An evaluation of mango (*Mangifera indica* L.) germplasm for future breeding programme

Manveen Kaur¹, J. S. Bal¹, L. K. Sharma²* and S. K. Bali²

¹Department of Horticulture, Khalsa College, Amritsar, Punjab, India.
²Department of Soil Science, North Dakota State University, Fargo, ND-58108, USA.

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Evaluation of physical and chemical characteristics of fruit crops has been successfully used for selection of improved cultivars for breeding programs. The study was conducted at typical subtropical conditions in North-West India for evaluating the variability of mango germplasm to conserve the elite ones and identify the superior genotypes based on fruit quality for multiplication and for future crop improvement. Fourteen genotypes were tested for their physiological and chemical characteristics. Randomized complete block design was used and critical difference was used to compare quality characteristics of fourteen mango genotypes. Maximum fruit weight was found in Chausa whereas maximum reducing and total sugars were observed in Malda. Dashehari ranked first in respect of yield per tree, that is, 148.90 kg/tree. Local Selection-I was the earliest to mature. Among all genotypes Chausa, Kala Gola, Hundel and Gola showed tendency towards regular bearing. The Alphonso, Malda and Chausa was identified for superior traits like total soluble solids/acid ratio (TSS/acid ratio); Chausa and Langra Banarasi for high pulp percentage and pulp stone ratio; Rattaul for excellent flavour; ‘Local Selection-I’ for regular bearing and Dashehari for higher yield. These identified genotypes may be good donor in future hybridization programme to evolve the superior varieties.

**Key words:** Mango, breeding, germplasm, genotype.

**INTRODUCTION**

Mango (*Mangifera indica* L.) is one of the ancient fruits of India and its cultivation appeared to have begun 4000 years ago (Condole, 1984). It was originated as alloplloid and its home was suggested as eastern India extending from Assam to Burma or possibly further in Malay region (Popeneo, 1920). Based on recent findings (Mukherjee, 1997) the centre of origin and diversity of genus *Mangifera* is now firmly established in South East Asia.

The genus *Mangifera* consists of 41 species and all the edible cultivars of mango belong to single species *M. indica* L. A large variability exists in mango germplasm throughout the country (Gupta et al., 1996). Being an ancestral home for mango germplasm, India is having more than thousand verities, which are widely distributed in different agro climatic zones (Yadav and Rajan, 1993). India is the largest mango producing country, with an annual production of 16.2 mt and occupies an area of 2.38 m ha, which accounts for 65% of total world production. There are bright prospects of building up a flourishing trade for the export of this fruit. Although, mangoes are exported to nearly 20 countries, whereas its products are export to over 40 countries (Negi et al.,...
In India, improvement of mango through breeding was initiated as early as 1911. However, systematic hybridization work was started during forties. As a result, four hybrids namely, Swarna Jehangir (Chinnswarnarekha × Jehangir), Neelogoa (Neelum × Mulgoa), Neeluddin (Neelum × Himayuddin) and Neelshan (Neelum × Baneshan) were released at Fruit Research Station, Kodur, Karnataka (India). Mango varieties Neelphonso (Neelum × Alphonso), Neeleshan (Neelum × Baneshan), Neeleshwari (Neelum × Dashehari) were developed at Gujarat Agricultural University. New hybrids Mallika (Neelum × Dashehari), Amarpali (Dashehari × Neelum) were developed at IARI, New Delhi. Ratna (Neelum × Alphonso) Sindhu (Ratna × Alphonso) which was referred to as seedless were developed at Konkan Krishi Vidyapeet, Dapoli, Maharashtra (India). At APAU, Hyderabad, AuRumani (Rumani × Mulgoa) and Manjeera (Rumani × Neelum) hybrids were developed after systematic hybridization work. At IIHR, Bangalore, Arka Aruna (Banganappalli × Alphonso), Arka Puneet (Alphonso × Banganappalli), Arka Anmol (Alphonso × JanardhanPasand) were developed which were regular bearer.

