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Improving fruit quality and Yield of Khenazi date palm (*Phoenix dactilifera L.*) grown in sandy soil by application of nitrogen, phosphorus, potassium and organic manure

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Abstract

During three During three years we had investigated main fruit quality traits, yield, and fruit maturation on Khenazi date palm (*Phoenix dactilifera* L.). The experiment was designed in CRBD with five treatments plus the control. The fertilizers applied were comprised of urea (46% nitrogen) of two levels, triple superphosphate (48% P_2O_5), potassium sulphate (%K_2SO_4) and organic manure. All experimental trees received 100g mixture of micronutrients. The results showed that fruit flesh weight, flesh to seed ratio, fruit length, fruit width, fruit volume, maturity, number of fruits per strand, number of fruits per bunch and fruit yield were strongly affected by fertilizers application. On the other hand all fertilizers increased TSS and lowered moisture content with the exception of nitrogen which did not show any effect in moisture content in the first season. Thus, using NPK and organic manure is recommended for sustainable Khenazi date palm production in sandy soil in United Arab Emirates (U.A.E.)

Keywords: Phoenix dactilifera, Kkenazi, Bunch, Arid zone, U.A.E

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1. Introduction

Date palm (*Phoenix dactylifera L.)* is one of the oldest cultivated trees in the world according to FAO (2010). Date palm is the most common fruit tree grown under hot, semi-arid and arid-regions (Marzouk, 2011). It has been used for generations due to its remarkable nutritional health and economic value, in addition to its aesthetic and environmental benefits. Dates offer useful prospects for fighting hunger and diseases (Suleiman et al*.,* 2012). Date palm trees require relatively great amounts of macro and micro nutrients to achieve good growth and give reasonable economic production. Fertilization is therefore one of the important practices which increases date production and improves fruit quality. A research done on the date palm showed that proper application of macro and micro nutrient fertilizers is necessary to increase quantitative, qualitative and economic output of date production in palm groves (Shaaban and Mahmoud, 2012). Nitrogen is a major element required by all plans and adequate nitrogen is essential for tree growth, leaf cover, blossom formation, and fruit set and fruit size. (Sharma, 2016). Most date producers have adopted the practice of producing acceptable yield without application of nutrients. This level of production can be greatly improved by fertilizer addition which also improves the quality of fruits (Ibrahim et al., 2013). Abou Sayed-Ahmed et al. (2005) studied the influence of N, P and K fertilizer application on yield of Amry date Palm grown in sandy soil for three successive seasons and found that 0.40 kg N/tree was the best application to increase the yield. El-Hammady et al. (1987) reported that the application of N increased the number of growing leaves and leaf content of N, P and K of Sewy date palm. Application of mineral fertilizers with organic or biofertilizer proved to be highly effective in improving nutritional status, fruiting and fruit quality of various fruit trees (Ibrahim et al., 2013). Most date growers do not apply chemical fertilizers or apply them in improper amounts.

Therefore, the aim of this study is to quantify the effect of N, P and K and organic manure fertilization treatments on the fruit production and fruit quality of Khenazi date palm trees grown in sandy soil in United Arab Emirates.

2. Materials and methods

2.1. Plant material and experimental design

The study was carried out during three successive growing seasons of 2011, 2012 and 2013 in a private orchard located at Al hello in Ajman Emirate (UAE) for Khenazi date palm cultivar, 12 years old, grown in sandy soil. Analysis of the experimental orchard soil is presented in appendix (1). Palms were planted at space 7×7m apart. Selected trees were as uniform as possible in growth and vigor and free from insect's damage and diseases. All the routine agro-technical operations were carried out according to the traditional schedule for date palm plantation. The leaf/bunch ratio was adjusted at the value of 8:1 for all experimental palms. In addition, chemical fertilizers were not applied to the experimental trees before the initiation of the present experiment.

The fertilizer treatments consisted of urea (46%N), triple superphosphate (48% P_2O_5), Potassium sulphate (50% K_2SO_4), organic manu re and the control. Six soil treatments were arranged in a completely

randomized block design (CRBD) with three replicates (1 plot = 2palms). All data were subjected to analysis of variance (ANOVA) using R software programme. Mean separation was carried out ($P<0.05$) using Tukeys significant difference test (Harhash and Abdel-Nasser, 2010).

