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REGULAR ARTICLE

Impact of organic manure and combination of N P K S, on yield, fruit quality and fruit mineral content of Khenazi date palm (*Phoenix dactylifera* L.) cultivar

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Abstract

This study was carried out during three successive seasons 2011, 2012 and 2013 at a private orchard located in Al- Hello in Ajman Emirate (UAE). The experiment was designed to study the effect of organic manure and NPKS as soil application on yield, fruit quality, and fruit mineral nutrient content of Khenazi date palm cultivar grown in sandy soil. Fertilization treatments consisted of N1, 600g or N_2, 1000g (urea 46%N), P 800g (triple superphosphate, 48% P_2O_5), K 1200g (potassium sulphate, 50% K_2SO_4) and S 700g sulphur (90% granular S), in addition to organic manure. Al experimental trees received 100g mixture of micronutrients, with the exception of the control. The results showed that combination treatments and organic manure significantly affected fruit weight, flesh weight, fruit volume, moisture content and fruit TSS. Application of different fertilization treatments significantly affected yield components of fruit, number of fruits/strand, fruit number/bunch, fruit set percent and total fruit yield / palm. The study revealed that combination of fertilizers improved fruit nutrient content of N, P, K, Ca, Mg, Fe, Zn, Mn and Cu. Moisture and TSS% content, number of fruits/strand, number of fruits/bunch, fruit nutrients content of Fe, Mn and Zn were significantly different due to the application of N1+K+S.

Key words: Date palm, fertilizers, Khenazi, *Phoenix dactylifera*, sulphur

Introduction

Throughout the arid countries, date palm (*Phoenix dactylifera* L.) grows in wide ecological habitats, like desert oases, mangrove margins, steep limestone cliffs, and cultivated land. Also, date palm will exist in different kinds of soils, from waterlogged soils to extremely arid soils and it can tolerate up to 1.5% salinity (Al-Busaidi, 2012). FAO (2010) record date palm as one among the oldest cultivated trees in the world. Dates has been in existence since 6000 years owing to its high nutritional, health and economic values. All parts of this tree is useful (Sulieman et al., 2012). Date palm trees require relatively great amounts of macro and micronutrients to achieve good growth and give reasonable

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economic production. Shaaban and Mahmoud (2012) reported optimum fertilizer requirement of date palms for increasing the production.

The most limiting nutrients to plant growth in arid and semi-arid regions are nitrogen and phosphorus. A little work was conducted on sulphur cycle. However, the application of sulphur lowers soil pH and increase availability of nutrients (Idris et al., 2012). In addition, Sulphur is important to enhance the micro and macro element availability, which may increase the growth of plants (Abbas et al., 2015). Leaf length of Mishrig Wad Laggai date palm cultivar was increased due to sulphur application (Dawoud and Rauof, 2011).

Fahim and Saleh (2007) showed that the phosphorus and potassium fertilizers caused meaningful increase in yield and improvement fruit quality. In addition, Shahin (2007) found that, the best rate of potassium fertilization for the best growth, yield and leaf N, P and K content was 4.5 kg /palm / year.

Most of the soils of UAE are sandy soils consisting of 85% sand, low in organic substances and in major and minor elements. The soil of UAE is usually alkaline where pH is more than seven (ranges between7.5–8.5). In such cases, problems in absorption of trace elements from the soil by plants are expected. According to Al-Barshmgy (2010), there are deficiencies in phosphorus and microelements such as iron, zinc and manganese. Organic manure can play a valuable role as organic fertilizer. Many researchers have reported that organic manure is not sufficient to provide the palm with all its requirements to produce good yield (AL- Bakr, 1972).

Therefore, the objective of this research is to determine which fertilizer combinations and organic manure have the most effects in improving fruit quality and fruit yield of Khenazi date palm cultivar.

Materials and methods

The study was carried out during three successive seasons of 2011, 2012 and 2013 in a private orchard, at Al Hello in Ajman Emirate, United Arab Emirates, on Khenazi date palm cultivar, 12 years old, grown in sandy soil. Selected trees were as uniform as possible in growth and vigor, free from insect's damage and diseases. The regular recommended cultivation practices were followed for all the palms.

