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Evaluation of strawberry (*Fragaria x ananassa* Duchesne.) cultivars under polyhouse conditions in mid hills of Himachal Pradesh

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Abstract

Three micropropagated strawberry cultivars viz. Camarosa, Douglas and Sweet Charlie along with runners of Chandler (multiplied conventionally) were evaluated in a polyhouse at Palampur during 2013-14. The results showed significant variation in vegetative growth, fruit quality and yield parameters due to cultivars. The maximum leaf area (61.59 cm^2) was recorded in Camarosa whereas, the minimum (40.99 cm^2) in cultivar Sweet Charlie. Runner production and number of leaves per plant were significantly higher in cultivar Camarosa as compared to other cultivars. The yield attributes were also significantly varied among different genotypes. Chandler (7.81) remaining at par with Camarosa (6.80) resulted in significantly higher number of berries per plant. Berries yield was maximum in Camarosa (72.63 q/ha). The qualitative attributes of the fruits like berry size, weight, TSS, acidity and TSS/acid ratio were also significantly varied among cultivars.

Key words: Micropropagated, Strawberry, Camarosa, Sweet Charlie, Polyhouse, TSS, Runner, Acidity.

The cultivated strawberry (*Fragaria x ananassa* Duchesne.) is a natural hybrid being grown in cooler regions worldwide for delicious fruits with rich source of vitamins, minerals and various other bioactive compounds (Oszmianski and Wojdylo 2009). Commercially it is being grown in northern and central Europe, Asia and America. In India, it is being cultivated in Himachal Pradesh, Uttrakhand, Maharashtra, West Bengal, Delhi, Punjab, Haryana, Rajasthan and Nilgiri hills (Chadha 2001). The area under strawberry cultivation in Himachal Pradesh is 55 ha with annual production of 559 MT (Anonymous 2015). Strawberry has vast scope in areas which are located in vicinity of canning units and kitchen gardens. In Himachal Pradesh, strawberries are mostly grown under open field conditions. There are reports on higher early production when market prices are high, higher quality fruit, better insect pest, disease and weed control with reduced use of chemicals, decreased labor costs and more efficient water usage under plasticulture/greenhouse (Dinar 2003; Garwood 1998 and Poling 1993). However, strawberries grown using the plasticulture system, must be intensively managed (Dinar 2003). With a plasticulture system, there is considerably less margin for error with regard to soil treatment, timing, pest management, frost and freeze strategies and marketing (Poling *et al*. 2005). In Japan and Korea, about 90% of the total strawberry production is obtained from protected structures (Takeda 1999). Similarly, in Netherlands and Belgium, the strawberry is extensively cultivated under greenhouses or tunnels (Lieten 1993). The University of Florida released Sweet Charlie strawberry in 1992. This cultivar was planted on 38% of commercial strawberry acreage in Florida in 1996–97 which increased to 50% in 1998– 99. Douglas, another promising short day strawberry cultivar having a large plant size and leaves with berry size of 22.0 g was released for California in 1980 (Royce and Victor 1980). The cultivar Chandler was the most frequently planted in South-East US due to its phenotypic stability; long harvest period, adequate cold tolerance, early maturity, flavour, color and high yield. Camarosa recently introduced California cultivar, was becoming increasingly popular due to its firmer flesh, which allows transit of berries to more distant marketplaces whereas, Sweet Charlie, an early ripening cultivar from Florida, enabled growers to find a

production niche early in the season when crop value is at its highest (Poling 1993).

Management technology of strawberry under green-house conditions, like cultivar selection, seedling preparation, growing system, population density and integrated pest management, has been developed in central Florida to attain marketable yields of 350 to 450 g per plant (7 to 9 kg/m^2) with population densities of 20 plants/m^2 (Paranjpe and Cantliff 2003). Garwood (1998) concluded that although plasticulture systems were expensive to implement but the increased productivity and reduced labour costs allowed for higher returns. From Himachal Pradesh, Shylla and Sharma (2010) reported that strawberry cultivar Chandler grown under poly-house condition with different plastic mulches resulted in advancement of flowering with highest yield under yellow polythene mulch as compared to black, silver or purple coloured plastic mulches. While, better quality fruits were obtained under black polythene mulch. The work on varietal evaluation was not done earlier under Palampur conditions, therefore, the present study was conducted to evaluate strawberry cultivars under ordinary tunnel type polyhouse condition for their growth, fruiting, yield attributes and yield.

