Research Article

Comparison of Variability in Exotic Genotypes of Strawberry (*Fragaria* × *Ananassa* duch.) in Climatic Conditions of Pakistan

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Abstract | The unique fruit characters of new strawberry genotypes reveal their importance for the current and next breeding initiatives. The aim of present research was to assess the plant, flower and fruit characteristics of three exotic strawberry genotypes. In this respect, an experiment was conducted in the research area of the Horticultural Research Institute of Ayub Agricultural Research Institute, Faisalabad, Pakistan during the year of 2019-2021. Results revealed that Sogoya germplasm have maximum survival (85.71%), number of leaves (16.55), leaf area (62.41 cm^2), No. of flowers (38), No. of fruits (46), fruit length (41.69 mm), fruit weight (12.12) and yield (634.2g/plant) was included. While in qualitative characteristics germplasm Sogoya revealed highest total soluble solids (10.85%), total sugars (8.61%) and vitamin C (66.24 mg/100g). The outcomes of this study depicted that exotic genotype Sogoya has the potential to develop into a unique and valuable variety.

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Introduction

Strawberry (*Fragaria x ananassa* Duch.) belongs to family Rosaceae and is cultivating for its fruit all over the world. Strawberry fruit is non-climacteric nature, so harvested at ripening stage. It is an aggregate fruit that is very delicate in nature. The fruit has a pleasing color, pleasing taste and is also a high-quality source of carbohydrates, vitamins and antioxidants compounds like phenols (Pramanick *et al.*, 2017). This plant behaves as a small perennial herb with a shallow root system in temperate climates, but it behaves like an annual in sub-tropical climates (Finn and Strick, 2008). More than 20 Fragaria species and various cultivars are grown commercially in numerous countries (Gaafar and Saker, 2006). The majority of the time, a strawberry plant's genotypic and phenotypic relation depends on the cultivars (Asrey *et al.*, 2004). Assortment of various genotypes along superior type variation for the desired characters is the vital base of any advance program of crop (Singhania *et al.*, 2006). Growers choose varieties mostly based on fruit quality and yield, which are significantly impacted by genetics, environment, and cultural practices (Wang *et al.*, 2010). The farmer required maximum yield, continue supply of fruit and bearing large fruit varieties

(Cordenunsi *et al*., 2003). The quality traits may be nutritional or sensory. Customers prefer strawberries with a variety of sensory attributes (Schopplein *et al*., 2002; Cordenunsi *et al*., 2003). The assessment of the ideal maturity also depends on physical or chemical features (Sturm *et al*., 2003). Performance of the strawberry market can be affected by various elements, including the firmness and skin hardness of the fruit. Firm fruits can indirectly increase and extend their shelf life since they are less likely to bruise when handled (Rutkowski *et al*., 2006). Strawberry consumption has been found to be a rich source of antioxidant phenolic chemicals (Meyers *et al*., 2003). It is reported that strawberry cultivation has been successful in different zone of the country. However, farmers of Pakistan have ample knowledge regarding the technologies for successful commercial strawberry production. Among the necessary technologies for the strawberry cultivation, the lack of suitable variety is the prime need to be urgently made up to sustain its adaptation by farmers. Considering the above facts, this experiment was arranged to assess the growth and yield of several varieties of strawberry and to evaluate the gathered strawberry germplasm for morphological traits and choose the best one based on those traits.

Materials and Methods

The research was conducted during the year of 2019-2021 at the Horticultural Research Institute's experimental site, which is part of the Ayub Agricultural Research Institute (31.42° N, 73.09° E longitude, altitude 189m) in Faisalabad, Pakistan. With warm summers and mild winters, this region is located in a subtropical climate. With a relative humidity of 29.07% and over 18.88mm of rainfall during cropping, there were 36.46°C and 28.46°C on average for the highest and lowest temperatures during the cropping season, respectively. The soil had a loamy texture, a pH of 8.1, and 0.86% organic content. The soil fertility was satisfactory, with 200 ppm of accessible potassium and 8.1 ppm of available phosphorus. Three strawberry varieties (Sogoya, Chandler, and Norial) runners were arranged from Curtin University, Australia and used as treatment because they were healthy and free of disease. In the month of October, these runners were planted. With three repetitions, the research was set up with a Randomized Complete Block Design (RCBD). Ten plants were selected from each plot for data collection. For the conservation of soil moisture, preserve humidity and reduce weeds, black mulch was used around the plants until the harvesting. Weeds were eliminated every 15 days until the crop was ready for harvest. Irrigation was done according to crop needs, or as needed to keep the soil moist in the field in order to grow healthier plants. Fruits were picked when fully developed. Analyses of the fruit samples were performed after harvesting. The vegetative traits, such as plant success (%), the number of leaves per plant, the area of leaf, the weight (g), the length (mm), the diameter, and the yield of fruits per plant, were noted. Fruit was weighed fresh using an electronic scale, and its length and diameter were measured using a digital caliper. Using a digital refractometer measured total soluble solids (TSS) that expressed in Brix. Total acidity (TA) was calculated using Ranganna's (1986) AC technique and represented as a percentage.

