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Benefits of different sources and concentrations of potassium and calcium foliar spray on yield and fruit quality of Medjool date palms

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Abstract

This research was run out during 2019 and 2020 seasons, and included two experiments, to study the effect of potassium (K) and calcium (Ca) as a foliar spray on yield and fruit quality of Medjool date palms. Inflorescences of Medjool date palms were sprayed three times (after fruit set then at the beginning of Kimri stage and the third at Khelal stages) in the first experiment with potassium citrate (KC) or potassium nitrate (KN) at 1, 2 and 3%, while in the second experiment, the inflorescences were sprayed with calcium nitrate (CaN) or calcium chloride (CaC) at 0.5, 1 and 1.5%. From the first study results, foliar spray with KN at 3% could be used to improve fruit yield and quality of Medjool dates. In the second study, it could be recommend tospray date palms with CaN at 1% or spraying CaC with 0.5% to obtain a high yield with good fruits properties.

Keywords: Medjool date palm, fruit properties, potassium citrate, potassium nitrate, calcium nitrate, calcium chloride, yield.

1. Introduction

The date palm (*Phoenix dactylifera* L.) is an ancient domestic fruit crop found in Middle Eastern countries, and its fruits play an essential role in many people's diets. It has long played a significant part in the people's economic and social lives in these areas. In Egypt, total harvested area of dates attained about 50834 ha with total production of 1690959 tons [1]. It is generally recognized that date palm nutrient requirements can be met during fertilizer application for interplant crops, although this pattern of application dependents on soil texture and interplant crops. Aside from that, the nutrient requirements of date palms vary substantially depending on their stage of life [2].

Foliar application may be a possible alternative for highly mobile nutrient [3]. Spraying potassium (K) has a significant impact on fruit set production and quality since it regulates a variety of physiological and biochemical processes within the plant. Also, it improves nutrient status, increases salt tolerance [4], plays a necessary role in proteins and amino acids synthesis, furthermore sugar translocation and assimilates inside the plant plus accumulating of carbohydrates [5]. Further, at the plant tissues K level controls the cell water content and carbohydrate biosynthesis [6, 7], as well as nitrogen (N) uptake and translocation from the roots to the areal parts [8].

Calcium (Ca) plays an important role in fruit quality production. It has a limitation of availability in the soil because of soil related constraints like adverse soil pH, poor soil structure and due to its lesser mobility in soil, etc. In other cases, the absorbed nutrient is inadequately translocated inside the plant; in these cases, adding these nutrients to the soil is ineffective, and foliar feeding is the best option for supplementing the nutrient demand [9]. Spraying macro and micro nutrients had a significant impact on fruit set, retention, and development, as well as improving yield and fruit quality [10]. Because of Ca is essential for cell elongation and cell division, it is one of the most critical minerals in determining fruit quality [11]. Except for the addition of small manures in the winter as a source of trace elements, little attention has been devoted to nutrient elements, particularly Ca^{+2}, for palm nutrition, especially those planted on sandy soil. Ca's main function is to prevent the establishment of an abscission zone between fruit pedicles and bearing branches, as well

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as to regulate enzyme activity and photosynthesis [12].

The purpose of this research was to study the effect of spraying potassium citrate (KC) and potassium nitrate (KN) in the 1st experiment, and calcium nitrate (CaN) and calcium chloride (CaC) in the 2nd experiment on palm yield and fruit quality of Medjool dates as results of the high economic values of this cultivar and the lack of previous studies on managing K and Ca nutrients imbalances of date palm production.

2. Materials and methods

The research was carried out during two seasons (2019 and 2020) on 15 years old date palms (*Phoenix dactylifera* L.) Medjool cv. grown on sandy soil at 6×6 meters apart under drip irrigation system in a private orchard located at 63 km from Cairo-Alexandria desert road, Egypt.

