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Research Article

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Comparative study on fruit development of four cultivars of Mango (*Mangifera indica* L.) in River Nile State, Sudan

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ABSTRACT

An experiment was carried out to investigate mango (*Mangifera indica L.*) fruit development by recording the rate of increase of fruit size and fruit characteristics during the season (2017-2018) of the study. The experiment was conducted in a randomized complete design. Four cultivars (Kitchener, Alphonse, Mabroka and Naylum) were used in the investigation. From each cultivar three trees were selected. Seventy two fruits were labelled. Each one was measured every 2 weeks and for ten consecutive weeks.This was done to determine the rate of fruit development under the prevailing conditions. The results of the experiment showed that the highest values of development of mango fruits and the highest mean of fruit size occurred during the period of development of the fruits from the second week through the tenth week. The results showed that there was a significant increase in the size of the fruit during the first four weeks and a non-significant increase in the following weeks. This is in addition to the physical analysis which included dimensions and weights of fruits during the different stages of maturity. The results showed that there was superposition and difference between the four cultivars during different maturity stages. The Naylum cultivar gave the highest length or longest fruits at the full ripe stage, whereas the shortest fruit exhibited by the Alphonse cultivar at the full ripe stage. The Naylum cultivar gave the highest width at the green stage, where the shortest width was given by the Kitchener cultivar at the full ripe stage, the Naylum cultivar gave the highest weight at the full ripe stage where the shortest weight was given by the Kitchener cultivar at the green stage. The results showed that there was superposition between Kitchener and Alphonse cultivars at the semi ripe stage.

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INTRODUCTION

The mango (*Mangifira indica* L.) is a juicy stone fruit (drupe) belonging to the genus *Mangifera* and family Anacardiaceae consisting of numerous tropical fruit trees, cultivated mostly for edible fruit. The majority of these species are found in nature as wild mangoes. They all belong to the flowering plant family Anacardiaceae. The mango is native to South Asia from there it has been distributed worldwide to become one of the most cultivated fruits in the tropics (Morton, 1987; Kostermans & Bompard, 1993).

Mango is now recognized as one of the best fruits of all indigenous fruits due to its excellent flavor, attractive fragrance, and beautiful shades of color, delicious taste and high nutritive value. It is grown commercially in eighty seven countries. Several hundred varieties are grown in the Indian subcontinent, but a few specific varieties are commercialized according to the preferences of different regions of the countries. India contributes about 64% of the world mango production. Other mango producing countries are Mexico, Pakistan, Brazil, Philippines and Thailand. The total world production of Mango is 15.7 million metric tons (Shafique *et al.*, 2006).

Mango production in Sudan has been practiced for a long time. Areas under mango cultivation were increased from 27.5 thousand hectares in 2003 to 29.9 thousand hectares in 2013. Accordingly, production was increased from 602 thousand tons in 2003 to 641 thousand tons in 2013. Main production is all year around, except September-October. Season of export is from December to August. The dominant variety in Sudan is Kitchener, which is called Baladi and represents 90 percent of the total cultivated mango (http://www.2014).

Cultivation is entirely on the fertile silt loamy soils irrigated by rivers or underground water using surface irrigation. Twenty four mono-embryonic and seven poly-embryonic Indian cultivars are commonly available in Sudan. Other mango varieties were

introduced from South Africa and evaluated recently includes Tommy Atkins, Keitt, Kent and Sensation. The existing plantings of these introduced varieties have shown that these can be grown and adopted by farmers successfully and provide a starting point for expansion and export (http://www.2014).

In plants, early fruit development can be divided into three phases. The earliest phase involves the development of the ovary and the decision to abort or to proceed with further cell division and fruit development, which is generally referred to as fruit set. In the second phase, fruit growth is due primarily to cell division. The third phase begins after cell division ceases. During this phase, fruit growth continues, mostly by cell expansion, until the fruit reaches its final size. This growth phase is the most visible and physiologically most significant because of the strong sink activity exerted by the expanding cells. There are different types of fruit display variations of this general developmental program (Gillaspy *et al.*, 1993). Harvesting of mature fruits should be carefully done, especially with high tree canopy to avoid skin (peel) injuries. After picking off the fruit, harvested fruits should be kept under shade for primary sorting and before packing in carton boxes (Badreldin, 2014).

The objective of this study is to determine the optimum stage of fruit maturity and consequently the proper time to harvest the four studied cultivars.

MATERIALS AND METHODS

The experimental area was located in River Nile State (Shandi Locality), about 180 kilometers north of Khartoum. It lies between the latitudes (16-22) North and longitudes (32-35) East. The total area of this state is about 124000 sq. km.

