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Diversity of Mango (*Mangiferaindica* L.) Cultivars in Shendi Area: Morphological Fruit Characterization

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***Abstract* – Morphological characterization allows for the study of plant variation using visual attributes. Fruit have been the major descriptors for identification of different varieties of fruit crops. The study was carried out to identify mango (*Mangiferaindica* L.) varieties in Sudan based on morphological fruit characters. Fruits were collected in triplicate representing 30 cultivars. Sixteen cultivars were grafted genotypes of Indian or Egyptian origin, 11 cultivars were grown directly from seeds (Balady) and 3 cultivars imported recently from South Africa. IPGRI (2006) descriptors were used in the study. Comparisons between means were made by least significant differences (LSD). The results indicated a high intraspecific diversity of mango varieties. Significant differences($p \leq 0.05$) were obtained between the three genotypes and within each of them. Mango fruits showed significant differences ($p \leq 0.05$) in size, weight and circumferences depending on the cultivar. The length ranged between 7.9 to 20.1 Cm, the width 6.1 to 11.6 Cm, the weight between 195.7 to 1154.4 gm and 19.6 to 36.9 Cm for the circumference. The fruit shape, apex shape and slope of shoulder were also a variety characteristics. More than 50%of the grafted cultivars fruits were oblong with acute apex ending with long cure shoulder where as seedlings varieties have varying fruit shape with oblong apex and rising shoulder. South African cultivars were elliptic or roundish in shape ending with long cure shoulder. No significant differences were observed between cultivars regarding fruit beak type and sinus type. The fruit skin weight % vary greatly between cultivars ranging between 9.6 and 19.7 % with yellow or green colors. The weightand texture and color of the pulp were genotypes dependant. The weight % of the pulp vary between 85% and 72.2 % for the grafted cultivars followed by the seedling and South African cultivars respectively. The pulp fiber content showed great variations in quantity and quality of mango cultivars with a range of 7.0 to 45% fiber weight %. The seed length, width, thickness and weight % vary between cultivars and were proportional to those of the fruit.**

***Keywords* – Mango, Morphological Characterization.**

I. INTRODUCTION

The mango (*Mangiferaindica L.*) is one of the most important horticultural crops worldwide. Mangoes are a member of the *Anacardiaceae* family that comprises 73 genera, fitted in the order *Sapindales*. Thisorder belongs to the sub-class *Rosidae*from the class *Magnoliopside* and division *Magnoliophyta*[1]. With 700 species the genus *mangifera* to which mangoes belong consists of 69 species and is classified into tow Sub-genera with several sections based on morphological characteristics. Among the species ,*M. indica* is the most important, although there are other species that also produce edible.

Mangoes are grown all over Sudan and are leading the Sudanese horticultural export. The annual production of mango in Sudan in 1999 was 190 thousand tons [2] which increased to 603.00 (mmt) in the year 2004 according to[3]. Reference [4] reported that the production of mango in Sudan has expanded tremendously because of the opened channels to European and Arab markets.

Many cultivars of excellent fruit quality are currently grown such as Abu-Samaka, Alphonse, Dibsha, Zibda, Galbeltor and Shendi. However the majority of the mango fruit crop in Sudan is harvested from seedling trees, of which the local cultivar (Kitchener) is leading. Although the quality of fruit of these seedling trees is fairly good, they are usually too fibrous and not suitable for export especially to European markets [5].The buildup of mango export industry in Sudan is dependent on mass propagation and planting of superior cultivars which are acceptable to all international markets.

In Sudan mango cultivars are classified into four groups; namely, seed propagated, monoembryonic, polyembryonic and newly introduced cultivars. The seed propagated cultivars are characterized by variations in colors and shapes. The most important seed propagated cultivar is Kitchener (early – maturing cultivar – called Baladi) which represents 90% of the total production in Sudan[6]. Reference [7] report that in Sudan mango cultivars are classified into three groups: True Indian cultivars, Egyptian seedling cultivars of Indian origin such as Zibda, Alphonse, Malgoba and Hindibesinara and Sudanese seedling cultivars of Indian origin of high quality including Shendi, Timoor, Nailm, Mabroka, Debsha and the famous sort Abu-Samaka .

