CHARACTERIZATION OF LOCAL AND EXOTIC MANGO GERMPLASM UNDER JOYDEBPUR CONDITION

BY
MD. NAYEEM AL IMAM
Reg. No. 01040

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Approved by:

Dr. Md. Amjad Hossain
Principal Scientific Officer
HRC, BARI , Gazipur
Supervisor

Prof. Md. Ruhul Amin
Dept. of Horticulture and Postharvest Technology
Sher-e-Bangla Agricultural University
Dhaka
Co-supervisor

Prof. Md. Ruhul Amin
Chairman
Examination Committee

উদ্যানতত্ত্ব গবেষণা কেন্দ্র

Horticulture Research Centre

Bangladesh Agricultural Research Institute
Joydebpur, Gazipur-1701, Bangladesh

Fax : 880-2-9261495
Tel. 9257003
E.mail:
drmahossain1959@yahoo.com

CERTIFICATE

This is to certify that the thesis entitled, "CHARACTERIZATION OF LOCAL AND EXOTIC MANGO GERMPLASM UNDER JOYDEBPUR CONDITION" submitted to the Department of Horticulture & Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (MS) in HORTICULTURE embodies the result of a piece of bona fide research work carried out by MD. NAYEEM AL IMAM, Registration No.01040 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or sources of information, as has been availed of during the course of this investigation has duly acknowledged.

Dated: 30 June, 2008
Place: Dhaka, Bangladesh

(Dr. Md. Amjad Hossain)
Principal Scientific Officer
Supervisor

BISMILLAHIR RAHMANIR RAHIM

All Praises are Due to Almighty Allah Who Kindly Enabled the Author to Complete this Research Work


DEDICATED TO
MY
DIVINE FATHER AND BELOVED MOTHER

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ABSTRACT

An investigation was carried out to Characterize 25 local and exotic mango germplasm at the Fruit Research Farm of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, during September, 2006 to August, 2007. The number of fruit set per panicle was maximum for Ananas (30.25) and minimum for Maldah (5.00). Individual fruit weight ranged from 110 g in Kalachini to 560 g in Fazli. Number of fruit per plant was maximum in BARI Aam-2 (198) and minimum in M-3896 (31). BARI Aam-2 yielded the highest (36.08 kg/plant) followed by Kent (27.77 kg/plant), Pahatun (25.97 kg/plant) and Maldah (25.8 kg/plant). The germplasm Mollika (79.69 %) and Kalachini (52.915%) had highest and lowest edible portion. Maximum pulp to stone ratio was found in Kalachini (0.89) and minimum in Shinduri (0.14). Kent contained the highest TSS (22.23%) and lowest TSS was in Totapuri (16.27%). Pulp pH was the lowest in Ahaping (4.14%) and highest in Totapuri (5.42%), whereas Summer Behest had the highest (0.54%) titratable acidity. The germplasm Kalachini was top in respect of reducing sugar (7.37%) and non reducing sugar was the highest in Summer Behest (15.10%). Maximum sugar acidity ratio was noted in Totapuri (81.51). Most of the germplasm under study performed very well in respect of yield, quality and pest & disease reaction. BARI Aam-1, BARI Aam-2, Kent and Rashunkoa were promising among the germplasm tested. Germplasm like Mollika, Ruby, Dashehari, Shinduri and M-3836 possessed attractive skin colour.

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ABBREVIATIONS AND ACRONYMS

ABBREVIATIONS	ACRONYMS
%	Percent
^{0}C	Degree Celsius
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CV%	Coefficient of Variation
df	Degrees of freedom
et al.	and others
g	Gram
ha	Hectare
HRC	Horticulture Research Centre
IBPGR	International Board For Plant Genetic Resources
LSD	Least Significant Difference
ml	Milliliter
MT	Metric ton
N	Normality
NS	Not significant
pH	Hydrogen ion conc.
ppm	Parts per million
RH	Relative humidity
SAU	Sher-e-Bangla Agricultural University
TSS	Total soluble solids
var.	Variety

CHAPTER I

INTRODUCTION

Mango (*Mangifera indica* L.), a member of the family Anacardiaceae, is one the choicest fruits in the world. It occupies relatively the same position in the tropics as is enjoyed by the apple in temperate America or Europe. Mango has got a unique position in respect of nutritional quality, taste, cosumer's preference etc., among the fifty kinds grown in Bangladesh (Ahmad, 1985). The fruit is believed to have originated in the Eastern India, Asam, Burma or in the Malayan region (Mukherjee, 1997).

Mango is popular for some of its special features such as excellent flavor, attractive fragrance, beautiful shades of colour and delicious taste from diversified varieties. It has medium calorific and high nutritional values. Carbohydrate content in ripe mango pulp is 16.9% (Salunkhe and Dasai, 1984). Besides, mango contains appreciable quantity of provitamin A, vitamin C and soluble sugar (Samad *et al.*, 1975). The fruit has really of immense value in respect of money and prosperity.

Mango is grown over wide geographical areas particularly in India, Pakistan, Brazil, Mexico, the Philippines, Indonesia, Thailand, Burma and Srilanka. It has gained popularity in Egypt, South-east Africa, Hawaii and Northwest Australia. Producing 9.64 million tons of fruit from an area of 1.17 million hectare, India is the single largest producer of mangoes with approximately 66% of the world mango production (Jacobi *et al.*, 2001). In Bangladesh, mango ranks first in terms of area and only third in respect of production. According to BBS (2006), Bangladesh produces 243 thousand tones of mangoes per annum from 50.59 thousand hectares of land.

Mango has been cultivated in Indo-Bangladesh for more than 4000 years (Candole, 1984). The wild mangoes particularly, *M. sylvatica* Roxb. is still found in the Chittagong Hill Tract of Bangladesh. The mango varieties in the country belong to only *M. indica* L., which are predominantly monoembryonic in nature.

In the past, mango was commonly propagated by seeds resulting innumerable varieties. The fruit grows in almost all parts of the country. But the commercial and good quality grafted mangoes with known varietals identity are mostly confined to the North-Western districts. On the contrary, mangoes of unknown varieties (gooti mangoes) are grown in the South-Eastern and other parts of Bangladesh (Bhuyan, 1995). Although mango production is increasing in the developed countries but unfortunately in Bangladesh its production is declining. The average yield of mango in this country is only 5.77 t/ha (BBS, 2006)

With the rapid increase in population, the nutritional as well as economic problems are getting worse parallel. To overcome these problems, development of mango varieties by evaluation at different agro-climatic regions may be a programme of immediate importance. For a reversal of the decline and to bring mango on the right track, replacement of all the inferiors by the right varieties must be ensured. This requires a wide survey and collection of superior mango germplasm from home and abroad, and thereafter their detailed evaluation under Bangladesh conditions or even for specific regions is necessary.

The commercial mango varieties namely, Gopalbhog, Khirsapat, Langra, Fazli, Ashwina etc. have been selected from chance seedlings and found in different parts of the Indian sub-continent. Still, there may be other superior chance seedling(s) available in the countryside of Bangladesh that remains unnoticed to the scientists. Some of these may be higher yielder with superior quality and posses a regular bearing habit.

Recently, some exotic mango varieties are gaining popularity in Bangladesh. If the exotic germplasm can ecologically be adapted to the agro-climatic conditions of our country, these would offer a scope to increase yield and production of mango here to a considerable extent, which also could help to enrich our varietal lot.

Again, characterization is an important aspect for documentation of the performance of the studied cultivars, which subsequently will help to introduce, select and improve the existing mango varieties. Unfortunately, information regarding the physico-morphological and physico-chemical characteristics of mango varieties growing under different regions of Bangladesh is scanty. Only a few characters of a limited number of cultivars have been studied (Bhuyan and Islam, 1989; Sardar *et al*., 1998). But variation exists in terms of physico-chemical composition among the mango varieties, even variations of fruit characters for a variety may occur because of difference in soil and climate or because of variable rootstock used in propagation (Jagirdar and Maniyar, 1960).

Considering its importance the study was undertaken with the following objectives:-

1. To investigate into the performance of local and exotic germplasm under Joydebpur condition.
2. To select suitable germplasm for cultivation in Bangladesh.
3. To identify suitable germplasm that could act as gene donors in hybridization programme.

CHAPTER II

REVIEW OF LITERATURE

Mango is a highly valued crop in Bangladesh, but information on the morphological and physico-chamical characteristics of different varieties under Joydebpur condition are scanty. Several research works have been done in the world to the flower and fruit characteristics of mango. Some available research findings in this connection have been reviewed and presented here under the following heads.

2.1 Climate and soil

According to Singh (1969) mango grows up to an altitude of 4,000 feet but the fruiting is poor above 2,000 feet. Chacko and Randhawa (1971) attributed the delay of the latter to the low temperatures that prevail in northern India. Singh (1969) stated that mango can grow in almost all types of soil. But a well drained, deep loamy soil is generally conducive to successful mango culture. The pH range of soil from 5.5 to 7.5 is desirable. Bondad (1989) stated that many of the mango growing areas have well drained loamy soil with pH 5.0-7.0. Ahmad (1994) stated that although Bangladesh is basically good for mango cultivation yet the more favored areas are the North-West and relatively lesser favored are in the extreme South-East and North-East considering the climate (rainfall, relative humidity) and soil. North-Western region have high temperature, low rainfall and humidity than Eastern side which favors the production of good quality mango.

According to Singh (1969) mango is damaged by frost at temperatures below 1.1 ^{0}C to 2.2 ^{0}C. Grafted plants are more susceptible than seedlings, especially during the first three years. Ideal growth takes place at 23.9 ^{0}C to 26.7 ^{0}C. Singh (1969) stated that mango grows successfully in areas with an annual rainfall of 771 mm to 642.5 mm with little or no irrigation.

In the Philippines, the mango committee (Anon., 1978) recommends the growing of the crop in a well-drained deep loamy soil with an elevation below 600 m and pH of 6 to 8. Ahmad (1989) stated that the optimum soil for mango is about in two meter in depth. The tolerable pH range being as wide as 4.0 to 8.5, though optimum is said to be 5.5 to 7.5. The soil should be provided with organic matter, phosphorus and sulphur, besides usual nitrogen and potassium.

Bondad and Valmayor (1979) stated that mango requires relatively higher temperatures but there are variations in cultivar responses. They observed that in wet areas where Pico and Carabao did not perform well, Kachamitha flowered profusely and fruited abundantly. Ahmad (1989) narrated that setting of fruits is adversely affected by fog, rain or cloudy weather in January to March when the trees flower. Mild showers at the time of development and enlargement of fruits are good, but storms affect them adversely, often resulting in immature fruit-drops.

2.2 Morphological characteristics of mango

2.2.1 Growth character

Bhuyan and Guha (1995) carried out an experiment on some exotic mango germplasm under Chapainawabganj condition of Bangladesh and stated that Pahutan had the maximum tree volume (29.60 m^3) and base girth 49.50 cm but the lowest leaf area (34.93 cm^2). The minimum tree volume (5.37 m^3) and base girth (25.00 cm) were recorded in M-2686 and Agmamashu, respectively. Rad had the maximum leaf area (60.24 cm^2). Islam *et al.* (1995) recorded the highest base girth in Krishnachura (2.32 cm) while the minimum in Rajbhog (1.42 cm) among the eight cultivars studied. Hossain *et al.* (2002) noted a wide variation among the observed varieties at Jessore for leaf area where the highest (120 cm^2) and the lowest (41.5 cm^2) values were obtained from Badshabhog and Neelumbori.

2.2.2 Floral characteristics

Ali and Mazher (1960) described different time of emergence of flowers in various mangos growing tracts viz. February- March in Multan, Pakistan; February in North India and late November and December in Southern India. Valmayor (1962) consented that blooming period is dependent on the combination of environmental factors and condition of the plant. An investigation was done by Islam *et al.* (1995) at Mango Research Station, Nawabgonj on floral characteristics of eight mango cultivars and stated that flower bud emergence of all the cultivars took place in January. The duration of flower bud emergence ranged from 22.5 to 29.09 days. According to Bhuyan and Guha (1995), Palmer and Amrapali were the earliest and the latest in respect of flowering time among the fourteen exotic mango germplasm studied.

Singh (1978) reported that under North Indian conditions percentages of perfect flowers in the variety Dashehari and Langra were 30.6 and 69.8, respectively. On the other hand, in South Indian mangoes it varied from 16.41% in Neelum to 3.17% in Allampur Baneshan. Bhuyan and Islam (1989) studied the physio-morphological characteristics of five popular mango cultivars. They opined that Gopalbhog had the maximum number of panicles (2.13) per shoot, whereas Fazli had the maximum number of main branches (26.13) per panicle and Khirsapat and Ashwina both had the longest panicle (31.67 cm). Haque *et al.* (1993) evaluated 20 elite mango cultivars at southern Bangladesh and observed that the length of panicles varied from 26.6 to 46.0 cm. They also found greater male and bisexual flower ratio in Brindabani (19:1) and Safeda (11:1).

An Investigation was carried out by Bhuyan and Islam (1989) to study the physico-morphological characteristics of five popular mango cultivars. They reported that Fazli and Ashwina were the earliest (27.01.86) and the latest (04.02.86) in respect of flower initiation. Flowering duration of the cultivars ranged from 18 days in Khiraspat to 25 days in Ashwina.

Haque *et al.* (1993) evaluated 20 elite mango cultivars at southern Bangladesh during 1992-93 and stated that cv. Baromashi flowered earlier (2nd half of December) than the others. Majumder *et al.* (2001) stated that the flowering time in mango is dependent on the climatic factors prevailing in an area; the flowering period of mango is usually of short duration of 2 to 3 weeks; low temperature may extend it, whereas higher temperatures may shorten it. Sardar and Hossain (1993) mentioned that under the climatic condition of Rajshahi the germplasm Amrapali, Mollika and Rad flowered in the 3rd - 4th week of February.

A study was conducted by Iqbal *et al.* (1995) on the performance of exotic mango germplsm at Chapai Nawabgonj. They recorded the highest male flower (93.39%) from the germplasm Carabao and the lowest from Kent (69.86%). Bisexual flowers of 18 different germplasm were in the range of 6.61 to 30.46%. Mango flowers are borne in terminal or pyramidal panicles, glabrous or pubescent; the inflorescence is widely branched, usually densely flowered with hundreds of small flowers. Both male and perfect flowers are found within a single inflorescence. From a keen observation, Mukherjee (1997) concluded that the ratio of male to perfect flowers is strongly influenced by environmental and cultural factors. Hossain and Talukdar (1974) studied the panicle characteristics, where its colour varied from deep to light green. They also noticed distinctive colour in certain varieties such as pink to light pink and chocolate.

Sardar *et al.* (1998) studied the physico-morphological characteristics of ten mango cultivars and noted that under the climatic condition of Rajshahi, Kohitoor and Fazli were the earliest (15.1.93) and the latest (31.1.93), respectively to initiate flowering. Moreover, flowering duration of different cultivars ranged from 25 to 35 days. Majumder *et al.* (2001) studied the flowering characteristics of mango in Queensland, Australia and stated that flowering occurs between June and October. In Fiji, flowering starts in July and extends through September/October. The flowering characteristics of mango in Egypt showed that flowering occurred during November to January. Singh

(1954) reported that the number of hermaphrodite flowers was the least in the upper part of the panicle but the percentage was the highest. He also stated that the percentage of hermaphrodite flowers varied from 0.74 in Rumani to 69.8 in Langra.

The mango inflorescence or panicles bear mainly two types of flowers- male and perfect, though neutral flowers are also encountered occasionally. The number of flowers per panicle varied between 1000 and 6000, depending upon the cultivars (Mukherjee, 1997). Hossain *et al.* (1977) studied flush characters and floral morphology of mango which revealed that the panicle length ranged from 13.97 to 27.68 cm. They also observed the highest ratio of male flowers (93.23%) from Gopalbhog. Among the studied varieties, Khirshapat produced the highest percentage of bisexual (18.88) and the lowest percentage of male flowers (81.12).

Majumder *et al.* (2001) reported that the sex ratio in different cultivars was greatly influenced by the environment in which they were grown. Even the same cultivars behaved differently in different locations. This was illustrated by the fact that some of the south Indian cultivars of mango, like Neelum, Baneshan, Allumpur, Janadhan Pasand and Willard when grown under North Indian conditions had significantly lower proportion of perfect flowers than under South Indian conditions. They also reported that perfect flower to be 30.6% in Dashehari, 42.9% in Chawsa, 9.20% in Bombay Green, 14.9% in Fazli, 8.40% in Himsagar, 16.41-55.7% in Neelum, 6.61-21.0% in Bangalora, 3.67% in Baneshan, 5.67-8.44% in Mulgoa, 32.49% in Pairi, 55.2% in Carabao and 47.9% in Pico, 75.3% in hybrid Sai-Sugandh and 25.6% in Mollika.

2.2.3 Fruit set and fruit drop

Fruit set implies that the flower has been pollinated and fertilized and in consequence, the ovary and accessory tissues started growing into a fruit. Singh (1978) reported that fruit set and ultimate retention per panicle were much higher in medium and late emerged panicles as compared with the early ones and it was a varietal character depending upon time of flowering, efficient cross-pollination and fruit drop intensity. Initial fruit set in mango is directly related to the proportion of perfect flower, although the final fruit set dose not necessarily depend on this ratio (Iyer *et al.*, 1989). An investigation was carried out by Uddin *et al.* (1995) to study the performance of six primarily selected lines of mango. They recorded the highest fruit set per panicle (19.33) from NMS-003 and the lowest (6.33) from NMS-023. Iqbal *et al.* (1995) conducted an experiment to evaluate the performance of 18 exotic mango germplasm. They stated that number of fruit set per panicle varied from 1.22 to 37.53. Moreover, they recorded the highest (2.20) fruit-harvest per panicle from Amraplai and the lowest (1.00) from kent.

Singh (1954) stated that the development of fruit in varieties 'Langra' and 'Dashehari started in the last week of March and completed by the end of 2nd week of June. On the other hand, fruit drop in various stages is common problem in mango fruit. It may occur due to lack of pollination, abnormalities of floral parts, formation of abscission layer, lack of nutrient and water in soil. Hossain and Talukdar (1974) studied the characteristics of Bangladesh mangoes grown at Rajshahi and recorded the maximum number of fruit set per panicle in Ranipasad (41.80) and the the lowest in Kishandhog (5.20). They also observed the increased fruit dropping (up to 98.47%) at pea stage. At marble stage they recorded maximum fruit dropping in Surmai Fazli (47.81%) and minimum is Dilsad (1.93%). Fruit dropping was minimum in mature stage, which was in the range between 0.10 and 3.26%. Finally they narrated that fruit harvest per panicle varied from 0.17 to 7.54%. An experiment was conducted by Islam *et al.*, (1995) on fruit characteristics and they observed that the

percentage of fruit dropping over initial fruit set ranged from 58.61 (Rajbhog) to 97.77 (Motichur).

2.2.4 Harvesting time

In India, Pandey (1984) stated that the harvesting time of Mollika and Amrapali was 3rd week of July. Sardar and Hossain (1993) reported that under the climatic condition of Rajshahi, the germplasm Amrapali, Mollika and Rad were harvested in the second week of July. Hossain (1989b) reported that mango under Bangladesh condition took about four to six month to reach maturity after flowering. Bhuyan and Islam (1989) carried out and experiment at the Mango Research Station, Nawabgonj and reported that the fruit of all the studied cultivars were harvested between 31-5-86 and 27-7-86. Gopalbhog was the earliest and Ashwina was the latest in respect of harvesting time. They also noted that Ashwina took maximum time (167 days) for maturity from flower initiation. According to Haque *et al.* (1993) harvesting time varied from 118 to 163 days at southern region of Bangladesh where they evaluated 20 cultivars of mango. Gopalbhog was the earliest (118 days) and Baromashi was the latest (163 days) in harvesting.

