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EFFECT OF POTASSIUM NITRATE ON YIELD AND QUALITY OF 'DHAKKI' DATE PALM

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Fruit quality improvement of date palm has always been an issue that can be resolved by using different approaches, and one of them is the application of chemical fertilizers. Potassium is the least used nutrients by the growers in this part of the world although it is a major nutrient necessary to improve the yield and fruit quality of date palm. Keeping in view the importance of potassium, the objective of the present research was performed to investigate the role of potassium in improving yield and quality of 'Dhakki' date palm. For this purpose, seven different treatments were used for the experiment including:(i) Control (distilled water spray); (ii) KNO_3 at 1%; (iii) KNO_3 at 1% + urea at 2%; (iv) KNO_3 at 2%; (v) KNO_3 at 2% + urea at 2%; (vi) KNO_3 at 3%; (vii) KNO_3 at 3% + urea at 2%. The application of KNO_3 was performed at 'Kimri' stage of fruit development. The randomized complete block design was used including three replications. Pre and post-harvest physicochemical parameters were evaluated that included fruit drop, fruit length, diameter, fruit weight, percent pulp, bunch weight, total soluble solids, reducing, non-reducing and total sugars in the fruits. The results revealed that during both seasons of study, KNO_3 alone and mixed with urea significantly showed better results however the application of KNO_3 at 2% is found to be more effective in minimizing fruit drop (46.99% and 50.05%) and enhancing other variables i.e. fruit length (54.41mm and 53.46mm), diameter (43.15mm and 41.31mm), fruit weight (13.69g and 13.53g), percent pulp (90.99% and 93.59%), bunch weight (8.21kg and 8.11 kg) and total soluble solids (76.07 and 76.83 °Brix) during both seasons of study hence resulting in improved yield and fruit quality of 'Dhakki' date palm.

Keywords: *Phoenix dactylifera* L., macronutrient application, quality attributes.

INTRODUCTION

Date palm *(Phoenix dactylifera* L.) is one of the most important and oldest plants cultivated by man. It is widely grown throughout the tropical and subtropical areas of the world. Pakistan ranked the 6th position in the world and has cultivated area of 100,611 hectares with an annual production of 0.471 million tons (FOASTAT, 2019).

'Dhakki' is one of the best of date palms in Pakistan. This cultivar has got high market value due to its large size, highest pulp percentage, high sugar content and attractive color and shape. However, the growers of 'Dhakki' date face many problems that include the high intensity of fruit drop, non-availability of pollens because of late flowering nature, infestation by date palm weevil and minimum use of fertilizers. Large quantities of date palm go to dry dates locally known as 'Chohara' resulting in limited availability of processed table dates in the market. There are many reasons for the non-availability of fresh dates of 'Dhakki' date palm in the market, i.e., high post-harvest losses, non-availability of the processing unit and special market, and no special support for growers (Baloch, 1999).

A low percentage of fruit set and a high percentage of fruit drop are considered the most important factors that restrain the quantity and quality of date palm cultivars. Fruit drop is a complex phenomena where several factors are involved including physiological and pathological reasons (Youssef et al., 2015). Hence, there is a need to adopt several practices and approaches that aim to improve the quality and yield of date fruits. Among these, mineral nutrients application is one of the practices that can perform a major role in the quality production of date fruit. Despite its importance, it has been observed that very few growers apply complete fertilizers, so there is a need to improve the quality of processed dates. In this regard, some macro and micronutrients have a significant effect on the production and quality of dates (Al-Hamoudi, 2006).Micronutrients affect the germination of pollen grains and growth of the pollen tube in different plant species. Among these micronutrients, potassium has a significant effect on fruit set, yield and quality (Talaie *et al*., 2001; Wojcik and Wojcik, 2003; Khayyat *et al*., 2007; Hussain et al., 2017). Besides this, potassium also shows a great effect on the water content of the cell, different biosynthesis and mobilization process of plant tissues (Abdel- Bary., 1999;

Saleh and El-Monem., 2003; Shahin., 2007; Harhash and Abdel-Nasser., 2010; Khayyat *et al*., 2007). Potassium is also necessary by the plants for the growth and enlargement of cells and fruits (Marshner, 1995). In the biosynthesis process of sugars, enzymes are activated by potassium (Archer, 1988). Different researchers reported that foliar application of potassium and boron has a significant effect on the production and quality of different fruit crops. These positive effects of potassium had also been reported while working on fruit crops, i.e., mango, banana, grape and peach (Saleh and El-Monem, 2003; Attia *et al*., 2001; Coban, 2002; Hassanein, 2004).

Despite significant characteristics of potassium, its use in our farming system is very limited. Nitrogen and phosphorus are the only nutrients applied with the understanding that our soils contain enough amount of potassium. Therefore, keeping in the view the importance of potassium, this research was carried out with the objective to improve growth, yield and quality of 'Dhakki' dates using bunch application of KNO_3.

MATERIALS AND METHODS

***Experimental area*:** The trial was conducted at Agriculture Research Institute Dera Ismail Khan_Pakistan, during two consecutive seasons 2015 and 2016 with the aim to examine the effect of bunch application of $KNO_3$to improve yield and fruit quality of 'Dhakki' date palm. For assessments, 21 palms of nearly equal size, age and growth vigor were selected for this trial. Normal cultural practices were performed to all palms. The same source of pollen grains was used for pollination.