Mango fruit have great variations in size, shape, weight, flesh and skin color and quality . The fruit are nearly round, oval, ovoid – oblong , or somewhat kidney – shaped , often with a beak at the apex , and are usually more or less lop – sided . It was6.25-25 cm in length and 1.8-2.26 Kg in weight. The skin is leathery , waxy , smooth , fairly thick , aromatic and ranges from light or dark – green to clear yellow , yellow-orange , yellow and reddish – pink , or more or less blushed with bright , dark – red or purple – red , with fine yellow , greenish or reddish dots , and thin or thick whitish , gray or purplish bloom when fully ripe [8]-[9]. Fruit color at maturity is genotypes dependent. The meso - carp can be fibrous or fiber free with flavor ranging from turpentine to sweet [10]. The flesh of a mango is peak-like and juicy, with more or less numerous fibers radiating from the husk of a single large kidney-shaped seed. Fibers are more pronounced in fruits grown with hard water and chemical fertilizers [9].

There is a single, longitudinally ribbed, pale yellowish-white, woody stone, flattened, oval or kidney-shaped, sometimes rather elongated seed or stone. Stone has along one side a beard of short or long fibers clinging to the flesh cavity, or it may be nearly fibreless. Within the stone is the starchy seed, either monoembryonic or polyembryonic[9]. The seed of mango is solitary, large and flat, ovoid oblong andis surrounded by the fibrous endocarp at maturity. The testa is thin and papery [10]. The seed may fill stone partially or completely [11].

The application of morphological markers is the simplest of the formal, standardized and repeatable method of evaluating crop genetic diversity. Some of the most important advantage of using morphological characterization are that published descriptor lists are readily obtainable for most major crop species, it can be carried out in situ, is relatively low- cost and easy to perform. Morphological characterization is the first step that should be done before more profound biochemical or molecular studies are carried out [12].

The aim of this study is to identify mango cultivars morphologically on bases of their fruit and seed morphology and fiber content.

II. MATERIALS AND METHODS

Sampling area

Shendi is located on the east bank of the river Nile, river Nile state it is north-east of Khartoum about 170 Km, between latitudes (16 -42) north and longitude (33-26) east, it is the main area of mango cultivation in Sudan. Many cultivars have been grown in this area.

Sampling materials

Thirty mango (*Mangiferaindica* L) trees were used in this study. Nineteen of which were grafted trees of known varieties .V.Z: Abu samaka ,Shendi, Nailum, Mitlaky, Mabroka, Zibda, Alphonse, Galbeltowr, Malgoba, Julik, Timor, Dibsha, Mahmoudi, Walibasha, Bet Abusamaka, Segrest .These varieties were well known in Sudan and cultivated for many years by formers.

Recently three cultivars were introduced from South Africa these were,Elkent, Elkeitt, Tommyatkinz. Eleven varieties were grown directly from seedling which in clude: Kutchineer, Bitbady, Wadsrear, Sinaria, Shabala, Shreefia, Yageen, Bizrtshendi, Rasmctul, Taiba, Higazia. These cultivars showed high production with high quality fruits.

Morphological characterization

Morphological characterization of the selected cultivars was carried-out for fruits using Biodiversity International Descriptor [13].

Fruit measurement:-

Mature mango fruits were collected from the selected farms and selected varieties. From each variety three mango fruits were collected from each of the three replicates.

Fruit shape

The fruit morphological parameters determined were: shape, apex and the beak type , the shape of the fruit shoulder and the sinus of the fruits .

The fruits under test were weighted (gm) using the normal balance .The length and width of the fruits were measured in Cm at the most longer and wider part of the fruit by the vernier. The circumference was measured using plastic meter. and the average of readings were tabulated .

Skin of ripe fruit

The skin color of the collected samples was determined. The weight of the fruit skin was measured.The skin of the fruit was removed by hand and washed many times to remove the adhering fibers.The sample was transferred to the laboratory for measurement by sensitive balance.Three fruit were used from each tree and three replicates were used for each variety.