After the independence with the establishment of Punjab Agricultural University in 1962, the research activities undertaken by state Agriculture Department were shifted to the University. Thus, the planning of continuing the project of evaluation of germplasm was stopped in the Punjab Government Orchard. At present, the orchard is under the control of state department of Horticulture and main thrust is being given on commercial crop production and sale of grafted plants but not on evaluating and conserving the collected genetic diversity. Thus, the genetic base is eroding at very fast rate. The present studies were therefore undertaken for evaluating the variability of the mango in the orchard to conserve the elite ones for multiplication and crop improvement. The objective of the study was to evaluate morphological characteristics of the mango germplasm and isolate to identify the superior genotype based on fruit quality for future breeding programs.

**MATERIALS AND METHODS**

The present study was conducted to study the performance of mango germplasm available in Punjab Government Progeny Orchards and Nursery, Attari District Amritsar. Amritsar represents typical subtropical conditions prevailing in North West India with an elevation of 231.52 m above sea level. Temperature reaches to 45°C in summer and winters are cold with occasional ground frost. The evaluations of mango germplasm for tree and fruit quality characters were carried out. The fruits from the identified germplasm of mango were harvested at maturity and were placed for ripening at room temperature for 2 to 3 days. Tree characters were measured with usual method. Thereafter, the fruit samples were analysed for physico-chemical evaluations in the P. G. Laboratory of Horticulture Department, Khalsa College, Amritsar.

**Physical characteristics**

Tree height of different mango varieties were measured with the help of calibrated bamboo stick and expressed in meters, whereas tree spread and trunk girth were measured with the help of measuring tape. To get a mean canopy diameter, two observations on each of east west and north south sides of selected tree were recorded. The trunk girth was recorded at a height of 15 cm above the graft union on each selected tree. The weight of fruit sample of different mango varieties under testing was taken with the help of simple pan balance. Ten fruits of mango were randomly taken as sample from each tree. Average fruit weight was calculated in grams/fruit. Fruit size, length and breadth were recorded with the help of Vernier Caliper and their average was calculated in centimeters. The colour of fruit was assessed on the basis of Royal Colour Chart. These observations were taken at the optimum maturity of the fruit.

Pulp weight was calculated by subtracting the peel and stone weight from total weight of fruit. Pulp content was expressed in percentage. To calculate the Pulp/Stone Ratio, the stone weight was subtracted from the total weight of fruit and the value obtained was divided by stone weight.

**Chemical characteristics**

**Total soluble solids and acidity**

The content of total soluble solids was determined with the help of digital Refractometer and the values were corrected at 20°C with the temperature correction chart and expressed as percent. The total titrable acidity was determined by titrating a known volume of finely blended juice with 0.1 N NaOH solution using phenolphthalein as an indicator. The end point was marked by appearance of pink colour which persisted for few seconds. The results were expressed as percent titrable acidity:

\[
\% \text{ Acidity} = \frac{0.067 \times 0.1N \text{ NaOH used(ml)}}{\text{Juice taken(ml)}}
\]

Total soluble solids/ Acidity ratio (TSS/Acidity ratio) was calculated by dividing the value of TSS with that of corresponding titrable acidity.

**Sugars**

Ten gram fruit pulp was taken in 100 ml beaker and volume made with distilled water. One gram of lead acetate was added for precipitating the extraneous matter. The solution was allowed to stand for half an hour. Then Potassium oxalate (1 g) was added to remove excess of lead. The filtered solution called as aliquot was ready for estimation of reducing total sugars.
Reducing sugars

Five millilitres each of Fehling solution (A and B) were taken in a flask. The above prepared aliquot was taken in burette and four drops of methylene blue indicator were added. Then, it was titrated against Fehling solution (A and B) mixed over a hot plate. The blue colour of the solution started changing to red. The titration was continued till the end point was noted as appearance of permanent brick red colour. The volume of aliquot used was noted as ‘A’:

\[
\text{Reducing Sugar}\% = \frac{\text{titrate value against Fehling solution}}{\text{Stock Solution}} \times \frac{\text{Weight of Sample Sol. Used}}{100} \\
\]

\[
ss = 0.05 \times \frac{100}{10^6 A} \times 100
\]

