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RESEARCH ARTICLE

Effect of slow release fertilizers on growth and fruiting of Khalas date palm

Salem, E. H. [1,*] and Hassan A. M. Ali[2]

[1] *Horticulture Department, Faculty of Agriculture & Natural Resources, Aswan University, Aswan, 81528, Egypt*
[2] *Fruit Science, Horticulture Department, Faculty of Agriculture, Beni Suef University, Beni Suef, 62521, Egypt*

Abstract

The current investigation was carried out during 2018 and 2019 seasons to study the effect of some fertilizer practices on yield, fruit quality and some mineral content of Khalas date palm grown in a private farm, Luxor Governorate, Egypt. Results showed that significant improved due to use slow release fertilizers as well as comparing total soluble fertilizers in terms of vegetative growth and nutritional status yield, bunch weight and fruit quality during both seasons. Using 600 g of N and 300 g of K via slow release fertilizers form had improved the growth and nutrient status of date palms as well as increase the fertilization efficiency. Also, it could be suggested that fertilizing by 60 to 75 of RDN and RDK via slow release fertilizers to improve the nutrient status of palm and gave the high bunch weight and consequently high yield/palm. Moreover, these fertilization treatments via slow release form gave high yield with good fruit quality compared with using 100% of RDN and RDK via mineral source during both studied seasons. On the light of previous results, it could be concluded that Fertilizing the palm by 60 to 75% of recommended doses of fertilization via slow release form to get high yield with good fruit quality. In addition, reduce the environmental pollution and increase the fertilization efficiency.

Keywords: Date palm, Nitrogen, Potassium, Slow release fertilizers, Yield, Fruit quality.

Introduction

Date palm is the most important crop that widely grown in different districts over all the world. It plays an important role in the economical and social life of the people and considered a symbol of life in desert in Egypt. It can grow and produce under different types of soil from light sandy to heavy clay soil. Also, it has high adaptability to stress conditions as it tolerates high levels of salinity, drought and harsh weather (FAO, 1982 and Jaradat and Zaid, 2004). Dates one of the almost ideal food that provides a wide range of required essential nutrients with many potential health benefits (Jaradat and Zaid, 2004 and Parvin *et al.*, 2015).

Date palm varieties are of three main types according to its fruit moisture content, i.e. soft, semi-dry and dry. Khalas date palm cultivar is one of the best soft dates in upper Egypt has been seen and it has many marketing advantages in both Khalal or rutab stages. The dates yield and quality can vary depending on cultivar, soil conditions and cultural practices. Fertilization is an important and limiting factor for growth,

***Corresponding author: El Nopy H. Salem**
Email: nopysalem@yahoo.com
+201153006669
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nutritional status and fruiting of fruit corp. therefore, fertilization is one of the important practices which increase date palm production and improves fruit quality (Soliman and Osman, 2003; Hussein, 2008; El-Salhy *et al.*, 2008 and El-Salhy *et al.*, 2017). Nitrogen is a major element required by all plants and adequate nitrogen is essential for tree growth, leaf cover, blossom formation and fruit set and fruit quality (Marschner, 1995 and Ahmed, 2008). In Egypt, fertilizer consumption per hectare of the cultivated area is 10 times more than consumption on average per hectare of the whole world for all nutrients (El-Salhy, 2004).

Potassium (K) is a mobile element in the plant and is an activator of enzymes that are essential for photosynthesis and respiration as well as enzymes that produce starch and proteins. It also activities enzymes involved in plant growth and improves the fruit quality (Dhillon, 1999; Tamim *et al.*, 2000; Ahmed, 2008 and Osman, 2010).

Mineral fertilizers and other chemicals commonly used in agricultural production not only have harmful effects on the environment but also they are a very great danger that harmful residues may remain in food (Bogatyre, 2000). So, the investigators restored to new attitude by using slow release, organic and bio-fertilizers instead of mineral fertilizers marking good use of its advantages (Subba Rao, 1984, Verna, 1990 and El-Salhy, 2004). Thus, it is preferred to use the natural fertilizers to avoid pollution and to reduce the costs of chemical fertilizers (Furuya, 1995). Using controlled released fertilizers provide nutrient to plants as needed over an extended period of time. These fertilizers can provide higher nutrient use efficiency. Using slow release fertilizers seems to be very effective in improving growth and fruiting of most fruit trees. These findings might be due to continuous amendment of nutrients during all growth and fruit development stages (Koo, 1988; Miller *et al.*, 1990; Furuya, 1995; Fageria and Baligar, 2005 and El-Salhy *et al.*, 2010). Feldspar rock contains potassium is ranges from 10 to 13% and is a slow release fertilizer (Barker *et al.*, 1997 and Abdel-Rahman, 2010).