Treatments and design: Pre-harvest application of KNO_3 was applied on selected 'Dhakki' date palms. For the purpose of experiment seven treatments were used that included: (i) Control (distilled water spray); (ii) KNO_3 at 1%; (iii) KNO_3 at 1% + urea at 2%; (iv) KNO_3 at2%; (v) KNO_3 at2% + urea at 2%; (vi) KNO_3 at 3%; (vii) KNO_3 at 3% + urea at 2%. The foliar spray was performed at 'Kimri' stage (2^{nd} stage of fruit development) as at this stage the fruit is young, elongated, green in color with hard texture (Hui., 2006; Ahmed *et al*., 2013). Sprays were applied using a knapsack sprayer. A number of spathes were maintained to 10 spathes per palm. Extra (smallest and earliest) spathes were removed. The solution of 1% concentration was prepared by dissolving 10 g of required nutrient in 1 L of distilled water. Similarly, 2% and 3% solutions were prepared by adding 20 and 30 g, respectively of required nutrient per 1L of distilled water. The randomized complete block (RCB) design was used with three replications (each with one palm tree). Ten strands were randomly selected in each selected bunches per palm for the measurement purpose. From that, 10 fruits samples/strands of 'Dhakki' were taken at the ripening stage to perform different physicochemical analyses.

***Fruit drop (%)*:** Fruit drop was in the month of June, July and August during both seasons and percent fruit drop for each month was calculated using the formula:

Fruit drop (%) = Total number of dropped fruit / Total number of retained fruit ×100 (Ashraf*et al*., 2012).

Fruit length and diameter (mm): Fruit length and diameter of ten fruits per strand were measured with the help of Vernier caliper three times during both seasons. Percent increase in fruit length and diameter for each month were recorded.

Fruit weight (g): The weight of fruit from all selected strands per bunch (ten fruits in each strand) was recorded using electrical balance and the average was calculated.

Pulp percent: The weight of ten fruits was measured with the help of an electrical balance. Then the stone was removed, pulp weight was measured and its percentage was calculated using the following formula:

Pulp percentage = Total pulp weight / total fruit weight × 100.

Fruit pH: The pH of fruits was determined using a Jenway 3510 bench pH meter (Cole-Parmer, Staffordshire, UK).

Potassium (mg/g): Potassium content in fruit was determined with the help of flame photo meter (Sherwood Model 410).

Chemical analysis of fruit: For chemical properties assessment samples of 100 g fresh pulp from each treatment was taken and placed in a blender with 200 ml of distilled water. The samples were blended for around 2-3 minutes with the purpose to assure complete extraction and homogenization. Then sample of 2 g pulp from each treatment was taken in a beaker to determine total soluble solids (TSS, °Brix), reducing sugars, non-reducing sugars, total sugars, potassium content (%) and pH of the fruit. All these parameters were determined by the standards of AOAC (1984) methods.

For determination of TSS, 2 gram pulp solution from each treatment was taken. Then a few drops of the sample were placed on prism of a digital refractometer (Krüss DR301-95; A. Krüss Optronic, Hamburg, Germany) with automatic temperature compensation at 20 °C, and then the results were expressed in °Brix.

Sugars content: Total sugars, reducing sugars and non-reducing sugars were determined using Fehling A and B solutions according to the method of Lane and Eynon as described in the A.O.A.C., 1995.

Statistical analysis:The percentage data were arcsine square root-transformed to normalize the variance before analysis of variance (ANOVA). All data were subjected to ANOVA by using Computer software Statistix-8. The mean values of the treatments were compared using Tukey's test (Steel et al., 1997).

RESULTS

Fruit drop (%): Fruit drop (%) recorded at different times during both seasons of study is presented in Figure 1 and 2. Differences among the treatments for total fruit drop and its

distribution at various periods of growth were found significant statistically during both seasons of study, where KNO_3 individually or mixed with urea significantly reduced the fruit drop. Minimum drop of 46.99% and 50.05% (1st and 2nd season, respectively), was recorded when KNO_3 at 2% was sprayed individually as compared to control where fruit drop percentage was 76.52 and 73.49 for 1st season and 2nd season, respectively.

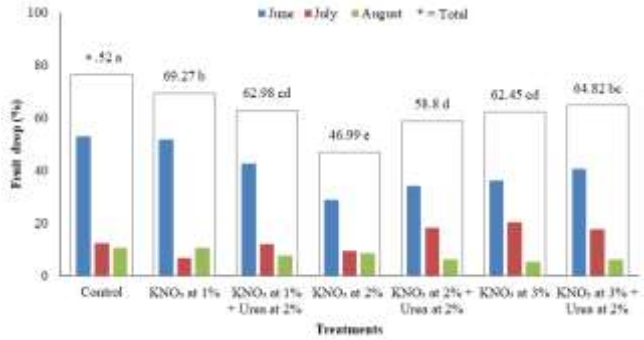

Figure 1. Fruit drop (%) of 'Dhakki' date palm for 1st season (2015). Means followed by different letters in columns are significant at 5% level of probability.

