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# GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE IN GRAPEFRUIT (*Citrus paradisi*) GENOTYPES

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**ABSTRACT:** Variability assessment of six grapefruit varieties was done based on 22 qualitative and quantitative morphological characters. The maximum variability was observed for leaf lamina width (CV = 12.03), while the minimum variability was noted for petiole wing width (CV = 0.13). The maximum heritability ($h^2$) coupled with maximum genetic advance percentage of mean (GA) was observed for petiole wing width (100 and 45.96, respectively), followed by spine length (100 and 25, respectively) and rootstock diameter (85 and 21.44, respectively), while the minimum heritability coupled with the minimum genetic advance percentage of mean was observed for leaf lamina length (7 and 0.70, respectively).

***Keywords :*** *Qualitative traits, quantitative traits, vegetative characters, variability, heritability, grapefruit.*

Citrus is a sub-tropical fruit and belongs to family Rutaceae. It is one of the most famous fruit grown all over the world. The north-eastern region of India is considered as one of the natural home of few citrus species. The genus Citrus belongs to the tribe *Citreaea*, subtribe *Citrinae* subfamily Aurantioideae. Citrus is grown in every tropical country and in those regions of sub-tropical countries, where winter temperature do not fall below 0°C (Reitz, 10).

Morphological study is an essential component for the assessment of diversity and classification. Even today, morphological study is being considered and has been deployed as an initial step for cultivar identification and diversity assessment with Jawandha *et al.* (7) watermelon (Huh *et al.,* 6), sweet potato in lemon (Elameen *et. al.,* 4) and agave (Rodrguez *et al.,* 11). Furthermore, important horticultural characters are reported to be controlled by multiple genes (Campos *et al.,* 3; Liu and Deng, 8) and are of low heritability.

Despite of huge genetic diversity, very little work has been done in the past highlighting the distinguishable morphological features. Proper identification of trees is essential to establish trueness-to-name in commercial channels. Moreover, the testing of advanced selection and of new cultivars is an important aspect of fruit breeding (Harding, 5).

Thus the present study on six grapefruit varieties was undertaken to examine the performance in specific agro-climate for the purpose of commercial cultivation.

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## MATERIALS AND METHODS

The present study was carried out at Punjab Agricultural University, Ludhiana to evaluate vegetative-morphological characterstics of six grapefruit (*Citrus paradisi*) varieties namely, Foster, Marsh seedless, Ray Ruby, Red Blush, Rio Red and Ruby Red (Fig. 2, 3, 4, 5) . The experiment was laid out in RBD with four replications for each variety and one plant per replication. Morphological characterization of tree and leaves was done using descriptors developed for citrus by International Plant Genetic Resources Institute (IPGRI), Rome, Italy (Anon., 1). Quantitative data were statistically analysed and mean, least significant difference (LSD), coefficient of variation (CV) and genetic advance % of mean were calculated.

Tree characters observed were tree shape, density of branches, tree growth habit, branch angle, spine density, spine shape, spine length, rootstock diameter, scion : rootstock ratio, leaf division, leaf lamina attachment, leaf lamina length, leaf lamina width, leaf thickness, leaf length: leaf width ratio, leaf lamina shape, leaf lamina margin, leaf apex, petiole wings, petiole wing width and petiole wing shape, shoot tip colour, shoot tip surface and junction between petiole and lamina.

## RESULTS AND DISCUSSION

Tree shape was recorded as spheroid in all the grapefruit varieties (Table 1). The tree growth habit was spreading in all the grapefruit varieties. Dense branching habit was recorded in all the grapefruit varieties. The branch angle was observed to be

medium with no variation. Spine density and spine shape was low and straight, respectively in Foster, Marsh Seedless, and Ruby Red, while it was medium and straight in Ray Ruby, Red Blush and Rio Red. The shoot tip surface and shoot tip colour was to be glabrous and green, respectively in all the grapefruit varieties. Leaf division, leaf lamina attachment and leaf lamina shape was recorded as simple, brevipetiolate and ovate, respectively in all the grapefruit varieties. Leaf lamina margin, leaf apex, and junction between petiole and lamina was recorded as dentate, attenuate, and fused, respectively (Fig. 1).

