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Study on strawberry (*Fragaria x ananassa* Duch.) varieties for growth, fruit bio-chemical and yield parameters under western malwa plateau conditions of Madhya Pradesh

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Abstract
A research trial was carried out in the experimental field of Department of fruit science, KNK College of Horticulture Mandsaur Madhya Pradesh during the year 2017-2018 to evaluate some strawberry varieties in sub-tropical region (Western Malwa Plateau condition) of Madhya Pradesh. The runners of 12 strawberry varieties i.e., *viz*. V_1 (Northwest), V_2 (Tioga), V_3 (Pajaro), V_4 (Seascape), V_5 (Fern), V_6 (Chandler), V_7 (Shimla Delicious), V_8 (No.5), V_9 (Dil Pasand), V_{10} (Larson), V_{11} (Torrey) and V_{12} (Sweet Charlie) were planted at 30x30cm apart on the ridge beds at end of October. The design of experiment was Randomized block design (RBD). The results of the study indicated that out of the varieties tried, the strawberry variety V_6 (Chandler) proved to be the best in producing maximum plant height (14.27cm), leaf length (7.70cm), leaf width (12.08cm) except the number of runner(s) per plant. The number of runner(s) per plant was recoded in variety V_8 (No.5) 5.53 runner(s) per plant. The best result in 12 strawberry varieties of biochemical characters was found in variety V_6 (Chandler) proved to be the best in producing lowest fruit acidity (0.98) and highest pectin (0.47%), higher ascorbic acid (56.67mg), however highest TSS (14.04^0B) were found in variety V_9 (Dil Pasand) and maximum reducing sugar (4.80) was recoded in variety V_{12} (Sweet Charlie). The maximum yield (17250.22kg) was recoded in variety V_6 (Chandler) which was statistically *at par* with variety V_{12} (Sweet Charlie) 15103.56kg. Based on the experimental findings it was concluded that variety V_6 (Chandler) and V_{12} (Sweet Charlie) be recommended as best variety under the Western Malwa Plateau condition of Madhya Pradesh.

Keywords: Strawberry, different varieties like chandler, sweet charlie, tioga and pajaro; fruit TSS, fruit acidity, ascorbic acid, pectin

1. Introduction
Strawberry (*Fragaria x ananassa* Duchesne) is one of the most delicious, refreshing and nutritious soft fruits of the world. It belongs to family Rosaceae and is native to America. Strawberry is an herbaceous perennial short day plant. It was first introduced by the NBPGR Regional Research Station, Shimla (Himachal Pradesh) in the early sixties (Gowda *et al.*, 2016) [8]. Strawberry is one of the most delicious fruits in the world. In India, it was introduced in the early sixties, but these efforts made to popularize it failed due to poor adaptation of the introduced varieties and lack on technical know-how. Later, many more varieties were introduced and production technology was standardized, which led to increase its area and production (Sharma and Sharma, 2004) [19]. In general, its cultivation had been confined only to temperate regions, but development of day-neutral cultivars had made its entry in tropical and subtropical areas as well (Sharma *et al.*, 2003) [18].
There is a considerable variation among different strawberry cultivars for their adaptability in a particular set of agro-climatic conditions. Besides quick returns, strawberry fruits are attractive with distinct and pleasant flavour/aroma, rich in vitamin-C and minerals. Strawberry fruits have a special demand by fruit processing industrial for preparing various products. The strawberry cultivation is associated with many problems. Among all characters fruit character have always remained of prime importance and are much influenced by environmental factors. Since strawberry is a crop of temperate regions of the world, its cultivation has been extended to subtropical regions like Maharashtra, Punjab, and Haryana. However, no information was available on the cropping behavior of strawberry cultivars in the semi temperate climate of mid hills (Sharma *et al.*, 2014) [20]. The research work for finding suitable varieties has however, been limited to sub-tropical regions (Western Malwa Plateau condition) of Madhya Pradesh. Therefore, the present investigation was planned with the objective to assess growth, yield and

quality characters of the performance of 12 strawberry varieties in district Mandsaur of Madhya Pradesh.