Using the Statistix 8.1 software tool, data of two years of experiments were merged and evaluated for various quantitative and qualitative aspects. The least significant difference test (LSD) ($P< 0.05$) was used to compare any significant differences between the mean values.

Results and Discussion

Results showed that there was significant survival % due to germplasm. Maximum plant survival (85.71%) was obtained from Sogoya and lowest was noted in Norial (59.57 %) (Figure 1). This result indicated that the survival % of different strawberry genotype was different and this character was genetically controlled.

Similar results and trends were also exhibited in terms of number of leaves. Non-significant difference was found in germplasm. Maximum leaf number (16.55) was observed from Sogoya and minimum number of leaves (14.11) was observed in Norial germplasm (Figure 1). Our results are not in line with Islam *et al*. (2013) who stated that V1 germplasm yielded the largest number of leaves (15.8) and V2 germplasm yielded (14.1).

In three germplasm samples, strawberry leaves revealed highly substantial variance. The highest leaf area (62.41 cm^2) was recorded in Sogoya germplasm whereas, the minimum leaf area (21.03 cm^2) was observed from Norial germplasm. Deviation with reverence to leaf area could be recognized to the

fact that different cultivars may respond differently to factors like as light, temperature, photoperiod, availability of nutrients in the soil, and the distribution of metabolites among the above-ground plant parts (Islam *et al.*, 2013).

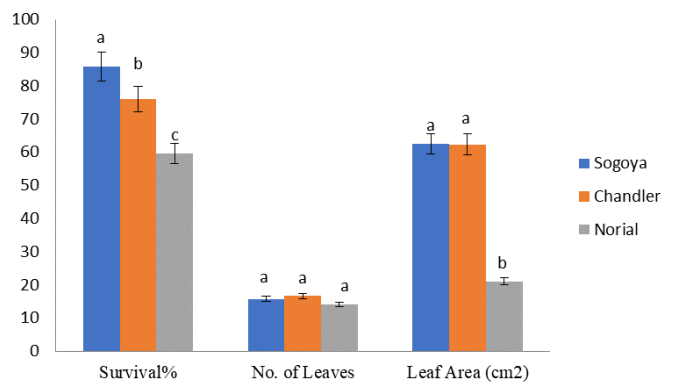

Figure 1: *Survival % of plants, No. of leaves and leaf area.*

The average Number of flowers was significantly varied by different germplasm of strawberry. Maximum number of flower (46) was recorded, while minimum (22) number of flowers was recorded in Norial germplasm (Figure 2). Variations were also marked in the reproductive parameters due to the varieties. Maybe more intense lighting in the area is the reason for the rise in flowering plants. Atefe *et al.* (2012) also found that number of flower plant varied significantly among the strawberry germplasm.

Figure 2: *No. of flowers, No. of fruits, fruit length, fruit width and fruit weight of strawberry genotypes.*

No. of fruits per plant was statistically maximum (38) in Sogoya following by Chandler (34) which was statistically greater than the minimum value of this parameter (11) as was recorded from Norial (Figure 2). It may be mentioned that the variety Sogoya had more flowers but did not show number of fruits accordingly. Probably number of fruits was fewer due to the dropping of some flowers which did not set fruiting due to genetically erosion. According to Morgan (2006), the quantity of achene generated, which is determined by pollination and fertilization throughout blooming, determines the final size and shape of the berry.

The measurement of fruit length was shown that maximum average value 41.69mm was recorded in Sogoya while lower value in Norial (21.11mm). Length of fruit also significantly varied with the germplasm.

The width of fruit was influenced significantly with the germplasm. Maximum fruit width (27.6 mm) was noted in Chandler while minimum fruit width (21.29 mm) was recorded in Norial. Our results are same in line with Hossan *et al.* (2013) who described that maximum average diameter (24.6 mm) was recorded from SG-1 while the lowest diameter (21.1 mm) as was recorded from RABI-3. Similar results were described by (Islam *et al.*, 2013).

For the fruit sector, the average fruit weight is an important factor, especially when the fruits are meant to be consumed fresh. The strawberry fruit under investigation ranged from 12.12 g (Sogoya) and 3 g (Norial) the differences between those being non-significant. It means the highest photosynthesis ensuing higher food materials, better fruit size and fruit weight (Islam *et al.*, 2013).

The resistance to storage and transportation is correlated with the firmness of the strawberry fruit. Fruit firmness analysis revealed that genotypes: Norial and Chandler registered the highest values of fruit firmness (0.56kg and 0.33kg), while the lowest value was recorded for Sogoya cv. (0.25kg). Temocico *et al.* (2019) noted that different strawberry genotypes 9-21-4, Garda and Argentera depicted significant results.

The greatest amount of yield (634.2 g/plant) was produced by Sogoya genotype (Figure 3) while genotype Norial gave the lowest yield (250.2 g/plant). This was brought on by the highest flowering and heavier fruit. The results are consistent with Belakhud *et al.* (2015) finding that Chandler had the highest yield per plant (616g), while Addie had the lowest fruit yield per plant (90g).