Pulp measurement

The pulp color and texture of the collected sample weredetermined .The pulp weight of each sample was measured as follows :-

The total weight of the fruit was measured in grams by sensitive balance. The skin of the fruit was removed by hand and washed to remove the adhering fibers and then weighted.

The seed of the fruit was washed genteelly and weighted.

The weight of the skin and the weight of the seed were subtracted from the total fruit weight.

The balance of this was determined as the pulp weight.

Fiber

Fiber weight

The weight of the fruit fiber was measured as follows:

A random area from the fruit fiber was splitted and weighted including the skin and pulp. The weight of the skin was measured and the pulp weight was determined.

The pulp was washed genteelly in Amish to separate the fibers from the rest of the pulp. Then the fibers were weighted.

The weight of the fibers in the fruit was calculated as follows:

$$\frac{The\ weight\ of\ the\ total\ pulp\ X\ the\ fiber\ weight\ in\ the\ black}{Pulp\ weight\ in\ the\ black}$$

Fiber content percentages %

The fiber content percent of the fruit was calculated as follows:

$$\frac{The\ fiber\ weight}{The\ pulp\ weight} * 100$$

Seed measurement

From the fruit samples the seeds were washed 3-5 times to remove any fibers or pulp. The weight of the seeds was measured using the normal sensitive balance in 3 replicates.

The seed length, width and the thickness was measured at the middle of the seed using the vernier as in the fruit measurement.

The pattern of venation and the veins of the seed were determined.

III. Results and Discussion

Fruit

Fruit length, width, weight and circumference

The fruit length, width, weight and circumference of mango fruits were of the major descriptors mango cultivars tested(Table 1).

The fruit length showed significant differences ($p \leq 0.05$) between the cultivars, ranging between 21.167 and 7.967cm in length. The grafted cultivars showed the longest ones compared to the others followed by the seedling and the South African cultivars. Julik, Segrest and Abu Samaka showed the longest cultivars giving a length over the averageMitlaky, Walibasha, Shendi and Timor gave the shortest cultivar below the average. The seedling cultivars showed a little variation between the cultivars fruit length ranging between 15.267 and 10.233cm which are around the average length compared to the grafted cultivars which gave a very wide range. The South African cultivars showed the shortest fruit length.

As the fruit length, the fruit width showed a significant difference ($p \leq 0.05$) between the cultivars. The grafted cultivars showed a wide variation regarding the fruit width unlike the seedling cultivars with exception of the Sinaria cultivar. The South African cultivars showed an average fruit width shorter than the seedling cultivars and longer than the grafted ones.

The fruit weight and the fruit circumference followed the same trend of the fruit width. The grafted cultivars showed the higher fruit weight and circumference compared to the other. Rasmctul cultivar showed the highest weight.

The fruit of mango showed varying size and weight and circumferences depending on the cultivars. A finding reported by [14] who reported a length of 7.0- 18cm. References[15]-[16] reported variations concerning length and weight of the mango fruit. They reported these variations in mango genotypes. The study showed that Julik and Segrest have the longest fruit as reported by [14]

Fruit shape, apex shape and slope of shoulders

The shape of the grafted cultivars was almost oblong (62%) except for few cultivars with elliptic shape (12.5%) and (25%) roundish in shape. The shape of the seedling cultivars vary between cultivars depending on the variety. South African cultivars were elliptic and roundish and no oblong fruits observed.

The fruit apex shape followed the same trend of the fruit shape, as (62.5%) of the fruit apex were acute and obtuse in the grafted cultivars, whereas the seedling cultivars showed (64%) oblong fruit apex. The fruit apex of the South African cultivars showed the same shape regardless the cultivars.