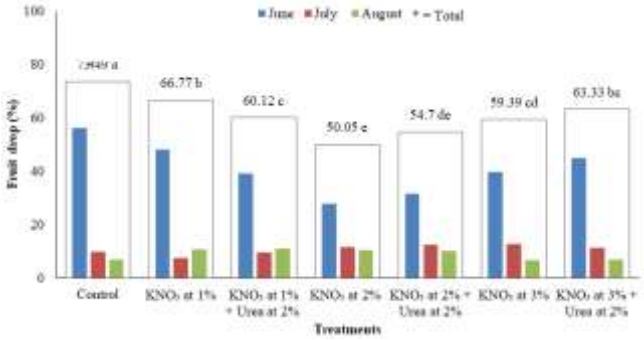

Figure 2. Fruit drop (%) of 'Dhakki' date palm for 2nd season (2016). Means followed by different letters in columns are significant at 5% level of probability.

It was also observed that during both seasons' maximum fruit drop occurred in the month of June. The current trial showed that applying KNO_3 efficiently decreased the fruit drop in this month as compared to July and August in both seasons of study. Trees with no treatment had a maximum of 53.01% and 56.42% fruit drop in the month of June of both seasons, respectively. In both seasons spraying the trees with KNO_3 at 2% was the most effective treatment in controlling fruit drop at this stage and showed only 28.88% drop in June 1st season, and 27.79 in June 2nd season, respectively (Figures 1 and 2).

Fruit length and diameter (mm): Spraying bunches with KNO_3 significantly increased the fruit length in both season of study. Maximum fruit lengths 54.41 mm (1st season) and 53.46 mm (for 2nd season) were recorded as compared to control treatments that showed minimum fruit length of 44.41mm and 42.33 in 1st and 2nd season respectively (Figure 3 and 4).

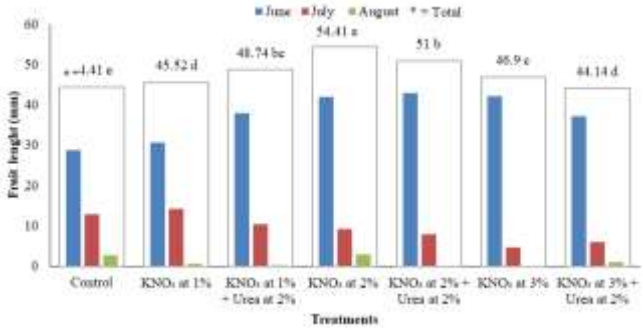

Figure 3. Fruit length (mm) of 'Dhakki' date palm for 1st season (2015). Means followed by different letters in columns are significant at 5% level of probability.

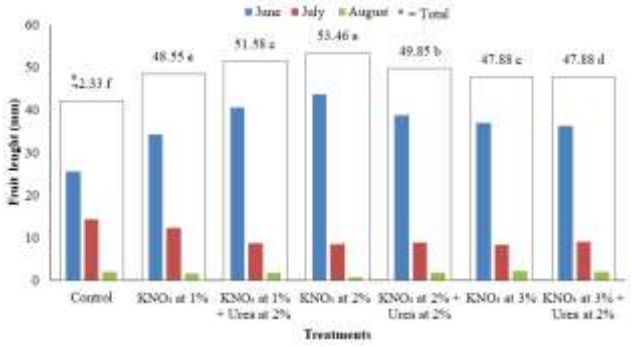

Figure 4. Fruit length (mm) of 'Dhakki' date palm for 2nd season (2016). Means followed by different letters in columns are significant at 5% level of probability.

The highest increase in fruit length was recorded in the month of June as compared to July and August for both seasons that showed maximum length of 43.07% (1st season) and 43.84% (for 2nd season) by spraying KNO_3 at 2% mixed with urea at 2% and KNO_3 at 2% alone in comparison to control treatments that presented minimum fruit length of 28.73% and 25.60% in June of 1st season and 2nd season, respectively (Figure 3 and 4).

Almost similar trends were observed for fruit diameter during both seasons of study as it was observed in the case of fruit length. Spraying bunches with KNO_3 either alone or mixed with urea helped to produce fruits with a larger diameter. Differences among the treatments for fruit diameter measured at the time of harvesting were found significant statistically during both seasons of study. (Control plants (with no application) produced fruit with a minimum diameter of 28.16mmand 26.77mm while maximum fruit diameters of

43.15mm and 41.31mm were recorded in bunches sprayed with KNO_3 at the rate of2% followed by all other treatments in 1st and 2nd season, respectively (Figure 5 and 6).

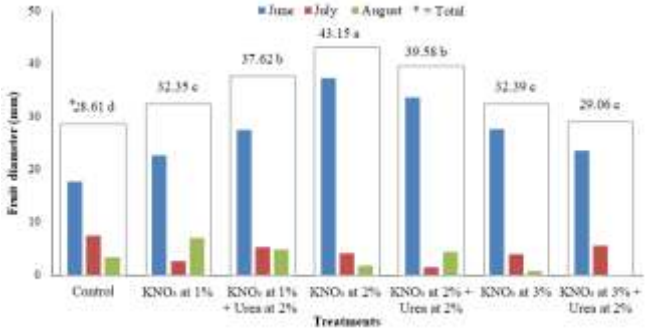

Figure 5. Fruit diameter (mm) of 'Dhakki' date palm for 1st season (2015). Means followed by different letters in columns are significant at 5% level of probability.

