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# Genetic variability and character association studies for yield-related traits in strawberry (Fragaria × Ananassa)

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**Abstract**
The study employed a Randomized Complete Block Design with three replications to assess morphological variability and examine interrelationships among various traits. Statistical analyses included correlation studies and path coefficient analysis to determine direct and indirect effects of different morphological parameters on key performance indicators in the selected strawberry cultivars. Coefficients of variability were high for plant spread, leaf number/plant, number of fruits/plant and average berry weight whereas high heritability coupled with high genetic gain was observed for plant spread and number of fruits/plants. Yield/plant was positively and significantly associated with plant spread, leaf number/plant, duration of flowering, fruit length, breadth, number of achenes/fruits, number of fruits/plants, average berry weight and TSS.

**Keywords:** Coefficient of variability, heritability, positive direct effect, genetic gain

## Introduction

The cultivated strawberry (Fragaria x annanasa Duch.) is an octaploid (2n=8x=56) species of family Rosaceae that has economic importance related to fruit yield. The cultivated species is a hybrid between two Native American species. In most of the breeding programmes, the higher yield in the resulting variety is the ultimate aim. The yield itself is based on the interaction of a number of components amongst themselves as well as the environment in which the plant grows. Therefore, it becomes more difficult to evaluate for this complex character directly. Hence, the determination of the association existing between different characters has to be made. Keeping in view the existing variation, the present study on variation and character association was undertaken to assess its extent and magnitude of variability in respect of vegetative and fruit traits.

## Methodology

The present investigations on "Evaluation of strawberry genotypes through morphological and molecular markers" were carried out in the department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.). The details of the experiment conducted, material used and techniques employed for studies have been described briefly.

The statistical analysis was carried out for each observed character by using MS- Excel and SPAR 1.0 packages. The mean values of data were subjected to analysis of variance as described by Gomez and Gomez (1984) [3] for Randomized Block Design.

All the traits, which differed significantly, were utilized further for the estimation of genetic parameters i.e Mean performance and genetic variability, Heritability, Genetic gain, Genetic advance, Correlation coefficients and Path analysisThe expected genetic advance (GA) resulting from selection of five per cent superior individuals and was worked out as suggested by Allard (1960). The Genetic gain expressed in per cent ratio of genetic advance and population mean and it was calculated by the method given by Johnson *et al.* (1955) [4]

## Result and Discussion

The parameters of variability *i.e.* in respect of coefficients of variability (phenotypic and genotypic), heritability (in broad sense) and genetic advance as per cent of mean (genetic gain) were worked for morphological, floral and fruit. The observed variations in the various traits among the studies cultivars are due to the combined effect of genotype and environment.

The results showed that phenotypic coefficients of variability were higher in magnitude than genotypic coefficients of variability for all the characters under study, though difference was very less in majority of the cases except flower size, fruit length, fruit breadth, average berry weight and yield per plot. The genotypic and phenotypic coefficients of variability were highest for the trait days to flower after planting during both the years (Table 1). Indicated values were 36.96 and 38.52 during the year 2015-16 and 36.84 and 37.69 during the year 2016-2017. The characters days to flower after planting followed by number of flowers per plant which registered the values 33.13 and 33.66 during first and second year (32.79). The lowest values of coefficient were recorded for duration of flowering for genotypic and phenotypic coefficient of variation during both the years (4.93 and 5.06; 4.93 and 5.18, respectively).

The estimates of heritability (broad sense) varied from 47.47 to 99.61 per cent for different characters in the first year (2015-16) and 52.48 per cent to 95.97 per cent in the second year (2016-17) of investigation. The broad sense heritability estimates for leaf number per plant and leaf area were highest *i.e.* 99.61 and 95.97 were in the first and second year respectively during 2015-16 and 95.50 per cent for days to flowers (2016-17) for days to flowering. The lowest heritability values were observed for flower size (47.47 %) and plant height (52.48 %) during first and second year, respectively followed by plant height in first year (59.20 %) and number of flowers per plant (61.46 and 62.82 respectively) in both the years. The lowest value for genetic advance was for the character flower size (0.27 and 0.23 respectively) during both the years of study. The values for genetic gain (expressed as per cent of population mean)

ranged from 9.90 to 73.05 during the first year and from 9.67 to 74.16 during the second year, was highest for days to flowering followed by number of flowers per plant during both the years. The lowest genetic gain was registered for duration of flowering which was 9.90 for first year and 9.67 during second year (Table 1).