Previous studies emphasized the beneficial effects of using different fertilizers sources as well as slow release fertilizers on growth and fruiting of date palms (El-Assar, 2005; Al-Kharusi *et al.*, 2007; Ahmed, 2008; El-Salhy *et al.*, 2008; Marzouk and Kassem, 2011; Kassem, 2012; Al-Obeed *et al.*, 2013; Ibrahim *et al.*, 2013; Soti *et al.*, 2015; Elamin *et al.*, 2017; El-Salhy *et al.*, 2017 and Omer *et al.*, 2018).

The aim of this study was to evaluate the effect of slow release fertilizer on growth and fruiting of Khalas date palm.

Materials and Methods

This study was carried out during two successive seasons of 2018 and 2019 in a private orchard, at Luxor Governorate, Egypt. On Khalas date palm trees of 9 years old grown in sandy soil, and spaced 7.5x7.5 m apart. Irrigation through drip irrigation system with EC 2100 ppm of irrigation water. Physical and chemical analyses of the experimental soil shown in Table 1.

Thirty six female palms trees of healthy with no visual nutrient deficiency symptoms, nearly uniform in shape, size and productivity were chosen and devoted to achieve this experiment. All palms received the regularly agricultural practices that are used in the orchard i.e. irrigation, pest control and pollination.

The experiment involved two studied factors (A and B). The first factor (A) included the effect of potassium fertilization (main plot), as follow:

1. Application of 500 g K/palm via potassium sulphate.
2. Application of feldspar (11.5% K2O), 3.25 kg/palm + 20 ml potassin.

3. Application of feldspar (11.5% K2O), 2.6 kg/palm + 20 ml potassin.

Fertilization (sub plot), as follow:

1. Application of RDN, 1000 g/palm in mineral-source (control).
2. Application of 750 g/palm via slow release (19.5%, 3.85 kg).
3. Application of 600 g/palm via slow release (19.5%, 3.10 kg).
4. Application of 500 g/palm via slow release (19.5%, 2.56 kg).

Soil application of nitrogen, as mineral-N was divided into equal three doses applied three times a year i.e. April, June and July in each season. In addition, potassium sulphate was added at two equal doses on May and July. Feldspar plus potassin and slow release-N added once middle of February.

The experiment was designed as split plot design with three replicates for each treatment and each replicate was represented by one palm.

In general, the following measurements were determined during the two studied seasons.

1- Four mature leaves were chosen during July, on each palm to determine number of pinnae/leaf and pinnae area (cm2) as pinnae area = length x max. width x 0.84, according to Shabana and Antoun (1980). The whole leaf area (m2) was obtained from multiplying the pinnae area by the number of pinnae/leaf.

2- Leaf mineral content. To determine leaf mineral content N, P and K, leaf samples were taken during November and washed with tap water then with distilled water to remove the dust. After washing, they were dried in an electric oven at 70°C for 72 hours. The dried leaves were ground, digested and prepared for analysis using the methods described by Wilde *et al.* (1985).

3- Yield: All bunches were harvested at Khalal stage, bunches of each palm were picked and weighed and then the yield/palm (kg) was recorded.

4- Fruit physical and chemical properties: Fifty fruits were taken at harvest from each palm to determine of some physical and chemical fruit properties were determined according to A.O.A.C. (1995). Data were statistically analyzed and differences between treatments means were compared using L.S.D. test at 5% level according to Gomez and Gomez (1984) and Mead *et al.* (1993).

Table1. Some physical and chemical properties of the experimental soil.

Soil depth (cm) 0-30							
Mechanical analysis (fraction %)		Chemical analysis					
Clay	1.6	Total $CaCO_3$ %	3.80	Mn	0.42	K^+	6.3
Silt	6.5	Ec $dS.m^{-1}$ (1:5)	2	Zn	0.51	$CO^{-}_3 + HCO^{-}_3$	4.37
Sand	91.90	pH (1:2.5 suspension)	7.9	Cu	0.1	Cl^-	14.25
Texture grade	Sandy	Total N (ppm)	7	Ca^{+2}	8.5	SO^{-}_4	7.41
		P	5.6	Mg^{+2}	2.69		
		Fe	31	Na^+	1.3		

Results

1- Vegetative growth and nutritional status:

Data illustrated in Tables (2, 3 and 4) showed the effect of nitrogen and potassium slow release fertilizers and interaction between them on leaf traits and its content of N, P and K of Khalas date palm during 2018 and 2019 seasons. It is obvious from data that the results took similar trend during the two studied seasons.

