International Journal of Multiphysics
Volume 18, No. 4, 2024
ISSN: 1750-9548

Performance Evaluation of Selected Introduced Mango Cultivars under the Environmental Conditions of Egypt

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Abstract

The performance of introduced mango (*Mangifera indica* L.) cultivars under different agro-climatic conditions is an important consideration for improving productivity and fruit quality. Therefore, this study was conducted during the 2023 and 2024 growing seasons to evaluate the vegetative growth, flowering behavior, yield, and fruit quality of six introduced mango cultivars (Glenn, Deshiri, Naomi, Osteen, Keitt, and Tommy Atkins) grown under the environmental conditions of Ismailia Governorate, Egypt. Ten-year-old trees grafted onto seedling rootstocks were arranged in a randomized complete block design with three replicates. Measurements included vegetative growth, flowering characteristics, fruit set, fruit retention, yield, and physical and chemical fruit attributes. Significant differences were observed among the evaluated cultivars for all studied parameters. Osteen exhibited the greatest vegetative growth, recording the longest shoots and the largest leaf area, whereas Glenn showed the earliest flowering and harvesting. Keitt produced the lowest percentage of floral malformation and the highest fruit set, fruit retention, and fruit yield, reaching 35.06 and 37.18 kg tree^{-1} during the 2023 and 2024 seasons, respectively. In contrast, Deshiri produced the heaviest fruits, while Glenn recorded the highest pulp percentage, total soluble solids, total and reducing sugars, together with the lowest acidity and fiber contents, indicating superior eating quality. The observed differences were mainly associated with the genetic characteristics of the cultivars and their adaptation to the local environmental conditions. Overall, Keitt was identified as the most promising cultivar for commercial production under Ismailia conditions, followed by Glenn and Deshiri, whereas Naomi showed the least favorable performance. These findings provide valuable information for cultivar selection and support the expansion of sustainable mango production under environmental conditions similar to those of Ismailia Governorate.

Keywords: Imported mango cvs; growth, fruiting, productivity.

1. Introduction

Mango (*Mangifera indica* L.) ranks among the world's most economically significant fruit crops, thriving particularly in tropical and subtropical climates **(Sharma *et al*., 1995 and Schaffer *et al*., 1997)**. Its nutritional profile is notable for rich concentrations of sugars, essential amino acids, dietary minerals, vitamins, and antioxidant compounds **(Chandler, 1987 and El-Hadi, 1999)**. Within Egypt, mango holds a strategic position among fruit crops, yet the performance of introduced cultivars varies considerably across different growing regions. This variability is shaped by the interplay of genetic makeup, prevailing environmental conditions, and applied agronomic practices **(Yamashita, 2000)**.

The expansion of mango cultivation in Egypt has driven a growing body of research focused on cultivar evaluation. Numerous studies have consistently shown that vegetative growth, productivity, and fruit quality are

highly site-specific, underscoring the necessity of regionally tailored cultivar recommendations **(Abd El-Hadi, 2006; Khattab *et al*., 2007; Shaban, 2009; Masoad-Amal, 2010; Raddy *et al*., 2011; Fahmy, 2016; Mohamed *et al*., 2016 and Hamad, 2021)**. Consequently, identifying high-performing cultivars that are well-adapted to local conditions is essential for optimizing orchard productivity and profitability.

The present investigation was undertaken to generate comprehensive data on the phenological, vegetative, reproductive, and fruit quality traits of six imported mango cultivars grown under the specific agro-climatic conditions of Ismailia Governorate. The findings are intended to assist growers in selecting the most suitable cultivars for sustainable production in this region.

2. Materials and Methods

2.1. Experimental Site

The present investigation was carried out during two successive growing seasons (2023 and 2024) in a private mango orchard located on Sami Saad Road, Ismailia City, Ismailia Governorate, Egypt. The orchard is characterized by sandy soil with a groundwater table deeper than 2.0 m.

