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New Insights of Potassium Source Impacts as Foliar Application on the Yield and Fruit Quality of Barhee Date Palms

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ABSTRACT

This experiment was carried out during two successive seasons of 2018 and 2019 in a private orchard located at Regwa district, Cairo, Alexandria Road, Beheira Governorate, Egypt, in order to assess the effect of different potassium forms and concentrations on yield, and fruit quality of Barhee date palm grown in sandy soil under drip irrigation system. So, foliar spray of potassium forms such as mono potassium phosphate (KH_2PO_4) and di- potassium phosphate (K_2HPO_4) at different concentrations i.e. 1% and 2 % were applied three times a year (one day before pollination, at the beginning of Kimri stage and at the beginning of fruit color break) on yield and fruit physiochemical characteristics. The results showed that all different potassium forms at different concentrations increased fruit yield and improved fruit physical and chemical characteristics as compared with the control during both seasons of the study. Finally, it could be concluded that foliar spray with both di-potassium phosphate and mono-potassium phosphate each at 2 % were the best treatments for improving the most studied parameters of Barhee date palm during the two seasons of the study.

Keywords: Barhee date palm, yield, fruit properties, Mono and Di- potassium phosphate

1. Introduction

Date palms (*Phoenix dactylifera*) are the most common fruit tree grown in arid and semiarid of the Middle East and North Africa regions. In Egypt, the total cultivated areas of dates attained about 333901 ha with total production of 1603762 tons (FAO, 2019).

Barhee date palm cultivar is considered one of the major and a widespread date palm cultivar and one of the most favorite fruits to consumers which harvested and consumed at the Khelal stage when its fruits reach full maturity (partially-ripe) with yellow color. Plant nutrients can be delivered in a variety of ways, including soil, foliar, and spraying approaches. Foliar application is one of the most frequent strategies for delivering the required nutrients to plants in sufficient quantities, improving plant nutritional status while also increasing crop output and quality (Smoleń, 2012). So, foliar fertilization is a supplemental nutrition method with macro and micro nutrients. In addition, when fertilizers are supplied to the leaves, they are absorbed faster than when they are applied to the soil. Therefore, when soil conditions impede root uptake or during rapid growth periods, nutrient needs may exceed root supply through K foliar fertilizer sprays which considered a viable option for providing nutrients to the plants (Swietlik and Faust, 1984; Toscano *et al.*, 2002). Potassium is one of the most important macro-elements, particularly for fruit trees, where it plays a key role in plant growth and development. Furthermore, numerous prior studies have looked into the impacts of potassium on fruit crop output and quality (Al-Hamoudi, 2006; Harhash and Abd el-Nasser, 2010; Al-Obeed *et al.,* 2013; Awad *et al.,* 2014; Malaka *et al.,* 2016; Zagzag and Salem, 2017; Alaa El-Din *et al.,* 2018; Enas *et al.,* 2018; Hashem *et al.,* 2020; Khodair *et al.,* 2021 and Abdullah Alebidi *et al.,* 2021). Potassium as a foliar treatment is now a cost-effective, quick, and high-efficiency option to meet the nutritional demands of trees during important periods away from soil–cation interactions. Potassium is an essential component for plant growth and for agriculture to maintain high yields. Potassium is frequently referred to as a key

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component in crop productivity. (Baghdady *et al.,* 2020). Potassium's vital function in quality formation originates from its role in increasing photosynthate production and transport to fruits. Many metabolic activities, such as photosynthesis, translocation, and enzyme systems, are affected by a potassium deficiency (Kuzin *et al.,* 2020). Potassium is frequently used to increase yield and fruit quality in different crops, also increasing shelf life of the fruits is also linked to adequate potassium nutrition (Thippeshappa *et al.,* 2014). Based on the foregoing the purpose of this study is to evaluate the impact of foliar sprays with different potassium forms such as mono and di-potassium phosphate at different levels on yield and fruit quality of Barhee date palm cultivar.

