RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
54 (4) 864-875, 2022
http://doi.org/10.54910/sabrao2022.54.4.17
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

COMPARATIVE STUDY ON FRUIT YIELD AND QUALITY TRAITS OF THE NEW MANGO CULTIVARS GROWN UNDER EGYPT CONDITIONS

S.A. ELSHAHAWY[1*], S.A. NOMIER[1], F.S. MOHSEN[1], M.M. GAD[1], and R.A. KELANI[2]

[1]Department of Horticulture, Faculty of Agriculture, Zagazig University, Zagazig, Egypt
[2]Department of Tropical Fruits Research, Horticultural Research Center, Egypt
*Corresponding author's email: salwaelshahawy5@gmail.com
Email addresses of co-authors: safnom228@yahoo.com, faridmsamy@yahoo.com, dr.mmgad82@gmail.com, redakelani16@gmail.com

SUMMARY

Mango (*Mangifera indica* L.) is Egypt's third major fruit crop. The latest study aimed to evaluate 11 foreign mango cultivars Kent, Palmar, Yasmina Rose, Shelly, Nam Doc Mai, Osten, Glenn, Sensation, Kensington Pride, Heidi, and Joa, in two successive seasons of 2018 and 2019, under Egyptian environmental conditions. The experiment comprised a randomized complete block design (RCBD) with 11 treatments and three replications to analyze the mango cultivars for floral aspects, fruit yield, its components, and fruit quality characteristics. Results indicated that cultivars Sensation and Yasmina Rose produced the highest fruit yield per tree. Cultivars Osten, Yasmina Rose, and Kent gained the maximum fruit weight. The study noted the uppermost value of fruit retention (%) for cultivars Palmar, Osten, and Joa. As for the initial fruit set, the highest value appeared in cultivars Heidi and Yasmina Rose, while cultivars Heidi and Kensington Pride revealed the highest value of fruit pulp firmness at the early stage of ripening in July. The Shelly cultivar recorded the highest percentage of pulp per fruit, while the lowest fruit fibers and total acidity percentage came from the Glenn cultivar. The fruits of Nam Doc Mai cultivar contained the highest total soluble solids and total sugar percentages, whereas fruits of the Heidi cultivar contained the highest value of vitamin C. Cultivars noted with the alternate bearing habit consisted of Kensington Pride, Palmer, and Shelly, while all other cultivars exhibited regular bearing. Mango cultivars Glenn, Nam Doc Mai, Osten, Kensington Pride, Shelly, Joa, Yasmina Rose, Sensation, Kent, Palmer, and Heidi (first mentioned, most recommended in descending order) received high recommendations for successful cultivation under the Egyptian environmental conditions based on relatively better fruit setting and quality.

Keywords: Mango (*Mangifera indica* L.), cultivars, evaluation, flowers, fruit yield, retention, fruit quality, fruit fibers and acidity

Key findings: The 11 mango cultivars exhibited varied differences in their characteristics. Reasons for these variations can be mainly due to their varied genetic makeup, as well as, the interaction between mango genotypes and the environment.

Communicating Editor: Prof. Naqib Ullah Khan

Manuscript received: August 30 2022; Accepted: October 11, 2022.

To cite this manuscript: Elshahawy SA, Nomier SA, Mohsen FS, Gad MM, Kelani RA (2022). Comparative study on fruit yield and quality traits of the new mango cultivars grown under egypt conditions. *SABRAO J. Breed. Genet.* 54 (4) 864-875. http://doi.org/10.54910/sabrao2022.54.4.17

INTRODUCTION

Mango (*Mangifera indica* L.) stands among the most well-liked fruit crops in the world and occupies third place after citrus and grapes in Egypt (Elshiekh and Dosoukey, 2001; Alam *et al*., 2006; Haseeb *et al*., 2020). It's a supreme fruit in terms of flavor, enticing flavor with diverse colors, and a great source of nutrient content (Bekele *et al*., 2020; Zahid *et al*., 2022). According to the latest statistics from the Economic Agricultural Affairs Sector of the Ministry of Agriculture and Land Reclamation in 2020, the mango cultivated area of Egypt reached 125,460 ha, and 112,905 ha showed fruitful producing about 1,203,743 t of fruits, with an average of 1.811 t h^{-1}. Mango production concentrates in the regions of El-Sharkia, El-Giza, El-Ismailia, EL-Fayoum, and El-Behera (Nubariya) (Abourayya *et al*., 2011; Marzouk *et al*., 2017).

Mango is primarily grown between Northeast India and Myanmar (Sahu *et al*., 2016). After India, China ranks second in global mango production, while Egypt and Nigeria lead the mango-producing countries in Africa (Patil *et al*., 2018). Indian and Pakistani mango cultivars typically mature with richly colored skin; conversely, Southeast Asian cultivars typically have skin that ranges from green to yellow. However, cultivars from the two main mango groups hybridize easily, resulting in a wide range of productivity and commercial quality (Menzel and Le-Lagadec, 2017 Fitmawati *et al*., 2018, 2021; Ho and Tu, 2019). Generally, although Egypt has an excellent opportunity for mango production, the productivity of different mango cultivars associates with soil and climatic conditions (Wall-Medrano *et al*., 2020).

Previous studies showed vast differences among various mango cultivars grown for growth and fruiting behaviors under different climatic conditions (El-Khawaga and Maklad, 2013). Different cultivars' inherent variances in photosynthesis, plant hormones, fruit set, fruit retention, tree size, and leaf area could all play a vital role in the diversity of fruit yield, and a study reported on significant variations among the mango genotypes for fruit yield (Dhillon *et al*., 2004). Producers seek mango cultivars that are more productive with stable yield and good quality, simple to cultivate, and adapted to challenging climatic conditions. Meantime, customers seek the highest fruit quality with an emphasis on color and flavor, while traders and distributors require mango types with greater resistance to handling and transit (Sousa *et al*., 2012). In mango cultivars, the pulp content and other fruit quality traits depend on environmental influences and vary with the climatic conditions (Padhiar *et al*., 2011; El-Atawy *et al*., 2021, Juliantari *et al*., 2021). Prior research underlined the advantages of evaluation studies for choosing the finest mango cultivars for the different localities to achieve the highest fruit yield (Naz *et al*., 2014).

Flowering behavior, sex expression, yield, and physicochemical characteristics of mango cultivars significantly determine their performance under varied environmental conditions. An evaluation of mango cultivars took place to compare their relative performance and found that climate mostly influenced the fruit yield attributes (Kishore *et al.,* 2015)**.** Therefore, the presented study aimed to evaluate 11 foreign mango cultivars (Kent, Palmer, Yasmina Rose, Shelly, Nam Doc Mai, Osten, Glenn, Sensation, Kensington Pride, Heidi, and Joa) under the climatic conditions of Egypt.

MATERIALS AND METHODS

Plant material and procedure

The existing study used 4-5-year-old foreign mango cultivars cultivated in sandy soil, spaced at 2 m × 4 m apart under drip irrigation through two subsequent seasons in 2018 and 2019 in a private orchard at Almansoria, Giza Governorate, Egypt. The study selected 11 mango cultivars (Kent, Palmer, Yasmina Rose, Shelly, Nam Doc Mai, Osten, Glenn, Sensation, Kensington Pride, Heidi, and Joa) and used their accessions. Trees from each cultivar (accessions) underwent investigation, with each selected tree replicated three times. In addition to the recommended production practices already done in the orchard, such as pruning, hoeing, irrigation, diseases, pests, and weed management, all the mango cultivars also received a basal dose of the recommended fertilizers.