The fertilizer treatments were comprised of urea (46%N) N1 600g and N2 1000g divided into four equal doses, superphosphate (48% P2O5), 800g divided into four equal doses, Potassium sulphate (50 %KS_2O_4) 1200g divided into two equal doses, sulphur 700g (90% granular sulphur), 700g divided into two equal doses, mixture of microelements divided into two equal doses, organic manure and the control. Six soil treatments were accurately arranged in a completely randomized block design (CRBD) with three replicates (one replicate = two palms). All data were subjected to analysis of variance (ANOVA) using R software program. Mean separation was carried out ($P<0.05$) using Tukey's significant difference test as (Harhash and Abdel-Nasser, 2010).

The treatments were as follows

1-N1+ P+S; 2- N2+P+S; 3- N1+K+S; 4-N2+ K+S; 5- Organic manure 50 kg/palm; 6-Control.

A mixture of microelements 100g and 700g of granular Sulphur were used for each tree and 50 kg / tree organic manure was added once in November, while granular Sulphur was added in combination with nitrogen and phosphorus two times in December and February. Nitrogen with phosphorus were added in January and March consecutively. Potassium fertilizer was added in combination with nitrogen and Sulphur in March and April each year respectively. Microelements divided into two equal doses were added in January and March each year. Each fertilizer treatment was applied in a trench method, one meter away from the palm trunk, and then irrigated directly after addition of the fertilizers.

Measurements

Fruit quality

Sample of 50 full mature fruits were randomly selected from each palm at Bisr stage in the mid of July to determine the fruit physical characteristics. Fruit volume was determined by water displacement method (Harhash and Abdel-Nasser, 2010). After pitting, fruit flesh weight (g) was recorded.

Chemical characteristics such as total soluble solids (TSS) were determined by hand refractometer (Shareef, 2011) and fruit moisture content was determined according to the methods of AOAC (2005).

Fruits numbers per strand

At harvest time, at the peak of fruit color development during July, ten strands were chosen from each tree and the number of fruits per strand was counted.

Fruits numbers per bunch

Mature fruits at Bisr stage were extracted by hand from the bunch from all its strands and total number of fruits per bunch was determined.

Yield per palm (kg)

Total yield per tree in the three seasons was determined by harvesting eight bunches from each palm and the weight was recorded in kilogram.

Fruit nutrients content

To determine fruit mineral content of N, P, K, Ca, Mg, Fe, Mn, Zn and Cu, a sample of 50 mature date fruits from each treatment was used, then the fruits were divided into pieces and seeds were discarded. Aliquot of approximately 50g was dried at 75 ◦C in the oven until constant weight. The dried fruits were ground in a grinder and sieved through 0.053 mm sieve. 0.5 g of the sample was accurately weighed and digested with 200ml perchloric acid (65%) and 150ml concentrated Nitric acid (65%) and the digest was transferred to 100 ml volumetric flask. All samples of fruits were analyzed for mineral contents using Varian ICP-OES, according to US-EPA method number 2007 (EPA, 2001). Total nitrogen was determined by semi-micro Kejldhal method (Bremner, 1965).

Results

Fruit quality

Fruit flesh weight, volume, TSS and moisture content

The results shown in (Tables 1, 2 & 3) clearly indicated that all tested fertilization treatments significantly increased average fruit weight, flesh weight, fruit volume than the control. However, in the first season fertilization treatment with N1+K+S recorded the highest fruit weight and fruit flesh weight than N2 +P+S and the organic manure, but in the second season treatment N1+K+S significantly increased fruit and flesh weight than N2+K+S and organic manure. In the third season, N1+K+S and N2+P+S significantly increased fruit and fruit flesh weight over organic manure. Moreover, N1+P+S in first and second seasons significantly increased fruit and fruit flesh weight than the organic manure while in the third season no significant difference obtained between N1+P+S and organic manure. N2+P+S increased fruit and flesh weight in the second and third seasons. Also, N1+K+S increased volume of the fruit over N2+P+S, N2+K+S and organic manure in the first season. While in the second season all combinations treatments increased volume of the fruit than organic manure. In the third season, N2+P+S and N1+K+S increased fruit volume more than organic manure. Concerning fruit TSS and moisture content, N1+K+S and N1+P+S treatments increased TSS over organic manure and the control in the first season, while in the second and third seasons N1+K+S was more efficient in TSS compared to all other fertilization treatments and the control. The lowest moisture content obtained was from N1+K+S in the three seasons (Table 2, 3).