Total sugars

Twenty-five millilitres of above aliquot was taken into 100 ml measuring flasks and to this 25 ml distilled water was added and thereafter, 5 ml of HCl (60% by Vol.) was added. The solution was left over night at room temperature for acid hydrolysis. The centigrade thermometer was placed in the flask and it was heated on water bath in such a way that the temperature rose to 68°C in 10 min. The flask was still kept at 68°C for another 5 min. Then, a piece of litmus paper was put into the flask and neutralized the inverted sugars with 10% NaOH in the initial stage and with 0.1 NaOH near the neutralization point. The volume was made 100 ml by adding distilled water and titrated this against boiling Fehling solution in case of reducing sugars:

\[
\text{Total Sugars(%) = 0.05} \times \frac{\text{Stock Sol.}}{\text{Wt. of sample}} \times \frac{\text{Second stock sol.}}{\text{Sol. of Aliquot used x Vol.of sol. used}} \times 100
\]

Yield per tree

The yield of mango varies with the variety, periodicity of flowering, growing conditions, influencing the size of plants and productivity varies also with locality. The yield/tree was recorded at optimum maturity in kg.

Time of optimum maturity

The time of maturity depends upon various external characters like appearance of waxy coating, dots on the fruits and relative size of the fruit. Some ripened fruits when start dropping, it is said that maturity of the particular variety is reached. The fruit samples for physico-chemical analysis were taken at optimum maturity and maturity period was recorded.

Regularity of bearing

Alternate bearing has been one of the major problem in north Indian mango cultivars. The bearing behaviour was depending upon various environmental conditions and genetic make up. The regularity of bearing was assessed during the research period. However, the knowledge about bearing in the past was also taken from the employees of the orchard. The data recorded for various parameters were subjected to statistical analysis by using Randomised Block Design (Singh et al., 1998). Analysis of variance was conducted for various characters by using computer programme CPCS1 (Cheema and Singh, 1990).

RESULTS

Physical characteristics

A wide range of variability in respect of various tree characters, viz. tree height, tree spread and trunk girth was observed. Maximum tree height was recorded in the genotype Kala Gola to the tune of 13.76 m, which was closely followed by Gola with the tree height of 13.60 m (Table 1). Whereas, the plants of Amarpali registered the minimum height (4.24 m).

Mango genotypes under study differed in their growth habit. Tree spread (North-South and East-West) ranged from 4.43-16.43 and 5.10-17.50 m, respectively (Figure 1). Significantly maximum tree spread of 16.16 m NS and 17.50 m EW was measured in Chausa followed by 14.30 m NS and 13.16 m EW, in Malda, 14.63 m NS and 12.13 m EW ‘Local Selection-II’, whereas Amarpali had minimum tree spread (4.47 m NS and 5.10 m EW). In respect of trunk girth genotype Kala Gola recorded maximum trunk girth (2.87 m) followed by Chausa, Local Selection-I, Alphonso and Gola having trunk girth of 2.78, 2.63, 2.46 and 2.44 m, respectively, whereas Amarpali registered the lowest trunk girth (Figure 2).

The fruits of Chausa exhibited biggest fruit having fruit weight of 301.33 gm, whereas the genotype, Local Selection-II exhibited the smallest fruits with the average fruit weight of 80.63 gm. The average fruit weight of the evaluated germplasm ranged from 80.53 to 301.33 gm (Table 1). The selection Chausa recorded the maximum fruit weight to the tune of 301.33 gm showing the significant superiority over all evaluated genotypes. It was followed by Langra Banarasi and Gola having the fruit weight 293.60 and 236.42 gm, respectively (Table 1).