An experiment was conducted by Islam *et al.* (1995) on physio-morphological characteristics of eight mango cultivars and noted that Satiarkara (BARI Aam-1) was early and Kuapahari was late maturing cultivars. The time required for fruit maturity of different cultivars ranged from 86 to 117 days. Sharma and Josan (1995) reported that fruit of Langra matured during the second week of July, whereas those of Mollika and Amrapali in third week of July. Sardar *et al.* (1998) reported that Gopalbhog and Ashwina were early and late cultivar, respectively in respect of harvesting time. Ashwina took the maximum number of days (134) for maturity from flowering and the shortest period (92 days) was taken by Gopalbhog.

2.2.5 Yield

The yield of mango varied from area to area, season to season and variety to variety. Majumder *et al.* (2001) reported that the yield is a highly variable factor depending upon the cultivars and age of the plants, climatic conditions, incidence of pests and diseases etc. Singh (1978) reported that at the start of bearing the yield may be as low as 10 to 15 fruit (2 to 3 kg) per tree and rising to 50 to 75 fruit (10 to 15 kg) in subsequent years. Sardar *et al.* (1995) studied the performance of introduced mango germplasm under Bangladesh conditions and recorded the highest yield of 150 fruit (27.0 kg/plant) from the variety Amrapali. They further recorded the lowest yield 30 fruit (3.5 kg/plant) from Pahutan. Uddin *et al.* (1995) investigated the performance of six primarily selected mango lines and reported that NMS-035 produced highest yield (44.1kg/plant). On contrary, NMS-027 produced the lowest yield (3.8 kg/plant) among the lines studied.

Another experiment on the performance of introduced mango germplasm under Bangladesh conditions was carried out by Bhuyan and Guha (1995). The highest yield per tree (20.36 kg) was obtained from the germplasm Ruby which was followed by Palmer (16.90 kg), Pahutan (15.05 kg) and Keitt (11.23 kg), respectively while the lowest yield was given by (0.89 kg) from M-3896.

2.3 Physical characteristics of fruits

Lodh *et al.* (1974) evaluated the physico-chemical characteristics of mango fruits and pointed out that the weight of fruit varied from 209 to 622g. The length and thickness of fruit ranged between 10.06 and 13.59 and 5.96 and 9.31 cm, respectively. A wide variation was also observed in respect of pulp (66.0 to 75.0), peel (13.0 to 20.0) and stone (12.0 to 16.0) percentage. Mollah and Siddique (1973) studied the physico-chemical characteristics of some mango varieties of Bangladesh and found the variety Gobindabhog was the highest (620.42 g) in size, while Langra had the highest pulp content (77.47%)

Quantitative characteristics like length, breadth and thickness of fruit varied from 7.21 to 14.00, 6.15 to 9.70 and 5.96 to 8.66 cm, respectively.

Pandey (1984) reported that ripe fruits of Carabao, Irwin, Kent, Keitt, Mollika, Pahutan, Palmer and Amrapali were yellow, orange yellow, greenish yellow, bright yellow, apricot yellow, light yellow, light greenish to orange yellow and apricot yellow colour, respectively. Hossain *et al.* (2002) narrated that among the varieties under study at Jessore, the highest pulp content (676 g), peel content (106 g) and stone content (70 g) was obtained from Madrajee while the lowest pulp (55 g) and peel content (22 g) was recorded from Bhabani and the lowest stone (22 g) from Lata Bombai.

In a study on physico-chemical characteristics of some mango varieties, Bhuyan and Islam (1986) recorded the highest fruit weight (1014.45 g) in Fazli and the lowest (202.88 g) in Khude-khirsapat. Wide range o f variability among the varieties was recorded in fruit size, percentage of edible (64.94-81.49) and non-edible portions (18.51-35.06), stone size and thickness of fruits (6.02-8.92 cm). Fazli had the longest fruit (17.70 cm) and Satiarkara had the shortest (8.26 cm). The highest breadth of fruit (10.74 cm) was also observed in Fazli and that of the lowest (6.54) in Fonia. The stone percentage of Gopalbhog was the highest (19.25) and that of Fazli was the lowest (8.07). The peel percentage varied from 8.87 to 17.32 among the studied varieties. The stone length ranged from 6.50 to 14.8.cm and breadth from 3.38 to 6.50 cm. Islam *et al.* (1992) conducted an experiment on physico-chemical characteristics of ten mango cultivars and narrated that the cultivar Dudshar produced the largest fruit (13.4× 7.0× 6.2 cm) and Khude- Khirsapat the smallest (8.3×6.6×6.0 cm). Krisnachura had maximum fruit weight (425 g) and Khude-khirsapat had the minimum (212 g). Percent edible portion was the highest in Khude-khirsapat (73) and the lowest in Satiarkara (65.2). Fruit of Fonia, Gourjeet, Satiarkara and Khude-khirsapat had thin skin while fruit of Krishnachura were thick skinned.

An investigation was carried out by Saha and Hossain (1988) to evaluate the fruit characteristics of 11 mango cultivars at Joydebpur. They stated that quantitative characteristics namely length, breadth and thickness of fruits varied from 7.6 to 14.1, 5.9 to 7.3 and 5.5 to 8.2cm respectively. Significant difference was found in respect of weight of fruit (137.2 to 608.3 g), percentage of pulp (50 to 81.5), stone (9.3 to 23.4) and peel (9.2 to 27.0). Fruit of Fazli were better in respect of size and percent edible portion. Bhuyan and Islam (1989) studied the physical characteristics of some popular mango cultivars and reported that fruit weight varied from 208.0 to 654.44 g. The highest fruit weight (654.44 g) was found in Fazli which had the highest pulp weight too. The maximum (72.82%) edible portion was recorded in Ashwina and the minimum (59.13) in Gopalbhog. Hossain *et al.* (2002) noted a wide variation among the observed varieties at Jessore for individual fruit weight where the highest (852 g) and the lowest (103 g) values were obtained from Madrajee and Bhabani.

Fruit characteristics, such as size, shape and pulp of different mango varieties under the climatic condition of Rajshahi was investigated by Hossain and Talukdar (1974). Data indicated that the variety Fazli had the heaviest fruit (683.27 g) and the lightest was from the Bira (113.86 g). The pulp weight ranged from 66.63 to as high as 538.69 g. Stone characteristics in respect of length, breadth and weight were also studied. The stone length varied from 3.81 to 12.32 cm. A wide variation was observed in stone breadth among the studied varieties as it ranged from 2.94 to 7.41 cm. Stone weight was the highest (144.58 g) in Dilsad and the lowest (13.99 g) in Gopalbhog. Maximum pulp to stone ratio was found in Hazi Langra (1:0.44) whereas it was the lowest (1:0.05) in Fonia.

Ghose and Hossain (1988) studied the physico-chemical composition of 10 mango varieties at Joydevpur and reported that mango varieties under study varied greatly in shape, size, skin colour and weight. The variety Kalibhog produced the largest fruit (13.1× 8.6 × 8.6 cm) while Brindaboni the smallest one

(7.1× 5.4× 4.9 cm). Again, Kalibhog had the maximum fruit weight (655 g) but Brindanoni the minimum (106 g). Further Kalibhoig contained the highest pulp (78.5%), the lowest stone (9.8%) and peel (11.7%). Kalibhog was considered superior in respect of size, shape, edible portion, taste and finally the flavour to all the concerned 10 varieties. Hossain *et al.* (2002) reported a wide variation among the observed varieties at Jessore for fruit size where the longest fruit (16.6 cm) and the shortest (6.6 cm), the widest (12.2 cm) and narrowest (5.2 cm), the thickest (10.1 cm) and thinnest (4.8 cm) values were obtained from Madrajee and Bhabani respectively.

An investigation was carried out by Saha and Hoissain (1988) to evaluate the fruit characteristics of 11 mango cultivars. They reported that skin colour at ripe stage varied from yellowish green to bright yellow. Wide variation was also recorded in shape of fruits. Pulp colour ranged from yellow to red. Gopalbhog was better in respect of the pulp colour and taste.

In an experiment at RARS, Hathazari, Chittagong, Ahmad *et al.* (1989) evaluated ten relatively small-fruited mango varieties and narrated that the mean weight of fruits was 151.2g with proportion of pulp, skin and stone being 68.4, 15.9 and 15.8 percent, respectively. The heaviest fruits were in Kalia (214.8 g), Deori (175.5 g) and Sultan Pasand (176.6 g). The highest proportion of pulp was in Narikeli (75.9 %), Latabombai (74.8%), Bombai (71.8%) and Sultan Pasand (71.6%). The proportion of the skin of Bombai was highest (20.5%) whereas that of Narkeli was the lowest (11.7%). In Bihar, India, Syamal and Mishra (1987) reported that Fazli produced the heaviest fruit (506 g) followed by Langra (310 g) and Sinduri (294 g). Fazli and Langra also had high pulp contents. According to Bhuyan and Guha (1995), considering the fourteen exotic mango germplasm the highest and lowest edible portions were recorded in Pahutan (74.31%) and M-2686 (45.21%), respectively.

Haque *et al.* (1993) conducted an experiment at southern Bangladesh and found that the length of the fruit ranged from 10 to 17 cm and the breadth 8.5cm in Baromashi to 14.7 cm in Badshabhog. Fruit thickness varied from 4.8 to 8.6 cm. Bigger and heavier fruit were found in Mohanbhog (670 g) and Fazli (615 g). Fruit weight ranged from 159 to 670 g. Significant differences were observed in case of stone length (5.0 to 11.5 cm), breadth (3.0 to 6.0 cm) and thickness (1.7 to 3.0 cm). Stone weight varied from 14.0 to 70.0 g among the cultivars.

Sardar and Hossain (1993) studied the performance of five introduced mango varieties namely Amrapali, Mollika, Carabao, Pahutan and Rad. They observed that under Bangladesh conditions the fruits of all these varieties were excellent in appearance. Mollika produced the biggest fruit (463.4 g) followed by Rad (230.5 g). The maximum edible portion was obtained from Mollika (76.1%) followed by Rad (73.4%) and Pahutan (73.01%). An experiment was conducted by Iqbal *et al.* (1995) to investigate the performance of exotic mango germplasm. Marked variation in fruit characteristics was observed. Keitt produced the biggest fruit (675.8 g) while the smallest (62 g) fruit was found in M-3809. Rad had the highest edible portion (79.06%) whereas Agmamashu had the lowest (60.47%). Again Kent produced heaviest stone (47.08) but Rad produced the longest stone (10.56 cm). Stone characteristics like length, breadth and thickness were varied from 5.35 to 10.56, 2.35 to 4.28 and 1.17 to 2.17 cm, respectively.

Palaniswamy *et al.* (1994) noted that mango fruit weight ranged between 101.1 and 670.0g and pulp percentage between 53 and 83 among the 29 cultivars of Tamil Nadu, India. Samad (1975) examined the physical and bio-chemical characteristics of fruits of 10 mango varieties and pointed out that the fruit of Fazli was the largest (512.83 g) in size and contained the highest pulp (388.57 g). Islam *et al.* (1990) observed a wide range of variability in different fruit characteristics among the eight uncommon varieties. The fruits of Safeda were biggest (460 g) having highest quantity of pulp (343 g). Brindaboni and Dil Pasanda had the smallest (165 & 166 g) and the later contained the lowest

quantity of pulp (92 g). The highest and lowest edible portions were recorded in Kalapahar (70%) and Kanaibashi (51%), respectively.

In semi-arid region of Moharashtra, India, Chaudhari *et al.* (1997) evaluated the South Indian mango varieties and narrated that the quantitative characters like length and diameter of fruits varied from 6.7 to 15.0 and 5.5 to 10.2cm respectively. Less variation was observed in percentage of pulp (46.5 to 68.0), peel (14.3 to 28.0) and stone (16.1 to 27.8). Sadar *et al.* (1998) observed a wide range of variability in respect of different physico-chemical characteristics of mango fruit. Skin and pulp colour of ripe fruits varied from green to yellow and yellow to orange, respectively. The largest fruit (578.3 g) was recorded in Fazli and the smallest fruit (126.9 g) in Bhabani. Fazli had the longest fruit (15.5 cm) and the shortest (7.6 cm) in Ilsapeti. Fruit breadth and thickness varied from 5.5 to 8.9 and 5.0 to 8.2 cm, respectively. The longest (11.4 cm) and the widest (5.7 cm) stone were found in Fazli whereas that of Ilsapeti was shortest (5.6 cm) as well as narrowest (3.1 cm). Thickness of stone was the highest (3.2cm) in Ashwina and lowest in Ilsapeti (1.8 cm). Percentage of edible and non-edible portions varied from 58.5 to 75.1 and 24.9 to 41.5, respectively. Furthermore, Ilsapeti had the highest stone portion (26.2%) and the lowest in Kishanbhog had the lowest (12.5%).

Fruit skin colour at maturity is genotype dependent. Fruit of Bombay is green; Carabao, Manila, Mulgoa and Arumanis are greenish- yellow and Haden, Keitt and Tommy atkins have a striking red blush as reported by Mukherjee (1997). Islam *et al.* (1992) conducted an experiment on physico-chemical characteristics of ten mango cultivars and narrated that pulp colour o f Gourjeet and Rajbhog was deep yellow and that of Kanchamitha was light yellow. Pulp colour of fruits of the remaning cultivars was yellow. Haque *et al.* (1993) observed that maximum fruit turned to yellow or greenish yellow during ripening while the cvs. Kohitur and Summer Behest turned to red and reddish yellow.

2.4 Bio-chemical characteristics of mango

2.4.1 Moisture content

An investigation was carried out by Absar *et al.*, (1993) to find out the moisture content of mango at different stages of maturity. They reported that at the full ripen stage moisture varied 71.22 to 79.40%. Moisture content in ripe pulp of mangoes were 78.86% (Bhatnargar and Subramanyam, 1973), 81% (Salunkhe and Desai, 1984) indicating an overall rise in percent moisture content. Moisture content of green pulp of Fazli mangoes was 79.95% and ripe mango had 90% (Shahjahan *et al.*, 1994). Srivastava (1967) reported that the green unripe mango contained higher percentage of moisture compared to ripe mango. In Pakistan, Chaudhury and Farooqui (1969) observed 79.83% moisture in the cultivars Sindury, Bombay. Ali and Mazher (1960) studied the various characteristics and chemical composition of mango and reported that the fruit contained water from 76 to 86% according to variety.

2.4.2 pH

pH content in Fazli mango at harvest and last day storage respectively has been reported as 3.84 and 4.88 (fruit harvest at 127 days after fruit set) (Shajahan *et al.*, 1994). Joshi and Roy (1988) stated that there was a steady rise in pH of the fruit of Alphonso mango during storage. Samad *et al.* (1975) reported that pH of the juice of mango was in range between 4.0 and 4.5. Fazli ranked the first position (4.45) whereas it was the lowest in the pulp of Ranibhog (4.0). Absar *et al.* (1993) observed the highest pulp pH in Khirsapat (5.2) and the lowest (4.0) in Ashwina On the contrary; Kumar *et al.* (1993) found the maximum pH (4.64) in Fazli. Reducing sugar content of mango varied from 2.6 to 7.1% as described by Chaudhari *et al.* (1997).

2.4.3 Reducing sugar

Sharma and Josan (1995) carried out an experiment with five mango varieties namely Dashehari, Langra, Mollika, Amrapali and Alphonso. They noted the highest reducing sugar (4.18%) in Dashehari and the lowest in Alphonso (2.56%). In Bihar, India, Syamal and Mishra (1987) conducted an experiment with some important mango varieties to determine the chemical composition and found the highest sugar (5.82%) in Langra. Reducing sugar increased gradually with fruit ripening (Upadhyay and Tripathi, 1985). Lodh *et al.* (1974) analyzed eight varieties of mango and stated that reducing sugar varied from 2.70 to 3.85. Samad *et al.* (1975) evaluated ten varieties of mango and reported that the reducing sugar content of the fruit under the study was in the range between 3.26 in Ranibghog and 5.98% in Gopalbhog. Reducing sugar content was 4.23% in Fazli as reported by Sarker and Mushi (1978). Acerding to Chaudhari *et al.* (1997), percent non-reducing sugar in ripe mango fruit differed widely. They evaluate South Indian mango varieties under Semi-arid region of Maharashtra and observed 6.2 to 11.5% non-reducing sugar. Rangavalli *et al.* (1993) found a gradual increase in non-reducing sugar content. Sarker and Mushi (1978) worked on non-reducing sugar content at ripening stage and found 17.35% and 15.75% non-reducing sugar in Fazli and Gopalbhog respectively.

2.4.4 Non-reducing sugar

A study was carried out by Samad *et al.* (1975) with some common mango varieties of Bangladesh. They reported that non-reducing sugar content was found to be within the range of 1.62 to 6.60%. In India, Lodh *et al.* (1974) conducted an experiment at the Indian Institute of Horticulture Research, Hessarghatta. They analyzed eight varieties of mango for their chemical composition. In case of non-reducing sugar the variety Mulgova attained the first position (19.75%) whereas Totapuri the least one (4.42%). Chaudhari and Farooqui (1969) estimated 7.27 to 12.35% non-reducing sugar in some

common and local varieties of mango in Pakistan. In Korea, Kim *et al.* (1996) reported that the respiration rate increased at higher storage temperature but decreased with storage period. They also stated that total sugar content of fruit decreased with storage. Sucrose content of fruits increased but glucose and fructose decreased when fruits were stored at lower temperature.

2.4.5 Total soluble solid (TSS) content

The soluble solids in mango flesh mainly consist of sugars, soluble pectin, organic acids, vitamin C etc. Some information on change in total soluble solids is cited below. Absar *et al.* (1993) reported that TSS in ripe stage of mango varieties ranged from 16.80-22.20%. They observed the highest TSS (22.2%) in Langra, while Fonia was the lowest (16.80%) one. Hossain *et al.* (2002) observed TSS range from 13.7 % to 20.9 % among the varieties studied at Jessore, where the highest value from Himsagar and the lowest from Madrajee. In another study, carried out by Sardar *et al.* (1998) revealed that TSS of mango fruit varied from 16.8 to 21.6%. In India, Sharma and Josan (1995) evaluated five mango cultivars under arid irrigated region of Panjab and reported that Dashehari had the highest TSS (20.7%). The minimum TSS (15.2%) was recorded from Alphonso. Chaudhari *et al.* (1997) in a study with mango fruit found that TSS varied from 16.5 to 23.5%. Mollah and Siddique (1973) reported that TSS of mango cultivars Fazli and Langra were 12.2 and 18.0%, respectively. Popenoe (1964) made a report on the chemical composition of different varieties of mango and noted that TSS was more than 20%. Lodh *et al.* (1974) analyzed eight varieties of mango where TSS ranged from 15.40% (Totapuri) to 21.40% (Bombay green). On the other hand, Palaniswamy *et al.* (1974) observed 11.8 to 26.8 percent TSS in South Indian mango cultivars.

Prasad (1977) found the maximum TSS (21.5%) in Alphonso and minimum (16.41%) in Bangalora when he evaluated south Indian mango varieties in Northern India. Increase in the percentage of TSS during storage was recorded

in mango (19.68%). Srivastava (1967) found that total soluble solids increased while the acidity of the fruit generally decreased. Jana *et al.* (1998) studied 20 mango varieties of West Bengal, India and found that variety Daudia had the highest titrable acids (0.58%). Chaudhari *et al.*, (1997) carried out an experiment with 21 mango cultivars and chemical analysis was performed. They narrated that titrable acidity of mango varieties differed greatly. It was the maximum (0.59%) in Himsagar and the minimum (0.14%) in Jahangir. Sharma and Josan (1995) estimated 0.253 to 0.473% acidity in five common varieties of mango in India.

In Shujabad, Pakistan, Haq and Javaid (1995) conducted an experiment on physico- chemical characteristics of local and exotic mango varieties and noted the highest titrable acidity (0.55%) in Zafran and the lowest in Alphonso (0.23%). According to Shahjahan *et al.* (1994) percent acidity in ripe mango fruit of cultivars Fazli, Langra, Khirsapat and Gopalbhog were 0.10, 0.06, 0.26 and 0.21, respectively. Significant difference in total acidity was observed by Prasad (1977), where the highest acids (0.585%) were found in the variety Bangalora and the lowest in Alphonso (0.32%). Lodh *et al.* (1974) investigated the chemical composition of eight varieties of mango and noted that acidity varied from 0.11 to 1.33 percent.