Data recorded

The recorded data on floral aspects, fruit yield, and quality traits of foreign mango cultivars appear in Figure 1. Four panicles underwent identification for each replicated tree of each mango cultivar. Recording followed for the characteristics of panicle length (cm), sex ratio, number of perfect and male flowers, and the first number of fruit sets. Table 1 displays

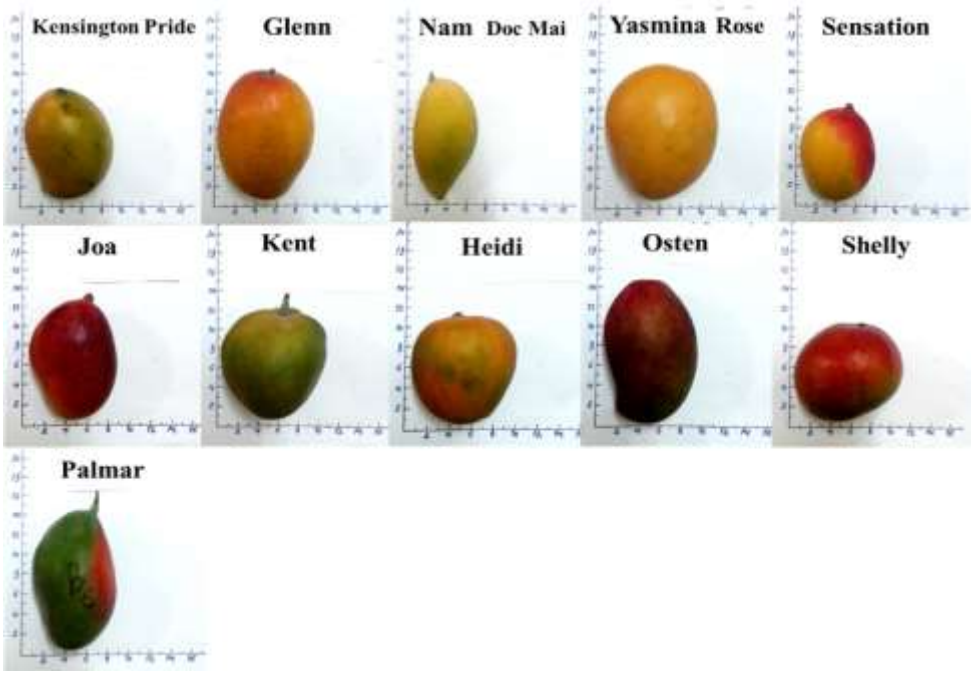

Figure 1. Fruit shapes in different mango cultivars were used in this study.

Table 1. Monthly average temperature and relative humidity (%) under Giza conditions for two seasons of 2018 and 2019

Month	Air temperature (°C)						Relative humidity (R.H. %)	
	Min.		Max.		Avg.		Avg.	
	2018	2019	2018	2019	2018	2019	2018	2019
Jan.	11.17	8.11	20.31	19.36	16.19	13.54	70.81	51.86
Feb.	11.12	8.29	24.12	22.05	17.48	15.06	58.47	54.78
March	14.11	12.34	28.34	23.74	21.20	17.64	47.29	55.18
April	16.26	14.83	28.51	27.39	22.46	21.00	45.68	46.75
May	21.50	19.75	34.55	34.89	27.65	27.30	41.99	32.12
June	22.23	23.89	35.78	36.11	28.68	29.61	39.10	40.98
July	24.85	24.79	36.74	36.66	30.25	30.33	44.73	42.30
August	25.23	24.86	35.92	36.69	30.03	30.40	48.87	43.17
Sept.	23.88	23.43	34.17	33.81	28.61	28.04	51.38	51.59
Oct.	19.79	20.64	30.63	31.18	25.03	25.81	55.02	57.10
Nov.	14.63	15.88	26.13	27.42	20.16	21.59	59.22	54.54
Dec.	11.13	11.63	21.21	21.29	15.66	16.34	66.25	66.30
Av.	18.04	17.37	29.70	29.22	23.62	23.06	52.40	49.72

Source: Central Laboratory for Agro-climatic-Agriculture Research Center

the monthly minimum and maximum temperatures and relative humidity percentages for the Giza Governorate throughout the 2018 and 2019 seasons. In both seasons, the harvested fruits in July were transported immediately to the fruit laboratory at the Department of Horticulture, College of Agriculture, Zagazig University, Egypt, to evaluate the fruit yield and quality traits as follows:

Floral aspects

The inflorescences aspects evaluation took place at full bloom in March. Length of panicle, sex ratio, perfect (hermaphrodite) flower (%), male flower (%), and initial fruit set (%) determination used the following equation:

$$\text{Initial fruit set}(\%) = \frac{\text{Number of fruit set at pea stage}}{\text{Number of perfect flowers}} x100$$

Yield and its components

Fruit yield per tree (kg), number of fruits per tree, average fruit weight (g), and fruit retention (%) recording transpired, averaging a sample of 12 fruits for each treatment/replication. The estimation of the index of alternate bearing (biennial bearing index) per individual tree proceeded according to the following equation (Singh, 1948; Wilcox, 1949):

$$\text{Alternate bearing index (Biennial bearing index)} = \frac{\text{Difference between two successive yields}}{\text{the sum of two successive yields}} x100$$

Fruit characteristics

Harvesting of fruits transpired after full maturity and the early stage of ripening (half ripe) (Yahia, 1999; Vithana *et al*., 2019). At the harvest stage in July, the selection of random samples of 20 ripe fruits from each cultivar per replication followed to determine the fruit's physical attributes and chemical constituents. The fruit size (cm^3), fruit shape index (fruit length and width), the pulp (%) per fruit, seed (%) per fruit, and fruit pulp firmness (Newton***)*** validation on five fruits per replication and measurements went on from each fruit using a push-pull dynamometer (Model FD 101) on opposite sides. The fruit fiber content establishment used the method outlined by Toliba *et al*. (2014), as follows:

$$\text{Cured fiber}(\%) = \frac{\text{Fiber weight}}{\text{Core sampel weight}} x100$$

Acquiring fiber weight, 2 g sample of dry ground or core sample weight got weighed, with 200 ml of the previously prepared sulphuric acid added to the sample content, then boiled for 30 min, and followed by adding a previously prepared 200 mM sodium hydroxide. The resulting content was placed on a recommended piece of cloth for speed and ease of the separation process using the air pump and Buechner funnel to wash the sample with a solution of a previously prepared potassium sulfate. Then, placing the sample in the recommended filter paper number, it was dried anaerobically, and subjected to dry for 3 h at 105℃. The resulting sample on the filter paper (ash + fiber) was then placed in the Chinese crucible to dry, clean, and identify its weight, and lastly placed in the combustion oven for 3 h at a temperature of 550℃–600℃ to get rid of the ash. Finally after cooling the crucible, the resulting sample was dried and weighed.

The measurement of total soluble solids (TSS; Brixº) in the mango juice used a hand refractometer (A.S.T., Japan), acquiring the maturity index (TSS/acid ratio) and total acidity (%).

