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Yield and quality characters of different strawberry (*Fragaria x ananassa* Duch.) cultivars growing under mid hill conditions of Himachal Pradesh

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Abstract

The present investigation was carried out on fifteen genotypes of strawberry (*Fragaria x ananassa* Duch.) to ascertain the extent of variability present in the material and association among different traits. On the basis of results it is concluded that 'Sweet Charlie' was earliest to flower and duration of flowering was longest in 'Chandler' (97.08 days). 'Elyana' outscored other cultivar for prolonged flowering duration (219.50), flower size (2.84 cm), fruit size (35.91×31.40 mm), number of fruits/plant (32.93) and total yield (6.77 kg/plot). TSS content was highest in 'Selva' and titratable acidity in 'Etna' (0.94%) while 'Sweet Charlie' had maximum (8.02%) total sugars.

Keywords: Average berry weight, prolonged flowering, biochemical parameters, elyana

Introduction

Strawberries are important fruits with excellent dietary source due to their unique taste, flavour, ascorbic acid, potassium, fibre, other secondary metabolites and simple sugar source of energy (Kafkas *et al.*, 2007) [16]. The fruit is a good source of vitamin A (60 IU/100g) and vitamin C (30-120 mg/100g) and also has high pectin (0.55%) content, available in the form of calcium pectate, which serves as an excellent ingredient for jelly making (Mitra,1991) [21].

The added advantage with strawberry is that it gives early and high returns per unit area compared to other fruits because its crop is ready for harvesting within six months after planting. Crop is grown in wide climatic conditions, ranging from temperate to tropical climate. Major strawberry producing countries are USA, Turkey, Spain, Korea and Egypt. In India, Maharashtra is the leading state in strawberry production, also grown in Dehradun and Nainital (Uttarakhand), Srinagar (Jammu and Kashmir) and hills of Darjeeling (West Bengal). Recently, its area has increased considerably in Haryana and Punjab. In Himachal Pradesh major strawberry producing areas are in Kullu, Kangra, Sirmour, Solan and Shimla and occupy an area of 55 ha with annual production of 354 MT (Anonymous, 2014) [1]. Genetic improvement of cultivated strawberry began in the mid 18th century and breeding programmes have made rapid progress in its improvement in the past 50 years (Hancock *et al.*, 1996) [11]. Due to large number of strawberry cultivars grown today, there is a pressing need for the development of reliable method for identifying strawberry cultivars and for assessing genetic diversity in strawberry germplasm for breeding purposes as on number of occasions a single cultivar has been given different names. Keeping in view these aspects, the present investigation was carried out for two years (2015-16, 2016-17) in the experimental field of Department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh for evaluation of different strawberry cultivars for yield and biochemical parameters.

Materials and Methods

The present investigations were carried out in the department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.). The planting of the experimental material was done in the Kalaghat farm of the university. To carry out the investigations on the varietal evaluation of strawberry, the planting of runners was done on raised (15 cm) beds on 1st week of November, 2015 and 2016. Individual plants were spaced at 30 cm between the rows and plant to plant distance was kept at 30 cm. Sixteen plants of each of the fifteen strawberry cultivars were planted in 1.5 x 1.0 m raised beds for detailed investigations.

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During the course of study, recommended cultural practices were followed in the experimental materials. Physical and chemical characteristics of the cultivars were recorded under field and laboratory conditions of the department during the year 2015-16 and 2016-17.

Length and breadth of berry was measured in cm with Verniers calliper and mean was calculated. The weight of the representative fruits of each cultivar from each plant was recorded and average weight per berry was worked out. The yield per plot was calculated by multiplying the mean weight with average number of fruits harvested per plant. Total soluble solids were recorded from the juice obtained from randomly selected berries from all the cultivars in each replication with the help of refractometer of 0-32° Brix range. Acidity and sugar contents were calculated by the method given by AOAC (1984). Total soluble solid acid ratio and sugar/acid ratio was estimated by dividing total soluble solids and sugars by titratable acidity. All statistical analysis was performed as per Panse and Sukhatme (1995) [24].

Results and Discussion

The scope of improvement of any crop depends upon the magnitude of genetic variability present in the available germplasm. Greater the variability in the available germplasm, better would be the chances of selecting superior genotypes (Simmonds, 1962) [29].

Results pertaining to flowering characteristics are presented in table 1. Analysis of variance as regards the days to flowering

indicated substantial varietal variation, varied from 115.46 to 138.26 days. Flowering was earliest in 'Sweet Charlie' (115.46 days) and differed statistically from all other cultivars. The variations in this character further could be assigned to the amount of heat during the growth period (Joolka and Badiyala, 1983) [15], and the climatic condition during growth period, genetic makeup of the cultivar, plantation site individually or collectively may have influenced the flowering duration (Kidmose *et al.*, 1996) [17].