The soil is mostly clay. The climate is mild and dry in winter and with little rain in summer, (100-150 mm) per year. The mean maximum temperature throughout the year is about 47 °C and the mean minimum temperature is about 8 °C. Mango trees under the study were planted in 1957 at 12x12 meter spacing. The study was continued for two seasons. The trees received regular irrigation throughout the experimental period. The materials used in this study were paper, meter, ruler, needle, sheets, string and Vernier caliper (thickness), balance. The data collection was done every 14 days.

The length and width of each fruit was determined by using a Vernier caliper. The diameters were measured in centimeters and weight was measured by using a balance. At the end of the study period the data collected showing the increase in the size of fruit were tabulated and graphed. Collected data were analyzed using ANOVA computer program.

RESULTS AND DISCUSSION

Development of mango fruits (*Mangifera indica* L.) was recorded for four cultivars (Kitchener, Alphonse, Mabroka and Naylum). The mean of size during the period of the fruits development from the second week to the tenth week for all fruits are shown in Table 1 and Figure 1. The data in Table 1 and Figure 1 showed that the size of the fruit of Kitchener, Alphonse, Mabroka and Naylum cultivar in the second and fourth weeks were (16.22, 21.55 cm), (15.67, 20.17 cm), (15.78, 21.71 cm) and (18.16, 23.77 cm). These results showed a significant difference between them during the development of mango fruits in those weeks. The obtained results of the same cultivars for the fourth and sixth weeks were (21.55, 23.72 cm), (20.17, 23.78 cm), (21.71, 27.89 cm) and (23.77, 30.50 cm). These results showed a significant difference between them during the development of mango fruits in those weeks. The obtained results of the same cultivars for the sixth and eighth weeks were (23.72, 24.38 cm), (23.78, 24.83 cm), (27.89, 30.02 cm) and (30.05, 32.31 cm) respectively. These results for (Kitchener and Alphonse) showed no significant difference between them during the development of mango fruits through those weeks. The obtained results of the same cultivars for eighth and tenth weeks were (24.38, 24.72 cm) and (24.83, 24.89 cm) respectively. These results showed no significant difference between them during the development of mango fruits in those weeks.

As shown in Table 1 and Figure 1, the obtained results of Mabroka and Naylum cultivars for sixth and eighth weeks were (27.89, 30.02) and (30.05, 32.31).

The results for Mabroka and Naylum show significant difference between them during the development of the fruits through these weeks. The obtained results of these cultivars for eighth and tenth weeks were (30.02, 30.50 cm) and (32.31, 32.77 cm). These results showed no significant difference between them during the development of fruits in those weeks.

The statistical comparison for development of the mango fruits from the second week through the tenth week showed that there was significant increase in size of fruit in the first weeks and non- significant increase in the following weeks. The first weeks

Table 1: Development (cm) of mango fruit of four cultivars per week

Mango cultivar	Weeks				
	2	4	6	8	10
Kitchener	16.22 ± 0.19^{g}	21.55 ± 0.25^{e}	23.72 ± 0.19^{d}	24.38 ± 0.67^{d}	24.72 ± 0.19^{d}
Alphonse	15.67 ± 0.34^{g}	20.17 ± 0.58^{e}	23.78 ± 0.79^{d}	24.83 ± 0.44^{d}	24.89 ± 0.19^{d}
Mabroka	15.78 ± 0.48^{g}	21.71 ± 0.77^{e}	27.89 ± 0.25^{c}	30.02 ± 0.91^{b}	30.50 ± 1.32^{b}
Naylum	18.16 ± 0.29^{f}	23.77 ± 0.92^{d}	30.05 ± 2.08^{b}	32.31 ± 2.01^{a}	32.77 ± 2.33^{a}
P-value			0.0**		
$Lsd_{0.05}$			1.559		

Values are mean±SD. Mean value (s) bearing different superscript (s) are significantly different ($P\leq0.05$)

are the period of cell division and hence increase in number while the later weeks were periods of increase in cell size.

This result is in agreement with Elsadig and Suleiman (2013), who showed that the size of Lime fruit increased with increasing time from the first week to the ninth week.

The size increased in the first weeks at an increasing rate, while it increased at a decreasing rate during the ninth week of growth, until it ceased. Also this result is in agreement with that of Sohad (2019) who showed that the diameter of Guava fruits significantly increased with the advancement in age.

The data in Table 2 and Figure 2 showed that physical properties of mango fruit for the four cultivars during the three different maturity stages (Length cm). The obtained results of the fruit length (cm) for each cultivars (Kitchener, Alphonse, Mabroka and Naylum) cultivars at the three maturity stages (green, semi ripe and full ripe) were (9.47, 9.46, 9.45 cm) (9.47, 9.15, 8.76 cm) (11.98, 12.56, 13.13 cm) (13.48, 13.80, 14.10 cm).These results indicated significant difference in the fruit length for all cultivars except Kitchener cultivar which showed no significant difference during the three maturity stages.