2.4.6 Titratable acidity

Srvastava (1967) conducted an experiment with 22 mango cultivars collected from various parts of India. He showed that acid content ranged from 0.18 to 0.56% in ripe fruit. In Tamilnadu, India, Palaniswamy *et al.* (1974) studied 29 cultivars of mango. The variation of titratable acidity ranged from 0.4 to 0.58%. Lodh *et al* (1974) investigated the chemical composition of eight varieties of mango and consented that acidity varied from 0.11 to 1.33 percent. Significant difference in total acidity was observed by Prasad (1977), where the highest acids (0.585%) were found in the variety Bangalora and the lowest in Alphonso (0.32%).

According to Shahjahan *et al.* (1994) percent acidity in ripe mango fruit of cultivars Fazli, Langra, Khirsapat and Gopalbhog were 0.10, 0.06, 0.26 and 0.21, respectively. Sharma and Josan (1995) estimated 0.253 to 0.473% acidity in five common varities of India. In Shujabad, Pakistan, haq and Javaid (1995) noted highest titratable acidity (0.55%) in Zafran and lowest in Alphonso (0.23%). Chaudhury *et al.* (1997) narrated that titratable acidity in the mango varieties differed greatly. It was the maximum (0.59%) in Himsagar and the minimum (0.14%) in Jahangir. Jana *et al.* (1998) studied the 20 mango varieties of West Bengal, India and found that variety Daudia had the highest titratable acids (0.58%).

2.4.7 Sugar/acidity ratio

Lodh *et al.* (1974) reported that sugar/acidity ratio varied from 5.50 to 109.20. Langra showed the maximum (109.20) sugar/acidity ratio, which may be responsible for its wide popularity. In India, Sharma and Josan (1995) evaluated five varieties of mango under arid-irrigated region of Punjab and recorded the highest (16.49) sugar/acidity ratio in Dashehari while Mollika the least (8.54) one.

2.5 Disease incidence

Rain, fog or cloudy weather favours the development of mango diseases (Gangolly *et al.* 1957). Majumder *et al.* (2001) reported that anthracnose is a serious disease in humid and high rainfall areas of India. Ann *et al.* (1994) claimed that rainfall, high relative humidity and high temperature favoured anthracnose development. Continuous rainfall was the most important factor contributing to anthracnose on mango fruit. Bhuyan and Guha (1995) studied the performance of some exotic mango germplasm under Bangladesh condition. They reported that Carabao, M-3836, Mollika and Amrapali were resistant to anthracnose and Ruby was highly susceptible. They also observed that the germplasm Agmamashu was resistant to red rust whereas Ruby and

Amrapali were highly susceptible to the disease. Iqbal *et al.* (1995) conducted an experiment on the performance of exotic mango germplasm where all exotic germplasm were affected by malformation (41.84%). An experiment was conducted by Reza (1995) to evaluate 27 mango germplasm of Regional Horticulture Research Station, Nawabgonj against malformation. Lata Bombai showed the highest (52.08%) malformed panicles whereas Fazli and Mahananda (BARI Aam-1) were free from the disease. He pointed out that all the studied exotic mango germplasm were infected by malformation.

Patwary *et al.* (1995) evaluated local genotypes of mango and noted that SOM-1019 and SOM-1047 were moderately susceptible to scab. Mortuza (1992) conducted an experiment with 26 germplasm (local and exotic) of mango at The Mango Research Station, Nawabgonj. He concluded that Amritobhog, Sandha, M-2750 and M-3896 were free from anthracnose. All the varieties were free from powdery mildew except Ruby, Rad, Keitt and Pahutan. Zill was free from red rust while Ruby was the most susceptible.

Study on relative susceptibility of different mango germplasm to floral malformation indicated that it varied with the variety (from 0 to 58%). (Anon., 2004). Commercial varieties namely Fazli, Langra and Ashwina were found free from this disease. Gopalbhog and Khirsapat had negligible (0.1 to 2%) and slight (2.1 to 5%) incidence respectively. The exotic germplasm were found more susceptible to it. Clara (1927) observed that warm weather with intermittent showers during flowering favoured the development of anthracnose. Tiwari and Singh (1999) reported that cultivars Banbalia, Bombay Green and Dilpasand were moderately resistant to anthracnose. Survey of mango orchards of Nawabgonj, Rajshahi, Dinajpur, Chuadanga and Meherpur indicated that the major diseases were anthracnose, powdery mildew, sooty mould, die-back, scab, stem end rot, malformation and red rust (Anon., 2004). Anthracnose was highest in seedling mangoes. Sooty mould and red rust were highest in Fazli. Khirsapat showed the highest infestations of malformation and die back.

2.6 Insect

Survey on mango orchards in North-West Bangladesh showed that the major insects are mango hopper, shoot gall spelled, fruit fly, leaf gall midge, leaf cutting weevil and shoot borer (Anon. 2004). In South-East areas in addition to the above, mango defoliator, mango fruit and nut weevil are very serious. At Joybebpur and in the surrounding, stem borer was found to be very serious. Alam *et al.* (1989) reported that Gopalbhog had the lowest and Khirsapat exhibited the highest infestation of mango hopper. Hossain (1989a) reported that fruit weevil is the most destructive and a major pest in the eastern parts of Bangladesh.

According to Karim and Ahmed (1989), the mango fruit fly is a major pest of the ripening fruits of Fazli, Khirsapat, Langra and some other medium to big fruited varieties of mango in the North-Western districts of Bangladesh. This is also a major pest on all other mango varieties including seedling mango varieties all over Bangladesh. Sarker and Rahman (1995) conducted an experiment with different germplasm of mango at the Mango Research Station, Nawabgonj. Among the varieties, Ruby was highly susceptible to mango fruit fly (37.5%) while Pahutan, Agmamashu, Keitt, Kent, M-2750, M-3836, M-3896, Tiakathi and Sandavarati were less susceptible. Fruit fly infestation did not occur on Carabao, Irwin, Hayati, Prosadbhog, Rad, Lata bombai and Golapkhash.

CHAPTER III

MATERIALS AND METHODS

3.1. Experimental site

The present experiment was conducted at the Fruit Research Farm of the Horticulture Research Centre Bangladesh Agricultural Research Institute (BARI), Joydebpur and Gazipur.

3.2. Climate

The experimental area is situated in 24° N latitude and 90°26′ E longitude. The area characterized by moderate to heavy rainfall, high humidity, high temperature, short clear sunshine during the month from April to September and scanty rainfall, low humidity, low temperature, long clear sunshine and short day during the rest period of the year. Details of the weather data of Gazipur location are presented in Appendix 1.

3.3. Soil

Gazipur area was occupied by shallow red brown terrace soil (AEZ 28). Soils in the valleys were dark grey, heavy clays, acidic in reaction with pH 5.9-6.0

3.4. Materials

Twenty five germplasm of mango were involved in this study. Among these, Six germplasm were local viz Kalachini, BARI Aam-1, BARI Aam-2, Shinduri, Fazli and Deshi Rangin) and the rest were exotic which were introduced from different countries and now successfully grown in our country viz Ananas, Ahaping, Pahutan, Zillate, M-3836, Mollika, Maldah, Florigon, Summer Behest, Kent, Totapuri, Ruby, Dashehari, Roshunkoa, Palmar, Kuphari, M-3896, Chowsha, Keitt). One year old grafts were planted in July, 1993 at the Fruit Research Farm of BARI maintaining a distance of 8 m × 8 m. A single tree of each variety constituted the unit plot. The present study was carried out during September 2006 to August 2007.

3.5. Experimental design

The experiment was laid out in a non replicated Randomized Complete Block Design (RCBD). A single tree of each germplasm constituted the unit of replication.

3.6. Intercultural operation

3.6.1. Weeding and soil loosening

The orchard was ploughed two times at the beginning of the rainy season to suppress the weed growth and also to break capillaries. The orchard was ploughed again at the end of rainy season to suppress weed growth conserve soil moisture and to provide good for root growth.

3.6.2. Irrigation

Irrigation was given when the trees are in full bloom stage and another at pea stage of fruit in modified basin method. Again after application of fertilizers, the plants were irrigated so that the soils around it remain sufficiently wet at least up to 15 days.

3.6.3. Fertilization

Fertilizer @ 30 kg FYM, 1000 g urea, 500 g TSP, 350 g MP, 350 g gypsum and 15 g zinc sulphate were applied per plant in two split at circular trench (60 cm broad, 30 cm deep) 3 m away from the trunk. First split was applied at the end of May and again at the end of September. These operations were done following the recommendation of Hossain (1989a).

3.6.4. Pruning

Pruning of dead, diseased, insect infested, parasitic plant parasite infested and half dead stems was done during October to allow maximum light and air and to keep insect-pest population under control.

3.6.5. Disease and pest management

Two full cover spray applications with cypermethrin 10 EC (Cymbush 10 EC) @ 1 ml/L along with Tilt 250 EC @ 0.5 ml/L of water first within 10 days of flowering when the flowers were not opened and the second after one month of first application were done to control mango hopper and anthracnose.

3.7. Methods used for studying the physico-morphological characters

3.7.1 Leaf

The characteristics of leaf shape, leaf margin and leaf tip were recorded by using the Descriptors for Mango (IBPGR, 1989).

The leaf area was estimated following the method of Saidha and Rao (1985).

Leaf area (cm^2) Y= K. X

Where K is constant (0.737) and X is the length × breadth of leaf.

Measurements relating to length and breadth were recorded from ten randomly selected leaves of each tree.

3.7.2 Full bloom

The date of full bloom was noted when about three fourth of the flowers of the inflorescence were opened. The date was determined by making frequent observations of the plant. Duration of flowering was also recorded.

3.7.3 Shape, position and colour of panicle and type of flower

The parameters were recorded using the Descriptors for Mango (IBPGR, 1989)

3.7.4 Percent flowers

Male, perfect and unopened flowers were counted from ten randomly selected panicles of each tree and expressed as percentage of total number of flowers per panicle.

3.7.5 Harvesting time

Harvesting time was determined by the incidence of the dropping of a few normal ripe fruits from the plant naturally.

3.7.6 Number of fruits per tree

Total number of mature fruits per plant was recorded.

3.7.7 Weight of fruits per tree

Immediately after harvesting the fruits were weighed by a top load balance.

3.8. Methods used for studying the physical characteristics

For this study, the mature fruits were collected randomly from the selected plants. Ten of selected fruits were kept on the laboratory desk at room temperature for recording their physical characteristics. The data were recorded at full ripe stage.

3.8.1 Shape of fruit, skin colour and flesh colour

It was determined by using the Descriptor for Mango (IBPGR, 1989) and eye estimation.

3.8.2 Fruit weight

After ripening, 10 fruits of each tree were weight by top load balance and average was computed by dividing it by 10.

3.8.3 Length, breadth and thickness of fruits

Length, breadth, and thickness of fruits were recorded with the help of a slide calipers from the previously selected 10 fruits collected from each of the replicated variety.

3.8.4 Peel and stone weight

Peeling of the fruit and separation of the pulp from the stone were carefully done by hand. Weights of the peel and stone of the selected mango fruits were taken with the help of top load balance.

3.8.5 Percent edible portion

Percent edible portion was calculated by the following formula:

$$\text{Percent edible portion} = \frac{\text{Fruit weight- (Stone weight + peel weight)} \times 100}{\text{Fruit weight}}$$

3.9. Methods used for studying the bio- chemical characteristics

3.9.1 Moisture content of pulp

A dry empty crucible was weighed in an electric balance. Then a defined quantity of sample was taken in the crucible and weighed in a balance. Then crucible with the sample was placed in the oven and dried at a temperature of 150^0C for 24 hrs. After drying the crucible with sample was removed from the oven and cooled in a desicator. After cooling, the crucible was weighed. From this weight, moisture content of the sample was calculated.

For accuracy, minimum three times replicated samples were dried in the oven and average moisture content was determined. Percent moisture content was calculated using the following formula:

$$\% \text{ Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where,

W_1= weight of empty crucible

W_2= Weight of crucible + sample

W_3= Weight of crucible + sample (dry)

3.9.2 Total soluble solids (TSS)

Total soluble solids (TSS) content of mango pulp was determined by using refractometer. A drop of mango juice squeezed from the fruit pulp was placed on the surface of the prism of the refractometer. Percent TSS was obtained from direct reading of the instrument. Temperature corrections were made by using the methods by Ranganna (1979).

3.9.3 pH of fruit pulp

pH and pH-4 buffer tablet (BDH chemicals Ltd., Poole, England) was dissolved in water and made up to the mark of 100 ml with distilled water.

Extraction of fruit juice: For determination of pulp pH, 4 g of fresh pulp was taken in a conical flask with 10 ml of distilled water. Then the pulp was crushed thoroughly in a mortar and pestle and extract was filtrated through two layers cloths.

Procedure: The electrode assembly of the pH meter was dipped into the standard buffer solution of pH-7 taken in a clean and dry beaker. The temperature correction knob was set to 28^0 C and the fine adjustment was made by asymmetry potentially knob to pH-7. After washing with distilled water, the electrode assembly was dipped into a solution of standard pH-4 and adjusted to the required pH by fine asymmetry potential knob. The electrode assembly was raised, washed twice with distilled water and then rinsed with mango juice and finally it was dipped into the juice of mango and pH was recorded from the meter.

3.9.4 Determination of reducing sugar

Reducing sugar content of mango pulp was determinate by dinitrosalicylic acid method (Miller, 1972).

Extraction of sugar from sugar pulp: Total sugar content of mango pulp was determined coloimetrically by the anthrone method (Jayaraman, 1981). Following reagents were used for the determination of total sugar:

i) Anthrone reagent: The reagent was prepared by dissolving 2 g of anthrone in one liter of concentrated H_2SO_4.

ii) Standard glucose solution: A standard solution of glucose was prepared by dissolving 10 mg of glucose in 100 ml of distilled water.

Procedure: Aliquot of 3ml of the extract was pipetted into a test tube and 3ml of DNS reagent was added to each of this solution and mixed well. The test tubes were heated for 5 minutes in boiling water bath. After the colour has developed, 1 ml of 40% Rochelle salt was added when the contents of the tubes were still warm. The test tubes were then cooled under running tap water. A reagent blank was prepared by taking 3 ml of distilled water and 3 ml of DNS reagent in tube and treated similarly. The absorbance of solution was measured at 575 nm in a colorimeter.

The amount of reducing sugar was calculated from the standard curved of glucose. The percentage of reducing sugar present in the mango pulp was determined by using the following formula:

$$\% \text{ Reducing sugar (g/100g of sample)} = \frac{\text{Quantity of reducing sugar obtained}}{\text{Weight of sample}} \times 100$$

3.9.5 Estimation of non- reducing sugar

Non-reducing sugar content of mango pulp was calculated by using the following formula:

% Non-reducing sugar = % total sugar - % reducing sugar

3.9.6 Titratable acidity

The titratable acidity of mango pulp was determined by method of Ranganna (1979). The following reagents were used for the determination of titratable acidity.

Acidity Reagents

i) 0.1 N NaOH

ii) 1% Phenolphthalein indicator

Procedure: Acidity was determined following the methods of Ranganna (1979). Known volumes of the mango pulp were measured in graduated cylinders and then these were transferred to beakers. The juice was then cooled and poured back to the same graduated measuring cylinder and made up to the lost volume with distilled water.

Titration: Ten ml pulp was taken in a 100 ml conical flask. Tow to threedrops of phenolphathalenin indicator was added and then the conical flak was shaken vigorously. It was then filtered immediately with 0.1 NaOH solutions from a burette till a permanent pink colour was appeared. The volume of NaOH solution required for titration was noted from burette reading.

Percent titratable acidity was calculated using the following formula:

$$\% \text{ Titrable acidity} = \frac{T \times N \times V_1 \times E}{V_2 \times W \times 1000} \times 100$$

Where,

T= Titre

N= Normality

V_1= Volume made up

E = Equivalent weight of acid

V_2 =Volume of sample taken for estimation

W= Weight of sample

3.10. Disease incidence

Mango germplasm were evaluated from September 2006 to August 2007 against major diseases and physiological disorder viz. anthracnose, floral malformation and stem end rot. The incidence of disease was recorded in natural epiphytotic conditions. Diseases scoring was recorded following 1-9 scale of the Descriptors for Mango (IBPGR, 1989), considering up to 30% infection as low susceptibility, 31-50% infection as medium and above 50% infection as high susceptibility .

3.11. Insect pest incidence

Mango germplasm were evaluated from September 2006 to August 2007 against major insect pest's viz. fruit fly, fruit weevil and stem borer. The incidence of insect pests was recorded in natural epiphytotic conditions.

3.12. Statistical analysis

The recorded data on different parameters were statistically analyzed by using scientific calculator as suggested by Gomez and Gomez (1984).

CHAPETER IV

RESULTS AND DISCUSSION

The results on different characters of 25 local and exotic mango germplasm have been presented and discussed under three main heads.

4.1 Studies on the morphological, flowering and fruiting characteristics

The results of the study on morphological characteristics of different mango germplasm are presented in Table 1. The findings have been discussed in this chapter under the following sub- headings.

4.1.1 Leaf characteristics

Results presented in Table 1 revealed that the local and exotic mango germplasm varied widely in respect of leaf characteristics.

4.1.1.1 Length of leaf

The germplasm M-3836 and M-3896 had the longest (28.56 cm) leaf followed by kent (27.62 cm), Ananas (26.20 cm), Chowsha (23.58 cm) and Summer Behest (23.04 cm). The shortest leaf was found in the Deshi Rangin (13.80 cm) preceded by Kalachini (14.50 cm) and Maldah (15.73 cm). Hossain and Uddin (1995) reported that length of leaf in different varieties of mango ranged from 16.75 to 24.70 cm.

4.1.1.2 Breadth of leaf

The germplasm Chowsha had the widest (7.06 cm) leaf breadth followed by Kupahari (6.93 cm) and Kent (6.80 cm). The narrowest leaf was found in the Deshi Rangin (3.87cm) preceded by Kalachini (4.53 cm) and Ahaping (4.34 cm). Hossain and Uddin (1995) reported that breadth of leaf in different varieties of mango ranged from 3.78 to 8.03 cm.

4.1.1.3 Leaf area

The leaf area was the highest in Kent (138.42 cm^2) followed by Chowsha (122.69 cm^2) and Fazli (122.02 cm^2). The leaf area was lowest in Deshi Rangin (39.36 cm^2) preceded by Kalachini (48.48 cm^2). Bhuyan and Guha (1995) found the maximum leaf area (60.24 cm^2) in Rad and the minimum leaf area (34.93 cm^2) in Pahutan among the 4 years old grafted plants of exotic varieties of mango studied under Chapai Nawabgonj condition. This variation might be due to variation in varities.

4.1.1.4 Length of petiole

Wide variation was recorded for petiole length Maldah showed the longest (4.33 cm) petiole followed by Totapuri (4.20 cm) and Palmar (4.03 cm). The shortsest petiole (1.67 cm) was found in Deshi Rangin (Table 1). Rahaman *et al.* (2003) also reported that of length of petiol of different varietics of mango ranged from 1.67 to 4.33 cm.

4.1.1.5 Leaf shape

The leaves of Roshunkoa, Pahutan, Florigon, Kent, Totapuri and Fazli were oblong – lanceolate in shape and those of Kuphari, Ruby, Ananas, Maldah and Kalachini were the eilliptical lanceolate. The reamaning germplasm were lanceolate in shape. Rahaman *et al.* (2003) reported 3 types of leaf shape viz. lanceolate, elliptical, oblong.

4.1.1.6 Leaf margin

The leaf margin of BARI Aam-1, BARI Aam-2, Maldah, Fazli, Deshi Rangin, Ananas, Pahutan, M-3836, Mollika, Florigon, Summer Behest, Totapuri, Roshunkoa, Palmar, M-3896 and Keitt were flat. The leaf margins of the remaining germplasm were wavy. Bhuyan *et al.* (2003) found 2 types of leaf margin flat and wavy.