2.2. Plant Materials and Experimental Design

Six introduced mango (*Mangifera indica* L.) cultivars, namely Glenn, Deshiri, Naomi, Osteen, Keitt, and Tommy Atkins, were selected for evaluation. At the beginning of the experiment, all trees were 10 years old, budded onto seedling rootstocks, and planted at a spacing of 4.0 × 2.0 m. Each cultivar was represented by six healthy and uniform trees with similar vigor. The experiment consisted of six treatments corresponding to the six evaluated cultivars and was arranged in a randomized complete block design (RCBD) with three replicates, each replicate consisting of two trees.

2.3. Orchard Management, Soil, and Climatic Conditions

Throughout the experimental period, all trees received the recommended fertilization program and were subjected to the standard orchard management practices routinely adopted in the orchard, including irrigation, pruning, cultivation, and integrated control of weeds, insect pests, and diseases. The physical and chemical properties of the experimental soil were determined according to **Black (1965)**, and the results are presented in Table 1. Monthly meteorological data, including maximum and minimum air temperatures and relative humidity during the 2023 and 2024 growing seasons, were obtained for Ismailia Governorate and are presented in Figure 1.

Table 1. Physical and chemical properties of the experimental soil

Characters	Values	Characters	Values
Sand %	81.0	Total N %	0.09
Silt %	10.5	P (ppm olsn method)	6.0
Clay %	8.5	K (ppm ammonium acetate)	71.0
Texture	Sandy	Zn ppm	0.33
pH (1: 2.5 extract)	8.10	Fe ppm	0.72
E.C. (1: 2.5 extract (mmhos/ 1cm/ 25ºC)	1.1	Mn ppm	0.41
O.M. %	0.25		
$CaCO_3$ %	1.30		

