**Evaluation and Analysis of local mango (*Mangifera indica* L.*)* landraces**

ABSTRACT

India is the largest producer of choicest table varieties of mango in the world, and wide variability has been found in fruit shape, size and taste, but commercial importance is given to nearly about 30 mango cultivars in the country. An attempt was made to study characterization and evaluation in mango. In the present investigation, one hundred genotypes of mango were selected and coded with location-wise abbreviation. Among the identified genotypes, twenty-five elite promising mango accessions were selected on the basis of desirable horticultural traits for final evaluation in a randomized block design (RBD) with three replications. Observations were recorded on various morphological parameters. The obtained data was applied to a Principal Component Analysis (PCA) using R software, and the packages HSAUR and Hmisc. Maximum fruit weight (200.00 g) and fruit breadth (7.50 cm) was recorded in AKS-1 and fruit length (10.90 cm) in AA-7 genotype, whereas, minimum values of these characteristics i.e. 80.10g fruit weight was noted in genotype AP-1 and 5.50 cm fruit length and 4.10 cm fruit breadth was noted in genotype AR-1. Maximum pulp percentage was recorded (64.00%) in genotype AA-7 and minimum in AKCA-14 (55.26%), however, maximum pulp: stone ratio (7.04) was noted in genotype AKCA-14 and minimum (1.99) in AGKB-64. Fruits with thickest peel (2.19 mm) were harvested from genotype AA-7 and with minimum peel thickness from genotype AP-1 (0.30 mm). Maximum specific gravity (1.12) was observed in genotype AA-2 and minimum in genotype AA-39 (1.00). Maximum stone weight, length and breadth i.e. 52.86g, 9.00 cm and 6.10 cm was recorded in genotypes AA-19, AA-7 and AA-3. Whereas, minimum stone weight (10.00 g), length (4.70 cm) and breadth (2.96 cm) was noted in AKCA-14, AP-1 and GQ-3 genotypes. The heaviest seed (25.10g) was found in genotype AA-19 and the minimum seed weight was recorded in genotype AP-1 (5.10g). Seed length and width were maximum in ABG-1 (5.83 cm) and AA-9 (4.15 cm) genotypes. Minimum seed length and width was recorded in genotypes AP-1 (3.00 cm) and GQ-3 (1.92 cm). The information was compared with similar information for Indian landraces of Mangoes. It was concluded that the germplasm with desirable traits can be proved to be good genetic material for the utilization in future breeding programmes for improving the mango varieties in Punjab or South America. Genotypes AKS-1 and AA-19 were excellent in terms of fruit weight. Hence, it can be included for future systematic breeding as well as hybridization programme of mango to inculcate and/or concentrate favourable attributes among the improved progenies.

Key words: *Mangifera indica*; Genotype susceptibility; Punjab; India

**1. Introduction**

The mango is cultivated mostly in frost-free tropical and warm subtropical climates; almost half of the world’s mangoes are cultivated in India (Ierla et al., 2013; Singh & Singh 2021a). Until the middle of the twentieth century, mango was regarded as a significant economic crop in Asian nations only. Later on, mango farming spread and now continues to develop in fresh sub-tropical and tropical regions. It has become a significant export commodity in non-traditional mango producing nations where the substantial percentage of their fruit production is exported (Rajan, 2021). India is the largest producer of choicest table varieties of mango in the world and wide variability has been found in fruit shape, size and taste but commercial importance is given to nearly about 30 mango cultivars in the country (Hussain et al., 2021; Singh & Singh 2021b). Key regions, such as the Lucknow-Saharanpur belt in Uttar Pradesh, the Murshidabad area of West Bengal, and the Hyderabad area of Andhra Pradesh, have emerged as centers of diverse mango collections, contributing significantly to genetic diversity and broader mango conservation (Rajan et al., 2024). But still, the mango industry lags far behind in the world due to low productivity, higher incidence of insect pests, diseases and physiological disorders, etc. Mango is a cross-pollinated fruit crop, and almost the majority of mango cultivars under cultivation in the world are selections from open pollinated seedling populations. The mango fruit itself is a fleshy drupe, displaying variations in size, shape, and colour. The most appealing and edible part of the fruit is the fleshy mesocarp. Within each mango fruit lies a single seed enclosed within a stony endocarp (Bura et al., 2023). The seedling wealth in the state is depleted rapidly due to adoption of wheat-paddy crop rotation, sunflower, potato, maize, high value crops, etc., and farmers are uprooting the old indigenous mango plantations (Navprem et al., 2012; Harikumar, 2016). The mango germplasm conserved at Government Gardens in the state is not properly characterized, and it is the need of the hour to evaluate and characterize the existing germplasm in the central and sub-montane zones of the Punjab to use them in future breeding programmes (Singh & Singh 2021a). The varieties existing are numerous, with different qualities, some of them are superior ones, with attractive colour, tolerant to diseases, etc., but not resistant to certain problems. Such mango germplasm is not known to other parts of India. Thus, there is tremendous possibility of such material to act as source for further propagation as well as breeding material for hybridization to evolve new varieties with desirable traits.