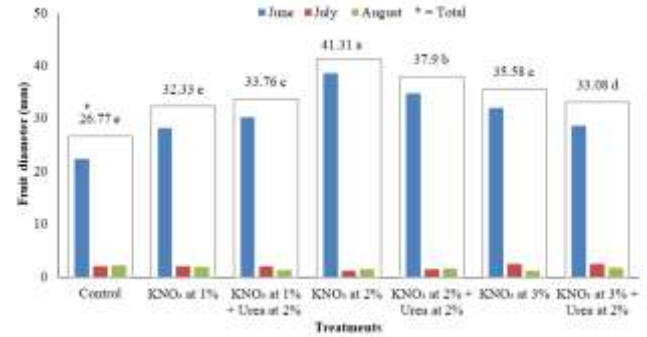

Figure 6. Fruit diameter (mm) of 'Dhakki' date palm for 2nd season (2016). Means followed by different letters in columns are significant at 5% level of probability.

Fruit diameter distribution showed maximum increase of 37.25% and 38.66%in June when bunches were sprayed with KNO_3at 2% as compared to control treatments where minimum increase in diameter in June was recorded17.76% and 22.34% in 1st and 2nd season of study respectively (Figure 5 and 6).

Fruit weight (g): Bunches sprayed with KNO_3 at all concentrations either with or without urea significantly increased the fruit weight as compared to the fruit of untreated bunches during both seasons. Untreated bunches (control) produced fruits with minimum weights of 10.59 g and 10.87 g for the 1st and 2nd season respectively. Maximum fruit weight after drying was observed when bunches were sprayed with KNO_3 at 2% presenting 13.69g and 13.53g for the 1st and 2nd season, respectively (Table 1).

Pulp percent: An increasing trend in pulp production was observed in the fruit of bunches sprayed with KNO_3, however, the results were found at par with the pulp recorded in the fruit of bunches that were not treated. Significant differences for the percent pulp during both seasons of the study were observed. Maximum pulp 90.99% and 93.59% for both seasons were recorded in the fruit of bunches treated with KNO_3at 2% as compared to control treatments that showed pulp of 89.93% 83.73% for 1st and 2nd season, respectively (Table 1).

Bunch weight (kg): During both seasons of study, bunch weight was significantly improved by the application of KNO_3 to bunches. The highest bunch weight i.e. 8.21 kg (1st season) and 8.11 kg (2nd season) was obtained when KNO_3 was sprayed at 2% in comparison to untreated bunches (control) that produced a significantly lowest bunch weight of 6.35and 6.52 kg in both seasons respectively (Table 1).

Chemical Properties of the fruit

Fruit pH: It was observed that as the concentration of KNO_3 increased, the pH of the fruit also increased. Fruit with no application had minimum pH (6.07) while maximum pH (6.53 and 6.60 respectively) was recorded when KNO_3 was applied at 3% either with or without urea. The value of pH recorded for the fruits harvested from the plants sprayed with KNO_3 at 2%, both with urea or without urea, was 6.40. Spraying bunches with various concentrations did not affect the pH content in the fruit in 2nd season of study. Differences among the treatments were found non-significant statistically. The pH content in the fruit ranged from 6.47 to 6.67 (Table 2).

Table 1. Effect of KNO_3 on fruit weight, pulp percent and yield of 'Dhakki' date palm for 2015 (1st season) and 2016 (2nd season).

Treatments	Fruit weight (g)		Pulp percent (%)		Bunch weight (kg)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control (water spray)	10.59 e	10.87 e	89.93 ab	83.73 b	6.35 e	6.52 e
KNO_3 at 1%	10.95 d	11.60 d	89.05 b	83.92 b	6.57 d	6.95 d
KNO_3 at 1% + urea at 2%	12.56 b	12.54 c	89.91 ab	86.93 b	7.53 b	7.52 c
KNO_3 at2%	13.69 a	13.53 a	90.99 a	93.59 a	8.21 a	8.11 a
KNO_3 at2% + urea at 2%	12.52 b	12.87 b	90.15 ab	87.83 b	7.50 b	7.72 b
KNO_3 at 3%	12.15 c	12.56 c	90.94 a	86.26 b	7.28 c	7.53 c
KNO_3 at 3% + urea at 2%	11.93 c	12.41 c	89.93 ab	85.40 b	7.15 c	7.44 c
LSD	0.233	0.25	1.27	4.43	0.14	0.15

Means followed by a different letter (s) in column are significant at 5% level of probability.

Table 2. Effect of KNO_3 on fruit pH, total soluble solids (TSS) and potassium content of 'Dhakki' date palm for 2015 (1st season) and 2016 (2nd season).

Treatments	Fruit pH		TSS (°Brix)		Potassium content (mg/g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control (water spray)	6.07 d	6.47^{NS}	73.20 e	73.57 e	7.47 b	7.46 b
KNO_3 at 1%	6.10 d	6.50	73.57 e	73.90 de	7.57 b	7.56 b
KNO_3 at 1% + urea at 2%	6.23 c	6.63	73.70 de	75.7 7 b	7.57 b	7.56 b
KNO_3 at2%	6.40 b	6.67	76.07 a	76.83 a	7.53 b	7.53 b
KNO_3 at2%+ urea at 2%	6.40 b	6.57	75.27 b	74.67 c	7.57 b	7.56 b
KNO_3 at 3%	6.53 a	6.50	74.33 c	74.57 cd	8.73 a	8.73 a
KNO_3 at 3%+ urea at 2%	6.60 a	6.57	74.13 cd	74.00 cde	8.83 a	8.83 a
LSD	0.119	0.39	0.542	0.72	0.169	0.17

Means followed by a different letter (s) in column are significant at 5% level of probability.

