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# GENETIC VARIABILITY AND CHARACTER ASSOCIATION STUDIES IN IDENTIFIED KAGZI LIME (*CITRUS AURANTIFOLIA* SWINGLE) GENOTYPES

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## ABSTRACT

The present study on variability, heritability, genetic advance as percentage of mean and character association in 24 kagzi lime genotypes with three check varieties PDKV lime, Sai-Sharbati and Chakradhar for different characters of growth, fruiting and quality levels were evaluated. High GCV was found for fruit set per cluster (40.50 %), fruit set per cent per cluster (32.47 %), fruit yield per tree (30.66 %), number of fruits per tree (24.72 %) and number of seed per fruit (22.93 %). In all case phenotypic variance were higher than genotypic variance. The highest heritability was observed in number of seeds per fruit (89.00 %) and expected genetic advance for number of fruits per tree (63.10 %). Fruit yields per tree exhibited highly positive correlation for number of fruits per tree (0.93, 0.91), juice percentage (0.55, 0.42), fruit weight (0.58, 0.55), fruit volume (0.52, 0.43), number of fruits per cluster (0.92, 0.70) and fruit set percentage per cluster (0.97, 0.65). Hence, selection of these traits may be followed for the improvement of kagzi lime through direct selection and for developing new hybrids.

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## INTRODUCTION

Citrus is the third most important fruit crop in India. It is grown in 0.48 million ha area with a total production of 4.27 million tonnes (Kumar *et al.,* 2013). Indian is chief producer of lime in the World. The cultivation is gaining momentum as the fruits are rich source of vitamin C and possess high medicinal values. These are known to have cu-rative value for various diseases of bones and joints, bilious diseases, prevention of capillary bleeding, piles, dysentery, cold, influenza, habitual constipation and scurvy.

The study of kagzi lime germplasm available in the various orchards of Vidarbha shall boost up the pace of improvement of the crop through various improvement devices. To evolve improved cultivars with better quality, information on association of quantitative and qualitative characters are of immense value in selection. The chances of success of any crop improvement programme increases to a greater extent due to genetic variability within the available germplasm. Thus, the greater variability in the initial material will ensure evolution of desirable recombination by using suitable breeding methods. Kagzi lime being an open pollinated and heterozygous crop with adequate genetic variation helps in selection of desirable commercial types (Ranpise, 1993). The extent of variability in kagzi lime for vegetative and fruit characteristics has been estimated by several workers (Jature and Chakrawar, 1981; Ranpise, 1993; Kumar *et al.*, 2013). Efforts were made in the past to collect kagzi lime variability from various sources (Patil, 1983). For continued improvement of kagzi lime through breeding to overcome threats from diseases, insect pests or biotic stresses and to evolve varieties according to consumer preferences, a diverse gene pool is essential. Effective selection of genotypes for desirable traits is determined by the estimates of heritability along with genetic advance. The progress in breeding programme depends on magnitude of genetic variability present in breeding material (Himabindu *et al.,* 2016). So, it is imperative to identify superior strains of kagzi lime for their collection, conservation, evaluation and utilization in the future breeding programmes. Hence, the present investigations were carried out to record the ex-tent of genetic variability among existing kagzi lime genotypes, association of characters related to fruit yield and quality, and locate the elite genotypes pos-sessing desirable fruit characteristics.

## MATERIALS AND METHODS

The experiment was conducted during 2013-14 at AICRP on Fruits (Citrus), Dr. P.D.K.V., Akola (MS) in 24 genotypes of kagzi lime from various orchards and zygotic seedling selections. These are being maintained in the citrus collection block. The experimental site comes under semi arid ecosystem. The soil was heavy clay with medium fertility status and good water-holding capacity. The observations on tree growth, fruit development, fruit quality and yield were recoreded, when all the genotypes came in fruiting. Fruit diameter and peel thickness was recorded with the help of vernier callipers. T.S.S. was determined with the help of digital refractometer (4406 ATAGO). Estimation of fruit volume (ml) by water displacement method, specific gravity (weight/volume) and Fruit shape index [(Equatorial diameter + Polar diameter)/2)] was followed. Acidity (%) and ascorbic acid (mg/100 ml) was estimated using standard method (Ranganna, 1973). One tree of each treatment selected, marked, and kept under observations for recording various observations. The observations recorded were as per the keys explained by Mrinalini (2005) and Patil (2014). Since the study is based on single tree observation, the samples for observations were collected from each direction i.e. East, West, South and North and each of these directions were considered as one replication. Morphological observations of the trees as well as of the fruits were recorded. Studies were undertaken when the fruits physiologically mature. In each genotype, fruits were randomly collected for their qualitative as well as quantitative characters. The statistical analysis was as for the proportion of genotypic variance to phenotypic variance and heritability percentage in broad sense is calculated by the formulae as suggested by Johnson *et al*. (1955). The character association analysis was carried out as per the standard method suggested by Panse and Sukhatme (1978).

