The demand for strawberry fruits for domestic as well as export markets has been increasing steadily. The standard planting time in the valley ranges from late October to the first fortnight of November, and harvesting from 15 March to late April in controlled conditions and from the second fortnight of April to late May in open conditions. Climatic conditions under various production methods during the growing season may affect fruit quality. Soluble solids concentration, acidity and colour of strawberry fruit have all been reported to be affected by environmental factors (Sacks and Shaw, 1994; Vlachonasis *et al.*, 1995), as well as harvest date (Shaw, 1988). Temperature is an important factor for floral initiation under short day conditions. The optimum temperature for short day floral initiation is 15-18°C, while below 10°C and above 25°C short day induction is rather ineffective (Manakasem and Goodwin, 2001; Sonstebly and Heide, 2006; Verheul *et al.*, 2007). Although

both diurnal and nocturnal temperatures are important, strawberry requires an optimum daytime temperature of 22°C and nighttime temperature of 13°C for maximum growth and yield (Shoemaker, 1977). Growing strawberries under polyhouse decreases the dependence of fruit quality on climate and soil conditions. Such cultivation system also enables better water, light and temperature control to a certain extent. In Kashmir valley, cultivation is generally carried out under open field conditions and takes advantage of the local climatic conditions, but due to the long duration of winters the availability of fruit is very late. There is no information regarding the protected cultivation and management practices on the performance of commercialized cultivars of strawberry in the Kashmir valley. Hence, the present study was conducted to study the feasibility of growing strawberry under polyhouse to obtain an early crop and to evaluate the cultivars which may be suitable for commercial exploitation.

2. Materials and Methods

Experimental site and material

The experiment was laid out under polyhouse during 2008-09 and 2009-10 at Krishi Vigyan Kendra, Pulwama, Jammu and Kashmir. The KVK is located at 33° North and 74° East at an altitude of 1601 m amsl. The mean annual rainfall ranges from 500 to 850 mm. The minimum and maximum temperatures of the station during summers range between 10 and 30°C and between -4 and 10°C dur-

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ing winter under open conditions. A polyhouse with steel pipe framework clad with twin layer UV stabilized 200 µm plastic sheet of was used to create a modified environment. The polyhouse was additionally fitted with a high pressure fan on each west side. Under the polyhouse the temperature was maintained up to 25°C. The soil of the location is silty clay, loam neutral in reaction (pH 7.07) having organic C 10.02 g/kg, available N 248.6 kg/ha, available P 14.7 kg/ha and available K 250.3 kg/ha. The experimental materials were comprised of eight commercial cultivars ('Catskill', 'Chandler', 'Confutura', 'Gorella', 'Pajaro', 'Selva', 'Tioga' and 'Fern') collected from SKUAST-K and the Department of Horticulture, Ramban, Jammu and Kashmir. The experiment was laid out in a completely randomized block design (CRBD) with three replications. The spacing between the runners was 30 x 30 cm on 1 x 1 m² raised beds of 15 cm height with 55 cm spacing between the beds. Uniform runners were planted in the first week of November 2008 in three rows on each bed accommodating nine runners. For the second year crop, the emerged runners were removed in the last week of October 2009 in order to maintain the proper spacing for the next year's crop. Usual irrigations, manures and fertilizers, weeding and hoeing were applied equally to the experimental plots during the study years.

Observations recorded

Data were recorded for different growth, flowering and fruiting characters for three years. Plant spread (cm) and length of the runners (cm) was measured with the help of a measuring tape. Number of runners per plant, number of flowers per plant and number of berries per plant were counted from five randomly selected plants. Days to first flower was recorded from the date of planting of runners to initiation of first flower. Flower duration was counted by subtracting the date of initiation of first flower from the date of last flowering. Percentage of berry set was calculated by dividing the number of berries by the number of flowers. Yield per plant (g) was calculated by weighing whole fruits from a single plant. Ten fruits were randomly selected for all the physio-chemical characters. Berry weight was deter-

mined with the help of a weighing scale; berry length and width were determined using a Vernier Calliper. TSS, acidity and TSS/acid ratio were estimated using standard procedures. Total sugar and reducing sugar were determined by Shaffer Somogy, micro method (Ranganna, 1991). Data on temperature and humidity under polyhouse were recorded with a portable thermohygrometer.

Data analysis

The pooled data of two years were statistically analyzed following Panse and Sukhatme (1985). The mean of attributes was compared by paired 't' test and the least significant difference was calculated at 5% level.

3. Results and Discussion

The average monthly data on minimum and maximum temperature and relative humidity inside the polyhouse from transplanting to harvesting are presented in figure 1.