Materials and Methods

The experiment was conducted at the experimental farm of Department of Horticulture. The area falls under mid hill zone of Himachal Pradesh. In this study, three micropropagated strawberry cultivars viz. Camarosa, Douglas and Sweet Charlie along with Chandler (multiplied conventionally at the research farm) were evaluated for their vegetative growth and fruiting attributes under naturally ventilated tunnel type polyhouse during 2013-14. The climate of Palampur is generally sub-temperate and semi-humid characterized by cold winters. The soil of the site was silty clay loam with slight acidic pH ranging between 5.67 to 6.06. Three micropropagated strawberry cultivars (Sweet Charlie, Camarosa and Douglas) were obtained from TERI, New Delhi after hardening in June 2013. These plantlets were kept as such for two months in trays with growing media mixture consisting of cocopeat, vermiculite and perlite at the ratio of 1:1:1 (Fig 1a). In the month of August the plants were again transplanted in well prepared nursery beds under polyhouse, the plants were kept as such for two months. In first week of October they attained transplantable height with well developed root system and leaves were planted again at 25 x 25 cm, in well prepared beds along with healthy and uniform runners of Chandler (obtained from demonstration field of the Department). At the time of transplanting in beds the micropropagated plants were 10 months old with well developed root system and leaves (Fig 1b & c). FYM at 50 tonnes per hectare along with 40 kg each of P_2O_5 and K_2O was applied at the time of bed preparation. Nitrogen was applied at 80 kg per ha in two split doses, half one month after the establishment of plants and remaining half before flowering. Experiment was laid down in a complete randomized block design. The growth parameters viz., leaf area, number of leaf per plant and runner production were taken after fruit harvesting. Leaf area was determined by non-destructive method of leaf area model described by Demirsoy *et al*. (2005) as follows:- Leaf area (cm^2) = 1.89 + 2.145 x upper lobe length x left lobe width. The fruit quality parameters viz. size, weight, TSS, titratable acidity and TSS/Acid ratio were recorded as per standard methods (AOAC 2010). The data were analyzed by using software ASSEX at 5% level of significance.

Results and Discussion

Vegetative growth

A perusal of data presented in Table 1 revealed that growth parameters viz. leaf area, number of leaf per plant, fresh and dry weight of leaf, crown diameter and runner production were significantly different under genotypes. Maximum leaf area was recorded under Camarosa (61.59 cm^2) followed by Douglas (54.83 cm^2), Chandler (48.00 cm^2) and Sweet Chrlie (40.99 cm^2). However, Fernandez *et al.* (2001) obtained more leaf area in Chandler as compared to Camarosa and Sweet Charlie under plasticulture in North Carolina State University. In the present study, overall growth was more in Camarosa. Similar trend was also observed in production of number of leaves per plant. The cultivar Camarosa had maximum number of leaves followed by Douglas and Chandler. The fresh and dry weight of leaves was also significantly varied among different genotypes. The cultivars Camarosa had maximum fresh weight of leaf followed by Douglas and Chandler and minimum in Sweet Charlie. This may be attributed to the more vegetative growth and leaf area in Camarosa which might have increased accumulation of more dry matter in leaves. Further, the specific leaf area is an important index of leaf structure and it is largely a function of leaf thickness. Moreover, the leaf area and number

are phenotypic features of a cultivar which are controlled by genetic make-up of cultivars and environment (Chiarello *et al*. 1989).

Crown growth and runner production

The number of runners per plant and crown growth was also significantly influenced due to cultivars under polyhouse condition (Table 1). The highest number of runners was recorded in Camarosa (10.67/plant) followed by Chandler, Douglas and Sweet Charlie in that order. However, Douglas and Sweet Charlie were statistically at par. Similar trend was also observed in crown development during the course of study. In a study by Paranjpe and Cantliffe (2003) the runner production in cultivar Festival was comparable to a number of other commercial cultivars grown under greenhouse conditions in central Florida. However, in present study it was observed that the strawberry cultivar Camarosa had vigorous and larger plant size as compared to other cultivars which might be due to more number of runners per plant. Danial *et al*. (2007) reported that the type of media used did not significantly affect the number of runners in strawberry cultivar Festival when grown under greenhouse condition. Fernandez *et al*. (2001) reported that root and crown dry matter production was more in cultivars of California origin i.e. Chandler and Camarosa, whereas, Sweet Charlie, a cultivar from Florida, showed lower dry matter accumulation and relative growth rate.

Fruiting and yield

Flowering was started in last week of January and first picking was done in last week of March. The strawberry cultivar Sweet Charlie was the earliest to flower, followed by Chandler, Camarosa and Douglas (data not given). Camarosa and Chandler (7.81 and 6.80 berries/plant, respectively) gave significantly higher number of berries per plant over other two varieties (Table 2). The overall yield was highest in Camarosa (72.63 q/ha) and minimum yield was recorded in Sweet Charlie (29.78 q/ha). The maximum production in Camarosa might be attributed to the maximum berry size (18.97 g) as compared to other cultivars (Table 3). Similar results were also reported by Fernandez *et al*. (2001) when three cultivars viz., Camarosa, Chandler and Sweet Charlie were evaluated under plastic culture in Tidewater Research Station, Plymouth US. In contrast, Michael and Umeda (1999) reported more number of berries and weight in cultivar Chandler than Camarosa when both were planted on different dates in low desert area of Arizona.

