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STUDIES ON THE COMPARATIVE PERFORMANCE OF STRAWBERRY CULTIVARS UNDER MID-HILL CONDITIONS OF NORTH-WESTERN HIMALAYAS

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ABSTRACT

The performance of 16 strawberry genotypes under the mid-hill conditions of Himachal Pradesh was evaluated during 2012 and 2013. 'Gorella' with fruit size of 37.48 x 28.49 mm, weight of 13.73 g and yield of 5.92 kg per plot was the best followed by 'Chandler' and 'Sweet Charlie'. Achene number per fruit was highest in 'Belrubi' (172.50). 'Sweet Charlie' had shortest maturity time from planting (154.67 days) followed by 'Chandler' (155.50 days) whereas 'Brighton' had longest time (170.33 days). TSS content was the highest in 'Pajaro' (12.03 °B). Cultivar Sweet Charlie had minimum titratable acidity (0.54%) and maximum total sugar content (7.43%). Maximum anthocyanin content was recorded in cultivar 'Chandler' (72.02 mg/100g). From comparative study of cultivars Gorella, Chandler and Sweet Charlie out performed other cultivars.

INTRODUCTION

The modern cultivated strawberry (*Fragaria x ananassa* Duch.) is a hybrid between two native American species, *Fragaria chiloensis* and *Fragaria virginiana*. The fresh, ripe fruit of strawberry is a rich source of vitamins and minerals. 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 (Garg *et al.*, 2015). In India, it is cultivated to a limited extent in plains and sub-mountainous areas of Himachal Pradesh, Uttarakhand, Uttar Pradesh, Maharashtra, Karnataka Punjab, Haryana and Madhya Pradesh where irrigation facilities are available (Garg *et al.*; 2014.) In Himachal Pradesh major strawberry producing areas are Kullu, Kangra, Sirmour, Solan and Shimla.

For any crop to be adapted at a place genetic diversity and its performance under specific agro ecological condition is very essential. Strawberry has considerable genetic variability and precise information on cultivars performance under different agro-climatic condition is essential before their recommendation for cultivation. Further with passage of time, demand for new cultivars does arise. Hence, the proper and systematic evaluation of germplasm would yield useful information with regard to their suitability for commercial cultivation, and through characterization build a database regarding their performance under a set of agro-climatic situation. In the present strawberry cultivation scenario, an ideal variety is one that grows well in different climatic conditions produce firm and large fruits of good quality and attractive colour with good processing and dessert quality. The purpose of the investigation was to identify the best performing cultivar (s) to be recommended for cultivation.

MATERIALS AND METHODS

The present study was conducted at the experimental field of Department of Fruit Science, Dr Y S Parmar University of Horticulture and Forestry, Solan during the year 2011-2013. Runners of sixteen strawberry cultivars namely Douglas, Catskill, Confectura, Pajaro, Brighton, Shasta, Belrubi, Elsantha, Addie, Chandler, Ofra, Sweet Charlie, Gorella, Torrey, Fern and Selva were planted on 1.5 x 1.0 m raised beds during first week of October in randomized block design with 3 replications consisting of 16 plants in each replication. Individual plants were spaced at 30 cm between the rows and plant to plant distance also was kept at 30 cm. During the course of study, all the recommended cultural practices were followed. The fruit size and weight of ten randomly selected berries were determined and the average was worked out (IBPGR, 1986). The number of achenes per fruit in ten fruits per cultivar were counted and expressed as average number of achenes (IBPGR, 1986). The flowers were tagged as they opened and days to fruit maturity were worked out as per the method given by Wilson and Giamalva (1954). 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 was recorded for each cultivar and yield was expressed as kg per plot. The biochemical constituents like total soluble solids were determined with the help of a hand refractometer, the

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acidity was estimated in terms of citric acid and sugar content was determined by volumetric method based on principle that sucrose content of berry is quantitatively hydrolyzed to glucose and fructose in the presence of HCl (AOAC1989), while anthocyanin pigment was determined by absorbance method (Harborne, 1973). The data obtained from the present investigation were subjected to statistical analysis in accordance to Gomez and Gomez (1983).

