



Influence of foliar application with moringa (*Moringa oleifera* L.) aqueous leaf extract on fruit set, yield and fruit quality of Selmy date palms.

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Abstract

This study was conducted on Selmy date palms (*Phoenix dactylifera* L.) cultivated on sandy soil in a private orchard located at 63 kilometers from Cairo-Alexandria-desert road, Egypt, during 2018 and 2019 seasons. Palms were sprayed with 0, 5, 6 and 7% of moringa aqueous leaf extract (MALE) at three hours before pollination then four and eight weeks after pollination. Palms treated with 6% MALE exhibited significantly higher fruit setting %, fruit retention %, bunch weight (g), yield/palm (kg), soluble solids %, total sugars %, reducing and non-reducing sugars % compared with the untreated palms in both seasons. Also, overall acidity was not affected by any of these treatments. It could be concluded that foliar spray of 6% MALE can be employed to enhance fruit set retention, yield/palm as kg, total soluble solids % and total sugars % of Selmy date palms.

Keywords: Moringa aqueous leaf extract; fruit quality; Selmy date palms.

1. Introduction

In the Middle East countries, date palm is described as one of the ancient domestic's fruit crops. Many cultivars are cultivated in Egypt in various places based on their climatic requirements, particularly average temperature and relative humidity which affect fruit growth and development. Total harvested area of dates in Egypt aligned about 333901 ha with total production of 1603762 tons [1].

In the realm of agriculture, the present tendency is to employ natural materials including plant extracts or antioxidants to speed up production and fruit quality to avoid the reliance of chemical materials that are injurious to human and environment [2]. Moringa (*Moringa oleifera* L.) is regarded as one of the world's most beneficial trees. Every portion of this tree has a remarkable impact on food, medicine, and industry [3, 4]. Moringa leaves often include vitamins (A and C), minerals (Ca, Fe), β -carotene [5, 6, 7, 8], active natural antioxidants and cytokinin [9].

By-product, moringa aqueous leaves extract (MALE) can be utilized as an organic fertilizer. It has a similar impact to artificial hormone activity because of the extract contains zeatin, purine, adenine speculative of plant hormone group cytokinin [9, 10, 11], that enhance the antioxidant activities of many enzymes and protect cells from the ageing effects [12]. Many studies have already shown that foliar spray with MALE caused a favorable improve vigor

growth [2], enhanced seed germination, promoted root growth [13], postponed fruit senescence and raised yield quality and quantity [14, 15, 16]. In addition, impart the ability of crops to stand adverse environmental condition [2]. Spraying date palm bunches with MALE or garlic extract three times (three hours before pollination, four and eight weeks after pollination) resulted in the highest initial fruit set, fruit retention, and yield in both seasons. Furthermore, when compared to the control, the whole treatments improved some fruit physical features, such as fruit weight, volume and length, also flesh weight. Moreover, it raised TSS, total sugars and decreased sugars percentages. On the contrary, there was no substantial effect on total acidity percentage [17]. In addition, using MALE led to enhance "Hollywood" plum trees' productivity [18], as well as, accelerate biomass production in "Washington" Navel orange trees at the concentration of 3% [19]. Hence, this study aimed to evaluate foliar application of MALE in enhancing fruit set, yield and quality of Selmy date palms cultivar.

2. Methods

2.1. Plant Materials

This research was conducted on 15-year-old date palms (*Phoenix dactylifera* L.) Selmy cultivar grown on sandy soil and planted at 6 meters apart under drip irrigation system in a private orchard located at 63

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kilometers from Cairo-Alexandria desert road, Egypt, throughout the two seasons of 2018 and 2019. The palms chosen were healthy, had approximately uniform growth vigor and fruiting, and received regular horticultural practices. To avoid the influence of metazenia, hand pollination was done by inserting fresh male strands (5 strands) into the middle of the female spathe using the same source of pollen in both seasons.