Table 1. Effect of fertilizers application on fruit physical and chemical characteristics of Khenazi date palm cultivar during 2011 season.

Treatments	fruit weight (g)	flesh weight (g)	fruit volume Cc	TSS %	Moisture %
N1+P+S	13.82ab	12.85abc	13.41abc	51.33a	75.06b
N2+P+S	13.12bc	12.15cd	12.29cd	50.50ab	75.20b
N1+K+S	14.81a	13.86ab	14.35a	52.00a	66.66c
N2+K+S	13.50ab	12.52abc	12.75bc	50.00ab	74.97b
Organic manure	11.61c	10.65d	11.33d	47.83b	74.83b
Control	9.63d	8.64e	9.13e	43.83c	84.51a

Values within a column with the same letter are not significantly different at (P<0.05).

Table 2. Effect of fertilizers on fruit physical and chemical characteristics of Khenazi date palm cultivar during 2012 season.

Treatments	fruit weight (g)	flesh weight (g)	fruit volume Cc	TSS %	Moisture %
N1+P+S	14.01abc	13.15bc	13.45a	49.00b	70.40b
N2+P+S	14.43abc	13.32abc	13.49a	49.00b	70.17b
N1+K+S	15.17a	14.37a	14.23a	53.00a	62.55c
N2+K+S	13.87bc	12.84c	13.03a	49.00b	70.68b
Organic manure	11.89e	10.97d	11.c3	48.00b	70.27b
Control	10.02f	9.11e	9.10d	42.00c	80.04a

Values within a column with the same letter are not significantly different at (P<0.05).

Table 3. Effect of fertilizers on fruit physical chemical characteristics of Khenazi date palm cultivar during 2013 season.

Treatments	fruit weight (g)	flesh weight (g)	fruit volume Cc	TSS %	Moisture %
N1+P+	14.37ab	13.36ab	13.92ab	48.83bd	69.58b
N2+P+S	15.17a	14.09a	14.50a	50.17bcd	72.52b
N1+K+S	15.25a	14.41a	15.10a	53.79a	64.22c
N2+K+S	14.02ab	13.06ab	13.62ab	51.00bc	69.06b
Organic manure	12.58b	11.64b	12.35b	50.50bcd	69.77b
Control	10.17c	9.20c	9.93c	45.00e	82.14a

Values within a column with the same letter are not significantly different at (P<0.05).