## RESULTS AND DISCUSSION

Genetic variability has been observed among twenty four kagzi lime genotypes in their various characters. A wide variation has been recorded in the characters *viz.,* number of flowers per cluster (6.25 to 8.25), number of fruit set per cluster (1.25 to 5.75), fruit set percentage per cluster (19.05 to 76.79), leaf area (16.15 to 18.46 cm$^2$), polar diameter (3.08 to 4.20 cm), equator diameter (2.95 to 4.13 cm), fruit weight (39.45 to 58.53 g), fruit volume (33.01 to 54.30 cm$^3$), fruit shape (0.99 to 1.12) fruit size (17.36 to 9.08 cm$^2$), number of segments (10.25 to 9.75), number of seeds per fruit (1.50 to 11), peel thickness (1.70 to 2.73 mm), total soluble solids(7.33 to 8.25 $^0$Brix), juice percentage (35.31 to 52.49), specific gravity (0.91 to 0.95), ascorbic acid (25.79 to 31.91 mg/100 ml of juice), acidity (7.03 to 8.66 %), TSS/acidity ratio (0.90 to 1.11), number of fruit per side of tree (73.00 to 237) and fruit yield per side of tree (3.47 to 13.89 kg/side of tree) among all the selected genotypes (Table 1).

In the present investigation the phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the characters (Table 1), indicating the substantial modifying effect of environment in the expression of all traits studied. These results corroborate the view of Singh *et al*. (1980) in mandarin, Ranpise (1993) in kagzi lime; Mrinali (2005) and Patel *et al*. (2015) in guava.

High genotypic coefficient of variation (Table 1) was observed for number of fruit set per cluster, number of fruit set percent cluster, fruit yield/tree, number of fruits per tree, number of seeds/fruit, fruit volume, fruit weight juice percentage, acidity, TSS/ acidity ratio and fruit yield per tree. High GCV is an indication of greater range of variability among the population and scope of improvement of these characters through simple selection. Similar findings pertaining to different traits including the characters fruit weight, fruit yield, juice percentage and fruit yield per tree was noticed by Singh *et al*. (1980) in mandarin, for number of fruits per tree, fruit volume in papaya by Singh *et al*. (1997), fruit weight and fruit volume in mango by Nayak *et al*. (2013). However, the highest PCV was observed for number of fruit set per cluster, fruit set per cluster, fruit set percent per cluster, fruit weight, seeds per fruit, fruits per tree and fruit yield. Similar result was noticed by Chakrawar and Jature (1980) in acid lime. The differences between the GCV and PCV for all the characters were narrow suggesting that the characters were less affected by environment (Himabindu *et al.,* 2016).

The highest heritability (Table 1) was reported in number of seeds per fruit (89.00 %) followed by fruit yield (80.00 %) and number of fruits (79.00 %). Patel *et al*. (2015) reported that heritability value for fruit yield was high in guava. The high heritability indicated the effectiveness of selection based on phenotypic performance but does not necessarily mean high genetic advance for the particular trait. The characters with high heritability when associated with high genetic gain may be attributed to the additive gene effects (Panse, 1957), which