2.2. The treatments

The treatments were as follows:

- N1600 g divided into four equal doses
- N2 1000g divided into four equal doses
- P 800 g divided into four equal doses
- K 1200 g divided into two equal doses
- Organic manure
- Control

A mixture of microelements 100g was used for each tree and50 kg / tree organic manure was added in November, while nitrogen and phosphorus fertilizers were added in December, January, February and March consecutively. The potassium fertilizer was added in March and April each year respectively. Each fertilizer treatment was applied in a trench method one meter away from the palm trunk and then irrigated directly after addition of the fertilizer treatments.

2.3. Measurements

2.3.1. Fruit quality

Sample of 50 full mature fruits were randomly selected from each palm at Bisr stage in the mid of July for determining the fruit physical characteristics. Chemical characteristics such as total soluble solids (TSS) were determined by hand refractometer (Shareef et al., 2011) and fruit moisture content was determined according to the methods of AOAC (2005) as follows:

$$\text{Moisture \%} = \frac{\text{M-INITIA} - \text{M-DRIED}}{\text{M-INITIAL}} \times 100$$

where, M-INITIA weight and M-DRIED weight are of the sample before and after drying respectively.

2.3.2. Fruit maturation %

Ten strands were collected randomly from each tree and mature fruits were counted and divided by the total number of fruits (Shareef et al., 2012) and Al-jabary et al. (2009) and then fruits maturation percentages were calculated by using the following method:

$$\text{Maturation \%} = \frac{\text{Number of mature fruits}}{\text{Total number of fruits at Bisr stage}} \times 100$$

2.3.3. Number of fruits per strand and bunch

At harvest time mature fruits, at Bisr stage at the peak of fruit color development during July, a number of ten strands were chosen from each tree and the number of fruits per strand was counted. Fruits were extracted by hand from the bunch from all its strands and total number of fruits per bunch was determined by counting the number of all fruits per bunch.

2.3.4. Yield per palm (kg)

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

2.3.5. Soil Physical and chemical properties:

Soil chemical characteristics were determined according to the method of US-EPA, method number 2007 (US-EPA, 2001), while soil physical characteristics were determined as described by Chapman and Pratt (1961).

3. Results

3.1. Fruit quality

3.1.1. Fruit and flesh weight (g) flesh to seed ratio, fruit length, fruit width and fruit volume cc

The results obtained (Tables 1, 2, & 3) clearly indicated that all tested fertilization treatments significantly increased average fruit and flesh weight, fruit width and fruit volume compared with the control (unfertilized). Regarding flesh to seed ratio in the first season results showed some variability, however phosphorus (800g) proved to be the most efficient compared with the control (Table 1).

In the second and third seasons all tested fertilization treatments produced higher positive effect in flesh seed ratio (Tables 2 & 3). On the other hand, fertilization treatments with nitrogen (1000g), phosphorus (800g) and potassium (1200) clearly increased fruit length over the control. Furthermore, tabulated data in (Tables 2 & 3) of the second and third seasons showed that all tested fertilization treatments induced high positive effect on fruit length than the control.

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

Treatments	fruit weight (g)	flesh weight (g)	flesh seed/ratio	fruit length (cm)	fruit width (cm)	fruit volume (cc)
N1	11.29c	10.22d	9.55ab	3.70cd	2.34b	11.00d
N2	14.43ab	13.31abc	11.88ab	4.10ab	2.40ab	14.00ab
P	13.17bc	12.33bc	14.68a	4.01abc	2.40ab	12.80bc
K	15.11a	14.01a	12.74ab	4.01abc	2.42ab	14.50a
Organic manure	11.61c	10.65d	11.09ab	3.84bcd	2.34b	11.33d
Control	9.63d	8.64e	8.72b	3.58d	2.12c	9.13e

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

Table 2. Effect of fertilizers application on fruit physical characteristic on Khenazi date palm cultivar during 2012 season