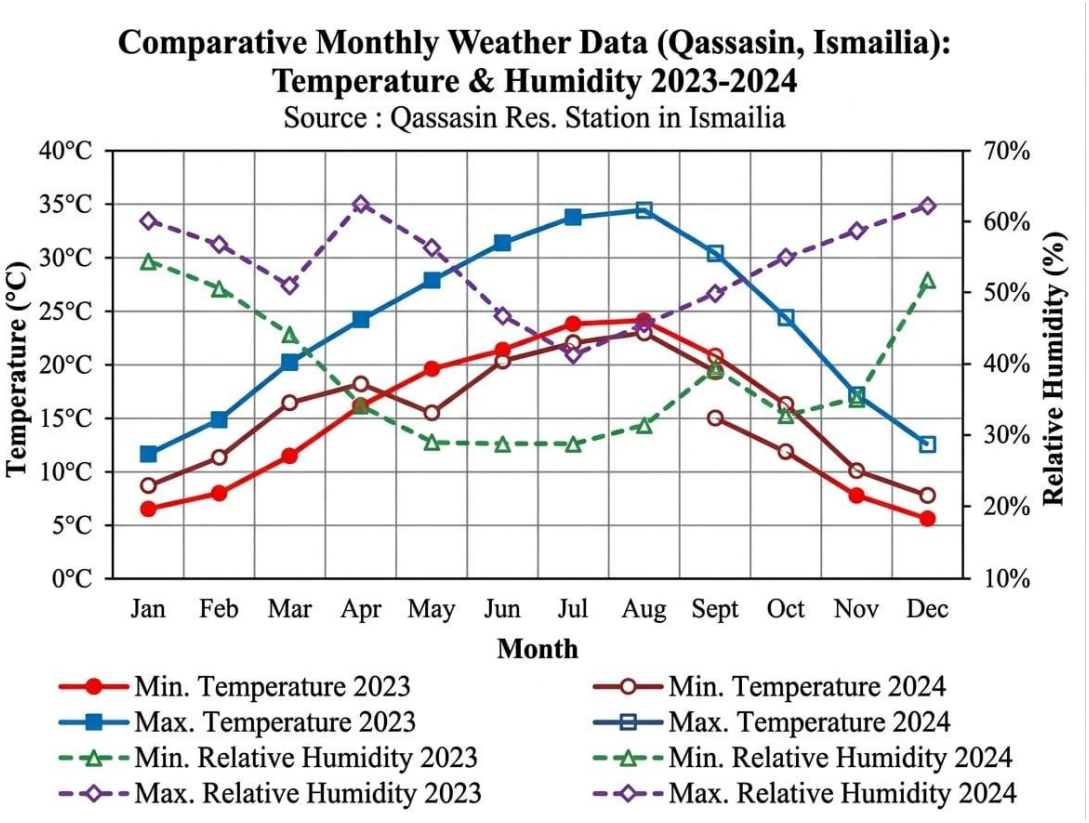

Figure 1. Monthly average temperature and relative humidity % for two seasons of 2023 and 2024

2.4. Vegetative Growth Measurements

Ten current-season spring shoots were randomly selected from the ten previously labeled secondary branches of each tree to determine shoot length (cm). Twenty fully expanded leaves located below the panicles were collected from each selected shoot to measure leaf length and maximum leaf width. Leaf area (cm²) was estimated using the following equation described by **Ahmed and Morsy (1999)**:

$$\text{Leaf area} = 0.70\ (L \times W) - 1.06$$

Where: **L** is the leaf length (cm) and **W** is the maximum leaf width (cm).

2.5. Flowering, Yield and Fruit Quality Measurements

At the flowering stage, the dates of flower bud opening and full bloom were recorded. In addition, the percentage of floral malformation, fruit set, and fruit retention per panicle were determined for each cultivar. Fruits were harvested at the commercial maturity stage when the flesh developed a yellowish color and the fruit shoulders became rounded or flattened. The harvesting date (days from flowering) was recorded for each cultivar. Total yield was expressed as both fruit weight (kg tree^{-1}) and the number of fruits per tree. For fruit quality evaluation, ten fruits were randomly collected from each tree. The physical characteristics, including average fruit weight, fruit length, fruit diameter, fruit thickness, pulp percentage, seed weight, and peel weight, were determined according to **A.O.A.C. (2000)**. The chemical characteristics included total soluble solids (TSS%) measured using a hand refractometer, total and reducing sugars determined according to **Lane and Eynon (1965)**, total titratable acidity expressed as grams of citric acid per 100 ml of juice according to **A.O.A.C. (2000)**, and total fiber percentage.

2.6. Statistical Analysis

The collected data from both experimental seasons were subjected to statistical analysis according to the procedures described by **Snedecor and Cochran (1990)**. Differences among treatment means were evaluated using the Least Significant Difference (LSD) test at the 5% probability level.

3. Results and Discussion

3.1. Vegetative Growth Characteristics

3.1.1. Shoot Length and Leaf Area

The vegetative growth performance of the six evaluated mango cultivars differed significantly during both experimental seasons (Table 3). Among the investigated cultivars, Osteen produced the greatest shoot length and leaf area, followed by Tommy Atkins, whereas Glenn exhibited the lowest values for both parameters. The remaining cultivars showed intermediate responses.

The superior vegetative growth observed in Osteen may be attributed to its greater genetic vigor and its better adaptation to the prevailing environmental conditions of Ismailia Governorate. Variations in shoot elongation and leaf expansion among cultivars are generally associated with genotypic differences in growth potential, nutrient utilization efficiency, canopy architecture, and their interaction with local climatic conditions. These factors collectively influence photosynthetic capacity and carbohydrate accumulation, thereby affecting vegetative development.

The present findings are consistent with those reported by **(Baita *et al*., 2010; Singh and Bhargava, 2011; Abourayya *et al*., 2012; Silva *et al*., 2014; Fahmy, 2016; Mohamed *et al*., 2016 and Hamad, 2021)**, who demonstrated that vegetative growth characteristics vary considerably among mango cultivars because of genetic constitution and environmental adaptation.

3.2. Flowering Characteristics

3.2.1. Flower Bud Opening and Full Bloom

The flowering behavior of the evaluated mango cultivars varied noticeably under the environmental conditions of Ismailia Governorate (Table 3). Flower bud emergence for all cultivars began during January; however, the timing differed among cultivars. **Glenn** was the earliest cultivar to initiate flowering, with flower buds opening during the second week of January. In contrast, the remaining cultivars exhibited relatively later flowering.