Cultivar Elyana (32.93) exhibits highest number of fruits per plant followed by 'Chandler' (31.74). Large size fruits (35.91×31.40 mm) and highest average berry weight (12.65g) was observed in 'Elyana'. All the cultivars differed significantly with regard to duration of flowering, fruit length and breadth (Table-1). Cultivar 'Elyana' shows longest duration of flowering (219.5 days) followed by 'Fern' (62 days). Similar variation in fruiting was also observed by Asrey and Singh (2004) [4], according to whom cultivar Chandler (39.66), Selva (35.00), Fern (26.66) and Gorella (25.33) had higher fruiting potential which is quite similar to the present work ('Elyana'-32.93, 'Chandler'- 31.74, 'Gorella'-28.07, 'Selva'- 26.41). The variation in fruiting has also been reported by Dhaliwal and Singh (1983) [7] where 'Gorella' produced 28 fruits per plant under Ludhiana conditions. The findings of Grewal and Dhaliwal (1984) [10] however are contradictory as they registered lower number of fruits per plant (3.75 to 18.55) which were much lesser than observed in the present findings.

Table 1: Evaluation of different strawberry cultivars for duration of flowering, fruit length, breadth, average berry weight, yield/plot and yield/plot (Pooled data)

Cultivars	Duration of Flowering	Fruit Length	Fruit Breadth	Number of fruits/plot	Average Berry Weight	Yield/plot	Yield/plot
Addie	41	24.35	18.68	15.15	8.57	129	1.85
Belrubi	45.5	30.38	19.82	25.28	12.23	309	4.04
Brighton	55.5	23.05	19.09	13.70	8.34	114	1.84
Chandler	51.5	33.77	25.11	31.74	12.45	395	5.73
Confectura	42	22.59	20.06	18.91	6.98	132	2.03
Douglas	51	24.61	21.48	25.35	9.39	238	3.95
Etna	45	24.05	17.54	14.31	8.02	119	1.91
Fern	62	25.77	21.73	13.17	7.80	109	1.87
Gorella	40	28.63	22.99	28.07	10.17	285	4.67
Elyana	219.5	35.91	31.40	32.93	12.65	418	6.77
Selva	60.5	28.28	21.56	26.41	12.45	329	4.57
Shasta	42.5	28.83	21.72	19.33	8.51	164	2.12
Sweet Charlie	52.5	31.98	25.74	23.24	11.17	260	4.12
Tioga	46.5	22.38	19.24	21.94	10.81	238	3.60
Torrey	55	30.63	24.52	10.13	11.23	117	1.88
CD _{0.05}	2.63	1.99	1.72	1.41	1.37	1.29	0.62

These differences in number of fruits per plant may be ascribed to the differences for the cultivars taken for study, their potential of bearing cultural practices adopted during evaluation, agro-climatic conditions of the test site. The fruit potential is a genetical feature and cultivars are known to differ.

Cultivar 'Elyana' produced the longest fruits (35.91 cm) followed by 'Sweet Charlie' (25.33). Fruit breadth was also found to be higher in 'Elyana' (31.40) followed by 'Sweet Charlie' (25.74 cm). The differences in fruit size were primarily due to plant vigour, competition among fruits, the inflorescence, number and size of developed achiness, climatic condition and plant material (Janick & Eggert, 1968; Moore *et al.*, 1970) [22].

The maximum yield per plot to the tune of 6.77 kg was

obtained in 'Elyana'. Cultivar Chandler with a yield of 5.73 kg/plot was found next in order. The minimum yield of 1.84kg/plot was recorded on cultivar Brighton. However, these figures for yield on different cultivars of strawberry are not on agreement with strawberry grown elsewhere. These variations on the yielding potential may be ascribed to the fact that strawberry yields are markedly influenced by environmental parameters like photoperiod, temperature and light intensities.

Cultivar 'Selva' exhibits highest (12.26°B) closely followed by 'Sweet Charlie' (11.31°B). Asrey and Singh (2004) [4] from their investigation also reported highest TSS in 'Chandler' (7.50 °B) compared to 'Douglas' and 'Fern', which is similar with the present investigation although value obtained was about 1.5 times higher. The observations of Sharma and

Thakur (2008)^[27] and Dwivedi (2011)^[11] are in contradiction where indicated lowest TSS was recorded in 'Selva' (7.55 °B) whereas it is maximum in the present study (12.26°B). The

findings of Jami *et al.* (2015)^[3] and Ashadpoor *et al.* (2015) also do not match with the current findings of higher TSS value.

