Bangladesh J. Nuclear Agric, 35: 145-155, 2021 *ISSN 0258-7130*

FRUIT DIVERSITY OF TEN MANGO (*Mangifera indica* L.) GERMPLASM OF CHAPAINAWABGANJ DISTRICT IN BANGLADESH

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Abstract

An experiment was conducted to study ten mango (*Mangifera indica* L.) germplasm during July 2018 to May 2019 in Shibganj, Chapainawabganj. Fruit characteristics varied greatly among the studied mango germplasm. The germplasm, Fazli was the largest fruit (Length 14.47 cm, Breadth 8.40 cm, Thickness 7.80 cm) having maximum fruit weight 743.33 g and the highest pulp quantity 614.67 g with highest pulp/peel & stone ratio (4.80) among the germplasm. Ripen mango contained the highest TSS (°Brix) in the germplasm Langra (20.67%) which was better than Fazli. The largest stone was recorded in Fazli (Length 11.60 cm, Breadth 4.87 cm, Thickness 2.70 cm) having maximum weight 66 g whereas minimum in Khirsapat 39.13 g among the germplasm. From biplot analysis it was recorded that there was a positive correlation between fruit weight and pulp weight in the germplasm Fazli. From genetic diversity analysis it was revealed that Fazli had higher genetic similarity and Ashina had lower genetic similarity with another germplasm. The dendrogram generated from the unweighted pair group arithmetic average (UPGMA) cluster analysis broadly placed 10 mango cultivars into four major clusters. The cluster size varied from 1 to 5. Cluster I was the largest cluster comprising of five germplasm. The tendency of clustering among mango cultivars revealed that they have strong affinity towards further breeding program.

Key words: Germplasm, multivariate analysis, biplot, correlation, refractometer, UPGMA

Introduction

Mango (*Mangifera indica* L.) is one of the most important cultivated commercial and widely distributed fruits of tropical and subtropical countries of the world belonging to the family Anacardiaceae. It is popular in the world and being important for its excellent flavor, attractive color and delicious taste. Records suggest that it has been in cultivation in the Indian subcontinent from 4000 years ago (Candole, 1984). It is also reported that mango has an origin from the Indo-Myanmar region, especially the North-Eastern part of India (Iyre, 1991).

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In Asia, especially in Bangladesh mango is the most popular fruit. Mango is the national fruit of Bangladesh, India, Pakistan, and the Philippines. It is also the national tree of Bangladesh since 2012. Mango has got a unique position in respect of nutritional quality, taste, consumer's preference etc. among the different kinds of fruits grown in Bangladesh. The major mango producing countries in the world are India, Pakistan, Mexico, Brazil, Haiti, Bangladesh, Philippines and USA. India is the single largest producer of mango with approximately 66% of the world mango production (Jacobi *et al*., 2001) and Bangladesh is in 7^{th} position in terms of worldwide mango production. According to BBS (2020) Bangladesh produced about 1222368 metric tons of mango in the year of 2019-2020 from 235348 acres of land. The main mango growing districts are Chapainawabganj, Rajshahi, Dinajpur, Naogaon and Kushtia in Bangladesh. In the year of 2019-2020 in Chapainawabganj 187174 metric tons of mangoes were produced from 62800 acres of land. The main commercial part of mango is its pulp. Quality of mango pulp depends on the varietal superiority and environmental susceptibility of a region. Fibrous pulp has low economic potentiality than non-fibrous. Sometimes magnetic resonance and fluorescence are used for controlling the quality of Mango (Bureau, 2009). In most cases higher fruit weight has comparatively more pulp to peel and stone ratio than the lower one (Rahman *et al*., 2016). The gemplasm having heavy fruit weight has more edible portion (Barua *et al*., 2013). So, high pulp containing mango germplasm are very much important to meet up food demands and for industrial purposes. Mechanical properties of mango fruits such as firmness and elasticity are also very important attributes for fruit handling, transport, storage, and consumer acceptability (Elsheshetawy *et al*., 2016). This study helps to assess variations and to establish genetic relationships among the mango the germplasm at morphological level.