4.1.1.7 Leaf tip

Chowsha, Dashehari, Ruby, Kent, Summer Behest, Florigon and Ananas, Fazli had the acuminate life tip. Life tip of the remaining germplasm were acute type. Bhuyan *et al.* (2003) found 2 types of leaf tips viz. acuminate and acute.

Table 1. Leaf characteristics of 25 local and exotic mango germplasm

Germplasm	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)	Petiole length (cm)	Leaf shape	Leaf margin	Leaf tip
Ahaping	19.84	4.34	63.45	3.33	Lanceolate	Wavy	Acute
Ananas	26.20	5.20	100.40	2.90	Elliptic lanceolate	Flat	Acuminate
BARI Aam-1	20.00	6.37	93.89	2.80	Lanceolate	Flat	Acute
BARI Aam-2	21.00	6.50	100.60	2.67	Lanceolate	Flat	Acute
Chowsha	23.58	7.06	122.69	2.90	Lanceolate	Wavy	Acuminate
Deshi Rangin	13.80	3.87	39.36	1.67	Lanceolate	Flat	Acute
Dashehari	21.20	4.60	71.87	3.67	Lanceolate	Wavy	Acuminate
Fazli	25.20	6.57	122.02	3.50	Oblong lanceolate	Flat	Acuminate
Florigon	23.02	6.20	105.18	3.47	Oblong lanceolate	Flat	Acuminate
Kalachini	14.50	4.53	48.48	2.10	Elliptic lanceolate	Wavy	Acute
Keitt	18.97	5.03	70.32	2.73	Lanceolate	Flat	Acute
Kent	27.62	6.80	138.42	3.53	Oblong lanceolate	Wavy	Acuminate
Kuphari	19.67	6.93	100.46	3.93	Elliptic lanceolate	Wavy	Acute
M-3836	28.56	5.10	107.34	3.50	Lanceolate	Flat	Acute
M-3896	28.56	5.10	107.34	3.50	Lanceolate	Flat	Acute
Maldah	15.73	4.90	56.80	4.33	Elliptic lanceolate	Flat	Acute
Mollika	22.76	5.14	86.21	3.93	Lanceolate	Flat	
Pahutan	19.30	4.84	68.84	2.73	Oblong Lanceolate	Flat	Acute
Palmar	21.13	5.93	92.34	4.03	Lanceolate	Flat	Acute
Roshunkoa	18.13	4.77	63.73	3.63	Oblong lanceolate	Flat	Acute
Ruby	18.07	5.00	66.58	2.33	Elliptic lanceolate	Wavy	Acuminate
Shinduri	17.83	4.77	62.68	2.73	Lanceolate	Wavy	Acute
Summer Behest	23.04	4.59	77.94	3.03	Lanceolate	Flat	Acuminate
Totapuri	19.98	5.46	80.39	4.20	Oblong lanceolate	Flat	Acute
Zillate	22.12	4.84	78.90	3.67	Lanceolate	Wavy	Acute
Mean	21.19	5.37	85.04	3.23	-	-	-
Range	13.80-28.56	3.87-7.06	39.36-138.42	1.67-4.33	-	-	-
SE	0.78	0.87	0.45	0.13	-	-	-
CV (%)	18.44	16.31	5.98	20.23			

4.1.2 Flowering and harvesting characteristics of 25 mango germplasm

The flowering and harvesting characteristics of 25 mango germplasm are presented in Table 2.

4.12.1 Time of flower bud emergence

The time of flower bud emergence in all the germplasm under the study took place between 22 December and 12 January (Table 2). Flower bud emergence was the earliest (22 December) in Ahaping followed by Palmar (23 December), Deshi Rangin, Ananas, Pahutan, Ruby, Dashehari (25 December). Germplasm Maldah was the latest (12 January) in flower bud emergence. The other germplasm were intermediary in this respect. The present investigation is partial agreement with the research findings of Haque *et al.* (1993) who reported that the flower bud emergence took place from third week of December to last week of January.

4.1.2.2 Time of first panicle emergence

The panicle was first noticed in Ahaping (05 January) followed by Roshunkoa (13 January) while Maldah was the latest (14 February). This result partially supported the finding of Uddin *et al.* (1997) who reported that the panicle emergence took place from 25 December to 23 February.

4.1.2.3 Time of first flower opening

The time of first flower opening in all the germplasm under the study took place between 18 January to 22 February (Table 2). Flower were opened first in Ahaping (18 January) and Maldah was the latest (22 February). The other germplasm were intermediary in position. Present result is partially supported the findings of Uddin *et al.* (1997) who reported that first flowering took place between January 25 to March, 10 in different mango varieties at Chapai Nawabganj. Mujumder and Sharma (1990) reported that flowering time varied with the varieties and area where they grown, Bose (1985) also reported the same observation.

4.1.2.4 Time of full bloom

Full blooming was first noticed from 07 February in Ananas and last on 17 March in BARI Aam-2. The other germplasm were intermediary in position. Uddin *et al.* (1997) reported that first full blooming was noted in 26 February and last in 29 March. Valmayor (1962) who reported that the variation of blooming period is dependent upon a combination of environmental factors and the condition of the plant.

4.1.2.5 Date of harvest

The fruits of all the germplasm were harvested between 10 June to 27 July 2007 (Table 2) Summer Behest and Maldah were the earliest and latest, respectively in respect of harvesting time. The results are in agreement with the findings of Bhuyan and Islam (1989) and Sardar and Hossain (1993). But Uddin *et al.* (1997) who evaluated 14 mango cultivares at Chapai Nawabganj and reported that the fruits of all the germplasm were harvested between 20 June to 15 July.

4.1.2.6 Days to maturity (from flowering to harvest)

A wide variation was observed among the germplasm in respect of days to maturity from flowering. Maximum time (169 days) was required for Ahaping followed by Ananas (167 days). Zillate took the minimum time (115 days) preceded by Florigon (117days) and BARI Aam-1 (120 days). The results are in line with the observation of Hossain (1989a) who reported that mango under Bangladesh conditions takes about four to six month to reach maturity after flowering. These findings differed with that of Sardar *et al.* (1998) who consented that harvesting time varied from 92-134 days under the climatic conditions of Rajshahi. This might be due to environmental fluctuation over the year and the locality.

Table 2. Flowering and harvesting characteristics of 25 local and exotic mango Germplasm

Germplasm	Time of flower bud emergence	Time of first panicle emergence	Time of first flower opening	Time of full bloom	Date of harvest	Days to maturity (from flowering to harvesting)
Ahaping	22 December	05 January	18 January	09 February	4/7/07	169
Ananas	25 December	30 January	20 January	07 February	5/7/07	167
BARI Aam-1	28 December	30 January	21 February	12 March	19/6/07	120
BARI Aam-2	29 December	31 January	19 February	17 March	3/7/07	136
Chowsha	28 December	30 January	15 February	13 March	7/7/07	127
Deshi Rangin	25December	29 January	19 February	10 March	3/7/07	136
Dashehari	25 December	26 January	19 February	13 March	25/6/07	128
Fazli	27 December	26 January	18 February	09 March	29/6/07	133
Florigon	28 December	26 January	20 February	08 March	30/6/07	117
Kalachini	27 December	02 February	20 February	13 March	26/6/07	128
Keitt	27 December	26 January	17 February	11 March	15/7/07	136
Kent	29 December	20 January	13 February	09 March	28/6/07	138
Kuphari	30 December	30 January	20 February	10 March	2/7/07	136
M-3836	28 December	23 January	15 February	02 March	26/6/07	137
M-3896	31 December	24 January	16 February	05 March	5/7/07	121
Maldah	12 January	14 February	22 February	16 March	27/7/07	127
Mollika	29 December	30 January	17 February	08 March	16/6/07	130
Pahutan	25 December	28 January	20 February	12 March	6/7/07	140
Palmar	23 December	30 January	16 February	12 March	2/7/07	130
Roshunkoa	27 December	13 January	30 January	16 March	25/6/07	148
Ruby	25 December	25 January	20 February	13 March	25/6/07	130
Shinduri	30 December	26 January	18 February	13 March	2/7/07	136
Summer behest	30 December	24 January	14 February	13 March	10/6/07	138
Totapuri	29 December	20 January	13 February	09 March	28/6/07	122
Zillate	30 December	15 January	12 February	05 March	30/6/07	115
Mean	-	-	-	-	-	113.68
Range	-	-	-	-	-	115-169
SE	-	-	-	-	-	2.54
CV (%)	-	-	-	-	-	11.20

4.1.3 Panicle Characteristics

Results of different panicle characteristics of 25 local and exotic mango germplasm are presented in Table 3 and Table 4.

4.1.3.1 Panicle colour

Panicle colour of BARI Aam-1, Maldah, Fazli, Zillate, M-3836, M-3896 and Chowsha were light green while BARI Aam-2, and Deshi Rangin, Ahaping, Pahutan, Kent, Totapuri, Dashehari and Kuphari had dark red colour panicle. Shinduri had light green with red patches while Mollika, Summer Behest and Ruby had green with red patches colour panicle. Crimson colored panicle was observed in Ananas while the rest were light red colour panicle (Table 3). Islam *et al.* (2004) found panicle colour light green to dark red.

4.1.3.2 Panicle position

Most of the germplasm was both terminally and auxiliary except Ananas, Totapuri and Chowsha which had terminal panicale only (Table 3). Bhuyan *et al.* (2003) was found panicale position terminal and axillary.

4.1.3.3 Panicle shape

The panicle of Kalachini, Shinduri, Fazli, Deshi Rangin, Pahutan, Summer Behest, Kuphari and M-3896 was conical in shape and that of BARI Aam-2, Dashehari, Totapuri, Mollika, M-3836, Zillate and Keitt was pyramidal in shape. The remaning germplasm was broadly pyramidal type (Table 3). Kabir (2001) found two types of panicle shape conical and pyramidal.

4.1.3.4 Branching habit

Most of the mango germplasm had secondary branches in their panicles except Deshi Rangin, M-3896 and Chowsha tertiary branches in the panicle. Fazli had secondary and tertiary branches (Table 3). Kabir (2001) found two types of branches.

Table 3. Qualitative panicle characteristics of 25 local and exotic mango germplasm

Germplasm	Colour of panicle	Position of panicle	Shape of panicle	Branching habit
Ahaping	Dark red	Terminal & axillary	Broadly pyramid	Secondary
Ananas	Crimson	Terminal	Broadly pyramidal	Secondary
BARI Aam-1	Light green	Terminal & axillary	Broadly pyramid	Secondary
BARI Aam-2	Dark red	Terminal & axillary	Pyramid	Secondary
Chowsha	Light green	Terminal	Broadly pyramidal	Tertiary
Dashehari	Dark red	Terminal & axillary	Pyramidal	Secondary
Deshi Rangin	Dark red	Terminal & axillary	Conical	Tertiary
Fazli	Light green	Terminal & axillary	Conical	Secondary & tertiary
Florigon	Light red	Terminal & axillary	Broadly pyramidal	Secondary
Kalachini	Light red	Terminal & axillary	Conical	Secondary
Keitt	Light red	Terminal & axillary	Pyramidal	Secondary
Kent	Dark red	Terminal & axillary	Broadly pyramidal	Secondary
Kuphari	Dark red	Terminal & axillary	Conical	Secondary
M-3836	Light green	Terminal & axillary	Pyramidal	Secondary
M-3896	Light green	Terminal & axillary	Conical	Tertiary
Maldah	Light green	Terminal & axillary	Broadly pyramid	Secondary
Mollika	Green with red patches	Terminal & axillary	Pyramidal	Secondary
Pahutan	Dark red	Terminal & axillary	Conical	Secondary
Palmar	Light red	Terminal & axillary	Broadly pyramidal	Secondary
Roshunkoa	Light red	Terminal & axillary	Broadly pyramidal	Secondary
Ruby	Green with red patches	Terminal & axillary	Broadly pyramidal	Secondary
Shinduri	Light green with red patches	Terminal & axillary	Conical	Secondary
Summer behest	Green with red patches	Terminal & axillary	Conical	Secondary
Totapuri	Dark red	Terminal	Pyramidal	Secondary
Zillate	Light green	Terminal & axillary	Pyramidal	Secondary

4.1.3.5 Number of panicles per shoot

Wide variation was recorded number of panicles per shoot among the mango germplasm studied (Table 4). The maximum number of panicles per shoot (3.33) was recorded in M-3896 followed by Ananas (3.00), BARI Aam-2 (2.67), Fazli (2.67) and Pahutan (2.67). While the minimum number of panicles per shoot (1.00) was observed in Totapuri preceded by Zillate (1.33), Palmar (1.33) and Kent (1.33). Bhuyan and Islam (1989), Haque *et al.* (1993) and Islam *et al.* (1995) also observed the variation in number of panicles per shoot among different mango varieties.

4.1.3.6 Length of panicle

Large variation was observed among different mango germplasm in respect of panicle length (Table 4). Dashehari had the longest (42.16 cm) panicle followed by Ruby (36.67 cm), Totapuri (35.12 cm) and Kent (32.85 cm). The shortest panicle (14.36 cm) was found in Kalachini, which was different from the remaning germplasm. Hossain and Talukder (1974) reported that panicle lengths in different mango varities ranged from 13.97 to 22.60 cm. Islam *et al.* (1995) found 27.79 to 33.77 cm which is similar to present findings.

4.1.3.7 Breadth of panicle

Breadth of panicle ranged from 11.11 cm in Chowsha to 22.85 cm in Totapuri (Table 4). Hossain and Ahmed (1994) also recorded wide variation in panicle breadth among the varieties studied.

4.1.3.8 Number of main branches per panicle

The germplasm Dashehari had the highest number of main branches per panicle (46.00), followed by Roshunkoa (45.00), Ahaping (44.00) and Fazli (42.67). BARI Aam-1 had the lowest (22.67) number of main branches preceded by Kalachini (24.00) and Zillate (25.33) (Table 4). The present result is in partial accordance with the findings of Haque *et al.* (1993) who recorded 20 to 74 numbers of main branches per panicle in 20 mango cultivars. The results have also some similarities with the findings of Islalm *et al.* (1995).

Table 4. Quantitative panicle characteristics of 25 local and exotic mango germplasm

Germplasm	Number of panicle/shoot	Length of panicle (cm)	Breadth of panicle (cm)	No. of main branches/ Panicle
Ahaping	2.00	28.86	22.06	44.00
Ananas	3.00	21.44	20.33	30.33
BARI Aam-1	2.67	19.68	11.12	22.67
BARI Aam-2	2.00	22.07	22.83	40.33
Chowsha	2.00	22.07	11.11	25.33
Dashehari	2.33	42.16	18.55	46.00
Deshi Rangin	2.00	21.77	12.63	30.00
Fazli	2.67	22.88	14.45	42.67
Florigon	2.00	27.51	13.68	28.67
Kalachini	1.67	14.36	11.58	24.00
Keitt	1.33	27.21	13.68	26.67
Kent	1.33	32.85	13.72	29.33
Kuphari	1.67	27.51	14.42	28.67
M-3836	1.67	23.58	14.06	29.67
M-3896	3.33	21.27	14.05	33.67
Maldah	1.67	25.80	12.86	29.67
Mollika	1.67	29.57	16.46	28.33
Pahutan	2.67	27.68	21.52	33.67
Palmar	1.33	26.21	11.64	29.00
Roshunkoa	2.00	23.45	22.71	45.00
Ruby	2.67	36.67	20.86	30.33
Shinduri	1.67	27.02	14.05	26.67
Summer Behest	2.33	26.49	20.38	34.67
Totapuri	1.00	35.12	22.85	36.00
Zillate	1.33	21.27	12.63	25.33
Mean	2.08	26.68	16.17	32.02
Range	1.00-3.33	14.36-42.16	11.11-22.85	22.67-46.00
SE	0.13	1.06	0.82	1.32
CV (%)	20.15	19.92	22.48	20.61

4.1.4 Floral characteristics

4.1.4.1 Leafy bracts

Leafy bracts were present in almost all the germplasm under study (Table 5) except Pahutan and Kent. This finding is similar to Islam *et al.* (2004).

4.1.4.2 Flower diameter

Large variation in respect of flower diameter was observed among the germplasm studied (Table 5). The maximum flower diameter was recorded in Chowsha, Fazli and Maldah (7.00 mm) while minimum diameter was in M-3836 and Shinduri (4.00 mm). Khan *et al.* (2004) was found flower diameter 3.00 mm to 7.00 mm in Ananas and Pahuatan.

4.1.4.3 Type of flower

The flower type of 23 local and exotic mango germplasm under study was pentamerous. Remaning two germplasm M-3836 and Sumer Behest had both tetra and pentamerous type of flower (Table 5). Islam *et al.* (2004) also found tetra and pentamerous type of flower.

4.4.4 Nature of disc

The nature of disc in all the germplasm were swollen (Table 5). This finding is similar to Islam *et al.* (2004).

4.1.4.5 Number of stamens

Among 25 mango germplasm under study 23 had 1 stamen per flower while Ahaping had 3 and Pahutan had 2 stamens per flower (Table 5). Khan *et al.* (2004) and Islam *et al.* (2004) also found 1 to 3 stamens in Ananas and Pahutan.

4.1.4.6 Density of flower

Scarcely flower density was observed in all the mango germplasm under study (Table 5) and densely flower observed in Chowsha and Kent. This finding is similar to Islam *et al.* (2004) and Khan *et al.* (2004).

Table 5. Floral characteristics of 25 local and exotic mango germplasm

Germplasm	Leaf bracts	Flower diameter (mm)	Type of flower	Nature of disc	No. of stamen/ flower	Density of flower
Ahaping	Present	6.00	Pentamerous	Swollen	3	Scarcely
Ananas	Present	6.00	Pentamerous	Swollen	1	Scarcely
BARI Aam-1	Present	6.00	Pentamerous	Swollen	1	Scarcely
BARI Aam-2	Present	6.00	Pentamerous	Swollen	1	Scarcely
Chowsha	Present	7.00	Pentamerous	Swollen	1	Density
Deshi Rangin	Present	6.00	Pentamerous	Swollen	1	Scarcely
Dashehari	Present	6.00	Pentamerous	Swollen	1	Scarcely
Fazli	Present	7.00	Pentamerous	Swollen	1	Scarcely
Florigon	Present	6.00	Pentamerous	Swollen	1	Scarcely
Kalachini	Present	5.00	Pentamerous	Swollen	1	Scarcely
Keitt	Present	6.00	Pentamerous	Swollen	1	Scarcely
Kent	Absent	6.00	Pentamerous	Swollen	1	Densety
Kuphari	Present	6.00	Pentamerous	Swollen	1	Scarcely
M-3836	Present	4.00	Tetra & Pentamerous	Swollen	1	Scarcely
M-3896	Present	5.00	Pentamerous	Swollen	1	Scarcely
Maldah	Present	7.00	Pentamerous	Swollen	1	Scarcely
Mollika	Present	6.00	Pentamerous	Swollen	1	Scarcely
Pahutan	Absent	6.00	Pentamerous	Swollen	2	Scarcely
Palmar	Present	6.00	Pentamerous	Swollen	1	Scarcely
Roshunkoa	Present	6.00	Pentamerous	Swollen	1	Scarcely
Ruby	Present	6.00	Pentamerous	Swollen	1	Scarcely
Shinduri	Present	4.00	Pentamerous	Swollen	1	Scarcely
Summer Behest	Present	6.00	Tetra & Pentamerous	Swollen	1	Scarcely
Totapuri	Present	6.00	Pentamerous	Swollen	1	Scarcely
Zillate	Present	6.00	Pentamerous	Swollen	1	Scarcely
Mean	-	5.92	-	-	-	-
Range	-	4.00-7.00	-	-	-	-
SE	-	0.148	-	-	-	-
CV (%)	-	12.56	-	-	-	-

4.1.5 Percentage of male, bisexual and unopened flowers

Ratio of male, bisexual and unopened flowers of 25 local and exotic mango germplasm are presented in figure 1 and discussed below:

4.1.5.1 Male flower (%)

The highest rate of male flower (95 %) was found in BARI Aam-1 followed by Florigon, Totapuri, Shinduri (93 %) and Kent (94 %) (Fig. 1). The lowest rate of male flower (56 %) was recorded from Mollika preceded by M-3896 and Ruby (59 %). Iqbal *et al.* (1995) observed 69.86 to 93.39 % male flower in 18 mango germplasm.

