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Genetic Diversity Studies in Strawberry (*Fragaria × ananassa* Duch.) under Temperate Climatic conditions of North West Himalayas

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ABSTRACT: Strawberry (*Fragaria ananassa* Duch.) is one of the most important berries in the world and also became an important fruit in Kashmir valley in recent past. However, most of the commercial genotypes currently in cultivation in Kashmir were developed in other countries with environmental adaptations often inadequate for the regional conditions. This study was carried out as many new varieties such as Everly, Kimberly, Honeoye etc. were introduced for the first time at SKUAST-K hence, giving rise to the need to evaluate all these varieties for various important traits so that these can be used according to the requirement in various breeding programmes as potential donor parents based on the heritability values. Investigation on genetic diversity among 15 strawberry genotypes was carried out for various horticultural traits using RCBD with three replications during the year 2017-18. Divergence analysis using Mahalanobis D^2 statistics revealed significant results as genotypes under study got grouped into seven distinct clusters. Cluster-V and Cluster-VI had the greatest inter-cluster distance of 50362.27, while Cluster-VI had the highest mean value for fruit weight (11.09 g), reducing sugars (6.74 percent), and bloom duration (55.56 days). The maximum mean value for S.S.C. (11.31°Brix) and total sugars (7.66 percent) was recorded in case of Cluster-VII while Cluster-V recorded maximum mean value for yield plant^{-1} (119.67g). The contribution towards genetic divergence was maximum (71.43 percent) from fruit yield. The genotypes evaluated during the investigation recorded significant amount of variability for various descriptive and quantitative characteristics. Thus, the diversity observed among the genotypes during this investigation can be used to identify potential genotypes which maybe beneficially exploited either by direct selection of superior genotypes or by using such genotypes as donor parents in various hybridization programme keeping in view the high heritability in various desired traits of horticultural importance. These results could lay the foundation for further breeding and conservation of strawberry.

Keywords: Genetic diversity, clusters analysis, strawberry, genotypes.

INTRODUCTION

Strawberry is one of the most popular refreshing soft fruits, known for its attractive appearance, high nutritional value, pleasant aroma, and other health benefits. Strawberry is believed to have the highest quantity of antioxidants and foliate of all fruits and vegetables. Strawberry is also high in vitamin C and silicon, which is beneficial to the healing and strength of all connective tissues and arteries. Besides, the presence of ellagic acid in strawberry has been found to prevent cancer and other potential heart ailments (Singh *et al*., 2013). All strawberry varieties under cultivation are octaploid (2n=56). Temperatures of 22–23°C during the day and 7–13°C at night are ideal for strawberry growth and development. Strawberries prefer loam soil with generous amounts of organic matter. It is highly perishable in nature and botanically strawberry is an aggregate fruit (Etario of achenes). Strawberry has been found to give the highest potential economic yield in the shortest period of time than any other fruit crop (Sharma and Sharma, 2004; Das *et al*., 2015). The endodormancy of strawberry is caused by short day and low temperature conditions and this problem can be tackled to some extent in some cultivars by additional daily light exposures and in all cultivars by maintaining temperatures around freezing (Antunes *et al*., 2010). Strawberry is a temperate-climate crop. However, in recent years, the tendency has shifted, and there has been a massive rise in both its area and output in India's subtropical and tropical plains (Sharma *et al*., 2006). Hundreds of strawberry cultivars are currently grown commercially throughout India. The approval for a diverse palette by both the consumers as well as producers at country level is largely responsible for strawberry's contribution to overall fruit production (Korbin and Mezzetti 2010). This has happened mainly due to standardizing of modern agricultural techniques and also by the introduction of many varieties that are insensitive to available heat and light period like Fern, Sweet Charlie, Chandler, etc. from different countries which have performed very well under diverse climatic conditions prevailing in India.