The total sugar content (%) determination calorimetrically employed the phenol sulphonic acid method at 480 nm wavelength, calculating the concentration as glucose (Dubois *et al*., 1956). Measuring the vitamin C content (Ascorbic acid [mg] per 100 g pulp) used the dye 2, 6-dichlorophenolindophenol (da-Silva *et al*., 2013).

Statistical analysis

The arrangement of the treatments in a randomized complete block design took place for the 11 cultivars. Each cultivar acquired samples from three of its mango trees for three replicates. The one-way analysis of variance (ANOVA) technique, according to Snedecor and Cochran (1980), analyzed the collected data using the Statistix 9 program. Duncan's multiple range test was used to compare the individual comparisons between the obtained means, with a 0.05 level of significance (Duncan, 1955).

RESULTS

Floral aspects

Analysis of variance revealed significant differences among the mango cultivars for the traits, i.e., panicle length, sex ratio, initial fruit set (%), and the percentages of perfect and male flowers (Table 2). The panicle lengths varied from 18.53 to 36.90 cm for all cultivars in both seasons. The maximum length of the panicle showed in the mango cultivar Palmer, followed by Kent and Sensation cultivars in 2018 (first season), while in 2019 (second season), the longest panicle came out from the mango cultivar Heidi, followed by Glenn, Kent, and Nam Doc Mai. However, the shortest panicle recording resulted for Kensington Pride and Nam Doc Mai in 2018, while cultivars Kensington Pride, Sensation, and Shelly, displayed the shortest panicles in 2019. All other mango cultivars exhibited moderate values for panicle length during both seasons.

Table 2. Floral aspects of some mango cultivars grown under Egypt conditions during the 2018 and 2019 seasons.

Cultivars	Panicle length (cm)	Sex ratio	Initial fruit set (%)	Male flower (%)	Perfect flower (%)
First season – 2018					
Kent	34.87^{ab}	2.10^{e}	0.765^{bc}	67.67^{d}	32.33^{a}
Palmer	36.90^{a}	6.23^{bcd}	1.60^{bc}	85.33^{bc}	14.67^{bc}
Yasmina Rose	21.10^{ef}	7.83^{abc}	2.10^{abc}	88.33^{ab}	11.67^{cd}
Shelly	21.33^{def}	9.50^{a}	2.52^{ab}	90.33^{a}	9.67^{d}
Nam Doc Mai	19.77^{f}	4.73^{d}	1.85^{abc}	82.67^{c}	17.33^{b}
Osten	29.87^{bc}	4.80^{d}	1.09^{bc}	82.67^{c}	17.33^{b}
Glenn	30.90^{bc}	5^{d}	0.203^{C}	83.33^{c}	16.67^{b}
Sensation	34.13^{ab}	5.67^{cd}	0.790^{bc}	85^{bc}	15^{bc}
Kensington Pride	18.53^{f}	5.13^{d}	0.638^{bc}	83.67^{c}	16.33^{b}
Heidi	26.70^{cd}	9.23^{a}	3.84^{a}	89.67^{a}	10.33^{d}
Joa	25.77^{cde}	8.57^{ab}	2.01^{abc}	89.67^{a}	10.33^{d}
Second season – 2019					
Kent	30.43^{ab}	3.87^{a}	2.07^{b}	79^{a}	20.67^{b}
Palmer	27.10^{bc}	3.23^{ab}	2.30^{b}	76^{ab}	24^{ab}
Yasmina Rose	23^{cd}	3.30^{ab}	3.40^{a}	76.33^{ab}	23.33^{ab}
Shelly	22^{d}	3.43^{ab}	1.44^{bcd}	77^{ab}	23^{ab}
Nam Doc Mai	29.57^{ab}	3.27^{ab}	1.84^{bc}	76.33^{ab}	23.67^{ab}
Osten	23.67^{cd}	3.40^{ab}	0.944^{cde}	77.33^{ab}	22.67^{ab}
Glenn	31.23^{ab}	2.93^{b}	0.408^{e}	74.67^{b}	25.33^{a}
Sensation	22.23^{d}	3.70^{a}	1.81^{bc}	78.67^{a}	21.33^{b}
Kensington Pride	21.57^{d}	3.73^{a}	0.993^{cde}	79^{a}	21^{b}
Heidi	33.47^{a}	3.70^{a}	1.46^{bcd}	78.67^{a}	21^{b}
Joa	28.63^{b}	2.97^{b}	0.846^{de}	75^{b}	25^{a}

Means with the same letter within the same column are not significantly different at P <0.05.

The sex ratio in all the mango cultivars varied from 2.10 to 9.50 in both seasons (Table 2). The Shelly and Heidi cultivars gave the highest sex ratio in the first season, followed by Joa and Yasmina Rose cultivars. In the second season, the mango cultivars Kent, Kensington Pride, Sensation, and Heidi recorded the highest sex ratio, followed by Shelly, Osten, Yasmina Rose, Nam Doc Mai, and Palmer cultivars. The least values of sex ratio resulted from the Kent cultivar in the first season and Glenn in the second season. All other cultivars exhibited medium values for the sex ratio during both seasons.

The cultivars Heidi, Shelly, Yasmina Rose, Joa, and Nam Doc Mai, possessed, at par, the initial fruit set percentage in the 2018 season (Table 2). However, the cultivar Glenn recorded the lowest percentage of initial fruit set during both seasons. In the second season, the Yasmina Rose cultivar contributed the highest value of the initial fruit set (%), followed by five other mango cultivars, i.e., Palmer, Kent, Nam Doc Mai, Heidi, and Shelly, in descending order. All other cultivars showed moderate values for the initial fruit set percentage in the second season.

Among all the mango cultivars, the male flower percentage varied from 67.67% to 90.33% in 2018 and 2019 (Table 2). Concerning the first season, the highest male flower percentage showed in the cultivars Shelly, Heidi, Joa, and Yasmina Rose, while the lowest male flower (%) was with the Kent cultivar. In the second season, cultivars Kent, Kensington Pride, Sensation, and Heidi gave the maximum values of male flower percentage. The cultivars Glenn and Joa provided the lowest male flower percentage in the second season, while other cultivars in the second season revealed moderate and same values for male flower percentage.

The perfect flower percentage varied from 9.67% to 32.33%, for all the mango cultivars, for both seasons (Table 2). The maximum values for perfect flower percentage resulted from the Kent cultivar in the first season and the Glenn cultivar in the second. The lowest values of perfect flower percentage came from the Shelly, Heidi, and Joa cultivars in the first season, while the Kent, Sensation, Kensington Pride, and Heidi cultivars showed the least values for perfect flower (%) in the second season. All other mango cultivars produced medium and the same percentage of perfect flowers in both seasons.

Yield and its components

Based on the analysis of variance, the 11 foreign mango cultivars showed significant differences in total fruit yield per tree, the number of fruits per tree, and fruit weight (Table 3). Among all the mango cultivars, the total fruit yield per tree varied between 4.07 to 22.33 kg. Cultivars Sensation, Yasmina Rose, and Joa showed maximum fruit yield per tree in the 2018 and 2019 seasons. However, the minimum values of total fruit yield per tree came from the cultivars Kensington Pride, Nam Doc Mai, and Glenn in the first and second seasons, respectively, as well as cultivars Palmer and Shelly in the first season only. The other mango cultivars showed medium values for total fruit yield per tree in both seasons.