Concerning the effect of slow release of nitrogen, the results indicated that pinna area and leaf area as well as leaf N, P and K concentration significantly increased by fertilized with 75 to 60% of recommended dose of nitrogen (RND) via slow release compared to use RND via fast nitrogen fertilizer. Highest values of pinna area and leaf area as well as leaf N, P & K percentage were recorded due to use 75% of RND via slow release. no significant differences in theses parameters were observed due to raise used dose used from 60 to 75% of RND via slow release fertilizer. Moreover, the data indicated that no significant differences of these studied traits due to either 50% of out RDN via slow release fertilizer or use the total RDN via fast N form. Thus, it could be concluded that using 60 to 75% of RDN via slow release improve the vigour and nutrient status of palm and increase the fertilization efficiency.

As regard to the effect of different form of potassium fertilization, data indicated that leaf traits and its N, P and K content significantly increased due to use feldspar as slow release either 75 or 60% of recommended potassium dose (RKD)/palm compared to the fertilization by potassium sulphate (check treatment). Raising the K-slow release does from 60 to 75% of RKD/palm failed to show any significant increase in such leaf traits.

In addition data in Tables (2, 3 and 4) indicated that leaf traits i.e. pinna area, total leaf area as well as leaf N, P and K concentration significantly increased as a result of interaction between the two studied factors. The highest values were obtained in palms that fertilized with 750 g N and 375 g K via slow release of nitrogen and potassium, respectively. the highest values of leaf area ,leaf N&K content were obtained as a result of (3.38 & 3.36 m2), leaf N concentration (2.00 & 2.05%) and leaf K concentration (1.75 & 1.65) due to use slow release N and K at 75% of recommended of them during the two studied seasons, respectively. In other hand, the highest values of leaf area (2.88 & 2.98 m2) and N% (1.51 & 1.55) and K% (1.38 & 1.37%) due to fertilize with N and K at 100% of recommended doses via fast mineral source (check treatment) during the two studied seasons, respectively. Then, the increment percentage of total leaf area was (17.36 & 14.68%), N % (32.45 & 32.25) and K% (26.58 & 20.44%) due to fertilize with 750 g N and 375 g K via slow release compared to fertilize with 1000 g N and 500 g K via fast mineral fertilizers during the two studied seasons, respectively. No significant differences were observed between high and low doses of N&k via slow release forms.

Therefore, from economical point of view it is suggested that fertilizing Khalas dates with 600 g of N and 300 g K via slow release fertilizers to improve growth vigor of palms, nutrient status and increase fertilization efficiency. These results emphasized the importance of using the slow release fertilizers to improve the vigor and nutrient status of date palms as well as increase the fertilization efficiency

2- Bunch weight and yield/palm:

Over mentioned data in Tables (4 & 5) showed the effect of nitrogen and potassium slow release fertilizer and interaction between them on yield and yield components of of Khalas date palm during 2018 and 2019 seasons. it is

obvious from data that the results took similar trend during the two studied seasons.

Concerning the effect of nitrogen slow release fertilizer, the results showed that fruit set percentage, bunch weight and yield/palm took similar tendency and significantly increased due to fertilize with 60 or 75% of RDN via slow release compared to use RDN via fast nitrogen fertilizer during the two studied seasons. The highest fruit set and heaviest bunch weight and yield/palm were recorded due to use the 75% of RDN via slow release. Heaviest bunch weight (13.89 & 13.67 kg) and yield/palm (134.05 & 132.27 kg/palm) were recorded on palm that fertilized with 750 N via slow release, against (116.20 & 115.10 kg) on palm that fertilized with 100% via mineral-N during the two studied season, respectively. No significant differences in these traits due to reduced the dose of slow release N form from 75% to 60% of RDN. Hence the increment percentage of yield/palm attained (15.36 & 14.91%) due to fertilize with 75% and 60% of RDN via slow release compared to use 100% of RDN via fast mineral fertilizer during the two studied seasons, respectively.