Among tree and leaf characters (Table 2). variability was recorded to be maximum for leaf lamina width (CV =12.03), while the minimum for petiole wing width (CV = 0.13) Rootstock diameter was the maximum in Red Blush (108.24 mm), while minimum was in Foster (81.54 mm). Scion : rootstock diameter ratio was the maximum in Ruby Red (0.92), while the minimum was in Marsh Seedless (0.74). Spine length was the maximum in Red Blush (5.89 mm), while the minimum was in Ray Ruby (4.14 mm). Leaf lamina length was recorded as maximum in Red Blush (119.98 mm), while the minimum was in Ruby Red (104.61 mm). Leaf lamina width was the maximum in Rio Red (78.02 mm), while minimum was in Ruby Red (63.94 mm). Leaf lamina length : width ratio was the maximum in Ruby Red (1.74), while the minimum was in Foster (1.46). Likewise, leaf thickness was the maximum in Foster (0.47 mm), while minimum was in Ruby Red (0.36 mm). Petiole wing width was the maximum in Rio

**Table 1 : Qualitative tree and leaf chatacters of grapefruit varieties**.

| Characters | Foster | Marsh seedless | Ray Ruby | Red Blush | Rio Red | Ruby Red |
|---|---|---|---|---|---|---|
| **Tree shape** | Spheroid | Spheroid | Spheroid | Spheroid | Spheroid | Spheroid |
| **Tree growth habit** | Spreading | Spreading | Spreading | Spreading | Spreading | Spreading |
| **Branch density** | Dense | Dense | Dense | Dense | Dense | Dense |
| **Branch angle** | Medium | Medium | Medium | Medium | Medium | Medium |
| **Spine density** | Low | Low | Medium | Medium | Medium | Low |
| **Spine shape** | Straight | Straight | Straight | Straight | Straight | Straight |
| **Shoot tip colour** | Green | Green | Green | Green | Green | Green |
| **Shoot tip surface** | Glabrous | Glabrous | Glabrous | Glabrous | Glabrous | Glabrous |
| **Leaf division** | Simple | Simple | Simple | Simple | Simple | Simple |
| **Leaf lamina attachment** | Brevipetiolate | Brevipetiolate | Brevipetiolate | Brevipetiolate | Brevipetiolate | Brevipetiolate |
| **Leaf lamina shape** | Ovate | Ovate | Ovate | Ovate | Ovate | Ovate |
| **Leaf lamina margin** | Dentate | Dentate | Dentate | Dentate | Dentate | Dentate |
| **Leaf apex** | Attenuate | Attenuate | Attenuate | Attenuate | Attenuate | Attenuate |
| **Petiole wing shape** | Obdeltate | Obcordate | Obdeltate | Obdeltate | Obdeltate | Obdeltate |

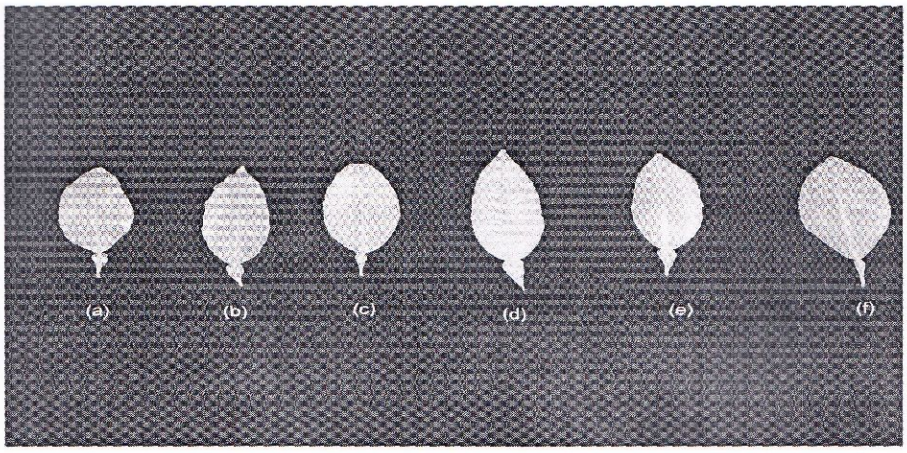


Fig. 1 : Leaf morphology in grapefruit varieties viz., (a) Ruby Red, (b) Rio Red, (c) Marsh Seedless, (d) Red Blush, (e) Ray Ruby and (f) Foster.