Furthermore, pruning was done to maintain the ratio of mature leaves to cluster (1:8). The number of spathes per palm was adjusted to ten bunches by removing the palm's earliest, latest, and smallest inflorescences.

2.2. Preparation of moringa aqueous leaf extract

100 gm of moringa (*Moringa oleifera* L.) leaves powder were bought from **selling unit of moringa**

products, NRC, Dokki, Giza, Egypt, then added to 1 liter of distilled water. The mixture was kept for 24 hours, and Whatman filter paper No. 1 was used to filter the extract [20]. Then after, water was used to dilute the extract to reach the concentrations of 0, 5, 6, and 7% which sprayed directly over palms till run off, and Tween 20 at 1% was used as a surfactant. Table 1 shows the chemical analysis of 100g *Moringa oleifera* dry leaf powder [21]. As well as, Figure 1 shows the separation chromatograms of the identified chemical compounds in MALE, and Table 2 shows that ellagic acid (54.18 mg/100g), vanillic acid (18.79 mg/100g), p-hydroxy benzoic acid (14 mg/100g), catechol (12.32 mg/100g), and gallic acid (12.12 mg/100g) were the main identified phenolic compounds [22].

Table 1 Chemical analysis of 100 gm *Moringa oleifera* leaves powder.

Components name	Leaf powder
Proximate content	
Moisture%	07.5
Carbohydrate(g)	38.4
Protein(g)	27.1
Fat(g)	02.3
Fiber(g)	18.8
Mineral content	
Ca (mg)	2.00
Mg (mg)	368
P (mg)	204
K (mg)	1.32
Cu (mg)	0.60
Fe (mg)	28.2
S (mg)	870
Vitamins content	
A (B-carotene) mg	16.3
B1 (thiamine) mg	2.60
B2 (riboflavin) mg	20.5
B3 (nicotinic acid) mg	8.20
C (ascorbic acid) mg	17.3
E (tochopherol acetate) mg	113
Amino Acid composition of crude protein	
Arginine (g/16g N)	1.33
Lysine (g/16g N)	1.32
Methionine (g/16g N)	2.00
Threonine (g/16g N)	1.19
Leucine (g/16g N)	1.95
Tryptophan (g/16g N)	0.43
Phenylalanine (g/16g N)	1.39
Isoleucine (g/16 g N)	0.83
Valine (g/16g N)	1.06
Histidine (g/16g N)	0.61

Table 2 Identified chemical composition of phenolic components & caffeine of MALE by HPLC.

Compound	Concentration (mg/100 g)
Gallic acid	12.12
Catechol	12.32
p-Hydroxy benzoic acid	14
Caffeine	6.57
Vanillic acid	18.79
Caffeic acid	ND *
Syringic acid	3.69
Vanillin	ND
p-Coumaric acid	1.93
Ferulic acid	1.20
Ellagic acid	54.18
Benzoic acid	ND
o-Coumaric acid	2.37
Salicylic acid	4.70
Cinnamic acid	ND