**Table 1: Estimates of variability, heritability, expected genetic advances per cent of mean**

| Sr. No. | Character | Range | Mean | PCV (%) | GCV (%) | ECV (%) | Heritability ($h^2$) % | Expected genetic advance as % over mean (EGA) |
|---|---|---|---|---|---|---|---|---|
| 1 | Number of flowers per cluster | 6.25-8.25 | 6.84 | 11.05 | 6.63 | 8.84 | 35.00 | 0.56 |
| 2 | Number of fruit set per cluster | 1.25-5.75 | 2.64 | 49.95 | 40.50 | 29.23 | 65.00 | 1.78 |
| 3 | Fruit set percent per cluster | 19.05-76.79 | 38.20 | 45.12 | 32.47 | 31.33 | 51.00 | 18.39 |
| 4 | Leaf area (m$^2$) | 16.15-18.46 | 17.75 | 3.94 | 3.33 | 2.11 | 71.00 | 1.02 |
| 5 | Fruit weight (g) | 39.45-58.53 | 48.34 | 12.49 | 9.41 | 8.21 | 56.00 | 7.06 |
| 6 | Fruit volume (cm$^3$) | 33.01-54.30 | 44.13 | 14.57 | 12.81 | 8.54 | 65.00 | 8.70 |
| 7 | Number of seeds/fruit | 1.50 -11.00 | 9.40 | 24.22 | 22.93 | 7.79 | 89.00 | 4.20 |
| 8 | Peel thickness (mm) | 1.70-2.73 | 2.22 | 14.71 | 11.98 | 8.53 | 66.00 | 0.44 |
| 9 | Total soluble solids ($^o$Brix) | 7.33-8.25 | 7.66 | 4.37 | 3.55 | 2.54 | 66.00 | 0.45 |
| 10 | Juice percentage (%) | 35.31-52.49 | 43.15 | 11.22 | 7.42 | 8.41 | 43.00 | 4.37 |
| 11 | Specific gravity | 0.91-0.95 | 0.93 | 1.14 | 0.78 | 0.83 | 47.00 | 0.01 |
| 12 | Ascorbic acid (mg/100 ml juice) | 25.79-31.91 | 28.19 | 8.67 | 5.38 | 6.80 | 38.00 | 1.94 |
| 13 | Acidity (%) | 7.03-8.66 | 7.71 | 6.19 | 5.10 | 3.51 | 67.00 | 0.66 |
| 14 | TSS/acidity ratio | 0.90-1.11 | 1.00 | 5.82 | 3.87 | 4.34 | 44.00 | 0.05 |
| 15 | Number of fruits per tree | 73.00-237 | 139.01 | 27.74 | 24.72 | 12.58 | 79.00 | 63.10 |
| 16 | Fruit yield per tree | 3.47-13.89 | 6.76 | 34.18 | 30.66 | 15.11 | 80.00 | 3.82 |

