

Studies on the comparative performance of strawberry cultivars under mid-hill conditions of north-western Himalayas

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ABSTRACT

A field trial was conducted during 2012 and 2013, to evaluate the performance of 13 strawberry genotypes under the mid-hill conditions of Himachal Pradesh. Strawberry cultivars, viz., Chandler, Camarosa, Confictura, Ofra, Festival, Sweet Charlie, Douglas, Ventana, Selva, Gorella, Pajaro, Eclair and Sequoia were planted on raised beds of 2 m × 2 m size at a spacing of 50 cm × 25 cm during first week of October in a randomized block design with three replications. The results revealed that the cultivars Festival and Camarosa were best with respect to the plant height and leaf area. The cultivars Sweet Charlie and Ofra were earliest to flower and the duration of flowering was longest in Camarosa and Sweet Charlie. The cultivars Festival, Chandler, Camarosa and Sweet Charlie stood promising with respect to yield and fruit size. The highest yield of 35.10 and 40.08 MT/ha during 2012 and 2013, respectively was recorded in cv. Chandler followed by cv. Festival (29.76 and 35.24 MT/ha during 2012 and 2013, respectively). The cultivar Festival produced berries of bigger size, weight and had more firmness as compared to cultivar Chandler. The TSS content was maximum in Sweet Charlie, which also recorded the lowest acid content. Sequoia recorded the highest anthocyanin content, followed by cultivars Camarosa and Festival.

Key words: Strawberry, cultivars, fruit yield, quality.

INTRODUCTION

The cultivated strawberry (*Fragaria × ananassa* Duch.) has resulted from a cross between two wild strawberries: *Fragaria virginiana* (Meadow strawberry) and *Fragaria chiloensis*. It is one of the most important soft fruits of the world, suitable for cultivation under various agro-climatic conditions (Singh *et al.*, 17). The berries are good source of vitamin A (60 IU/100 g), vitamin C (30-120 mg/100 g), pectin, potassium, calcium and phosphorus (Sharma, 16). The presence of ellagic acid, which prevents cancer and occurrence of heart diseases and the abundance of anthocyanins have made it a more valuable fruit (Nazir *et al.*, 12). The agro-climatic conditions of Himachal Pradesh are congenial for strawberry cultivation. Early efforts to popularize its cultivation in Himachal Pradesh received a setback on account of poor returns per unit area due to non-availability of high yielding cultivars. Later on, Elsita and Senga Sengana cultivars introduced from West Germany were also poor in yield and quality. However, a major breakthrough was seen with the introduction of Chandler, Tioga, Torrey, Blakemore, Florida 90, Catskill, Shasta, Robinson and Fairfax from America during the late seventies, some of which like Chandler (Chandel and Badiyala, 4), Tioga and Torrey displayed high yield of excellent quality fruits (Awasthi and Badiyala, 3). Although in India, Chandler is the

most predominant variety on account of its higher yield and better fruit size, yet there is a great scope for diversification of varieties having early maturity and longer shelf-life. Keeping this in view, the study was conducted to test the performance of some new strawberry cultivars under the mid-hill conditions of Himachal Pradesh.

MATERIALS AND METHODS

The present investigation was conducted at the experimental field of Department of Fruit Science, Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan during 2012 and 2013. The experiment was laid out in a randomized block design consisting of 13 cultivars replicated thrice. The cultivars used in the present study were Camarosa, Confictura, Ofra, Festival, Sweet Charlie, Douglas, Ventana, Selva, Gorella, Pajaro, Éclair, Sequoia and Chandler as a check. Well rooted uniform runners were planted on raised beds (15 cm) of size 2 m × 2 m, at a spacing of 50 cm × 25 cm @ 32 runners per bed, during first week of October. The uniform cultural practices were followed in each beds during the course of investigation. In each bed, 10 healthy plants were tagged for recording data on various plant growth, floral, fruit yield and quality parameters. The various vegetative characteristics, viz. plant height, spread, leaf area and number were observed at the end of fruiting, when the plants attained their full growth,

