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RESEARCH ARTICLE

Varietal Evaluation of the Strawberry (*Fragaria* × *ananassa* Duch) based on the Yield and Physico-chemical Parameters

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The present experiment was carried out to study the physico-chemical characters of eleven strawberry genotypes to identify genotypes with higher yield and better quality fruits for Western Uttar Pradesh condition. Among all genotypes, maximum fruit length (37.9 mm), fruit breadth (33.4 mm) and fruit weight (13.3 g) were recorded in genotype Chandler. The early fruit setting was recorded in genotypes Gorella, Belrubi and Brighton whereas early fruit maturity was observed in genotypes Selva (98 days after transplanting) and Seascape (100 days after transplanting). The maximum fruit set (81.4 %), number of fruits per plant (22.3) and fruit yield per plant (311.1 g) were observed in genotype Chandler followed by Seascape and Confutura. The genotype, Chandler registered maximum values for total soluble solids (12°B), TSS/acid ratio (21.8), reducing sugar (7.9 %) and total sugar (9.4 %) alongwith minimum acidity (0.6 %). Chandler was comparatively superior for most of the yield and quality characters Therefore, it could be recommended for commercial cultivation in the north Indian plains.

Key Words: Biochemical parameters, Strawberry, *Fragaria*×*ananassa*, Fruit quality, Fruit setting

Introduction

Strawberry (*Fragaria* × *ananassa* Duch) is a natural hybrid being grown in cooler regions worldwide for delicious fruits with rich source of vitamins, minerals and various bioactive compounds (Oszmianski and Wojdylo, 2009). Strawberry is a non-climacteric fruit and a fruit reaches full maturity stage within 28-30 days after anthesis, with maximum fruit weight and size. The fruit is widely accepted for its characteristic aroma and sweetness. Strawberry has vast scope in areas which are located in vicinity of canning units and kitchen gardens. Strawberry is successfully grown in a broad range of climates including temperate, grassland, Mediterranean and subtropical areas (Hancock, 2000). Strawberry is mainly propagated through runners, which produce roots when they come into contact with soil. Runner development is stimulated by long day lengths (11-14 hours) and warm temperature (16-27 °C); therefore, runners emerge mostly during the summer months. In temperate climate condition, its plants behave like a small perennial herb (Finn and Strike, 2008) with shallow root system whereas in sub-tropical climate it behaves as annuals. These genetic characteristics results in the production of the fruits of different size, shape, taste and color (Mishra *et al*., 2015). Therefore, the sub-tropical areas of the country depends upon temperate region for runners every year, however, the produce comes earlier as compare to hilly areas and fetch good price. Yield and yield contributing characters are the ultimate goal of any crop production and the fruit quality and nutrient components is the basic requirement of a crop improvement. Therefore, the choice of a locally adaptable genotype is of paramount importance for successful strawberry cultivation (Asrey and Singh, 2004). Hence, studies about these important traits are necessary for successful cultivation of this crop in a new area. There are very little studies have been conducted on the performance of strawberry genotypes for yield and fruit quality parameters. Considering all above points, the current study was undertaken with the objective to evaluate the most adaptable strawberry genotypes for yield and physico-chemical characters under local of North Indian agro-climatic zone.

Materials and Methods

The present study was carried out at the Horticulture Research Centre of Department of Horticulture (29.04

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°N latitude and 77.42 °E longitude & 237 MSL), Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut during 2014-15. The uniform and healthy runners of eleven strawberry varieties (Chandler, Douglas, Selva, Confutura, Etna, Gorella, Belrubi, Brighton, Seascape, Pajaro and Dana) were procured from IARI, Regional station, Shimla, Himachal Pradesh (Table 1). The characteristics features of 11 genotypes and physical variability for fruit size and shape is given in Table 1. The runners were transplanted in well prepared 1.5×1.5 meter raised beds with the spacing of 30×30 cm in the second fortnight of November, 2014-15. The experiment was laid out in a randomized block design with three replications. All the strawberry genotypes selected for the experiment were grown with recommended plant protection measures. Date of first fruit set and days to maturity in each genotype was recorded. Five plants of each genotype were selected randomly for observations. Fruit of different strawberry genotypes were classified into four shapes. Fruit length and fruit diameter of five randomly selected fruits were measured with Generic 150mm/6 Inch Lcd digital electronic carbon fiber Vernier Caliper and fruit weight was taken using electronic balance. Number of fruits/plant was recorded by calculating the per cent fruit set per plant with the formula given by Westwood (1993).