**Table 2 : Quantitative tree and leaf characters of grapefruit varieties.**

| Varieties | Rootstock diameter (mm) | Scion : rootstock ratio | Spine length (mm) | Leaf lamina length (mm) | Leaf lamina width (mm) | Leaf lamina length : width ratio | Petiole wing width | Leaf thickness (mm) |
|---|---|---|---|---|---|---|---|---|
| **Foster** | 81.54[b] | 0.82[c] | 5.2[c] | 112.54[a] | 75.27[ab] | 1.46[d] | 0.47[a] | 0.47[a] |
| **Marsh Seedless** | 101.37[a] | 0.74[d] | 4.54[e] | 114.69[a] | 68.29[ab] | 1.66[b] | 0.39[b] | 0.39[b] |
| **Ray Ruby** | 107.26[a] | 0.88[b] | 4.14[f] | 115.08[a] | 71.01[ab] | 1.72[a] | 0.4[b] | 0.4[b] |
| **Red Blush** | 108.24[a] | 0.75[d] | 5.89[a] | 119.98[a] | 71.28[ab] | 1.65[b] | 0.39[b] | 0.39[b] |
| **Rio Red** | 107.54[a] | 0.83[c] | 5.11[d] | 119.17[a] | 78.02[a] | 1.59[c] | 0.38[bc] | 0.38[bc] |
| **Ruby Red** | 84.87[b] | 0.92[a] | 5.28[b] | 104.61[a] | 63.94[b] | 1.74[a] | 0.36[c] | 0.36[c] |
| **Mean** | **98.47** | **0.82** | **5.03** | **114.34** | **71.3** | **1.64** | **0.39** | **0.39** |
| **LSD (P=0.05)** | **14.17** | **0.03** | **0.02** | **17.04** | **12.74** | **0.02** | **0.02** | **0.02** |
| **CV** | **9.69** | **2.32** | **0.34** | **10.03** | **12.03** | **1.08** | **0.13** | **4.35** |

**Table 3 : Variability, heritability and genetic advance for different quantitative vegetative characters in grapefruit varieties**.

| Characters | VG | VP | GCV | PCV | $h^2$ (%) | GA (%) of mean |
|---|---|---|---|---|---|---|
| **Rootstock diameter (mm)** | 124.23 | 146.98 | 11.32 | 12.31 | 85 | 21.44 |
| **Spine length (mm)** | 0.37 | 0.37 | 12.13 | 12.14 | 100 | 25.00 |
| **Scion : rootstock ratio** | 0.00 | 0.01 | 8.55 | 8.63 | 98 | 17.46 |
| **Leaf lamina length (mm)** | 2.14 | 30.76 | 1.28 | 4.85 | 7 | 0.70 |
| **Leaf thickness (mm)** | 0.00 | 0.00 | 8.81 | 9.09 | 94 | 17.58 |
| **Leaf lamina width (mm)** | 6.48 | 24.86 | 3.57 | 6.99 | 26 | 3.75 |
| **Leaf lamina length : width ratio** | 0.01 | 0.01 | 6.25 | 6.27 | 99 | 12.83 |
| **Petiole wing width (mm)** | 16.75 | 16.75 | 22.31 | 22.31 | 100 | 45.96 |

Red (22.88 mm), while minimum was in Ray Ruby (15.37 mm).

A wide range of variability was observed for all variables. Estimation of genotypic variance (VG), phenotypic variance (VP), phenotypic coefficient of variance (PCV), genotypic coefficient of variance (GCV), heritability ($h^2$) and genetic advance of mean were calculated (Table 3). Estimation of genotype VG and VP indicated that variance due to genotypes and phenotypes were found maximum for rootstock diameter, followed by petiole wing width and leaf lamina length. The variation (phenotypic variation) present in a population is due to genotypic and environment effects confirming to reports of Jawandha *et al.* (7) in lemon and Shukla *et al.* (12) in ber. The highest PCV and GCV (22.31) was recorded for petiole wing width (22.31 and 22.31) followed by spine length of tree (12.14 and 12.13) and rootstock diameter (12.31 and 11.32), respectively. The characters like rootstock diameter and petiole wing width is highly by environment than others.