RESULTS AND DISCUSSION

The cv. Gorella had the highest fruit length during both the years and 'Addie' and 'Catskill' had the lowest value (Table 1). Maximum pooled mean fruit breadth (28.49 mm) was observed in 'Gorella' and was statistically similar to 'Sweet Charlie' and 'Chandler' and minimum was (17.12 mm) in 'Brighton' which was at par with cultivars Shasta and Belrubi. Large fruit size is a feature of 'Gorella' and several researchers

(Rosati *et al.*, 1982, Hancock *et al.*, 1996, Sharma *et al.*, 2002 and Singh *et al.*, 2008) have observed the same. Garg *et al.* (2015) recorded maximum fruit length (34.48 mm) and breadth (27.90 mm) in cultivar Chandler. The variation in fruit size may be attributed to the unlike dry matter partitioning and assimilation in fruits of different genotypes (Garg *et al.*, 2015).

Number of achenes per fruit varied from 141.00 to 175.00 during 2011-12 and 135.00 to 170.00 in 2012-13 (Table 1), maximum being in cultivar Belrubi and minimum in 'Pajaro' during both the years. Wide variation in achene number per fruit that ranged from 128-160 indicated a quadratic relationship between fruit weight and total number of achenes (Khanizadeh *et al.*, 1993). Findings of Garg (2013) revealed that achene number per fruit varied from 140.00 (Douglas) to 195.17 (Belrubi).

Cultivar 'Sweet Charlie' took least number of days for fruit maturation (Table 2) compared to all other cultivars and was at par with 'Chandler' whereas 'Brighton' was late to mature and

Table 1: Fruit characteristics of different strawberry cultivars

Cultivars	Fruit length (mm)		Fruit breadth (mm)		Number of achenes per fruit				
	2011-12	2012-13	Pooled	2011-12	2011-12	Pooled	2011-12	2012-13	Pooled
Torrey	28.36	26.70	27.53	20.83	22.27	21.55	153.00	157.00	155.00
Sweet Charlie	37.46	34.03	35.75	30.05	26.47	28.26	155.67	160.33	157.50
Ofra	25.53	27.39	26.46	19.64	20.60	20.12	148.00	144.33	146.00
Chandler	36.62	35.33	35.97	26.64	28.81	27.72	173.67	168.00	170.50
Gorella	38.49	36.48	37.48	29.72	27.25	28.49	155.33	150.00	152.67
Pajaro	25.50	28.74	27.12	20.57	22.46	21.52	141.00	135.00	138.00
Brighton	26.05	27.35	26.70	15.54	18.70	17.12	144.00	147.67	146.17
Douglas	30.70	28.68	29.69	22.44	20.42	21.43	142.67	136.00	139.34
Selva	27.43	28.15	27.79	18.70	20.52	19.61	165.00	160.00	162.50
Addie	23.35	25.61	24.48	20.62	22.00	21.31	169.00	162.00	165.50
Shasta	25.40	27.53	26.46	18.79	16.57	17.68	143.00	147.00	145.00
Catskill	26.30	24.70	25.50	20.42	21.17	20.80	153.67	160.00	156.84
Elasantha	26.39	25.66	26.02	19.23	20.48	19.85	142.67	148.33	145.00
Belrubi	32.04	30.58	31.31	17.81	18.91	18.36	175.00	170.00	172.50
Fern	26.72	27.79	27.25	21.03	18.80	19.92	148.00	136.00	142.00
Confectura	30.86	32.33	31.60	24.92	22.41	23.67	155.00	147.00	151.00
CD0.05	2.40	2.78	1.68	3.76	3.77	2.10	4.34	3.07	3.07

Table 2: Days to maturity, number of fruits per plant, average berry weight and total yield of different strawberry cultivars