2. Material and Methods

The present investigation was laid out in RBD with 12 varieties as treatments and three replications during the year 2017-2018 at the *Instructional cum Research Fruit Orchard*, Department of Fruit Science, K.N.K. College of Horticulture, Mandsaur (M.P.). Runners of 12 strawberry varieties i.e., *viz*. V_1 (Northwest), V_2 (Tioga), V_3 (Pajaro), V_4 (Seascape), V_5 (Fern), V_6 (Chandler), V_7 (Shimla Delicious), V_8 (No.5), V_9 (Dil Pasand), V_{10} (Larson), V_{11} (Torrey) and V_{12} (Sweet Charlie). The runner were procured from Veer Chandra Singh Gadwali Uttarakhand Horticulture and Forestry Univarcity Bharsar Podi Gadwal and acclimatized for a day. The soil of the experiment plot was well prepared by repeated ploughing followed by planking to obtain a fine tilth. The soil ploughed 2-3 times by soil turning, plough, harrowed, leveled and the weeds were rooted out. The well rooted runners of uniform size were transplanted on well prepared raised beds. Runners of strawberry having 2-3 full open leaves were transplanted randomly at the spacing 30cm x 30cm in the experimental plots. Healthy and sound runners were selected for planting. Runners were placed in the receiving medium to a depth so that the crown remained exposed but the roots were all buried. Once in place, the soil around the plant was packed and patted firm, down, around the base of the stem. After planting the plants were irrigated immediately. Various post planting operations were done which mainly include spraying of nutrients, irrigation, mulching, plant protection measures etc. Optimum soil moisture level was maintained in the plots through light irrigation as and when required. Observations on morphological and bio-chemical characters were recorded on 5 randomly selected plants in each treatment. The data were subjected to statistical analysis following standard procedures (Panse and Sukhatme, 1989).