Total Soluble Solids - TSS (°Brix): Significantly higher TSS (76.07 and 76.83 °Brix) content for both seasons were recorded in the fruit of bunches sprayed with KNO_3at2% as compared to bunches remained untreated (control) that showed the lowest content of TSS 73.20 and 73.57 °Brix, respectively (Table 2).

Potassium Content in fruit (mg/g): Differences among the treatments were found significant for potassium content in the fruit during both seasons of study. The highest amount of potassium was found in the fruit of bunches that were sprayed with a maximum concentration of KNO_3 combined with 2% and 3% urea having 8.83 mg^{-1}while 8.73 mg^{-1}in the fruit sprayed with KNO_3 at 3% solution in both seasons, respectively. Both of these treatments were found statistically similar. All other treatments including control resulted in a statistically similar amount of potassium in the fruit ranging from 7.47 to 7.57 and 7.46 to 7.56 mg g^{-1}, respectively, in both seasons of study (Table 2).

Potassium content in the fruit increased with the increase in the concentration of potassium application. Increased yield, fruit size, pulp percentage and reduced drop were recorded in the same treatments where KNO_3 was applied as a foliar spray which confirms that the application of KNO_3 has a definite role in improving these parameters. A similar result of the increase in potassium content has also been observed when potassium was applied to 'Khalas' date palm bunches (Harhash and Abdel-Naseer, 2010).03477787618

Reducing Sugars, Non-Reducing Sugars and Total Sugars: The current studies also showed that all concentrations of KNO_3 significantly improved the sugar content in the fruit of 'Dhakki' dates. Chemical analysis of the fruit showed that fruits harvested from all the treated plants had increased content of reducing sugars with a maximum of 52.82 and 52.45% and 53.50 and 51.83% were recorded in the fruits sprayed with KNO_3at 2% with and without urea, for 1st season and 2nd season, respectively. While during both seasons minimum reducing sugar content of 48.69% and 48.10% was found in the fruit of bunches remained untreated (control) (Table 3).

Non-reducing sugars, however, decreased at the higher concentrations of KNO_3inthe first season of study where untreated fruits (control) showed the maximum percentage of non-reducing sugars (11.16%) as compared to all other treatments. In case of 2nd season of study significant differences were observed among treatments, where a maximum of 13.27% non-reducing sugar was found in bunches sprayed with KNO_3 at 2% followed by all other treatments while minimum non-reducing sugar was observed in control treatment 10.37% (Table 3).

Table 3. Effect of KNO_3 on reducing, non-reducing and total sugars of 'Dhakki' date palm for 2015 (1st season) and 2016 (2nd season).

Treatments	Reducing Sugars (%)		Non-Reducing Sugars (%)		Total Sugars (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control (water spray)	48.69 d	48.10 e	11.16 a	10.37 c	59.86 e	58.47 e
KNO_3 at 1%	49.67 cd	49.03 d	10.89 a	11.33 b	60.56 d	60.37 d
KNO_3 at 1% + urea at 2%	50.68 bc	50.80 c	10.80 a	11.73 b	62.62 a	62.53 bc
KNO_3 at2%	52.82 a	53.50 a	9.99 ab	13.27 a	61.67 b	66.77 a
KNO_3 at2%+ urea at 2%	52.45 a	51.83 b	8.45 b	11.77 b	60.99 c	63.60 b
KNO_3 at 3%	51.03 b	50.57 c	9.88 ab	11.33 b	60.91 cd	61.90 c
KNO_3 at 3%+ urea at 2%	50.68 bc	50.23 c	10.03 ab	11.30 b	60.71 cd	61.53 c
LSD	1.09	0.75	2.15	0.50	0.405	1.13

Means followed by a different letter (s) in column are significant at 5% level of probability.

Similarly, in the first season of study, the highest amount of total sugars (62.62%) were found in the fruit sprayed with KNO_3 at 1% with urea at 2%, while in 2nd season 66.77% was observed in bunches sprayed with KNO_3 at 2% as compared to all other treatments.

DISCUSSION

Quality improvement is a major issue of all fruits especially in date palm as it not only affects the produce but can also alter its market value. Different factors are involved that reduces the quality of date palm; fruit drop is one of them as it is the top most problems faced by date growers now a days. In the current study it has been observed that maximum fruit drop occurred in the month of June (also known as the June drop) showed that at high temperature growth of the embryo is at its extreme causing embryo to consume most of the endosperm for fruit growth. As embryo completed its developmental cycle, secondary endosperm appears resulting in auxins production that is needed to hinder abscission accompanying fruit drop (Racsk *et al.*, 2007). Besides this, it is believed that fruit drop is mainly due to an imbalance between the level of auxins and ethylene within fruit tissues. Ethylene triggers the system for abscission layer formation and hydrolytic enzymes (cellulase and polygalacturonase) that break down the cell walls leading to fruit drop (Stover *et al*., 1998; Wood, 2011). Reduction in pre-harvest fruit drop by the combined foliar spray of these nutrients, especially KNO_3 can be attributed to the activation of auxins that are responsible for inhibiting fruit drop by strengthening fruit pedicels through their synergistic relationship (Reetika *et al*., 2018). Reduction in fruit drop has also been observed in many fruits using different macro and micro nutrients, i.e., $ZnSO_4$ at 0.5% reduced fruit drop in 'Kinnow' mandarin (Razzaq *et al*., 2013; Ullah et al., 2012). K_2SO_4 reduced fruit drop in date cultivars (Salama *et al*. 2014). Furthermore, the use of KNO_3, K_2SO_4, urea and boron also found to reduce fruit drop in persimmon fruit (Kaseem *et al*., 2010).