Table 1: fruit length, width, weight and circumference of mango cultivars

Cultivar	Length (cm)	Width (cm)	Weight (gm)	Circumference (cm)
Abu samaka	16.367	8.733	528.533	27.633
Nailum	12.600	8.733	490.133	27.033
Mitlaky	9.733	6.633	278.100	21.967
Mabroka	11.000	8.733	433.600	26.400
Zibda	10.033	7.500	300.267	23.067
Alphonso	11.400	6.933	249.233	22.333
Galbeltowr	12.267	9.400	505.133	27.867
Shendi 1	8.600	6.100	195.733	20.033
Malgoba	10.100	8.367	481.100	27.433
Julik	21.167	6.900	512.400	21.633
Timor	9.933	6.200	220.833	20.567
Dibsha	12.967	9.100	603.567	29.500
Mahmoudi	13.400	7.533	390.600	23.100
Walibasha	7.967	6.433	187.300	20.033
Bet abusamaka	13.867	10.500	675.500	33.300
Segres	20.167	10.700	818.167	33.200
Average	12.598	8.031	429.387	25.319
Elkeitt	11.533	9.100	474.933	27.300
Elkent	10.833	9.333	459.533	28.300
Tommy atkinz	9.433	7.567	312.233	24.633
Average	10.933	8.667	382.233	26.744
Kutchineer	10.833	8.000	317.867	23.600
Bet bady	14.467	11.633	845.233	36.967
Wad srear	10.233	9.800	537.033	30.767
Sinaria	10.933	6.133	245.700	19.667
Shabala	12.900	10.167	648.067	31.800
Higazia	10.400	9.233	482.100	27.900
Yageen	10.767	8.433	385.167	25.767
Taiba	11.100	9.667	619.167	31.200
Bizrtshendi	15.267	8.267	497.200	24.900
Rasmctul	13.767	11.933	1154.433	39.467
Shreefia	12.033	10.800	747.233	33.267
Average	12.064	9.4600	589.018	29.573
SE±	0.181	0.072	13.779	0.244

The slope of the fruit shoulder differ greatly between the grafted and seedling cultivars. Almost all the grafted cultivar ending in a long cure shoulder where as the seedling cultivars shoulder slope is rising and then rounded. Two of the South Africa cultivars end in a long cure while Elkent cultivar has a rising and then rounded shoulder slope Table (2).

Table 2: Fruit shape, apex shape and slope of shoulders of mango cultivars

Cultivar	shape	apex shape	slope shoulder
Abu samaka	Oblong	Acute	Sloping abruptly
Nailum	Elliptic	Obtuse	Ending in along cure
Mitlaky	Elliptic	Obtuse	Ending in along cure
Mabroka	Oblong	Acute	Rising and then rounded
Zibda	Oblong	Acute	Ending in along cure
Alphonso	Roundish	Obtuse	Rising and then

Cultivar	shape	apex shape	slope shoulder
			rounded
Galbeltowr	Roundish	Obtuse	Rising and then rounded
Shendi 1	Oblong	Acute	Ending in along cure
Malgoba	Roundish	Obtuse	Rising and then rounded
Julik	Oblong	Acute	Ending in along cure
Timor	Oblong	Acute	Ending in along cure
Dibsha	Oblong	Acute	Rising and then rounded
Mahmoudi	Oblong	Acute	Ending in along cure
Walibasha	Roundish	Obtuse	Ending in along cure
Bet abusamaka	Oblong	Acute	Rising and then rounded
Segrest	Oblong	Acute	Ending in along cure
Elkeitt	Elliptic	Obtuse	Ending in along cure
Elkent	Roundish	Obtuse	Rising and then rounded
Tommy atkinz	Roundish	Obtuse	Ending in along cure
Kutchineer	Oblong	Acute	Rising and then rounded
Bet bady	Roundish	Obtuse	Rising and then rounded
Wad srear	Roundish	Obtuse	Rising and then rounded
Sinaria	Oblong	Acute	Ending in along cure
Shabala	Roundish	Obtuse	Rising and then rounded
Higazia	Roundish	Obtuse	Rising and then rounded
Yageen	Elliptic	Obtuse	Rising and then rounded
Taiba	Elliptic	Acute	Rising and then rounded
Bizrtshendi	Oblong	Acute	Sloping abruptly
Rasmctul	Roundish	Obtuse	Rising and then rounded
Shreefia	Oblong	Acute	Rising and then rounded

The fruit and apex shapes and the slope of shoulders vary greatly between the cultivars. Reference [14] reported these variations among mango genotypes and even among the same cultivar.