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while the data on number of runners per plant was recorded at the end of season (September). The leaf area was measured with the help of a leaf area meter (LI-COR 3000). The data on flower initiation (days after planting) was recorded as the period between the date of planting and the date of first anthesis (Kidmos *et al.*, 11). The other floral parameters, viz. number of flowers per plant and duration of flowering were recorded during the flowering season. Days taken from planting to fruit harvest was considered as the period between the planting date to the first harvest. The number of fruits per plant, i.e. primary, secondary and tertiary were counted per pedicel at the time of fruit maturity. The ripe berries were harvested at complete red colour stage. The weight of entire fruits harvested from each plot of 4 m² size was recorded for each cultivar and accordingly, the yield per hectare was worked out. The fruit size and weight of ten randomly selected berries were determined and the average was worked out. The fruit shape was determined as suggested in 'Strawberry shapes' (Anon, 1). The berry firmness was measured with the help of a penetrometer (Push-Pull Dynamometer, model: DT 101, kg. 1 × 10 gr. / Lb 2 × 0.02 Lb), with the plunger of diameter 0.0380 inches/ 0.96 mm and the average firmness was expressed in pounds (Lb). The biochemical constituents like total soluble solids, were determined with the help of a hand refractometer, the acidity was estimated in terms of citric acid and sugar content was determined by volumetric method based on the principle that sucrose content of berry is quantitatively hydrolyzed to glucose and fructose in the presence of HCl (AOAC, 2), while the anthocyanin pigment in the berry skin was determined by absorbance method (Harborne, 7). The data obtained from the present investigation were subjected to statistical analysis in accordance to Gomez and Gomez (6).

RESULTS AND DISCUSSION

The data on various vegetative characters of strawberry cultivars under study has been presented in Table 1. The maximum plant height was registered in cv. Festival (25.5 and 28.5 cm) during the year 2012 and 2013 respectively, followed by Camarosa, while the maximum plant spread was registered in cv. Confictura (51.0 and 53.67 cm) during both the years, followed by Camarosa. The minimum plant height (13.0 and 12.8 cm) and plant spread (36.50 and 37.50 cm) during 2012 and 2013, respectively was recorded in cv. Ofra. The cv. Festival recorded the maximum leaf area (206.52 and 219.45 cm²) in the year 2012 and 2013, respectively. The highest number of leaves was registered in cv. Pajaro. Cultivar Confictura recorded the highest number of

Table 1. Vegetative characteristics and phonological features of strawberry cultivars.

Cultivar	Plant height (cm)		Plant spread (cm)		Leaf area (cm ²)		No. of leaves		No. of runners		Initiation of flower (days after planting)		Duration of flowering (days)		No. of flowers per plant		Planting to harvest (days)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Chandler	24.13	25.0	48.50	49.34	181.21	179.93	25.67	27.34	75	75	128.00	129.00	84.34	85.00	34.00	35.00	189.00	188.00
Camarosa	25.03	26.4	49.00	52.00	197.88	187.11	23.00	21.00	68	68	122.34	123.00	111.00	113.00	25.00	26.00	180.67	182.00
Confictura	19.06	20.13	51.00	53.67	161.65	163.73	42.67	41.34	84	84	127.34	126.34	97.00	97.67	53.00	52.00	186.67	187.67
Gorella	20.8	22.16	44.16	44.25	169.88	168.55	39.00	40.00	73	73	124.00	124.00	91.00	91.00	32.00	31.00	181.00	182.67
Ofra	13.0	12.8	36.50	37.50	135.45	137.75	18.34	17.34	43	43	119.00	120.67	71.00	73.00	16.00	15.00	174.34	176.67
Festival	25.5	28.5	47.50	48.67	206.52	219.45	25.00	23.67	51	51	126.00	128.34	105.00	105.00	27.00	29.00	178.34	179.34
Ventana	17.16	17.0	37.50	39.50	152.90	151.85	22.34	21.00	58	58	122.00	124.00	106.00	107.34	18.00	19.00	186.00	186.67
Sweet Charlie	21.8	23.6	44.50	46.34	180.61	174.68	22.67	21.00	66	66	118.00	119.34	107.00	106.00	26.00	28.00	175.00	178.34
Selva	20.0	21.0	44.00	43.83	179.48	180.68	40.00	40.67	62	62	128.34	128.67	85.00	84.00	19.00	18.00	182.00	182.34
Eclair	17.5	17.5	41.16	41.83	133.49	131.84	19.34	18.34	83	83	125.00	124.00	99.00	101.00	19.00	20.00	180.34	181.67
Douglas	21.5	21.8	44.90	46.67	152.59	151.84	41.34	40.34	78	78	124.34	124.00	91.67	91.00	32.00	33.00	181.00	183.00
Seqoia	17.34	17.34	37.50	39.00	133.44	132.87	19.00	18.34	40	40	122.34	123.00	98.34	100.00	18.00	19.00	187.67	188.00
Pajaro	22.5	24.5	42.34	41.16	134.06	134.72	43.00	45.00	65	65	123.34	124.00	96.67	98.0	35.00	36.00	182.00	183.00
CD (p = 0.05)	0.75	0.75	1.00	1.06	1.30	0.68	1.40	1.28	1.74	1.74	1.97	1.49	1.42	1.65	1.74	1.73	1.75	1.63

runners (84) per plant and it was statistically at par with Eclair. The variation among cultivars with respect to the vegetative characters could be designated to the genetic attributes of respective cultivars. Similar trends were also observed by Rao and Lal (12), who recorded higher plant height and leaf area in cvs. Chandler and Camarosa than in Gorella and Pajaro.