2. Materials and Methods

This study was carried out during two successive seasons (2018 and 2019) on 15 years old Barhee date palms grown on sandy soil with 7×8 meters apart under drip irrigation system at a private orchard located at Regwa district, Kilo 64 of Cairo - Alexandria Road, Beheira Governorate, Egypt. The selected palms were uniform in vigor as possible. Fertilization program and other agricultural practices were the same for all palms. All palms were pollinated with the same male pollen source in both seasons. Palms were subjected to five spraying treatments with three replicates per each treatment with three bunches for each replicate (5 treatments × 3 replicates × 3 bunches = 45 bunches on 15 palms), treatments were arranged in a randomized complete block design and the experimental bunches were sprayed three times in each season as follows: the 1st spray was carried out one day before pollination, the 2nd spray was done at the beginning of Kimri stage and the 3rd spray was carried out at the beginning of fruit color break (Khelal or bisr stage), respectively. The experiment treatments were as follow:

1- Spraying with water only (control).
2- Spraying di-potassium phosphate at 1%.
3- Spraying di-potassium phosphate at 2%.
4- Spraying mono-potassium phosphate at 1%.
5- Spraying mono- potassium phosphate at 2%.

Triton B at 0.1% as wetting agent was added to all treatments besides control and praying was conducted by small hand gun sprayer until run-off. So, the following parameters were measured for both seasons as follows:

Fruits were harvested at full mature stage at the mid of September, according to skin color (the whole fruit should be yellow, and the yellowish green area should not exceed 0%. The following measurements were carried out as follow:

2.1. Yield/palm (kg)

At harvest time (mid-September in both seasons, bunches were harvested and weighed, and the total yield (kg) /palm was measured.

2.2. Average bunch weight (kg)

Average bunch weight (kg) was estimated by dividing the total yield / number of bunches/palm.

2.3. Fruit physical properties

At harvest time samples of 30 fruits per each treatment 10 fruits from each bunch (as a replicate) were randomly chosen to determine fruit physical properties i.e. weighting of (fruit, flesh and seed) (g), fruit length and diameter (cm), fruit shape index (L/D cm) and fruit volume (cm^3).

2.4. Fruit chemical properties

Fruit chemical properties such as total soluble solids (TSS %) was determined in fruit flesh juice using hand refractometer according to A.O.A.C., (1980), also fruit acidity (%) was determined according to the method described in A.O.A.C., (1980). TSS acid ratio was estimated by dividing TSS % on total acidity values of fruit juice. Fresh weight was used to determine total sugars and reducing sugars percentage according to Dubois *et al.* (1956). Then after, non-reducing sugars (%) were calculated by the difference between both of them.

2.5. Statistical analysis

The obtained data were subjected to statistical analysis according to the methods described by Snedecor and Cochran, (1990). Mean separation was done using Duncan multiple range test at 5% (Duncan, 1955).

3. Results

3.1. Yield/palm (kg) and average bunch weight (kg)

Regarding bunch weight (g) and yield as (kg) / palm, results in Table 1 clearly show that all spraying treatments significantly increased bunch weight (g) and yield as Kg / palm during both studied seasons as compared with the control treatment. Generally, the highest values of bunch weight (10.3 and 10.6 kg) and yield/palms (103.0 and 106.0 kg) were received foliar application with di potassium phosphate at 2 % in the 1st and 2nd seasons, respectively. On the contrary, control treatment recorded the lowest bunch weight and yield / palm (9.03 and 9.3 kg) and (90.3 and 93.0 kg) in the two seasons of the study, respectively. On the other hand, other treatments gave intermediate values.

Results presented in Table 1 show that, fruit, flesh and seed weight (g) were significantly affected by different spraying potassium forms as compared with the control treatment during both seasons of the study. In general, the highest fruit weight (15.5 and 16.3 g) and flesh weight (14.3 and 16.26 g) were recorded due to foliar spray with di potassium phosphate at 2 % during both seasons, respectively. On the contrary, the lowest fruit weight (11.7 and 11.9 g) and flesh weight (10.4 and 10.6 g) were recorded with the control treatment in both seasons of the study, respectively. Other treatments were in between range. As for seed weight, results in the same Table reveal that, control treatment gave the heaviest seed weight (g) (1.36 and 1.36 g) in the two seasons of the study, respectively. Meanwhile, there was no significant difference with different treatments during the two seasons of the study.