Analyzing total soluble solid content of the fruits, there were highly significant differences between the

studied genotypes. Thus, Sogoya have highest value of the total soluble solid content (10.85 Brix), whereas Chandler and Norial genotypes had the lowest value of total solid contents (9.93 and 6.40 Brix, respectively). TSS of different cultivar ranged from 6.00 to 10.01 Brix, while Laugale and Bite (2006) stated values from 8.4 to 11.6% dependent on the cultivar.

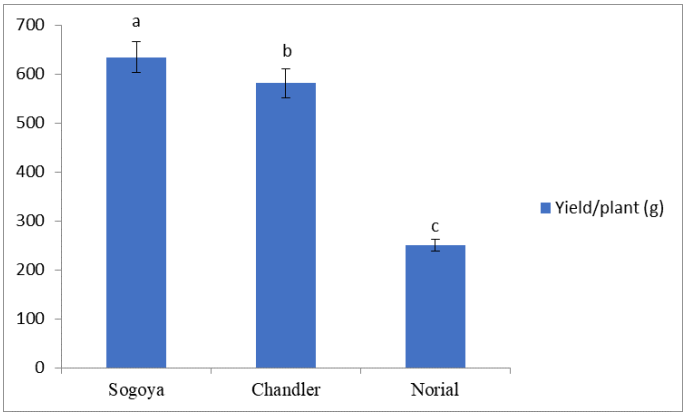

Figure 3: *Yield of strawberry genotypes.*

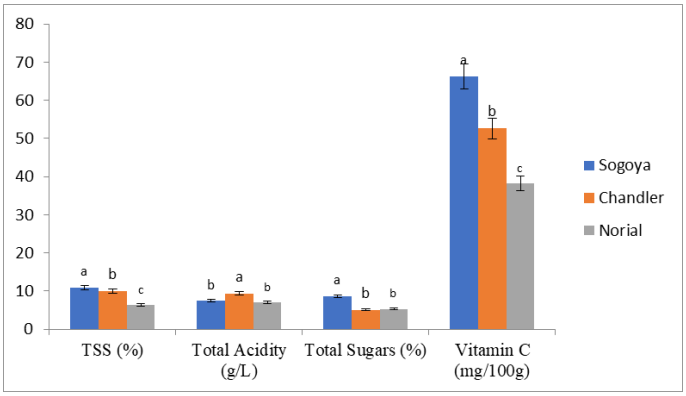

Figure 4: *TSS%, total acidity, total sugars and vitamin C of strawberry genotypes.*

According to several scientists, strawberry harvested from field crops grown in cooler climate has higher acidity values. High sugar and low acid concentration produce the best flavor in strawberry fresh fruit Chandler cv. had the highest total acidity content value (9.3 g/L), whereas Norial had the lowest (7 g/L) total acidity content (Figure 4). Total acidity values ranged from 3.9g/l to 9.2g/l, in various researches studies on various strawberry cultivars TSS/TA ratio was found to be very essential since it delivers information on the balance of sugars and acids in the fruit. For this reason, it is considered to be the major parameter for defining fruit quality (Kim *et al.*, 2013).

Total acidity readings reached from 3.9 g/l to 9.2 g/l. In numerous studies on various strawberry cultivars, the TSS/TA ratio was discovered to be extremely significant since it labeled how the sugars and acids in the fruit are balanced. Because of this, it is regarded as the primary factor in determining the quality of fruit (Kim *et al.*, 2013).

One of the crucial sensory factors that affect how customers behave is strawberry sweetness. Acid and sugar worked together to create the strawberry fruit's flavor. The total sugar falls within the normal range of species and the average limit for strawberry fruit is 5.02-8.90%. Significant differences were noted among genotype. The figures found by Bharat and Rao (2010) were in line of the current study and the total sugar also showed marked variation among the studied cultivars. In addition to genotype and other significant factors including weather conditions from pre-crop to post-harvest activities, vitamin C level in fresh strawberries is regulated by these factors (Lee and Kader, 2000). With an average amount of 60 mg/100g, Strawberry as a significant source of vitamin C (Cordenunsi *et al.*, 2002). The Figure 3 shows that the average value of the vitamin C content of the strawberry genotype analyzed falls within the normal range of variation (66.24-60.26 mg/100g fresh fruit). The richest genotype in vitamin C is Sogoya cv. (66.24 mg/100g) and the lowest content was highlighted at Norial cv. (60.26 mg/100g).

Conclusions and Recommendations

The evaluation of physiochemical characteristics of the three exotic strawberry cultivars that were under study's characteristics brought out the variations between genotypes. The new selection Sogoya has shown higher values of following parameters: Fruit weight, yield total soluble solids, total sugars and also by the content of vitamin C.

Novelty Statement

The research work in this study evidently demonstrated that exotic genotype Sogoya has the potential to become a new and valuable variety of Pakistan considering some of the most important fruit quality characteristics.

Author's Contribution

Amina: Contribution as execution of research trial & main investigator.
Muhammad Zahid Rashid: Removed plagiarism and performed statistical work.

Muhammad Asim Rashid: Write up and assistance in the research.
Amina Rashid: Design the research study and conducted the biochemical analysis.

Conflict of interest
The authors have declared no conflict of interest.

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