Also, No significant differences were noticed on the studied parameters as a result of using 50% of RDN via slow release or 100% RDN fast mineral form.

As regard to effect of slow release of potassium fertilizer, data indicated that fruit set, bunch weight and yield/palm significantly increased due to use feldspar as a slow release K at either 2.6 or 3.25 kg compared to 500 g of K2O palm during the two studied seasons. Raising the feldspar dose from 2.6 to 3.25 K palms failed to show any significant increase in yield components during the two studied seasons. The heaviest yield/palm was (130.83 & 128.60 kg/palm) detected on palm that fertilized with 3.25 kg feldspar, against (118.71 & 118.40 kg/palm) on palm that received 500 g (K2O). Then the increment percentage of yield/palm attained to (10.21 & 8.78%) due to fertilize with 75% of RDK (3.25 kg feldspar) compared to 100% of RDK (500 g, K2O)/palm during the two studied seasons, respectively.

So, these results emphasized that using feldspar as slow release-K improve the vigour and nutrient status of palms, such improvement surely reflected on increasing the yield components.

In addition data in Tables (4 & 5) indicated that the yield components significantly responded to interaction between the two studied factors. The highest values were recorded obtained on palms that fertilized with 75% of recommended dose of nitrogen and potassium via slow release forms. The highest recorded yield/palm was (138.60 & 136.30 kg/palm) due to 750 g N and 375 g (K2O) via slow fertilizers during the two studied seasons, respectively. In other hand, the recorded yield/palm was (106.90 & 107.50 kg/palm) due to 1000 g N and 500 g (K2O) via fast mineral fertilizers during the two studied seasons, respectively. Then, the increment percentage of yield/palm was (29.65 & 26.79) due to fertilize with 75% out RDN and RDK via slow release form compared to use the RDN and RDK via fast mineral fertilizer during the two studied seasons, respectively. No significant difference due to fertilize with 600 or 750 g (N) and 300 or 375 g (K2O) via slow release fertilizers.

As an overview, the results declared that the combination effects significantly increased the yield than increment due to individual effects of either pruning or Mg treatments.

Table 2. Effect of slow release fertilizers on pinna area and leaf area (m2) of Khalas date palm during 2018 and 2019 seasons.

A / B	Pinna area (cm^2) (2018)				Pinna area (cm^2) (2019)				Leaf area (2018)				Leaf area (2019)			
	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)
N_1	135.60	142.68	141.10	139.79	138.27	145.62	143.83	142.57	2.88	3.15	3.09	3.04	2.93	3.19	3.21	3.11
N_2	141.83	149.11	147.53	146.16	144.59	152.16	150.22	148.99	3.11	3.38	3.35	3.28	3.16	3.36	3.44	3.34
N_3	140.28	147.45	145.65	144.46	143.38	150.73	149.36	147.82	3.04	3.33	3.28	3.22	3.08	3.38	3.39	3.27
N_4	139.46	146.22	145.11	143.60	142.24	149.50	148.11	146.62	3.02	3.28	3.24	3.18	3.07	3.35	3.28	3.22
M (K)	139.29	146.37	144.85		142.12	149.50	147.88		3.01	3.29	3.24		3.06	3.34	3.30	
LSD	A= 3.93	B= 3.88	AB= 6.72		A= 4.28	B= 4.10	AB= 7.11		A= 0.15	B= 0.14	AB= 0.24		A= 0.14	B= 0.12	AB= 0.21	

K_1 Application of 500 g K/palm via potassium sulphate.
K_2 Application of feldspar (11.5% K_2O), 3.25 kg/palm + 20 ml potassin.
K_3 Application of feldspar (11.5% K_2O), 2.6 kg/palm + 20 ml potassin.
N_1 Application of RDN, 1000 g/palm in mineral-source (control).
N_2 Application of 750 g/palm via slow release (19.5%, 3.85 kg).
N_3 Application of 600 g/palm via slow release (19.5%, 3.10 kg).
N_4 Application of 500 g/palm via slow release (19.5%, 2.56 kg.

Table 3. Effect of slow release fertilizers on leaf N % and P percentage of Khalas date palm during 2018 and 2019 seasons.