3.2. Fruit physical properties

Results in Table 2 indicate that foliar application of different sources of potassium gave the highest values for fruit physical properties as well as fruit length (cm), fruit width (cm), fruit shape index (cm) and fruit volume (cm^3) as compared with control treatment in the two seasons. In this respect, foliar application of di potassium phosphate at 2 % gave the highest fruit length (3.66 and 3.76 cm) and fruit diameter (3.0 and 3.0 cm) followed in descending order by foliar spray with mono potassium phosphate at 2% which produced 3.6 and 3.66 cm for fruit length and 2.76 and 2.86 cm fruit diameter in both seasons of the study, respectively. On the other side, the lowest values were obtained from the control palms which gave 3.4 and 3.46 cm for fruit length and 2.56 and 2.46 cm for fruit diameter in the two seasons of the study, respectively. With regard to fruit shape index, results in the same Table indicate that, the highest value was obtained from the control (1.32 and 1.40) in the 1st and 2nd seasons, respectively. Meanwhile, there were no significant differences among all of the test treatments. Concerning fruit volume (cm^3), results in Table 2 shows that during both seasons of the study, all treatments significantly increased fruit volume as compared to the control palms. The highest fruit volume was recorded from foliar spray with di potassium phosphate at 2% which gave 16.3 and 16.6 cm^3, followed in descending order by foliar spray with mono potassium phosphate at 2% (14.56 and 15.0 cm^3). Meanwhile, the lowest values were recorded from the control palms (12.3 and 12.3 cm^3) in the 1st and 2nd seasons, respectively. Other treatments were in between range.

3.3. Fruit Chemical properties

The results presented in Table 3 clearly indicate that, all spraying potassium sorts had a significant effect on TSS, acidity, TSS/acid ratio, total sugars, reducing sugars and non-reducing sugars percentages in the fruits as compared to the untreated palms in both seasons. In this respect, it is clear that TSS% and TSS/acid ratio were significantly increased with the foliar treatment with di potassium phosphate at 2 % which recorded 41.3 and 43% for TSS and 165.5 and 176.7% for TSS/acid ratio in the 1st and 2nd seasons, respectively. On the contrary, the lowest values were obtained from the control which gave 35.2 and 35.7% for TSS and 95.13 and 102.23% for TSS/acid ratio during the two seasons of the study, respectively. As for fruit acidity results, the same Table demonstrate that all treatments decreased acidity % as compared with the control during the two seasons of the study. In this respect the high values of acidity % were recorded from control treatment since it was 0.37 and 0.35% in both

Table 1: Effect of foliar spray with mono and di-potassium phosphate on yield and some physical properties of Barhee date palms.

Treatments		Yield/palm (kg)		Bunch weight (kg)		Fruit weight (g)		Flesh weight (g)		Seed weight (g)	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
T_1	Control	90.3d	93.0c	9.03d	1.36a	11.7d	11.9e	10.4d	10.6e	1.36a	1.36a
T_2	Di-potassium phosphate 1%	95.0c	94.3c	9.5bc	1.26ab	14.2b	14.0c	12.9b	12.76c	1.26ab	1.23b
T_3	Di-potassium phosphate 2%	103.3a	106.0a	10.3a	1.26ab	15.5a	16.3a	14.3a	15.16a	1.26ab	1.23b
T_4	Mono-potassium phosphate 1%	92.0cd	93.6c	9.2cd	1.23b	12.7c	12.5d	11.5c	11.2d	1.23b	1.30ab
T_5	Mono-potassium phosphate 2%	98.0b	99.0b	9.8b	1.26ab	14.5b	14.9b	13.2b	13.66b	1.26ab	1.26b

Table 2: Effect of foliar spray with mono and di- potassium phosphate on some fruit physical properties of Barhee date palm**.**

Treatments		Fruit length (cm)		Fruit diameter (cm)		Fruit Shape index		Fruit volume (cm^3)	
		2018	2019	2018	2019	2018	2019	2018	2019
T_1	Control	3.40c	3.46c	2.56c	2.46c	1.32a	1.40a	12.30e	12.3d
T_2	Di-potassium phosphate 1%	3.53abc	3.50c	2.70bc	2.83ab	1.31a	1.23b	14.33c	15.0b
T_3	Di-potassium phosphate 2%	3.66a	3.76a	3.00a	3.00a	1.22b	1.26b	16.30a	16.6a
T_4	Mono-potassium phosphate 1%	3.46bc	3.53bc	2.66bc	2.73b	1.29ab	1.29b	13.40d	13.2c
T_5	Mono-potassium phosphate 2%	3.6ab	3.66ab	2.76b	2.86ab	1.3ab	1.27b	14.56b	15.0b

Table 3: Effect of foliar spray with mono and di- potassium phosphate on some fruit chemical properties of Barhee date palm.