Healthy palms were chosen, they had approximately uniform growth vigour and fruiting, and all of them were subjected to the same horticultural practices. Furthermore, pruning was done to keep the ratio of bunch/mature leaves at 1:8 by removing extra earliest, latest, and smallest inflorescences, also number of spathes per palm was reduced to ten bunches. To avoid metaxenic effects, artificial pollination was used with only one source of pollen grains over the two study seasons.

Treatments

The study included two independent experiments. Twenty-one palms for each study were selected and divided into seven treatments in three replicates (one palm per each). Then, they were arranged in a randomized complete block design (RCBD). The following treatments were managed:

First experiment treatments

1- Control (sprayed with water only).
2- Potassium citrate at 1%.
3- Potassium citrate at 2%.
4- Potassium citrate at 3%.
5- Potassium nitrate at 1%.
6- Potassium nitrate at 2%.
7- Potassium nitrate at 3%.

Second experiment treatments

1- Control (sprayed with water only).
2- Calcium nitrate at 0.5%.
3- Calcium nitrate at 1%.
4- Calcium nitrate at 1.5%.
5- Calcium chloride at 0.5%.
6- Calcium chloride at 1%.
7- Calcium chloride at 1.5%.

Palms were sprayed three times: the 1st spray was carried out after fruit set, then the 2nd spray at the beginning of Kimri stage, and the 3rd spray at the beginning of fruit color break (Khelal stage), respectively. Spraying was applied in the morning by a hand sprayer using Triton B as a wetting agent.

Measurements

Fruit physical and chemical characteristics:

At the beginning of October in both seasons (when the fruits reached Tamer stage), bunches were harvested and the average of bunch weight and fruit yield (kg/tree) were recorded. Then, thirty fruits as a sample were picked from each bunch randomly to determine the physiochemical characteristics as following:

1. Fruit physical characteristics:

Average of fruit weight was recorded, then the other fruit properties were measured [length (cm), diameter (cm), shape index (L/D)]. Finally, flesh and seeds were weighed (g).

2. Fruit chemical characteristics:

Total soluble solids percentage (TSS %) in fruit juice was determined by hand refractometer. Furthermore, acidity was determined as malic acid percentage due to the method described [13] and TSS/ acid ratio was calculated.

Total sugars (%) were determined in methanol extract using the phenol sulphoric acid method and the percentage was calculated on fresh weight basis [14].

Also, reducing sugars (%) were determined using methanol extract [13]. Then after, non-reducing sugars (%) were calculated by the difference between total and reducing sugars.

Statistical analysis

Data were tabulated and COSTAT program was used to the statistical assess of the calculated data for analysis of variance. Then after, Duncan values at probability of 0.05 were used to compare the significant differences among the various treatments [15].

3. Results

First experiment

1. Fruit physical characteristics:

Bunch weight (kg)

In this respect, the obtained results in Table 1 indicate that, T_7 recorded the best value (12.4 and 12.9 kg) in the 1st and 2nd seasons, respectively, followed by T_4 which recorded 11.3 kg in the first season and T_6 12.3 kg in the second one. However, T_1 gave the lowest values (10.1 and 10.3 kg) in both seasons.

Yield/palm (kg)

The results in Table 1 clear that, T_7 gave the highest yield/palm (124 and 129 kg/palm) followed by T_6 which recorded 113 and 123 kg/palm in both seasons of the study. However, T_1 gave the least values (101 and 103 kg/palm) during both seasons of the study.

Fruit weight (g)

Palms treated with T_7 were significantly higher in the average of fruit weight (25.06 and 27.26 g) in the 1st and 2nd seasons, respectively followed by T_4 which gave 23.33 and 23.80 g in the two seasons. In this respect, T_1 (control) recorded the lowest value (18.63 g) in both seasons.

Flesh weight (g)

The results indicate that T_7 gave the highest significant value (23.63 and 26.06 g) in Tamer stage during the two seasons of the study, respectively, followed by T_4 which recorded 21.86 and 22.60 g in the 1st and 2nd seasons, respectively. On the contrary, T_1 (control) recorded the lowest fruit flesh weight (17.06 and 17.33 g) in the 1st and 2nd seasons.