Strawberry has considerable genetic diversity and as such precise information regarding the performance of cultivars under various agro-climatic conditions is essential before being recommended for cultivation. Moreover, with the passage of time, the demand for new cultivars may arise due to decline in the performance of a cultivar with change in climatic conditions of the location. Also strawberry is very heterozygous in nature as a result of which it suffers from rapid loss of vigor, fruit size and yield due to inbreeding (Spangelo *et al.*, 1971). Therefore, it becomes essential to conduct a proper genetic diversity studies so as to ensure availability of varieties as per the demand in the market. Thus, it becomes important to design and develop a strategy that is capable of not only preserving this rich diversity of germplasm but also identifies the superior genotypes that can be used in to improve various traits of interest like yield and other important quality characteristics of commercially grown strawberry varieties through selection and various other breeding methods. This goal can be achieved only when the already existing potential varieties are systematically surveyed, evaluated and standardized (Lone and Wafai 1995). In the present case, an ideal variety is one that has adaptability in a wide range of agro-climatic conditions, produces large, firm fruits of attractive colour and good quality besides having good processing and desert quality. It is thus very important to carry out the study programmes involving the studies of genetic variability with the help of suitable parameters such as GCV, heritability estimates, and GA for an efficient breeding programme (Atta *et al*., 2008; Mishra, *et al*., 2015).

MATERIALS AND METHODS

The study was conducted at SKUAST-K, Shalimar, Srinagar, during the academic year 2017-2018. The experimental site selected for this experiment is situated at an elevation of 1685 metres amsl, receiving about 600 millimeters rainfall annually. With three replications, the experiment was set up in RCBD. The experimental area was divided into three blocks, each of which was further divided into 15 beds of 2 × 1m, and strawberry runners were planted randomly across each block at a spacing of 30 × 30cm, accommodating around 20 plants per bed, following proper site preparation. Kimberly, Winter Dawn, Curaltar, Everly, Sea Scape, Missionary, Honeoye, Jutogh Special, Katrain Sweet, Chandler, Oso Grande, Selva, Catskill, Brighton, and Camarosa were among the 15 types whose runners were received from CITH and SKUAST-K nursery. Proper care was taken from time to time which included various intercultural operations like irrigation, weeding, mulching etc. Manual harvesting was carried out in 3-4 pickings when about 80% of the fruit turned bright red. Because strawberry is a short-lived crop, different parameters were estimated soon after harvesting. A standard measuring scale was employed for measuring the height and spread of plants (cm) while a top pan electronic balance was used to measure the weight (gm) of berries and the values thus obtained were used to calculate yield per hectare. The soluble solid concentration (SSC) of mature fruit juice was determined using a hand refractometer (0-32°B), while the titrable acidity was evaluated by the process of titration wherein freshly prepared fruit juice was titrated against 0.1 N sodium hydroxide with phenolphthalein used as an indicator A.O.A.C. (1980). Fruit volume (cm^3) was measured using the water displacement method, and specific gravity was calculated by dividing the weight of the fruit as obtained by the weighing machine by the volume of water displaced. The volumetric approach, which is based on the idea that sucrose content in the fruits in presence of HCl is broken down into glucose and fructose, is used to determine total sugar and reducing sugar content A.O.A.C (1980). Total sugar and reducing sugar were calculated as a percentage of the fresh weight of the fruit pulp. The Mahalnobis D^2 statistics were used to cluster the cultivars into different groups on the basis of 11 different attributes brought under study. Tocher's technique (Rao, 1952) was used to divide the genotypes into distinct clusters, with the requirement that every line in the same cluster had a lower D^2 value on average than those in two different groups.