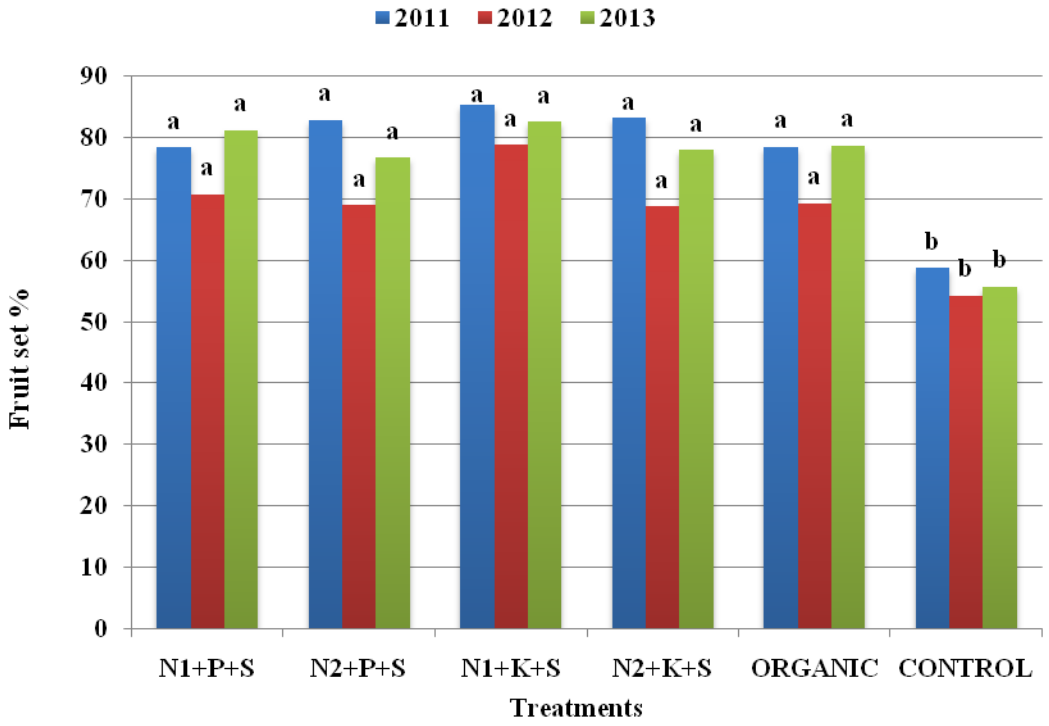
Fruit set and fruit yield per tree

Fruit set

Regarding fruit set in response to adding fertilization treatments, it is evident from the data presented in (Fig. 1) that all the studied fertilization treatments resulted in a significant increase in fruit set percentages against the control in the three seasons of experimental study. This shows that the second season was an off year, while the first and third seasons were on-year seasons.

Number of fruits per strand

The results presented in (Fig. 2) revealed that fertilization treatments with combination of N1+P+S and N1+K+S significantly increased the number of fruits per strand as compared with the control in the first season. Moreover, combination of N1+K+S fertilization treatment proved to be more efficient in increasing number of fruits per strand than N2+P+S and organic manure. On the other hand, all tested fertilization treatments significantly increased number of fruits per strand in the second and third seasons than the control, but combination of N1+K+S proved to be more efficient in increasing number of fruits per strand than those of other fertilization treatments in the second and third seasons.



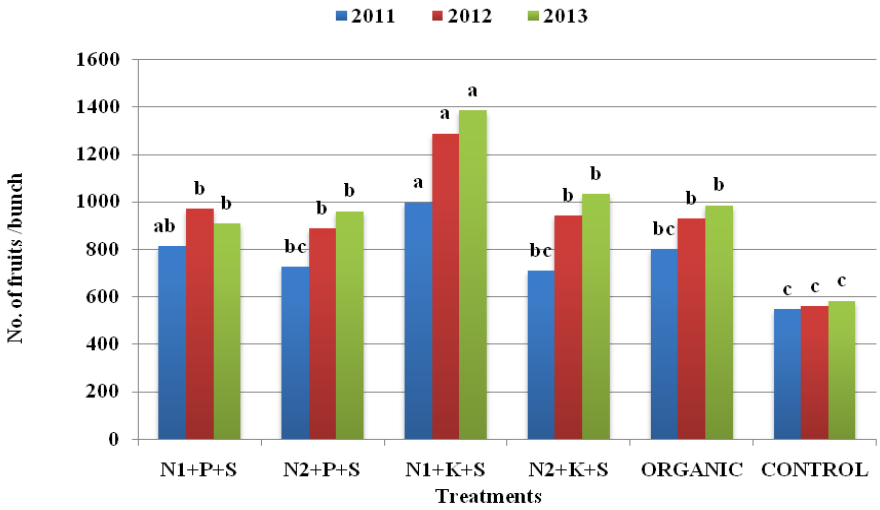
Values within a column with the same letter are not signifcantly different at $P < 0.05$.

Figure 1 : Effect of fertilizers application on fruit set

N1+P+S= Nitrogen (600g) + Phosphorus (800g) + Sulphur (700g).
N2+P+S= Nitrogen (1000g) + Phpsphorus (800g) + Sulphur (700g).
N1+K+S= Nitrogen (600g) + Potassiym (1200g) + Sulphur (700g).
N2+K+S= Nitrogen (1000g) + Potassium (1200g) + Sulphur (700g).

Number of fruits per bunch

The effect of different fertilization treatments on number of fruits per bunch is presented in (Fig. 3). Results of the first season demonstrated that application of fertilization treatments with combination of N1+P+S and N1+K+S significantly increased the number of fruits per bunch compared with the control, moreover combination of N1+K+S fertilization treatments proved to be more efficient in increasing number of fruits per bunch than N2+P+S and organic manure. All tested fertilization treatments significantly increased number of fruits per bunch in the second and third seasons more than the control; but combination of N1+K+S proved to be more efficient in increasing number of fruits per bunch compared with other fertilization treatments.