Treatments		TSS (%)		Acidity (%)		TSS/acidity ratio		Total sugars (%)		Reducing sugars (%)		Non reducing sugars (%)	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
T_1	Control	35.20d	35.76d	0.37a	0.35a	95.13c	102.23c	33.96d	35.33d	23.06d	23.86d	11.23d	11.46d
T_2	Di-potassium phosphate 1%	38.86bc	40.03b	0.27b	0.25bc	143.9b	160.30b	39.9b	40.96b	26.8b	27.63b	13.13b	13.33b
T_3	Di-potassium phosphate 2%	41.33a	43.0a	0.256c	0.24c	165.5a	176.76a	43.0a	43.76a	29.36a	29.96a	13.6a	13.8a
T_4	Mono-potassium phosphate 1%	37.40c	38.13c	0.256bc	0.25bc	145.6b	150.53b	36.8c	37.6c	24.5c	25.13c	12.3c	12.46c
T_5	Mono-potassium phosphate 2%	39.36b	39.73b	0.25bc	0.26b	153.2ab	150.76b	40.8b	41.23b	27.83b	28.03b	12.9b	13.2b

seasons of the study, respectively. Regarding total sugars, reducing sugars and non-reducing sugars percentages, results represented in Table 3 stated that all treatments, significantly improved the fruit chemical properties in compared to the control during both seasons of the study. In this respect, the highest values were observed due to using di potassium phosphate at 2%, since it were 43.0 and 43.76 % for total sugars, 29.36 and 29.96% for reducing sugars and 13.6 and 13.8% for non-reducing sugars in the 1st and 2nd seasons respectively. On the other hand, control treatment scored the lowest values in this respect since it recorded 33.96 and 35.33% for total sugars, 23.06 and 23.86% for reducing sugars and 11.23 and 11.46% for non-reducing sugars in both seasons of the study, respectively. As regard to the other treatments, they gave intermediate values.

4. Discussion

The importance of potassium (K) in plant nutrition and agricultural crop production has been well documented and foliar spray is being an ideal method of its application for increasing the yield and improving the fruit quality. The present results, regarding the influence of different potassium forms on the yield of Barhee date palms and it is component are in accordance with those found by Taiz and Zeiger, (2002) who reported that potassium is essential for flowering pollen grain germination and seed development, also potassium stimulates nitrate reductase (a starch synthetase) and the two enzymes produced protein and carbohydrates in a balanced manner, respectively. On the other side, potassium is essential for photosynthesis and subsequent carbohydrates translocation and metabolism of which contribute to higher crop yields (Taiz and Zeiger, 2002). Moreover, regulation of biosynthesis conversion and allocation of metabolites is due to potassium which ultimately increases the yield. On the contrary, many studies strongly suggest that potassium is responsible for increasing crop output in direct or indirect ways. In addition, the increases of yield due to the foliar application of different potassium forms may be due to the significant absorption of NPK nutrients, the pronounced positive effects on leaf chlorophyll and carbohydrate contents as well as C/N ratio which lead to healthy trees with a good nutritional status and hence improve fruit weight and increase the yield. These explanations are agreed with Kumar *et al.* (2006); Quaggio *et al.* (2011). The obtained results are in agreement with those obtained by Shen *et al.* (2016); El-Mahdy *et al.* (2019) on pear and orange. Also, Vijay *et al.* (2017) on Jaffa sweet orange indicated that spraying different levels of potassium had positive effects on increasing yield especially potassium nitrate at 4%.

Regarding the effect of potassium source on fruit physical properties, potassium is responsible not just for increasing production but also for better harvest quality. As a result, K ensures high-value crops and grower benefits. Because of its link to greater crop production, K is commonly referred to the "quality element" according to several scientists. Potassium fertilization increased productivity and fruit quality compared to the untreated palms cv 'Kabkab' (Abdi and Hedayat 2010). Generally, potassium regulates cell water level as well as carbohydrate production and mobilization in plant tissues. As a result, carbohydrates play a significant role in vegetative development, fruit set, yield, and fruit quality (Harhash and Abdel-Nasser, 2007; Shahin, 2007). So, potassium is required for basic physiological functions such as sugar and starch creation, protein synthesis, cell division, and fruit formation, and it may improve fruit size, flavor, and coloring (Abbas and Fares, 2008). Regarding increasing the fruit physicochemical properties, the increment could be attributed to the fact that potassium regulates cell water content as well as carbohydrates biosynthesis and mobilization in plant tissues. As a result, carbohydrates play an important role in vegetative growth, fruit set, yield, and fruit quality (Harhash and Abdel-Nasser, 2007; Khayyat *et al.,* 2007; Shahin, 2007 and Harhash and Abdel-Nasser, 2010). These results are in line with those obtained by Abdi and Hedayat, (2010); Osman, (2010); Jahanshah *et al.* (2016) who investigated the impact of potassium fertilization on date palm yield and fruit quality, and discovered that potassium fertilization resulted in the largest fruit and flesh weight and length. In addition, potassium (K), a crucial necessary nutrient that is commonly referred to as the "quality element," is essential for photosynthate synthesis and delivery to fruits, starch creation, and protein synthesis. Potassium has a big impact on the size, colour, and soluble solids of apple fruit (Anjum *et al.,* 2008). It encourages healthy vigorous tree development as well as increased size of fruit and cell strength. Furthermore, K is necessary for fruits than any other nutrient which its size is connected to the amount of K in the leaves (Stiles and Reid, 1991). This could be owing to increased cell division and elongation, as well as photosynthate transfer to the sink as a result of K fertilization; these findings are consistent with those of Enas *et al.* (2018); Hashem *et al.* (2020); Khodair *et al*. (2021) Abdullah Alebidi