Treatments	Fruit weight (g)	Flesh weight (g)	Flesh seed/ratio	Fruit length (cm)	Fruit width (cm)	Fruit volume (cc)
N1	12.61de	11.64d	12.00d	3.74c	2.33b	11.42bc
N2	14.13abc	13.12bc	12.99cd	4.01b	2.36ab	13.22a
P	13.65cd	12.73c	13.83bc	4.02b	2.40ab	12.93ab
K	15.02ab	14.11ab	15.50b	4.01b	2.41ab	14.23a
Organic manure	11.89e	10.97d	11.92d	3.80c	2.31b	11.c3
Control	10.02f	9.11e	10.01e	3.52d	2.18d	9.1d

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

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

Treatments	Fruit weight (g)	Flesh weight (g)	Flesh seed/ratio	Fruit length (cm)	Fruit width (cm)	Fruit volume (cc)
N1	12.61b	11.66b	12.27b	3.83c	2.38a	12.37b
N2	14.40ab	13.40ab	13.40b	3.93bc	2.38a	13.98ab
P	15.11a	14.14a	14.57b	4.05b	2.36a	14.76a
K	15.17a	14.11a	13.31b	4.05b	2.42a	14.62a
Organic manure	12.58b	11.64b	12.38b	3.79c	2.342a	12.35b
Control	10.17c	9.20c	9.48c	3.55d	2.16b	9.93c

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

3.1.2. Fruit total soluble solids and fruit moisture content

The depicted data in (Table 4) indicated that all tested fertilization treatments increased fruit total soluble solids (TSS) during the three seasons of the study compared with the control, moreover all tested fertilization treatments gave the lowest fruit moisture content than the control with exception of nitrogen 600g (N1) and 1000g (N2) in the first season only compared with the control.

Table 4. Effect of fertilizers application on fruit total soluble solids and moisture content on Khenazi date palm cultivar during 2011, 2012and 2013 seasons

Treatments	TSS	moisture %	TSS	moisture %	TSS	moisture %
	2011		2012		2013	
N1	47.83b	77.88ab	47.00b	70.90b	48.50d	72.14b
N2	50.33ab	77.75ab	47.67b	69.99b	48.33d	72.61b
P	47.83b	75.30b	48.17b	70.49b	49.00bcd	72.05b
K	51.83a	74.97b	49.17b	70.14b	51.08b	70.75b
Organic manure	47.83b	74.83b	48.00b	70.27b	50.50bcd	69.77b
Control	43.83c	84.51a	42.00c	80.04a	45.00e	82.14a

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

3.1.3. Fruit maturation %

It is clear from data in (Figure 1) that all the studied fertilization treatments resulted in significant increments in fruit maturation percentages compared with the control in the three seasons of study.

3.2. Number of fruits per strand and bunch

The effect of different fertilization treatments on number of fruits per strand and number of fruits per bunch are presented in Figures 2&3. Results of the first season revealed that fertilization treatments with nitrogen (1000g) and potassium (1200g) significantly increased the number of fruits per strand and number of fruits per bunch as compared with the organic manure and the control. Whereas, all tested fertilization treatments significantly increased fruit number per strand and number of fruits per bunch in the second and third seasons compared with the control.

3.3. Yield per palm tree (kg)

The results in (Figure 4) clearly indicate the effect of fertilization treatments on the fruit yield per palm. In the three seasons, experiments showed that fruit yield was affected by fertilization treatments. However, in the first season application of nitrogen 1000g (N2) and potassium (1200g) produced higher fruit yield per palm than the control. Also it is evident from the data in (Figure 4) that all tested fertilization treatments produced higher fruit yield in seasons two and three compared with the control with the exception of nitrogen, 600g (N1).