**2. Materials and Methods**

In the present investigation, one hundred genotypes of mango were selected and coded with location wise abbreviation as AA for Amritsar Attari, AKCA for Amritsar Khalsa College, AP for Amritsar Pairewal, AUG for Amritsar Ugar Aulak, AGKB for Amritsar Guru Ka Bagh, ABG for Amritsar Bhure Gill, AKS for Amritsar Katli Sakka, AR for Amritsar Rayya, GQ for Gurdaspur Qadian, GRB for Gurdaspur Ranjit bagh and GJB for Gurdaspur Jawahar Bagh. Among the identified genotypes, twenty-five elite promising mango accessions were selected on the basis of desirable horticultural traits for final evaluation in a randomized block design (RBD) with three replications. The physicochemical analysis of properly matured mango fruits was taken at random and was placed in bamboo baskets lined and covered with newspaper and stored at ambient conditions for ripening (Singh & Singh, 2021a, b).

Fruit size: The length and breadth of fruits harvested from selected plants were recorded with the help of Vernier Calliper and their average was calculated in cm.

Fruit weight: The weight of fruits harvested from selected plants was taken with the help of a simple pan balance and their average was calculated to find out the weight of fruit in grams.

Specific gravity: Specific gravity was determined by dividing the average fruit weight in g by the average fruit volume in cc.

Stone size: The length and breadth of the stone from selected fruits was recorded with the help of Vernier Calliper and the average stone size was expressed in cm.

Stone weight: The stone (after removing skin and pulp and washing thoroughly with water) weight of selected fruit was taken with the help of a simple pan balance and the average was calculated in grams.

Seed size: The length and width of the seed (after removing from the stone) from selected fruits was recorded with the help of Vernier Calliper and the average stone size was expressed in centimetres.

Seed weight: The seed after removing from the stone of the selected fruit was taken with the help of a simple pan balance and the average was calculated in grams.

Pulp content: Pulp weight was calculated by subtracting the peel and stone weight from the total fruit weight of selected fruits. Pulp content was expressed in percentage.

Pulp/stone ratio: The pulp weight was subtracted from the total weight of fruit and the value obtained was divided by the stone weight of the selected fruit.

Peel thickness: The peel thickness of selected fruits was recorded as mean of three measurements per fruit from Basal, middle and apical portion of fruit with the help of screw gauge and expressed in mm.

The obtained data was applied to a Principal Component Analysis (PCA) using R software (R Core Team, 2021), and the package HSAUR (Everitt & Hothorn, 2016) and Hmisc (Harrell, 2016).