Cultivars	Days to maturity from planting			Berry weight (g)			No. of fruits/plant			Total yield (kg/plot)		
	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
Torrey	165.00	164.33	164.67	9.59	9.00	9.30	14.33	10.67	12.50	1.95	2.45	2.20
Sweet Charlie	155.00	154.33	154.67	12.34	10.34	11.34	22.67	25.33	24.00	4.75	4.20	4.48
Ofra	161.00	161.33	161.67	8.14	7.52	7.83	17.67	15.67	16.67	1.88	2.16	2.02
Chandler	156.33	154.67	155.50	12.07	13.64	12.86	33.67	29.33	31.50	5.77	5.42	5.60
Gorella	165.33	166.67	166.00	13.37	14.08	13.73	27.67	30.33	29.00	5.81	6.03	5.92
Pajaro	166.67	164.67	165.67	9.72	10.21	9.97	16.67	14.67	15.67	2.55	2.16	2.36
Brighton	169.67	171.00	170.33	8.83	9.75	9.29	13.00	17.33	15.17	1.96	2.04	2.02
Douglas	161.33	160.00	160.67	11.05	12.36	11.71	26.67	23.33	25.00	4.38	4.58	4.48
Selva	168.33	168.00	168.17	7.72	9.23	8.47	25.33	28.33	26.83	3.11	3.19	3.15
Addie	163.33	165.33	164.33	7.15	8.61	7.89	12.67	16.33	14.50	1.59	1.82	1.70
Shasta	169.33	170.33	169.83	7.52	7.04	7.28	18.67	21.33	20.00	2.27	2.02	2.14
Catskill	165.33	163.33	164.33	6.95	7.46	7.21	16.33	19.67	18.00	1.85	1.64	1.75
Elasantha	167.67	166.67	167.17	7.77	8.26	8.02	10.33	8.67	9.50	1.52	1.19	1.36
Belrubi	163.33	166.33	164.83	8.50	8.05	8.28	22.67	24.33	23.50	3.20	3.42	3.31
Fern	169.33	168.67	169.00	7.31	7.86	7.59	12.67	15.33	14.00	1.73	2.02	1.88
Confectura	169.00	168.00	168.50	9.94	11.24	10.59	23.33	20.33	21.83	3.43	3.17	3.30
CD0.05	2.45	2.60	2.28	2.33	0.93	1.38	5.81	5.65	4.59	0.52	0.54	0.41

Table 3: Physico-chemical characteristics of different strawberry cultivars

Cultivars	TSS (o Brix)			Titratable acidity (%)			Total sugars (%)			Anthocyanin mg/100g		
	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
Torrey	11.53	10.60	11.07	0.66	0.63	0.64	6.85	7.26	7.06	61.83	60.06	60.95
Sweet Charlie	11.80	11.64	11.72	0.56	0.52	0.54	7.51	7.36	7.43	68.96	70.12	69.54
Ofra	8.73	9.20	8.97	0.75	0.77	0.76	5.65	6.53	6.09	56.12	55.54	55.83
Chandler	11.67	10.73	11.20	0.64	0.60	0.62	6.52	6.83	6.68	70.82	73.22	72.02
Gorella	10.07	9.73	9.90	0.55	0.59	0.57	6.04	5.87	5.96	63.65	60.12	61.89
Pajaro	12.20	11.87	12.03	0.61	0.63	0.62	6.13	6.10	6.11	62.33	62.35	62.34
Brighton	10.47	9.80	10.13	0.66	0.68	0.67	6.43	6.55	6.49	55.14	53.39	54.27
Douglas	9.73	10.27	10.00	0.69	0.72	0.70	6.37	6.07	6.22	68.52	67.36	67.94
Selva	11.47	12.13	11.80	0.68	0.64	0.66	6.02	5.82	5.92	56.68	56.24	56.46
Addie	10.87	10.53	10.70	0.60	0.62	0.61	6.18	6.43	6.31	66.59	64.87	65.73
Shasta	9.53	10.13	9.83	0.74	0.70	0.72	6.43	6.17	6.30	60.56	62.02	61.29
Catskill	8.60	9.07	8.83	0.89	0.86	0.87	5.95	6.26	6.12	65.40	63.28	64.34
Elasanth	9.87	9.73	9.80	0.81	0.79	0.80	5.84	5.67	5.75	70.71	68.65	69.68
Belrubi	10.00	9.67	9.83	0.75	0.72	0.74	6.07	6.35	6.21	58.72	59.56	59.14
Fern	9.87	9.87	9.87	0.71	0.68	0.70	6.23	5.98	6.11	59.51	62.46	60.99
Confectura	9.33	9.53	9.43	0.60	0.56	0.58	6.35	6.26	6.30	64.15	61.45	62.80
CD0.05	2.08	1.77	1.24	0.07	0.06	0.06	0.51	0.58	0.36	5.20	5.32	4.25