* ND = not detected

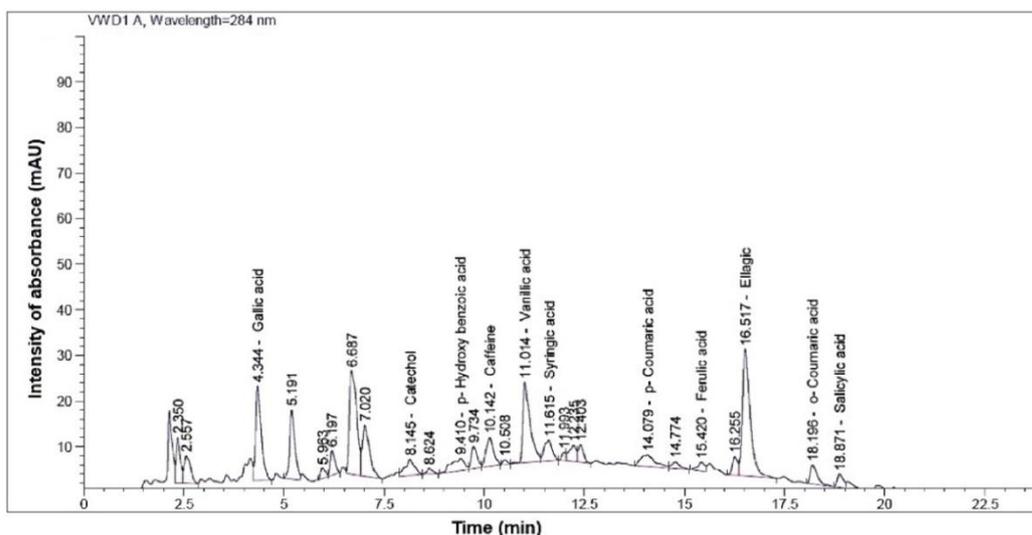


Figure 1 HPLC chromatogram of phenolic compounds and caffeine identified in MALE

2.3. Treatments

The experiment followed randomized complete block design (RCBD) with three replicates for each treatment (4 treatment × 3 replicates = 12 palms). The four treatments were as follows:

- 1- Control (spraying with water only).
- 2- Spraying with moringa extract at 5%.
- 3- Spraying with moringa extract at 6%.
- 4- Spraying with moringa extract at 7%.

All palms in each treatment were sprayed three times (3 hours before pollination then 4 and 8 weeks after pollination). Bunches were sprinkled with a small hand sprayer until run-off.

2.4. Measurements

2.4.1. Fruit set and fruit retention (%)

One month following pollination and at harvesting time, the initial fruit set and fruit retention percentage were recorded. The following equations were used to get fruit set and fruit retention percentage:

$$\text{Fruit set \%} = \frac{\text{Number of fruits setting on the strand}}{\text{Total Number of flowers/strand}} \times 100$$

$$\text{Fruit retention \%} = \frac{\text{Number of retained fruits/strand}}{(\text{Number of retained fruits} + \text{Number of flower scars})} \times 100$$

2.4.2. Fruit physical characteristics

Thirty fruits were picked from each bunch randomly to determine fruit weight (g), flesh weight (g), seed weight(g), fruit volume (cm³), fruit dimensions (fruit length and diameter in cm). Then, fruit shape index (length/diameter) was calculated.

Bunches of each palm were harvested at full mature stage (beginning of September), according to skin color and weighted to determine the yield/palm (kg).

2.4.3. Fruit chemical characteristics

Total soluble solids (TSS %): A hand refractometer was used to determine TSS of date fruit juice [23].

Acidity (%) was determined as malic acid percentage [23].

TSS/acid ratio was calculated.

Total sugars (%) and reducing sugars (%): Flesh weight was used to determine total sugars and reducing sugars percentage according to Lane and Eynon method [23], then after, **non-reducing sugars (%)** were calculated by the difference between both of them.

Statistical analysis

Data were subjected to analysis and COSTAT program was used to statistically assess it for analysis of variance. Then after, Duncan values at a probability of 0.05 were used to compare the significant differences between the whole treatments [24].

3. Results

3.1. Fruit set and fruit retention percentages

Fruit set (%)

Table 3 shows that, foliar application of MALE at 5, 6 and 7% significantly increased the fruit set percentage compared with the control. Spraying 6% MALE produced the best fruit set percentage, with 62.56 % and 64.4 % in both seasons, respectively. During the study's two seasons, control treatment gave the lowest fruit set % (55.93% and 57.46%, respectively).

Fruit retention (%)

Concerning fruit retention% (Table 3), spraying MALE at 6% recorded the highest value of fruit retention% (40% and 41.1%) in the 1st and 2nd seasons as compared with the control and rest of treatments. Nevertheless, the lowest fruit retention% was obtained from control which gave 33.7% and 35.2% in the two seasons.