On the other hand in comparison between the four cultivars for their fruit length during the three maturity stages (green, semi ripe and full ripe). The obtained results for the four cultivars at the green stage were (9.47, 9.47, 11.98, 13.48 cm), the obtained results for the four cultivars at the semi ripe stage were (9.46, 9.15, 12.56, 13.80 cm) and the obtained results for the four cultivars at the full ripe stage were (9.45, 8.76, 13.13, 14.10 cm). These results reavled that the four cultivars showed significant differences between each other in their fruit lengths. These variations might be due to the genetic variations and to agricultural practices. These results were comparable with those of Rayan (2016) who showed that Kitchener was not different and Alphonse was different in the three maturity stages respectively. These results were in conformity with Siddig *et al.* (2016) who showed that Kitchener fruit length was significantly different in the three stages. This variation might be due to environmental condition, genetic makeup and agricultural practices.

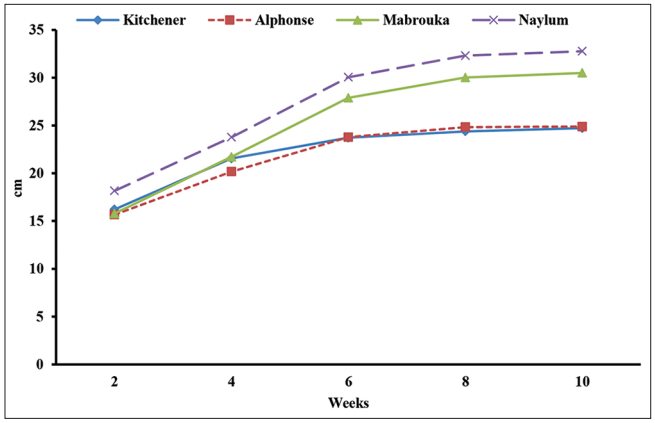

Figure 1: Development of mango fruit of four cultivars per week

The data in Table 2 and Figure 3 showed that physical properties of mango fruit for four cultivars during the three different maturity stages (width cm). The obtained width results for (Kitchener, Alphonse, Mabroka and Naylum) cultivars at the three maturity stages (green, semi ripe and full ripe) were (7.10, 7.09, 7.08 cm), (6.86, 7.02, 7.29 cm), (7.67, 8.10, 8.43 cm) and (8.69, 8.61, 8.53 cm).The results for Kitchener cultivar showed no significant difference in the three maturity stages, while Mabroka cultivar showed no significant difference in semi ripe and full ripe stages. On the other hand Alphonse and Naylum cultivars, in the three maturity stages were significantly different among them. This might be due to the genetic makeup difference between the cultivars. The widths of fruit of (Kitchener, Alphonse, Mabroka and Naylum) during the green maturity stage were (7.10, 6.86, 7.67, 8.69 cm) respectively, for the semi ripe maturity stage were (7.09, 7.02, 8.10, 8.61 cm) respectively, and for the full ripe stage were (7.08, 7.29, 8.43, 8.53 cm). These results showed no significant difference between Ketchener and Alphonse cultivars at semi ripe stages but there was significant difference in this stage between Mabroka and Naylum cultivars. There were significant differences at green and full ripe stages between the four cultivars. This might be due to the genetic variation between the cultivars and agricultural practices. These results agree with those found by Rayan (2016) who showed that Kitchener and Alphonse were not significantly different during the green stage but there were significant differences during the semi ripe and full ripe stages. These results were also comparable with those of Siddig *et al.* (2016) who showed that Kitchener was significantly different from others. This variation might be due to environmental condition, genetic makeup and agricultural practices.

Table 2: Physical characteristics of mango fruit of four cultivars during three different maturity stages

Mango cultivar	Length (cm)			Width (cm)			Weight (gm)		
	Maturity stage								
	Green	Ripe	Full ripe	Green	Ripe	Full ripe	Green	Ripe	Full ripe
Kitchener	9.47±0.95^{g}	9.46±0.77^{g}	9.45±0.71^{g}	7.10±0.58^{h}	7.09±0.55^{h}	7.08±0.59^{h}	169.70±8.91k	174.30±8.69^{j}	246.50±10.22^{g}
Alphonse	9.47±0.68^{g}	9.15±0.59^{h}	8.76±0.65^{i}	6.86±0.59^{j}	7.02±0.53^{h}	7.29±0.56^{g}	201.80±11.25^{i}	222.70±9.58^{h}	252.20±10.71^{f}
Mabroka	11.98±1.04^{f}	12.56±1.11^{e}	13.13±1.16^{d}	7.67±0.61^{f}	8.10±0.60^{d}	8.43±0.62^{d}	363.70±14.78^{e}	376.60±14.21^{d}	414.50±15.68^{c}
Naylum	13.48±1.19^{c}	13.80±1.15^{b}	14.10±1.24^{a}	8.69±0.63^{a}	8.61±0.63^{e}	8.53±0.61^{c}	414.00±15.06^{c}	517.00±16.35^{b}	572.1±18.33^{a}
P-value		0.0005**			0.0004**			0.0**	
$Lsd_{0.05}$		00754			0.0754			0.705	