Fruit beak type and sinus type

The two parameters showed a different trend regarding the cultivar. No significantdifferences between the grafted, South African and seedling cultivars.Most of the cultivars showed a shallow or absent sinus with very few cultivars showing deep sinus.(Table 3).

Table 3: Fruit beak type and sinus type of mango cultivars

Cultivar	Fruit beak type	Fruit sinus type
Abu samaka	Mammiform	Shallow
Nailum	Point	Shallow
Mitlaky	Absent	Absent
Mabroka	Mammiform	Deep
Zibda	Prominent	Shallow
Alphonso	Point	Absent
Galbeltowr	Prominent	Shallow
Shendi 1	Mammiform	Deep
Malgoba	Point	Absent
Julik	Mammiform	Shallow
Timor	Point	Shallow
Dibsha	Mammiform	Deep
Mahmoudi	Mammiform	Shallow
Walibasha	Absent	Absent
Bet abusamaka	Mammiform	Absent
Segrest	Mammiform	Shallow
Elkeitt	Prominent	Absent
Elkent	Point	Absent
Tommy atkinz	Absent	Absent
Kutchineer	Point	Shallow
Bet bady	Prominent	Absent
Wad srear	Absent	Absent
Sinaria	Mammiform	Deep
Shabala	Prominent	Absent
Higazia	Absent	Shallow
Yageen	Prominent	Absent
Taiba	Mammiform	Absent
Bizrtshendi	Mammiform	Deep
Rasmctul	Point	Shallow
Shreefia	Absent	Deep

The beak type and sinus type of the fruit is the most characteristic feature of the fruit. Reference [9]reported that the beak may be prominent or represented merely as dob. These findings were in accordance with the findings of this study. Reference [17]reported the same finding.

Skin weight% and color

The grafted cultivars skin weight% showed a wide range of the percentage (9.6-19.7%) compared to the other cultivars with a narrow range (9.5-14.3%) in the seedling cultivars and (12.5-16.5%) in South African cultivars. The average skin weight% of the South African cultivar was higher (14.2%) compared to the local cultivars: (13.6%) The grafted and (12.3%) seedling cultivars.

The colors of the skin also vary greatly between cultivars with the green and yellow colors among all the cultivars regardless the cultivar either grafted or seedling. The skin color of the South African cultivar showed different color from the local cultivar from red, red yellow and red green colors.(Table 4).

Reference [10] reported that the skin weight% and color at maturity is genotypes dependant. The rind weight and thickness vary greatly from 0.5mm to 2.5mm. The results obtained showed that the skin color of mango fruits ranged from green, yellowish green, yellow and orange a finding coincide with the findings of [14].

Table 4: Skin weight % and color of mango cultivars

Cultivar	Skin weight %	Skin color
Abu samaka	14.1	Green-yellow
Nailum	13.9	Yellow
Mitlaky	16.1	Green
Mabroka	13.7	Green-yellow
Zibda	12	Light yellow
Alphonso	13.1	Yellow
Galbeltowr	11	Green
Shendi 1	9.8	Yellow
Malgoba	16.4	Green
Julik	9.6	Green-yellow
Timor	19.7	Green
Dibsha	15.1	Green-yellow
Mahmoudi	11.9	Yellow
Walibasha	14.4	Green
Bet abusamaka	11.3	Green-yellow
Segrest	15.9	Green
Average	**13.6**	
Elkeitt	16.5	Green-yellow
Elkent	13.6	Red yellow
Tommy atkinz	12.5	Red
Average	**14.2**	
Kutchineer	13.5	Orange
Bet bady	13.2	Yellow
Wad srear	13.5	Green
Sinaria	14.3	Yellow
Shabala	13.6	Green-yellow
Higazia	9.5	Green
Yageen	13.4	Yellow
Taiba	10.4	Yellow
Bizrtshendi	10.6	Green-yellow
Rasmctul	10.1	Yellow
Shreefia	13.1	Green
Average	**12.3**	
SE +		

Pulp weight%, texture and color

As shown in table (5) the weight% texture and color of the mango cultivars showed clear variations between them. The pulp content % ranged from 72.2 to 85.3% of the total weight of the fruit in the grafted cultivars. Seven cultivars of the study group have more than 80% pulp, these cultivars include Julik, Galpeltowr and Bet Abusamaka with an average % of 79.4% of the total fruit weight. South African cultivars showed an average pulp percent of more than 80% which is lower than most of the grafted cultivars. Likewise, all the seedling cultivars showed a high pulp percent (≥ 80%) except Kutchineer and Sinaria with a total average of 81.7%.