The fruit weight in all the mango cultivars under study ranged from 214.17 to 461.80 g (Table 3). The heaviest mango fruits stood out from cultivars Osten, Yasmina Rose, and Kent in the first season, in contrast in the second season. The most significant fruit weight came from Yasmina Rose, Kensington Pride, and Shelly cultivars, followed by the Kent cultivar. The cultivars Nam Doc Mai and Sensation gave the minimum fruit weight of mango fruits, followed by Heidi and Joa cultivars for both seasons. All other cultivars had medium values for fruit weight in both seasons. The number of mango fruits per tree ranged from 13.67 to 101.33 (Table 3). Cultivar Sensation showed the highest number of fruits per tree in both seasons, whereas cultivar Kensington Pride displayed the least number of fruits per tree in both seasons. Other mango cultivars revealed medium values for the said trait.

Results illustrated significant variations for alternate bearing index and fruit retention in the mango cultivars for both seasons (Table 3). The alternate bearing index ranged between 2.88% and 44.33% in this study. The highest index percentage was observed in the cultivars Kensington Pride, Palmer, and Shelly, whereas other mango cultivars had low values. The three cultivars, i.e., Kensington Pride, Palmer, and Shelly, demonstrated an alternate bearing habit, while the other eight cultivars exhibited regular bearing. The fruit retention varied from 10.52% to 32.07% among the mango cultivars across both seasons (Table 3). However, higher fruit retention came from cultivars Palmer and Joa in the first and second seasons, respectively. The lowest fruit retention was observed in the Kensington Pride cultivar in the first season and the Nam Doc Mai cultivar in the second.

Table 3. Alternate bearing index, fruit retention percentage, fruit yield and its components of some mango cultivars grown under Egypt conditions during the 2018 and 2019 seasons.

Cultivars	Fruit weight (g)	Fruits tree^{-1}	Yield tree^{-1} (kg)	Fruit retention (%)	Alternate bearing index
First season – 2018					
Kent	426.43^{ab}	30^{cde}	12.63^{bcd}	21.67^{ab}	
Palmer	272.23^{de}	30.33^{cde}	8.30^{de}	31.37^{a}	
Yasmina Rose	454.43^{a}	37.33^{cd}	16.97^{ab}	16.11^{ab}	
Shelly	317.87^{cd}	28^{cde}	8.83^{cde}	19.20 ^{ab}	
Nam Doc Mai	220.60^{e}	27.67^{cde}	6.13^{e}	27.46^{ab}	
Osten	461.80^{a}	30^{cde}	13.90^{bc}	27.90^{ab}	
Glenn	377.47^{bc}	24.33^{de}	8.77^{cde}	15.47^{ab}	
Sensation	220.53^{e}	101.33^{a}	22.33^{a}	25.30^{ab}	
Kensington Pride	294.07^{d}	13.67^{e}	4.07^{e}	10.52b	
Heidi	302.67^{d}	46.67^{bc}	14.17^{bc}	11.56b	
Joa	288.97^{d}	59^{b}	17.13^{ab}	15.77^{ab}	
Second season - 2019					
Kent	338.37^{bc}	41^{cd}	13.87^{bcd}	20.31^{bc}	4.95^{e}
Palmer	325.23^{c}	50^{c}	16.17^{bc}	18.71^{bc}	31.87^{ab}
Yasmina Rose	446.90^{a}	50.33^{c}	22.27^{a}	17.54^{bc}	14.27^{bc}
Shelly	395.93^{ab}	40^{cd}	15.80^{bc}	17.80^{bc}	28.90^{ab}
Nam Doc Mai	214.17^{e}	37.67^{cd}	8.07^{e}	13.36c	13.50^{bc}
Osten	304.30^{cd}	38.67^{cd}	11.73^{cde}	21.17^{bc}	14.03^{bc}
Glenn	277.53^{cde}	36de	9.93^{de}	21.97^{abc}	9.33^{c}
Sensation	247.03^{de}	89.33^{a}	22.23^{a}	17.30^{bc}	9.40^{c}
Kensington Pride	431.63^{a}	24^{e}	10.37^{de}	18.77^{bc}	44.33^{a}
Heidi	238.83^{e}	64.67^{b}	15.37^{bc}	24.17^{ab}	15.03^{bc}
Joa	230.67^{e}	72^{b}	16.77^{ab}	32.07^{a}	2.88^{e}

Means with the same letter within the same column are not significantly different at P <0.05.

Fruit characteristics

Fruit physical attributes

For the fruit size (cm^3), fruit shape index, and fruit pulp firmness (g/cm^2), the mango cultivars revealed significant differences (Table 4). The Kent, Yasmina Rose, and Osten cultivars had the maximum fruit size, followed by the Glenn, Shelly, Heidi, and Kensington cultivars, with the same values in the first season. In the second season, the Yasmina Rose and Kensington Pride cultivars showed the largest fruit size, followed by the Shelly, Kent, Palmer, and Osten cultivars. Cultivar Nam Doc Mai had the lowest values for fruit size in both seasons, respectively, followed by the Sensation and Palmer cultivars in the first season, and the Joa, Heidi, and Sensation cultivars in the second season, with the same values, in terms of fruit weight and volume.

The Nam Doc Mai cultivar displayed the highest value of fruit shape index recorded in both seasons, followed by the Osten, Palmer, and Joa in the 2018 and 2019 seasons (Table 4). The lowest fruit shape index observation showed in the Shelly cultivar. However, all other mango cultivars exhibited medium values for fruit shape index. The mango fruits' mechanical features, such as, firmness, are also crucial for fruit handling, transportation, storage, and customer acceptability, in anticipation of the likelihood of bruising and mechanical damage.

The recorded maximum fruit pulp firmness resulted from the Sensation and Heidi (6.19 and 6.66 Newton) in the first season, followed by four other mango cultivars, viz., Joa, Palmer, Yasmina Rose, and Osten. However, cultivars Kensington Pride, Palmer, and Kent showed the maximum fruit pulp firmness in the second season, followed by cultivars Osten, Shelly, Glenn, and Yasmina Rose. Cultivar Nam Doc Mai had the lowest fruit pulp firmness in both seasons. All other cultivars had moderate values of fruit pulp firmness for both seasons.

In the first season, all the mango cultivars exhibited no significant differences in pulp percentage per fruit (Table 4). But in the second season, cultivars Osten, Shelly, Yasmina Rose, Kensington Pride, Glenn, Kent, and Joa showed the highest pulp percentages per fruit. The least and at par pulp percentage per fruit was achieved by cultivars Sensation and Heidi in 2018, while cultivars Palmer and Nam Doc Mai in 2019. A careful investigation of the data showed significant variations among the mango cultivars for seed (%) and fibers (%) per fruit across both seasons (Table 4).

Table 4. Fruit physical attributes of some mango cultivars grown under Egypt conditions during the 2018 and 2019 seasons.