4.1.5.2 Bisexual flower (%)

Mollika had the highest percentage (39 %) of bisexual flowers followed by M-3896 (37 %). Minimum bisexual flower (2 %) was noted in BARI Aam-1 and Kent preceded by Shinduri (3 %), Keitt, Totapuri, Florigon, Deshi Rangin and Maldah (4 %) (Fig. 1). The results of the present experiment are in partial agreement with the findings of Singh (1978) who recorded 3.17 to 16.41 % bisexsual flower in South India Mangoes. Maiti *et al.* (1971) asserted that number of bisexual flowers varied with variety and season. Uddin *et al.* (1995) who evaluated 18 exotic mango germplasm at Chapai Nawabganj and reported that the bisexual flower (%) of the studied germplasm varied from 6.61 to 30.46.

4.1.5.3 Unopened flower (%)

A wide variation was observed among the tasted germplasm in respect of unopened flowers (Fig. 1). Maximum unopened flowers (20 %) were recorded in Ruby distantly followed by Dashehari (14 %), Roshunkoa (12 %), M-3836 and Chowsha (11 %). Minimum unopened flowers (3 %) observed in BARI am-1, Totapuri, Fazli , Florigon and Zillate. This finding differs with that of Hossain and Talukder (1974), who recorded 5.50 to 24.66% identified flower.

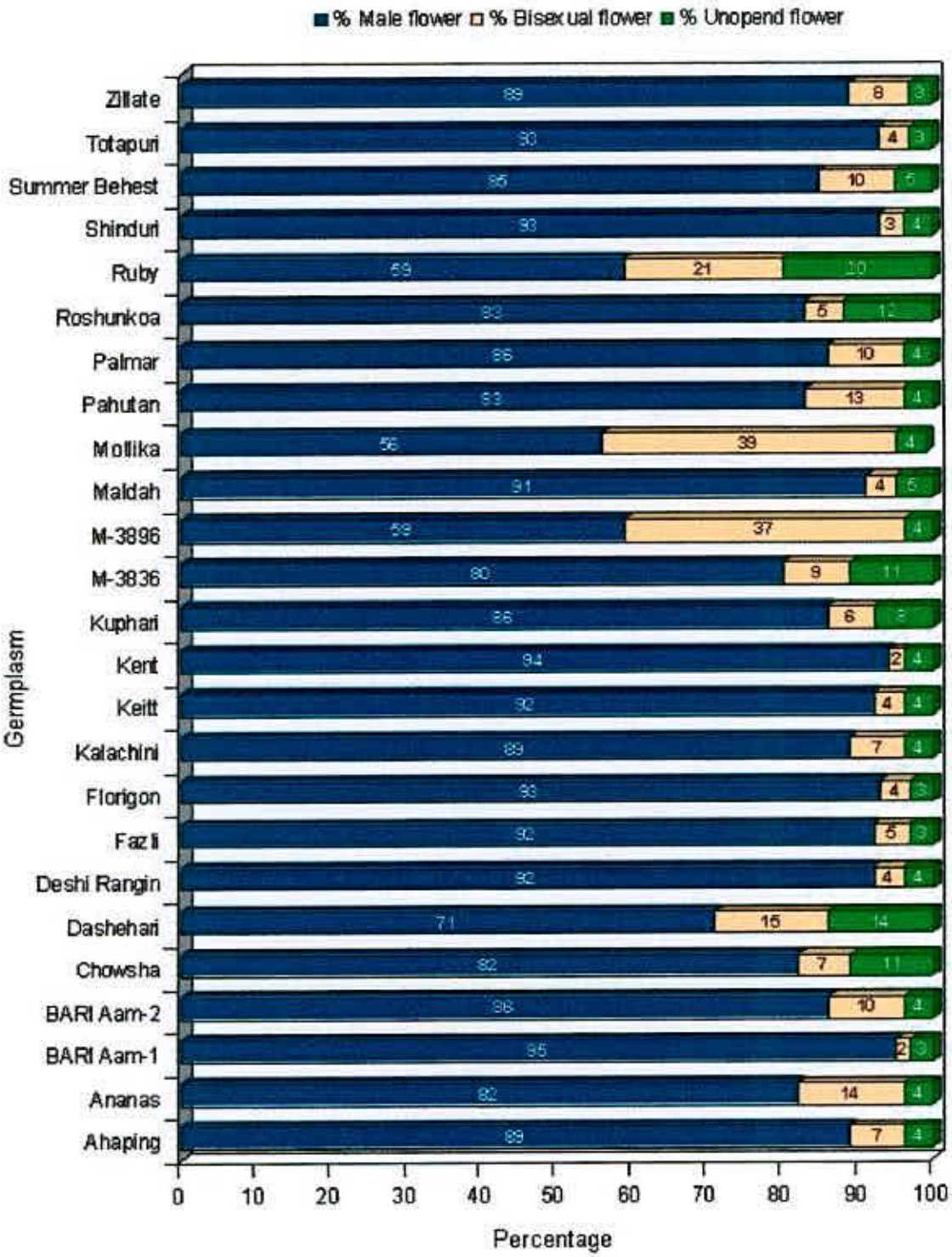


Fig. 1. Percentage of male, bisexual and unopened flowers in 25 local and exotic mango germplasm.

4.1.6 Fruiting characteristics

4.1.6.1 Number of fruit set per panicle

Number of fruit set per panicle was the highest (30.25) in Ananas followed by Ruby (28.35), Phutan (27.80) Totapuri (26.25) and BARI Aam-1 (26.20). Maldah had the lowest number of fruit set per panicle (5.00) preceded by Kupahari (6.40) and Palmar (6.50) (Table 6). Iqbal *et al.* (1995) stated that fruit set is a varietals character also depending upon time of flowering, efficient cross pollination and fruit drop intensity. This might have occurred due to the variation of environmental factors.

4.1.6.2 Number of fruit retained per panicle

Number of final fruit retained per panicle varied widely among the mango germplasm studied (Table 6). Summer Behest retained maximum fruit per panicle (6.20) upto harvest followed by Pahutan (4.20), Ahaping (3.50), Ananas (3.40) and Rashunkoa (3.33). The minimum fruits per panicle were retained by Fazli (0.80) preceded by Maldah (1.20) and Ruby (1.21). Iqbal *et al.* (1995) stated that number of fruit retained per panicle varied from 1.22 to 37.53.

4.1.6.3 Percent fruit retention

Wide variation was observed among the mango germplasm in case of percent fruit retention (Table 6). It was highest in Palmar (35.54%) followed by M-3896 (32.35%), M-3836, Chowsha (27.17 %) and Kuphari (27.05%). The lowest fruit retention was found in Fazli (3.23%) (Table 6). Talukder (1974) obtained 0.17 to 7.54 % fruit per panicle in different mango varieties. Hossain and Talukder (1974) obtained 0.17 t0 7.54 % fruit retention in different mango varieties.

Table 6. Fruit set and fruit retention of 25 local and exotic mango germplasm

Germplasm	Number of fruit set/panicle	Number of fruit retained/ panicle	(%)Fruit retention
Ahaping	24.40	3.50	14.34
Ananas	30.25	3.40	11.24
BARI Aam-1	26.20	1.90	7.25
BARI Aam-2	25.60	1.80	7.03
Chowsha	9.20	2.50	27.17
Dashehari	25.00	1.89	7.56
Deshi Rangin	6.80	1.50	22.09
Fazli	24.80	0.80	3.23
Florigon	8.40	1.80	21.43
Kalachini	7.20	1.53	21.25
Keitt	7.20	1.20	16.67
Kent	6.60	1.30	19.77
Kuphari	6.40	1.73	27.03
M-3836	9.20	2.50	27.17
M-3896	6.80	2.20	32.35
Maldah	5.00	1.20	24.00
Mollika	8.20	1.70	20.73
Pahutan	27.80	4.20	15.11
Palmar	6.50	2.31	35.54
Roshunkoa	22.40	3.33	14.87
Ruby	28.35	1.21	4.27
Shinduri	8.60	1.40	16.28
Summer Behest	25.40	6.20	24.41
Totapuri	26.25	1.25	4.76
Zillate	14.40	2.20	15.28
Mean	14.35	2.37	18.93
Range	5.00-30.25	0.80-6.20	3.23-35.54
SE	1.78	0.22	0.76
CV (%)	38.13	27.80	18.91

4.1.7 Fruit yield per plant

4.1.7.1 Number of fruits per plant

A wide range of variation observed in respect of fruit yield (number) was found in all the germplasm studied (Fig 2). BARI Aam-2 produced the highest number of fruit per plant (198) followed by BARI Aam-1 (150), Kalachini (145) and Ananas (130). The lowest number of fruits per plant was obtained from M-3896 (31) preceded by Chowsha (32), Mollika (32) and Keitt (35). Singh (1978) reported that at the start of bearing fruit number in the plant may be as low as 10 to 15 per tree rising to 50 to 75 fruits in the subsequent year.

4.1.7.2 Weight of fruits per plant

The genotypes included in the experiment varied greatly in respect of weight of fruits per plant (Fig 2). BARI Aam-2 produced the highest yield per plant (36.08 kg) followed Kent (27.77 kg), Pahutan (25.97 kg), and Maldah (25.80 kg). The lowest yield (5.10 kg) per plant was given by Florigon preceded by Chowsha (5.56 kg), Dashehari (6.15 kg) and M-3496 (8.77 kg). Lodh *et al.* (1974), Haque *et al.* (1993) and Iqbal *et al.* (1995) also reported the variation of fruit weight among the different mango varieties.

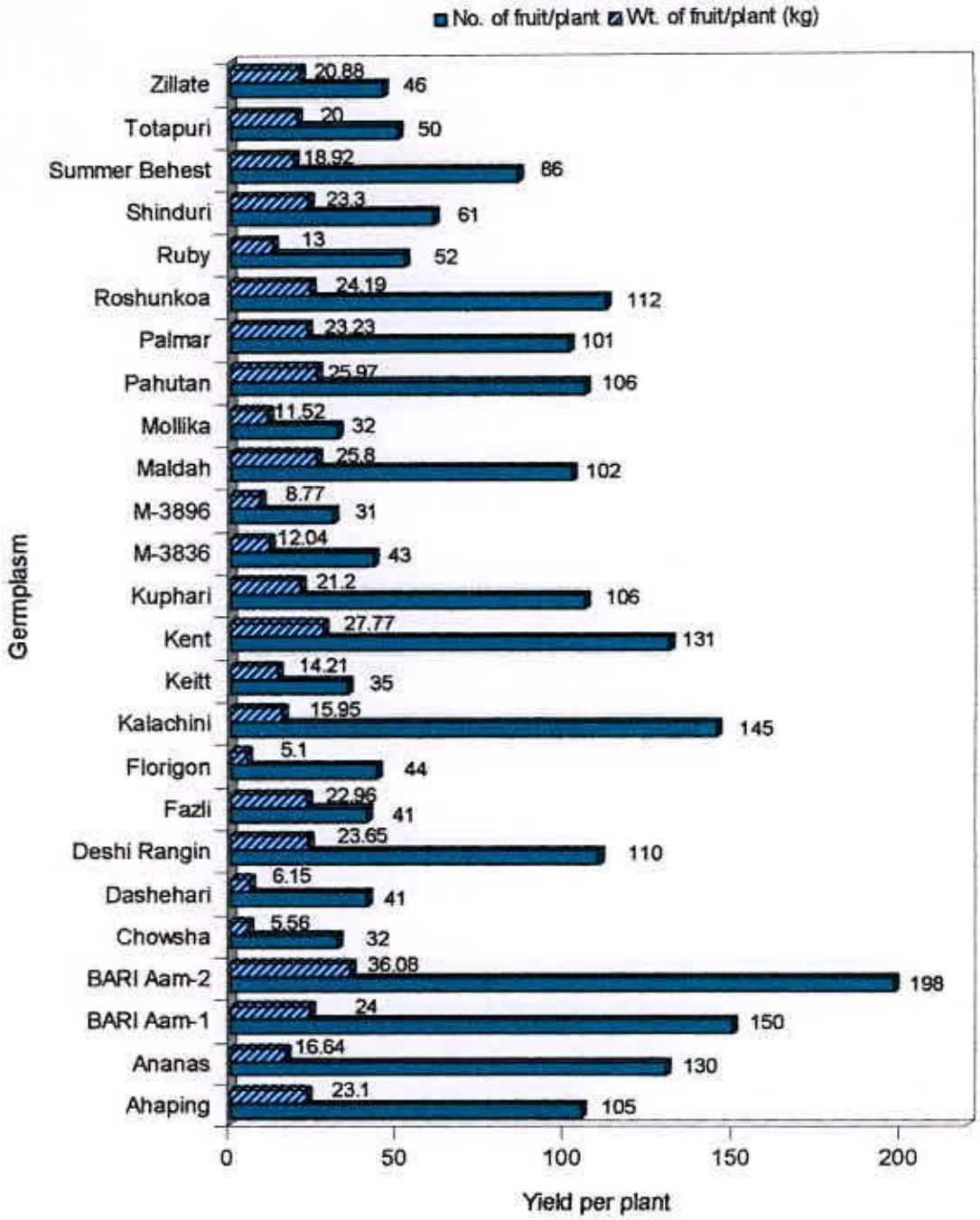


Fig. 2. Number of fruits per plant and weight of fruits per plant of 25 local and exotic mango germplasm.

4.2 Fruit characteristics

Different fruit characteristics of 25 local and exotic mango germplasm presented in Table 7 and Table 8. Pictorial views of fruit characteristics of 21 germplasm are shown in plates 1. Pictorial views of four germplasm are missing from BARI computer due to the virus affecting.

4.2.1 Shape of fruits

The shape of Kalachini, Fazli and Zillate were oblong oval while that of BARI Aam-2, Deshi Rangin, Ananas, Mollika and Florigon, were oblong round. Maldah were ellipsoid and Phautan and Dashehari were almost roundish oblong and BARI Aam-1, Ahaping, Palmar was round in shape. The shape of Shinduri, Kuphari, Ruby,Totapuri, Kent, Summer Behest, M-3836, M-3896 were oblong whereas, Roshunkoa, Chowsha, Keitt were oval (Table 7). The results are in conformity with the findings of Saha and Hossain (1988).

4.2.2 External appearance

Good appearance of mango has the highest phenotypic acceptability for consumption. Among the 25 local and exotic mango germplasm appearance of BARI Aam-1, Shinduri, Maldah, Fazli, Ananas, Pahutan, Zillate, M-3836, Palmar, Kuphari, M-3896 and Chowsha were good (Table 7). Fruits of Kalachini, BARI Aam-2, Ahpaning, Mollika, Deshi Rangin, Florigon, Summer Behest, Kent, Totapuri, Dashehari, Rosunkoa, Ruby and Keitt were medium.

4.2.3 Skin colour of fruit at ripe stage

The skin colour of ripe fruits of Kalachini and BARI Aam-1, BARI Aam-2, Maldah and kent were greenish light yellow while Fazli, M-3836 were yellowish green. Ripe fruits of, Mollika, Florigon, Kuphari, M-3896 were light yellow that Deshi Rangin, Totapuri were light green. Germplasm Shinduri, Ahaping, Ruby were redish yellow where as Roshunkoa, Palmar and Summer Behest had yellow coloured fruits (Table 7). Mukherjee (1997), who reported that fruit colour at maturity is dependent on genotype.

4.2.4 Peeling quality

Peeling was easy in Kalachini, BARI Aam-1, BARI Aam-2, Shinduri, Maldah, Fazli, Ananas, Ahaping, Pahutan, M-3836, Mollika, Florigon, Summer Behest, Kent, Ruby, Dashehari, Roshunkoa, Palmar, Kuphari, M-3896, Chowsha, and it was difficult in remaning germplasm (Table 7). Rahman *et al.* (2004) two types of peeling such as present and absent.

4.2.5 Skin thickness

The fruit skin was thick in Shinduri, Pahutan, Florigon, Mollika, Ruby, Roshunkoa, M-3896 and Keitt while it was thin BARI Aam-1, BARI Aam-2, Maldah, Fazli, Deshi Rangin, Ananas, Ahaping, Zillate, Summer Behest, Kent, Totapuri, Dashehari, M-3836, Roshunkoa, Palmar, Kuphari, Chowsha. Fruits were medium skinned in the remaning germplasm (Table 7). Islam *et al.* (2004) was found three types of skin thickness viz. thick, m-thick and thin. Similar result also found by Rahman *et al.* (2004).

4.2.6 Pulp colour

The pulp colour of the fruits was orange in M-3836, Kent, Keitt. That of Ruby light yellow. Pahutan and Zillate had red yellow pulp. The remaining germplasm had yellow pulp (Table 7). Islam *et al.* (1995) was found 5 types of pulp colour.

4.2.7 Fruit weight

Highly variation was found in the fruit weight of different mang germplasm (Fig. 3). The heaviest fruit (560 g) was recorded in Fazli followed by Zillate (454 g), Keitt (406 g) and Totapuri (400 g). The lightest fruit was obtained from kalachini (110 g), preceded by Florigon (116g) and Ananas (128 g). In the present study wide variation in fruit weight of the different mango germplasm had been noticed. Lodh *et al.* (1974), Haque *et al.* (1993) and Iqbal *et al.* (1995) also reported the variation of weight among the different mango germplasm.

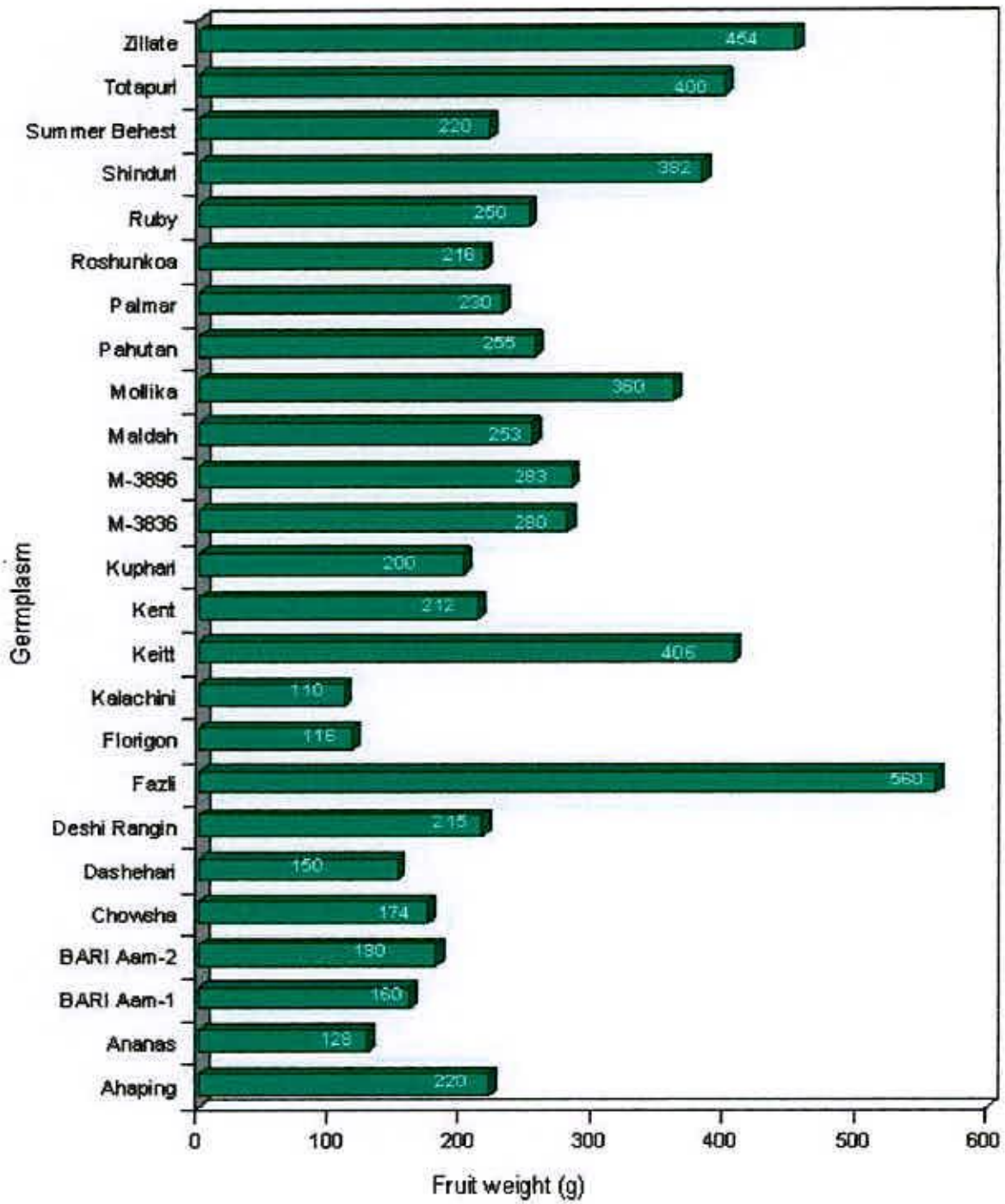


Fig. 3. Variation in fruit weight among mango germplasm.