**Table 2: Estimation of genotypic and phenotypic coefficient for various characters (r).**

| | | Genotypic and phenotypic correlation<br>Number of flowers per cluster | Fruits set per cluster | Fruits set percentage / cluster | Leaf area (cm²) | Fruit weight (g) | Fruit volume (cm³) | Fruit Shape index | Number of seeds per fruit | Peel thickness (mm) | TSS (⁰Brix) | Juice per centage (%) | Specific gravity | Ascorbic acid(mg/ 100ml of juice) | Acidity (%) | TSS/ acidity ratio | Fruits /tree | Yield/ tree (Kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of flowers | G | 1 | 0.9094** | 0.8696** | 0.1024 | 0.8433** | 0.8694** | 0.5127** | 0.09 | -0.1445 | 0.5555** | 0.7282** | 0.4454** | 0.5511** | 0.1253 | 0.3797 | 0.4595** | 0.6703** |
| | P | 1 | 0.4413* | 0.2222 | 0.056 | 0.3608 | 0.3921 | -0.0814 | 0.066 | -0.1244 | 0.2228 | 0.2229 | 0.2145 | 0.175 | 0.1215 | 0.035 | 0.2707 | 0.3817 |
| Number of fruits | G | | 1 | 0.9938** | 0.1933 | 0.7218** | 0.6084** | 0.53** | 0.3881 | -0.3068 | 0.5211** | 0.4821** | 0.5098** | 0.484** | 0.2764 | 0.1315 | 0.789 | 0.9293** |
| per cluster | P | | 1 | 0.9677** | 0.1516 | 0.4386* | 0.42 | -0.0462 | 0.2505 | -0.1918 | 0.3721 | 0.3696 | 0.2034 | 0.2337 | 0.2406 | 0.0297 | 0.6111** | 0.7079** |
| Fruit set percentage | G | | | 1 | 0.1981 | 0.6688** | 0.5309** | 0.5199** | 0.4743** | -0.3035 | 0.4897** | 0.4202* | 0.5114** | 0.4025 | 0.2706 | 0.1063 | 0.8565** | 0.9694** |
| per cluster | P | | | 1 | 0.1525 | 0.3604 | 0.3401 | -0.0172 | 0.2634 | -0.1427 | 0.3256 | 0.3395 | 0.1628 | 0.1762 | 0.2172 | 0.0202 | 0.5815** | 0.649** |
| Leaf area (cm²) | G | | | | 1 | 0.1804 | 0.1199 | -0.0457 | 0.4607** | 0.0804 | 0.394 | -0.2516 | 0.1598 | 0.0219 | 0.1164 | 0.216 | 0.2667 | 0.2806 |
| | P | | | | 1 | 0.0637 | 0.0967 | -0.0212 | 0.371 | 0.1125 | 0.2148 | -0.2064 | 0.0798 | 0.0133 | 0.0867** | 0.0791 | 0.1339 | 0.1391 |
| Fruit weight (g) | G | | | | | 1 | 0.9624** | 0.4554** | 0.0661 | -0.253 | 0.393 | 0.646** | 0.3338 | 0.4951** | 0.3168 | -0.0526 | 0.2678 | 0.583** |
| | P | | | | | 1 | 0.8605** | -0.0875 | 0.0368 | -0.1145 | 0.2735 | 0.4368* | 0.2348 | 0.3557 | 0.2558 | -0.0736 | 0.1737 | 0.5493** |
| Fruit volume (cm³) | G | | | | | | 1 | 0.3846 | 0.0223 | -0.2465 | 0.3943 | 0.7249** | 0.351 | 0.3882 | 0.2818 | -0.0059 | 0.2128 | 0.5208** |
| | P | | | | | | 1 | -0.031 | 0.0113 | -0.0777 | 0.2464 | 0.3567 | 0.1948 | 0.3278 | 0.2355 | -0.0682 | 0.0988 | 0.4318* |
| Fruit shape index | G | | | | | | | 1 | 0.1319 | -0.0509 | -0.0131 | 0.4167** | 0.2646 | 0.5805** | -0.1904 | 0.2477 | 0.2218 | 0.3232 |
| | P | | | | | | | 1 | -0.0287 | 0.0784 | 0.1074 | -0.0017 | -0.0463 | 0.1154 | 0.0924 | -0.0135 | -0.0205 | -0.0546 |
| Number of | G | | | | | | | | 1 | 0.3333 | 0.06 | -0.0195 | 0.2378 | -0.4739** | -0.0258 | 0.1042 | 0.4464 | 0.3824 |
| seeds / fruit | P | | | | | | | | 1 | 0.276 | 0.0307 | 0.0063 | 0.1641 | -0.238 | -0.0312 | 0.0665 | 0.3552 | 0.305 |
| Peel thickness (mm) | G | | | | | | | | | 1 | -0.4038 | -0.0368 | 0.115 | -0.806** | -0.6061** | 0.4427* | -0.0519 | -0.1622 |
| | P | | | | | | | | | 1 | -0.2877 | -0.0217 | 0.0024 | -0.3333 | -0.4696** | 0.2969 | -0.0317 | -0.0983 |
| TSS (⁰Brix) | G | | | | | | | | | | 1 | -0.0607 | 0.1891 | 0.6532** | 0.6644** | 0.0305 | 0.325 | 0.4151 |
| | P | | | | | | | | | | 1 | -0.0313 | 0.0375 | 0.3051 | 0.4665** | 0.2429 | 0.2557 | 0.3271 |
| Juice percentage (%) | G | | | | | | | | | | | 1 | 0.6828** | 0.0828 | -0.3265 | 0.3916 | 0.3692 | 0.5545** |
| | P | | | | | | | | | | | 1 | 0.3394 | 0.1874 | -0.1509 | 0.1372 | 0.2818 | 0.4259* |
| Specific gravity | G | | | | | | | | | | | | 1 | -0.1183 | -0.2705 | 0.5798 | 0.1986 | 0.3209 |
| | P | | | | | | | | | | | | 1 | 0.0403 | -0.1061 | 0.1599 | 0.1106 | 0.2052 |
| Ascorbic acid (mg/ | G | | | | | | | | | | | | | 1 | 0.5711 | -0.1694 | -0.0225 | 0.1948 |
| 100ml of juice) | P | | | | | | | | | | | | | 1 | 0.3516 | -0.1447 | 0.0194 | 0.1795 |
| Acidity (%) | G | | | | | | | | | | | | | | 1 | -0.7261 | -0.0396 | 0.0764 |
| | P | | | | | | | | | | | | | | 1 | -0.7412 | -0.0616 | 0.0505 |
| TSS/ acidity | G | | | | | | | | | | | | | | | 1 | 0.3485 | 0.2831 |
| | P | | | | | | | | | | | | | | | 1 | 0.25 | 0.1845 |
| Number of fruits | G | | | | | | | | | | | | | | | | 1 | 0.9348** |
| / tree | P | | | | | | | | | | | | | | | | 1 | 0.9129** |
| Yield / tree (Kg) | G | | | | | | | | | | | | | | | | | 1 |
| | P | | | | | | | | | | | | | | | | | 1 |