Cultivars	Fruit size (cm^3)	Fruit shape index	Fruit pulp firmness (Newton)	Pulp $fruit^{-1}$ (%)	Seed $fruit^{-1}$ (%)	Fibers (%)
First season – 2018						
Kent	422.23^{ab}	1.22^{c}	2.81^{bc}	85.17^{a}	12.90^{ab}	22.15^{a}
Palmer	278.33^{def}	1.63^{b}	3.58^{b}	72.93^{a}	12.13^{ab}	9.81^{g}
Yasmina Rose	457.20^{a}	1.25^{c}	2.96^{bc}	75.23^{a}	11.97^{ab}	12.20^{d}
Shelly	332.23^{cd}	0.78^{d}	1.89^{bc}	85.10^{a}	11.03^{bcd}	8.85^{h}
Nam Doc Mai	225^{f}	2.10^{a}	1.33^{C}	72.17^{a}	11.60^{abc}	18.52^{b}
Osten	469.43^{a}	1.64^{b}	3.01^{bc}	81.27^{a}	7.87^{d}	9.84^{g}
Glenn	391.67^{bc}	1.39^{c}	1.03^{C}	78.47^{a}	8.43^{cd}	8.17^{i}
Sensation	232.77^{ef}	1.37^{c}	6.19^{a}	72.40^{a}	13.87^{ab}	13.86^{c}
Kensington Pride	303.33^{d}	1.33^{c}	1.91^{bc}	77.07^{a}	14.57^{a}	11.63^{e}
Heidi	313.33^{d}	1.16^{c}	6.66^{a}	78.70^{a}	8.17^{d}	12.12^{d}
Joa	292.23^{de}	1.77^{b}	3.92^{b}	70.40^{a}	10.87^{bcd}	11.16^{f}
Second season – 2019						
Kent	374.43^{bc}	1.22^{de}	14.67^{a}	63.53^{abcd}	9^{bc}	23.19^{a}
Palmer	351.10^{bcd}	1.56^{b}	15.48^{a}	53.13^{cd}	9.07^{bc}	10.32^{f}
Yasmina Rose	483.23^{a}	1.20^{e}	8.45^{c}	69.77^{ab}	12.27^{a}	12.19^{d}
Shelly	386.20^{b}	0.813^{f}	11.55^{b}	70.60^{a}	7.13^{cd}	9.41^{g}
Nam Doc Mai	229.33^{f}	1.99^{a}	1.60^{e}	54.60^{bcd}	7.43^{cd}	18.89^{b}
Osten	335.23^{bcde}	1.62^{b}	11.98^{b}	74.50^{a}	7.67^{cd}	9.77^{fg}
Glenn	300.13^{cdef}	1.35^{cd}	10.38^{bc}	68.07^{abc}	9.50abc	8.03^{h}
Sensation	281.47^{def}	1.35^{cd}	6.11^{d}	49.07^{d}	9.33^{bc}	13.97^{c}
Kensington Pride	469.10^{a}	1.32^{cde}	15.62^{a}	69.07^{ab}	8.43^{bcd}	11.16^{e}
Heidi	261.33^{ef}	1.21^{de}	5.92^{d}	51.83^{d}	6^{d}	12.22^{d}
Joa	232.13^{f}	1.36^{c}	4.59^{d}	61.50^{abcd}	10.93^{ab}	12.17^{d}

Means with the same letter within the same column are not significantly different at P <0.05.

The highest and same seed (%) per fruit recorded came from cultivar Kensington Pride, Sensation, Kent, Palmer, and Yasmina Rose in the first season, followed by cultivars Shelly, Nam Doc Mai, Glenn, and Joa. As for the second season, the highest values for seed (%) per fruit resulted from Yasmina Rose, Joa, and Glenn, followed by four other cultivars, i.e., Kent, Palmer, Sensation, and Kensington Pride. In contrast, mango cultivars Osten and Heidi had the lowest seed (%) values per fruit in both seasons. Cultivars Shelly and Nam Doc Mai in 2018, and cultivars Kent, Palmer, Sensation, and Kensington Pride in 2019, produced medium values for seed (%) per fruit.

The various mango cultivars recorded significant differences in fruit fiber percentage in both seasons (Table 4). The maximum fiber percentage in fruit showed for cultivar Kent, followed by four others—Nam Doc Mai, Sensation, Shelly, and Heidi—in both seasons. Notably, the lowest fruit fiber percentage surfaced with the cultivar Glenn in the 2018 and 2019 seasons. All other cultivars had medium values for fruit fiber percentage.

Fruit chemical constituents

Results revealed that mango cultivars owned significant differences for TSS (Brix^0), total acidity %, TSS/acid ratio, total sugars %, and vitamin C content (mg ascorbic/100 mg). In mango cultivars, the total soluble solids varied from 13.27 to 20.90 Brix^0 (Table 5). The recorded highest value of total soluble solids came from cultivar Nam Doc Mai in both seasons, followed by cultivars Yasmina Rose, Sensation, Kensington Pride, Glenn, and Heidi in both seasons. Cultivars Palmer, Shelly, Osten, and Joa provided lower TSS than other tested cultivars in both seasons. The mango cultivar Kent had a value between 16.60 and 15.67 Brix in both seasons.

Total acidity ranged from 0.193% to 0.660% among all the mango cultivars (Table 5). The maximum total acidity showed in cultivars Heidi, Kent, and Palmer during the first season. Cultivars Joa, Heidi, Kent, and Palmer gave the highest percent of acidity in the second season. Inversely, the mango cultivar Glenn produced the minimum acidity in both seasons. All other cultivars had moderate values for total acidity. In mango cultivars

Table 5. Fruit chemical constituents at ripe stage of some mango cultivars grown under Egypt conditions during the 2018 and 2019 seasons.

Cultivars	TSS (Brix^0)	Total acidity (%)	TSS/acid ratio	Total sugars (%)	Vitamin C (mg 100 g^{-1})
First season – 2018					
Kent	16.60^{bc}	0.467^{b}	37.83^{cd}	15.24^{g}	16.5^{bc}
Palmer	13.27^{c}	0.383^{bc}	34.87^{cd}	14.66^{h}	28.6^{bc}
Yasmina Rose	18.20^{ab}	0.363^{bcd}	51.13^{bcd}	18.44^{ab}	12.1^{c}
Shelly	13.93^{c}	0.253^{cd}	61.03^{abc}	16.40^{f}	11^{c}
Nam Doc Mai	21.53^{a}	0.237^{cd}	93.77^{a}	19.98^{a}	24.2^{bc}
Osten	13.67^{c}	0.233^{cd}	63.10^{abc}	17.15^{e}	20.9^{bc}
Glenn	16.33^{bc}	0.193^{d}	91.20^{a}	14.04^{i}	12.1^{c}
Sensation	17.87^{b}	0.300^{bcd}	59.57^{abc}	19.77^{ab}	30.8^{b}
Kensington Pride	17.90^{b}	0.297^{bcd}	67^{abc}	19.37^{c}	20.9^{bc}
Heidi	16.27^{bc}	0.660^{a}	26.47^{d}	19.59^{ab}	66^{a}
Joa	13.33^{c}	0.237^{cd}	56.24^{bcd}	14.70^{h}	17.6^{bc}
Second season – 2019					
Kent	15.67^{cd}	0.447^{ab}	35.53^{e}	16.60^{de}	25.1^{bc}
Palmer	13.40^{e}	0.427^{ab}	31.38^{e}	15.87^{e}	23.2^{bcde}
Yasmina Rose	17.80^{b}	0.403^{bc}	44.70^{cde}	20.24^{a}	15.5^{ef}
Shelly	14.67^{de}	0.320^{bcd}	46.83^{cde}	17.57^{cd}	13.5^{f}
Nam Doc Mai	20.90^{a}	0.300^{bcd}	70.23^{ab}	20.29a	24.2^{bcd}
Osten	14.60^{de}	0.257^{cd}	58.90^{abc}	18.89^{bc}	16.4^{def}
Glenn	17.13^{bc}	0.237^{d}	73.93^{a}	15.57^{ef}	13.5^{f}
Sensation	16.87^{bc}	0.407^{bc}	42.43^{cde}	20.89^{a}	29^{b}
Kensington Pride	16.07^{bcd}	0.257^{cd}	62.53^{bcd}	19.74^{ab}	19.3^{cdef}
Heidi	16.70^{bc}	0.447^{ab}	38.43^{de}	20.06^{ab}	59.9^{a}
Joa	15.20^{cde}	0.577^{a}	29.70^{e}	14.46^{f}	22.2^{bcde}