Table 7. Qualitative fruit characteristics of 25 local and exotic mango germplasm

Germplasm	Shape of fruit	External appears	Skin colour at ripe stage	Peelig quality	Skin thickness	Pulp colour
Ahaping	Round	Medium	Redish yellow	Easy	Thin	Yellow
Ananas	Oblong round	Good	Greenish yellow	Easy	Thin	Yellow
BARI Aam-1	Round	Good	Greenish light yellow	Easy	Thin	Yellow
BARI Aam-2	Oblong round	Medium	Greenish light yellow	Easy	Thin	Yellow
Chowsha	Oval	Good	Greenish yellow	Easy	Thin	Yellow
Dashehari	Roundish oblong	Medium	Greenish yellow	Easy	Thin	Yellow
Deshi Rangin	Oblong round	Medium	Light green	Difficult	Thin	Yellow
Fazli	Oblong oval	Good	Yellowish green	Easy	Thin	Yellow
Florigon	Oblong round	Medium	Light yellow	Easy	Thick	Yellow
Kalachini	Oblong oval	Medium	Greenish light yellow	Easy	Medium	Yellow
Keitt	Oval	Medium	Green with light red	Difficult	Thick	Orange
Kent	Oblong	Medium	Greenish yellow	Easy	Thin	Orange
Kuphari	Oblong	Good	Light yellow	Easy	Medium thick	Yellow
M-3836	Oblong	Good	Yellowish green	Easy	Medium thick	Orange
M-3896	Oblong	Good	Light yellow	Easy	Thick	Yellow
Maldah	Ellipsoid	Good	Greenish light yellow	Easy	Thin	Yellow
Mollika	Oblong round	Medium	Light yellow	Easy	Thick	Yellow
Pahutan	Roundish oblong	Good	Greenish yellow	Easy	Thick	Red Yellow
Palmar	Round	Good	yellow	Easy	Thin	Yellow
Roshunkoa	Oval	Good	yellow	Easy	Thick	Yellow
Ruby	Oblong	Medium	Redish yellow	Easy	Thick	Light Yellow
Shinduri	Oblong	Good	Redish yellow	Easy	Thick	Yellow
Summer Behest	Oblong	Medium	yellow	Easy	Thin	Yellow
Totapuri	Oblong	Medium	Light green	Difficult	Thin	Yellow
Zillate	Oblong oval	Good	Greenish yellow	Difficult	Thin	Red Yellow

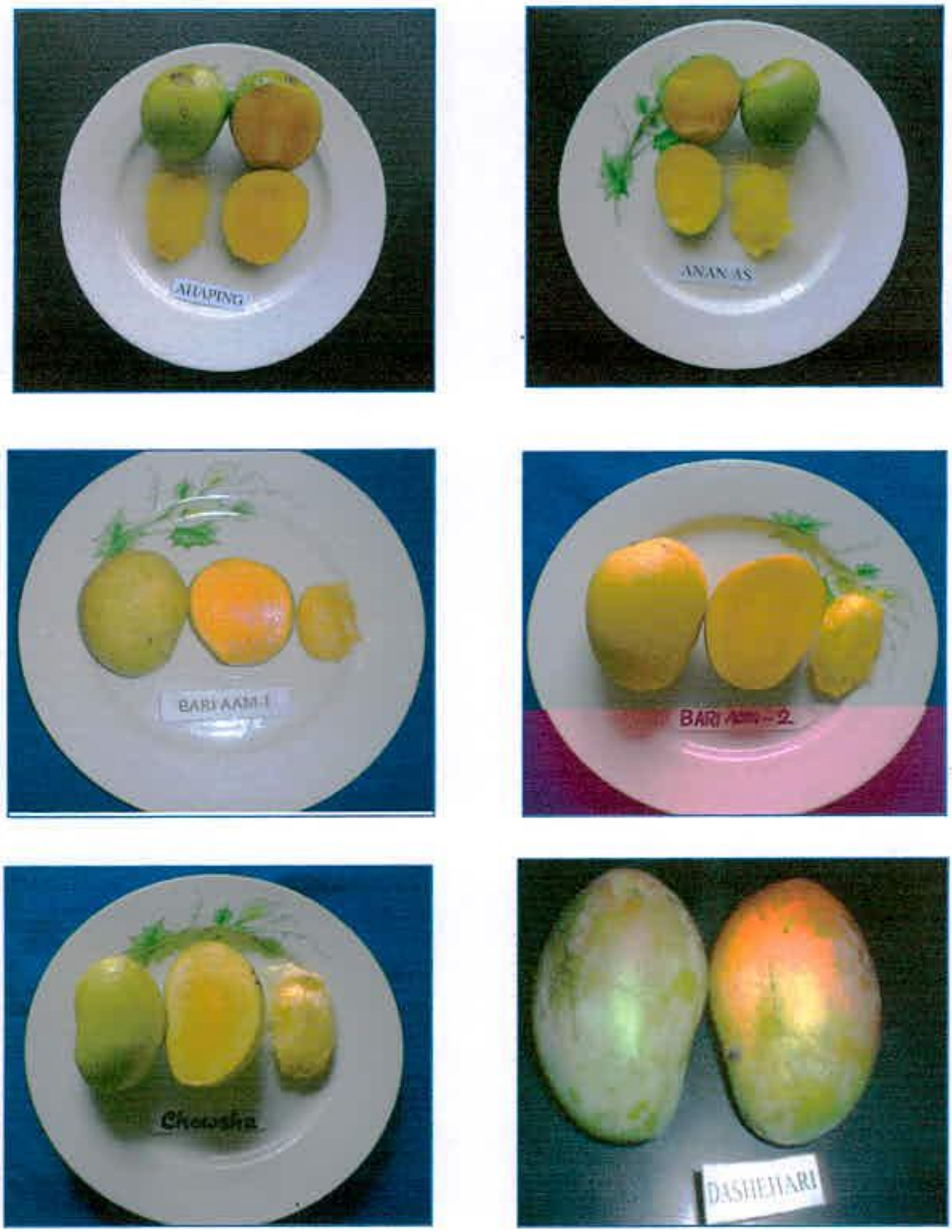


Plate 1. Variation in fruit character among mango germplasm.

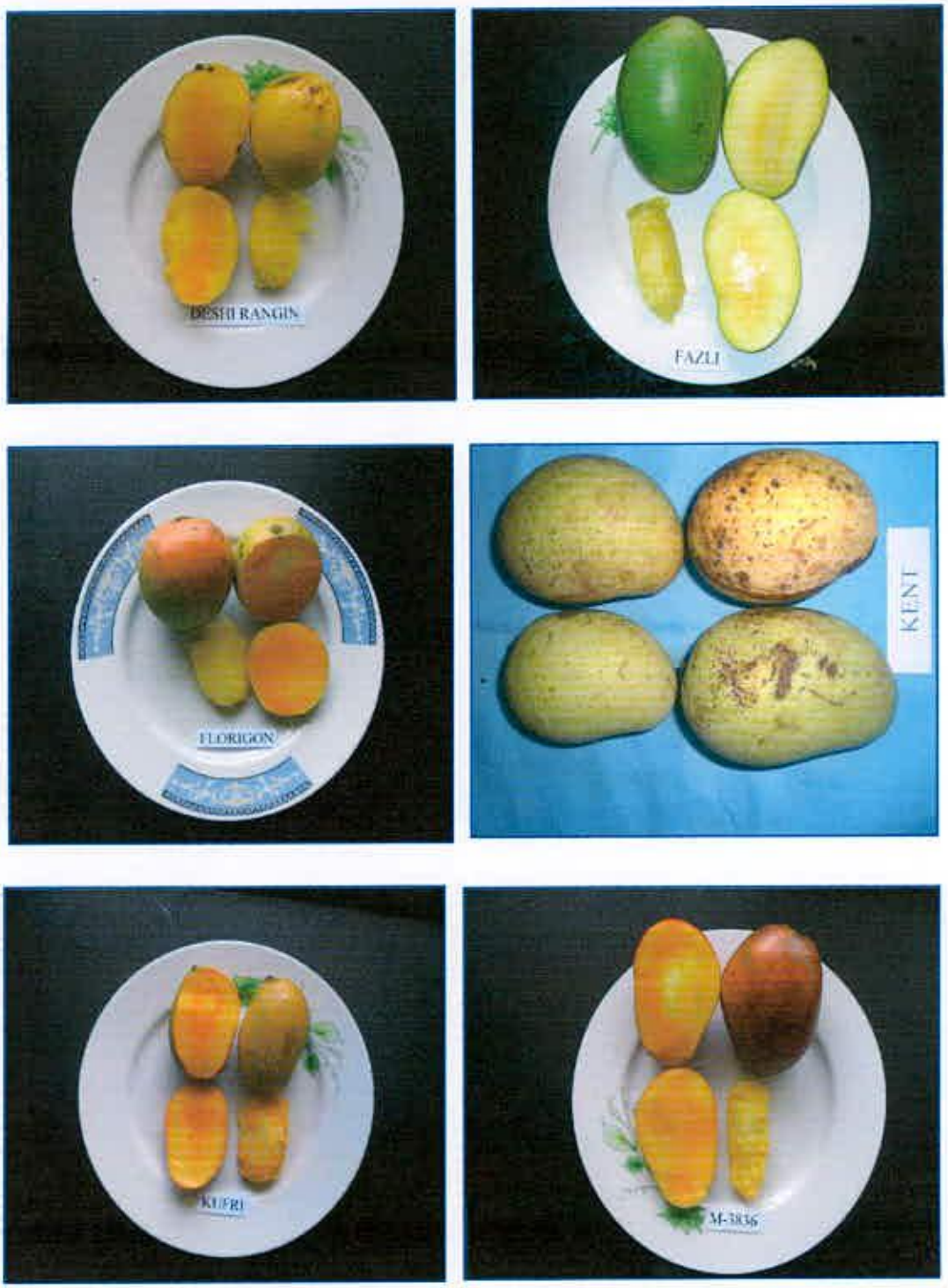


Plate 1. (Continued)

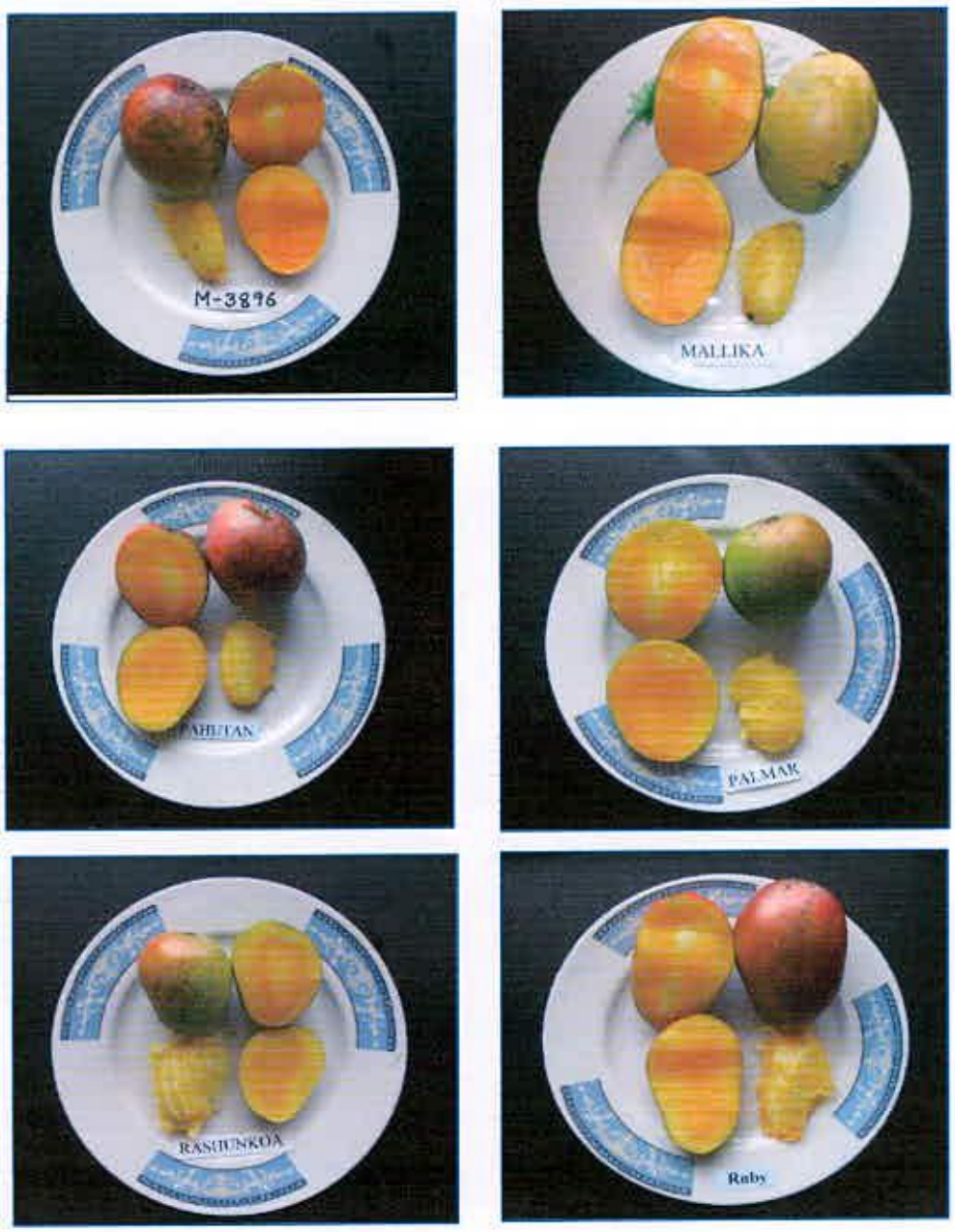
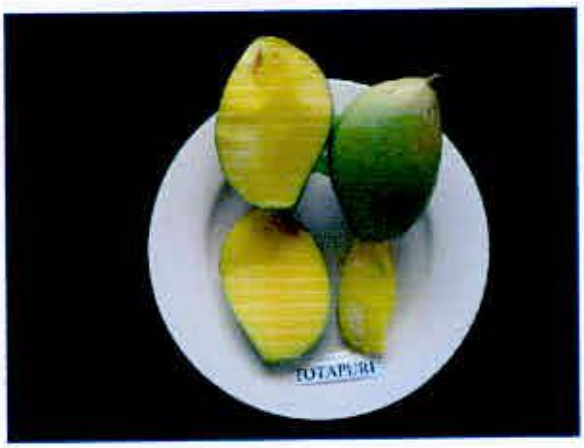


Plate 1. (Continued)



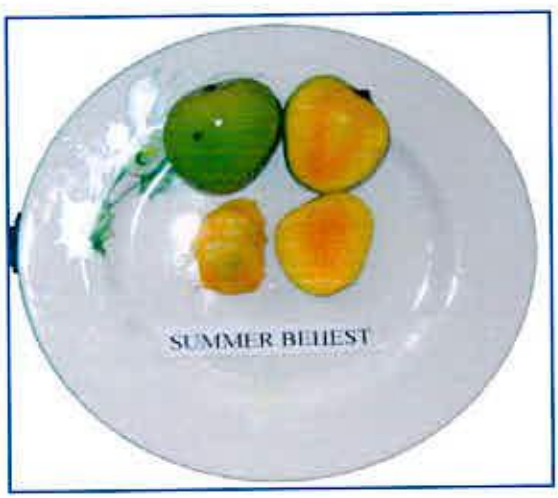


Plate 1. (Continued)

4.2.8 Fruit size

Fruit length: Wide range of variation was observed among the germplasm in respect of fruit length. Fazli proudced the longest fruit (12.82 cm) followed by Palmar (10.93 cm), Totapuri (10.68 cm), Keitt (10.46 cm) and Mollika (10.44 cm) whereas BARI Aam-1 produced the shortest fruit (6.46 cm) preceded by Kalachini (6.56 cm), Ananas (6.78 cm) and Florigon (6.88 cm) (Table 8).

Fruit breadth: A wide range of variation in respect of fruit breadth was found in all the mango germplasm studied (Table 8). Summer Behest produced the widest fruit (9.56 cm) followed by Aphaping (8.80 cm) and Shinduri (8.50 cm). While the narrowest fruit was noticed in M-3836 (5.00 cm) preceded by BARI Aam-2 (5.12 cm).

Fruit thickness: Mango germplasm under study showed large variation in fruit thicness. The thickest fruit (8.38 cm) was in Fazli followed by Zillate (8.30 cm), Palmar (7.66 cm), Keitt (7.50 cm) BARI Aam-2 had the lowest fruit thichness (4.66 cm) (Table 8). From an experiment Sardar *et al.* (1998) reported that length, breadth, and thickness of mango fruits varied from 7.6 to 15.5, 5.5, to 8.9 and 5.0 to 8.2 cm, respectively. Mollah and Siddique (1973), Prasad (1977) and Saha and Hossain (1988) also found different fruit size in different mango varieties.

Table 8. Quantitative fruit characteristics of 25 local and exotic mango germplasm

Germplasm	Fruit Size (cm)		
	Length	Breadth	Thickness
Ahaping	7.92	8.80	6.48
Ananas	6.78	7.20	5.08
BARI Aam-1	6.46	5.82	5.26
BARI Aam-2	6.70	5.12	4.66
Chowsha	8.50	5.22	5.22
Dashehari	10.00	8.12	6.60
Deshi Rangin	8.14	6.96	6.30
Fazli	12.82	5.60	8.38
Florigon	6.88	5.92	4.92
Kalachini	6.56	5.28	5.10
Keitt	10.46	7.50	7.50
Kent	8.58	6.88	5.36
Kuphari	8.18	5.98	5.98
M-3836	9.20	5.00	6.80
M-3896	8.14	7.06	7.06
Maldah	8.58	7.06	6.76
Mollika	10.44	7.00	6.82
Pahutan	8.74	7.36	6.82
Palmar	10.93	7.66	7.66
Roshunkoa	8.26	6.26	6.22
Ruby	9.54	6.90	6.46
Shinduri	8.88	8.50	7.49
Summer Behest	8.16	9.56	6.20
Totapuri	10.68	7.05	6.90
Zillate	10.20	7.42	8.30
Mean	8.82	7.05	6.41
Range	6.46-12.82	5.00-9.56	4.66-8.38
SE	0.34	0.24	0.20
CV (%)	19.75	17.43	15.76

4.2.9 Percent edible portion

Percent edible portion of fruits is an important character for selecting quality fruits and in this study Mollika (79.69%) had the highest edible portion (Fig. 3) followed by Fazli (79.29%), Ruby (78.80%), Kent (78.77%), Zillate (78.42 %), Chowsha (78.39 %) and Kalachini (52.91%) had the lowest edible portion preceded by Dashehari (57.75 %) and Pahutan (59.02%). Sarder *et al.* (1995) reported the maximum edible portion was obtained in Mollika (76.10 %) followed by Pahuatan (73.01 %). Bhuyan and Islam (1986) found 59.13 to 77.82 % edible portion of five mango cultivers.