Seed weight (g)

Results in Table 1 show that the average seed weight was affected in the 1st season; however, there was no significant change in the second season.

Fruit length (cm)

Results in Table 2 indicate that fruit length of Medjool cultivar was significantly affected by foliar spray with KC and KN at 1, 2 and 3% in the studied seasons. In this concern, the highest fruit length was obtained from T_7 which recorded 6.10 and 5.26 cm, followed by T_6 which gave 6.03 and 5.13 cm in both seasons of the study. While, T_1 (control) produced the lowest fruit length (5.03 and 4.63 cm) in the two seasons of the study.

Fruit diameter (cm)

Table 2 shows that different treatments had a substantial impact on the fruit diameter of the Medjool date palms when compared to T_1 (control) in the two seasons. In both seasons the best results were obtained from T_7 (3.56 and 3.00 cm), followed by T_4 (3 cm) in both seasons, respectively. While the lowest fruit diameter was recorded from T_1 which gave 2.76 and 2.83 cm.

Fruit shape index

Table 2 shows in the first season that different treatments had a substantial impact on the fruit shape index, while in the second one fruit shape index lacked significance among all treatments.

2. Fruit chemical characteristics:

Total soluble solids percentage (TSS %)

Results presented in Table 3 show that all foliar sprays of KC and KN at 1, 2 and 3%, increased significantly the total soluble solids as compared with the control. The highest total soluble solids were obtained from T_7 which recorded 38.8 and 39 %, while the lowest TSS% was produced from T_1 which gave 27.5 and 29 % in the two seasons of the study.

Total acidity percentage (%)

Results in Table 3 indicate that all foliar sprays with KC and KN at 1, 2 and 3% decreased significantly the total acidity percentage as compared with the control. The highest total acidity percentage was recorded from T_1 which produced 0.59 and 0.46 % in both seasons, respectively, while the lowest total acidity percentage was obtained from T_7 in the first season. Meanwhile, the lowest total acidity percentage was produced from T_2 and T_3 which gave 0.29 %.

TSS/acid ratio

Table 3 shows that in both seasons of the study, all treatments had a significant effect on the TSS/acid ratio when compared to the control. T_7 had the greatest TSS/acid ratio in the 1st season with 137, while T_6 had the highest TSS/acid ratio in the 2nd season (121.56). Meanwhile, the lowest TSS/acid ratio was obtained from T_1 which produced 46.6 and 63 in both seasons, respectively.

Total sugars (%)

Results in Table 3 indicate that all foliar sprays with KC or KN at 1, 2 and 3% increased significantly total sugars % as compared with the control in the two seasons of the study. Palms treated with T_7 show an increase in total sugars in the fruits at Tamer stage which recorded 61.59 and 61.3 % in the first and second seasons, respectively. On the contrary, the untreated palms T_1 gave the lowest value (44 and 44.7 %) in this study.

Reducing sugars (%)

The results in Table 3 show that different treatments had a substantial impact on reducing sugars when compared to the control. The highest reducing sugars percentages was obtained from T_7 which recorded 43.43 and 43.23 % in the two seasons of the study. While as, the lowest reducing sugars percentage (30 and 32 %) was obtained from T_1 in the 1st and 2nd seasons, respectively.

Non-reducing sugars (%)

Regarding non-reducing sugars, the results in Table 3 indicate that all treatments had a significant effect on the content of non-reducing sugars in the fruit during the studied seasons since T_7 produced the best values (18.16 and 18.1 %), However T_1 (control) ranked the last values (14 and 12.7 %) in the 1st and 2nd seasons, respectively.