et al. (2021). They investigated the impact of potassium fertilization on date palm yield and fruit quality and discovered that potassium fertilization resulted in the highest fruit weight, flesh weight and fruit dimension.

Pointed out the effect of spraying different potassium forms on fruit chemical characteristics; potassium is required for basic physiological operations such as the creation of carbohydrates starch and protein synthesis which is why the results were obtained. In addition, potassium plays a vital role in the synthesis of carbohydrates and their translocation from leaves to fruits and accumulation of sugars and other soluble solids in the fruits, also the synthesis of more organic acids or the role of potassium in advancing the maturity by improving the quality parameters at early stage as quality parameters like TSS, acidity and sugars which influenced by harvesting stages. The obtained results are appeared to be in close agreement with the findings reported by Amro *et al.* (2014); Malaka *et al.* (2016); Zagzog and Salem, (2017); Hashem *et al*. (2020); Enas *et al.* (2018); Khodair *et al.* (2021); Abdullah Alebidi *et al.* (2021). They found that potassium improved the chemical properties of fruits such as (TSS%, total sugars, reducing and non-reducing sugars percentage).

5. Conclusion

Based on the abovementioned results, it could be concluded that all foliar spray of various sources of potassium that applied three times a year (one day before pollination, at the beginning of Kimri stage and at the beginning of fruit color break) during the crop growth period was found to be better not only for achieving good yields but also quality parameters of Barhee date palms. Finally, foliar spray with both di-potassium phosphate and mono-potassium phosphate each at 2 % were the best treatments for improving the most studied parameters of fruit Barhee date palms during the two seasons of the study.

References

Abbas, F. and A. Fares, 2008. Best management practices in citrus production. Tree For. Sci. Biotech., 3:1-11.

Abdi, G.H. and M. Hedayat, 2010. Yield and Fruit Physiochemical Characteristics of 'Kabkab' Date Palm as Affected by Methods of potassium Fertilization. Advances in Environmental Biology, 4(3): 437-442.

Abdullah, A., A. Khalid, M. Mohamed, M. Essam, S. Mohamed, A. Nagah, A. Rashid and E. Ahmed, 2021. Effect of spraying Algae Extract and potassium nitrate on yield and fruit quality of Barhee date palms. Agronomy, 11, 922: 2-9.

Alaa El-Din, K.O., S.A. Rahed and A.A. Mohmoud, 2018. Effect of foliar spraying with potassium dehydrogenase phosphate and yeast extract on yield and fruit quality of Sukary date palm (*Phoenix dactylifera* L.) in Saudi Arabia. Advances in Agricultural Science, 6(3):25-32.

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

Al-Obeed, R.S., H.A. Kassem and 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 Science Journal, 10(4):1111-1118.

Amro, S., M. Salama, Omima, M. El-Sayed, H.M. Osama, and El-Gammal, 2014. Effect of effective microorgansms (EM) and potassium sulphate on productivity and fruit quality of Hayany date palm grown under salinity stress. J. of Agric. and Veterinary Sci., 7: 90-99.

Anjum, R., Kirmani, N.A., Nageena, N. and Sameera, S., 2008. Quality of apple cv. Red Delicious as influenced by potassium. Asian Journal of Soil Science, 3:227-229.

AOAC International, 1980. Official Methods of Analysis; AOAC: Rockville, MD, USA.