Means with the same letter within the same column are not significantly different at P <0.05.

under investigation, the TSS/acid ratio ranged from 26.47 to 93.77 (Table 5). Cultivar Nam Doc Mai, Glenn, and Osten displayed the uppermost values of TSS/acid ratio in both seasons, respectively, as well as, cultivars Shelly, Sensation, and Kensington Pride in the first season only. The lowest TSS/acid ratio values were recorded in the cultivars Kent, Palmer, and Heidi in both seasons, and cultivar Joa in the second season only.

Total sugars varied from 14.04% to 20.89% among all studied mango cultivars (Table 5). The cultivars Nam Doc Mai, Sensation, Heidi, and Yasmina Rose provided the highest percentage of total sugars in both seasons, and cultivar Kensington Pride in 2019 only. As for the lowest percentages of total sugars, the Glenn and Joa cultivars revealed this in both seasons. Other mango cultivars had medium values for total sugar percentage (Table 5). Among the mango cultivars, the vitamin C content varied from 11 to 66 mg ascorbic/100 mg (Table 5). Cultivar Heidi had the maximum values of vitamin C in both seasons. However, the least values of vitamin C came from the cultivars Yasmina Rose, Glenn, and Shelly in both seasons. Other cultivars revealed moderate values for vitamin C.

DISCUSSION

Mango cultivars have varied values of floral aspects, fruit yield, and fruit characteristics, which allow cultivation of these cultivars under Egypt conditions. The floral sex ratio varies among mango cultivars as influenced by the surrounding environment. Mango is a highly cross-pollinated crop typically pollinated by insects (Reddy, 2021). More than half of the mango blossoms do not get any pollen, and only three pollen grains per bloom get pollinated in nature (Alcaraz and Hormaza, 2021). The initial fruit set is closely associated with the percentage of mango-perfect flowers, though the eventual fruit set is independent of it (Rangare *et al*., 2022). The flowering and fruiting behavior varied among the cultivars (El-Khawaga and Maklad, 2013; Dangi *et al*., 2017; Ddamulira *et al*., 2019; Saheda *et al*., 2019). If the index of alternate bearing is less than 25%, the tree is in standard bearing, whereas the tree is in alternate bearing if the index is more than 25% (Noperi-Mosqueda *et al*., 2020).

The conservation of nitrogen supplies, made available by potassium nitrate spraying, lessens alternate bearing (Yeshitela *et al*., 2004). Therefore, the use of potassium nitrate sprays to induce flowering requires validation to lessen the effects of alternate bearing among mango genotypes grown in Uganda. Regarding fruit weight, the number of fruits per tree, and total yield per tree, the differences among cultivars might be due to genetic variability, intrinsic traits, climatic adaptability, and management approach in cultivated areas, which can be applied to growing mango cultivars suitable in each region. This could also serve as a crucial diagnostic trait for selecting mango cultivars for the local environment. The 11 mango cultivars' varied reactions to various biotic and abiotic challenges, farming techniques, genetic and growth factors, blooming, and fruit set could be all the factors in the latest findings. Sarkar *et al*. (2001) and Uddin *et al*. (2006) reported that different mango cultivars varied in fruit weight, which might be due to genetic and physiological factors.

Mango fruit with a pleasing appearance has the highest phenotypic acceptability among customers. The number of fruits per tree is more important than fruit weight to promote production and yield in the cultivars under subtropical conditions (Souza *et al*., 2018). Mango genotypes' mean yield was adversely affected by alternate bearing, and this can be alleviated by artificial flower induction. Cultivars and seasons substantially impacted mango fruit set, fruit drop, and fruit yield. Fruit set, fruit drop, and yield revealed in cultivars Glenn (78.0%, 22.0 %, and 49.6 kg/tree), Kent (77.5%, 22.5%, and 36.5 kg/tree), Heidi (43.8%, 56.2%, and 35.7 kg/tree) and Kensington Pride (54.2%, 34.7%, and 3.5 kg/tree), respectively (Ddamulira *et al*., 2019).

Mango cultivars with inherent differences in photosynthesis, plant hormones, fruit set, fruit retention, tree size, and leaf area could play an important role in the diversity of the fruit yield among them, and reports on significant variations in fruit yield exist (Hoda *et al*., 2003; Dhillon *et al*., 2004). The study results showed agreement with the past findings as they mentioned significantly varied values for yield and physicochemical fruit parameters among the mango cultivars (Y Mohamed *et al*., 2016; Indian *et al*., 2018; Gautam *et al*., 2019). Based on genetic makeup, various researchers have observed that mango cultivars significantly differed in fruit length and width and fruit form index (Jilani *et al*., 2010). In mango cultivars, the pulp content also varies with the climatic conditions (Anila and Radha, 2006; Padhiar *et al*., 2011). Cultivars may differ in terms of fruit

weight and volume due to genetic variability, innate traits, environmental adaptability, and management approach in each region.

In cultivar Palmer, the fruits looked attractive, in terms of harvesting and shipping, showed the best firm values, and displayed improved physical and chemical qualities (Modesto *et al*., 2016). Mango cultivars Keitt and Kent showed the highest values of pulp weight and total sugar percentages, while cultivar Kent had the lowest crude fiber percentage compared with other genotypes investigated for physicochemical qualities in Spain's subtropical Mediterranean region (Rodríguez Pleguezuelo *et al.*, 2012). Mango cultivars Sensation and Kensington exhibited the lowest pulp:seed ratios, while the Gleen, Palmer, and Osteen cultivars had the fruits with the maximum flesh content. In cultivar Osteen, the fruits demonstrated that the pulp and seeds have the best compatibility. The TSS:TA ratios for cultivars Kent and Palmer displayed the greatest, which may be a sign of the impact on their flavor. Cultivars Osteen and Tommy Atkins had the standard parameters for high-quality fruits and can be recommended for their performance and sustainable yield in such types of environments (Pleguezuelo *et al*., 2012).

The Sensation mango cultivars recorded the lowest values of fruit length, width, total fruit weight, pulp weight, and pulp percentage (Hussein and Ali, 2019). The highest average of the total reducing and non-reducing sugars was reported in the fruit of mango cultivar Glenn, while mango cultivar Kent showed a fruit length of 13.2 cm, a fruit width of 10.3 cm, with green fruit color (Igbari *et al*., 2019). The variation among the cultivars revealed in fruit size, fruit shape index, fruit pulp firmness, pulp and seeds (%), and fibers (%) per fruit might be due to the differences in the mango genotypes and agro-climatic conditions and the inherent variation in the absorption and translocation of photosynthates and plant hormones. The alteration in cell wall structure during ripening and the degradation of complex carbohydrates into more minor compounds by hydrolytic enzyme activity might be due to differences in TSS among the mango cultivars (Kittur *et al*., 2001).