Spraying KNO_3 in present studies significantly boosted fruit length and diameter in both seasons that shows that potassium application has important role in increasing fruit physical attributes and this increase can be result of improving cell size or cell number by uptake of nutrient elements in the form of foliar application hence initiating metabolic processes to improve fruit quality (Harhash and Abdel-Nasser, 2010; Elsabagh, 2012; Al-Obeed *et al*., 2013). Additionally, these nutrients increased the rate of sugar transport to actively growing regions helping in the development of fruits in the form of fruit length and diameter (Yasin *et al*., 2012). Potassium is also found to be more important in photosynthesis and osmoregulatory reactions initiating physiological processes such as enzymes activation, osmotic pressure regulation, and also support sugar translocations. Moreover, potassium is also involved in the mobilization of carbohydrates biosynthesis that ultimately affects the physical attributes of many fruit crops (Gollback *et al*., 2003). An increase in fruit length and diameter has also been observed by many researchers while working on different date palm cultivars (Zagzog and Salem, 2016; Omar *et al*., 2017).

Moreover, application of nutrients (especially potassium) is involved in increasing fruit weight, yield and improving the quality of different date palm cultivars (Baldi *et al.*, 2004; Khayyat *et al*., 2007). The increase in fruit weight is the effect of potassium on carbohydrates in different fruit growing regions as it is involved in expanding cells resulting in extensive plant development. Similarly, potassium also triggers enzymes that have important role in synthesis and transport of sugar inside plant tissues and its deficiency can negatively affect fruit growth (Marschner, 1995; Shahin, 2007; Abdi and Hedayat, 2010; Elsabagh, 2012). An increase in fruit weight has also been reported while working with different date palm cultivars (Khayyat *et al*., 2007; Osman, 2010; El-Assar and El-Sehrawy, 2011).

An increase in pulp percent could also be the result of uptake of nutrients that ultimately initiate metabolic processes resulting in increased fruit size and number (Khayyat *et al*., 2007). Date palm 'Zahidi' and 'Kabkab' showed an increase in pulp percent with the application of potassium (Aboutaleb and Mohacmadi, 2015). It was observed that KNO_3 applied at the rate of 2% had a better effect on bunch weight as compared to other concentrations applied. Increase yield of fruit during both seasons showed the positive application effect of potassium to bunches that helps in nutrients uptake hence improving fruit set, reducing fruit drop and increasing fruit size ultimately resulting in increased bunch weight (Desouky *et al.*, 2007; Shahin, 2007; Elsabagh *et al*., 2012).

KNO_3 spray found to increases TSS in both seasons of the research as this is the characteristic of potassium that helps in transportation of sugar from leaves to another part of the fruits subsequently improving fruit quality (Prasad *et al*., 2015). Application of potassium is also found to increase TSS content in different fruits like date, apple and grape (Chanana and Gill, 2008, Kaseem *et al*., 2010; Ali *et al*., 2014; Shareef, 2016).

Similarly, in the present study it has also been observed that potassium application increased and improved the quality of date fruit by improving carbohydrate contents. This increase in total sugar content (carbohydrates) can be attributed to more assimilation influence power of leaves that caused more availability of sugars to fruit as potassium has a dominant role in enhancing photophosphorylation and dark reaction of photosynthesis ultimately resulted in more carbohydrates accumulation (Ahlawat and Yamdagini, 1981).Working with various application methods of potassium fertilizers on different date palm cultivars also proved that potassium alone or along with other micronutrients improved fruit quality, reducing, non-reducing and total sugar content (Darwesh *et al*., 2015; Omar *et al.*, 2017; Saleh *et al*., 2018).

Conclusion: The results of study revealed that KNO_3 alone and combined with urea significantly reduced fruit drop, improved, fruit length, diameter, fruit weight, percent pulp, bunch weight (kg), total soluble solids, reducing, non-reducing and total sugars in the fruit, however the application of KNO_3 at2% is more effective in enhancing yield and improving fruit quality of 'Dhakki' date palm. Hence, it is recommended for farmers and growers to use this amount in future for the quality improvement of date palms.

REFERENCES

Abdel-Bary, A.M. 1999. Physiological studies on fertilization of Anna apple trees. M. Sc. Thesis. Faculty of Agriculture, Mansoura University.

Abdi, G.H., M. Hedayat. 2010. Yield and fruit physiochemical characteristics of 'Kabkab' date palm as affected by methods of potassium fertilization. Adv. Environ. Biol. 8:437-443.

Aboutalebi, A., A. Mohammadi. 2015. Evaluating the effects of 2, 4-D, naphthalene acetic acid and potassium nitrate on yield and fruit quality of date palm (*Phoenix dactylifera*) cv. Zahedi. IJB.6:192-200.

Ahlawat, V.P., R. Yamdagni. 1981. Effect of potassium sprays on quality of guava (*Psidium guajava* L.) cv. Sardar. Agric Sci Digest. 1:213-14.

Ahmed, S., M. Sajid, A. Latif., N. Ahmed.,M. Junaid.,N. Mahmood.,M. Umair. 2013. Effect of Indole acetic acid on fruit drop and fruit quality of date palm cultivars. Ann. Bot. 2:1-6.