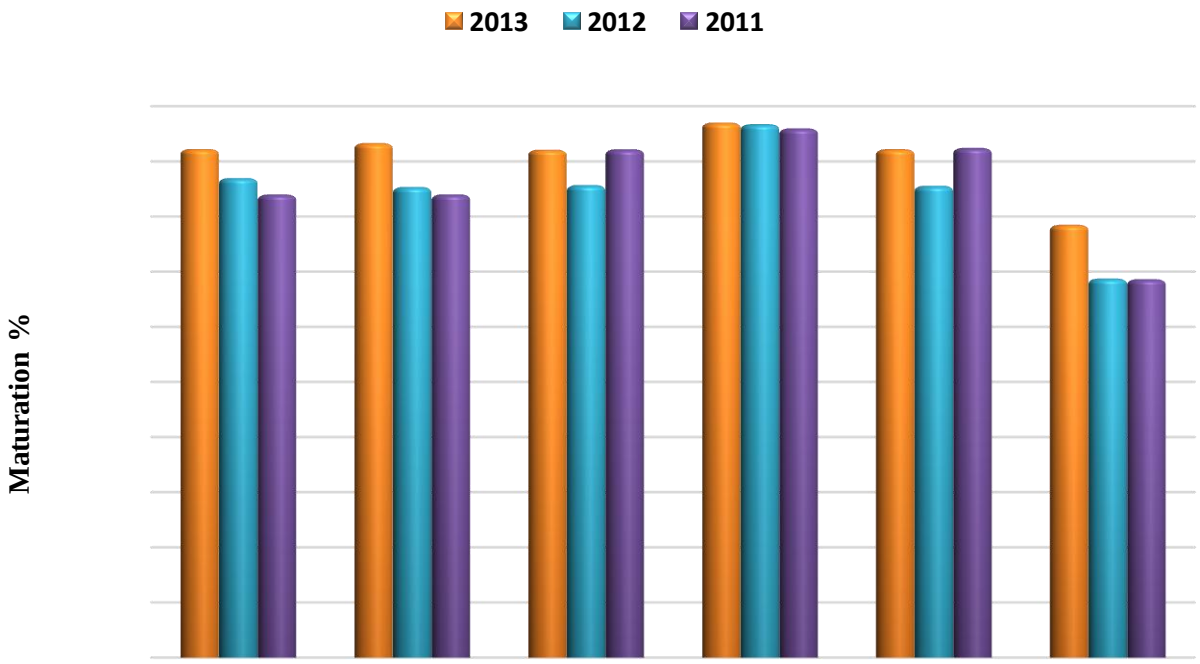

Figure 1. Fruit maturation pecent

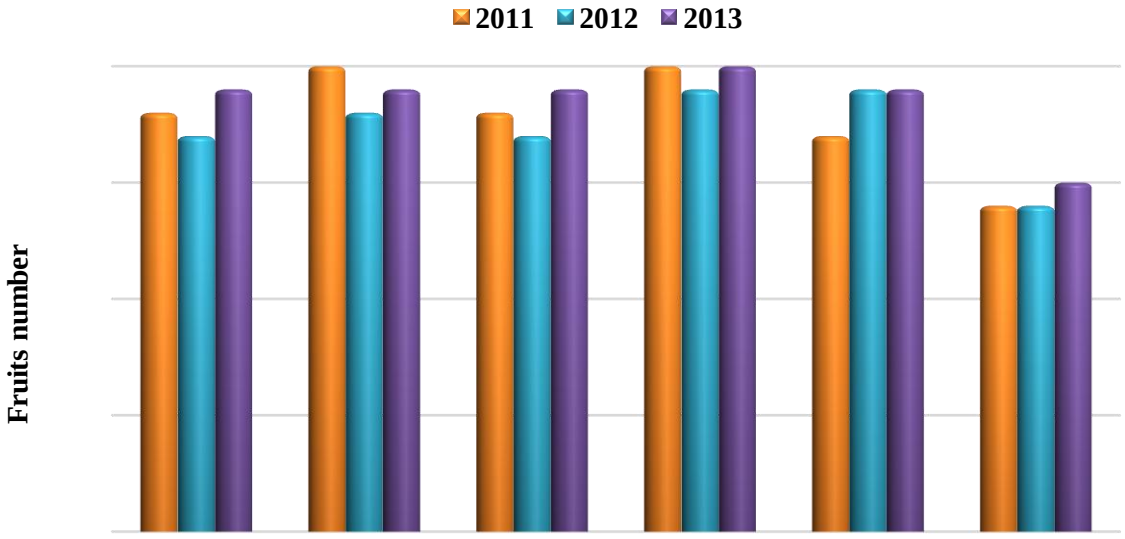

Figure 2. Effect of fertilizers application on fruit number per strand

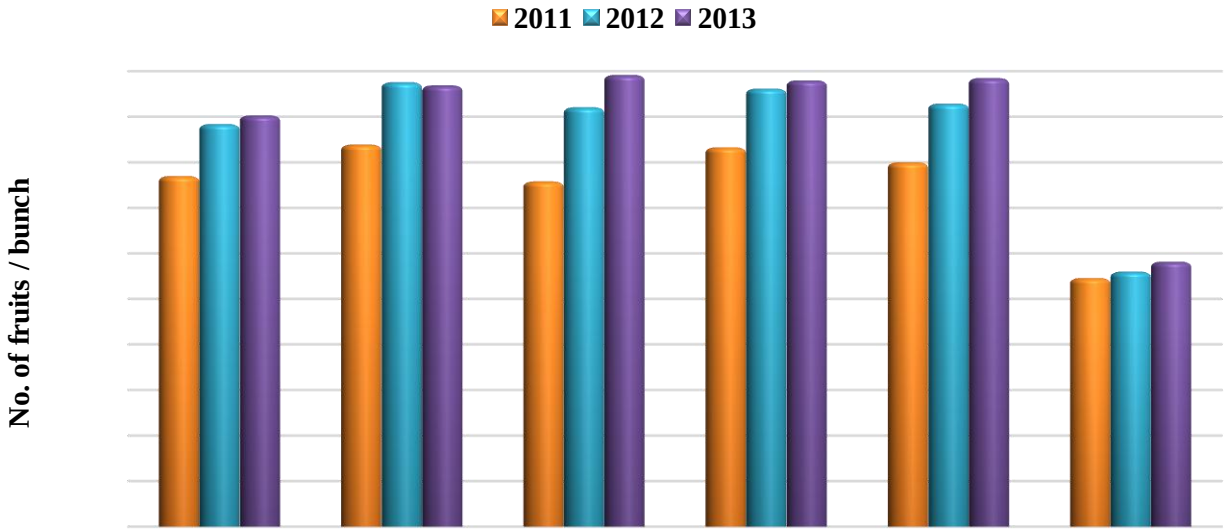

Figure 3. Effect of fertilizers application on number of fruits per bunch

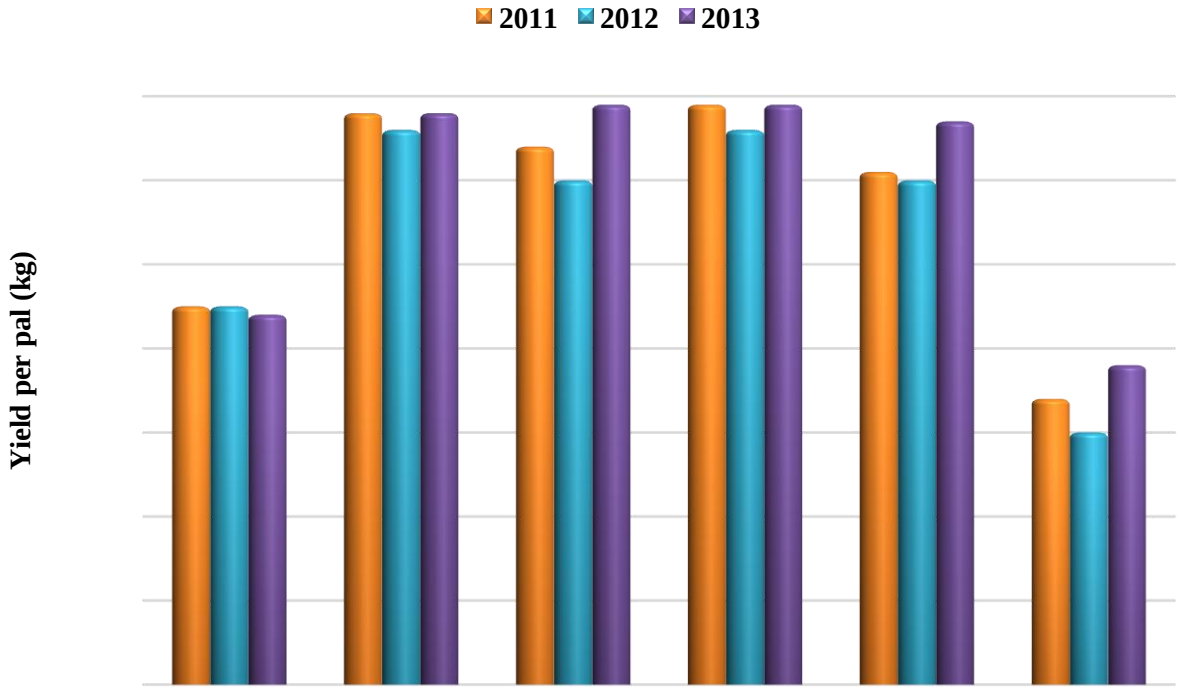

Figure 4. Effect of fertilizers application on yield per palm

4. Discussion

4.1. Fruit quality

4.1.1. Fruit and flesh weight (g) flesh to seed ratio, fruit length, fruit width and fruit volume (cc)

The obtained results as presented in (Tables 1, 2, & 3) showed that application of N, P, K and organic manure caused significant increases in fruit flesh weight, flesh to seed ratio, fruit length/width and fruit volume. These improvements might be interpreted by efficient uptake and metabolism of N, P and K under the conditions of the study, therefore increase in nutrients uptake enhanced fruit traits. The results also revealed that treatments increased the availability of N, P and K. The increments in fruit traits by adding N may be due to the fact that nitrogen is the basic protein building unit and protein is the basic cell building unit and involved in many physiological processes (Idris et al., 2012). Applying phosphorus is the most effective practice for feeding Khenazi date palm and producing the best fruit quality. Liu