Table 2: Evaluation of strawberry cultivars for total soluble solids, acidity, reducing, non-reducing, total sugars, TSS/acid ratio and Total sugars/acid ratio (Pooled data)

Cultivars	TSS (° Brix)	Titrateable acidity (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total Sugars (%)	TSS/acid ratio	Total sugars/acid ratio
Addie	10.31	0.79	4.52	1.87	6.29	13.01	8.15
Belrubi	10.48	0.80	4.14	1.77	5.80	12.81	7.33
Brighton	9.93	0.81	3.69	1.63	5.25	12.24	6.55
Chandler	11.01	0.69	4.73	2.01	6.62	14.97	9.77
Confectura	9.05	0.73	3.81	3.41	5.35	13.32	8.07
Douglas	9.42	0.76	3.56	2.33	5.80	12.77	7.74
Etna	9.27	0.94	3.24	1.70	4.88	11.69	5.26
Fern	8.14	0.72	4.13	1.69	5.72	12.46	8.00
Gorella	9.17	0.81	3.72	1.51	5.14	13.22	6.44
Elyana	10.95	0.76	4.73	4.33	6.70	15.06	9.17
Selva	12.26	0.66	3.95	2.66	6.50	18.14	10.00
Shasta	9.23	0.93	3.37	2.79	6.08	10.30	6.63
Sweet Charlie	11.31	0.81	4.87	1.98	8.02	13.14	8.51
Tioga	9.46	0.78	3.60	3.25	5.07	10.32	6.56
Torrey	8.17	0.79	3.69	4.40	6.75	9.96	7.48
CD _{0.05}	0.84	0.05	0.27	0.34	0.27	0.96	0.90

The highest acidity (0.94%) was observed on cultivar 'Etna' followed by 'Shasta' (0.93%). Kidmose *et al.* (1996)^[17] and Nagre *et al.* (2005)^[23] also observed a significant variation for titrateable acidity accordingly 'Selva' had minimum acidity which is in line with the present investigation and also with the work of Sharma and Thakur (2008)^[27] and Miserendino *et al.* (2009)^[19] who observed lowest acidity in 'Selva' (0.57%) and highest in 'Etna' (1.07%). Recently Garg (2013)^[9] and Mishra *et al.* (2015)^[20] recorded acidity value which is similar to as that reported in the present investigation. Findings of Hassan *et al.* (2001)^[12] however are contradictory as they found highest acid content in 'Chandler' compared to highest registered in 'Etna' in current work. Paydas *et al.* (1995)^[25] reported higher acidity content (1.01) in 'Torrey' than present investigation. According to Kidmose *et al.* (1996)^[17] titrateable acidity is affected by maturity time, harvest and climate conditions. Lowest TSS and acidity was registered in 'Fern' (8.14°B) and Selva (0.66%) respectively. The possible explanation for difference may be due to the fact that cultivars grown under sunny days and cool nights have better TSS and acid contents than grown under cloudy, humid and warm nights (Avidov, 1986; Kindmor *et al.*, 1996)^[5, 17].

On the other hand hot, wet conditions during harvest season are known to increase fruit acidity (Sistrunk and Moore, 1971)^[31]. The highest total Sugars (8.02%) reducing sugars (4.87%) was observed in cultivar 'Sweet Charlie'. The maximum reducing sugars (4.40%) found in 'Torrey'. Present findings are in close conformity with the work of Das *et al.* (2007)^[6], Singh *et al.* (2008)^[30], Lal *et al.* (2010)^[18] who observed relatively higher value of reducing sugars in 'Sweet Charlie' (3.95%) than 'Chandler' (3.52%). The present results are in divergence with the findings of Shukla *et al.* (1980)^[28] and Dhaliwal and Singh (1983)^[7], who indicated a significant variation for the characters reducing sugars (3.81 to 9.96%) and non reducing sugars (0.13 to 1.61%). Such type of relationship has also been observed by Sharma and Thakur (2008)^[27], where 'Chandler' recorded relatively higher value (6.10%) and 'Catskill' minimum value for non-reducing sugars (0.59%). The reasons for deviation in fruit sugar may

be described due to differences in growing conditions and climatic variation (Sharma & Thakur 2008)^[27]. Further, it is concluded that among fifteen cultivars Chandler, Elyana and Sweet Charlie were the best in yield and physio-chemical attributes at Himachal Pradesh mid hill conditions.

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