GCV associated with high heritability (80% and more) indicated that the selection would be effective for the improvement of these characters but a character with low heritability (40% or less) selection may be comparatively difficult or virtually impractical due to the masking effect of the environment on the genotypic effects (Burton, 2). This indicated that selection for spine length, petiole wing width, scion : rootstock ratio and leaf thickness.

In a similar study, Panse (9) suggested that if heritability is mainly due to genetic additive effects, a high genetic advance with heritability may be expected. In the present investigation high genetic advance coupled with high heritability was observed for petiole wing width, spine length and rootstock diameter. These characters also showed the highest GCV and PCV, and selection would be highly effective.

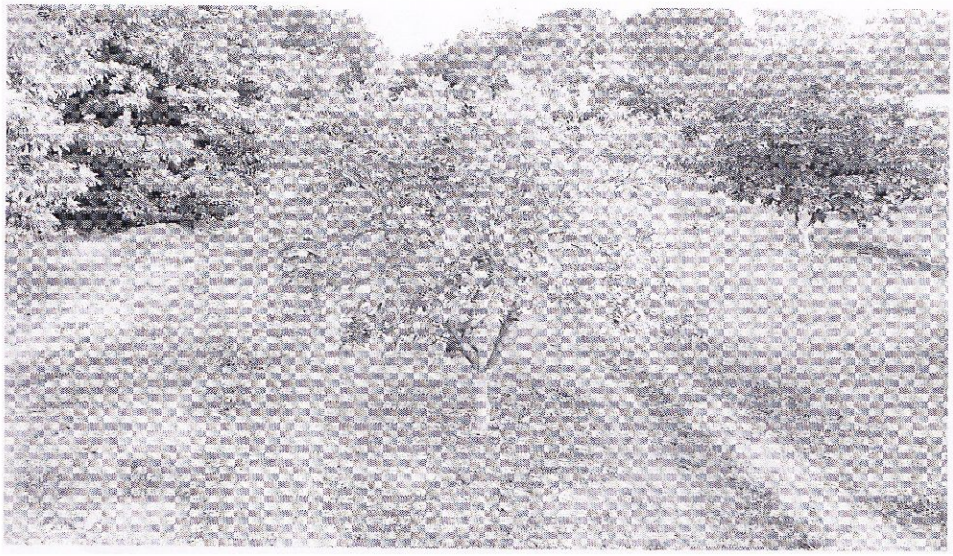

Fig. 2 : Tree Morphology in Foster.

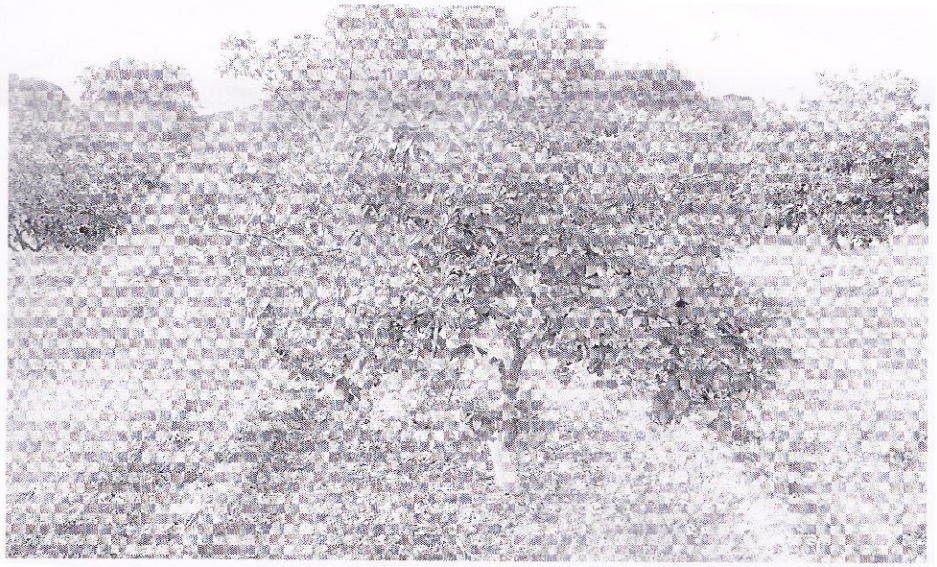

Fig. 3: Tree morphology in Marsh Seedless.