The pulp textures vary with the cultivar under test from firm, soft and juicy. The grafted cultivars showed a very high variation with 7 cultivars firm, 5 soft, 4 juicy. The three South African cultivars showed a firm pulp texture and about 50% of the seedling cultivars have a firm texture. The firm pulp texture was the dominant in more than 50% of the cultivars tested.

The pulp color also vary according to the cultivar tested, the yellow color is the most color observed among the grafted and seedling cultivars whereas the South African cultivars showed an orange pulp color.

The pulp weight% texture and color of the ripe fruit vary greatly among the cultivar tested. The findings were reported by [17] who showed that the color of the pulp is normally yellow to yellow orange with soft and intermediate soft texture. The pulp weight% depends on the size, weight and length of the fruit beside the weight% of the skin and seed. This parameter is a cultivar characteristic.

Table 5: Pulp weight %, texture and color of mango cultivars

Cultivar	Pulp weight %	Pulp texture	Pulp color
Abu samaka	81.9	Firm	Yellow
Nailum	78.4	Juicy	Orange
Mitlaky	77.2	Soft	Yellow-orange
Mabroka	79.8	Firm	Yellow
Zibda	79.6	Juicy	Light yellow
Alphonso	79.4	Juicy	Light yellow
Galbeltowr	83.6	Soft	Yellow
Shendi 1	80	Juicy	Orange
Malgoba	73.1	Firm	Light yellow
Julik	85.3	Soft	Orange
Timor	72.2	Soft	Yellow-orange
Dibsha	79.8	Soft	Light yellow
Mahmoudi	82.1	Firm	Orange
Walibasha	73.8	Firm	Yellow
Bet abusamaka	83.1	Firm	Yellow
Segrest	80.9	Firm	Yellow-orange
Average	**79.4**		
Elkeitt	80.8	Firm	Yellow
Elkent	80.1	Firm	Orange
Tommy atkinz	80.6	Firm	Orange
Average	**80.5**		
Kutchineer	74.5	Firm	Orange

Bet bady	82.8	Soft	Orange
Wad srear	82.4	Soft	Yellow-orange
Sinaria	76	Firm	Yellow
Shabala	81.4	Firm	Yellow
Higazia	81.8	Firm	Yellow
Yageen	80.4	Firm	Yellow
Taiba	87.3	Juicy	Yellow-orange
Bizrtshendi	82.4	Soft	Orange
Rasmctul	87	Juicy	Orange
Shreefia	82.4	Firm	Yellow
Average	**81.7**		

Fiber weight percentages

The fiber content of the fruits showed a significant differences ($p \leq 0.05$) between the cultivars. (Table 6). Alphonso showed the lowest fiber content (7.0%) followed by Zibda and Dibsha with no significant differences between them. The grafted cultivars vary in their fiber content ranging from (7.0 to 42.3%) with an average of (27.8%). South African cultivars showed a very high fiber content (45%) compared to the other cultivars either grafted or seedling cultivars which showed the lowest fiber content (23.4%).

The pulp fiber content showed great variations in quantity and quality of mango cultivars. Fibers were either very fine with less percentage in the pulp as in Abusamaka or thick with high percentage as in Kutchineer. (Elgozuli, 2011). These findings agree with the result of the study as the average fiber percentage in the grafted cultivar was less than of the seed cultivars. Reference [14]reported a range of fiber% of 0.3 to 20% which is very low compared to a range of 7 to 57.5 in this study.