**3. Results and Discussion**

Morphological characteristics of fruit, stone and seed, the data regarding fruit, stone and seed morphology showed tangible genetic diversity in the different evaluated seedling mango plants as represented in Table 1. Amongst the evaluated germplasm, fruit length varied from 5.50 to 10.90 cm. The maximum fruit length (10.90 cm) was noted in the genotype AA-7. It is clear from the tabular data that the maximum fruit breadth was observed in genotype AKS-1 i.e. 7.50 cm. Fruit weight varied from 80.10 to 200.00 g with the maximum fruit weight recorded in the genotypes AA-19 and AKS-1. Next in the order were genotypes AA-7, AA-1, AA-8, AR-1, AA-2, AA-39, AA-29, AGKB-64, ABG-1, AA-9, AUG-1, AA-20 and GQ-3 having fruit weight of 165.00, 135.00, 133.30, 130.00, 123.30, 120.00, 120.00, 120.00, 115.00, 110.00, 106.70, 100.10 and 100.00 g, respectively. The genotype AA-7 contained the highest quantity (64.00%) of pulp. The lowest pulp percentage (55.26%) was in AKCA-14. Singh (2002) also noticed the maximum mango fruit pulp content as 67.17%, while evaluating twenty-one mango varieties. The pulp: stone ratio varied from 1.99 to 7.04. The genotype AKCA-14 revealed the highest pulp: stone ratio and it was closely followed by GJB-1 and AP-1 genotypes with pulp: stone ratio of 5.94 and 5.67, respectively. Specific gravity of mature fruits ranged from 1.00 to 1.12. The maximum specific gravity was noted in genotype AA-2. The present findings are in conformity with the findings of Kumar (2004), who also observed similar variability in specific gravity of different mango varieties. The thinnest (1.30 mm) and thickest (2.16 mm) peel was observed in genotypes AA-19 and AP-1, respectively. This result is in line with the research findings of Harikumar (2016), who evaluated peel thickness of various mango germplasm. The maximum stone length (9.00 cm) was recorded by genotype AA-7, followed by genotypes AKS-1, AA-19, AA-1, AA-9, ABG-1, AA-15, AA-3, AA-8, AA-2, GJB-1, AA-39 and AUG-1. Stone breadth varied from 2.96 to 6.10 cm in the evaluated seedling mango germplasm, where the least measure was recorded for this in genotype GQ-3. Almost identical results had been reported by Ierla (2013), who obtained the variation of fruit breadth from 6.50 cm to 8.50 cm, while evaluating one hundred and three mango accessions. Fruits with the heaviest (52.36 g) and lightest (10.00 g) stone weights were noted in the genotypes AA-19 and AKCA-14, respectively. These results, regarding stone weight, are in accordance with the findings of Rajan *et al*. (2009). Seed length ranged from 3.00 to 5.83 cm with the maximum in genotype ABG-1. The highest seed width was recorded in AA-9 (4.15 cm). Seed weight varied from 5.10 to 25.10 g. The maximum and minimum for this were documented from genotypes AA-19 and AP-19, respectively.

The correlation analysis revealed the existence of significant direct associations between seed weight with percentage, thickness, stone length, stone weight, and seed length; seed width with stone length and stone breadth, seed length with percentage, thickness, stone length and stone weight, stone weight with percentage, ratio, thickness and stone length, stone breadth with stone length, and thickness with percentage (Table 2). Finally, a significant inverse relation was found between seed weight, thickness, ratio, ratio with percentage (Table 2).

The results of PCA revealed that the main contributor factors for axis 1 were thickness, stone weight, and seed weight, whereas for the second axis, the main contributor variables were gravity, stone breadth, and seed width (Table 3, Figure 1). The PCA results revealed that landraces AA-4, AA-7, AA-29, AA-39, AA-42, AA-101, ABG-1, AGKB-4, AP-1, AUG-1 and GQ-3 have low values of seed width, stone breadth, and stone length (Fig. 1), whereas a second group joined AA-1, AA-8, AA-15, and AKS-1, that have high values of seed length, percentage, thickness, stone length and stone weight (Fig. 1). A third group joined AA-2, AA-3, AA-9, and AA-16 that has high values of gravity, seed width and stone breadth (Fig. 1), finally a fourth group joined sites with high ratio values AKCA14, GJB-1, AA-16 and AR-1 (Fig 1). From the overall outcomes of the present investigation, it is evident that the germplasm with desirable traits can be proved to be good genetic material for the utilization in future breeding programmes for improving the mango varieties in Punjab (Singh & Singh 2021a,b; Kumar et al., 2021) or South America (Muñoz-Redondo et al., 2021; Tuisima-Coral & Escobar-García, 2021). Genotypes AKS-1 and AA-19 were excellent in terms of fruit weight, and can be included for future systematic breeding as well as hybridization programme of mango to inculcate and/or concentrate favourable attributes among the improved progenies (Lawson et al., 2019; Jena & Chand, 2021).