Table 3 Influence of foliar spray with MALE on fruit set and retention of Selmy date palms.

Treatments	Fruit set (%)		Fruit retention (%)	
	2018	2019	2018	2019
T ₁ Control	55.93c	57.46d	33.7	35.20d
T ₂ Moringa	59.26b	60.20c	35.93c	37.00c

extract at 5 %

T ₃ Moringa extract at 6 %	62.56a	64.40a	40.00a	41.10a
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T ₄ Moringa extract at 7 %	60.13b	61.50b	38.00b	37.73b
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3.2. Fruit physical characteristics

Fruit weight (g)

Significantly, an increase in fruit weight was observed in Selmy date palms treated with MALE at 5, 6 and 7% in the two seasons of the study in comparison with the control. The highest fruit weight was recorded from palms treated with MALE at 6% which gave 18.2 and 18.6 g followed by MALE at 5% which exhibited 17.3 and 16.5 g in both seasons. On the other hand, the control palms gave the lowest fruit weight (13.2 and 13.8 g) in both seasons, respectively.

Flesh weight (g)

Results in Table 4 show that, flesh weight was significantly increased when the spathes were sprayed with moringa extract at 5, 6 and 7% in both seasons of the study as compared with the control. The highest flesh weight was produced from T₃ (MALE at 6%) which gave 16.76 and 17.16 g, then after T₂ which exhibited 15.8 and 15.0 g in the two seasons. Meanwhile, the control ranked the lowest flesh weight (11.5 and 12.2 g) in the 1st and 2nd seasons.

Seed weight (g)

When the spathes were sprayed with MALE at 5, 6, and 7 % compared with the control in the 1st season, the results in Table 4 shows that seed weight wasn't altered considerably. Otherwise in the second season, the lowest seed weight was recorded from T₃ (MALE 6%). It exhibited 1.43 g, while the lowest seed weight was obtained from the control which gave 1.6 g.

These results are in a line with those obtained on "Kinnow" mandarin [25], on "Khadrawi" date palm [17], where spraying MALE increased weight of fruit and pulp.

Bunch weight and yield/palm (kg)

Results in Table 4 indicate that, spraying MALE at 5, 6 and 7% significantly increased bunch weight in comparison with the control in the two seasons. Spraying palms with MALE at 6% ranked the 1st value of bunch weight, which recorded 11 and 11.36 kg, while the lowest bunch weight was exhibited from the control which gave 9.4 and 9.6 kg in the 1st and 2nd seasons, respectively.

It is evident from the results in Table 4 that all treatments had substantial impact on the yield/palm

of Selmy date palm in both seasons. Furthermore, spraying trees with MALE at 6% gave the best yield (110 and 113.66 kg) in the first and second seasons, respectively. Results clear that control gave the

minimum yield/palm (94 and 96 kg) in both seasons of the study.

Table 4 Influence of foliar spray with MALE on some physical characteristics, and yield of Selmy date palms

Treatments	Fruit weight (g)		Flesh Weight (g)		Seed weight (g)		Bunch weight (kg)		Yield/palm (Kg)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
T ₁ Control	13.23d	13.80d	11.53d	12.20d	1.66a	1.60a	9.40c	9.60d	94.00c	96.00d
T ₂ Moringa extract at 5 %	17.33b	16.53b	15.80b	15.03b	1.53ab	1.50b	10.13b	10.30c	101.33b	103.00c
T ₃ Moringa extract at 6 %	18.20a	18.60a	16.76a	17.16a	1.43b	1.43c	11.00a	11.36a	110.00a	113.66a
T ₄ Moringa extract at 7 %	16.33c	15.53c	14.83c	14.03c	1.50ab	1.50b	10.20b	10.60b	102.00b	106.00b

Fruit length (cm)

Results in Table 5 clearly show that, spraying MALE, significantly increased fruit length than the control treatment in both seasons. The highest fruit length was obtained from palms sprayed with MALE at 6% which exhibited 4.33 and 4.36 cm in the two seasons. Meanwhile, the lowest fruit length was obtained from the control, which gave 3.80 and 3.96 cm during the two seasons.