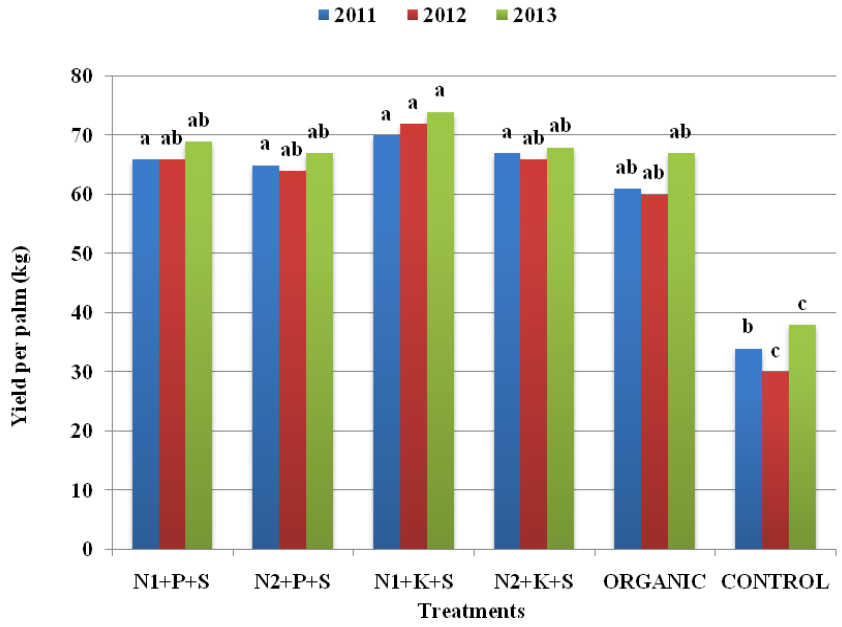
Values within a column with the same letter are not significantly different at $P < 0.05$.

Figure 3 : Number of fruit per bunch

N1+P+S= Nitrogen (600g) + Phosphorus (800g) + Sulphur (700g).
N2+P+S= Nitrogen (1000g) + Phosphorus (800g) + Sulphur (700g).
N1+K+S= Nitrogen (600g) + Potassium (1200g) + Sulphur (700g).
N2+K+S= Nitrogen (1000g) + Potassium (1200g) + Sulphur (700g).

Fruit yield

Fig. 4 shows the results of fruit yield per palm after fertilization treatments. The results of the three seasons showed that fruit yield was affected by fertilization treatments. However, in the first season application of combination N1+P+S, N2+ P+S, N1+K+S and N2+K+S produced higher fruit yield per palm over the control. In addition, it is evident from the data in (Fig. 4) that all tested fertilization treatments produced higher fruit yield in season two and three compared with the control.



Values within a column with same letter are not significantly different at $P < 0.05$.

Figure 4 : Effect of fertilizsers application on yield per palm

N1+P+S= Nitrogen (600g) + Phosphorus (800g) + Sulphur (700g).
N2+P+S= Nitrogen (1000g) + Phosphours (800g) + Sulphur (700g).
N1+K+S= Nitrogen (600g) + Potassium (1200g) + Sulphur (700g).
N2+K+S= Nitrogen (1000g) + Potassium (1200g) + Sulphur (700g).

Table 4. Effect of fertilizers application on fruit nutrients content of Khenazi date palm cultivar, season 2013.

Treatments	%				PPM				
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
N1+P+S	0.25a	0.09a	0.71ab	0.06a	0.09a	170.00b	13.00b	15.80b	4.80ab
N2+P+S	0.22ab	0.09a	0.74ab	0.05a	0.09a	169.30b	12.72b	15.83b	5.00ab
N1+K+S	0.26a	0.08ab	0.92a	0.07a	0.09a	266.00a	19.75a	23.27a	4.60ab
N2+K+S	0.22ab	0.07ab	0.84a	0.07a	0.09a	169.20b	12.80b	15.77b	4.23ab
Organic manure	0.21ab	0.09a	0.83a	0.06a	0.08a	166.90b	12.30b	16.07b	4.03ab
Control	0.14b	0.03b	0.35b	0.021b	0.040b	69.90c	4.10c	6.40c	1.66b

Values within a column with the same letter are not significantly different at (P<0.05).