A / B	Leaf N % (2018)				Leaf N % (2019)				Leaf P% (2018)				Leaf P% (2019)			
	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)
N_1	1.51	1.73	1.67	1.64	1.55	1.78	1.74	1.69	0.18	0.20	0.20	0.19	0.19	0.22	0.20	0.20
N_2	1.76	2.00	1.89	1.88	1.81	2.05	1.99	1.95	0.22	0.25	0.24	0.24	0.23	0.25	0.23	0.24
N_3	1.71	1.93	1.86	1.83	1.78	2.04	1.98	1.93	0.21	0.24	0.22	0.22	0.21	0.25	0.23	0.23
N_4	1.46	1.75	1.79	1.67	1.50	1.80	1.81	1.70	0.17	0.20	0.19	0.19	0.18	0.21	0.20	0.20
M (K)	1.61	1.85	1.80		1.66	1.92	1.88		0.20	0.22	0.21		0.20	0.23	0.22	
LSD	A= 0.06	B= 0.08	AB= 0.14		A= 0.07	B= 0.08	AB= 0.15		A= 0.01	B= 0.01	AB= 0.02		A= 0.01	B= 0.01	AB= 0.02	

Table 4. Effect of slow release fertilizers on leaf-K and fruit set percentage of Khalas date palm during 2018 and 2019 seasons.

A / B	Leaf-K % (2018)				Leaf-K % (2019)				Fruit set % (2018)				Fruit set % (2019)			
	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)
N_1	1.38	1.58	1.51	1.49	1.37	1.54	1.50	1.47	48.80	51.19	50.38	50.12	47.93	49.72	50.35	49.33
N_2	1.56	1.75	1.71	1.67	1.49	1.65	1.62	1.59	54.10	47.18	56.91	56.06	56.38	59.11	58.93	58.14
N_3	1.53	1.72	1.67	1.64	1.47	1.65	1.63	1.58	54.00	56.80	56.10	55.63	58.60	60.26	58.83	59.23
N_4	1.41	1.55	1.50	1.49	1.36	1.52	1.49	1.46	50.63	53.11	52.38	52.04	47.40	53.60	52.71	51.24
M (K)	1.47	1.65	1.60		1.42	1.59	1.56		51.88	55.36	54.63		52.79	55.80	55.31	
LSD	A= 0.05	B= 0.05	AB= 0.11		A= 0.06	B= 0.08	AB= 0.13		A= 2.54	B= 2.41	AB= 4.16		A= 2.68	B= 2.37	AB= 4.10	

Table 5. Effect of slow release fertilizers on bunch weight and yield/palm of Khalas date palm during 2018 and 2019 seasons.

A / B	Bunch weight kg (2018)				Bunch weight kg (2019)				Yield/palm kg (2018)				Yield/palm kg (2019)			
	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)
N_1	11.20	12.60	12.70	12.17	11.11	12.20	12.00	11.22	106.90	120.20	121.50	116.20	107.50	119.60	118.20	115.10
N_2	13.30	14.42	13.96	13.89	13.00	14.15	13.85	13.67	128.75	138.60	134.80	134.05	126.00	136.30	134.50	132.27
N_3	12.90	14.10	13.28	13.43	13.10	14.10	13.70	13.63	124.20	136.50	128.30	129.67	126.80	135.80	132.50	131.70
N_4	11.50	13.25	12.30	12.55	11.90	12.93	11.58	12.47	115.00	128.00	120.00	121.00	113.30	123.50	119.90	118.90
M(K)	12.23	13.59	13.06		12.14	13.26	12.26		118.71	130.83	126.15		118.40	128.80	126.28	
LSD	A= 0.73	B= 0.80	AB= 1.39		A= 0.69	B= 0.73	AB= 1.25		A= 5.12	B= 5.31	AB= 9.20		A= 6.11	B= 5.33	AB= 8.55	

Therefore, from economical point of view it is suggested to fertilized by 60 to 75% of RDN and RDK via slow release fertilizers to improve the growth and give the high bunch weight and consequently high yield/palm.

3- Fruit properties:

Over mentioned data in Tables (6 to 9) showed the effect of slow release of nitrogen and potassium fertilizers and interaction between them on physiochemical properties of Khalas dates during 2018 and 2019 seasons. It is obvious from data that the results took similar trend during the two studied seasons.

Concerning the effect of nitrogen slow release fertilizer, the results indicated that fruit physical properties i.e., fruit weight, pulp % and fruit dimension significantly increased due to use 60 or 75% of out of RDN via slow release fertilizer. Moreover, chemical properties i.e. total soluble solids, sugar content significantly increased due to use slow release fertilizer at any dose i.e. 50, 60 or 75% of RDN compared to use total RDN via fast mineral fertilizer. Highest fruit properties were recorded due to use 75% of RDN via slow release fertilizer. No significantly difference in these traits due to raise the used slow release from 60 to 75% of RDN.

