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VARIETAL ASSESSMENT AND VARIABILITY STUDIES IN GRAPEFRUIT (*CITRUS PARADISI* MAC FADYEN) GENOTYPES IN SUBTROPICAL ZONES OF PUNJAB, INDIA

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ABSTRACT
Varietal assessment is the pre requisite for the selection of superior genotypes through planned breeding programme. Since then six genotypes were identified as superior clones. Wide variability in mean fruit weight (342.50 - 538.75 g per fruit), mean fruit diameter (98.42 - 118.75 mm per fruit), mean fruit length (79.95 - 94.61 mm per fruit), mean density of oil glands/cm^2 (50.25 - 135.50), mean total soluble solids (8.25 - 8.81°Brix) and mean acidity (0.64 - 0.81%) were observed among the six grapefruit genotypes. In variability studies, among six genotypes of grapefruit revealed that highest genetic advance percentage of mean was recorded for density of oil glands (71.43%) followed by albedo thickness (40.07%) and fruit weight (32.48%), suggesting that further selection will be effective for improvement in these traits.

INTRODUCTION

Vast genetic diversity of wild and semi-wild Citrus germplasm of northeastern India has minimally been used for improvement programmes due to lack of their characterization. Variability study is an essential component for the assessment of genetic diversity and selection. Even today, it is being considered and has been deployed as an initial step for cultivar identification and diversity assessment with watermelon (Huh *et al.,* 2008), sweet potato (Elameen *et al.,* 2010) and agave (Rodrguez *et al.,* 2009). Furthermore, important horticultural characters are reported to be controlled by multiple genes (Campos *et al.,* 2005, Liu and Deng 2007) and are of low heritability. Sharma *et al.* (2004) indicated wide gaps in the knowledge of useful characters of various citrus species and varieties. Despite of huge genetic diversity, very little work has been done in the past highlighting the distinguishable morphological features. Keeping this in view the availability of wide range of grapefruit genotypes was maintained at College Orchard and Fruit Research Farm of Punjab Agricultural University, Ludhiana, the present study was planned to analyze variability in grapefruit genotypes for different morphological traits.

MATERIALS AND METHODS

The experiment was carried out during 2013 to 2015 at Punjab Agricultural University, Ludhiana to evaluate fruit characterstics of six grapefruit genotypes namely, Foster, Marsh seedless, Ray Ruby, Red Blush, Ruby Red and Rio Red. The experiment was laid out in RBD (Singh *et al.*, 1998) with four replication of each variety and one plant per replication. Morphological characterization of fruits was done using descriptor developed for citrus by International Plant Genetic Resources Institute (IPGRI), Rome, Italy Anonymous (1999). Quantitative data were statistically analyzed and mean, least significant difference (LSD), PCV, GCV, heritability (h^2) and genetic advance % of mean were calculated. Fruit characters were observed for density of oil glands/cm^2, fruit diameter, fruit length, fruit weight, albedo thickness, titrable acidity, TSS, fruit axis diameter, fruit rind thickness and number of segments per fruit. Ten fruits/ plant was collected randomly and observations were recorded on each fruit separately. Parameters like fruit diameter, fruit length, albedo thickiness were recorded using Digital Vernier Caliper, Mituyoto Inc., Japan. Total soluble solids content of fully mature fruits was recorded using Digital Hand Refrectrometer. Titrable acidity was estimated by titrating a known volume of pulp juice extracted against 0.1 N sodium hydroxide (NaOH) using phenolphthalein as an indicator. Data were analyzed statistically to an analysis of variance (ANOVA) and differences among the means were determined for significance at $p < 0.05$ by LSD test using the statistical analysis system software version 9.3 (SAS Institute Inc., Cary, NC, USA) at 5% level of probability. Mean and standard errors

of each sample were calculated for statistical comparison (Singh *et al*., 1998). The phenotypic coefficient of variance (PCV) and genotypic coefficient of variance (GCV), heritability% (h^2), genetic advance (GA) and genetic advance percentage of mean were computed by using following formulas.

PCV = Square root of phenotypic variance (PV) x 100/ Grand mean

GCV = Square root of genotypic variance (GV) x 100/ Grand mean

Heritability% (h^2) = Genotypic variance (GV) / Phenotypic variance (PV) x 100

Genetic advance (GA) = Square root of phenotypic variance (PV) x h^2 x k

Where k is the differential selection and value for k is 2.06 (in broad sense)