4. **Conclusion**

In conclusion,the germplasm with desirable traits can be proved to be good genetic material for the utilization in future breeding programmes for improving the mango varieties in Punjab or South America. Genotypes AKS-1 and AA-19 were excellent in terms of fruit weight, and can be included for future systematic breeding as well as hybridization programme of mango to inculcate and/or concentrate favourable attributes among the improved progenies.

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Table 1: Physical characters: description of physical fruit attributes in evaluated genotypes.

|  |  |  |
| --- | --- | --- |
| SelectionNumber | CollectorCode | Fruit characters |
| Fruit Size | FruitWeight (g) | Pulp (%) | Pulp / stone ratio | Specificgravity (w/v) | Peelthickness (mm) |
| Fruit length (cm) | Fruit breadth (cm) |
| 1 | AP- 1 | 5.55 | 4.12 | 80.10 | 55.97 | 5.67 | 1.03 | 1.30 |
| 2 | AKCA -14 | 6.10 | 5.19 | 80.40 | 55.26 | 7.04 | 1.05 | 1.34 |
| 3 | GJB -1 | 8.00 | 5.25 | 83.30 | 57.20 | 5.94 | 1.04 | 1.38 |
| 4 | AA -101 | 5.80 | 4.40 | 85.00 | 56.59 | 3.69 | 1.05 | 1.40 |
| 5 | AA-15 | 7.20 | 5.20 | 85.70 | 56.48 | 3.26 | 1.00 | 1.42 |
| 6 | AA-4 | 6.45 | 6.10 | 86.70 | 58.59 | 3.33 | 1.06 | 1.48 |
| 7 | AA -16 | 6.81 | 5.60 | 90.10 | 59.29 | 3.35 | 1.06 | 1.54 |
| 8 | AA -42 | 6.51 | 4.72 | 90.40 | 59.60 | 3.49 | 1.01 | 1.58 |
| 9 | GRB-1 | 6.40 | 4.50 | 93.30 | 59.18 | 3.66 | 1.03 | 1.60 |
| 10 | AA-3 | 7.28 | 6.70 | 96.70 | 58.79 | 2.89 | 1.07 | 1.63 |
| 11 | GQ-3 | 6.80 | 4.60 | 100.00 | 59.58 | 2.33 | 1.04 | 1.67 |
| 12 | AA-20 | 7.51 | 6.50 | 100.10 | 60.30 | 3.00 | 1.03 | 1.70 |
| 13 | AUG.1 | 6.70 | 5.28 | 106.70 | 58.90 | 2.67 | 1.06 | 1.72 |
| 14 | AA-9 | 8.48 | 5.50 | 110.00 | 60.84 | 3.07 | 1.08 | 1.74 |
| 15 | ABG-1 | 9.10 | 5.30 | 115.00 | 60.31 | 3.85 | 1.04 | 1.76 |
| 16 | AGKB-64 | 6.12 | 4.21 | 120.00 | 57.35 | 1.99 | 1.03 | 1.78 |
| 17 | AA-29 | 6.50 | 4.51 | 120.00 | 60.55 | 2.34 | 1.01 | 1.80 |
| 18 | AA-39 | 7.80 | 5.10 | 120.00 | 60.88 | 2.75 | 1.00 | 1.82 |
| 19 | AA-2 | 8.52 | 6.43 | 123.30 | 60.86 | 2.37 | 1.12 | 1.85 |
| 20 | AR-1 | 5.50 | 4.10 | 130.00 | 60.92 | 2.56 | 1.02 | 1.90 |
| 21 | AA-8 | 8.50 | 7.10 | 133.30 | 61.90 | 2.49 | 1.02 | 2.10 |
| 22 | AA-1 | 9.00 | 7.00 | 135.00 | 61.91 | 2.36 | 1.03 | 2.12 |
| 23 | AA-7 | 10.90 | 6.00 | 165.00 | 64.00 | 2.73 | 1.03 | 2.14 |
| 24 | AKS-1 | 9.50 | 7.50 | 200.00 | 60.12 | 2.52 | 1.08 | 2.15 |
| 25 | AA-19 | 9.40 | 7.30 | 200.00 | 61.11 | 2.54 | 1.00 | 2.16 |
| Range | 5.50 - 10.90 | 4.10 - 7.50 | 80.10 - 200.00 | 55.26 - 64.00 | 1.99 - 7.04 | 1.00 - 1.12 | 1.30 - 2.16 |
| Mean | 7.46 | 5.53 | 114.00 | 59.46 | 3.27 | 1.04 | 1.72 |
| S. Em. (±) | 0.052 | 0.055 | 2.124 | 1.224 | 0.059 | 0.0225 | 0.024 |
| C.D. at 5% | 0.104 | 0.111 | 4.271 | 2.460 | 0.118 | 0.0453 | 0.048 |