The data collected regarding fruit size (length and breadth) experienced a wide variation. The maximum fruit length of 11.70 cm was recorded in Hundel which was closely followed by 11.06 cm in Chausa and the minimum fruit length of 6.35 cm was observed in local Selection-I which was significantly less (Table 1). The fruits of Langra Banarasi were found to be having maximum fruit breadth (7.70 cm), which was followed by Hundel, Chausa, Kala Gola, where it was recorded as 7.60, 6.53, 6.10 cm, respectively. However, the fruits of Langra, Dashehari, Alphonso, Amarpali, and Dharbhanga recorded quite low fruit breadth to the tune of 5.80, 5.76, 5.70, 5.53 and 5.50 cm, respectively. The minimum fruit breadth of 4.60 cm was recorded by cultivar Local Selection-II (Table 1). Dashehari, Langra Banarasi, Langra, Kala Gola and Dharbhanga were grouped together having different shades of yellowish green 144A, 144A, 144B, 144C, 144B, respectively (Table 3). On the other hand, the Alphonso, Amarpali and Local Selection-II were placed in second group having yellowish green with variable shades 153B, 153D and153A presented in the colour chart, respectively. The peel colour of Rattaul has given the different appearance greenish yellow 163C and thus
showed marked variability for fruit colour. The pulp content (Table 2) of the different genotypes under evaluation experienced significant variability. The maximum pulp content of 89.78% was recorded in Chausa which was closely followed by 87.74% in Langra Banarasi and 84.34% in Local Selection-II. It was followed by Langra, Dashehari, Kala Gola, Dharbhanga and Alphonso with average pulp percentage of 79.23, 78.56, 74.00, 73.66, 73.16 and 72.1, respectively. The minimum average pulp content to the tune of (41.73%) was registered by Hundel.

The pulp stone ratio accrued in the present study experienced a highly striking variability (1.80-8.80) amongst the evaluated mango genotypes. The lowest pulp/stone ratio (1.80) was recorded in Local Selection-I and the highest (8.50) in Chausa. The genotypes Langra Banarasi, ranked at the next place with pulp stone ratio of 7.29. Amarpali was 3rd higher in pulp stone ratio (5.82). The genotypes, Local Selection-II, Rattual, Dharbhanga and Malda showed statistical equivalence with each other. As the pulp stone ratio is most ideal parameter for judging the fruit quality on the part of consumer and processing industry. The pulp stone ratio of Dashehari, Gola and Hundel were 3.36, 3.03 and 2.98, respectively which is very low and thus can be rated as inferior. The minimum pulp stone ratio of 1.80 was recorded in Desi.
Table 1. Average tree height, and trunk girth of different genetic resources of Mango.