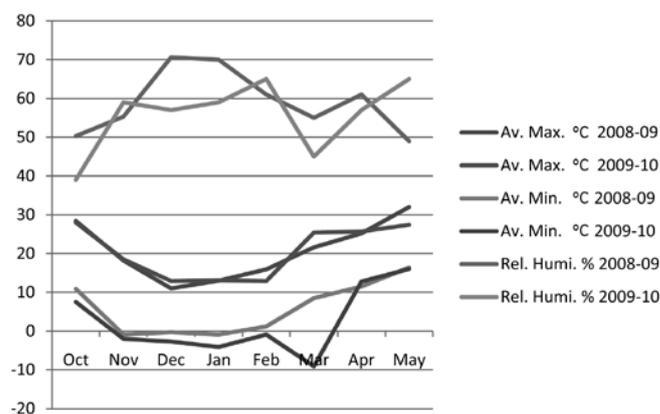


Fig. 1 - Average maximum, minimum temperature (°C) and relative humidity (%) month wise from transplanting to harvesting time.

The pooled data of two consecutive years shown in Table 1 reveal that 'Chandler' had maximum plant spread (27.43 cm) which was statistically at par with 'Catskill' (25.49

Table 1 - Growth and flowering characters of strawberry cultivars under polyhouse

Cultivar	Plant spread (cm)	No. of runners/ plant	Runners length (cm)	Days taken first flower to produce	Duration of flowering	Number of flower/ plant
Catskill	25.49 ef	7.09 ef	81.94 f	106 def	50.86 ab	26.92 e
Chandler	27.43 f	8.54 h	82.59 fg	101 bc	56.79 d	27.23 f
Confutura	24.18 cde	6.11 d	89.78 h	99 ab	53.92 bcd	20.93 ab
Gorella	25.44 def	5.67 bc	75.40 de	103 cd	51.12 abc	21.90 bc
Pajaro	21.75 ab	4.89 a	67.58 b	105 de	49.39 a	20.48 a
Selva	23.08 bcd	5.44 b	73.95 cd	116 h	47.82 a	21.84 bc
Tioga	20.19 a	7.35 fg	70.42 bc	97 a	55.49 cd	25.64 d
Fern	22.35 abc	6.93 e	60.92 a	110 g	48.91 a	21.45 bc
Mean	23.74	6.50	75.32	104.6	51.79	23.31
CD _{0.05}	2.40	0.29	3.70	3.84	4.43	0.99

cm) and 'Gorella' (25.44 cm), while minimum plant spread was recorded for 'Tioga' (20.19 cm). Maximum number of runners per plant in pooled data was found in 'Chandler' (8.54) which differed significantly from all other cultivars, whereas minimum number of runners per plant was recorded in 'Pajaro' (4.89). The pooled data of two years shows that 'Confutura' (89.78 cm) produced maximum runner length which differed significantly from the other cultivars; minimum length of runners was observed in 'Selva' (67.58 cm). Two years of data relative to runner length shows that in the first year runner length was greater than in the second year: the material may have degenerated with the passage of time (Childers, 1975). 'Tioga' (97) produced flowers earlier among the considered cultivars and was closely followed by 'Confutura' (99) and 'Chandler' (101); 'Selva' ranked last and took 116 days to produce first flower (Table 1). Runners of 'Chandler' (56.79) flowered for the maximum number of days followed by 'Tioga' (55.49) and 'Confutura' (53.92) which was statistically at par with both the cultivars, whereas 'Selva' (47.82) produced flowers for the fewest number of days. Kaska *et al.* (1997) cultivate nine cultivars of strawberry under high tunnels in Adana (Turkey) observed that 'Selva' took maximum days to produce first flower and flowered for least number of days while 'Chandler' flowered for maximum number of days.

Maximum number of flowers per plant (27.73) (Table 1) and maximum number of berries per plant (23.42) (Table 2) were both produced by 'Chandler' which was statistically at par with 'Catskill' (26.92) with respect to the number of flowers per plant, while for the number of berries per plant the former was significantly higher than all the cultivars. This indicates that the number of flowers per plant certainly has a bearing on the number of fruits per plant to be harvested, i.e. greater the number of flowers/plant, greater the number of fruits to be harvested but the total yield per plant may vary due to berry weight. 'Pajaro' (20.48) produced the fewest flowers per plant, which was statistically at par with 'Fern' (21.45), however the lowest number of berries per plant was produced by the latter (14.49) which was statistically at par with 'Pajaro'

(14.74). Paraskevopoulou-Paroussi *et al.* (1990) also recorded a minimum number of flowers per plant and number of berries per plant in 'Pajaro' and 'Fern' while growing these cultivars under greenhouse in northern Greece.