Al-Hamoudi, A.H. 2006. Studies on fruit set of date palm (Doctoral dissertation, M. Sc. Thesis, Faculty of Agriculture, Ain Shams University, Cairo, Egypt.

Ali, A., Perveen., S. S. N. M.Shah.,Z. Zhang.,F. Wahid., M. Shah., A. Majid. 2014. Effect of foliar application of micronutrients on fruit quality of peach. Am. J. Plant Sci. 5:1258.

Al-Obeed, R.S., H.A. Kassem.,M.A.Ahmed. 2013. Effect of levels and methods of potassium and phosphorus fertilization on yield, fruit quality and chemical composition of 'Khalas' date palm cultivar. Life Sci 10:1111-1118.

AOAC., 1985. Official Methods of Analysis, 14th ed., Association of Official Analytical Chemists, Washington, USA.

Archer, J.R., 1988. Crop Nutrition and Fertilizer Use. Farming Press Ltd. 2nd Revised edition. 278 pp. ISBN-10: 0852361750in Saudi Arabia (Challenges of Processing, Marketing, and Pests Control), Date Palm Research Center, King Faisal University, Al-Hassa. 5-8 May, 2007. Abstracts Book. Pp.1-73.

Ashraf, M.Y., M. Yaqub., J. Akhtar., M.A. Khan.,G. Ebert. 2013.Control of excessive fruit drop and improvement in yield and juice quality of Kinnow (*citrus deliciosa* x *citrus nobilis*) through nutrient management. Pak. J. Bot. 44:259-265.

Attia, M.M., H.A. Kassem., El-Shenawi, M.R. 2001. Effect of nitrogen and potassium fertilization on Willimams banana plants grown under calcareous soil conditions: 2. Yield and fruit quality. Alex. J. Agric. Res. 46:25-34.

Baldi, E., M. Toselli., D. Seudellar., M. Taglivini., B. Marangoni. 2004. Foliar feeding of stone fruit trees. Informatore-Agrorio. 60:43-46.

Baloch, A. 1999. Enhancement of post-harvest quality and stability of Dhakki dates using advanced technology. Pakistan Science Foundation, Islamabad.

Chanana, Y.R., M.I.S. Gill. 2008. High quality grapes can be produced in Punjab. Acta Hort .785:85-86.

Coban, H., 2002. Investigation on the effect of potassium nitrate (KNO_3) applications cluster and berry characteristics of Yavarlak cekirdeksiz grape cultivars. Anadlu. 12:65-74.

Darwesh, R.S.S., E.A. Madbolly., K. Abd-El Hameed. 2015. Influence spraying fruit set and soil application on the quality of date palm fruits (*Phoenix dactylifera* L.) Cv. Sewi. Internat. J. of Chem. Enviro. Biol. Sci. 3:191-197.

Desouky, M.A., A. El-Hamady., A. Hassan, Abdel Hamid. 2007. Date Palm Research Center, King Faisal Univ., Al-Hassa, 5-8 pp. 76. 2.

Elsabagh, A.S. 2012. Effect of bunches spraying with some macro and micro-nutrients on fruit retention and physical characteristics of Deglet Nour date palm cultivar during Kimiri stage. Res. J. Agric. Biol. Sci. 8: 138-146.

El-Assar, A.M., O.A.M. El-sehrawy. 2011. Influence of nutrients spray application on the yield fruit quality of 'Zaghoul' date palm cultivar. J. Agric.& Env. Sci. Dam. Univ., Egypt.pp.1-10

FOASTAT. Food and Agriculture Organization of the United Nations. FAOSTAT database results. 2019. Available at: <http://apps.fao.org>.

Gollback, D., F. Quigley., C.B. Michalowski., U.R. Kamasani., H.J.Bohnert. 2003. Salinity tolerant and sensitive rice (*Oryza sativa* L.,) regulate AFT1-Type potassium channel transcripts differently. Plant Mol. Biol. 51:71-81.

Harhash, M.M., G. Abdel-Nasser. 2010. Improving of fruit set, yield and fruit quality of" Khalas" tissue culture derived date palm through bunches spraying with potassium and/or boron. Aus. J. of Basic and Applied Sci. 4:4164-4172.

Hassanein, H. 2004. Effect of calcium and potassium foliar application on post-harvest peach fruit quality. Ph. D. Thesis. Faculty of Agriculture, Cairo University, Egypt.

Hui, Y.H.2006.Fruit and Fruit Processing; Blackwell Publishing: Ames, Iowa.pp.391-411.

Hussien, Ahmed., Ahmed, Y., Al-Essawy, A.A., Youssef, K. 2017. Evaluation of different salt-amended electrolysed

water to control postharvest moulds of citrus. Tropical Plant Pathology. 43:10-20. https://doi.org/10.1007/s40858-017-0179-8.

Khayyat, M., E. Tafazoli., S. Eshghi., S. Rajaee. 2007. Effect of nitrogen, boron, potassium and zinc sprays on yield and fruit quality of date palm. Am Eurasian J. Agric Environ Sci. 2:289-296.

Kassem, H.A., A.M. El-Kobbia., H.A. Marzouk.,M.M. El-Sebaiey. 2010. Effect of foliar sprays on fruit retention, quality and yield of Costata persimmon trees. Emirates J. Food Agri. 22:259-274.