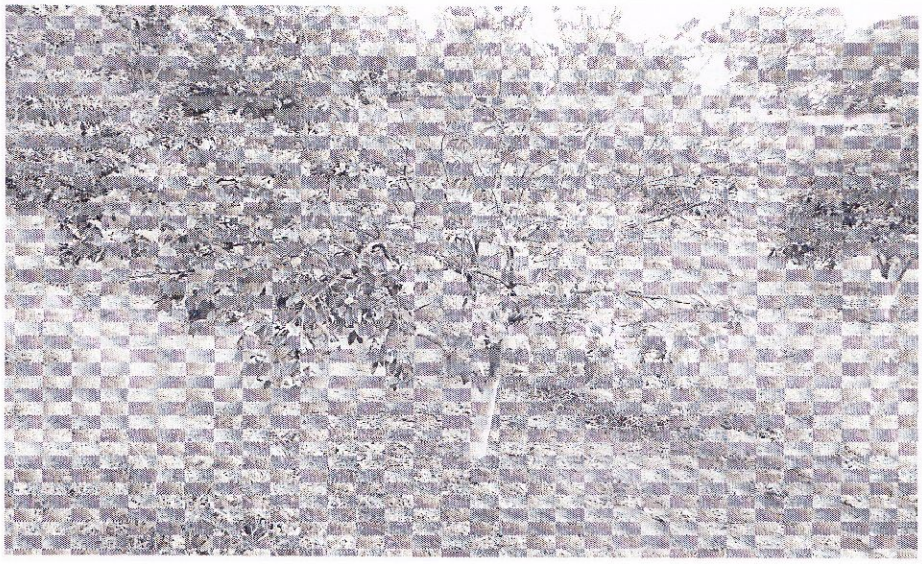

Fig. 4: Tree morphology in Red Blush.

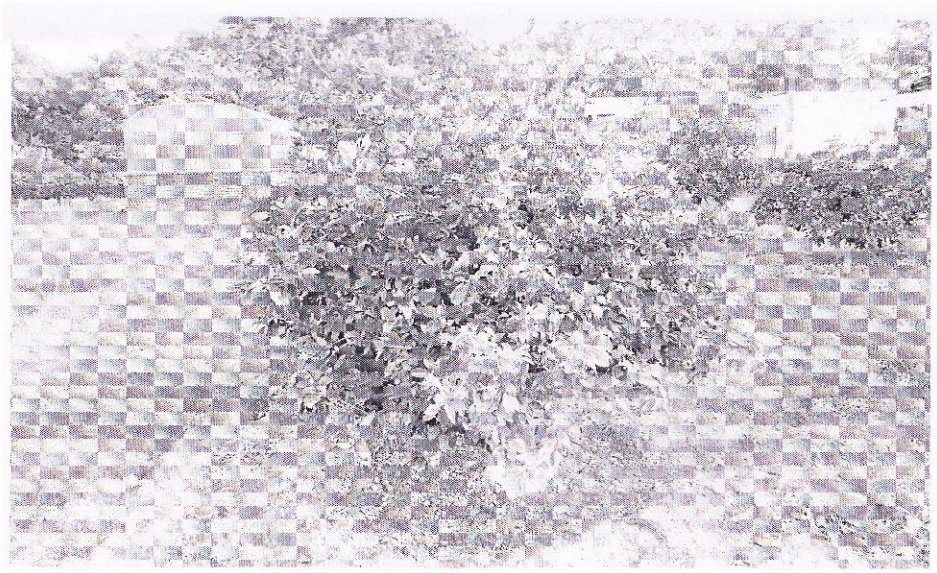

Fig. 5: Tree morphology in Ruby Red.

The study showed the existence of wide variation in vegetative characters among grapefruit varieties. These variations are indicative of the underlying genetic diversity and the influence of environmental factors.

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