The cultivars differed significantly with respect to their floral characters (Table 2). The cv. Sweet Charlie had the earliest flower initiation (118 and 119.34 days) during both the years and it was statistically at par with Ofra, while Selva and Chandler were late to flower. Gunduz and Ozdemir (6) also reported that cv. Sweet Charlie was earliest to flower than Chandler. The duration of flowering was longest in cv. Camarosa (111 and 113 days) during both the years, followed by 'Sweet Charlie' and 'Ventana'. The cv. Confictura recorded the highest number of flowers per plant (53, 52) during both the years, followed by Pajaro and Chandler. The results are in close conformity with the findings of Singh *et al.* (16), who recorded more flowers per plant in cvs Chandler, Confictura and Pajaro. Among the various cultivars, Ofra was earliest to harvest, which took only 174.34 and 176.67 days from planting to first harvest during the two years, followed by cv. Sweet Charlie. The results are in accordance to the findings of Hassan *et al.* (8) and Santos *et al.* (13), who obtained early maturity of fruits in cvs Ofra and Sweet Charlie than Chandler.

The data on fruit yield and fruit physical characteristics of different strawberry cultivars under study has been presented in Table 3. The cv. Chandler recorded the highest fruit yield (35.10 and 40.08 MT/ha during 2012 and 2013, respectively), followed by cultivars Festival (29.76 and 35.24 MT/ha in 2012 and 2013, respectively) and Sweet Charlie. The better fruit size and higher number of fruits per plant in cultivars Chandler, Festival, Sweet Charlie and Camarosa in the present study may be accounted for higher yield. The number of flowers per plant certainly has a positive bearing with the number of fruits harvested but the total yield may vary due to berry weight (Dhaliwal and Singh, 4). The cv. Festival recorded the longest berries (42.17 and 43.90 mm), followed by Camarosa and Chandler. The differences in fruit size were primarily due to plant vigour, competition among fruits, climatic conditions and plant nutrition (Sharma and Thakur, 14). The cv. Festival recorded the maximum berry weight (14.94 and 16.75 g) during both the years. It was statistically at par with cvs Camarosa and Chandler during the year 2012 and with Sweet Charlie in 2013. The better fruit size in cv. Festival accounted for heavier fruits. The firmest berries (0.48 and 0.46 Lb), during both the years, were recorded

Table 2. Fruit yield and fruit physical characteristics of different strawberry cultivars.

Cultivar	No. of fruits per plant		Yield per plant (g)		Yield per ha (t/ha)		Fruit length (mm)		Fruit dia. (mm)		Fruit wt. (g)		Fruit firmness (Lb)		Fruit shape
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	
Chandler	30.00	32.00	439.00	501.00	35.10	40.08	41.78	42.18	29.67	30.03	14.86	16.12	0.26	0.24	Conic and long wedge
Camarosa	22.00	23.00	330.00	372.00	26.40	29.76	41.99	42.42	28.22	30.03	14.90	16.27	0.46	0.44	Long wedge
Confictura	14.00	16.00	112.00	118.00	8.96	9.44	35.21	34.58	24.06	23.48	8.90	8.87	0.22	0.22	Conic
Gorella	27.00	26.00	229.00	221.00	18.32	17.68	35.11	35.27	27.15	26.80	9.15	9.70	0.23	0.23	Globose conic
Ofra	14.00	13.00	117.00	108.00	9.36	8.64	34.45	34.16	23.84	23.88	8.47	8.13	0.24	0.24	Globose conic
Festival	25.00	26.00	372.00	423.00	29.76	35.24	42.17	43.90	29.85	30.29	14.94	16.75	0.48	0.46	Long wedge
Ventana	14.00	14.00	126.00	125.00	10.08	10.00	35.62	35.31	21.78	22.37	9.48	9.41	0.32	0.30	Conic
Sweet Charlie	24.00	25.00	352.00	418.00	28.16	33.44	40.57	42.13	28.63	29.91	14.20	16.56	0.37	0.35	Conic
Selva	12.00	12.00	106.00	108.00	8.48	8.76	36.31	38.75	21.90	24.60	9.13	10.76	0.23	0.23	Globose conic
Eclair	15.00	16.00	182.00	232.00	14.56	18.56	38.07	37.67	28.88	29.73	12.06	14.41	0.25	0.25	Conic
Douglas	28.00	29.00	221.00	230.00	17.68	18.40	35.32	35.27	22.69	22.97	8.49	8.67	0.24	0.22	Globose conic
Sequoia	14.00	14.00	126.00	128.00	10.08	10.24	32.37	30.11	25.80	24.94	9.13	9.07	0.28	0.26	Globose conic
Pajaro	31.00	33.00	350.00	398.00	28.00	31.84	35.17	37.15	28.22	29.87	12.08	12.19	0.25	0.23	Conic
CD ($P = 0.05$)	1.74	1.73	1.73	1.72	1.75	1.75	1.15	0.85	0.87	0.69	0.51	0.41	0.01	0.01	