Materials and Methods

The experiment was conducted to study ten mango (*Mangifera indica* L.) germplasm during July 2018 to May 2019 in Shibganj, Chapainawabganj. The experimental site enjoyed a tropical climate characterized by comparatively low rainfall, high humidity, high temperature, long day and clear sunshine period during the month of April to September and scanty rainfall, low temperature, low humidity, short day and long clear sun shine period during the rest of the year. The experiment was conducted under Randomized Complete Block Design (RCBD) where each mango germplasm was considered as individual treatment of the experiment with three replications and the age of each germplasm was in between 25 to 30 years. Data on the following parameters were recorded from all the studied plants of 10 local germplasm of mango (Table 1) to compare the pulp quantity according to the plant descriptors of mango (IPGRI, 2006).

Table 1. Germplasm list and location of the collected germplasm

Serial No	Germplasm Name	Source Location
1	Fazli	Shibganj, Chapainawabganj
2	Shurma Fazli	Shibganj, Chapainawabganj
3	Tota Fazli	Shibganj, Chapainawabganj
4	Ashina	Shibganj, Chapainawabganj
5	Langra	Shibganj, Chapainawabganj
6	Bombai	Shibganj, Chapainawabganj
7	Khirsapat	Shibganj, Chapainawabganj
8	Gopalvog	Shibganj, Chapainawabganj
9	Lakkhonvog	Shibganj, Chapainawabganj
10	Kachmithi	Shibganj, Chapainawabganj

Parameters studied as follows:

i. Fruit Weight (g)
ii. Fruit Length (cm)
iii. Fruit Breadth (cm)
iv. Fruit Thickness (cm)
v. Peel Weight (g)
vi. Stone Weight (g)
vii. Stone Length (cm)
viii. Stone Breadth (cm)
ix. Stone Thickness (cm)
x. Pulp Weight (g)
xi. Pulp/Peel & Stone Ratio
xii. Total soluble solids (°Brix)

For estimation of pulp weight following formula was used:

Pulp weight (g) = Fruit weight (g) – {Peel weight (g) + Stone weight (g)}

For calculation of pulp to peel and stone ration following formula was used:

$$\text{Ratio of pulp to peel and stone} = \frac{\text{Pulp weight (g)}}{\text{Peel weight (g)} + \text{Stone weight (g)}}$$

For determination of TSS (°Brix) content following instrument was used:

Three samples of each treatment were taken. A drop of juice squeezed from the sample was placed on the surface of the prism of the refractometer and percent total soluble solids (°Brix) was obtained from direct reading by a BRIX model hand-held refractometer made by ERMA INC-Tokyo, Japan.

Statistical Analysis

The recorded data of the study for all characters was analyzed statistically using Wasp Web Agri Stat package program. The mean for all treatments were calculated and analysis of variance was performed by F variance test. The mean differences were evaluated by least significant different (LSD) test (Gomez and Gomez, 1984). Correlation study was done by Past and R studio software. Principal component analysis was done by Origin pro 2021 software.

Results and Discussion

Fruit weight

The fruit weight was varied significantly among the germplasm. It ranged from 183.33g to 743.33g. The highest fruit weight was observed in the germplasm Fazli 743.33g followed by Shurma Fazli, Tota Fazli and others. And the lowest fruit weight was recorded in the germplasm Gopalvog 183.33g (Table 2). Five mango germplasm were evaluated by (Bhuyan and Islam, 1989) where fruit weight ranged from 208g to 654.44g. The variation occurred mainly due to the differences in the genotypic constitution of the germplasm and the environment where they are grown.