Likewise, the full bloom period extended from the second week of February to the last week of March. Glenn reached full bloom earliest, whereas Keitt was the latest cultivar, attaining full bloom during the last week of March. Such differences in flowering phenology are mainly attributed to cultivar-dependent genetic characteristics and their responses to prevailing temperature and environmental conditions during floral induction and development. These observations agree with those reported by **(Ragab *et al*., 2002; Fahmy, 2016 and Mohamed *et al*., 2016)**, who found considerable variation in flowering time among mango cultivars grown under Egyptian conditions.

3.2.2. Floral Malformation

Significant differences were observed among the evaluated cultivars regarding the percentage of malformed inflorescences (Table 3). Across both seasons, floral malformation ranged from 3.70 to 5.11%. The highest percentages were recorded in Naomi (5.11 and 5.02%), followed by Osteen (4.65 and 4.60%), Deshiri (4.58 and 4.56%), Glenn (4.55 and 4.52%), and Tommy Atkins (3.95 and 3.90%), whereas Keitt consistently exhibited the lowest incidence (3.70 and 3.72%) during the first and second seasons, respectively.

The relatively low level of floral malformation observed in Keitt may explain its superior reproductive performance and subsequent fruit productivity. The incidence of malformed panicles is known to vary according

to cultivar susceptibility, environmental conditions during flower differentiation, nutritional status, and hormonal balance within the tree. Lower floral malformation generally results in a greater proportion of functional flowers capable of successful pollination and fruit set.

Table 3. Some vegetative aspects, date of flower buds opening, date of full bloom in the spraying growth cycle and percentage of floral malformation of some new mango cultivars grown under Ismailia governorate condition during 2023 and 2024 seasons

Mango cultivars	Shoot length (cm)		Leaf area $(cm)^2$		Date of flower buds opening		Date of full bloom		Floral malformation %	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
Glenn	22.8	24.0	68.5	71.0	2nd week of Jan.	2nd week of Jan.	2nd week of Feb.	3rd week of Feb.	4.55	4.52
Deshiri	32.5	33.8	74.5	76.0	3rd week of Jan.	3rd week of Jan.	4th week of Feb.	4th week of Feb.	4.58	4.56
Naomi	28.0	28.5	72.8	73.2	3rd week of Jan.	3rd week of Jan.	4th week of Feb.	4th week of Feb.	5.11	5.02
Osteen	41.5	43.0	94.0	95.5	3rd week of Jan.	3rd week of Jan.	4th week of Feb.	4th week of Feb.	4.65	4.60
Keitt	31.6	32.0	79.5	81.0	4th week of Jan.	4th week of Jan.	4th week of Mar,	4th week of Mar,	3.70	3.72
Tommy Atkins	39.5	41.0	88.0	89.5	3rd week of Jan.	3rd week of Jan.	2nd week of Mar.	2nd week of Mar.	3.95	3.90
New L.S.D. at 5%	1.3	1.6	2.2	2.3	-	-	-	-	0.11	0.13

3.3. Fruit Set and Fruit Retention

Marked differences were detected among the six mango cultivars with respect to both initial fruit set and fruit retention percentages (Table 4). Initial fruit set ranged from 9.70 to 13.45%, while fruit retention varied from 0.65 to 1.13% during the first season. Comparable trends were observed during the second season.

Among the evaluated cultivars, Keitt consistently recorded the highest percentages of initial fruit set (13.25 and 13.45%) and fruit retention (1.13 and 1.01%) during the first and second seasons, respectively. Conversely, Naomi exhibited the lowest values for both parameters, with initial fruit set of 9.70 and 9.88% and fruit retention of 0.65% in both seasons.