<table>
<thead>
<tr>
<th>S/N</th>
<th>Genetic resources</th>
<th>TH (m)</th>
<th>TG (m)</th>
<th>FW</th>
<th>FL</th>
<th>FB</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>'Local Selection-I'</td>
<td>11.83</td>
<td>2.63</td>
<td>91.26</td>
<td>6.35</td>
<td>4.26</td>
</tr>
<tr>
<td>T2</td>
<td>Dashehari</td>
<td>6.66</td>
<td>1.53</td>
<td>171.36</td>
<td>10.56</td>
<td>5.76</td>
</tr>
<tr>
<td>T3</td>
<td>Gola</td>
<td>13.60</td>
<td>2.44</td>
<td>236.42</td>
<td>8.13</td>
<td>7.03</td>
</tr>
<tr>
<td>T4</td>
<td>Langra Banarasi</td>
<td>12.53</td>
<td>1.89</td>
<td>293.60</td>
<td>9.63</td>
<td>7.70</td>
</tr>
<tr>
<td>T5</td>
<td>Langra</td>
<td>8.50</td>
<td>1.84</td>
<td>121.33</td>
<td>8.83</td>
<td>5.80</td>
</tr>
<tr>
<td>T6</td>
<td>Kala Gola</td>
<td>13.76</td>
<td>2.87</td>
<td>342.23</td>
<td>8.13</td>
<td>6.10</td>
</tr>
<tr>
<td>T7</td>
<td>Dharbhanga</td>
<td>8.20</td>
<td>1.82</td>
<td>190.46</td>
<td>8.33</td>
<td>5.50</td>
</tr>
<tr>
<td>T8</td>
<td>Alphonso</td>
<td>12.43</td>
<td>2.46</td>
<td>131.00</td>
<td>8.46</td>
<td>5.70</td>
</tr>
<tr>
<td>T9</td>
<td>Hundel</td>
<td>9.66</td>
<td>1.76</td>
<td>190.00</td>
<td>11.70</td>
<td>7.60</td>
</tr>
<tr>
<td>T10</td>
<td>Malda</td>
<td>8.47</td>
<td>1.92</td>
<td>161.00</td>
<td>9.50</td>
<td>6.60</td>
</tr>
<tr>
<td>T11</td>
<td>Amarpali</td>
<td>4.24</td>
<td>.54</td>
<td>199.66</td>
<td>9.23</td>
<td>5.53</td>
</tr>
<tr>
<td>T12</td>
<td>Rattaul</td>
<td>7.50</td>
<td>1.74</td>
<td>117.66</td>
<td>6.73</td>
<td>4.73</td>
</tr>
<tr>
<td>T13</td>
<td>Chausa</td>
<td>12.33</td>
<td>2.78</td>
<td>301.33</td>
<td>11.06</td>
<td>6.53</td>
</tr>
<tr>
<td>T14</td>
<td>'Local Selection-II'</td>
<td>10.43</td>
<td>1.75</td>
<td>80.63</td>
<td>5.80</td>
<td>4.60</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>10.2</td>
<td>2.01</td>
<td>176.32</td>
<td>8.86</td>
<td>5.96</td>
</tr>
<tr>
<td>C.D</td>
<td></td>
<td>2.68</td>
<td>.17</td>
<td>7.43</td>
<td>0.99</td>
<td>0.75</td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td>4.24-13.76</td>
<td>.54-2.87</td>
<td>80.6-301.33</td>
<td>6.35-11.70</td>
<td>4.26-7.70</td>
</tr>
</tbody>
</table>

TH-Tree Height, TG- trunk Girth, TS- Tree Spread, NS- North South, EW- East West, FW- Fruit Weight, FL- Fruit Length, FB- Fruit Breadth.

Chemical characteristics

A high range of variability for TSS content (11.35-28.95° Brix) was recorded in evaluated mango germplasm (Table 2). Malda (T10) ranked at the top with TSS content of 28.95° Brix, which was followed by Chausa (27.08), Alphonso (26.84) and Rataul (24.34). Minimum TSS of 11.35° Brix was recorded in Local Selection-II. Different mango varieties possessed varying level of acidity in the fruit pulp. The acidity ranged from 0.20 to 7.86% in different evaluated genotypes of mango. The minimum acidity of 0.20% was observed in Hundel that was closely followed by 0.22% in Dharbhanga and 0.33% in testing. Dashehari amongst the different genetic resources under
Table 3. Organoleptic rating of different genetic resources of mango.