et al. (2015) agreed with this result by finding that 134 kg/ha P_2O_5 produced best bean fruit appearance. The increments in fruit physical characteristics may be due to the potassium application, where it plays an important role in pH stabilization, osmoregulation, enzyme activation, protein synthesis, stomata movement, photosynthesis, cell extension, cell division, cell size, cell number and cell turgidity. These results are in accordance with Mengel and Kirkby (2001), Dialami and Mohebi (2010), Al-Obeed et al. (2013) and Rasmia et al. (2015). Applied N, P and K affected fruit length and width. However, the physical characteristics of fruits are expression of the plant's vegetative activity, so, it may be presumed that the N, P and K treatments at optimum level lead to increase in shoot and leaf development that is ultimately capable of manufacturing greater amount of food materials and when translocated to the fruit bearing areas lead to enhancement in length and width of the fruits. Similar results were reported by Dialami and Moheb (2010), Dawoud et al. (1994) on guava tree and Kumar et al. (2014) on guava. Abdi and Hedayat (2010) found that 'soil application of potassium increased fruit length and diameter on Kabkab date palm. The results are in line with Omotoso and Akinrinde (2013) on pineapple. Organic manure could enhance soil fertility, resulting in increasing nutriments availability and uptake by plants (Matthew and Karikari, 1995). This fact could give a good explanation for the present effect of organic manure in increasing the physical fruit length and width. Improved fruit flesh weights and volume upon addition of organic manure had been reported by Bashab et al. (2007), AL-Kahtani and Soliman (2012) and Abdel-Galil et al. (2014) on date palm tree.

4.1.2. Fruit total soluble solids and fruit moisture content

The cause for increasing percentage of total soluble solids when adding N, P, K and organic manure may be due to the role of these nutrients in the efficiency of the process of photosynthesis, thereby increasing manufactured materials in the leaves and then moving to the fruit (Eiada, 2013). Nasreen et al. (2014) obtained similar results on Mango trees. According to Botella et al. (2017) the increase of K^+ in the nutrient solution improved pepper fruit quality by increasing fruit TSS content. Bashab et al. (2007) on Barakawi date palm found that 60 kg organic manure per palm was superior in total soluble solids (TSS %). All applied fertilizers lowered fruit moisture content but, the lowest fruit moisture content was obtained from potassium (1200g) as shown in (Table 4). 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. Similar result was reported by Shareef (2011) on Khidrawi date palm.