The superior fruiting performance of Keitt may be attributed to its higher proportion of perfect flowers, greater pollen viability and germination capacity, and reduced floral malformation, all of which enhance fertilization efficiency and fruit retention. In contrast, the relatively poor reproductive performance of Naomi likely resulted from lower floral fertility and greater flower abscission. These results are supported by **(Mohamed *et al*., 2016; Fahmy, 2016 and Hamad, 2021)**, who reported that fruit set and retention are strongly influenced by cultivar characteristics, flower quality, and environmental conditions prevailing during the flowering period.

3.4. Harvesting Time

Significant differences in harvesting time were observed among the evaluated mango cultivars under the environmental conditions of Ismailia Governorate (Table 4). Harvest maturity extended from the last week of July to the last week of September, reflecting the wide variation in ripening behavior among the cultivars. Glenn was the earliest-maturing cultivar, with fruits reaching commercial maturity during the last week of July, whereas Keitt was the latest, being harvested in the last week of September. The remaining cultivars, namely Deshiri, Naomi, Osteen, and Tommy Atkins, matured during August.

The variation in harvesting date is mainly attributed to differences in flowering time and fruit developmental period among cultivars. Early flowering generally resulted in earlier fruit maturity, while delayed blooming

prolonged the fruit development cycle. These differences are largely controlled by the genetic characteristics of each cultivar and their interaction with the prevailing climatic conditions. Similar observations were reported by **(Sweidan *et al*., 2007; Shaban, 2009; Fahmy, 2016; Mohamed *et al*., 2016 and Hamad, 2021)**.

3.5. Number of Fruits per Tree and Yield

The evaluated mango cultivars exhibited significant differences in fruit production during both experimental seasons (Table 4). Fruit yield per tree ranged from 12.56 to 35.06 kg during the first season and from 13.28 to 37.18 kg during the second season. Among all cultivars, Keitt consistently produced the highest yield, reaching 35.06 and 37.18 kg tree^{-1} during the first and second seasons, respectively. Tommy Atkins ranked second, producing 22.30 and 24.48 kg tree^{-1}, whereas Osteen recorded the lowest yield, with 12.56 and 13.28 kg tree^{-1} in the respective seasons.

The superior productivity of Keitt can be attributed to its higher fruit set and fruit retention percentages together with its relatively low incidence of floral malformation. These reproductive characteristics allowed a greater number of fruits to develop and remain on the trees until harvest. Conversely, the lower productivity of Osteen may be associated with reduced fruit retention despite its vigorous vegetative growth, indicating that excessive vegetative development does not necessarily result in greater yield. This inverse relationship between vegetative vigor and reproductive efficiency has been reported previously for several mango cultivars. The present findings agree with those of **(Fahmy, 2016; Mohamed *et al*., 2016 and Hamad, 2021)**.

Table 4. Some fruit setting characteristics, number of fruits per tree, harvesting date and yield per tree of some new mango cultivars grown under Ismailia governorate condition during 2023 and 2024 seasons

Mango cultivars	Initial fruit set %		Fruit retention %		Number of fruits / tree		Harvesting date		Yield/ tree (kg.)	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
Glenn	12.50	12.40	0.74	0.71	35.0	33.0	4th week of July	4th week of July	18.74	17.95
Deshiri	10.55	10.60	0.80	0.82	50.0	52.0	1st week of Aug	2nd week of Aug.	14.00	16.12
Naomi	9.70	9.88	0.65	0.65	28.0	31.0	2nd week of Aug.	2nd week of Aug.	14.28	16.28
Osteen	11.20	11.50	0.78	0.75	31.0	32.0	3rd week of Aug	4th week of Aug.	12.56	13.28
Keitt	13.25	13.45	1.13	1.09	42.5	44.0	4th week of Sept.	4th week of Aug.	35.06	37.18
Tommy Atkins	11.50	11.65	0.95	0.90	46.5	48.0	4th week of Aug.	4th week of Aug.	22.30	24.48
New L.S.D. at 5%	0.58	0.66	0.22	0.25	1.3	1.6	-	-	2.31	2.44

3.6. Fruit Physical Characteristics

3.6.1. Fruit Weight and Dimensions

Significant cultivar-dependent variations were detected in fruit weight and fruit dimensions, including length, diameter, and thickness (Table 5). The evaluated cultivars exhibited distinct differences in fruit morphology during both seasons of the study.