Table 3. Bio-chemical constituents of fruits of different strawberry cultivars.

Cultivar	TSS (°Brix)		Titrateable acidity (%)		Total sugars (%)		Reducing sugar (%)		Non reducing sugar (%)		Anthocyanin content (OD value)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Chandler	8.74	8.76	0.64	0.60	6.03	5.98	3.58	3.57	2.32	2.28	0.35	0.38
Camarosa	8.86	8.74	0.53	0.49	4.80	4.84	3.49	3.49	1.24	1.28	0.39	0.42
Confictura	8.67	8.64	0.60	0.55	4.72	4.67	3.36	3.34	1.29	1.25	0.12	0.15
Gorella	7.73	7.86	0.68	0.65	4.69	4.66	3.35	3.33	1.27	1.26	0.27	0.30
Ofra	9.80	9.93	0.62	0.57	6.02	5.98	3.49	3.49	2.40	2.36	0.25	0.28
Festival	9.46	9.50	0.50	0.46	5.16	4.90	3.54	3.50	1.53	1.33	0.39	0.42
Ventana	8.40	8.40	0.48	0.42	4.67	4.64	3.35	3.34	1.25	1.23	0.24	0.27
Sweet Charlie	9.86	9.86	0.37	0.29	5.14	5.06	4.03	3.99	1.05	1.01	0.37	0.39
Selva	8.74	8.74	0.62	0.58	5.94	5.84	3.53	3.59	2.28	2.13	0.26	0.29
Eclair	9.73	9.40	0.39	0.30	6.58	6.57	4.39	4.40	2.08	2.06	0.32	0.35
Douglas	8.26	8.40	0.50	0.44	5.95	5.98	3.48	3.48	2.34	2.37	0.31	0.34
Sequoia	8.53	8.67	0.48	0.47	4.70	4.63	3.39	3.39	1.24	1.18	0.41	0.44
Pajaro	9.73	9.53	0.39	0.32	7.48	7.43	4.77	4.80	2.57	2.49	0.27	0.30
CD _(P=0.05)	0.18	0.18	0.02	0.01	0.09	0.18	0.03	0.02	0.09	0.18	0.01	0.01

in cv. Festival, followed in Camarosa and Sweet Charlie. The data on biochemical constituents of berries (Table 4) reveal that the cvs Sweet Charlie and Ofra had the highest TSS content. The lowest acidity was registered in cv. Sweet Charlie (0.37 and 0.29%, during 2012 and 2013, respectively), followed in cv. Eclair. The differences in cultivars with respect to the acid content was also reported by Chandel and Badiyala (3), which may be due to genetic and environmental effects, as cooler night and warmer days promote more synthesis of acid in fruits. Among the various strawberry varieties, Pajaro recorded the highest total sugars (7.48 and 7.43%) and reducing sugar (4.77 and 4.80%) during both the years, followed by Eclair and Sweet Charlie. The cv. Pajaro recorded the highest non-reducing sugar content (2.57 and 2.49%) during both the years. The highest anthocyanin content was registered in cv. Sequoia, followed by Camarosa and Festival. The differences in anthocyanin content in different cultivars may be due to genetic factors (Kader, 9).

On the basis of results obtained in present investigation, it is concluded that beside well established cultivar Chandler, the new cultivars like Sweet Charlie, Festival and Camarosa stand promising due to early maturity and more firmer fruits of better size and quality and can be recommended for commercial cultivation in the region.

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