RESULTS AND DISCUSSION

The value of genetic diversity in breeding is self-evident. As a result, it becomes critical to define and quantify such diversity, both in terms of its nature and magnitude, in order to determine whether it has a positive or negative impact on a breeding programme. Furthermore, for the sake of future genetic resource preservation and sustainable usage, it is vital to assure the highest possible availability of plant germplasm. Thus, evaluation, characterization and diversity estimation has been performed for various strawberry collections with an aim of better utilization. Genetic diversity is an important parameter that helps to identify genetically diverse parents that could preferably fit in a hybridization program which aims at bringing closer different gene constellations yielding desirable transgressive segregants in future generation. In other words, genetic divergence gives us an idea about the genetic distance between populations or species making it easy to understand as to how different or how similar different varieties are from each other. Thus, smaller genetic distance varieties have a close genetic relationship (i.e. such varieties are quite similar to each other genetically) whereas higher values of genetic distances indicate a more diverse relationship (i.e. such varieties are genetically diverse from each other). As a result, all genotypes were divided into seven clusters based on their performance in several parameters under investigation (Fig. 1). Cluster-II has the highest number of genotypes (5). Cluster-I, cluster-VI, cluster-III, cluster-IV, cluster-V, and cluster-VII had 4, 2, 1, 1, 1 and 1 genotypes, respectively. Singh *et al*. (2013) conducted a similar study on genetic divergence in which 22 strawberry genotypes were divided into four clusters. D^2 values for average inter- and intra-cluster divergence were calculated. Cluster VI had the highest intra cluster distance (4646.85), whereas Cluster II had the lowest value (2831.03). The highest inter cluster distance (50362.27) was observed between cluster IV and V, while the lowest (5370.07) was observed between cluster I and III, indicating that if cultivars from cluster IV and V are hybridized, superior recombinants or transgressive segregants can be obtained in future segregating generations in strawberry (Table 2). The inter cluster distance (i.e., the distance between clusters) was found to be greater than the intra cluster distance (i.e., the distance between genotypes within the same cluster), indicating that genotypes from different clusters have more genetic diversity than genotypes from the same cluster. In other words, inter-cluster distances were much higher than intra-cluster distances, indicating homogeneity among genotypes within the same cluster and heterogeneity among genotypes from different clusters. This result was comparable to that of Udin and Mitra (1994), who found that the inter cluster distance was greater than the intra cluster distance in Sesame. In addition, Singh *et al.* (2013); Chhetri *et al*. (2017) in strawberry and Baba *et al*. (2017) in sweet Cherry and Khatun and Rehman (2010) in snake-gourd obtained comparable results. Cluster-I was found to be superior for total number of flowers, total number of berries, percent berry set, and yield attributes based on the values of cluster means for various characters under study. Cluster V was found to be superior for total number of flowers, total number of berries, L:D ratio, and titrable acidity based on the values of cluster means for various characters under study (Table 3). As a result, better segregants can be created in segregating populations if parents from cluster I and cluster V are hybridized for these traits. In other words, the choice of clusters for use in hybridization programme can be made based on our requirements. Haque *et al*. (2015) conducted a study that was very much in line with this one. Singh *et al*. (2013) found the maximum intra cluster distance in cluster IV, which is consistent with the findings of our study. Furthermore, the findings of Chhetri *et al.* (2017) in strawberry and Lacis *et al*. (2010) in sour cherry are very similar to ours. Table 4 shows the percent contribution of several traits to total divergence, and a review of the data found that, of all the traits tested, yield per plant was by far the major contributor (71.43%), followed by total and reducing sugars (8.57%), and fruit weight (8.57%) (5.71%). Number of leaves per plant, bloom duration, SSC, and SSC-titrable acidity ratio made the least contribution to divergence (0.95 percent each). As a result, when characterizing strawberry genetic resources and analysing breeding material in the future, the most essential qualities in terms of variety should be taken intoaccount. The data obtained during the study shows tremendous diversity in the various physico-chemical attributes of selected genotypes of cherry. Significant per cent contribution of almost each trait towards total divergence depicts the importance of these traits as principal contributors to genetic diversity prevalent in such germplasm. The diversity in the present germplasm was also evident by the presence of considerable amount of variation among cluster means for different traits. These results thus showing wide diversity among genotypes, offers reliable data for selection of better genotypes.

Table 1: Distribution of various strawberry cultivars into different clusters.

Cluster number	No. of cultivars	Cultivars
I	4	Winter Dawn, Curaltar, Catskill, Jutogh Special
II	5	Oso Grande, Sea Scape, Honeoye, Selva, Camarosa
III	1	Kimberly
IV	1	Everly
V	1	Chandler
VI	2	Katrain Sweet, Brighton
VII	1	Missionary

Table 2: Average intra cluster (diagonal) and inter cluster (above diagonal) distance values in different strawberry (*Fragaria* × *ananassa* Duch.) cultivars.