Deshiri produced the heaviest fruits, with average fruit weights of 280.0 and 310.0 g during the first and second seasons, respectively. Differences were also observed in fruit length, width, and thickness, reflecting the genetic diversity among the investigated cultivars. While some cultivars produced large and elongated fruits, others were characterized by relatively smaller fruit size.

Fruit size is primarily determined by genetic factors; however, environmental conditions, assimilate availability, cell division and enlargement, and sink strength during fruit development also contribute substantially to these differences. Larger fruits generally indicate greater carbohydrate accumulation and more efficient translocation of photosynthates from the leaves to the developing fruits. Similar observations have been reported by **(Abourayya *et al*., 2012; Fahmy, 2016; Mohamed *et al*., 2016 and Hamad, 2021)**.

Table 5. Some physical characteristics of the fruits of some new mango cultivars grown under Ismailia governorate condition during 2023 and 2024 seasons

Mango cultivars	Average fruit weight (g.)		Average fruit height (cm.)		Average fruit diameter (cm.)		Average fruit thickness (cm.)	
	2023	2024	2023	2024	2023	2024	2023	2024
Glenn	535.5	544.0	13.50	13.70	9.40	9.50	7.5	7.6
Deshiri	280.0	310.0	9.75	10.00	6.00	6.10	4.8	5.0
Naomi	510.0	525.0	13.20	13.30	9.00	9.20	7.0	7.1
Osteen	405.0	415.0	11.30	11.50	7.20	7.50	5.5	5.6
Keitt	825.0	845.0	16.25	16.33	12.50	12.60	9.9	10.0
Tommy Atkins	480.0	510.0	12.80	12.90	8.90	9.11	6.5	6.6
New L.S.D. at 5%	28.3	29.5	1.66	1.98	0.92	0.99	0.7	0.8

3.6.2. Pulp, Seed, Peel, and Edible Portion

Significant differences were observed among the six mango cultivars regarding pulp, seed, and peel percentages as well as the edible-to-non-edible ratio (Table 6).

Pulp percentage ranged from 79.30 to 84.20% across both seasons. Glenn produced the highest pulp percentage, followed by Deshiri, Keitt, Naomi, and Tommy Atkins, whereas Osteen recorded the lowest values. A higher pulp percentage is considered one of the most desirable commercial characteristics because it directly increases the edible portion of the fruit.

Seed percentage varied from 6.30 to 9.00%. The highest seed percentages were recorded in Osteen and Tommy Atkins, while Glenn consistently exhibited the lowest values. Likewise, peel percentage ranged from 9.50 to 11.70%, with Osteen and Tommy Atkins producing significantly heavier peels than the remaining cultivars. Glenn showed the lowest peel percentage during both seasons.

Table 6. Some physical characteristics of the fruits of some new mango cultivars grown under Ismailia governorate condition during 2023 and 2024 seasons

Mango cultivars	Fruit pulp %		Fruit seed %		Fruit peel %		Edible / none edible portions	
	2023	2024	2023	2024	2023	2024	2023	2024
Glenn	83.90	84.20	6.50	6.30	9.60	9.50	5.21	5.33
Deshiri	82.90	83.0	7.00	7.00	10.10	10.00	4.85	4.88
Naomi	81.20	81.60	7.80	7.60	11.00	10.80	4.32	4.43
Osteen	79.30	79.90	9.00	8.60	11.70	11.50	3.83	3.97
Keitt	82.20	82.40	7.20	7.10	10.60	10.50	4.62	4.68
Tommy Atkins	80.39	80.65	8.11	8.05	11.50	11.30	4.10	4.17
New L.S.D. at 5%	0.11	0.13	0.07	0.08	0.09	0.11	0.06	0.08

The edible-to-non-edible ratio also differed significantly among cultivars, varying from 3.83 in Osteen to 5.33 in Glenn. The higher ratio recorded by Glenn reflects its superior fruit quality, resulting from its higher pulp content and relatively lower seed and peel proportions. Such differences are primarily governed by the genetic

characteristics of each cultivar and represent an important criterion for both fresh consumption and processing industries. Similar trends were previously reported by **(Abd El-Hadi, 2006; Abourayya *et al*., 2012; Fahmy, 2016; Mohamed *et al*., 2016 and Hamad, 2021)**.