Fruit quality

Camarosa produced larger size berries (18.97g/berry) followed by Douglas (14.92), Chandler (13.56) and Sweet Charlie (11.75 g/berry) (Table 3). Similarly, the length and breadth of the berries were also more in Camarosa (45.38 and 31.04 mm, respectively) and minimum in Sweet Charlie (35.63 and 27.06 mm, respectively). The colour of fruit and cavity are important characters of strawberry for marketing and processing. Different varieties exhibited varied berry colour and cavity size (Fig 2). Chandler had a nice dark red color with prominent cavity. Douglas also had similar cavity. Sweet Charlie was medium red with no cavity and Camarosa had slight cavity with white core and light red colored flesh. Kadir and Sidhu (2006) concluded that the fruit skin colour was the most important parameter that determines the quality of strawberry which was affected by the temperature during ripening. Sweet Charlie had more redcolouration as compared to Chandler at 20/15 °C temperature. Chandler produced redder fruits (Fig 2). The total soluble solids and titratable acidity of fruits varied significantly among different varieties (Table 2). The highest soluble solid (9.17%) was recorded in Chandler followed by Douglas (7.87%), Camarosa (6.83%) and Sweet Charlie (6.80%) in the given order. In a varietal evaluation of strawberries by Richard and Michael (2001) in Fresno CA there was more TSS content in Sweet Charlie (9.4%) as compared to Chandler (8.2%) and Camarosa (7.4%) and it increased gradually with the seasonal temperature rise. Titratable acidity was maximum in Chandler (0.71%) however, it was at par with Sweet Charlie (Table 3). Minimum acidity (0.63%) was recorded in Camarosa. Titratable acidity is very important constituent which is responsible for the flavour and is conditioned in part by the balance between sugars and acids expressed in ripe fruits (Beatriz *et al*. 2001). Total soluble solid to acid ratio was maximum (12.85) in cultivar Chandler and minimum (10.05) in Sweet Charlie. This high value of TSS: acid ratio might be attributed to the higher TSS content in Chandler as compared to other cultivars.

Based on this study, the varieties Camarosa and Chandler had maximum yield as compared to Sweet Charlie

Table 1. Leaf area, runner production and crown diameter of different strawberry cultivars under polyhouse condition

Growth parameters / Cultivars	Leaf area (cm^2)	No of leaf/plant	Leaf fresh weight (g)	Leaf dry weight (g)	Crown diameter (mm)	Number of runners/ plant
Douglas (tissue cultured)	54.83	21.08	1.35	0.65	44.81	6.78
Sweet Charlie (tissue cultured)	40.99	19.67	1.28	0.52	41.12	6.22
Camarosa (tissue cultured)	61.59	24.25	1.46	0.74	47.94	10.67
Chandler (runners)	48.00	20.33	1.31	0.57	43.82	8.22
CD (P=0.05)	3.47	0.75	0.03	0.03	0.83	1.38
SE	1.41	0.31	0.01	0.01	0.33	0.56

Table 2. Number of fruits and yield attributes of different strawberry cultivars under polyhouse condition

Yield attributes / Cultivars	Number of fruits/plant	Yield g/plant	Yield q/ha
Douglas (tissue cultured)	5.78	86.34	47.97
Sweet Charlie (tissue cultured)	4.55	53.60	29.78
Camarosa (tissue cultured)	6.80	130.70	72.63
Chandler (runners)	7.81	107.00	59.42
CD (P=0.05)	1.03	16.21	9.00
SE	0.42	6.62	3.68

Table 3. Fruit quality attributes of different strawberry cultivars under polyhouse condition

Fruit quality / Cultivars	Fruit size		Fruit weight (g)	TSS (%)	Acidity (%)	TSS/Acid ratio
	Length (mm)	Breadth (mm)				
Douglas (tissue cultured)	42.99	29.57	14.92	7.87	0.67	11.71
Sweet Charlie (tissue cultured)	35.63	27.06	11.75	6.80	0.71	10.05
Camarosa (tissue cultured)	45.38	31.04	18.97	6.83	0.63	10.31
Chandler (runners)	37.16	27.30	13.56	9.17	0.71	12.85
CD (P=0.05)	7.01	2.47	1.11	0.39	0.03	1.62
SE	2.86	1.01	0.45	0.16	0.01	0.67

Figure 1. Hardened tissue cultured strawberry plantlets a: (one month old) in rooting media mixture (Cocopeat+vermiculite+perlite); b: plants after one month of transplanting and c: plants in bearing stage under polyhouse condition

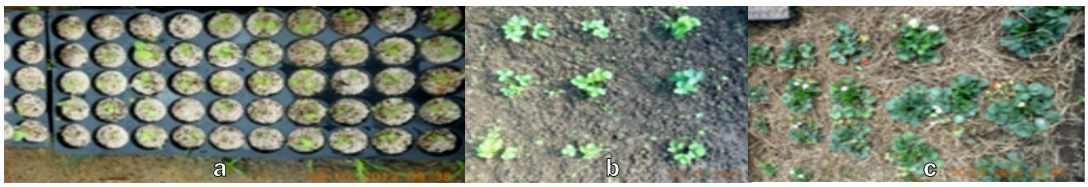

Figure 2 . Fruit shape and core of different cultivars under polyhouse conditions

while Chandler is still the preferred variety in Himachal Pradesh. Therefore, it can be concluded that more trials on varietal evaluation under protected structures should be conducted to evaluate suitability of these cultivars under protected structures.

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