$$\text{Per cent fruit set} = \frac{\text{Number of fruit set}}{\text{Total number of flowers}} \times 100$$

Yield per plant (g) was recorded at the time of harvesting. Total soluble solids of fruits were determined using a portable hand refractometer (DH, SHR95 model). Fruit titrable acidity was determined as per the methods described by AOAC (1990). TSS/acid ratio was calculated by dividing total soluble solids by acidity, whereas reducing sugars and total sugars were determined as per the method suggested by Ranganna (1997). Data recorded on different parameters was analyzed by standard procedure using OPSTAT home page of CCSHAU, Hisar (Sheoran *et al.*, 1998) described by Panse and Sukhatme, 1995.

Results and Discussion

The results of the present investigation clearly indicate that all the strawberry genotypes exhibited significant variation with respect to all the studied parameters. The genotype Gorella, Belrubi and Brighton set the fruits early (96 days after transplanting) followed by Douglas, Selva, Confutura, Etna, Pajaro and Dana (98 days after transplanting) (Table 2). The genotype, Seascape set first fruit on 100 days after transplanting, whereas

Table 1. Characteristic features of strawberry genotypes selected for the study

S. No.	Name of genotype	Features	Source of genotype
1.	Chandler	The plants are vigorous, high-yielding, produce desirable fruits. Fruits are very large and firm. Fruits are long and wedge-shaped to large and conical, brilliant red color, glossy, and have an exceptional flavor Fruits are good for eating fresh or shipping and also very good for freezing.	IARI, Regional Station, Shimla (HP)
2.	Douglas	Vigorous plant, clear foliage and semi-erect habit. Great fruits, of elongate conical shape and orange red colour. Firm flesh, red-coloured with pink centre, good taste and resistance to transport damages. High yielder.	IARI, Regional Station, Shimla (HP)
3.	Selva	One of the most remonting varieties in Northern Europe in the past. Fruits are very firm and Suitable for export. Taste is neutral. Plants are easy to cultivate.	IARI, Regional Station, Shimla (HP)
4.	Confutura	Produces small-sized fruits, conical to flat shaped fruits. Fruits have 0.7 % acidity and sugar content is 8%.	IARI, Regional Station, Shimla (HP)
5.	Gorella	Fruits have firm fleshy skin, 0.85% acid and 7.0% sugar content. Globose conic fruit shape.	IARI, Regional Station, Shimla (HP)
6.	Etna	Produces medium-sized fruits, conical to flat shaped fruits. Fruits have 0.94% acidity and sugar content is 7%.	IARI, Regional Station, Shimla (HP)
7.	Belrubi	Produces large-sized, conical to wedge-shaped fruits. Fruits have a mild tart-sweet flavor due to acidity 0.98%, sugars 6% content	IARI, Regional Station, Shimla (HP)
8.	Brighton	Fruits are very firm and Suitable for export. Taste is neutral. Plants are easy to cultivate. Fruit shape is Globose conic.	IARI, Regional Station, Shimla (HP)
9.	Seascape	Fruits are large and productive with excellent flavor. Suited for northeastern growers. Also suitable for hanging baskets and containers	IARI, Regional Station, Shimla (HP)
10.	Pajaro	Fruits have firm fleshy skin featuring, 0.97% acid and 5.5% sugar content. Suitable for processing and dessert preparations.	IARI, Regional Station, Shimla (HP)
11.	Dana	Produces small-sized fruits, conical to flat shaped fruits. Fruits have 1.0 % acidity and sugar content is 7%.	IARI, Regional Station, Shimla (HP)