Genetic advance percentage of mean = Genetic advance x 100/ Grand mean

RESULTS AND DISCUSSION

The investigation revealed that the genotypes differ widely for some of the considered characters (Table 1): ripening (early/ mid), fruit weight (342.50 - 528.75 g per fruit), fruit diameter (98.42 - 118.75 mm per fruit), fruit length (79.95 - 94.61 mm per fruit), albedo thickness (2.93 - 4.54 mm per fruit), density of oil glands (50.25 – 135.50 per cm^2), fruit skin colour (green yellow, dark yellow, yellow and pink yellow), pulp flesh colour (white, light red and red). Significant variation was recorded in fruit quality like total soluble content (8.25 – 8.81°Brix), acidity (0.64 - 0.81%) and number of segments per fruit (12.50 – 14.00 per fruit) was obtained among different grapefruit genotypes. Fruits of genotypes namely Rio Red and Ruby Red were matured early in the season (October), while maturity of the fruits of genotypes viz; Foster, Marsh seedless, Ray Ruby and Red Blush was recorded in November. Fruits of genotype namely, Rio Red and Ruby Red had pink yellow fruit skin, while fruits of Marsh seedless, Ray Ruby had green yellow fruit skin. The pulp flesh colour was light red in genotypes viz; Foster, Ray Ruby and Red Blush, while Rio Red and Ruby Red found to have red flesh of pulp. The highest mean fruit weight was recorded among the fruits of Rio Red (538.75 g), while the fruits of Red Blush had the lowest mean fruit weight (342.50 g). The highest mean fruit diameter and mean fruit length was recorded in Foster (118.75 mm and 94.61 mm, respectively), while the minimum mean fruit diameter and mean fruit length was observed in Marsh seedless (98.42 mm and 79.95 mm, respectively). Physio-chemical traits like total soluble solids (TSS) was reported maximum in Ruby Red (8.81°Brix), while the minimum total soluble solids was noted in Rio Red (8.25°Brix). Fruits of Ruby Red were acidic (0.81%) among all the genotypes, while fruits of Foster were reported as less acidic (0.64%). In a similar study the variations in fruit weight was recorded in pummelo by Ara *et* al. (2008). Likewise, Ishfaq *et* al. (2007) studied that among four grapefruit cultivars, Duncun had the maximum fruit weight (539 gm), while Shamber had the minimum fruit weight (503.0 gm). Kumar and Kerkhi (2015) studied genetic variability, heritability and genetic advance in spring wheat (*Tristicum aestivum* L.). Similarly, Kinley and Chinawat (2011) reported that fruit length was maximum in Samtse mandarin (50.8 mm) and the minimum was in Tsirang mandarin (44.2 mm). Likewise, Mallesh *et al*. (2015) also studied genetic variability in Okra

Table 1: Morpho -Physiochemical characters of fruits of different grapefruit genotypes

Genotypes	Density of oil glands/cm^2	Fruit diameter (mm)	Fruit length (mm)	Fruit weight (g)	Albedo thickness (mm)	Acidity (%)	TSS (° Brix)	Number of segments per fruit
Foster	85.00^{bc}	118.75^{a}	94.61^{a}	460.00^{ab}	4.54^{a}	0.64^{c}	8.72^{ab}	13.25^{abc}
Marsh Seedless	84.00^{c}	98.42^{d}	79.95^{d}	356.20^{c}	3.77^{d}	0.74^{b}	8.27^{c}	13.00^{bc}
Ray Ruby	50.25^{e}	108.13^{c}	84.67^{c}	403.75^{bc}	2.93^{e}	0.74^{b}	8.65^{abc}	13.50^{ab}
Red Blush	135.50^{a}	99.01^{d}	85.55^{c}	342.50^{c}	4.35^{b}	0.73^{b}	8.40^{bc}	12.50^{c}
Rio Red	94.25^{b}	113.44^{b}	90.82^{b}	538.75^{a}	2.85^{f}	0.74^{b}	8.25^{c}	13.50^{ab}
Ruby Red	60.50^{d}	108.24^{c}	90.28^{b}	506.75^{a}	4.26^{c}	0.81^{a}	8.81^{a}	14.00^{a}
MEAN	84.91	107.66	87.65	434.67	3.78	0.73	8.52	13.29
LSD (pd£0.05)	9.87	4.05	2.87	91.50	0.04	0.04	0.40	0.97

Different alphabets shows significant difference and same alphabets shows non significant difference among genotypes

Table 2: Variability among fruit characters in different grapefruit genotypes.

Characters	General mean	Range	GCV	PCV	Heritability in broad sense	Genetic advance	Genetic advance (% of mean)
Density of oil glands/cm^2	84.91	50.25 - 135.50	34.89	35.11	0.99	60.66	71.43
Fruit diameter (mm)	107.66	98.42 - 118.75	7.29	7.4	0.97	15.93	14.79
Fruit length (mm)	87.65	79.95 - 94.61	5.89	5.99	0.97	10.46	11.93
Fruit weight (g)	434.67	342.50 - 538.75	17.07	18.48	0.85	141.18	32.48
Albedo thickness (mm)	3.78	2.93 - 4.54	19.49	19.54	1	1.52	40.07
Acidity (%)	0.73	0.64 - 0.81	6.99	7.18	0.95	0.1	14
Total soluble soilds (TSS)	8.52	8.25 - 8.81	2.35	2.84	0.69	0.34	4.03
Number of segments per fruit	13.29	12.50 - 14.00	2.94	3.84	0.59	0.62	4.64

GCV = Genotypic coefficient of variance, PCV = Phenotypic coefficient of variance

(Abelomoschus esculatus (L.) Moench). In contrast Mitra *et* al. (2011) obtained more wide range of fruit weight in pummelo (570 – 2010 g). Similarly, Roy *et al*. (2014) reported that Type-4 pummelo had the maximum fruit weight (1.35 kg) as compared to Type-7 pummelo (0.78 kg per fruit). Singh *et al*. (2010) reported that out of six rangpur lime strains, Limonaria Rugosoda had the maximum fruit weight per fruit, while cultivar Texas had the minimum fruit weight.

In the variability studies, a wide range of variability was observed for almost all characters (Table 2). The co-efficient of variation (both genotypic and phenotypic) was higher for the characters like density of oil glands/cm^2 (35.11 and 34.89, respectively) followed by albedo thickness (19.54 and 19.49, respectively) and fruit weight (19.54 and 19.49, respectively).

GCV associated with high heritability (80% or more) indicated that selection would be effective for the improvement of these characters but for a character with low heritability (40% or less) selection may be comparatively difficult or virtually impractical due to masking effect of the environment on the genotypic effects (Burton, 1952). This indicated that selection for density of oil glands, albedo thickness, fruit weight and fruit diameter would be effective.

In a similar study, Panse (1957) suggested that if heritability is mainly due to additive genetic effects, a high genetic advance coupled with high heritability may be expected. In the present investigation high genetic advance (as percent of mean) was higher for density of oil glands/cm^2, albedo thickness, fruit weight, fruit diameter and fruit length respectively. So, selection would be highly effective for these traits.

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