4.2.10 Percent peel

The germplasm showed wide variation in respect of peel content (Fig. 4). Pahutan had maximum percentage of peel (26.28) followed by Shinduri (23.57), Kalachini (20.73), Dashehari (20.63) and M-3836 (20.00). The lowest percentage of peel (8.67) was observed in Mollika preceded by Kent (9.44), Ruby (10.00), Fazli (10.00), Chowsha (10.34 and Zillate (11.23). The result is some what in agreement with the findings of Bhuyan and Islam (1986) who found 9.92 to17.32% peels from 13 mango varieties and Ahmad *et al.* (1989) where they observed 11.70 to 20.50% peels in 10 mango varieties. This slight variation has occurred due to the variation of varieties or environment.

4.2.11 Percent stone

A wide range of variation in respect of stone was observed among the germplasm studied (Fig. 4). It was maximum for Kalachini the heaviest stone (26.36 %) followed by Dashehari (21.62 %). The minimum stone content was found in Shinduri (8.91%) closely followed by Totapuri (10.00%), Zillate (10.35%) and Keitt (10.35%). Bhuyan and Islam (1986) observed 8.07 to 19.25 % stone portion in 13 mango varities and Sardar *et al.* (1998) found 12.5 to 26.2 % stone portion in 10 mango varieties.

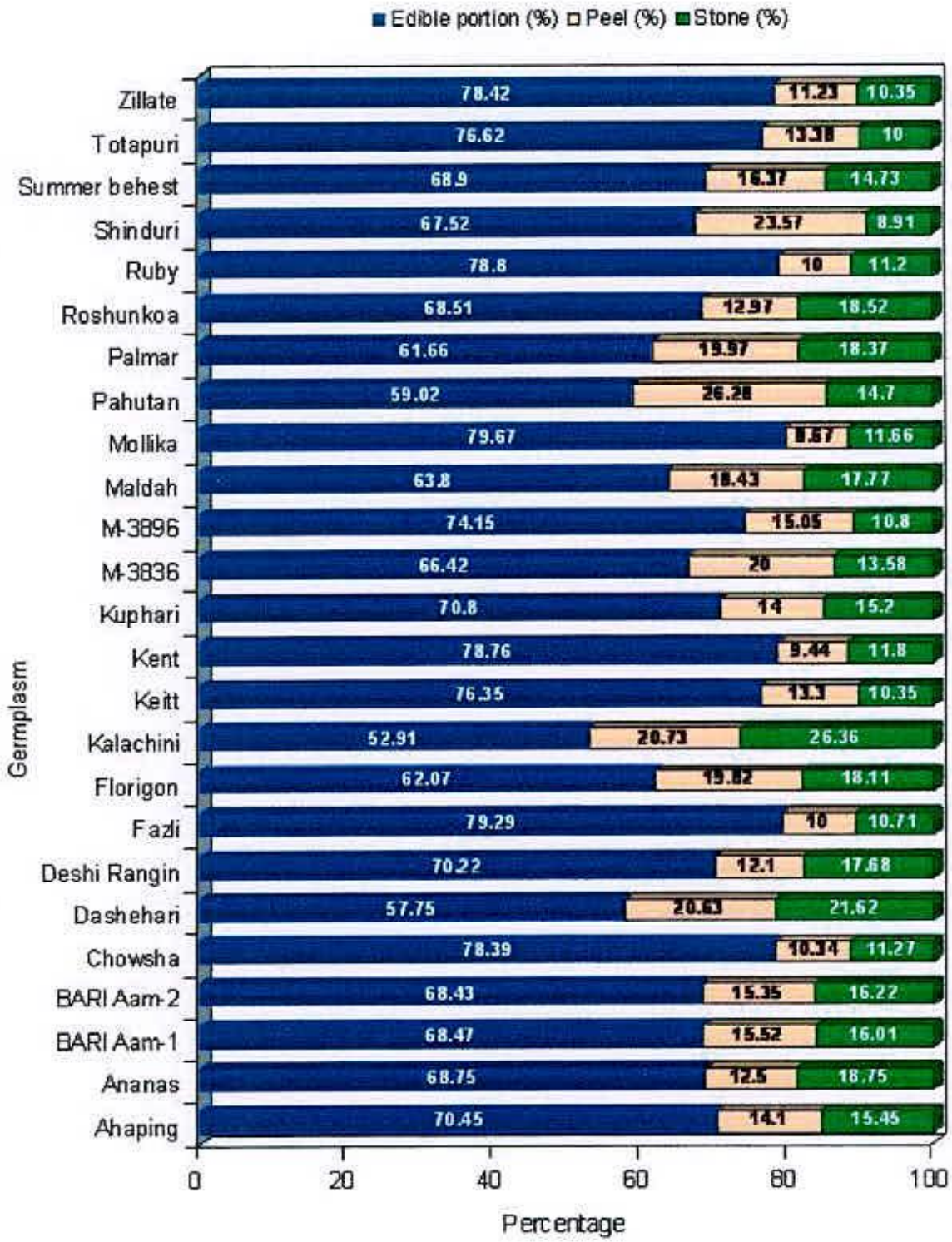


Fig. 4. Percent edible portion, percent peel and percent stone of 25 local and exotic mango germplasm

4.2.12 Stone characteristics

The stone characteristics in respect of weight, length, breadth, thickness and pulp to stone ratio were studied and results are presented in Table 9.

4.2.12.1 Stone weight

Fazli produced the heaviest stone (60.00 g) followed by Zillate (47.00 g), Maldah (45.00 g). The lightest stone was observed in Chowsha (19.60 g) preceded by Florigon (21.00 g) and other germplasm were intermediate (Table 9). The results of the present study are in partial agreement with the research findings of Haque *et al.* (1993) who recorded 14.00 g to 70.00 g stone weight.

4.2.12.2 Stone size

Stone length: The germplasm Fazli had the longest stone (10.73 cm) closely followed by Totapuri (10.65 cm) and Mollika (9.00 cm). While BARI Aam-2 produced the shortest stone (5.04 cm) preceded by BARI Aam-1 (5.10 cm) (Table 9). Sarder *e al.* (1991) studied 15 varieties of mango and found wide range of variation for stone length from 4.7 to 13.9 cm. Bhuyan and Islam (1989) found seed length from 6.88 to 12.22 cm.

Stone breadth: The widest stone (5.40 cm) was noted in Keitt followed by Shinduri (5.22 cm). The narrowest stone (2.54cm) was observed in BARI Aam-2 preceded by Chowsha (2.74 cm), Florigon (2.88 cm) (Table 9). Sarder *e al.* (1998) studied 15 varieties of mango and found wide range of variation for stone breadth from 3.3 to 4.8 cm. Bhuyan and Islam (1989) found seed breadth from 3.43 to 5.10 cm.

Stone thickness: Highest stone thickness was observed in Palmar (2.90 cm) followed by Maldah (2.44 cm), Fazli (2.20 cm), Florigon (2.20 cm) and Ahaping (2.18 cm). The germplasm Chowsha produced the thinnest stone (1.34 cm) preceded by BARI Aam-2 (1.54 cm) and Ananas (1.56cm) (Table 9). Kabir (2001) in an experiment with 12 mango germplasm found wide range of variation for stone thickness from 1.60 to 3.52 cm.

Table 9. Stone characteristics of 25 local and exotic mango germplasm

Germplasm	Stone weight (g)	Stone size (cm)			Pulp to Stone ratio
		Length	Breadth	Thickness	
Ahaping	34.00	6.18	3.46	2.18	0.22
Ananas	24.00	5.58	2.78	1.56	0.28
BARI Aam-1	23.00	5.10	3.06	1.70	0.30
BARI Aam-2	30.00	5.04	2.54	1.54	0.60
Chowsha	19.60	6.05	2.74	1.34	0.15
Dashehari	43.00	8.15	3.50	2.05	0.62
Deshi Rangin	38.00	6.46	3.54	2.08	0.26
Fazli	60.00	10.73	4.77	2.20	0.16
Florigon	21.00	5.72	2.88	2.20	0.30
Kalachini	40.00	7.18	3.66	1.94	0.89
Keitt	42.00	9.12	5.40	1.76	0.18
Kent	25.00	7.65	3.80	1.58	0.17
Kuphari	30.40	6.72	3.40	1.90	0.22
M-3836	38.00	7.02	3.60	1.96	0.21
M-3896	30.50	5.93	3.43	2.03	0.17
Maldah	45.00	7.26	4.74	2.44	0.28
Mollika	42.00	9.00	4.20	1.82	0.16
Pahutan	37.00	6.70	3.23	1.42	0.30
Palmar	42.33	8.95	3.97	2.90	0.30
Roshunkoa	40.00	6.54	3.66	2.00	0.28
Ruby	28.00	7.65	3.20	1.85	0.15
Shinduri	34.00	7.80	5.22	1.64	0.14
Summer Behest	32.40	7.06	4.66	1.84	0.22
Totapuri	40.00	10.65	3.95	1.85	0.15
Zillate	47.00	7.58	4.18	2.04	0.15
Mean	35.46	7.27	3.74	1.91	0.26
Range	19.60-60.00	5.04-10.73	2.54-5.40	1.34-2.90	0.14-0.89
SE	1.83	0.29	0.14	0.06	0.03
CV (%)	25.84	20.46	19.90	17.10	65.79

4.2.13 Pulp to stone ratio

Pulp to stone ratio range 0.14 to 0.89 was observed in all the mango germplasm studied (Table 9). Maximum pulp to stone ratio (0.89) was found in Kalachini while minimum ratio (0.14) was recorded in Shinduri. This finding differs with that of Hossain and Talukdar (1974) who recorded ratio 0.05 to 0.44. This might have occurred due to the genetical difference and /or the variation of environmental factors.

4.2.14 Bio-chemical characteristics

4.2.14.1 Moisture content

BARI Aam-1 contained maximum (86.36 %) moisture followed by Deshi Rangin (84.64 %), Pahuatun (83.94 %), Ananas (83.58 %) and BARI Aam-2 (82.28 %). The lowest moisture content (74.58 %) was found in Totapuri preceded by Kent (75.58%) and Maldah (75.87 %) (Table 10). The present results partially agreed with the research findings of Mollah and Sidique (1973) who recorded 78.11 to 87.12% moisture content in 12 mango varieties and Samad *et al.* (1975) found 78.96 to 87.55% moisture in 10 mango varieties.

4.2.14.2 Total soluble solids (TSS)

Total soluble solids content of 25 mango germplasm were measured at ripe stage and resented in (Fig. 5). Kent contained the highest TSS (22.23 %) followed by Maldah (22.21%), Roshunkoa (22.20 %), and M-3836 (22.13 %). The lowest total soluble solids (16.27 %) were recorded in Totapuri. The present findings are well agreed with the results of Bhuyan and Guha (1995) who found 16.22 % to 24.14% TSS in 14 mango germplasm under the climatic conditions of Rajshahi.

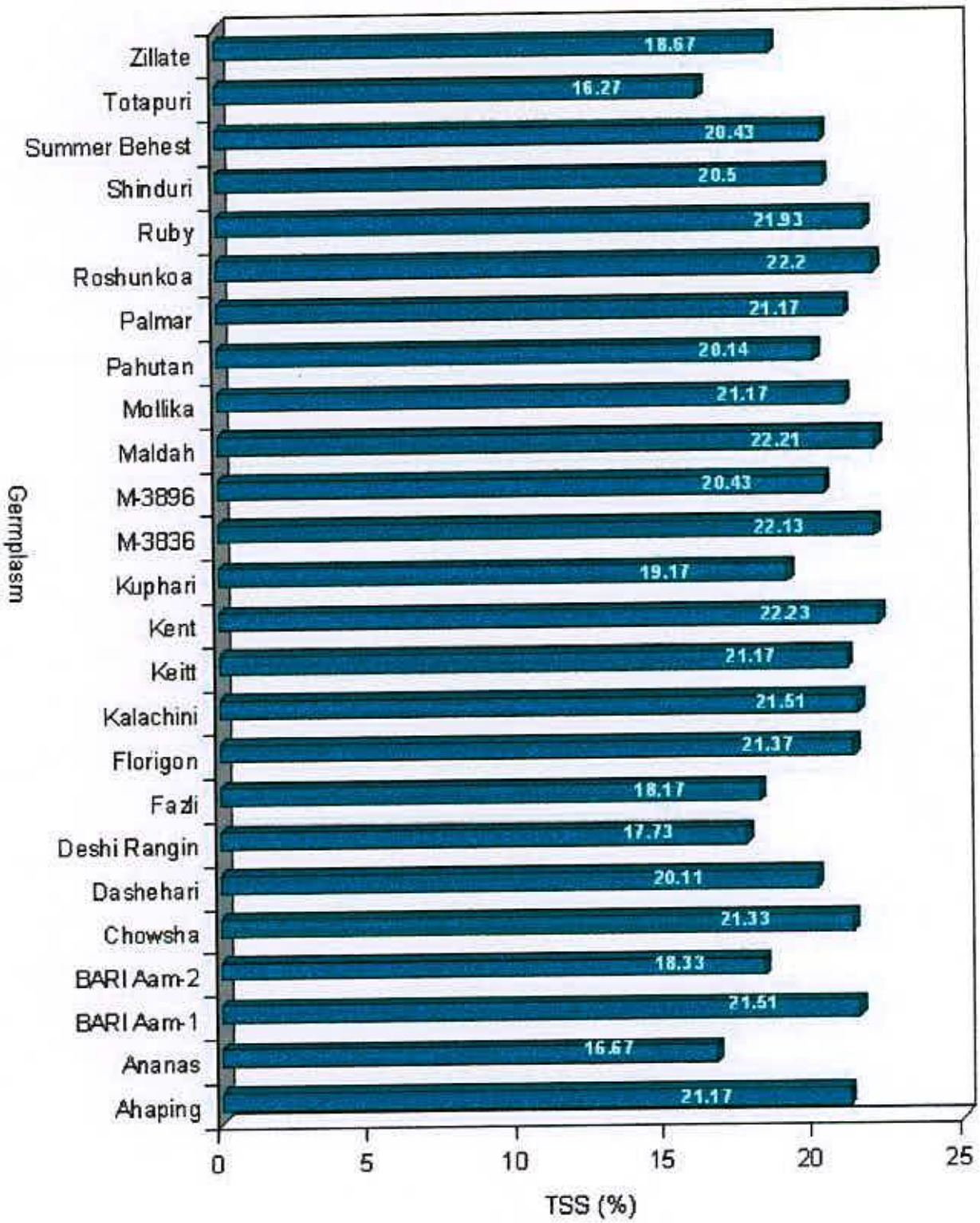


Fig .5. Percent of total soluble solids (TSS) content of local and exotic mango germplasm

4.2.14.3 Pulp pH

Pulp pH was the highest (5.42%) in Totapuri followed by Kalachini (5.29%), Summer Behest (5.25%) and Kent (5.24%). The lowest pH was noted from the juice of Ahaping (4.14 %) preceded by Deshi Rangin (4. 49%) and Shinduri (4.69%) (Table 10). Absar *et al,* (1993) found 4.0 to 5.2 pH in 10 mango varieties.

4.2.14.4 Reducing Sugar

Maximum reducing sugar (7.37%) was found in Kalachini, followed by Summer Behest (6.43 %) Totapuri (5.41%) and Maldah (5.24%). The lowest content of reducing sugar (2.82%) was observed in Phautan preceded by Ahaping (2.88%) (Table 10). The results are in agreement with that of Chaudhari *et al.* (1997) who reported 2.6 to 7.1 % reducing sugar in 19 souths Indian mango varieties. This difference might be due to genetical difference of germplasm as well as growing climate.

4.2.14.5 Non- reducing sugar

The germplasm Summer Behest had the highest of non-reducing sugar (15.10%) followed by Totapuri (15.01%), Kent (14.15%) and Zillate (14.07%). Pahutun (9.89%) had the lowest of non-reducing sugar preceded by BARI Aam-2 and M-3896 (10.14%), Deshi Rangin and Chowsha (10.38%) (Table 10). Sarker and Muhsi (1978) observed 15.75% non-reducing sugar in Fazli and Gopalbhog, respectively.

4.2.14.6 Titratable acidity

The highest titratable acidity (0.54%) was found in Summer Behest followed by Pahutan (0.53%), Ahaping (0.51%) and Deshi Rangin (0.51%). The fruit pulp of Chowsha (0.24%) had the lowest content of titratable acidity preceded by Totapuri (0.25%), M-3836 (0.26%), Shinduriand and Keitt (0.28%) (Table 10). The results iof the present study is with the results of Prasad (1977) where tiratable acid varied from 0.312 to 0.585%. Chaudhari *et al.* (1997) who recorded 0.14 to 0.59 % titratable acidity in some mango cultivars.

Table 10. Chemical composition of fruits of 25 local and exotic mango germplasm

Germplasm	Moisture (%)	pH	Reducing sugar (%)	Non-reducing sugar (%)	Titratable acidity (%)	Sugar acidity ratio
Ahaping	81.93	4.14	2.88	10.93	0.52	26.64
Ananas	83.58	4.74	3.21	11.48	0.32	45.96
BARIAam-1	86.36	4.80	3.32	11.51	0.46	32.68
BARIAam-2	82.28	4.94	5.01	10.14	0.36	46.57
Chowsha	78.51	5.00	5.02	10.38	0.24	46.57
Dashehari	77.46	5.08	3.17	10.43	0.45	27.14
Deshi Rangin	84.64	4.49	3.39	10.38	0.51	27.23
Fazli	81.43	5.00	3.24	12.70	0.33	48.92
Florigon	79.68	5.17	4.87	13.35	0.36	51.22
Kalachini	78.18	5.29	7.37	12.97	0.35	57.99
Keitt	80.64	5.17	3.32	11.48	0.28	27.14
Kent	75.58	5.24	4.72	14.15	0.35	54.06
Kuphari	80.64	5.16	4.42	12.16	0.40	41.83
M-3836	81.67	4.96	3.78	11.97	0.26	60.35
M-3896	77.46	4.94	3.21	10.14	0.35	39.41
Maldah	75.87	5.12	5.24	13.13	0.35	52.01
Mollika	80.64	5.03	4.07	12.84	0.43	39.41
Pahutan	83.94	4.83	2.82	9.89	0.53	24.19
Palmar	76.87	4.96	4.59	12.83	0.34	51.18
Roshunkoa	79.44	5.06	3.22	11.33	0.47	31.17
Ruby	79.56	5.03	3.14	11.38	0.44	29.50
Shinduri	80.79	4.69	4.88	12.28	0.28	60.21
Summer Behest	80.47	5.25	6.43	15.10	0.54	75.66
Totapuri	74.58	5.42	5.41	15.01	0.25	81.51
Zillate	79.66	5.04	5.02	14.07	0.33	57.38
Mean	80.04	4.98	4.23	12.08	0.37	45.42
Range	74.58-86.36	4.14-5.42	2.82-7.37	9.89-15.10	0.24-0.54	24.19-81.51
SE	0.58	0.052	0.21	0.50	0.017	3.01
CV%	3.52	5.24	27.11	20.63	23.60	33.16

4.2.14.7 Sugar/ acidity ratio

The mango germplasm showed marked variation in respect of sugar /acidity ratio. The highest sugar/acidity ratio (81.51) was recorded in Totapuri followed by Summer Behest (75.66). The lowest sugar/acidity ratio (24.19) was recorded in Pahutan preceded by Ahaping (26.64), Dashehari (27.14), Keitt (27.14) and Deshi Rangin (27.23) (Table 10). The results supported the findings of Lodh *et al.* (1974) where sugar/ acidity ratio ranged from 5.50 to 109.20. This difference might be due to genetical difference of germplasm as well as growing climate.