Table 2. Physical characters of strawberry fruits

Varieties	First fruit set (DAT)*	Fruit length (mm)	Fruit breadth (mm)	Fruit weight (g)	Fruit shape
Chandler	101	37.9	33.4	13.3	Conical & long wedge
Douglas	98	29.9	26.3	11.4	Globose conic
Selva	98	31.4	20.1	11.0	Globose conic
CONFUTURA	98	34.9	31.5	12.6	Flat conic
Gorella	96	33.3	27.9	11.3	Globose conic
Etna	98	25.3	19.5	9.2	Flat conic
Belrubi	96	32.6	24.4	11.2	Necked
Brighton	96	32.2	28.7	11.9	Globose conic
Seascape	100	36.5	31.6	13.0	Flat conic
Pajaro	98	28.0	22.4	10.7	Globose conic
Dana	98	29.8	22.2	8.8	Flat conic
Mean		32.1	25.2	11.4	
$CD_{0.05}$		1.75	1.82	0.87	

*DAT = Days after transplanting

Characterization for fruit traits

Varieties	Fruit set (%)	Number of fruit/plant	Days to maturity	Yield/plant (g)
Chandler	81.4	22.3	33.8	311.1
Douglas	77.3	19.3	31.6	220.0
Selva	71.5	14.8	29.5	179.1
CONFUTURA	79.1	21.6	32.0	296.6
Gorella	76.8	19.1	31.6	195.6
Etna	69.6	15.3	32.2	127.3
Belrubi	74.0	17.6	36.1	215.2
Brighton	72.5	16.3	34.5	210.8
Seascape	80.2	21.1	30.5	291.9
Pajaro	75.1	18.3	30.5	206.9
Dana	76.3	16.6	32.9	111.9
Mean	75.8	18.4	32.3	215.1
$CD_{0.05}$	1.53	1.47	1.58	9.91

genotype, Chandler observed quite late in first fruit set (101 days after transplanting). Fruit shape of different strawberry genotypes were classified into four shapes (Ishikawa *et al*., 2018). Genotype Chandler exhibited both conical and long wedge shaped fruits whereas Belrubi produced necked shaped fruits. The fruit shape of genotypes Douglas, Selva, Gorella, Brighton and Pajaro produced globose conic shaped fruits, while genotypes of Confutura, Etna, Seascape and Dana were flat conic in shape. These findings are in conformity with the earlier findings of Rahman and Ahmad (2009) and Rahman *et al*. (2015).

Genotype Chandler produced largest berries (37.9 mm) which was statistically at par with genotype Seascape (36.5) followed by Confutura (34.9 mm), Gorella (33.3 mm) while, smallest fruits were measured in Etna (25.3 mm) (Table 2). Maximum fruit breadth was measured in Chandler (33.4 mm) which was statistically at par with genotypes Seascape (31.6 mm) and Confutura (31.5 mm), whereas minimum fruit breadth was observed in Etna (19.5 mm). The maximum fruit weight was recorded in genotype, Chandler (13.3 g) which was statistically at par with Seascape (13 g) and Confutura (12.6 g) whereas minimum fruit weight was recorded in Dana (8.8 g). The results obtained by Pathak *et al.* (2006) and Kumar *et al.* (2011) was in conformity with the present findings. However, Kumar and Kumar (2011) and Moshiur *et al.* (2013) reported different results with respect to fruit length, fruit breadth and fruit weight which might be due to the prevailing environmental conditions of the areas and cultural practices followed during the experiment.

Significant results have been observed for yield, fruit set, number of fruit per plant and days to maturity

and are presented in Table 2. Maximum fruit set was recorded in genotype Chandler (81.4 %) which was statistically at par with Seascape (80.2 %) and closely followed Confutura (79.1 %) whereas Etna (69.6 %) observed minimum fruit setting. Earlier, Kumar and Kumar (2011) also showed similar result with respect to fruit set. Genotype Chandler produced maximum number of fruit per plant (22.3) which was statistically at par with Confutura (21.6) and Seascape (21.1). However, minimum number of fruit was produced by Selva (14.8). Similar reports for number of fruit per plant was also reported by Belakhud *et al.* (2015) and Neetu and Sharma (2018). Genotype Selva was earliest to mature (29.5 days) which was statistically at par with Seascape (30.5 days) and Pajaro (30.5 days) whereas late maturity was noticed in Belrubi (36.1 days) closely followed by Brighton (34.5 days). Similar variation was earlier reported by Kumar *et al.* (2011).