**Table 1:** Variability parameters for vegetative and floral characters

| | Mean | Range | Cofficient of variation (%) | | | Genetic Advance | Genetic Gain (%) |
|---|---|---|---|---|---|---|---|
| | | | Genotypic | Phenotypic | Heritability (%) | | |
| Plant height (cm) | | | | | | | |
| A | 22.42 | 17.40 - 25.44 | 8.24 | 10.71 | 59.20 | 3.02 | 13.07 |
| B | 22.36 | 18.86 - 27.53 | 8.83 | 12.19 | 52.48 | 2.94 | 13.19 |
| Leaf number/ Plant | | | | | | | |
| A | 25.24 | 17.27 - 35.87 | 20.19 | 20.23 | 99.61 | 12.01 | 41.51 |
| B | 23.46 | 15.30 - 32.33 | 18.34 | 19.34 | 89.94 | 8.41 | 35.84 |
| Leaf area | | | | | | | |
| A | 158.13 | 142.50 - 185.20 | 7.67 | 7.80 | 96.66 | 24.58 | 15.54 |
| B | 158.12 | 142.17 - 184.00 | 7.45 | 7.60 | 95.97 | 23.77 | 15.03 |
| Number of runner | | | | | | | |
| A | 22.89 | 12.67 - 41.87 | 23.06 | 23.50 | 96.23 | 17.22 | 46.60 |
| B | 20.42 | 10.86 - 41.87 | 35.48 | 36.54 | 94.29 | 14.49 | 70.98 |
| Flower size (cm) | | | | | | | |
| A | 2.42 | 2.14 - 2.87 | 7.89 | 11.46 | 47.47 | 0.27 | 11.20 |
| B | 2.42 | 2.22 - 2.80 | 6.46 | 8.80 | 53.86 | 0.23 | 9.77 |
| Days to flower | | | | | | | |
| A | 125.33 | 116.00 -138.67 | 36.96 | 38.52 | 92.05 | 61.4 | 73.05 |
| B | 125.7 | 116.17 - 138.88 | 36.84 | 37.69 | 95.50 | 62.82 | 74.16 |
| Duration of flowering | | | | | | | |
| A | 84.13 | 54.33 - 189.67 | 4.93 | 5.06 | 94.96 | 12.41 | 9.90 |
| B | 84.71 | 48.67 - 189.00 | 4.93 | 5.18 | 90.58 | 12.16 | 9.67 |
| Number of flowers | | | | | | | |
| A | 21.25 | 9.90 - 32.51 | 33.13 | 33.66 | 96.89 | 14.11 | 67.19 |
| B | 21.61 | 10.36 - 33.34 | 32.79 | 33.25 | 71.12 | 14.39 | 66.59 |

a = Year 2015-16 b = Year 2016-17

**Table 2:** Variability parameters for fruit characters

| | Mean | Range | Coefficient of variation (%) | | Heritability (%) | Genetic Advance | Genetic Gain (%) |
|---|---|---|---|---|---|---|---|
| | | | Genotypic | Phenotypic | | | |
| Days to maturity | | | | | | | |
| A | 161.32 | 119.66 - 171.70 | 7.86 | 8.15 | 93.06 | 25.22 | 15.63 |
| B | 162.4 | 116.64 - 173.37 | 8.58 | 8.81 | 94.70 | 27.94 | 17.20 |
| Fruit length | | | | | | | |
| A | 27.38 | 21.98 - 35.29 | 15.33 | 17.89 | 73.35 | 7.403 | 27.04 |
| B | 27.98 | 21.69 - 36.52 | 16.35 | 16.92 | 91.29 | 9.10 | 32.53 |
| Fruit breadth | | | | | | | |
| A | 21.25 | 17.01 - 31.15 | 15.82 | 18.00 | 77.21 | 6.32 | 28.63 |
| B | 22.83 | 18.07 - 31.67 | 15.68 | 16.41 | 97.20 | 7.04 | 30.86 |
| Average berry weight (g) | | | | | | | |
| A | 9.99 | 6.59 - 12.50 | 17.84 | 21.65 | 67.92 | 3.04 | 30.30 |
| B | 10.22 | 7.36 - 12.82 | 17.29 | 20.51 | 99.34 | 3.07 | 30.05 |
| Number of achene / fruits | | | | | | | |
| A | 158.63 | 136.05 - 193.75 | 12.94 | 12.96 | 99.65 | 42.24 | 26.61 |
| B | 159.41 | 135.39 - 195.65 | 13.04 | 13.08 | 90.01 | 42.71 | 26.78 |
| Yield / plot | | | | | | | |
| A | 2.18 | 1.09 - 4.08 | 47.07 | 49.73 | 89.57 | 3.20 | 91.77 |
| B | 3.3 | 1.68 - 7.01 | 47.97 | 50.56 | 90.01 | 3.09 | 93.76 |