Nigam *et al*. (2007) mentioned that ripe mango fruit contained fibers (0.7 g/100g), carbohydrates (16.9 g/100 g), and vitamin C (16 mg/100 g), while unripe mango fruit contained about fiber (0.7 g/100g), carbohydrates (10.1 g/100 g) and vitamin C (3 mg/100 g). Shaikh *et al*. (2021) reported that in mango genotypes, the fruit chemical constituents were, i.e., carbohydrate content (8.54%), crude fiber (0.8%), ascorbic acid (27.63mg/100g), TSS (18.13 ◦Bx), pH (4.6), and titratable acidity (0.7%). The differences in total sugars in mango cultivars might be due to genetic variability, inherent characteristics, and climatic adaptability in a particular region. Thus, it suggests that different mango cultivars can provide a higher amount of vitamin C and essential minerals (calcium, potassium, magnesium, and sodium), which will be a sustainable health benefit. The greater and lower TSS, acidity, and ascorbic acid values indicate inheritance, which is very useful in identifying the appropriate elite types of mango according to the requirements. This could serve as a crucial diagnostic trait for selecting mango cultivars for the local conditions.

CONCLUSIONS

Results revealed that 11 mango cultivars showed wide differences in their growth, flowering, fruit setting aspects, and fruit yield and quality. These phenotypic variations could be mainly due to the differences in their genetic makeup, as well as, a cultivar-by-environment interaction. Mango cultivars Glenn, Nam Doc Mai, Osten, Kensington Pride, Shelly, Joa, Yasmina Rose, Sensation, Kent, Palmer, and Heidi, come highly suggested for successful cultivation, under Egyptian conditions based on relatively better fruit quality, in descending order. Likewise, the mango cultivars Sensation, Yasmina Rose, Joa, Heidi, Kent, Osten, Shelly, Palmer, Glenn, Kensington Pride, and Nam Doc Mai, come highly recommended for excellent cultivation under Egyptian conditions based on relatively better fruit yield, in descending order.

REFERENCES

Abourayya M, Kassim N, El-Sheikh M, Rakha A (2011). Fruit physical and chemical characteristics at maturity stage of Tommy Atkins, Keitt and Kent mango cultivars grown under Nubariya conditions. *The Am. J. Sci.* 7: 228-233.

Alam M, Islam M, Uddin M, Barman J, Quamruzzaman A (2006). Effect of age of seedling and variety of scion in stone grafting of mango. *Sustain. Crop Prod.* 1: 27-32.

Alcaraz ML, Hormaza JI (2021). Fruit set in avocado: Pollen limitation, pollen load size, and selective fruit abortion. *J. Agron.* 11: 1603.

Anila R, Radha T (2006). Physico-chemical analysis of mango varieties under Kerala conditions. *J. Trop. Agric.* 41: 20-22.

Bekele M, Satheesh N, Sadik J (2020). Screening of Ethiopian mango cultivars for suitability for preparing jam and determination of pectin, sugar, and acid effects on physico-chemical and sensory properties of mango jam. *African J. Sci.* 7: e00277.

Dangi KK, Singh A, Varan R, Jain VK (2017). Characterization of different mango cultivars for fruit set and yield. *Indian J. Ecol.* 44: 751-754.

Da-Silva DI, Nogueira GD, Duzzioni AG, Barrozo MA (2013). Changes of antioxidant constituents in pineapple (*Ananas comosus*) residue during drying process. *Ind Crops Prod* 50: 557-562.

Ddamulira G, Ramathani I, Sebikejje T, Naluyimba R, Otim A, Pariyo A, Maphosa M (2019). Mango yield performance in Lake Victoria Cresent Region of Uganda. *Am. J. Plant Sci.* 10: 1141.

Dhillon W, Sharma R, Kahlon G (2004). Evaluation of some mango varieties under Punjab conditions. *J. Hortic. Sci.* 33: 157-159.

Dubois M, Gilles KA, Hamilton JK, Rebers Pt, Smith F (1956). Colorimetric method for determination of sugars and related substances. *J. Anal. Chem.* 28: 350-356.

Duncan DB (1955). Multiple range and multiple F tests. *Biometrics* 11: 1-42.

El-Atawy AA, Rizk MS, El-Demerdash ES, Ahmed MZS (2021). Expression of some salt tolerance genes isolated from Egyptian gray mangrove (*Avicennia marina*). *SABRAO J. Breed. Genet.* 53(4): 685-696. https://doi.org/10.54910/sabrao2021.53.4.11.

El-Khawaga A, Maklad M (2013). Evaluation of growth and productivity of some mango varieties grown under Aswan climatic conditions. *J. Appl. Sc* 2: 169-178.

Elshiekh A, Dosoukey I (2001). Evaluation of some Egyptian mango cultivars for exporting potential. *HortScience* 36: 528. (Abst.).

Fitmawati, Hayati I, Mahatma R, Suzanti F (2018). Phylogenetic study of Mangifera from Sumatra, Indonesia using nuclear and chloroplast DNA sequences. *SABRAO J. Breed. Genet*. 50(3): 295-312.

Fitmawati, Khairunnisa, Resida E, Kholifah SN, Roza RM, Emriza L (2021). Chemotaxonomic study of Sumatran wild mangoes (Mangifera spp.) based on liquid chromatography mass-spectrometry (LC-MS). *SABRAO J. Breed. Genet.* 53(1): 27-43.

Gautam DK, Kumar A, Kumar M, Kumar V, Prakash S (2019). Studies on flowering behaviour and bio-chemical attributes of commercial mango cultivars with special reference to Ratol. *Pharmacogn. J.* 8: 1105-1111.

Haseeb GM, Ghounim IE-S, Hmmam I, Mustafa MR (2020). Evaluation of four newly introduced mango (*Mangifera indica* L.) cultivars grown under EL-Giza conditions. *Plant Arch.* 20: 9405-9410.

Ho VT, Tu NT (2019). Genetic characterization of mango accessions through RAPD and ISSR markers in Vietnam. *SABRAO J. Breed. Genet*. 51(3): 252-265.

Hoda M, Singh S, Singh J (2003). Evaluation of ecological groups of mango (*Magnifera indica*) cultivars for flowering and fruiting under Bihar conditions. *Indian J. Agric. Sci.* 73: 101-105.

Hussein MA, Ali NKSMS (2019). Phenotypic, biochemical and molecular characterization of new Egyptian mango genotypes. *JAPP., Suez Canal Univ.* 8: 55-68.

Igbari A, Nodza G, Adeusi A, Ogundipe O (2019). Morphological characterization of mango (*Mangifera indica* L.) cultivars from South-West Nigeria. *IJS* 21: 155-163.

Indian G, Eslavath K, Mutharasu P, Dhanalakshmi V, Jeeva P (2018). Evaluation of potentiality of mango (*Mangifera indica* L) genotypes for physical attributes of fruits. Departament of Fruit Crops, HC&RI (TNAU), Periyakulam, Tamil Nadu, India. *Int. J. Chem. Stud.* 6: 2334-2338.