Second experiment

1. Fruit physical characteristics:

Bunch weight (kg)

In regard of bunch weight, the results in Table 4 show that all treatments increased significantly bunch weight and yield/ palm especially in comparison to T_1

(control) in both seasons of the study. The heaviest bunch was obtained from T_3 (calcium nitrate at 1%) which produced 12.7 and 13.0 kg in the two seasons of the study, followed by T_4 (Calcium nitrate at 1.5%) which produced 11.9 and 12.06 kg in the 1st and 2nd seasons, respectively. While T_1 (control) gave the lowest value of bunch weight (10.3 and 10.5 kg) in both seasons, respectively.

Yield/palm (kg)

It is evident from the results presented in Table 4 that yield/palm was significantly affected by different concentrations of calcium chloride and calcium nitrate in both seasons when compared with the control. The highest yield/palm was found by T_3 (calcium nitrate 1%) which recorded 127 and 130 kg followed by T_4 (calcium nitrate 1.5%) which gave 119 and 120 kg, Meanwhile, the lowest yield/palm was obtained from T_1 (control) which gave 103 and 105 kg in both seasons of the study. Other tested treatments gained intermediate results.

Fruit weight (g)

Results in Table 4 clear that, fruit weight was significantly affected by different concentrations of calcium chloride and calcium nitrate in comparison to the untreated palms (T_1) in the two seasons of the study. T_3 ranked the 1st in fruit weight which gave 29.7 and 30.53 g, followed by T_4 (24.36 and 25.03 g) in the two seasons of the study. While as, the lowest fruit weight (18.96 and 19.53 g) was recorded from T_1 (control) in the first and second seasons, respectively.

Flesh weight (g)

Flesh weight was affected significantly by different concentrations of calcium chloride and calcium nitrate in comparison to the control in the two seasons. The highest flesh weight was produced from T_3 (calcium nitrate at 1%) which recorded 28.53 and 29.33 g, followed by T_4 (calcium nitrate at 1.5%) which produced 23.06 and 23.8 g in the 1st and 2nd seasons, respectively, while the lowest value of flesh weight (17.7 and 18.16 g) in the two seasons was recorded due to the control treatment. The other tested treatments come in between.

Seed weight (g)

Results in Table 4 indicate that the highest value of seed weight (1.3 g) was produced from T_4 (calcium nitrate at 1.5%) in the first season, while in the second season the highest value of seed weight was obtained from T_1 (control) which gave (1.36 g). While the lowest value of seed weight was recorded from T_3 (calcium nitrate at 1%) which gave 1.16 and 1.20 g in the 1st and 2nd seasons, respectively.

Fruit length (cm)

Results in Table 5 reveal that, fruit length was affected significantly by different treatments especially when compared with the control in the 1st and 2nd seasons. T_4 (calcium nitrate 1.5%) recorded the best fruit length 4.83 and 5 cm, followed by T_3 (calcium nitrate 1%) which gave 4.5 and 4.6 cm in the two seasons of the study. While as, the lowest fruit length (3.96 and 4.23 cm) was produced from T_1 (control) in the 1st and 2nd seasons, respectively. The other tested treatments came in between.

Fruit diameter (cm)

Results in Table 5 show that, in the studied seasons all treatments affected significantly the fruit diameter in compared with the control. The highest fruit diameter was obtained from T_4 (calcium nitrate 1.5%) which recorded 3.4 and 3.5cm, followed by T_3 (calcium nitrate 1%) which gave 3.2 and 3.3 cm, while, the lowest fruit diameter was found with T_1 (control) which produced 2.76 and 2.9 cm in the 1st and 2nd seasons, respectively. Also, results in Table 5 clear that fruit length and diameter were not affected significantly by calcium chloride at 0.5, 1 and 1.5 % during the both seasons of the study.

Fruit shape index

In both seasons of the study, results in Table 5 show that, all treatments did not affect significantly this paramter.