3. Result and Discussion

The significant differences observed in the growth and fruit physical parameters among the 12 varieties tested are presented in table 1. The maximum plant height was found variety V_6 (Chandler) 14.27cm which was statistically at par with varieties V_3 (Pajaro) 14.00cm and V_9 (Dil Pasand) 13.41cm, followed in V_8 (No. 5) 12.13cm, whereas minimum plant height was recoded in variety V_5 (Fern) 9.65cm. In the climatic conditions prevalent at subtropical conditions at Madhya Pradesh, the plants of all the cultivars were observed tall in comparison to plants raised at Bihar (Das *et al.*, 2015) [6]. The reason for the variation in these cultivars could be that the genes responsible for the plant height did not express them fully with the same degree as it does at other places because of different agro-climatic conditions. Varietal differences in plant spread and height was also noted by Singh *et al.*, (2008) in Meghalaya which supports the present observation. The values of all the varieties were significantly different among all the varieties maximum leaf length was recoded in V6 (Chandler) 7.70cm. Varieties V4 (Seascape) 6.49cm, V12 (Sweet Charlie) 6.47cm and V9 (Dil Pasand) 6.46cm were followed the variety V6 (Chandler), albeit the minimum leaf length was observed in V11 (Torrey) 4.71cm. The leaf length of V6 (Chandler) was about 1.63 times greater than Torrey. The maximum leaf width was recoded in V6 (Chandler) 12.08cm. Varieties V12 (Sweet Charlie) 11.01cm, V4 (Seascape) 10.83cm and V1 (Northwest) 10.83cm were followed variety V6 (Chandler). The minimum leaf width was found in variety V11 (Torrey) 8.65cm. This difference in leaf length, leaf width and leaf area of the varietal might be due to the cultivars may react differently to photoperiod, light, temperature, nutritional status, available metabolites and their allocation the above ground plant parts (Tanaka & Muzuta, 1974, Shile, 1988) [23]. It was found that maximum number of runners per plant was recoded under variety V8 (No. 5) 5.53. Varieties V4 (Seascape) 5.13 and V6 (Chandler) 4.53 followed the variety V8 (No. 5), whereas the minimum number of runners per plant was observed in V11 (Torrey) 1.27. (Grewal and Dhaliwal, 1984) recorded runner production in the range of 1.30 to 7.55, which was much less to that registered in the present study but are in agreement with the work of Miserendino *et al.*, (2009) [12] who recorded a higher value for number of runners per plant in cultivar Selva. Higher or lower number of runners might be due to the differences in the prevailing agro climatic conditions, inherent potential of varieties for runner production and appropriate cultural practices adopted for strawberry culture. Maximum Total Soluble Solids (TSS) recorded in variety V_9 (Dil Pasand) 14.04 ^oB followed by VarietiesV_1 (Northwest) 13.45^oB and V_{10} (Larson) 13.23^0B whereas minimum Total Soluble Solids (TSS) recorded in variety V_{11} (Torrey) 8.46 ^oB. The results are in consonance with the results obtained by Dhaliwal and Singh (1983) [5] who reported that TSS content varied from 6.70% to 11.39% in strawberry cultivars. (Sharma, 2002) [18] obtained lowest TSS of 7.8^o B which is conformity with the present work. Higher TSS content in Shimla Delicious may be due to the favourable temperature and humidity during the fruit growth period, especially during night which might have influenced the retention of higher TSS in the ripe fruits (Sharma, 2002) [18]. (Shaw, 1990) [21] also reported that the Total Soluble Solids content was more dependent on environmental conditions during growth and development than genetic inheritance. It is early marked out from the Table that while minimum fruit acidity was percentage observed in variety V_6 (Chandler) 0.96 per cent. Maximum fruit acidity was found in variety V_4 (Seascape) (1.34%) followed by varieties V_2 (Tioga) 1.28% and V_{11} (Torrey) 1.23%. The varietal differences in acidity were also reported by (Chandel and Badiyala 1996) [3]. The present investigation is in the line with the findings of (Sharma and Thakur 2008) [18] that recorded highest acidity in Etna and are in disagreement with the findings of Hassan *et al.*, (2001) [9] who recorded the highest acidity percentage for cultivar Chandler. Singh *et al.*, (2008) [22] recorded that the acidity percentage of Shimla Delicious was 1.20% which is in agreement with the present work. The maximum ascorbic acid content recorded in variety V_6 (Chandler) 0.57mg which were followed by the varieties V_{12} (Sweet Charlie) 49mg, V_{11} (Torrey) 47mg and V_8 (No. 5) 41mg, whereas minimum ascorbic acid content recorded under the variety V_1 (Northwest) 32mg. The obtained results are in disagreement with the results obtained by Singh *et al.* (2008) [22]. They obtained 102.22, 87.24, 83.71, 70.50 and 68.73mg of ascorbic acid per 100 g of fruit in Chandler, Red Coat, Dana, Fern and Belrubi respectively. Maximum reducing sugars recorded in variety V_{12} (Sweet Charlie) 4.80% whereas, minimum reducing sugars recorded in V_2 (Tioga) 3.10%. Varieties such as V_6 (Chandler) 4.47%, V_9 (Dil Pasand) 4.30% and V_4 (Seascape) 4.17% were statistically *at par* with V_{12} (Sweet Charlie). The results are in agreement with those of Das *et al.* (2007) [4], who recorded higher reducing sugar in cv. Pajaro (7.12% and 4.11%, respectively) as compared to cultivars Sweet Charlie, Chandler and Douglas. However, Pajaro was