Jilani MS, Bibi F, Waseem K (2010). Evaluation of physico-chemical characteristics of mango (*Mangifera indica* L.) cultivars grown in DI Khan. *J. Agric. Res* 48: 201-207.

Juliantari E, Djuita NR, Fitmawati, Chikmawati T (2021). Genetic diversity of kweni fruit (*Mangifera odorata* Griffith) from Sumatra, Indonesia, based on morphological and ISSR analyses. *SABRAO J. Breed. Genet.* 53(3): 527-542.

Kishore K, Singh H, Kurian R, Srinivas P, Samant DJIJoPGR (2015). Performance of certain mango varieties and hybrids in east coast of India. 28: 296-302.

Kittur F, Saroja N, Tharanathan R (2001). Polysaccharide-based composite coating formulations for shelf-life extension of fresh banana and mango. *Eur. Food Res. Technol.* 213: 306-311.

Marzouk RI, El-Darier S, Mabrouk M, Khattab K (2017). Growth and molecular rxpression of okra seeds interacted with fourteen mango cultivars in mixed cropping system. *J. Agric. Sci.* 9.

Menzel CM, Le Lagadec M (2017). Can the productivity of mango orchards be increased by using high-density plantings? *Sci. Hortic.* 219: 222-263.

Modesto JH, Leonel S, Segantini DM, Souza JMA, Ferraz RA (2016). Qualitative attributes of some mango cultivars fruits. *Aust. J. Crop Sci.* 10: 565-570.

Naz S, Anjum MA, Chohan S, Akhtar S, Siddique B (2014). Physico-chemical and sensory profiling of promising mango cultivars grown in peri-urban areas of Multan, Pakistan. *Pak. J. Bot.* 46: 191-198.

Nigam S, Bhatt D, Jha A (2007). Different product of mango: The king of fruits. *J. Food Process* 10: 32-40.

Noperi-Mosqueda LC, Soto-Parra JM, Sanchez E, Navarro-Leon E, Perez-Leal R, Flores-Cordova MA, Salas-Salazar NA, Yanez-Munoz RM (2020). Yield, quality, alternate bearing and long-term yield index in pecan, as a response to mineral and organic nutrition. *Not Bot Horti Agrobot* 48: 342-353.

Padhiar B, Saravaiya S, Tandel K, Ahir M, Bhalerao P, Bhalerao R (2011). Performance of fruits of nine mango cultivars under South Gujarat conditions in relation to physical characters. *J. Asian hortic.* 6: 393-397.

Patil R, Deshmukh R, Bhaskar K, Jahagirdar S (2018). Growth and export performance of mango in India. *Int. j. curr. microbiol. appl. sci.* 6: 2667-2673.

Rangare N, Bhan M, Pandey S (2022). Assessment of weather effect on flower morphogenesis and fruit set in mango varieties in central India. *J. Agrometeorol.* 24: 33-37.

Reddy PVR (2021). Leafhopper (*Idioscopus* spp.) excreted honeydew distracts honey bees (*Apis* spp.) from visiting mango (*Mangifera indica* L.) flowers: An indirect loss inflicted by the sucking pests hitherto unaccounted. *J. Apic. Res.*: 1-5.

Rodríguez Pleguezuelo C, Durán Zuazo V, Muriel Fernández J, Franco Tarifa D, Technology (2012). Physico-chemical quality parameters of mango (*Mangifera indica* L.) fruits grown in a Mediterranean subtropical climate (SE Spain). *J. Agric. Sci.* 14: 365-374.

Saheda M, Balahussaini M, Ramaiah M, Balakrishna M (2019). Study on morpho-physical characters of mango flower varieties/hybrids in Kodur agro-climatic conditions. *Int. j. curr. microbiol. appl. sci.* 8: 28-38.

Sahu SC, Suresh H, Ravindranath N (2016). Forest structure, composition and above ground biomass of tree community in tropical dry forests of Eastern Ghats, India. *Not. Sci. Biol.* 8: 125-133.

Sarkar S, Gautham B, Neeraja G, Vijaya N (2001). Evaluation of mango hybrids under Telangana region of Andhra Pradesh. *Hort. J* 14: 13-21.

Snedecor G, Cochran W (1980). Statistical Methods 6th Ed-low state niv. *Press, Ames. Iowa USA*.

Shaikh RN, Agarkar BS, Kshirsagar RB, Bachate AH (2021). Studies on physical, chemical and mineral evaluation of mango (*Mangifera indica* L.). *The Pharma Innov. J.* 10(6): 446-449.

Singh L (1948). Studies in biennial bearing: III. Growth studies in 'ON'and 'Off'year trees. *J. Hortic. Sci.* 24: 123-148.

Sousa CAFd, Cavalcanti MILG, Vasconcelos LFL, Sousa HUd, Ribeiro VQ, Silva JALd (2012). 'Tommy Atkins' mango trees subjected to high density planting in subhumid tropical climate in northeastern Brazil. *Pesqui. Agropecu. Bras.* 47: 36-43.

Souza JMA, Leonel S, Modesto JH, Ferraz RA, Silva MdS, Bolfarini ACB (2018). Performance of mango cultivars under subtropical conditions in the state of São Paulo. *J. Biosci.* 34: 1-11.

Toliba AO, Rabie M, El-Araby GM (2014). Extending the shelf-life of cold stored strawberry by chitosan and carnauba coatings. *ZJAR* 41: 1067-1076.

Uddin M, Rahim M, Alam M, Barman J, Wadud M (2006). A study on the physical characteristics of some mango germplasms grown in Mymensingh condition. *IJSCP.* 1: 33-38.

Vithana MDK, Singh Z, Johnson SK (2019). Harvest maturity stage affects the concentrations of health-promoting compounds: Lupeol, mangiferin and phenolic acids in the pulp and peel of ripe 'Kensington Pride'mango fruit. *Sci. Hortic.* 243: 125-130.

Wall-Medrano A, Olivas-Aguirre FJ, Ayala-Zavala JF, Domínguez-Avila JA, Gonzalez-Aguilar GA, Herrera-Cazares LA, Gaytan-Martinez M, Nutraceutical BP, Potential H (2020). Health benefits of mango by-products. *J. Environ. Sci.*: 159-191.

Wilcox J (1949). Some factors affecting apple yields in the Okanagan Valley: V. Available P, K and Ca in the Soil. *J. Sci. Agric.* 29: 27-44.

Y Mohamed A, A Roshdy K, AF Badran M (2016). Evaluation Study of Some Imported Mango Cultivars Grown under Aswan Governorate Conditions. *Alex. Sci. Exch.* 37: 254-259.

Yahia E-HM (1999). Postharvest handling of mango. *ATUT/RONCO technical staff, Egypt. Accessed* 4: 2000.

Yeshitela T, Robbertse P, Stassen P, Science H (2004). Paclobutrazol suppressed vegetative growth and improved yield as well as fruit quality of 'Tommy Atkins' mango (*Mangifera indica*) in Ethiopia. *N. Z. J. Crop Hortic* 32: 281-293.

Zahid G, Aka Kaçar Y, Shimira F, Iftikhar S, Nadeem MAJGR (2022). Recent progress in omics and biotechnological approaches for improved mango cultivars in Pakistan. *Genet. Resour. Crop Evol*: 1-19.