Values are mean±SD. Mean value (s) bearing different superscript (s) are significantly different (P≤0.05)

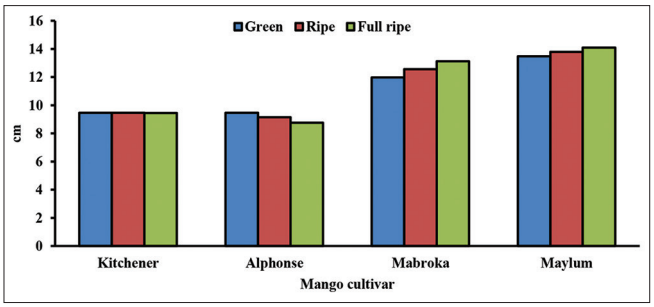

Figure 2: Length of mango fruit of four cultivars during three different maturity stages

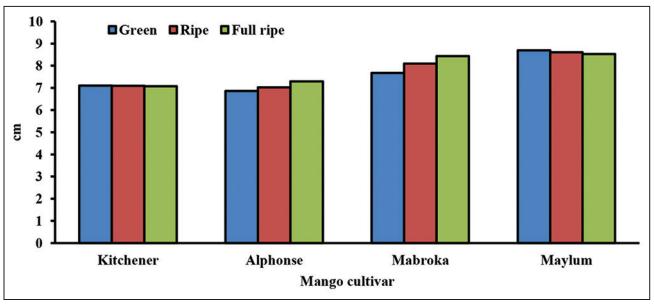

Figure 3: Width of mango fruit of fours cultivars during three different maturity stages

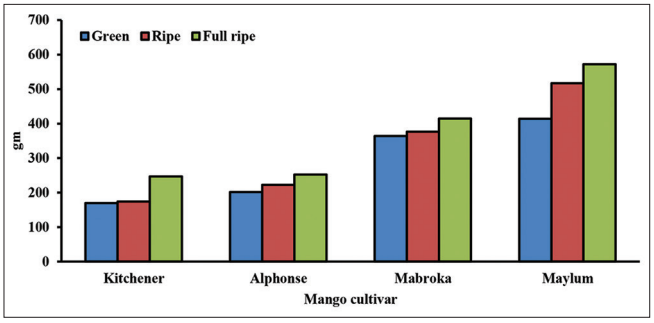

Figure 4: Weight of mango fruit of four cultivars during three different maturity stages

The data in Table 2 and Figure 4 showed that physical properties of mango fruit for four cultivars during the three different maturity stages. The whole weights (gm) of mango fruits for four cultivars during the three different maturity stages are shown. The obtained results for Kitchener cultivar for the three maturity stages (green, semi ripe and full ripe) were (169.70, 174.30, 246.50 gm) respectively. These results showed significant differences among them, also the results obtained by Alphonse, Mabroka and Naylum cultivars for the three maturity stages showed significant differences among them. These variations might be due to the genetic makeup. The obtained results for the green maturity stage for the four cultivars were (169.70, 201.80, 363.70, 414.00 gm) respectively, obtained results for the semi ripe maturity stage were (174.30, 222.70, 376.60, 517.00 gm) respectively, and for the full ripe stage were (246.50, 252.20, 414.50, 572.1 gm).These results during the different maturity stages showed significant differences between them. These variations might be due to fertilization, to the genetic makeup of cultivars or environmental conditions. On the other hand these results were comparable with those stated by Kamal (2016) for Kitchener and Alphonse, (147.40, 191.80, 174.10 gm) and (222.30, 143.90, 210.42 gm) in three maturity stages respectively. These results were highly significant different and this might be due to environmental condition, genetic makeup or agricultural practices.

CONCLUSION

Mango (*Mangiferain dica* L). is a very important fruit, especially in respect to nutrition and health and as an important export crop. The mango fruit develops and grows in size at an increasing rate during the first weeks of development. The fruit develops entirely within 16- 20 weeks. The longest fruits were of Naylum cultivar at the full ripe stage followed by Mabroka, Kitchener and Alphonse. The Naylum cultivar gave the highest width of mango fruit at the green stage followed by, Mabroka, Kitchener and Alphonse. The Naylum cultivar gave the highest weight of mango fruit at the full ripe stage followed by Mabroka, Alphonse and Kitchener. This study reveals that the appropriate harvest time is 16 weeks for Kitchener, Alphonse and Naylum while it is 20 weeks for Mabroka.

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