<table>
<thead>
<tr>
<th>S/N</th>
<th>Genetic resources</th>
<th>Colour of fruit</th>
<th>OR</th>
<th>TM</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>'Local Selection-I'</td>
<td>Yellowish Green 151&lt;sup&gt;A&lt;/sup&gt;</td>
<td>3.0</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; week of July</td>
</tr>
<tr>
<td>T2</td>
<td>Dashehari</td>
<td>Yellowish Green 144&lt;sup&gt;A&lt;/sup&gt;</td>
<td>6.6</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; week of July</td>
</tr>
<tr>
<td>T3</td>
<td>Gola</td>
<td>Yellowish Green 152&lt;sup&gt;B&lt;/sup&gt;</td>
<td>0.2</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; week of July</td>
</tr>
<tr>
<td>T4</td>
<td>Langra Banarasi</td>
<td>Yellowish Green 144&lt;sup&gt;A&lt;/sup&gt;</td>
<td>7.5</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; week of July</td>
</tr>
<tr>
<td>T5</td>
<td>Langra</td>
<td>Yellowish Green 144&lt;sup&gt;B&lt;/sup&gt;</td>
<td>6.8</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; week of July</td>
</tr>
<tr>
<td>T6</td>
<td>Kala Gola</td>
<td>Yellowish Green 144&lt;sup&gt;C&lt;/sup&gt;</td>
<td>1.5</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; week of July</td>
</tr>
<tr>
<td>T7</td>
<td>Dharbhanga</td>
<td>Yellowish Green 144&lt;sup&gt;B&lt;/sup&gt;</td>
<td>0.5</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; week of July</td>
</tr>
<tr>
<td>T8</td>
<td>Alphonso</td>
<td>Yellowish Green 153&lt;sup&gt;B&lt;/sup&gt;</td>
<td>8.0</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; week of July</td>
</tr>
<tr>
<td>T9</td>
<td>Hundel</td>
<td>Yellowish Green 151&lt;sup&gt;A&lt;/sup&gt;</td>
<td>7.0</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; week of July</td>
</tr>
<tr>
<td>T10</td>
<td>Malda</td>
<td>Yellowish Green 152&lt;sup&gt;A&lt;/sup&gt;</td>
<td>8.0</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; week of July</td>
</tr>
<tr>
<td>T11</td>
<td>Amarpali</td>
<td>Yellowish Green 153&lt;sup&gt;D&lt;/sup&gt;</td>
<td>7.6</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; week of July</td>
</tr>
<tr>
<td>T12</td>
<td>Rattaul</td>
<td>Greenish Yellowish 163&lt;sup&gt;C&lt;/sup&gt;</td>
<td>6.8</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; week of July</td>
</tr>
<tr>
<td>T13</td>
<td>Chausa</td>
<td>Yellowish Green 151&lt;sup&gt;A&lt;/sup&gt;</td>
<td>8.8</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; week of July</td>
</tr>
<tr>
<td>T14</td>
<td>'Local Selection-II'</td>
<td>Yellowish Green 153&lt;sup&gt;A&lt;/sup&gt;</td>
<td>6.0</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; week of July</td>
</tr>
</tbody>
</table>

OR- Organoleptic Rating at 10 Point Scale, TM- Time of Maturity.

Figure 3. Variability of reducing Sugar (RS) content in different mango cultivars.

Among all the evaluated genotypes of mango, Malda exhibited significantly maximum total and reducing sugar (Figures 3 and 4), followed by Chausa, Rattaul and Alphonso with total sugar content of 21.66, 19.36 and 19.23%, respectively (Figure 4). The minimum Total sugar content was recorded in that is, Dharbhanga, (8.26%). The genotypes Rattaul, Alphonso and Amarpali showed total sugar content above (19%). The next best genotypes accrued in the study were Hundel, Dashehari, Langra Banarasi and Langra having total sugar percentage 11.53, 11.50, 14.2, 15.26, 16.13 and 18.16, respectively.

The yield of the mango varieties varied with the growing condition and size of the plant. The varieties Dashehari (148.90 kg/ tree) and Rattaul (126.73 kg/ tree) were high yielding varieties followed by Chausa, Hundel and Local Selection-I having yield 114, 113.31, 112.70 kg yield/ tree, respectively (Table 2). The varieties Malda, Gola and Langra recorded yield of 108.74, 107.84 and 104.56 kg per tree, respectively. Minimum yield/ tree to the tune of 44.03 kg/ tree was recorded with Amarpali. All the Mango varieties in the progeny orchard of State Department of Horticulture, Attari (Amritsar) were irregular bearers except Hundel Dharbhanga, Kala Gola.
and Local Selection-I which showed regularity in bearing (Table 2).

**DISCUSSION**

**Physical characteristics**

The tree height and tree girth of Kala Gola has been found better than any other mango cultivar in previous studies of (Bakshi et al., 2012; Barhate et al., 2012; Desai and Dhandor, 2000; Singh et al., 2000) who have found similar results in the different agro climatic regions of India. Likewise, Sharma et al. (1999), who evaluated mango cultivars for tree vigour in arid-irrigated region of Punjab and found that mango cv. Langra was the most vigorous followed by Mallika, Sandhuri and Amarpali. (Shivanandam and Shashidhara 2007) also conducted the similar studies in the eastern region of Karnataka to evaluate six varieties and nine hybrids of mango for their growth and recorded the higher values for growth parameters.