Table 1 (Continuation).

|  |  |  |  |
| --- | --- | --- | --- |
| SelectionNumber | CollectorCode | Stone characters | Seed characters |
| Stone Size | Stoneweight (g) | Seed Size | Seed weight (g) |
| Stone length (cm) | Stone breadth (cm) | Seed length (cm) | Seed width (cm) |
| 1 | AP- 1 | 4.70 | 3.48 | 12.00 | 3.00 | 2.81 | 5.10 |
| 2 | AKCA -14 | 5.15 | 3.30 | 10.00 | 4.42 | 2.60 | 6.10 |
| 3 | GJB -1 | 6.20 | 4.30 | 12.10 | 5.65 | 2.71 | 5.84 |
| 4 | AA -101 | 5.00 | 3.11 | 18.10 | 4.55 | 2.41 | 9.10 |
| 5 | AA-15 | 6.80 | 5.00 | 20.12 | 5.00 | 3.00 | 10.15 |
| 6 | AA-4 | 5.41 | 3.60 | 20.10 | 4.40 | 2.10 | 10.12 |
| 7 | AA -16 | 5.90 | 4.80 | 20.70 | 4.45 | 2.65 | 10.50 |
| 8 | AA -42 | 5.80 | 4.25 | 20.15 | 4.49 | 2.20 | 10.16 |
| 9 | GRB-1 | 5.71 | 3.10 | 20.00 | 4.57 | 2.80 | 10.10 |
| 10 | AA-3 | 6.71 | 6.10 | 24.80 | 4.30 | 3.11 | 12.60 |
| 11 | GQ-3 | 5.70 | 2.96 | 30.00 | 4.52 | 1.92 | 13.85 |
| 12 | AA-20 | 5.50 | 3.50 | 25.00 | 5.20 | 3.10 | 12.87 |
| 13 | AUG.1 | 6.10 | 4.20 | 29.00 | 5.31 | 2.62 | 13.50 |
| 14 | AA-9 | 7.80 | 5.10 | 27.00 | 4.15 | 4.15 | 12.45 |
| 15 | ABG-1 | 7.10 | 3.45 | 23.80 | 5.83 | 2.92 | 12.28 |
| 16 | AGKB-64 | 5.10 | 3.20 | 40.10 | 4.71 | 2.61 | 15.76 |
| 17 | AA-29 | 5.67 | 3.07 | 35.90 | 4.50 | 2.30 | 14.10 |
| 18 | AA-39 | 6.11 | 3.15 | 32.00 | 5.80 | 2.72 | 13.95 |
| 19 | AA-2 | 6.50 | 4.52 | 36.10 | 4.51 | 2.73 | 15.10 |
| 20 | AR-1 | 4.80 | 3.12 | 37.10 | 4.48 | 2.85 | 17.60 |
| 21 | AA-8 | 6.70 | 4.50 | 38.10 | 4.60 | 3.51 | 18.10 |
| 22 | AA-1 | 8.60 | 3.90 | 40.15 | 5.81 | 2.70 | 17.10 |
| 23 | AA-7 | 9.00 | 3.52 | 44.12 | 5.70 | 2.40 | 20.10 |
| 24 | AKS-1 | 8.70 | 4.61 | 49.86 | 5.71 | 3.50 | 24.10 |
| 25 | AA-19 | 8.65 | 4.80 | 52.36 | 5.60 | 3.40 | 25.10 |
| Range | 4.70 - 9.00 | 2.96 - 6.10 | 10.00 - 52.36 | 3.00 - 5.81 | 1.92 - 4.15 | 5.10-25.10 |
| Mean | 6.38 | 3.95 | 28.75 | 4.85 | 2.80 | 13.43 |
| S. Em. (±) | 0.047 | 0.031 | 0.058 | 0.031 | 0.034 | 0.033 |
| C.D. at 5% | 0.095 | 0.062 | 0.117 | 0.062 | 0.069 | 0.067 |