Marschner H., 1995. Mineral Nutrition of Plants, Ed 2. Academic Press, Boston.

Omar, A.E.D.K., M.A. Ahmed., A.M. Al-Saif. 2017. Influences of seaweed extract and potassium nitrate foliar application on yield and fruit quality of date palms (*Phoenix dactylifera* L. cv. sukary). Advances in Agri. Sci. 5:16-22.

Osman, S.M. 2010. Effect of potassium fertilization on yield, leaf mineral content and fruit quality of Bartamoda date palm propagated by tissue culture technique under Aswan conditions. J. of Applied Sci. Research, 184-190.

Racsk, J., G.B Leite., J.L Petri., S. Zhongfu., Y. Wang., Z .Szab., M. Soltész. andJ. Nyéki. 2007. Fruit drop: The role of inner agents and environmental factors in the drop of flowers and fruits. Int. J. Hort. Sci. 13:13-23.

Razzaq, K., A.S. Khan., A.U. Malik., M. Shahid., S. Ullah. 2013. Foliar application of zinc influences the leaf mineral status, vegetative and reproductive growth, yield and fruit quality of 'Kinnow' mandarin. J Plant Nutr. 36:1479-1495.

Reetika, G.S., Rana1, M.K., Rana, Prince., G. Kant., 2018. Int. J. Pure App. Biosci. 6:1163-1169.

Salama, A.S., O.M. El-Sayed., O.H. El Gammal. 2014. Effect of Effective Microorganisms (EM) and Potassium Sulphate on Productivity and Fruit Quality of 'Hayany' Date Palm Grown Under Salinity Stress. J Agri Vet Sci. 7:90-99.

Saleh, J.H., A. Shahriari., M. Ghoreishi., M.R. Ahmadi., H.K. Hasanzadeh. 2018. Yield and fruit characteristics of "Piarom" of date palm as affected by trunk injected and soil applied iron in a calcareous soil. Sixth international date palm conference March 19th -21st Abu Dhabi.

Saleh, M.M.S., E.A. El-Monem. 2003. Improving the productivity of 'Fagri Kalan' mango trees grown under sandy soil conditions using potassium, boron and sucrose as foliar spray. Annals of Agric. Sci., Ain Shams Univ., 48:747-756.

Shahin, M. 2007. Effect of Potassium Fertilization on Growth, Leaves Nutrient Content, and Yield of 'Khalas' Date Palm in Al-Hassa Oasis (K.S.A). The Fourth Symposium on Date Palm in Saudi Arabia (Challenges of Processing, Marketing, and Pests Control), Date Palm Research Center, King Faisal University, Al-Hassa. 5-8 May, Abstracts Book, pp:77.

Shareef, J.H. 2016. Enhancing Fruit Set and Productivity in Date Palm (*Phoenix Dactylifera* L.) Berhi Cultivar Using Boron and Potassium. J. of Envir. Sci. Computer Sci, and Engineering and Tech (JECET); Sec. 5:108-114.

Steel, R.G.D., Torrie, J.H., Dickey, D.A.1997. Principles and Procedures ofStatistics. A Biometric Approach.3rded. McGraw Hill Book Co., Inc, Singapore. pp. 172-177.

Stover, E.W., C.B. Watkins., M.I. Fargione., K.A. Iungerman. 1998. Effects of AVG, NAA, ethephon and summer pruning on pre-harvest drop and fruit quality of McIntosh apples. Hort Sci. 33:513.

Talaie A., A.T. Badmahmoud., M.G. Malakout. 2001. The effect of foliar application of N, B and Zn on quantitative and qualitative characteristics of olive fruit. Iranian J. Agric. Sci. 32:727-736.

Talaie, A., A.T. Badmahmoud., M.G. Malakout. 2001. The effect of foliar application of N, B and Zn on quantitative and qualitative characteristics of olive fruit. Iranian J. Agric. Sci. 32:727-736.

Ullah, S., A.S. Khan., A.U. Malik.,I. Afzal., M. Shahid., K. Razzaq. 2012. Foliar application of boron influences the leaf mineral status, vegetative and reproductive growth, yield and fruit quality of 'Kinnow' mandarin. J. Plant Nutr. 35:2067-2079.

Wojcik, P., M. Wojcik. 2003. Effect of boron fertilization on conference pear tree vigor, nutrition and fruit yield and storability. Plant and Soil. 256:413-421.

Wood, B.W. 2011. Influence of amino ethoxyvinyl glycine (AVG) on yield and quality of nut crops from a commercial pecan orchard. HortSci.46:586-589.

Yasin, M., M. Ashraf., J. Yaqub., M. Akjtar., M. Alikhan., G. Ebert.2012. Contol of eexcessive fruit drop and improvement inyield and juice quality of Kinnow (*Citrus deliciosa x Citrus nobilis*) through nutrient management. Pak. J. Bot.44:259-265.

Youssef, K., Mustafa, Z., Mounir, G., Abo-Rehab, M. 2015. Preliminary Studies on Fungal Species Associated with Guava Fruit Drop Disease and Possible Management Egypt. J. Phytopathol. 43:11-23. http://dx.doi.org/10.21608/EJP.2015.91945.

Zagzog, O.A., F.M Salem. 2016. Effect of potassium and boron fertilization on yield and fruit quality of 'Hayany' date palm. Mid. East J. Agri Res.5:604-610.

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