Amongst the evaluated genotypes, Local Selection-I and II retained the fruit weight less than 100 gm and thus may be rated as sucking type mango. The fruits of Chausa were having fruit weight > 300 g and were placed in Group-I, whereas Langra Banarasi and Gola were placed in Group-2 with medium fruit weight of 200 to 300 g. Hundel, Amarpali, Dashehari Malda and Rattaul were placed in Group-3 having fruit weight 100 to 200 g. The class of mango having fruit weight ranging about 200 g is universally accepted as best quality mango. According to the observations of the present study Amarpali and Hundel recorded the fruit weight as 191.6 and 190.00 g. Thus, these two may be rated as superior most according to the universal acceptance norms of top quality. The findings of present studies are in accordance with the findings of (Singh and Maurya, 1986; Syed, 2009; Uddini et al., 2007; Kumar, 2004), who conducted research on evaluation of mango germplasm in different parts of country and abroad. However, the difference in weight of fruit might be due to difference in climatic conditions and genetic behaviour of genotype.

Fruit size major quality indices play a major role for the success of any fruit variety. Results of fruit size found in agreement with the previous research findings of (Kumar, 2004; Gurmani, 1989), who reported the range for fruit length from 6.93 to 12.00 cm and average fruit breadth from 5.30 to 7.90 cm. The fruit size in terms of length and breadth varied singly and not collectively. This might be due to genetic makeup of individual genotypes.

Various mango genotypes under observation, in general, attained yellowish green colour at maturity. However, the different colour tones of yellowish green were evidenced in different genotypes. The colour rating on the basis of comparison with colour chart of Royal Horticulture Society, London, was of yellow green having different shades 144, 151 and 153. Present findings are in conformity with the previous research work of Singh et al. (1988) who also noted variation in the colour in different mango varieties. The fruits of Amarpali presented the attractive appeal. Hence, this variety can be concerned most attractive amongst different evaluated genotypes.

Variability in pulp content in all the mango cultivar did not find any trend but random and similar results were reported in the past (Syed, 2009; Zaied et al., 2007). The high variability in pulp content ranging from 67.56 to 83.21% of Indian mango varieties have been reported by Desai et al. (2000) amongst 77 varieties under Goa

![Figure 4. Variability of total sugar (TS) content in different mango cultivars.](image-url)
conditions. High range of variability in pulp/stone ratio has also been well documented by Kumar (2004), Zaied et al. (2007), Rajan et al. (2009) in different genotypes of mango.

Chemical characteristics

High variability with respect to TSS content in different genetic resources collected from Punjab subtropics is in agreement with previous work done on mango germplasm evaluations in the country and abroad. Range for variability is in agreement with the earlier reports of Teotaia and Singh (1963) who reported variation in TSS from 13.8 to 22.0% in some important sucking mangoes of Uttar Pradesh, however, Bhuyan and Guha (1995) and Uddini et al. (2007) observed 16.22 to 24.14% in mango varieties of Bangladesh. Kumar (2004) reported variation in TSS from 18.40 to 21.54° Brix in selection of superior clones in cultivars Dashehari in Himachal Pradesh (Sirmor, Mandi and Kangra Districts). The study of Sharma et al. (1999) on four mango cultivars in arid irrigated region of Punjab is in close proximity with the findings of present study. The higher level of TSS observed in 'Dashehari' collected at government orchard Attari differ from the previous work of Yadav et al. (1982) on 'Dashehari' mango at Uttar Pradesh, also can be referred to the genotype variation in the same variety, may be the prevailing climatic condition. Gurmani (1989) also observed total soluble solids range from 16.25 to 18.75% in different mango genotypes.