2. Fruit chemical characteristics:

Total soluble solids percentage (TSS %)

Results show in Table 6 indicate that, all calcium spray treatments significantly increased total soluble solids (TSS), during both seasons when compared with T_1 (control). The best TSS percentage was recorded from T_5 (calcium chloride at 0.5%) since it gave 38 and 39.6 %, followed by T_4 (calcium nitrate at 1.5%) which recorded 36.5 and 37.9 %, while the lowest value of total soluble solids was produced from T_1 (control) which gave 27.5 and 26 % in the two experimental seasons, respectively. The other tested treatments came in between.

Total acidity percentage (%)

All treatments produced less acidity than the control. The highest acidity % was obtained from T_1 (control) which recorded 0.36 and 0.37 % in the first and second seasons, respectively. The other tested treatments gained intermediate.

TSS/acid ratio (%)

Results in Table 6 clear that all treatments increased significantly TSS/acid ratio as compared to the control in both seasons of the study. The highest value was found due to T_5 (calcium chloride at 0.5%) which gave 118.8 and 125.4 in both seasons of the study, followed by T_4 (calcium nitrate at 1.5%) which resulted 117.8 in the first season and T_6 (calcium chloride at 1%) which recorded 114.7 in the second season. While as, the lowest TSS/acid ratio was obtained from T_1 (control) which produced 78.7 and 70.8 in the two seasons of the study.

Table 1 Effect of foliar spray with potassium citrate and potassium nitrate on yield and some physical characteristics of Medjool date palms fruit.

Treatments		Bunch weight (kg)		Yield/palm (Kg)		Fruit weight (g)		Flesh weight (g)		Seed weight (g)	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
T_1	Control	10.1e	10.3g	101e	103g	18.63f	18.63e	17.06e	17.33e	1.56a	1.30a
T_2	Potassium Citrate at 1 %	10.4d	10.6f	104d	106f	20.66e	22.96d	19.26d	21.70d	1.40b	1.26a
T_3	Potassium Citrate at 2 %	10.7c	11.0e	107c	110e	22.23c	23.33cd	20.83c	22.10cd	1.40b	1.23a
T_4	Potassium Citrate at 3 %	11.3b	11.6d	113b	116d	23.33b	23.80c	21.86b	22.60c	1.46ab	1.20a
T_5	Potassium Nitrate at 1 %	10.7c	11.9c	107c	119c	21.50d	23.63cd	20.00d	22.36c	1.50ab	1.26a
T_6	Potassium Nitrate at 2 %	11.3b	12.3b	113b	123b	23.13b	24.76b	21.66b	23.66b	1.46ab	1.10b
T_7	Potassium Nitrate at 3 %	12.4a	12.9a	124a	129a	25.06a	27.26a	23.63a	26.06a	1.43b	1.20a

Table 2 Effect of foliar spray with potassium citrate and potassium nitrate on fruit length, fruit diameter and fruit shape index of Medjool date palms.

Treatments		Fruit length (cm)		Fruit diameter (cm)		Fruit shape index	
		2019	2020	2019	2020	2019	2020
T_1	Control	5.03e	4.63d	2.76d	2.83b	1.82bc	1.66a
T_2	Potassium Citrate at 1 %	5.50d	4.90c	2.96c	2.93ab	1.88ab	1.67a
T_3	Potassium Citrate at 2 %	5.73c	4.83cd	2.96c	2.90ab	1.93a	1.66a
T_4	Potassium Citrate at 3 %	5.86bc	5.00bc	3.06c	3.00a	1.89ab	1.67a
T_5	Potassium Nitrate at 1 %	5.90abc	4.90c	3.26b	2.90ab	1.81bc	1.70a
T_6	Potassium Nitrate at 2 %	6.03ab	5.13ab	3.46a	2.90ab	1.74cd	1.78a
T_7	Potassium Nitrate at 3 %	6.10a	5.26a	3.56a	3.00a	1.71d	1.75a

Table 3 Effect of foliar spray with potassium citrate and potassium nitrate on fruit chemical characteristics of Medjool date palms.