Table 2. Variation in fruit characteristics of the collected mango germplasm

Germplasm	Fruit Weight (g)	Fruit Length (cm)	Fruit Breadth (cm)	Fruit Thickness (cm)	Peel Weight (g)
Fazli	743.33 a	14.47 a	8.40 a	7.80 a	62.67 b
Shurma Fazli	570.00 b	14.07 a	7.87 cd	6.80 d	60.00 bc
Tota Fazli	535.00 b	13.20 b	7.03 f	6.23 e	52.00 d
Ashina	384.00 d	11.80 c	7.60 de	7.10 c	43.00 ef
Langra	346.00 e	10.00 d	7.50 e	6.90 cd	40.20 f
Bombai	420.00 cd	10.20 d	8.30 ab	7.70 a	78.67 a
Khirsapat	407.00 cd	9.03 e	8.03 bc	7.40 b	58.67 c
Gopalvog	183.33 g	8.70 e	6.63 g	6.07 ef	42.33 ef
Lakkhonvog	430.00 c	11.60 c	8.53 a	6.97 cd	57.43 c
Kachmithi	263.33 f	11.63 c	6.90 fg	5.97 f	44.67 e
CV (%)	5.10	2.17	2.20	2.27	3.53
LSD (0.05)	37.46	0.43	0.29	0.27	3.28

In a column, figure (s) with same letter do not differ significantly at 5% level

Fruit length

There was significant variation among the mango germplasm in relation to length of fruit. It ranged from 8.70 cm to 14.47 cm. The longest fruit length was observed in the germplasm Fazli 14.47 cm and the shortest fruit length was recorded in the germplasm Gopalvog 8.70 cm (Table 2). Five mango germplasm were evaluated by (Bhuyan and Islam, 1989) where fruit length ranged from 8.30 cm to 13.87 cm and stone length ranged from 6.88 cm to 12.22 cm.

Fruit breadth

It ranged from 6.63 cm to 8.40 cm. The highest fruit breadth was observed in the germplasm Fazli 8.40 cm and the shortest fruit breadth was recorded in the germplasm Gopalvog 6.63 cm (Table 2). Five mango germplasm were evaluated by (Bhuyan and Islam, 1989) where fruit breadth ranged from 6.38 cm to 9.55 cm.

Fruit thickness

Fruit thickness ranged from 5.97 cm to 7.80 cm. The highest fruit thickness was observed in the germplasm Fazli 7.80 cm and the lowest one was recorded in the germplasm Kachmithi 5.97 cm (Table 1).

Peel weight

Peel weight varied significantly among the mango germplasm. It ranged from 40.20g to 78.67g. The highest peel weight was observed in the germplasm Bombai 78.67g and the lowest peel weight was recorded in the germplasm Langra 40.20g (Table 2).

Stone weight

Stone weight ranged from 39.13g to 66.00g. The growth of the fruit is directly associated with the growth of the seed (Saini *et al*., 1971). The highest stone weight was observed in the germplasm Fazli 66.00g and the lowest stone weight was recorded in the germplasm Khirsapat 39.13g (Table 3).

Stone length

The stone length differed significantly among the mango germplasm. It ranged from 7.03 cm to 11.60 cm. The longest stone length was observed in the germplasm Fazli 11.60 cm and the shortest stone length was recorded in the germplasm Khirsapat 7.03 cm (Table 3).

Table 3. Variation in stone characteristics of the studied mango germplasm

Germplasm	Stone Weight (g)	Stone Length (cm)	Stone Breadth (cm)	Stone Thickness (cm)
Fazli	66.00 a	11.60 a	4.87 a	2.70 a
Shurma Fazli	60.33 ab	10.23 c	4.47 b	2.50 a
Tota Fazli	55.67 b	9.83 d	4.13 d	2.23 bc
Ashina	48.00 c	10.20 c	3.80 e	2.10 bcd
Langra	40.30 d	7.97 f	3.03 f	1.90 d
Bombai	41.30 d	8.73 e	3.90 e	1.93 d
Khirsapat	39.13 d	7.03 g	4.30 c	2.03 cd
Gopalvog	41.33 d	7.20 g	3.83 e	2.17 bc
Lakkhonvog	39.67 d	8.73 e	4.07 d	1.33 e
Kachmithi	43.67 cd	10.93 b	4.47 b	2.27 b
CV (%)	7.75	1.54	1.89	5.94
LSD (0.05)	6.32	0.25	0.14	0.22

In a column, figure (s) with same letter do not differ significantly at 5% level

Stone breadth

Highly significant variation was manifested among the mango germplasm. It ranged from 3.03 cm to 4.87 cm. The highest stone breadth was observed in the germplasm Fazli 4.87 cm and the lowest stone breadth was recorded in the germplasm Langra 3.03 cm (Table 3).