4.3 Pest and Disease incidence

4.3.1 Disease incidence

Major diseases of mango such as anthracnose, floral malformation and stem-end-rot in different germplasm are presented in Table 12. Pictorial views of the diseases are shown in Plates 2 and 3.

4.3.1.1 Anthracnose

The germplasm Pahtuan and Kuphari were found highly susceptible to anthracnose while Kalachini, Maldah and Zillate were moderately susceptible. The rest of the varieties were less susceptible to this disease. Bhuyan and Guha (1995) reported that M-3836 and Mollika were resistant and Ruby was highly susceptible to anthracnose under the climatic condition of Chapai Nawabgonj which is different from the findings of present study. This variation might be due to variation in growing condition.

4.3.1.2 Floral malformation

The results revealed that all the varieties were less susceptible to floral malformation except Pahutan and Kupahari. These two germplasm were highly susceptible to floral malformation (Table 11). Whereas Ahaping and Florigon were moderately susceptible. The remaining germplasm were less susceptible to the disease.

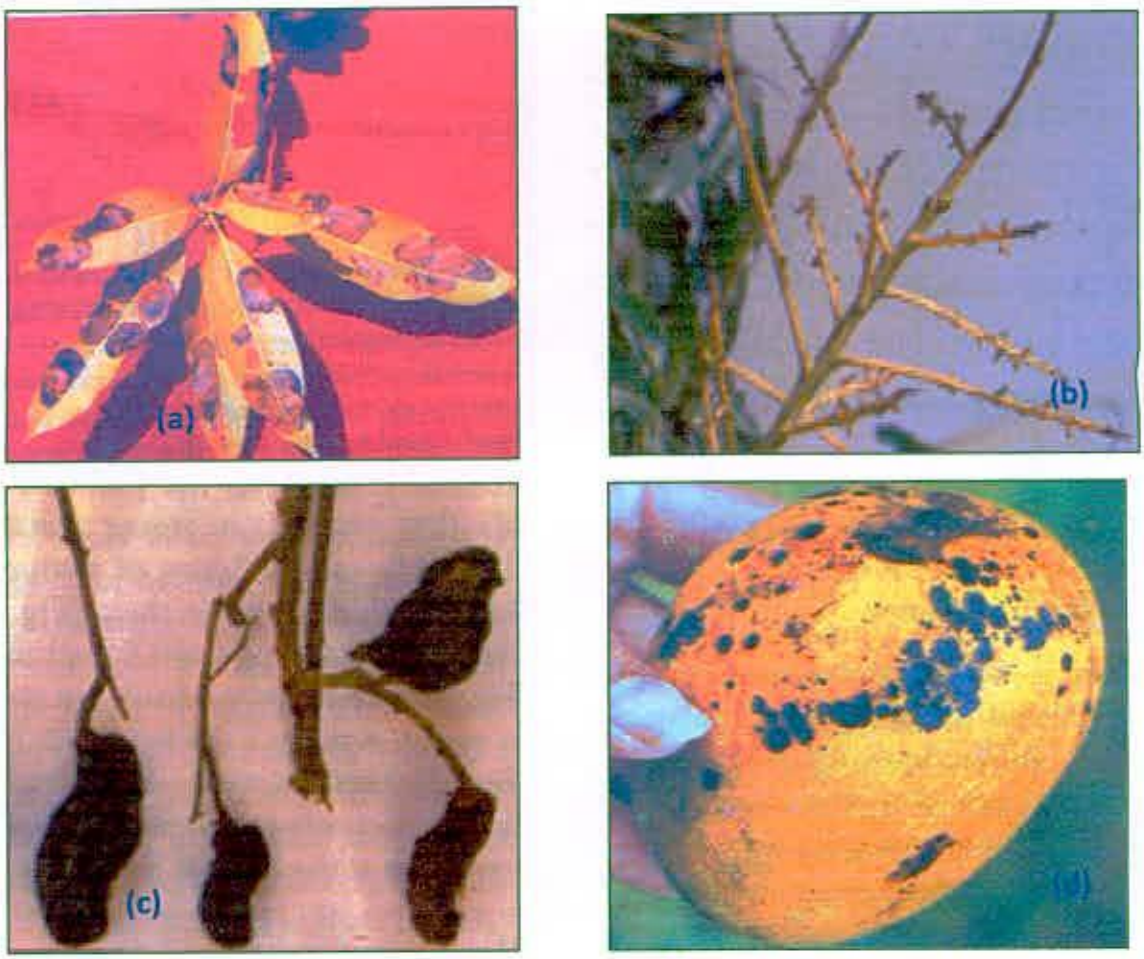


Plate 2. Photographs showing anthracnose disease infected (a) leaf, (b) Inflorescence, (c) developing fruit and (d) mature fruit of mango

Plate 3. Photographs showing incidence of (a) floral malformation and (b) stem-end-rot diseases in mango

Table 11. Disease susceptibility of 25 local and exotic mango germplasm

Germplasm	Anthracnose	Floral malformation	Stem-end-rot
Ahaping	LS	MS	LS
Ananas	LS	LS	MS
BARI Aam-1	LS	LS	LS
BARI Aam-2	LS	LS	LS
Chowsha	LS	LS	LS
Dashehari	LS	LS	LS
Deshi Rangin	LS	LS	LS
Fazli	LS	LS	LS
Florigon	LS	MS	LS
Kalachini	MS	LS	MS
Keitt	LS	LS	LS
Kent	LS	LS	LS
Kuphari	HS	HS	HS
M-3836	LS	LS	LS
M-3896	LS	LS	LS
Maldah	MS	LS	MS
Mollika	LS	LS	LS
Pahutan	HS	HS	HS
Palmar	LS	LS	LS
Roshunkoa	LS	LS	MS
Ruby	LS	LS	MS
Shinduri	LS	LS	LS
Summer Behest	LS	LS	LS
Totapuri	LS	LS	LS
Zillate	MS	LS	MS

LS: Low susceptible, MS: Medium susceptible, HS: High susceptible

The results are in conformity with the findings of Reza (1995) who evaluated 27 germplasm and reported that most of the exotic varieties were infected by floral malformation. Bhuyan and Guha (1995) also indicated that susceptibility of different mango germplasm to floral malformation varied with the variety (from 0 to 58%) under the climatic condition of Chapai Nawabgonj.

4.3.1.3 Stem-end-rot

Pahutan and Kupahari exhibited high susceptibility to stemend rot while Kalachini, Maldah, Ananas, Zillate, Ruby, and Roshunkoa were medium susceptible to the disease. Other varieties were less susceptible. Anonymous (1989) reported that stem-end-rot occured most in Fazli and then in Ashwina under the climatic condition of Chapai Nawabgonj which is in agreement with the present findings.

4.3.2 Insect pest incidence

Reaction of germplasm including in the experiment to insect pests of mango such as stem borer, fruit fly and fruit weevil are presented in Table 12, pictorial view of the insect pests and infested plant organs are showed in Plate 4.

4.3.2.1 Stem borer

Mango stem borer attacks stem and branches of mango trees and the upper portion of the infested parts are killed. BARI Aam-2, Maldah, Ananas, Ahaping, Pahutan, Summer Behest, Ruby, Palmar and Kupahari were medium susceptible to stem borer. The remaining germplasm were less susceptible (Table 12). Anonymous (1989) reported that at Joybebpur and in the surrounding areas, stem borer was found to be very serious. Hossain (1989a) stated that stem borer is a serious pest of North-Eastern and South-Eastern districts of Bangladesh.

4.3.2.2 Fruit fly

Moderate infestations of fruit fly were noticed in BARI Aam-2, Maldah, Ananas, Ahaping, Pahutan, Summer Behest, Ruby, Palmar and Kupahari were found in medium susceptible. The remaining germplasm were less susceptible (Table12). Anonymous (1989) conducted a survey on mango orchards in North-West Bangladesh and showed that fruit fly is one of major insect pest of mango. It is also reported that Khirsapat and Langra were more susceptible to fruit fly under the climatic condition of Chapai Nawabgonj.

4.3.2.3 Fruit weevil

Mango fruit weevil is one of the most destructive pests of mango fruits of trees grown from seeds. At Gazipur all the germplasm under study were less susceptible to that pest (Table 12). Anonymous (1989) reported that mango fruit and nut weevil is a very serious pest in North-Eastern and South-Eastern areas of Bangladesh. Hossain (1989b) also reported that mango fruit weevil is the most destructive and a major pest in the eastern parts of Bangladesh. It is observed that grafted trees are less susceptible to fruit weevil than the seedling trees of mango.

Table 12. Insect susceptibility of 25 local and exotic mango germplasm

Germplasm	Stem borer	Fruit fly	Fruit weevil
Ahaping	MS	MS	LS
Ananas	MS	MS	LS
BARI Aam-1	LS	LS	LS
BARI Aam-2	MS	MS	LS
Chowsha	LS	LS	LS
Dashehari	LS	LS	LS
Deshi Rangin	LS	LS	LS
Fazli	LS	LS	LS
Florigon	LS	LS	LS
Kalachini	LS	LS	LS
Keitt	LS	LS	LS
Kent	LS	LS	LS
Kuphari	MS	MS	LS
M-3836	LS	LS	LS
M-3896	LS	LS	LS
Maldah	MS	MS	LS
Mollika	LS	LS	LS
Pahutan	MS	MS	LS
Palmar	MS	MS	LS
Roshunkoa	LS	LS	LS
Ruby	MS	MS	LS
Shinduri	LS	LS	LS
Summer Behest	MS	MS	LS
Totapuri	LS	LS	LS
Zillate	LS	LS	LS

LS: Low susceptible, MS: Medium susceptible, HS: High susceptible

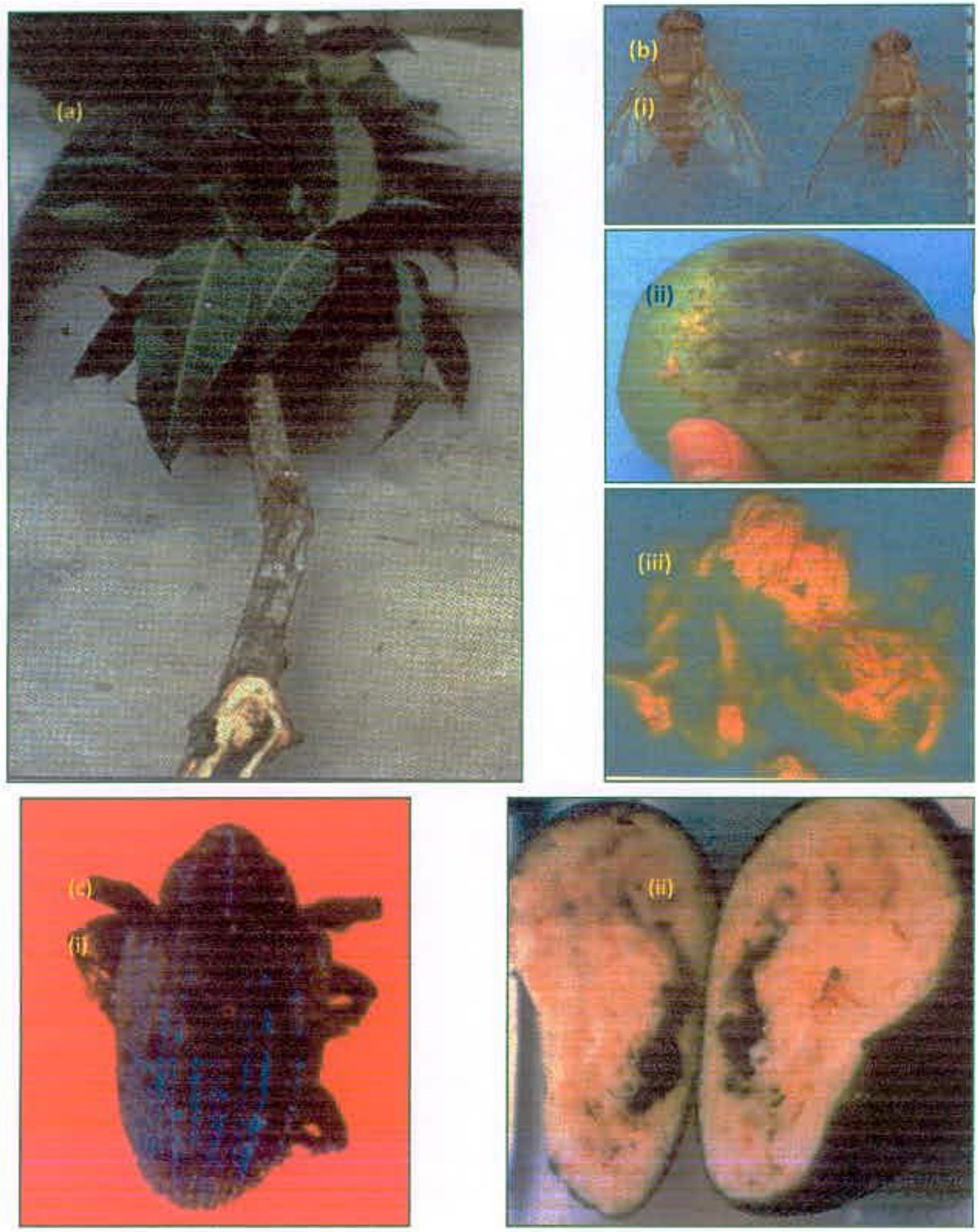


Plate 4. Photographs showing (a) stem borer infested branch, (b) fruit fly (i) adult male and female insect, (ii) fruit fly infested fruit, (iii) larvae of fruit fly (c) fruit weevil (i) adult fruit weevil and (ii) fruit weevil infested fruit.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out with 25 mango germplasm involving each of different characters at the Fruit Research Farm of Horticulture Research Center, Bangladesh Agricultural Research Institute, Joydebpur during September 2006 to August 2007. The objectives of the experiment were to evaluate the morphological and physico-chemical characteristics of mango under the agro-ecological condition of Joydebpur. The experiment was laid out in non replicated Randomized Complete Block Design.

Data on morphological as well as physico-chemical characteristics were studied. The results indicated that the flower bud emergence was earliest (22 December) in Ahaping and latest in the Maldah (12 January). Again panicle emergence was first noticed in Ahaping while Maldah was the (14 February). Flower was opened first in Ahaping (18 January) and Maldah was the latest (22 February). Full blooming was first noted in Ananas (05 February) and the latest BARI Aam-2 (17 March). The germplasm Summer Behest (10 June 2007) and Maldah (27 July 2007) were the earliest and the latest, respectively in harvesting time. On the other hand, maximum and minimum times were required for maturity of Ahaping (169 days) and zillate (115 days). Panicle colour in most of the germplasm varied from light green to dark red but crimson colour panicle was observed in Ananas and in general cases panicle was broadly pyramidal in shape. Most of the germplasm had secondary branches in their panicle except Deshi Rangin, M-3896, Chowsha which had tertiary branches as well. Ananas produced the maximum number of panicles per shoot, whereas minimum was in Totapuri. The longest panicle was noted in Dashehari (42.16 cm) and the shortest panicle was found in Kalachini (14.36 cm). The highest number of main branches was in Dashehari (46.00) and BARI Aam-1 (22.67) had the lowest number.

Maximum percentage of male flower was noted in BARI Aam-1(95 %) and the lowest male flower was recorded from Mollika (56 %). Mollika (39 %) had the highest percentage of bisexual flowers per panicle and minimum was in BARI Aam-1 (2 %). Maximum unopened flowers per panicle were in Ruby (20 %) and minimum was in BARI Aam-1 (3 %). The highest number of fruit set per panicle was noted in Ananas (30.25) and the lowest number was in Maldah (5.00). Highest and lowest number of fruit retained per panicle was in Summer Behest (6.20) and Fazli (0.80). Fruit retention ranged from 4.76 % in Totapuri to 35.54% in Palmar. BARI Aam-2 produced the maximum number (198) of fruits per plant. The minimum fruits were obtained from M-3896 (31). Weight of fruits per plant was the highest (36.08 kg) in BARI Aam-2 and the lowest (5.1 kg) in Florigon.

Wide variation were observed among the germplasm in terms of qualitative characteristics of fruits namely fruit shape, external appearance, skin colour, peeling quality, skin thickness and pulp colour. On the basis of these qualitative characters BARI Aam-1 was the best one among the germplasm studied. Highly difference was observed among the germplasm in respect of different quantitative characteristics of fruits. The heaviest and the lightest fruits were recorded in Fazli (560 g) and Kalachini (100 g), respectively. Fazli (12.82 cm) was longest and BARI Aam-1 (6.46 cm) had the shortest fruit. Fruit breadth was highest in Summer Behest (9.56 cm) and the lowest in M-3836 (5.00 cm). The thickest fruit was in Fazli (8.38 cm) followed by BARI Aam-2 (4.66 cm). The minimum edible portion was found in Kalachini (52.91%). Peel content ranged from 8.67 % in Mollika to 26.28 % in Pahutan while stone content varied from 8.91 % in Shinduri to 26.36% in Kalachini. Fazli had the heaviest (60.00 g) and the longest (10.73 cm) stone, while Keitt and Palmar had the broadest (5.04 cm) and the thickest (2.90 cm) stone. Pulp to stone ratio varied from 0.14 to 0.89.

The chemical composition of mango fruits was analyzed. Wide variation were recorded among the germplasm, BARI Aam-1 (86.36%) contained maximum moisture whereas Totapuri (74.58%) had the minimum moisture content. The germplasm Kent (22.23%) had the highest TSS and the minimum in Totapuri (16.27 %). Again, the germplasm Totapuri (5.42%) had the highest pH and the lowest in Ahaping (4.14%). Percentage of reducing sugar is maximum in Kalachini (7.37 %) and minimum in Pahutan (2.82 %). Non-reducing sugar and titrable acidity was high in Summer Behest. Sugar acidity ratio was high in Totapuri (81.51) and low in Pahutan (24.19).

Among the germplasm, Pahtuan and Kuphari were found highly susceptible to anthracnose while Kalachini, Maldah and Zillate were moderately susceptible. The rest of the germplasm were less susceptible to this disease. The results revealed that all the germplasm were less susceptible to floral malformation except Pahutan. Pahutan was highly susceptible whereas Ahaping and Florigon were moderately susceptible. The remaining germplasm were less susceptible. Pahutan and Kupahari exhibited the highest susceptibility while Kalachini, Maldah, Zillate, Ananas, Ruby, and Roshunkoa were medium susceptible to stem-end-rot. Other germplasm were less susceptible.

BARI Aam-2, Maldah, Ananas, Ahaping, Pahutan, Summer Behest, Ruby, Palmar, Kupahari were medium susceptible to stem borer. The remaining germplasm were less susceptible.

All the local and exotic mango germplasm were given better performance under Joydebpur condition.

From the above findings it could be concluded that among the germplasm, BARI Aam- 2, BARI Aam-1, Kent and Roshunkoa were found the best in respect of yield. Moreover, these were less to medium susceptible to pests and diseases. The germplasm Mollika, Ruby, Dashehari, Shinduri and M-3836 were attractive skin colour, which can be used as gene donor in hybridization programme. Over all performance of the germplasm under Joydebpur condition was satisfactory. It may be inferred from the above experiment that good quality mango can be grown under Joydebpur condition selecting appropriate germplasm. The experiment should be repeated under the same environment for further verification of the results.

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APPENDIX

Appendix 1. Monthly mean temperature, relative humidity and total rainfall during crop period at the experimental sites

Year	Month	Temperature (^{0}C)		Average relative humidity (%)	Total annual rainfall (mm)
		Maximum	Minimum		
2006	September	32.27	25.50	89.17	536
	October	32.55	24.79	89.90	36
	November	29.71	18.53	69.80	00
	December	29.57	13.09	66.35	00
2007	January	24.61	10.60	82.05	00
	February	26.70	10.33	84.05	48
	March	30.71	17.23	73.27	27
	April	33.13	22.84	81.90	71
	May	34.55	25.25	82.37	132
	June	32.07	25.98	89.77	654
	July	31.58	26.19	91.73	701
	August	32.54	26.60	85.54	324

Source: Bangladesh Meteorological Department, Agargaon, Dhaka.