3.7. Chemical characteristics of fruit

The chemical composition of the fruits differed significantly among the six imported mango cultivars (Table 7). Across both growing seasons, 'Glenn' consistently produced fruits with the highest total soluble solids (15.20 and 15.30%), total sugars (11.25 and 11.30%), and reducing sugars (5.20 and 5.30%). In contrast, this cultivar recorded the lowest total acidity (0.280 and 0.270%) and total fiber content (0.09 and 0.08%) in the 2023 and 2024 seasons, respectively. 'Naomi' ranked second for most of these quality attributes and showed a response pattern similar to that of 'Glenn' in both seasons. The observed variation in fruit chemical properties among the cultivars is likely associated with differences in their genetic background, which influence fruit development and the accumulation of biochemical constituents. In addition, cultivar-specific responses to environmental conditions, crop management practices, and harvest timing may have contributed to the differences recorded. Comparable findings have been reported by **Abd El-Hadi (2006), Sayed (2009), Abourayya *et al.* (2012), Fahmy (2016), Mohamed *et al.* (2016) and Hamad (2021)**.

Table 7. Some chemical characteristics of the fruits of some new mango cultivars grown under Ismailia governorate condition during 2023 and 2024 seasons

Mango cultivars	TSS %		Total acidity %		Total sugars %		Reducing sugars %		Total fibre %	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
Glenn	15.20	15.30	0.280	0.270	11.25	11.30	5.20	5.30	0.09	0.08
Deshiri	13.00	13.20	0.410	0.400	9.50	9.70	3.80	3.95	0.13	0.15
Naomi	14.72	14.90	0.310	0.305	10.70	10.75	4.80	4.90	0.16	0.15
Osteen	14.30	14.50	0.325	0.315	10.20	10.25	4.30	4.50	0.08	0.08
Keitt	13.68	13.85	0.360	0.350	10.00	10.10	4.00	4.10	0.11	0.09
Tommy Atkins	11.25	11.38	0.440	0.420	7.50	7.80	3.10	3.25	0.20	0.18
New L.S.D. at 5%	0.28	0.35	0.022	0.025	0.16	0.17	0.09	0.11	0.02	0.02

4. Conclusion

The present study demonstrated significant differences among the six introduced mango cultivars in terms of vegetative growth, flowering behavior, fruit set, yield, and fruit quality under the environmental conditions of Ismailia Governorate, Egypt. These variations were mainly attributed to the genetic characteristics of the cultivars and their differential adaptation to the local agro-climatic conditions. Among the evaluated cultivars, Keitt exhibited the best overall performance, producing the highest fruit set, fruit retention, yield, and desirable fruit quality attributes, indicating its superior adaptation to the study area. Glenn ranked second due to its early flowering and harvesting, high pulp percentage, and excellent fruit quality, while Deshiri showed promising performance, particularly in fruit size and productivity. In contrast, Osteen and Tommy Atkins exhibited intermediate performance, whereas Naomi showed comparatively lower reproductive efficiency and yield under the prevailing environmental conditions. Based on the overall evaluation of vegetative growth, reproductive performance, yield, and fruit quality, the investigated cultivars are recommended for commercial cultivation under the conditions of Ismailia Governorate in the following descending order: Keitt > Glenn > Deshiri > Osteen > Tommy Atkins > Naomi. Nevertheless, further multi-season and multi-location studies are recommended to confirm the stability of these cultivars under different environmental conditions and to support the selection of the most suitable mango cultivars for sustainable production in Egypt.

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