Fruit diameter (cm)

In this concern, results in Table 5 indicate that spraying MALE at 6% concentration significantly increased fruit diameter than at 5% or the control in the first season. Also, spraying MALE at 5, 6 and 7% had significantly increased the fruit diameter in comparison with the control in the second season.

Fruit shape index

Table 5 Influence of foliar spray with MALE on some physical characteristics of Selmy date palms.

Treatments	Fruit length (cm)		Fruit diameter (cm)		Fruit shape Index		Fruit volume (cm ³)	
	2018	2019	2018	2019	2018	2019	2018	2019
T ₁ Control	3.80c	3.96c	2.53b	2.60b	1.50a	1.52b	14.00d	14.00d
T ₂ Moringa extract at 5 %	4.13b	4.13b	2.63ab	2.63b	1.56a	1.56ab	17.20b	16.23b
T ₃ Moringa extract at 6 %	4.33a	4.36a	2.73a	2.73a	1.58a	1.59ab	17.63a	18.23a
T ₄ Moringa extract at 7 %	3.93c	4.26ab	2.53b	2.60b	1.55a	1.63a	15.90c	15.20c

3.3. Fruit chemical characteristics

Table 6 shows the effect of MALE on fruit chemical properties of Selmy date palms in 2018 and 2019 seasons.

Total soluble solids contents (%)

Different concentrations of MALE significantly increased TSS content in both seasons. Highest content of TSS% (34.66 and 35%) was observed from foliar application with 6% MALE in the 1st and

Results in Table 5 indicate that there was insignificant effect between all treatments and the control on fruit shape index in the first season of the study. While in the second season, foliar spray with MALE at 7% significantly increased it as compared with the control.

These findings are consistent with those obtained by [17, 18, 25].

Fruit volume (cm³)

Results in Table 5 show that fruit volume was significantly increased by all treatments as compared with the control during the study's two seasons. The highest fruit volume was recorded from spraying MALE at 6%, which gave 17.63 and 18.23 cm³. In the meantime, the lowest fruit volume was obtained from the control, since it exhibited 14.0 cm³ in both seasons, respectively.

2nd seasons, respectively, whereas the lowest TSS% content (26.66 and 27.33%) was observed with the control during the two seasons of the study.

Titrateable acidity (%)

Titrateable acidity percentage was decreased with increasing MALE concentration. No significant difference between applying MALE at 5, 6 and 7% was observed in the two seasons.

TSS/acid ratio

The ratio between TSS and acidity was significantly increased with the increase in MALE

concentration. Highest TSS/acid ratio was observed from foliar application of 6% MALE (115.5 and 125) in the 1st and 2nd seasons, whereas the lowest TSS/acid ratio was recorded by the control (65.5 and 68.9) during the two seasons.

Total sugars (%)

As shown in Table 6, all treatments had a significant difference in total sugars % in both seasons. However, spraying trees with MALE at 6% gave the highest total sugars (46.9 and 50 %) in both seasons, respectively. Besides, the lowest total sugars% was obtained from the control (36.3 and 36.7 %) during the two seasons.

Reducing sugars (%)

In this regard, results in Table 6 show that bunches treated with 6% MALE had a significant increase in reducing sugars % in comparison with the untreated

bunches. Spraying MALE at 6% recorded the highest reducing sugars values (35.3 and 38 %). However,

control treatment exhibited the lowest reducing sugars values (27.2 and 27.4 %) in both seasons, respectively.

Non- reducing sugars (%)

As shown in Table 6 results indicate that, foliar application of MALE considerably enhanced non-reducing sugars percentage in both seasons when compared with the control. The highest non-reducing sugars % was obtained when palms treated with MALE at 6% which gave 11.6 and 12 % in both seasons, whereas the lowest non-reducing sugars value (9.06 and 9.3 %) was obtained from the untreated palms in the 1st and 2nd seasons, respectively.