a = Year 2015-16 b = Year 2016-17

**Fruit characters**

Yield per plot showed maximum values of coefficients of variation, followed by average berry weight (Table 2). The respective values of genotypic and phenotypic coefficients for yield per plot were 47.07 and 49.73 in the year 2015-16; 47.97 and 50.56 in the year 2016-17. Days to maturity showed lowest value both for genotypic and phenotypic coefficient of variation *i.e.* 7.86 and 8.15; 8.58 and 8.81 respectively for both the years of study. The heritability estimates were highest for number of achenes per fruit during first (99.65 %) and 97.20 per cent for fruit breadth in the second year of study followed by days to maturity (93.06 %) during first year and 94.70 per cent (days to maturity) during second year of investigation.

The lowest heritability values were obtained for average berry weight followed by fruit length during first year (67.92 % and 73.35 %, respectively) followed by yield per plot (90.01 %) in the second year. The values of genetic advance and genetic gain for fruit characters are presented in the Table 2. The genetic advance was highest for the

character number of achenes per fruit (42.24 and 42.70 for first and second year, respectively) and minimum for average berry weight (3.04) during first year and 3.07 during second year of investigation. The genetic gain was registered maximum in yield per plot (91.77 in year 2015-16 and 93.76 in year 2016-17). Days to maturity showed lowest genetic gain of 15.63 in first year and 17.20 in the second year of study.

The GCV, along with heritability estimates, provides reliable estimates of the amount of GA to be expected through phenotypic selection (Burton, 1952) [2]. PCV was found higher than GCV for all the characters studied, which signifies the presence of environmental influence to some degree in the phenotypic expression of characters. Higher values of PCV and GCV indicated that the genotypes showed evidence of considerable variation among themselves with respect to morphological and biochemical characters. These findings are consistent with previous reports by Singh *et al*. (2008) [8] and Punetha *et al*. (2011) [7]. The present results align closely with the work of Moore *et al*. (1970) [6], Singh *et al*. (2010) [9], and Garg *et al*. (2014), who observed that fruit yield per plant is significantly and positively correlated with number of leaves per plant, average berry weight, total achenes developed, and total weight. The differences observed in fruit size can be attributed primarily to plant vigor, competition among fruits in the inflorescence, number and size of developed achenes, differences in activity among the achenes in the production of growth material, climatic conditions, irrigation, and plant nutrients. High heritability estimates for the characters indicate reduced environmental influence, suggesting good scope for improvement of these traits through direct selection (Kumar *et al*., 2012) [5]. The combination of higher heritability combined with high genetic advance was observed for fruit yield per plant, which may be attributed to additive gene action, indicating that selection would be effective for this character. Ara *et al*. (2009) reported that high heritability coupled with high GA for number of flowers and number of fruits in each year indicated that these characters were controlled by additive genes, and effective selection could be made for these parameters. The GCV, along with heritability estimates, provides reliable estimates of the amount of GA to be expected through phenotypic selection (Burton, 1952) [2].

## Summary and conclusion

High coefficients of variability were found for plant spread, leaf number per plant, number of fruits per plant and the average berry weight and may be used for improvement through selection. High heritability integrated with high genetic gain was observed in plant spread and number of achenes per fruit. Genetic advance was highest for number of achenes per fruit.

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