The fruit acidity highly depends upon the genotype and climatic condition where genotype generally play larger in defining the quality characters. The variations in fruit acidity were also reported in several studies in past for example Kumar (2004), who observed the range for acidity to the level of 0.14 to 0.34% in different mango varieties. Variations in acidity were also shown by Singh, 1998). However, the different range of variability in acidity has been observed by Singh and Maurya (1986) and Chaudhari et al. (1997) which can be owned to the genetic and climate differences. In the present study, varieties like Kala Gola and Gola exhibited higher acidity and thus their unripe fruits can be imminently suitable for dehydration and pickling. The variety with higher acidity level is not conducive for table purpose but most ideal for pickling. The genotype Kala Gola and Gola are thus suitable for culinary maturity. Selection called as Local Selection-I, when attain full maturity, is attacked by serious pest making it unfit for human consumption but it remains good at culinary maturity, hence it is also utilized for pickles.

Significant difference has been found in reducing sugar (3.40 to 19.27%) content of different mango genotypes evaluated in the present study. Rathore et al. (2009) recorded (3.8%) reducing sugar in Dashehari. Uddini et al. (2007) also reported lowest results regarding reducing sugars content of range from 2.82 to 7.35%. Chaudhari et al. (1997) reported 2.6 to 7.1% reducing sugar in 19 south Indian mango genotypes. Yadav et al. (1982) reported maximum reducing sugar to the tune of 6.86% in Dashehari. The varieties having reducing sugars > 5.0% will be considered suitable for table purposes.

Total sugars have been found variable within the cultivar. Lodh et al. (1974) obtained 7.35 to 13.20% total sugars in eight varieties of mango. Similarly, Singh (1968) and Uddini et al. (2007) recorded the variability for total sugar to the tune of 11.5 to 25 and 12.71 to 20.34%, which might be due to genetic difference as well as agro climatic conditions.

Data regarding TSS/acid ratio showed wide variation. The results are contrary to the findings of Lodh et al. (1974) who recorded TSS/ acid ratio ranged from 5.50 to 109.20. Variation in fruit may be due to inherent genetic variation. Local Selection-I, matured during Ist week of July considered to be as early maturing variety. Dashehari, Langra Banarasi, Langra, Dharbhanga, Alphonso and Hundel were considered to be mid-season varieties that matured during 2nd week of July. While the late maturing varieties Gola, Kala Gola, Amarpali and Chausa matured during 4th week of July. These differences could be due to variation in the genotype evaluated. Uddini et al. (2007) also showed wide variation in TSS/acidity ratio which ranged from 24.19 to 81.57.

Conclusion

Different genotypes can be used for different purposes. Tree height was maximum in Kala Gola, however, tree spread was recorded maximum in Chausa. Maximum stem girth was registered in Kala Gola and minimum in Amarpali. Maximum fruit weight was exhibited by Chausa. Amongst the evaluated germplasm, Chausa showed the highest pulp/stone ratio. TSS content ranged from 11.35 to 28.95%. In the identified germplasm of mango 'Malda' contained the highest reducing and total sugars percent. The evaluated genotypes 'Dashehari' ranked first in respect of yield per tree, that is, 148.90 kg/tree.

Local Selection-I was the earliest to mature, therefore it has an advantages as it can easily escape the rainfall. Amongst the genetic resources, Chausa, Kala Gola, Hundel and Gola showed tendency towards regular bearing. Alphonso, Malda, Dharbhanga, Rattaul and Local Selection-II were typical alternate bearer. Local Selection-I and Amarpali were regular bearer. Critical evaluation of mango genotypes grown in Punjab States government orchard Attari has the worth to be isolated for superior traits. Alphonso, Malda and Chausa for TSS/acid ratio; Chausa and Langra Banarasi for high pulp percentage and pulp stone ratio; Rattaul for excellent flavour; Local Selection-I for regular bearing and
Dashehari for higher yield. These identified genotypes can be good donor in hybridization programme to evolve the superior varieties under Punjab conditions.

Conflict of Interests

The authors have not declared any conflict of interests.

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