Table 6 Influence of foliar spray with MALE on chemical characteristics of Selmy date palms.

Treatments	TSS (%)		Acidity (%)		TSS/acidity ratio		Total sugars (%)		Reducing sugars (%)		Non reducing sugars (%)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
T ₁ Control	26.66c	27.33c	0.40a	0.39a	65.56c	68.9c	36.30c	36.70c	27.23c	27.40c	9.06c	9.30c
T ₂ Moringa extract at 5 %	30.00bc	31.33b	0.32b	0.30b	93.83b	103.26b	42.33b	44.00b	31.46b	32.93b	10.86b	11.06b
T ₃ Moringa extract at 6 %	34.66a	35.00a	0.30b	0.28b	115.56a	125.00a	46.93a	50.00a	35.33a	38.00a	11.60a	12.00a
T ₄ Moringa extract at 7 %	33.00ab	33.33ab	0.30b	0.28b	110.00a	118.90a	46.72a	48.99a	35.06a	37.16a	11.66a	11.83a

4. Discussion

The MALE contents from proteins, vitamins, β -carotene, phenolic, sugars and minerals (Ca, Mg, Fe, Na, P and K) as well as, specific hormones (auxin, gibberellins and cytokinins), may promote the internal mechanisms to control the fruit set and ovarian abscission and may be responsible for the increase in fruit set and fruit retention percent [26]. These findings corroborated those discovered that foliar treatment of MALE during the fruit set stage increased fruit set and decreased fruit drop [16].

The acquired results in terms of production and fruit physical features could be attributable to the high zeatin concentration of MALE. It described in plant as one of the most frequent types of naturally cytokinin, and it plays a key role in cell division and cell elongation, which stimulates plant development and has anti-aging and protective properties. MALE also contains proteins, vitamins (A, B group and E), β -carotene, phenolic amino acids, carbohydrates, minerals, numerous flavonoid pigments, and ascorbic acid, all of which help boost crop growth and yield [27 and 28]. In this respect, the findings are close to those cleared that spraying MALE at 4, 5 and 6% on "Hollywood" plum trees enhanced yield compared with the control treatment [18]. In this concern,

spraying date palm bunches with MALE gave the best results of yield [17]. The high potassium and zinc levels in MALE are also credited with the rise in fruit weight, length, and diameter. Potassium enhances the production and transfer of carbohydrates from the shoot to fruits (storage organs) and carbohydrate enzymes, which improves fruit quality [29].

The high sugars and starch content of *Moringa oleifera* leaves contributed to the increase in TSS content, acidity, and the ratio between them in Selmy date palm as a reaction to MALE treatment. Aside from, the extract of leaves contains lots of cytokinin, which promotes carbohydrate metabolism and the formation of new source-sink interactions, resulting in an increase in the concentration of fruit soluble solids [30].

Natural plant extracts, in general considered as an excellent approach to supply nutrients and other chemicals to plants. They need to grow and thrive. Many trace elements that plant requires are not available in most chemical formulations and are found in natural plant extracts.

5. Conclusions

Foliar application of MALE not only decreased the fruit drop%, but also raised fruit set%, yield, fruit

weight, fruit dimension, soluble solids content, total and reducing sugars % of Selmy date palms. Therefore, it could be concluded that foliar application with MALE at 6% (3 hours before pollination then 4, 8 weeks after pollination) as a bio-stimulants is low-cost supplier of plant growth hormones and minerals in particular with the organic farming trend of Selmy date palms.

6. List of abbreviations

MALE: Moringa aqueous leaf extract, **TSS:** Total Soluble Solids and **RCBD:** Randomized complete block design.

7. Conflicts of interest

There are no conflicts to declare.

8. Formatting of funding sources

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