The genotype Chandler recorded maximum fruit yield per plant (311.1 g) which was significantly higher among other genotypes whereas closely followed by Confutura (296.6 g) and Seascape (291.9 g) (Table 2). The minimum fruit yield per plant was produced by Dana (111.9 g). The variation in yield per plant was due to the inherent character of the germplasm. Rahman and Ahmad (2009) found that yield per plant of strawberry varied significantly and ranged from 442.5 to 129.8 g. Present findings were consonant with the results of Rahman and Ahmad (2009), Rahman *et al.* (2015) and Neetu and Sharma (2018). The yield per plant recorded in the present study was quite different from the earlier studies conducted by Kumar and Kumar (2011) and this may be due to the different agro-climatic conditions of a particular area.

The biochemical characteristics also exhibited a significant variation in different genotypes of strawberry (Table 3). Maximum total soluble solids was recorded in the fruit of genotype Chandler (12^{o}B) which was statistically at par with Seascape (11.8^{o}B) and Confutura (11.6^{o}B) while, minimum total soluble solids was registered in the fruit of Pajaro (8.4^{o}B). The maximum acidity was recorded in genotypes Pajaro (1.1%) and Dana (1.1%) whereas the minimum acidity was recorded in genotypes, Chandler (0.55%) which was statistically at par with Confutura (0.62%) and Seascape (0.64%). Genotype Chandler recorded maximum TSS/acid ratio (21.8) which was statistically higher among all the other genotypes whereas minimum TSS/acid ratio was recorded in Pajaro (8.4%). Earlier Pathak *et al.* (2006), Kumar and Kumar (2011) and Kumar *et al.* (2011) also reported similar results for these parameters.

Maximum reducing sugar (7.9%) and total sugar (9.4%) was recorded in genotype Chandler which was statistically at par with Seascape (7.7% and 9.2%) and Confutura (7.4 % and 8.9%) whereas minimum reducing sugar was observed in Brighton (4.7%) and minimum total sugar was observed in Brighton (6.6%). The variation in biochemical parameters among the genotypes might be due to the variation of genotypes and mostly affected by environmental factors. Similar results with respect to the reducing and total sugar were also reported in few of the genotypes which we study in our conditions (Pathak *et al.* (2006), Kumar and Kumar (2011) and Rahman *et al.* (2015), Belakhud et al. (2015) and Bhatia *et al.* (2017).

Table 3. Fruit biochemical characters of different strawberry genotypes

Varieties	TSSoB	Acidity (%)	TSS/acid ratio	Reducing sugar (%)	Total sugar (%)
Chandler	12.0	0.6	21.8	7.9	9.4
Douglas	9.1	0.8	12.0	5.2	6.8
Selva	10.8	0.7	15.2	6.4	8.1
CONFUTURA	11.6	0.6	18.7	7.4	8.9
Gorella	9.7	0.8	11.7	5.5	7.2
Etna	9.7	0.9	10.3	5.7	7.4
Belrubi	9.6	0.8	11.9	6.3	8.0
Brighton	8.9	0.9	9.8	4.7	6.6
Seascape	11.8	0.6	18.5	7.7	9.2
Pajaro	8.4	1.1	7.5	5.2	6.8
Dana	9.6	1.1	9.0	6.1	7.7
Mean	10.1	0.8	13.3	6.2	7.8
CD0.05	0.64	0.11	1.74	0.52	0.49

Conclusion

On the basis of results obtained from the present experiment on varietal evaluation for yield and quality characters, it can be concluded that the genotype, Chandler performed excellent for most of the yield and quality characters studied which can be recommended for commercial cultivation in local of North Indian agro-climatic zone for fetching higher yield with better fruit quality. These strawberry genotypes need to test under multi-location trials in different agro-ecological regions to identify the best genotypes adaptable to different areas.

References

AOAC (1990) Official and tentative methods of analysis. *Association of official Agricultural Chemists*. 15th ed. Washington DC USA.