Fruit nutrients content

Results in Table 4 illustrate fruit nutrient content of N, P, K, Ca, Mg, Fe, Mn, Zn and Cu which were investigated in season three only. It is evident from the data that fruit nitrogen was higher due to combination of N1+P+S and N1+K+S fertilization treatments over the control. In addition, fruit phosphorus content was significantly higher due to application of combination N1+P+S, N2+P+S and organic manure fertilization treatments over the control (Table 4). Meanwhile, fruit potassium content was significantly higher due to combination of N+K+S, N2+ K+ S and organic manure compared with the control. Furthermore, all tested fertilization treatments significantly increased fruit Ca, Mg, Fe, Mn, and Zn over the control (Table 4), but combination of N1+ K+S gave the higher values of Fe, Mn and Zn fruit content than those of other fertilization treatments. There were no significant differences obtained in fruit Cu content among all fertilizers treatments and the control (Table 4).

Discussion

Fruit flesh weight, volume, TSS and moisture content

The results presented in table (1, 2 & 3) showed that application of nitrogen in the form of urea (46%) in combination either with sulphur and phosphorus or sulphur with potassium caused significant improvement in fruit and flesh weights, fruit volume TSS and moisture content. These positive results may be due to the fact that urea enhances the performance of the palms. The availability of nitrogen and uptake by plants depends on the application form (Marzouk and Kassem, 2011). The results are also in line with the finding of Kassem (2012) who found that applied nitrogen in different forms alone or in combination with potassium, phosphorus and sulphur increased fruit fresh and fruit pulp weights. In addition, fruit flesh weight was increased when adding nitrogen combined with microelements on Barakawi dry date palm (Idris et al., 2012). Impact of phosphorus on increasing weight of fruit and flesh weight was accomplished by applying adequate phosphorus in combination with sulphur and nitrogen. This may have had enhanced the efficiency of soil characteristics and raised soil total content of phosphorus and hence increasing the availability of phosphorus under conditions of the present study. This finding also could be because soil reaction was decreased by sulphur, which created an acidifying soil environment by lowering alkalinity. However, application of sulphur increases availability of nutrients and improves presence and development of soil microorganisms because it reduces soil pH and improves date palm nutrition and growth markedly. There was positive effect in fruit and flesh weights due to organic manure. This result is partially in line with work of Bashab et al. (2007) who found that on Barakawi date palm cultivar, different fertilizer doses of organic manure increased fruit and pulp weights.

Effect of potassium in combination with nitrogen and sulphur caused fruit improvement in fruit flesh weight and fruit size (Tables 1, 2 & 3). This could be due to improving cell size or cell number and cell turgidity due to uptake of nutrients. However, fruit, weight and fruit volume were correlated with major macronutrients NPK and microelements in soil, so the acidifying effect of sulphur on soil and increasing nutrients uptake may have had enhanced fruit traits.

Some research workers reported that the uptake of nitrogen, phosphorus and potassium was increased with sulphur application (Rauof and Dawoud, 2015).

Fruit volume was increased as the result of addition of organic manure in the three seasons. Similarly, AL-Kahtani and Soliman (2012) found that agricultural waste + sheep manure resulted in higher values of fruit volume.

Fruit total soluble solids and fruit moisture content

All applied fertilizers had significant effects on TSS in the three seasons. The effect of nitrogen, phosphorus and potassium in combination with sulphur were more effective in increasing TSS, but combination of N1+K+S resulted in relatively higher TSS than other treatments (Tables 1, 2 and 3). The cause for increasing the percentage of total soluble solids by these elements may be due to the role of these elements in improving vegetative growth leading to effective absorption of nutrients. Also, due to their role in the efficiency of the process of photosynthesis, manufactured materials were increased in the leaves which then moved to the fruits, Eiada (2013). Similar work on Mango trees was obtained by Nasreen et al. (2014) who mentioned that combined nitrogen 760g, phosphorus 160g, potassium 250g and sulphur 90g significantly increased total soluble solids (TSS%) in mango fruit. Regarding the effect of organic manure, Bashab et al., (2007) on Barakawi date palm found that application of 60 kg organic manure per palm was superior in total soluble solids (TSS%). In addition, enhancement of K+ increased pepper fruit quality by increasing fruit firmness, TSS content, soluble sugars and ascorbic acid concentration (Botella et al., 2017).