S. No.	Clusters	I	II	III	IV	V	VI	VII
1.	I	**3311.25**	6232.42	5370.07	7235.61	19557.14	11785.49	9576.89
2.	II		**2831.03**	9583.93	16223.90	6990.87	24515.36	16153.63
3.	III			**0.00**	5184.12	24772.58	9757.66	11664.05
4.	IV				**0.00**	36088.29	7023.40	8480.04
5.	V					**0.00**	50362.27	33550.39
6.	VI						**4646.85**	8105.32
7.	VII							**0.00**

Table 3: Cluster means for various traits in different strawberry (*Fragaria* ×*ananassa* Duch.) cultivars.

Clusters	Plant height	Plant spread	Fruit weight	Fruit volume	Specific gravity	SSC	Titrable acidity	SSC/ Titrable acidity	Total sugars	Reducing sugars	Fruit yield/plant
I	27.93	28.63	9.36	8.95	1.02	10.36	1.01	10.06	5.90	5.43	83.68
II	24.76	25.07	10.65	10.86	1.00	9.59	0.98	9.80	5.95	5.39	104.26
III	21.83	22.83	16.30	13.00	1.25	9.20	0.71	12.89	6.50	6.14	82.58
IV	24.13	26.83	9.71	11.00	0.88	7.21	0.68	10.55	5.82	5.17	64.25
V	20.13	24.33	9.70	9.96	0.97	10.21	0.87	11.68	6.12	5.85	119.67
VI	21.62	23.58	11.09	12.36	0.89	10.51	0.96	12.36	7.49	6.74	68.46
VII	27.53	27.00	7.56	11.56	0.65	11.31	0.91	11.44	7.66	6.57	104.78

Table 4: Percent contribution of ten characters towards total genetic divergence in different strawberry (*Fragaria* × *ananassa* Duch.) cultivars.

Sr. No.	Characters	Per cent contribution
1.	Number of leaves/plant	0.95
2.	Bloom duration (days)	0.95
3.	Fruit weight (g)	5.71
4.	Soluble solids conc. (°Brix)	0.95
5.	Titrable acidity (%)	0.95
6.	SSC/Acid ratio	0.95
7.	Total sugars (%)	8.57
8.	Reducing sugars (%)	8.57
9.	Fruit yield (g/plant)	71.43
10.	Fruit yield/ha (q/ha)	0.95
Total		**100.00**

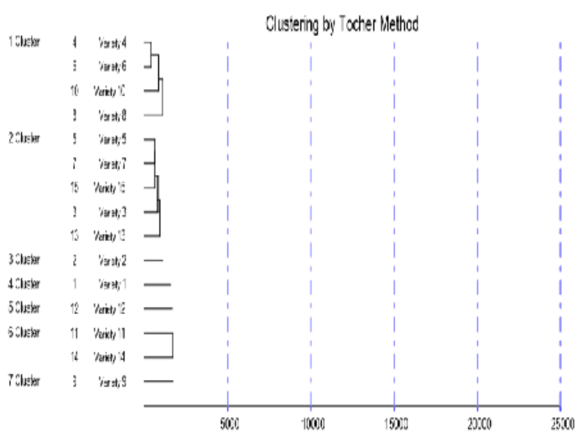

Fig. 1.

CONCLUSION

According to the discussion above, strawberry genotypes have a significant genetic diversity in terms of morphological and biochemical characteristics, therefore it is obvious that a systematic breeding and selection technique might be used to converge the elite allelic resources contained in these strawberry genotypes in order to recover high yielding recombinants with good quality features. The parents utilized in the hybridization programme should come from a variety of clusters separated by a large inter-cluster distance, and they should have high per se performance for the characteristics of interest, contributing the most to genetic divergence. Clusters containing just one genotype with certain features might be used as testers for expression of maximal heterosis in a hybridization programme to utilize heterosis.

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Conflict of Interest. None.

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