4.1.3. Maturation

Khenazi date palm responded to nitrogen, phosphorus, potassium and organic manure fertilization treatments in respect to fruit maturity traits as presented in (Figure 1). This result could be attributed to bioconversion that occurred during the ripening process in date fruit or may be related to increase of nutrient elements which led to raising the efficiency of photosynthesis process in leaves which was in turn reflected on maturation. This may be attributed to the activities of invertase and cellulase enzymes which affect the firmness and storing ability of fruits. This result is in agreement with Shareef (2011) on Khidrawi date palm, Al-jabary (2009) on Sayer date palm and Liu and Liu (2012) on pineapple, who found that fruit maturity was promoted by the organic manure and the fruits were sweeter in taste and better in fragrance.

4.2. Number of fruits per strand and bunch

The positive effect of fertilizers in increasing fruit numbers was perhaps attributed to proper amounts of N, P, K and organic manure applied directly to the soil which resulted in a higher number of fruits per plant (Figure 2). The increase in fruit numbers may be a reflection of the greater vigor in vegetative growth and higher growth rates. The result agrees with the findings of Navaneethakrishnan and Kumar (2013) who found that applied N and P 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 the maximum number of fruits per tree (940) was recorded by application of 1.5 nitrogen, 1.5 phosphorus and o.75 potassium kg/plant respectively. Related to organic manure, Garhwal (2014) reported that on Kinnow mandarin farm yard manure (FAY) up to 80kg/tree increased number of fruits per tree. Bakheit and Elsadig (2015) found that manure increased number of fingers per bunch on banana.

4.3. Yield per palm

The improvement in yield per palm as a result of chemical or manure application may be attributed to increase in cultivar photosynthetic ability as a result of good vegetative growth that was induced by fertilization treatments. This suggests that the cultivar produced more strands with more fruits than more fruits per strand. The results are in harmony with Ibrahim et al., (2013) who found that N, P and K produced the highest fruit yield per palm on Sewy date palm. The same trend was observed by Al-Qurashi (2015) who found that the highest fertilization regime applied either as soil broadcast or as feritigation produced the highest total yield per palm of Barhee date palm. Fatima and Dawoud (2016) investigated the effects of 1000g total N per palm and found that fruit yield of Barhi date palm was increased. Al-Obeed et al., (2013) noted that 1.0kg P +2.0kg K at three doses gave the highest yield of “Khalas” date palm. The lack of response to application of organic manure in season one might be due to the insufficient uptake of nutrients or may be related to slow release of nutrients during decomposition. Also, the result might be correlated to the factors

that affect organic matter breakdown such as biological activity, oxygen level, moisture level, soil pH and temperature. On the other hand the positive effect on yield in seasons two and three might be attributed to the benefits in reducing soil pH and salinity as well as enhancing the biosynthesis of natural hormones and antibiotics, nitrogen fixation, organic matter, water and nutrient uptake, biological activity and soil fertility. Also, improvement of yield per palm may probably be due to enhance 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 uptake. This result is supported by Adekiya and Agbede (2016) and Agyeman et al. (2014) who worked on tomato plant. It is probably that these increases resulted from increased availability and uptake through the modification of the soil pH, as reported by Marschner (1995).

5. Conclusion

Soils of UAE are sandy consisting of 85% sand and it is low in organic substances and in major and minor elements, in addition growers do not apply chemical fertilizers for date palm or apply it improper amounts. This work is designed to improve fruit quality and productivity of Khenazi date palm growing in sandy soil by adding different fertilization treatments .The results imply that all fertilizer treatments improved fruit quality, number of fruits per strand and number of fruits per bunch. Fruit quality and yield were improved by N, P, K and organic manure as soil treatments. Accordingly, these practices are recommended for Khenazi date palm cultivar grown in sandy soil.

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