Table 6: Fruit fiber weight % of mango cultivars

Cultivar	Fiber weight%
Abu samaka	17.8
Nailum	18.2
Mitlaky	29.4
Mabroka	30.6
Zibda	13.3
Alphonso	7
Galbeltowr	38.1
Shendi 1	26.2
Malgoba	39.8
Julik	24.5
Timor	29.2
Dibsha	17.5
Mahmoudi	42.3
Walibasha	32.2
Bet abusamaka	40.4
Segrest	39.3
Average	**27.9**
Elkeitt	57.3
Elkent	34.8
Tommy atkinz	42.9
Average	**45**
Kutchineer	26.9
Bet bady	20.5
Wad srear	18.2
Sinaria	33.6
Shabala	40.6
Higazia	16.4
Yageen	14.9
Taiba	25.9
Bizrtshendi	19.3
Rasmctul	13.4
Shreefia	27.5
Average	**23.4**
SE ±	

Seed length, width, thickness and weight%

Table (7) showed the length, width, thickness and weight% of the seed of the mango cultivars.

Julik cultivar showed the longest seed (16.433 cm) followed by Segrest and Abu samaka (15.033 and 12.967cm respectively). With grafted cultivars seed length average of (9.658 cm). South African cultivars showed a moderate seed length compaired to the other cultivars. The seedling cultivars average (9.179 cm) showed a narrow seed length range between (7.533 – 12.533cm).

Seed width did not vary greatly among the cultivars specially the cultivated cultivars which was around 3.743cm and 4.578 – 4.339 cm for the seed width in South African and seedling cultivars respectively. Bet bady cultivar showed the widest seed among all the cultivars. Julik was the smallest one (2.767 cm) although it was the longer one.

Malgoba cultivars showed the largest seed thickness (2.433 cm) followed by Nailum and Bet abusamaka with the same thickness (2.333 cm) with grafted cultivars seed thickness average of (1.939 cm). South African cultivars showed almost the same seed thickness which is lower than the other cultivars. The seedling cultivars average (2.036 cm).

Kutchineer cultivar showed the heaviest cultivar (37.900 gm) which is very heavy compared to the others. Except Malgoba (50.767 gm) and Nailum (37.867 gm) for the grafted cultivars and Higazia (41.833 gm) for the seedling cultivars. South African cultivars showed the weight among the groups. Although these cultivars showed a heavy seed weight, the percentage of the seeds from the total fruit weight.As reported by [17], length, width, thickness and weight of the mango seeds were varying among cultivars.Reference [14]reported that the seed length is proportional to the fruit length, but the width and thickness of the seeds have no definite pattern. The weight of the seeds was found to be related to the weight of the fruit as a large fruit has heavy seed weight.

Table 7: Seed length, width, thickness and weight% of mango cultivars

Cultivar	Seed length (cm)	Seed width (cm)	Seed thickness (cm)	Seed weight (gm)
Abu samaka	12.967	4.133	1.800	22.500
Nailum	8.633	3.700	2.333	37.867
Mitlaky	8.067	3.600	1.467	18.533
Mabroka	8.433	3.567	1.967	28.200
Zibda	7.667	3.767	1.833	25.367
Alphonso	6.167	3.433	1.833	18.767
Galbeltowr	9.433	4.300	2.000	27.200
Shendi 1	6.867	3.267	1.800	20.067
Malgoba	8.400	4.433	2.433	50.767
Julik	16.433	2.767	1.767	25.833
Timor	7.567	3.500	1.900	17.833
Dibsha	10.233	3.800	2.067	31.067
Mahmoudi	11.333	3.567	1.667	23.467
Walibasha	6.533	3.500	1.700	22.100
Bet abusamaka	10.767	4.333	2.333	37.967
Segrest	15.033	4.233	2.133	26.567
Average	**9.658**	**3.743**	**1.939**	**27.131**
Elkeitt	10.733	4.800	1.500	12.867
Elkent	8.500	4.433	1.600	19.267
Tommy atkinz	7.867	4.500	1.767	21.433
Average	**9.033**	**4.578**	**1.622**	**17.856**
Kutchineer	8.567	4.333	2.200	37.900
Bet bady	11.233	6.133	2.167	33.600
Wad srear	7.867	3.867	1.900	22.067
Sinaria	9.000	3.267	1.833	23.933
Shabala	9.733	4.233	2.233	32.800
Higazia	8.033	3.967	2.433	41.833
Yageen	8.500	4.233	1.567	24.100
Taiba	7.533	4.300	1.467	14.033
Bizrtshendi	12.533	4.167	2.100	35.067
Rasmctul	9.000	4.700	2.433	34.333
Shreefia	8.967	4.533	2.067	33.733
Average	**9.179**	**4.339**	**2.036**	**30.309**
SE ±	**0.104**	**0.039**	**0.029**	**0.867**