All applied combined fertilizers decreased fruit moisture content but, the lowest fruit moisture content was obtained from combination of N1+K+S as shown in (Tables 1 ,2 & 3). The decrease in moisture content may be associated with increasing dry matter content or may be associated with chemical changes in fruit during ripening stages. However, low moisture content hastens fruit maturation. Shareef (2011) reported similar result on Khidrawi date palm. He found that spraying with NPK at concentration 2.5%, led to decrease in water content of fruits.

Fruit set

All fertilizers treatments induced high positive effect on fruit set percentage (Fig. 1). The superiority of fruit set could be attributed to adequate rates of nutrients and the efficient use by plant parts. In addition, soil applications perhaps supply enough nutrients to improve fruit set percentage. The improvement in the fruit retention percentage was due to the effects of nutrients on carbohydrate influx or plant growth regulators synthesis in the growing fruits (Elsabagh, 2012). Spraying macro and micro nutrients has important role in fruit set, fruit retention, development, causes efficient yield, and quality improvement (Rasmia et al., 2015).

Number of fruits per strand

The positive effect of fertilizers perhaps was attributed to proper amounts of nitrogen, phosphorus, potassium, and sulphur in combination, as well as organic manure applied to the soil. This may be enhanced by elemental sulphur and thus led to change in soil reaction and hence increase the availability of macro and micronutrients used by different parts of plant. This may have had affected the number of fruits per plant. The result agrees with findings of Abbas et al. (2015). The acidity produced during elemental sulphur oxidation increases the availability of nutrients such as P, Mn, Ca, and SO4 in soils. This may have had enhanced growth performance of plants; moreover, sulphur application led to decrease in Na concentration and promoted the uptake of potassium. The increase in fruit numbers due to use of fertilizers may reflect the greater vigor in vegetative growth and higher growth rates. Regarding the effect of organic manure, Garhwal et al. (2014) reported that on Kinnow mandarin, farmyard manure (FAY) up to 80 kg/tree increased number of fruit per tree. Bakheit and Elsadig (2015) found that manure increased the number of fingers per bunch on banana.

Number of fruits per bunch

The increment in number of fruits per bunch could be attributed to the influence of nitrogen, phosphorus and potassium in combination with sulphur. In seasons two and three, a pronounced effect was observed in number of fruits per bunch (Fig. 2). Moniruzzaman et al. (2008) mentioned similar trend in combination effect of different levels of fertilizers. Application of N 120, P 80, K 60,

S 20, Zn 4 and B 1kg ha-1recorded the highest number of green pods per plant of French bean. Navaneethakrishnan et al. (2013) found that applied nitrogen and phosphorus (200g N, 5 split doses and, 60 g P2O5) on banana gave the highest number of hands per bunch and higher number of fingers per hand on ratoon banana cultivar. Ahmed et al. (2001) found that on mango tree application of 1.5 N, 1.5 P and 0.75 K kg/plant respectively recorded maximum number of fruits per tree (940).