The heaviest fruit (28.29 & 27.13 g) and highest TSS % (39.26 & 40.17%) were recorded due to fertilize with 750 g N/palm via slow release fertilizer, against lowest ones (25.25 & 24.76 g) and (35.93 & 36.68%) due to fertilize with 1000 g N/palm via fast mineral N fertilizer, during the two studied seasons, respectively. Hence, the increment percentage of fruit weight was (12.04 & 9.57) and TSS was attained (9.26 & 9.51%) due to use 75% of RDN via slow release form during the two studied seasons, respectively.

Regarding the effect of different potassium fertilization source, data in Table (6 to 9) indicated that using K2O at 300 or 375 g via slow release/palm significantly improved the fruit quality in terms of increasing fruit weight, pulp % and its dimension as well as total soluble solids and sugar contents compared to use 500 K2O/palm via fast mineral-K fertilizer. Raising the potassium dose from 300 to 375 g (K2O)/palms failed to show any significant increase in such fruit traits.

The recorded heaviest fruit was (27.77 & 26.93 g) and highest TSS % (39.01 & 39.83%) due fertilize with 375 g (K2O) via slow release, against lowest ones (25.15 & 24.51 g) and (36.76 & 37.47%) due to fertilize with 500 g (K2O)/palm via fast mineral-K fertilizer during the two studied seasons, respectively. Thus, the increment percentage of fruit weight was (10.42 & 9.87%) and TSS (6.12 & 6.30) due to apply 375 g (K2O) via slow release compared to 500 g (K2O) via fast mineral-K fertilizer, respectively.

In addition data in Tables (6 to 9) indicated that fruit traits i.e. fruit weight, dimension, pulp %, TSS and sugar contents significantly responded to interaction between the two studied factors. The highest values of fruit weight and TSS were obtained in palms that fertilized with 750% (N) and 375 g (K2O) via slow release form. The highest recorded fruit weight was (29.50 & 28.10 g) and TSS% (40.11 & 40.93%) due to use 75% of out of RDN and RDK via slow release fertilizer during the two studied seasons, respectively. In other hand, the recorded fruit weight was (23.50 & 23.38 g) and TSS % (34.62 & 35.28%) with use of 100% out of N & K via fast mineral fertilizer during the two studied seasons, respectively. Then, the corresponding increment percentage of fruit weight was (25.53 & 20.19%) and TSS (18.75 & 16.01%) during the two studied seasons, respectively. No significant difference due to fertilize with 60 or 75% of RDN and RDK in these fruit traits.

As an overview, the results showed that the combining effect was more effective in improving fruit characters than each fertilizer

Table 6. Effect of slow release fertilizers on fruit weight and pulp percentage of Khalas date palm during 2018 and 2019 seasons.

A / B	Fruit weight gm. (2018)				Fruit weight gm. (2019)				Pulp % (2018)				Pulp % (2019)			
	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)
N_1	23.50	26.11	26.15	25.25	23.38	25.63	25.26	24.76	80.61	84.62	83.28	82.50	81.43	85.68	84.93	84.01
N_2	26.80	29.50	28.56	28.29	25.70	28.10	27.60	27.13	83.62	87.68	86.93	86.08	84.90	88.75	88.56	87.40
N_3	25.83	28.51	27.80	27.38	24.85	27.50	26.68	26.34	83.23	87.16	86.59	85.66	84.25	88.73	87.36	86.37
N_4	24.48	26.96	25.90	25.78	24.10	26.48	25.95	25.51	82.87	86.35	86.63	84.28	84.80	88.81	88.11	87.24
M (K)	25.15	27.77	27.10		24.51	26.93	26.37		82.46	86.45	85.73		83.97	87.87	87.31	
LSD	A= 1.33	B= 1.22	AB= 2.11		A= 1.27	B= 1.41	AB= 2.44		A= 2.41	B= 2.37	AB= 4.04		A= 2.18	B= 1.93	AB= 3.34	

Table 7. Effect of slow release fertilizers on fruit dimension of Khalas date palm during 2018 and 2019 seasons.