Treatments		TSS (%)		Acidity (%)		TSS/acidity ratio		Total sugars (%)		Reducing sugars (%)		Non-reducing sugars (%)	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
T_1	Control	27.5f	29.0d	0.59a	0.46a	46.6f	63b	44.0f	44.7d	30.0e	32.0d	14.0b	12.7c
T_2	Potassium Citrate at 1 %	31.2e	31.83cd	0.56b	0.29c	55.7f	110.66a	48.5e	48.6cd	32.0d	34.16cd	16.5ab	14.5bc
T_3	Potassium Citrate at 2 %	34.0c	35.2abc	0.40d	0.29c	85.03d	118.7a	51.5d	50.3cd	35.0c	35.16cd	16.5ab	15.16bc
T_4	Potassium Citrate at 3 %	35.7b	37.5a	0.35e	0.40ab	102.03c	93.7b	54.0c	57.5ab	39.5b	42.5ab	14.5b	15.0bc
T_5	Potassium Nitrate at 1 %	32.9d	33.5bc	0.47c	0.32bc	70.06e	104.13a	47.6d	53.5bc	32.0d	37.73bc	15.6ab	15.7ab
T_6	Potassium Nitrate at 2 %	36.0b	36.83ab	0.30f	0.30bc	120.73b	121.56a	56.0b	57.3ab	40.3b	41.56ab	15.6ab	15.7ab
T_7	Potassium Nitrate at 3 %	38.8a	39.0a	0.28f	0.33bc	137.00a	118.63a	61.59a	61.3a	43.43a	43.23a	18.16a	18.1a

Table 4 Effect of foliar spray with calcium nitrate and calcium chloride on yield and some physical properties of Medjool date palms fruit.

Treatments		Bunch weight (kg)		Yield/palm (Kg)		Fruit weight (g)		Flesh weight (g)		Seed weight (g)	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
T_1	Control	10.30d	10.50d	103d	105d	18.96e	19.53e	17.7e	18.16e	1.26ab	1.36a
T_2	Calcium Nitrate at 0.5 %	11.16c	11.40c	111.6c	114c	21.9c	22.26c	20.7c	21.0c	1.20bc	1.26bc

T_3	**Calcium Nitrate at 1%**	12.7a	13.00a	127a	130a	29.70a	30.53a	28.53a	29.33a	1.16c	1.20c
T_4	**Calcium Nitrate at 1.5 %**	11.9b	12.06b	119b	120.6b	24.36b	25.03b	23.06b	23.8b	1.30a	1.23bc
T_5	**Calcium Chloride at 0.5 %**	11.40c	11.50c	114c	115c	20.43d	20.8d	19.2d	19.6d	1.23abc	1.20c
T_6	**Calcium Chloride at 1 %**	11.70b	11.86b	117b	118.6b	21.66c	21.76c	20.4c	20.46c	1.26ab	1.30ab
T_7	**Calcium Chloride at 1.5 %**	11.43c	11.60c	114.3c	116c	20.20d	20.6d	18.96d	19.36d	1.23abc	1.23bc

Table 5 Effect of foliar spray with calcium nitrate and calcium chloride on fruit length, fruit diameter and fruit shape index of Medjool date palms.

Treatments		**Fruit length (cm)**		**Fruit diameter (cm)**		**Fruit shape index**	
		2019	**2020**	**2019**	**2020**	**2019**	**2020**
T_1	**Control**	3.96d	4.23d	2.76c	2.9d	1.44a	1.46a
T_2	**Calcium Nitrate at 0.5 %**	4.30c	4.46bc	2.9bc	3.06c	1.46a	1.44a
T_3	**Calcium Nitrate at 1 %**	4.50b	4.6b	3.2a	3.36b	1.40a	1.38a
T_4	**Calcium Nitrate at 1.5 %**	4.83a	5.0a	3.4a	3.5a	1.42a	1.41a
T_5	**Calcium Chloride at 0.5 %**	4.26c	4.26cd	2.9bc	3.03c	1.48a	1.40a
T_6	**Calcium Chloride at 1 %**	4.30c	4.33cd	2.96b	3.06c	1.44a	1.39a
T_7	**Calcium Chloride at 1.5 %**	4.40bc	4.36cd	3.0b	3.03c	1.46a	1.42a