Table 2.

Correlation matrix for studied variables in the present study (“p” values lower than 0.05 denotes significant correlations).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variable | Seed weight | Seed width | Seed length | Stone weight | Stone breadth | Stone lenght | Thickness | Gravity | Ratio |
| Percentage | 0.72P < 0.01 | 0.20P = 0.33 | 0.44P = 0.02 | 0.72P < 0.01 | 0.06P = 0.76 | 0.62P < 0.01 | 0.85P < 0.01 | -0.05P = 0.82 | -0.66P < 0.01 |
| Ratio | -0.73P < 0.01 | -0.08P = 0.68 | -0.26P = 0.21 | -0.77P < 0.01 | -0.11P = 0.60 | -0.34P = 0.09 | -0.70P < 0.01 | 0.02P = 0.93 |  |
| Gravity | -0.06P = 0.78 | 0.15P = 0.46 | -0.19P = 0.35 | -0.06P = 0.76 | 0.34P = 0.10 | 0.08P = 0.68 | -0.06 |  |  |
| Thickness | 0.94P < 0.01 | 0.34P = 0.09 | 0.54P < 0.01 | 0.95P < 0.01 | 0.10P = 0.62 | 0.71P < 0.01 |  |  |  |
| Stone length | 0.67P < 0.01 | 0.46P = 0.02 | 0.61P < 0.01 | 0.62P < 0.01 | 0.47P = 0.01 |  |  |  |  |
| Stone breadth | 0.15P = 0.45 | 0.57P < 0.01 | 0.01P = 0.99 | 0.08P = 0.68 |  |  |  |  |  |
| Stone weight | 0.98P < 0.01 | 0.26P = 0.20 | 0.46P = 0.02 |  |  |  |  |  |  |
| Seed length | 0.50P = 0.01 | 0.08P = 0.71 |  |  |  |  |  |  |  |
| Seed width | 0.33P = 0.10 |  |  |  |  |  |  |  |  |

Table 3.

Contribution of studied variables to PCA.

|  |  |  |
| --- | --- | --- |
| Variable | Axis 1 | Axis 2 |
| Percentage | 0.369 | 0.113 |
| Ratio | -0.326 | -0.146 |
| Gravity | -0.014 | -0.450 |
| Thickness | 0.425 | 0.082 |
| Stone length | 0.394 | -0.238 |
| Stone breadth | 0.110 | -0.630 |
| Stone weight | 0.410 | 0.114 |
| Seed length | 0.262 | 0.144 |
| Seed width | 0.174 | -0.513 |
| Seed weight | 0.416 | 0.062 |



Fig. 1. Results of PCA for mangoes landraces and variables considered in the present study.