A / B	Fruit length (cm) (2018)				Fruit length (cm) (2019)				Fruit diameter (cm) (2018)				Fruit diameter (cm) (2019)			
	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)	K_1	K_2	K_3	M (N)
N_1	4.82	5.10	5.10	5.01	4.93	5.18	5.14	5.08	2.60	2.77	2.74	2.71	2.71	2.89	2.85	2.80
N_2	5.18	5.39	5.21	5.26	5.25	5.44	5.32	5.34	2.75	2.93	2.85	2.84	2.88	3.00	2.97	2.95
N_3	5.02	5.27	5.26	5.18	5.08	5.33	5.24	5.22	2.74	2.85	2.82	2.78	2.84	2.95	2.92	2.90
N_4	4.93	5.21	5.04	5.06	4.98	5.24	5.13	5.12	2.65	2.83	2.73	2.75	2.76	2.91	2.89	2.85
M (K)	4.99	5.24	5.15		5.06	5.30	5.21		2.68	2.85	2.79		2.80	2.94	2.85	
LSD	A= 0.15	B= 0.15	AB= 0.26		A= 0.14	B= 0.13	AB= 0.22		A= 0.07	B= 0.09	AB= 0.16		A= 0.10	B= 0.08	AB= 0.13	

Table 8. Effect of slow release fertilizers on TSS and total sugars of Khalas date palm during 2018 and 2019 seasons.

A / B	TSS % (2018)				TSS % (2019)				Total sugars % (2018)				Total sugars % (2019)			
	K_1	**K_2**	**K_3**	**M (N)**	**K_1**	**K_2**	**K_3**	**M (N)**	**K_1**	**K_2**	**K_3**	**M (N)**	**K_1**	**K_2**	**K_3**	**M (N)**
N_1	34.62	36.68	36.50	35.93	35.28	37.40	37.35	36.68	32.11	34.11	33.76	33.33	32.71	34.58	34.67	33.99
N_2	37.83	40.11	39.85	39.26	38.80	40.93	40.78	40.17	35.18	36.94	36.73	36.28	36.10	38.10	37.90	37.37
N_3	37.60	39.89	39.68	39.26	38.21	40.71	40.59	39.84	34.80	36.48	36.51	35.93	35.26	37.96	37.75	36.99
N_4	36.98	39.36	38.98	38.94	37.60	40.28	39.73	39.20	34.26	36.40	37.10	35.92	34.90	37.38	36.90	36.39
M (K)	36.76	39.01	38.75		37.47	39.83	39.61		34.09	35.98	36.03		34.74	37.01	36.81	
LSD	**A=** 0.96	**B=** 1.08	**AB=** 1.87		**A=** 1.13	**B=** 1.03	**AB=** 1.78		**A=** 0.89	**B=** 0.99	**AB=** 1.73		**A=** 0.80	**B=** 0.83	**AB=** 1.43	

Table 9. Effect of slow release fertilizers on Reducing sugar percentage of Khalas date palm during 2018 and 2019 seasons.

A / B	**Reducing sugar % (2018)**				**Reducing sugar % (2019)**				**Non-reducing sugar % (2018)**				**Non-reducing sugar % (2019)**			
	K_1	**K_2**	**K_3**	**M (N)**	**K_1**	**K_2**	**K_3**	**M (N)**	**K_1**	**K_2**	**K_3**	**M (N)**	**K_1**	**K_2**	**K_3**	**M (N)**
N_1	23.96	25.13	24.18	24.43	24.72	25.08	25.11	24.77	8.15	8.98	9.58	8.30	8.59	9.50	9.56	9.22
N_2	25.57	26.46	26.70	26.24	25.94	27.10	26.82	26.72	9.61	10.48	10.03	10.04	10.16	11.00	11.08	10.75
N_3	25.32	26.23	26.35	25.97	25.43	27.16	26.68	26.42	9.48	10.25	10.16	9.96	9.83	10.80	11.07	10.57
N_4	25.34	26.47	26.73	26.18	25.24	26.92	26.34	26.17	8.92	9.93	10.37	9.74	9.66	10.46	10.56	9.97
M (K)	25.05	26.07	25.99		25.18	26.57	26.24		9.04	9.91	10.04		9.56	10.44	10.57	
LSD	**A=** 0.62	**B=** 0.53	**AB=** 1.01		**A=** 0.52	**B=** 0.50	**AB=** 0.87		**A=** 0.38	**B=** 0.33	**AB=** 0.58		**A=** 0.41	**B=** 0.42	**AB=** 0.73	

alone on the fruit traits than improved due to individual effects of either nitrogen or potassium fertilization.