Table 6 Effect of foliar spray with calcium nitrate and calcium chloride on fruit chemical characteristics of Medjool date palms

Treatments		**TSS (%)**		**Acidity (%)**		**TSS/acidity ratio**		**Total sugars (%)**		**Reducing sugars (%)**		**Non-reducing sugars (%)**	
		2019	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
T_1	**Control**	27.5d	26.0d	0.36a	0.37a	78.73d	70.8d	44.00c	44.76d	30.00c	32.00d	14.0a	12.7c
T_2	**Calcium Nitrate at 0.5 %**	30.5cd	30.8c	0.35ab	0.37a	85.13cd	81.9d	46.50c	46.00cd	33.83bc	33.83cd	12.6a	12.6c
T_3	**Calcium Nitrate at 1 %**	32.0bc	34.7b	0.34ab	0.34ab	92.53bc	101.26c	53.16a	54.00ab	39.16a	38.83abc	14.0a	15.16a
T_4	**Calcium Nitrate at 1.5 %**	36.5a	37.9a	0.31c	0.35ab	117.80a	108.6bc	51.66ab	52.16abc	37.66ab	38.16abc	14.0a	14.0abc
T_5	**Calcium Chloride at 0.5 %**	38.0a	39.6a	0.32bc	0.31b	118.86a	125.4a	55.33a	57.00a	41.33a	42.66a	14.0a	14.3ab
T_6	**Calcium Chloride at 1 %**	35.0ab	36.6ab	0.30c	0.32b	115.43a	114.7ab	54.00a	55.20ab	39.00a	40.86ab	15.0a	14.3ab
T_7	**Calcium Chloride at 1.5 %**	29.7cd	31.6c	0.30c	0.32b	98.03b	99.0c	48.00bc	49.66bcd	34.00bc	36.00bcd	14.0a	13.6bc

Total sugars (%)

Results in Table 6 show that all treatments increased substantially total sugars as compared with T_1 (control) in both seasons of the study. The highest value of total sugars % was found with T_5 (calcium chloride 0.5%) which gave 55.3 and 57 %, followed by T_6 (calcium chloride 1%) which recorded 54 and 55.2 % and T_3 (calcium nitrate 1%) since it gave 53.16 and 54 % in the 1st and 2nd season, respectively. On the contrary, T_1 (control) gave 44.0 and 44.7 % in the two seasons of the study, which is considered as the lowest total sugars %.

Reducing sugars (%)

Results in Table 6 show that all treatments significantly increased reducing sugars as compared to the control in all seasons of the study. The highest value of reducing sugars was found with T_5 (calcium chloride at 0.5%) which recorded 41.33 and 42.66 %, while the lowest value of reducing sugars was recorded from T_1 (control) since it gave 30 and 32 % in the 1st and 2nd seasons, respectively. The other tested treatments came in the middle.

Non-reducing sugars (%)

Results in Table 6 clear that no significant differences were observed among all treatments including the control in the 1st season only. While, in the 2nd season the highest value of non-reducing sugars was exhibited from T_3 (calcium nitrate at 1%) which gave 15.16 %, followed by T_5 (calcium chloride at 0.5%) which gave 14.3 %.