The data in Table 2 reveal that 'Chandler' (86.01%) gave the maximum berry set, which was statistically at par with 'Tioga' (83.48 %); the minimum berry set (71.84%) was recorded for 'Pajaro'. Maximum yield per plot of berries was recorded in 'Tioga' (2.26 kg) which was statistically at par with 'Chandler' (2.19 kg) and 'Catskill' (2.17 kg), and minimum yield per plot was recorded in 'Selva' (1.08 kg). Paraskevopoulou-Paroussi *et al.* (1990) also noted that 'Pajaro' (24%) and 'Fern' (38%) produced marketable yield under greenhouse conditions in northern Greece, however, Kaska *et al.* (1997) reported that 'Chandler' and 'Selva' produced the highest and lowest yield, respectively under high tunnel conditions in Adana (Turkey). Observations from two years of data on yield per plant shows that yield was greater in the second year than the first which might be due to substantial annual variation in fruit set in strawberry (Smolarz *et al.*, 1968; Misisic *et al.*, 1976). 'Tioga' scored as having maximum berry weight (12.24 g) along with maximum berry length (5.10 cm) and berry breadth (4.73 cm), closely followed by 'Chandler'. 'Selva' had minimum berry weight (8.71 g), however minimum size [i.e. berry length (3.70 cm) and berry breadth (3.62 cm)] was recorded for 'Pajaro'. Pathak *et al.* (2006) observed similar results with respect to weight, length and breadth of berries while growing strawberry cultivars under cover.

Maximum TSS was scored by 'Catskill' (9.85%), followed by 'Tioga' (9.32%), however both these cultivars significantly differed from each other (Table 3); 'Selva' had minimum TSS (6.72%). Minimum acidity was observed in 'Catskill' (0.88%), closely followed by 'Tioga' (0.89%), yet the pooled data of two years showed non significant results. 'Catskill' (10.51) showed maximum TSS/acid ratio which was statistically at par with Tioga (10.47) while minimum TSS/acid ratio was recorded for 'Selva' (6.25). Maximum reducing sugar (6.27 %) and total sugar (8.09%) were observed in 'Catskill' which was the highest

Table 2 - Yield and fruiting characters of strawberry cultivars under polyhouse

Cultivar	Number of berries/ plant	Berry set (%)	Yield/plot (kg)	Berry weight (g)	Berry length (cm)	Berry breadth (cm)
Catskill	22.32 e	82.90 e	2.17 d	11.11 e	4.98 de	4.55 de
Chandler	23.42 f	86.01 f	2.19 d	12.11 f	4.79 d	4.31 c
Confutura	16.93 c	80.86 d	1.44 d	10.54 d	4.78 d	4.48 cd
Gorella	16.62 c	75.81 c	1.28 c	9.76 c	4.25 bc	3.76 a
Pajaro	14.74 a	71.84 b	1.18 b	9.03 b	3.70 a	3.62 a
Selva	15.94 b	72.73 b	1.08 a	8.71 a	4.39 c	3.72 a
Tioga	21.32 d	83.48 ef	2.26 d	12.24 f	5.10 e	4.73 e
Fern	14.49 a	66.95 a	1.13 ab	9.22 b	4.03 b	4.01 b
Mean	18.22	77.57	1.59	10.34	4.50	4.14
CD _{0.05}	0.64	2.73	0.09	0.27	0.22	0.23

Table 3 - Biochemical characters of strawberry cultivars under poly-house

Cultivar	TSS (%)	Acidity (%)	TSS/acid ratio	Reducing sugar (%)	Total sugar (%)
Catskill	9.85 h	0.88	10.51 g	6.27 f	8.09 e
Chandler	9.06 ef	0.94	9.64 d	5.45 d	7.18 d
Confutura	9.24 fg	0.97	10.11 e	5.85 e	7.14 d
Gorella	8.03 d	1.02	7.85 c	4.63 c	6.65 c
Pajaro	7.81 b	1.00	7.78 c	3.65 a	5.55 a
Selva	6.72 a	1.04	6.25 a	4.04 b	5.86 b
Tioga	9.32 g	0.89	10.47 fg	5.88 e	7.19 d
Fern	7.83 cd	1.02	7.64 bc	3.76 a	5.70 a
Mean	8.48	0.97	8.78	4.94	6.67
CD _{0.05}	0.20	NS	0.35	0.19	0.22

among all the studied cultivars, and 'Pajaro' scored minimum reducing sugar (3.71%) and total sugar (5.55%). Our investigation showed much variation in the various cultivars for all the characters and this could be attributed to the genetic make up of the cultivars (Dhaliwal and Singh, 1983; Chandel and Badiyala, 1996). Factors which may significantly influence strawberry composition include mineral and organic fertilization but weather conditions and variety are also important.

It is concluded from the present study that 'Chandler' for growth and yield characteristics, 'Catskill' for biochemical characters and 'Tioga' for yield and physical characters of strawberry fruits are profitable for cultivation under polyhouse conditions in the Kashmir valley.

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