Stone thickness

Stone thickness ranged from 1.33 cm to 2.70 cm. The highest stone thickness was observed in the germplasm Fazli 2.70 cm and the lowest one was recorded in the germplasm Lakkhonvog 1.33 cm (Table 3).

Pulp weight

Pulp weight varied significantly among the mango germplasm. It ranged from 175.00g to 614.67g. The highest pulp weight was observed in the germplasm Fazli 614.67g followed by Shurma Fazli, Tota Fazli and others. And the lowest pulp weight was recorded in the germplasm Kachmithi 175.00g (Table 4). BARI Aam-4 had heavy fruit weight and higher edible portion (78.66%) (Barua *et al*., 2013).

Table 4. Pulp characteristics and TSS (°Brix) of the collected mango germplasm

Germplasm	Pulp Weight (g)	Pulp/Peel & Stone Ratio	TSS (°Brix)
Fazli	614.67 a	4.80 a	17.33 b
Shurma Fazli	449.67 b	3.73 bc	15.67 cd
Tota Fazli	427.33 b	3.97 b	14.67 d
Ashina	293.00 de	3.24 d	15.67 cd
Langra	265.50 e	3.30 d	20.67 a
Bombai	300.03 cd	2.50 e	17.33 b
Khirsapat	309.20 cd	3.17 d	17.33 b
Gopalvog	99.67 g	1.17 g	19.67 a
Lakkhonvog	332.90 c	3.42 cd	12.67 e
Kachmithi	175.00 f	1.98 f	16.33 bc
CV (%)	6.03	6.54	4.76
LSD (0.05)	33.76	0.35	1.36

In a column, figure (s) with same letter do not differ significantly at 5% level

Pulp/peel & stone ratio

Pulp/peel & stone ratio of the fruits varied from 1.17 to 4.80 among mango germplasm. The highest ratio was observed in Fazli 4.80. The germplasm Kachmithi had the lowest 1.17 ratio (Table 4).

Total soluble solids (°Brix)

Total soluble solids contents of mango fruits were measured at ripen stage. It was observed there were variations in TSS (°Brix) among 60 mango genotypes ranged from 16.90 to 28.26 (Majumder *et al*., 2011). Ripen mango contained the highest TSS (°Brix) in the germplasm Langra 20.67 followed by Gopalvog, Khirsapat and Fazli. And the lowest in the germplasm Lakkhonvog 12.67 (Table 4).

Correlation among fruit weight and other selected traits

Correlation study indicated that there was a significant positive correlation between fruit weight and pulp weight along with fruit length, stone weight and pulp/peel & stone ratio. But fruit weight had a significant negative correlation with TSS (°Brix). Pulp weight, fruit length, stone length and stone breadth had also negative correlation with TSS (°Brix) (Fig. 1).