Table 8: Seed pattern of venation and veins of mango cultivars

Cultivar	Seed pattern of venation	Seed veins
Abu samaka	Parallel	Level with surface
Nailum	Parallel	Elevated
Mitlaky	Parallel	Level with surface
Mabroka	Forked	Depressed
Zibda	Forked	Elevated
Alphonso	Forked	Depressed
Galbeltowr	Parallel	Level with surface
Shendi 1	Forked	Elevated
Malgoba	Forked	Level with surface
Julik	Parallel	Depressed
Timor	Forked	Depressed
Dibsha	Parallel	Depressed
Mahmoudi	Parallel	Elevated
Walibasha	Forked	Level with surface
Bet abusamaka	Parallel	Depressed
Segrest	Parallel	Depressed
Elkeitt	Forked	Level with surface
Elkent	Parallel	Depressed
Tommy atkinz	Parallel	Depressed
Kutchineer	Forked	Depressed
Bet bady	Forked	Elevated
Wad srear	Forked	Elevated
Sinaria	Parallel	Depressed
Shabala	Forked	Elevated
Higazia	Forked	Depressed
Yageen	Parallel	Depressed
Taiba	Forked	Level with surface
Bizrtshendi	Parallel	Elevated
Rasmctul	Forked	Elevated
Shreefia	Forked	Elevated

Table 9: Fruit, Skin, Pulp, Fiber and Seed weight%

Cultivar	Fruit weight (gm)	Skin weight %	Pulp weight %	Fiber weight %	Seed weight %
Abu samaka	528.533	14.1	81.9	17.8	4.3
Nailum	490.133	13.9	78.4	18.2	7.7
Mitlaky	278.100	16.1	77.2	29.4	6.7
Mabroka	433.600	13.7	79.8	30.6	6.5
Zibda	300.267	12	79.6	13.3	8.4
Alphonso	249.233	13.1	79.4	7	7.5
Galbeltowr	505.133	11	83.6	38.1	5.4
Shendi 1	195.733	9.8	80	26.2	10.2
Malgoba	481.100	16.4	73.1	39.8	10.5
Julik	512.4	9.6	85.3	24.5	5.1
Timor	220.833	19.7	72.2	29.2	8.1
Dibsha	603.567	15.1	79.8	17.5	5.1
Mahmoudi	390.600	11.9	82.1	42.3	6
Walibasha	187.300	14.4	73.8	32.2	11.8
Bet abusamaka	675.500	11.3	83.1	40.4	5.6
Segrest	818.167	15.9	80.9	39.3	3.2
Average	**429.387**	**13.6**	**79.4**	**27.9**	**7**
Elkeitt	474.933	16.5	80.8	57.3	2.7
Elkent	459.533	13.6	80.1	34.8	6.3
Tommy atkinz	312.233	12.5	80.6	42.9	6.9
Average	**382.233**	**14.2**	**80.5**	**45**	**5.3**
Kutchineer	317.867	13.5	74.5	26.9	12

Cultivar	Fruit weight (gm)	Skin weight %	Pulp weight %	Fiber weight %	Seed weight %
Bet bady	845.233	13.2	82.8	20.5	4
Wad srear	537.033	13.5	82.4	18.2	4.1
Sinaria	245.700	14.3	76	33.6	9.7
Shabala	648.067	13.6	81.4	40.6	5
Higazia	482.100	9.5	81.8	16.4	8.7
Yageen	385.167	13.4	80.4	14.9	6.2
Taiba	619.167	10.4	87.3	25.9	2.3
Bizrtshendi	497.200	10.6	82.4	19.3	7
Rasmctul	1154.433	10.1	87	13.4	2.9
Shreefia	747.233	13.1	82.4	27.5	4.5
Average	**589.018**	**12.3**	**81.7**	**23.4**	**6**

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