was statistically similar with 'Shasta', 'Fern', 'Confectura', 'Selva'. In contrary, Asrey and Singh (2004) recorded lesser number of days taken for fruit maturity (95.00 to 110.00 days). 'Ofra' was earliest to harvest which took 174.34 and 176.67 days from planting to first harvest during 2011-12 and 2012-12 followed by 'Sweet Charlie' (Sahu and Chandel, 2014).

The pooled analysis revealed that 'Gorella' had maximum average berry weight of 13.73g and minimum (7.21g) in 'Catskill' (Table 2). The present findings are in alignment with Sharma *et al.* (2009) and Bhat *et al.* (2005) as maximum fruit weight was in Gorella under Jammu conditions. Garg (2013) and Sharma *et al.* (2014) observed maximum berry weight in 'Chandler' in Himachal Pradesh.

According to pooled analysis 'Chandler' produced maximum number of fruits (31.50) and was statistically similar with 'Gorella' while 'Elasanth' had minimum number (9.50) which was statistically similar with 'Fern' and 'Torrey' (Table 2). Similar to the present findings Sharma and Sharma (2006), Sharma and Thakur (2008) and Garg (2013) observed maximum number of fruits per plant in 'Chandler' followed by 'Gorella'. Yield may vary for the same cultivar due to varied agro climatic conditions (Hassan *et al.*, 2001, Verma *et al.*, 2002).

Highest yield of 5.92 kg per plot was recorded in cultivar 'Gorella' while minimum was in cultivar 'Elasanth' (1.36 kg/plot) (Table 2). Yield is a complex character and is indirectly affected by its contributing characters like flowers per plant, fruit set (%). It was noticed that yield potential under various conditions are influenced by photoperiod, temperature and light intensities. These findings are in alignment with the work of Kopylov and Pupova (1985) rated 'Gorella' to be high yielding cultivar out of twelve cultivars tested under Ukrainian conditions.

The TSS values ranged between 8.83 to 12.03°B (Table 3). Cultivar Pajaro showed highest TSS content which was at par with 'Selva', 'Sweet Charlie', 'Torrey', 'Chandler' and lowest TSS was registered in 'Catskill' which was statistically similar with 'Ofra', 'Gorella', 'Douglas', 'Shasta', 'Elasanth', 'Belrubi', 'Fern' and 'Confectura'. Similarly, 'Pajaro' exhibited highest

T.S.S. (12.17°B) among fifteen strawberry cultivars under Solan conditions (Sharma *et al.*, 2014). Sharma and Sharma (2002) under mid hill condition of Himachal Pradesh observed TSS value between 9.46-11.82 °B in different strawberry cultivars and it was 11.74°B in cultivar Pajaro. The cv. Catskill had the most acidic fruits whereas 'Sweet Charlie' fruits were least acidic (Table 3). The results are in line with the findings of Sahu and Chandel (2014) who recorded lowest acid content in 'Sweet Charlie'. In contrast Singh *et al.* (2008) recorded high acidity (1.04 %) in cultivar Sweet Charlie under their place of investigation. Cultivar Sweet Charlie registered maximum total sugars (7.51%). The reasons for deviation in fruit sugars may be ascribed to the differences in growing conditions and climatic variation and inherent nutritional status of the cultivars (Sullivan and Enzie, 1961). Highest anthocyanin content was recorded in 'Chandler' (72.02 g/100g) which was statistically similar with 'Douglas', 'Sweet Charlie' and 'Catskill' whereas minimum was in 'Elasanth' and was at par with 'Ofra'. Anthocyanin content recorded in 'Sweet Charlie' is in close conformity with that observed by Singh *et al.* (2008) (63.9 mg/100g) however, they registered much higher anthocyanin value in 'Chandler' (104.5 mg/100g) and 'Ofra' (125.4 mg/100g).

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