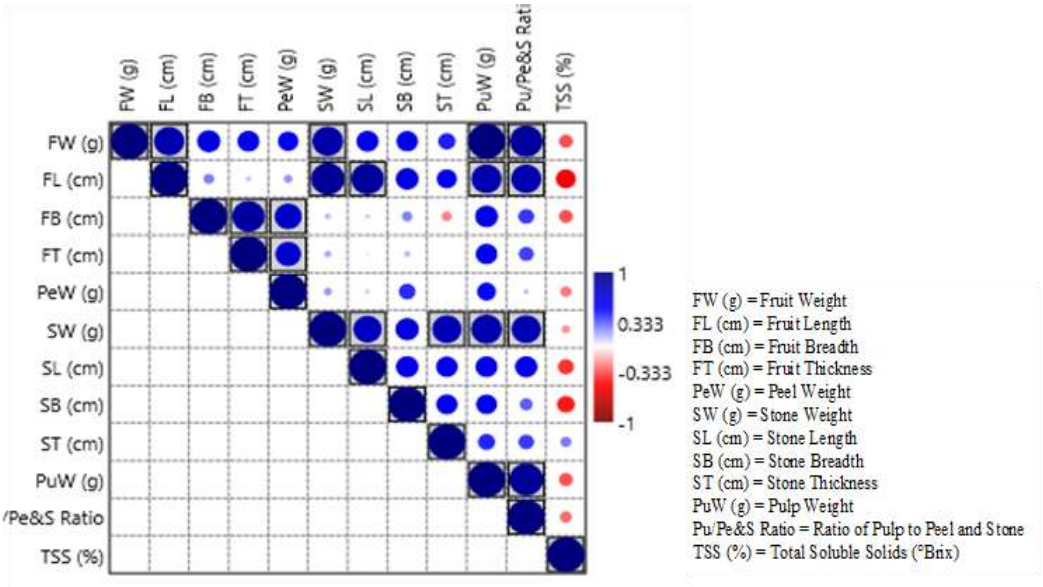

Fig. 1. Correlation among the studied traits of the selected mango germplasm.

Genotype by trait biplot for the selected traits

Biplot analysis mostly used to determine varietal stability in the multi-environmental trial (Farshadfar *et al*., 2013). Genotype by Trait (GT) biplot analysis describes the association among the traits across different genotypes (Yan and Reid, 2008). Biplot can also be used to determine gene expression of plants (Chapman and Smith, 2002). The Principal Component Analysis (PCA) identified a total of 10 Principal Components (PCs) for the selected traits. Among the PCs three having Eigen value greater than 1. The first two PCs explained about 74.54% of the total variation (Fig. 2). The association between selected

traits among the germplasm were visualized by the genotype by trait biplot analysis. The acute angle between two traits represents positive correlation while the obtuse angle between two traits represents negative correlation (Yan and Reid, 2008). Acute angle was found between fruit weight (FW) and pulp weight (PuW) along with fruit length (FL), fruit breadth (FB), fruit thickness (FT), peel weight (PeW), stone weight (SW), stone length (SL), stone breadth (SB), stone thickness (ST) and pulp-peel & stone ratio (Pu/Pe&S) indicating all of them had positive correlations.

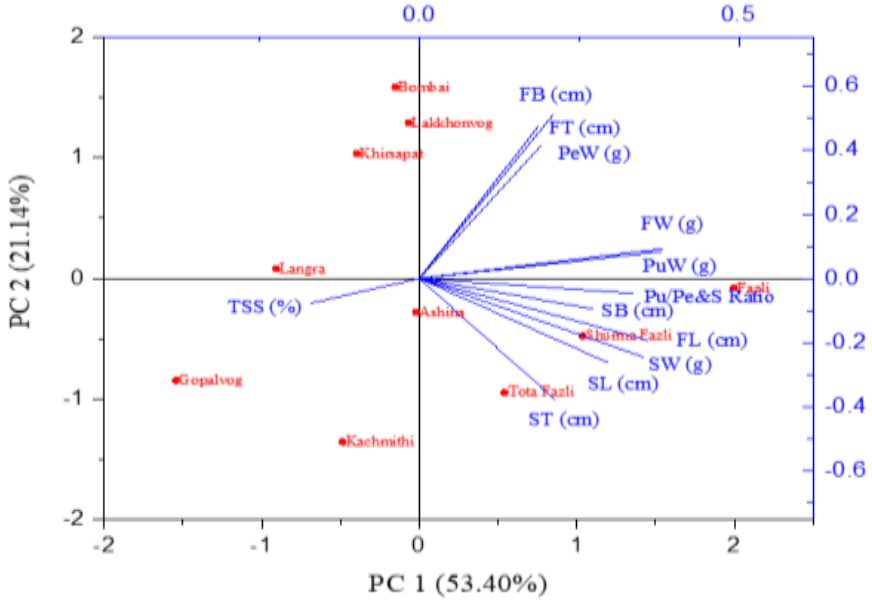

Fig. 2. Biplot analysis explaining the correlation and genotype by trait relationship of the selected mango germplasm

Obtuse angle was observed between TSS (°Brix) and fruit weight (FW) along with pulp weight (PuW), peel weight (PeW), stone weight (SW), pulp-peel & stone ratio (Pu/Pe&S) indicating they had negative correlations (Fig. 2). All these results indicating that direct selection for any trait would give positive rewards for the other traits which were positively correlated while it would bring negative results for the negatively related traits. Again, biplot analysis showed the trait profiles of the genotypes, especially those genotypes positioned far away from the origin (Yan and Reid, 2008).