*Significant at 5% level; ** Significant at 1% level.

can be effectively be improved by selection. On the other hand, high heritability and low genetic advance may be attributed to low phenotypic variability. These characters may be improved through hybridization, while low heritability estimates suggested that the selection for the character under consideration will not be effective.

Table 1 revealed that, expected genetic advance (EGA) expressed as percentage over mean ranged from 0.01 (specific gravity) to 63.10 (number of fruits per tree). High values of genetic advance as percentage of mean (> 20 %) were obtained in the present study for number of fruits per tree which indicated that selection of this character would be more effective. Such association may be attributed to the action of additive genes (Patel *et al.*, 2015). Similar findings with high EGA were pertaining to number of fruits and fruit yield reported in mandarin by Singh *et al.* (1980), Patel *et al.* (2015) in guava and Himabindu *et al.* (2016) in mango.

Generally high heritability accompanied with high genetic advance in a characters suggest that the inheritance of such character was governed mainly by additive gene effects and therefore improvement in these traits would be more effective by selection in the present material. During present study characters like number of fruit set per cluster, fruit weight, fruit volume, juice percentage, acidity (%), number of fruits per tree and fruit yield per tree had high heritability values along with the high genetic advance. Although, estimates of high heritability are useful to breeder as they provide basis of transmissible genes from parent to progeny. More reliable conclusion can be drawn when heritability is considered along with the genetic advance. Thus, the expressions of these traits were predominantly governed by additive gene effects and therefore selection based on phenotypic performance will be useful to improve these characters in future. More, over it was seen that these traits had less influence of the environment. The similar findings were also reported by Singh *et al.* (1997) in papaya and Patil (2014) in guava.

It is evident from Table 2 that the character association analysis between seventeen quantitative and qualitative characters was positive and significant between fruit yields per tree, number of fruits per tree, juice percentage, fruit weight, fruit volume and fruit set percentage. These characters were also positively interlinked among themselves.

The character fruit weight showed positive and significant correlation with fruit volume, fruit shape index, juice percentage and ascorbic acid at genotypic level. The similar correlation on fruit weight and juice percentage was reported by Chakrawar and Jature (1980), Patil (1983) and Desai *at al.* (1994).

The character average number of seeds per fruit showed negative and significant genotypic correlations with juice percentage and acidity. It indicates when the number of seeds per fruit increases, the juice percentage and acidity decreases. The similar association between number of seeds per fruit, total soluble solids and acidity was reported by Ranpise (1993).

Peel thickness character showed negative and significant genotypic correlation with ascorbic acid and acidity. It indicates, the increase in peel thickness increases the ascorbic acid and decreases acidity. The results are in concurrence with Desai *et al.* (1994). Ranpise (1993) reported the similar association between the peel thickness and acidity in kagzi lime genotypes. The positive and strong correlation was reported between TSS and acidity at both genotypic and phenotypic level. In acid lime, the similar result was reported by Bartholomew and Sinclair (1943).

The character juice percentage showed positive and significant correlations with, fruit weight, fruit volume, fruit yield per tree at both genotypic and phenotypic level. Similar result was noticed by Longkumer and Jahangir (2015) in mandarin. The number of fruits per tree was found highly significant with fruit yield per tree at both genotypic and phenotypic level. Therefore, the selection for number of fruits per tree will increased automatically lead to selection for higher yield. Similar results were reported by Patil (1983) in kagzi lime.

The studies indicate that the magnitude of correlation was significantly the highest between fruit yield per tree and number of fruits per tree (Table 2). The correlation among the yield contributing characters fruits per cluster, fruit set percent per cluster, fruit volume, and number of fruits per tree was highly significant. Thus an increase in number of fruits and fruit set percentage accompanies increase in yield per tree. Therefore, the selection for number of fruits per tree will lead to selection for higher yield. Improvement in kagzi lime by this method has reported by Patil (1983) and Jature and Chakrawar (1981).

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