Therefore, from economical point of view it is recommended that fertilizing by 750 g N and 375 g (K2O) via slow release fertilizers to improve nutritional status yield and fruit quality leading to an increase in the pickable yield. In addition, it minimizes the production costs and environmental pollution and increase the fertilization efficiency.

Discussion

Nitrogen is a necessary element for chlorophyll, protoplasm, protein and nucleic acid synthesis (Nijjar, 1985) so that its application can result in an increase in the cell number and cell size with an increase in the growth. Such effects increase the number and area of leaves. The improving effects of slow release on growth and fruiting might be attributed to their release of own N over a long period of tme according to the palm need. Also, it gave the highest values of residual N in soil due to their low activity index compared to fast release which gave the lowest values of available N left in the soil. In addition, the role of nitrogen in plants, which increase growth and development of all living tissue, responsible for accelerating the biosynthesis of proteins and carbohydrates (Koo, 1988; Furuya, 1995 and El-Salhy *et al.*, 2010).

Slow release fertilizer improve the nutrient status and the total leaf surface area of the trees which increase the synthesis of carbohydrates and proteins and consequently enhance cell division and enlargement leading to an increase in the fruit weight and consequently increased the bunch weight. Also, more available carbohydrates produced and translocated to the fruit can advance its maturity and improve the its chemical attributes. In addition, the importance of such fertilization treatments is considered for the organic farming production.

Such findings are of a good evidence for the importance of using the slow release to increase the efficiency use of fertilizers, control the release of nutrients to palm and consequently improve the soil fertility and palm nutrient status as well as produce the high yield with good fruit quality.

The above mentioned results were in accordance with those obtained by Koo, 1988; Zekri and Koo, 1991; Furuya, 1995; Alva *et al.*, 1998; Ahmed, 2008; El-Salhy *et al.*, 2010 and Soti *et al.*, 2015). They showed that replacing 50 to 75% of N requirements of the palms by a slow release form was very effective in improving the yield, with saving N fertilization cost and reducing nitrate pollution.

Potassium is an important element in the formation and function of proteins, fats, carbohydrates and chlorophyll and in maintaining the balance of salts and water in plant cell (Marschner, 1995). Crop demands for K become great expense due to lack of natural K resources. In addition, there are increasing interest and demand for organic, bio and slow releasing-K sources to conventional and organic farming.

The feldspar as a slow release-K gave a significant advantage if the release continues over a number of years. The residual material after release of potassium and other nutrients easily gets soil fertility. Nutrients from feldspar release at a rate that allows them to remain in the soil top to be utilized by plants. The feldspar effects due to its role as a potassium source which it activates a lot of physiological process as occur in plant such as maintaining cell organization, cell hydration and permeability. It activates many enzymes system such that occur in protein synthesis and formation of carbohydrates (Nijjar, 1985; Tamim *et al.*, 2000 and Abdel-Rahman, 2010).

These results emphasized the importance of potassium fertilization to get complete healthy trees. In addition, its usefulness on saving

potassium fertilization cost and reducing environmental problems, since the vinasse has high density syrup waste from the sugar industry, which may cause environmental problems.

The promotive effect of different potassium fertilizer sources on growth nutrient status and fruiting of fruit trees were emphasized by Bamiftah, 2000; Soliman and Osman, 2003; Badr, 2006; Ahmed, 2008; Abdel-Rahman, 2010; Osman, 2010; Ali *et al.*, 2011; Abdel-Aal *et al.*, 2013; Elamin *et al.*, 2017 and Omar *et al.*, 2018. They concluded that using different forms of potassium fertilization had a positive effect on growth and leaf mineral content, as well as yield and fruit quality.

Conclusion

It could be concluded that using 75% of recommended dose of nitrogen and potassium via slow release-N and K, fertilization sources to improve the palm nutrients status, yield and fruit quality leading to an increase in the pickable yield. In addition, it minimizes the production costs and environmental pollution which could be occurred by excess of chemical fertilizers and industrial wastes.

These advantages will eventually enable growers to obtain high yield with good fruit quality. Furthermore, using slow release sources improve the soil fertility and reduce the added fertilizer requirements. Thus, the growers are able to produce organic farming products. Which are sellable with high price and maintain the human health.

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