at par with Chandler (5.90%) and Douglas (6.25%) with respect to total sugar content. A similar trend was observed by (Asrey and Singh 2004), who recorded a higher reducing sugar content in cv. Selva (2.83%), followed in Chandler (2.79%) and Gorella (2.66%). However these cultivars were not significant with respect to their reducing sugar content. According to the Maximum pectin (%) noticed in variety V_6 (Chandler) 0.47% whereas the V_{12} (Sweet Charlie) 0.46%was *at par* with the variety V_6 (Chandler). Variety V_4 (Seascape) and V_9 (Dil Pasand) registered the same value 0.41% of the pectin. Similarly V_2 (Tioga) and V_{10} (Larson) possess the same value of pectin (%). Varieties V_5 (Fern), V_4 (Seascape), V_9 (Dil Pasand), V_2 (Tioga) and V_{10} (Larson) followed by V_6 (Chandler), while the minimum (0.37%) value was noted in the V_1 (Northwest). This might be due to the agro-climatic condition. Literatures are pectin content on specific varieties is not available yet. The observed value ranged from 11509.90kg/ha to 5514.60kg/ha. The Maximum yield/ ha variety was observed under the V_6 (Chandler) 11509.90kg/ha. Varieties V_{12} (Sweet Charlie) 9270kg/ha, V_1 (Northwest) 7884.60kg/ha, and V_3 (Larson) 7664.40kg/ha followed by V_6 (Chandler). The minimum yield/ha variety was found in V_{11} (Torrey) 5514.60kg/ha. which had a close proximity with the findings of Kumar *et al.*, (2011) [11] who observe that cultivar Ofra (37.20) had highest yield while minimum yield Selva (7.32 t/ha) at Sikkim condition. According to (Mitra 1991) [13] various components like yield per plant, number of crowns, number of leaves per plant, plant size, number of inflorescence, number of fruits per plant, fruit set and total number of achene's per berry are related with the yield per unit area.

Table 1: The significant differences observed in the growth and fruit physical parameters among the 12 varieties tested are presented

Varieties	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Number of Runners/plants	Fruit T.S.S. (^{0}B)	Fruit acidity (%)	Ascorbic acid (mg)	Reducing sugar (%)	Pectin (%)	Yield /Ha (kg)
V_1 (Northwest)	10.38	5.48	10.83	2.13	13.45	1.18	32.00	3.57	0.37	13442.37
V_2 (Tioga)	10.36	6.38	10.19	2.63	9.41	1.28	34.67	3.10	0.40	10446.37
V_3 (Pajero)	14.00	5.82	10.73	3.87	12.95	1.11	36.33	3.50	0.39	12720.00
V_4 (Seascape)	11.85	6.49	10.83	5.13	10.32	1.34	35.33	4.17	0.41	11444.30
V_5 (Fern)	9.65	5.84	9.75	2.53	10.80	1.03	31.67	3.53	0.42	11801.48
V_6 (Chandler)	14.27	7.70	12.08	4.53	12.33	0.98	56.67	4.47	0.47	17250.22
V_7 (Shimla Dalicious)	11.23	5.30	8.68	2.07	10.32	1.16	35.33	3.87	0.39	11813.04
V_8 (No. ***5)***	12.13	5.85	9.58	5.53	13.07	1.08	41.33	3.90	0.38	11012.59
V_9 (Dil Pasand)	13.41	6.46	10.57	3.60	14.04	1.17	33.33	4.30	0.41	10744.74
V_{10} (Larson)	9.95	5.68	8.93	2.33	13.23	1.22	38.33	3.80	0.40	12117.78
V_{11} (Torrey)	9.89	4.71	8.65	1.27	8.46	1.23	46.67	3.97	0.39	9013.63
V_{12} (Sweet Charlie)	11.21	6.47	11.01	3.87	11.76	1.03	48.67	4.80	0.46	15103.56
S.Em.±	0.24413	0.27003	0.16839	0.09225	0.05251	0.00929	0.47051	0.06468	0.00314	984.081
CD at 5%	0.71602	0.79197	0.49388	0.27056	0.15402	0.02724	1.37996	0.1897	0.0092	2886.21
CV (%)	3.66828	4.60677	4.84919	4.85414	0.77887	1.39832	2.07925	2.86235	1.33388	13.9226

4. Conclusion

On the basis of results, it is concluded that out of 12 strawberry varieties, the variety V_6 (Chandler) resulted best in growth and fruit bio-chemical parameters plant height, number of leaves, leaf length, leaf width, number of runners per plant, lowest acidity, higher ascorbic acid, higher pectin (%) and maximum yield. The highest fruit TSS recorded was recorded in Variety V_9 (Dil Pasand) and higher reducing sugar was found in variety V_{12} (Sweet Charlie).

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