4. Discussion

First experiment

Regarding the role of K in date palm yield, it is a crucial component for production since it is involved in the plant. The physiological role of K in improving various metabolic processes such as glucose synthesis translocation and accumulation could explain that the increase in date palm production is owing to KC and KN, respectively. In response to this opinion, it was found that photosynthesis translocation was influenced by the concentration of cell K [16]. Higher fruit yield in response to K application could be attributed to the role of K in maintaining cell turgidity and cell enlargement [17] or to its role in cytokinins content regulation which controlled of cell division [18]. Furthermore, K plays a key role in up regulation of CO_2 assimilation [19] and carbohydrates translocation [7]. The obtained results are consistent with those discovered previously [20, 21, 22].

The development of fruit physical characteristics including fruit weight, fruit size, fruit dimensions and pulp weight may be related to K action, where it plays a big role in enhancing cell size [23] or to pH stabilisation osmoregulation enzyme activation, protein synthesis, stomatal movement, photosynthesis and cell extension [24, 25]. The obtained results are in agreement with those obtained by previous studies [21, 26, 27], since using of K had a positive impact on yield and fruit physical characteristics of date palm, and gave the best results for fruit dimension and flesh weight.

K could be improved the chemical characteristics of the fruit by activating enzymes involved in sugar production and assisting in sugar translocation, as well as promoting the photosynthesis process [16]. Furthermore, K stimulates about 50 enzymes [28]. The acquired results looked to be very similar to those reported previously [20, 21, 26, 29, 30, 31] concerning TSS, total sugars, reducing and non-reducing sugars percentages.

Second experiment

The improvement in fruit physical characteristics as a result of Ca spray could be interpreted on the basis of its capacity in keeping plants 7 degrees ºF cooler by reflecting heat which reduces stress on the plants and enables basic physiological processes to continue in high temperature [32, 33, 34]. It could also be owing to photosynthesis' high efficiency and these chemicals are linked to hormone metabolism that stimulates the production of auxins which are necessary for fruit set and growth [35].

Furthermore, calcium accumulation in the leaves raises the Ca and other mineral content and this possibly contributing to increase cell division and root growth, which improves nutrient absorption [36, 37, 38].

These findings are matching with those obtained in apple [39], in peach [40], and on date palms [41]. The researchers reported that foliar spray of Ca increased fruit set, fruit weight and consequently increased the yield. Also, spraying bunches of Zaghloul and Samany cv. with calcium carbonate three times increased yield and improved fruit quality [42]. It could be suggested that foliar calcium spray at lower concentration raised apple fruit yield [43, 44].

Concerning fruit chemical characteristics, it is clear that, the rise in total soluble solids %, total sugars %, reducing sugars %, and non-reducing sugars % following Ca sprays could be attributed to this element's involvement in enhancing vegetative developing activities, allowing more nutrients to be absorbed easily [45]. Moreover, Ca has a role in the efficiency of photosynthesis process, thereby increasing manufactured minerals in the leaves which increases fruit and improves components and properties.

5. Conclusions

Yield of Medjool date palm and fruit quality parameters (physiochemical characteristics) were influenced by foliar spray with different sources and concentrations of K and Ca in both experiments in this study. It is clear in the 1st study that, the foliar application of KN at 3% showed a consistent and significant increase in the Medjool yield and fruit characteristics especially total sugars, reducing sugars and non- reducing sugars content comparing to the control and considered to be promising treatment under this experiment conditions. In the 2nd experiment, it could be concluded that spraying inflorescence of Medjool date palms with CaN at 1% three times [after fruit set, at the beginning of Kimri stage and at the beginning of color break (Khelal stage)] increased yield/palm, bunch weight, fruit weight, fruit length and fruit diameter. While using CaC at 0.5% improved fruit chemical properties (TSS %, total sugars % and non-reducing sugars %). It could be recommended to spray CaN at 1% three times under the condition of this experiment.

6. List of abbreviations

K: Potassium, **Ca:** Calcium, **KC:** Potassium Citrate, **KN:** Potassium Nitrate, **CaN:** Calcium Nitrate, **CaC:** Calcium Chloride, **N:** Nitrogen, **TSS:** Total Soluble Solids and **RCBD:** Randomized complete block design

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8. References

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