Yield per palm

The improvement in yield per palm because of chemical fertilizer or organic manure may be attributed to increase in photosynthetic ability due to good vegetative growth induced by these treatments. This suggests that cultivar produced heavier bunch as reflected by more strands with more fruits and more fruits per bunch with heavier fruit weights (Fig. 4). Nitrogen and sulphur interact to exert a strong effect on various growth parameters, such as biomass and yield (Salvagiotti and Miralles, 2008). Incorporation of chemical fertilizers as soil application has been reported to have an increasing effect on yield by several studies. Idris et al., (2012) stated that combination of N + P increased total yield of Barakawi dry date palm. Ibrahim et al. (2013) stated that applying N, P and K at the highest level produced the highest fruit yield per palm on Sewy date palm. The same trend was observed by Al-Qurashi et al. (2015) who noted that the highest fertilization regime (450 g N, 225 g P and 225 g K/tree yearly) applied either as soil broadcast or as feritigation produced the highest total yield per palm of Barhee date palm. Nasreen et al. (2014) studied combination of fertilizers nutrients (N, P, K and S) on mango and found that the treatment N 960, P 200, K 300 and S110 g/tree recorded the highest yield. The maximum average mango fruit yield of 61.22 kg\plant was achieved by application of 1.50km NPK /plant (Ahmed et al., 2001). Feng et al., (2017) working on potato found that the highest tuber yield was 38.0 Mg ha−1 for 90% NPK. Moniruzzaman (2008) reported that the highest pod yield of 23.14t ha-1 was obtained with 120-120-60-20-4-1 kg of N-P_2O_5-K_2O-S-Zn-B plus 0.5 kg Mo ha-1 on French bean. Applications of 140 or 80 kg nitrogen ha-1 at sowing alongside applications of 20 kg sulphur ha-1 resulted into higher yield of wheat (Hayat et al., 2015). The lack of response to application of organic manure in season one (Fig. 4) might be due to the insufficient of nutrients uptake or to factors that limit nutrients availability. The result could be related to the factors that affected organic matter breakdown such as biological activity, oxygen level, moisture level, soil pH and temperature (FAO, 2005). Application of organic manure led to the positive effect on yield in seasons two and three (Fig. 4), and that may be due reducing soil pH and salinity as well as enhancing the biosynthesis of natural hormones and antibiotics. In addition, improvement of yield per palm may probably be due to enhancing mineralization and release of nutrients from organic manure. It can be explained that organic manure application perhaps affects palm growth and fruit yield by influencing nutrient availability and release of nutrients for plant uptake and growth. Adekiya and Agbede (2016) reported that the application of chicken manure produced the highest fruit yield of tomato and this supports this result. Agyeman et al. (2014) who worked on tomato plant found that chicken manure produced significantly higher yields (20.5 and 20.3 respectively) compared to the control (12.9 t/ha).

Fruit nutrients content

Fruit mineral content differs by applying fertilizers treatments. The application of nitrogen 600g and 1000g, either with P and S or with K and S as well as organic manure, greatly increased fruit N, P, K, Ca, Mg, Fe, Mn and Zn content (Table 4). This means that combined treatments were efficient in improving vegetative growth and palm tree nutritional status as well as greater increase in nutrients uptake. This may explain the reason for their effect in improving the fruit mineral content of Khenazi cultivar. Kassem (2012) obtained similar increases in fruit mineral contents by NPK alone or by its combination on Zaghloul date palm. Also, higher fruit phosphorus may be affected by nitrogen and sulphur application and enhance efficiency of soil and raise the soil total content of P, hence increase availability of P. This result agrees with Marzouk (2011) who noted that the application of elemental sulphur increased fruit phosphorus content of Zaghloul date palm. Adding 1200g, potassium in combination with nitrogen and sulphur led to increase of fruit potassium content. In

addition, Khenazi cultivar may be capable of accumulating higher amounts of potassium in their leaves, which resulted in higher fruit potassium content. The increment in Ca and Mg was perhaps due to the effect of nitrogen, potassium, and sulphur in raising the amount of Ca and Mg in the fruit. These findings are in contrast with Kassem (2012) on Zaghloul date palm who stated that Ca and Mg content decreased with application of potassium fertilizer, but the result agrees with Heidari and Mohammad (2012) who reported that by increasing nitrogen levels, the values of N, P, K, Ca and Mg content increased in fruits of *Momordica charantia*. These results are partially in harmony with those obtained by Hussein (2008) who found that fruit N, P, K, Ca and Mg in Khalas date palm increased with addition of N and K to the trees. Fruit Fe, Mn and Zn content were higher due to combined N1+K+S. These obtained results are in accordance with Marzouk (2011) who reported that the highest amounts of potassium and sulphur increased fruit Fe and Mn content. The increase in fruit P, K, Ca, Mg, Fe, Mn and Zn concentration might be attributed to amendment of chemical and physical properties of soil by adding organic manure which maintains or increases the soil organic matter content. In addition, organic matter acts as a reserve of the nitrogen and other nutrients required by plants (Craswell and Lefroy, 2001).

Conclusion

In conclusion, combination of chemical fertilizers or organic manure fertilizers could be used to improve fruit quality, yield and fruit nutrient contents of Khenazi date palm. Combination of N1+K+S comprised of 600g nitrogen, 1200g potassium, 700g sulphur, and mixed with100g of microelements is recommended for Khenazi cultivar under the conditions of the present study, while 50Kg organic manure and mixed with100g of microelements was also beneficial for Khenazi cultivar.

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