Genetic Dissimilarity Analysis

Blue colored point showed lowest genetic dissimilar pair while red colored point indicated maximum genetic dissimilar pair. In Gower's matrix the germplasm Ashina was found to be the most dissimilar accession with others and the germplasm Fazli showed higher amount of similarity with another germplasm (Fig. 3). In this study genetic distance ranged from 0.1670 to 0.7942.

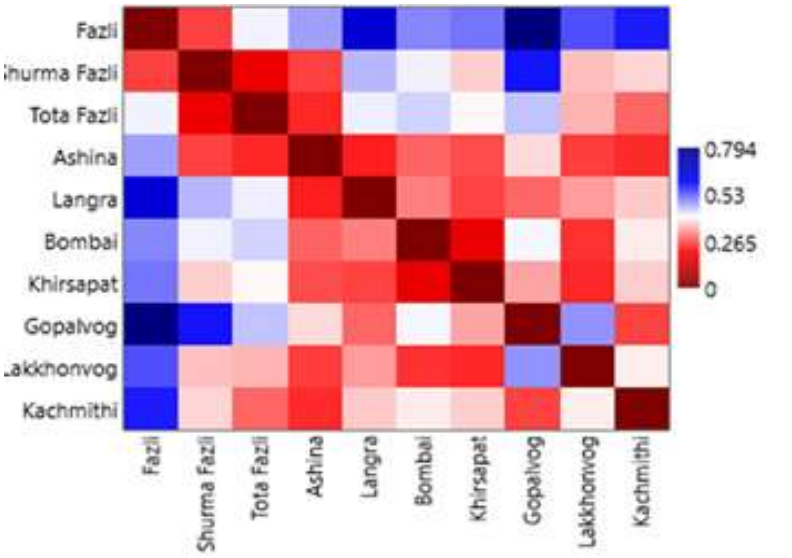

Fig. 3: Genetic dissimilarity matrix of the studied mango germplasm

Genetic similarity analysis using UPGMA

Dendrogram based on Gower similarity index generated from these 10-mango germplasm. The Unweighed Pair Group Method with Arithmetic Means (UPGMA) cluster tree analysis lead to the grouping of the 10 germplasm into four major clusters (Figure 4). Based on genetic distances different mango genotypes grouped into different sub-cluster (Molla *et al*., 2019).

Fig. 4. Dendogram showing the clusters among the studied germplasm

Cluster I included Ashina, Langra, Bombai, Khirsapat and Lakkhanvog. Cluster II included Gopalvog and kachmithi. Shurma Fazli, Tota Fazli were in cluster III. And cluster IV consisted of Fazli. From this study, the dendrogram revealed that the germplasm that were derivatives of genetically similar type form cluster together. Maximum mango germplasm (5) were included in cluster I and minimum (1) was in cluster IV.

Conclusion

Mango has been considered as an important fruit crop in many countries for its unmatchable taste, characteristic flavors, nutritional values and economic importance. World mango production is now spread over 100 countries and mango industry is the 6th largest tropical fruit industry in the world. Considering Fruit weight (743.33 g), Pulp weight (614.67 g), Pulp/peel & stone ratio (4.80) the germplasm Fazli was the best one among them. But in case of TSS (°Brix) Langra (20.67) performed better than Fazli. These variations can be used for selection of superior germplasm for cultivation at farmer's level as well as future breeding programme of mango in Bangladesh. Further collection of mango germplasm should be continued for getting more variability in respect of desired traits.

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