Asrey R and R Singh (2004) Evaluation of strawberry varieties under semi-arid irrigated region of Punjab. *Ind. J. Horti.* **61(2):** 122-124.

Belakhud B, V Bahadur and VM Prasad (2015) Performance of strawberry (*Fragaria×ananassa* Duch.) varieties for yield and biochemical parameters. *Pharma Inno. J.* **4(10):** 05-08.

Bhatia SK, R Sharma and R Kumar (2017) Effect of Different Planting Time and Spacing on Growth, Yield and Quality of Strawberry (*Fragaria×ananassa*) cv. Ofra. *Int. J. Pure App. Biosci.* **5(5):** 207-211.

Finn CE and BC Strik (2008) Strawberry genotypes for Oregon EC 1618-EOregon State Universitypp. 1-7.

Hancock JF (2000) Strawberry. CAB International Wallingford Oxford UK. p 213-237

Ishikawa T, A Hayashi, S Nagamatsu, Y Kyutoku, I Dan, T Wada, K Oku, Y Saeki, T U, T Tanabata, S ISOBE and N Kochi (2018) Classification of strawberry fruit shape by machine learning. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Towards Photogrammetry 2020, 4–7 June 2018, Riva del Garda, Italy**.**

Kumar A and P Kumar (2011) Studies on vegetative growth yield and quality attributes of strawberry under temperate agro-climatic zone conditions of Kashmir valley. *Haryana J. Horti. Sci.* **40(1&2):** 10-12.

Kumar A, RK Arasthe, B Panday, K Ramesh, R Denzanpa and H Rahmavi (2011) Varietal screening of strawberry (*Fragaria×ananassa* Duch.) under organic production system for fruit quality and yield in mid-hills of Sikkim Himalayas. *Ind. J. Genet. Res.* **24:** 243-45.

Mishra PK, RB Ram, and N Kumar (2015) Genetic variability heritability and genetic advance in strawberry (*Fragaria* × *ananassa* Duch.). *Turkish J. Agric. Forest.* **39:** 451-458

Moshiur RM, RM Mizanur, HM Mofazzal, MMA Khaleque, and KA Abdul (2013) Characterization and field performance of fifteen strawberry germplasm under Bangladesh conditions. *SAARC J. Agric.* **11:** 81-94.

Neetu and SP Sharma (2018) Evaluation of Strawberry Genotypes for Growth and Yield Characteristics in Plain Region of Chattisgarh India. *Int. J Curr. Microbiol. App. Sci*. **7(2):** 2835-2840.

Oszmianski J and A Wojdylo (2009) Comparative study of phenolic content and antioxidant activity of strawberry puree clear and cloudy juices. *Europ. Food Res. and Tech.* **228:** 623-631.

Panse VG and PV Sukhatme (1995) *Statistical Methods for Agricultural Workers* ICAR pp. 97-156.

Pathak PK, MR Gurung and SK Mitra (2006) Performance of strawberry genotypes under cover in the plains of West Bengal. *The Orissa J. Horti.* **34(2):** 35-37.

Rahman MM and MR Ahmad (2009) *Collection and evaluation of strawberry lines. Research Report on Horticultural Crops* 2008-2009. Horticulture Research Centre BARI Gazipur. Pp. 245-247.

Rahman MM, MM Rahman, MM Hossain, MAK Mian, and QA Khaliq (2015) Field performance and fruit quality of strawberry genotypes under subtropical climate. *Bangladesh J. Agr. Res.* **40(1):** 137-151.

Ranganna S (1997) *Handbook of Analysis and Quality Control for Fruit and Vegetable Products* (2nd ed.)**.** Tata McGraw Hill Publishing Company Limited New Delhi. 1112 p.

Sheoran, OP, DS Tonk, LS Kaushik, RC Hasija, and RS Pannu, (1998) Statistical Software Package for Agricultural Research Workers. Recent Advances in information theory, Statistics & Computer Applications by DS. Hooda & RC. Hasija Department of Mathematics Statistics, CCS HAU, Hisar (139-143).

Westwood MN (1993) *Temperate zone pomology*. W.H. Freeman and company San Francisco USA pp. 223.