Awad, M.A., S.M. Ismail and A.D. Al-Qurashi, 2014. Effect of potassium soil and foliar spray fertilization on yield, Fruit quality and nutrient uptake of (Seweda) date palm grown in sandy loam soil. J.of Food, Agric. and Envir., (1):305-311.

Baghdady, G.A., G.A. Abdrabboh, and M.A. Shahda, 2020. Effect of some preharvest treatments on yield and fruit quality of Crimson seedless grapvines. Environ. Sci., 15: 1–14.

Dubois, M., K.A. Gilles, J.K. Hamilton, P.A. Rebers, and F. Smith, 1956. Colorimetric Method for Determination of Sugars and Related Substances. Anal. Chem., 28: 350–356.

Duncan, D.B., 1955. Multiple range and Multiple F test. Biometrics, 11:1-42.

El-Mahdy, T.K., M.M. Abdel-Salam, R.A. Ibrahim and M.A. Mahmoud, 2019. Effect of different levels of potassium fertilizer on yield and fruit quality of old trees of "Balady" orange. A: Effect of different levels of potassium fertilizer on some physical properties and yield parameters of "Balady" orange. Assiut J. Agric. Sci., 50(1): 97 – 106.

Enas A.M. Ali, E.A.M. Mostafa and N.E. Ashour, 2018. The promotive effect of potassium silicate and active dry yeast for improving yield and fruit quality of Khalas date palm. Middle East Journal of Agriculture, 7(1):12-20.

FAO. FAOSTAT, 2019. Statistical Database Food and Agriculture Organization of the united Nation, Rome, Italy. http://www.faostat.fao.org/site/339/default.aspx.

Harhash, M.M. and G. Abdel-Nasser, 2007. Impacts of Potassium fertilization and bunch thinning on Zaghloul date palm The 4th symposium on date palm in K.S. A. 5-8 May book of Abst., 70.

Harhash, M.M. and 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. Australian Journal of Basic and Applied Sciences, 4(9):4164-4172.

Hashem, S.A., A. Jamaly, A.O. Yahia and A. Azmi, 2020. Foliar potassium Application improves fruits yield and quality of Medjool date palm. Fresenius Environmental Bulletin, 29(3):1436-1442.

Jahanshah, S., H. Yaaghoob, and G. Maryam, 2016. Is Trunk Injection More Efficient Than Other Iron Fertilization Methods in Date Palms Grown in Calcareous Soils? Journal of Advanced Agricultural Technologies, 3(3).

Khayyat, M., E. Tafazoli, S. Eshghi, and S. Rajaee, 2007. Effect of Nitrogen, Boron, Potassium and Zinc on Yield and Fruit Quality of Date Palm. American-Eurasian J. Agric. & Environ. Sci., 2(3): 289-296.

Khodair, O.A., M.M.A. Abd El- Rahman and E.M.A. Radwan, 2021. Role of potassium fertilization n improving of Hayani date palm fruiting. J. of Plant Production, Mansoura Univ., 12(3):299-304.

Kumar, A.R., N. Kumar and M. Kavino, 2006. Role of potassium in fruit crops - a review, Agric. Rev., 27: 284-291.

Kuzin, A.I., N.Y. Kashirskaya, A.M. Kochkina, and A.V. Kushner, 2020. Correction of potassium fertigation rate of apple tree (Malus domestica borkh.) in central Russia during the growing season. Plants, 9: 1366.

Malaka A.S., Omaima, M. Hafez, N.E. Ashour and E.A.M. Mostafa, 2016. Effect of foliar spraying with algae extract and potassium nitrate on yield and fruit quality of cv. Medjool date palm. Scholars Research library Der Pharmacial letter, 8(8):72-78.

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 Appl Res., 6: 184–190.

Quaggio, J.A., D.M. Junior and R.M. Boaretto, 2011. Sources and rates of potassium for sweet orange production. Sci. Agric. (Piracicaba, Braz.), 68(3): 369 – 375.

Shahin, M., 2007. Effect of Potassium fertilization on growth, leaves nutrients, content and yield of "Khalas" date palm in Al-Hassa oasis (King Saudi Arabia) The 4th symposium on date palm in Saudi Arabia 5-8 May book of Abst. pp.77.

Shen, C., Y. Ding, X. Lei, P. Zhao, S. Wang, Y. Xu and C. Dong, 2016. Effects of foliar potassium fertilization on fruit growth rate, potassium accumulation, yield, and quality of Kousui Japanese pear. Hortechnology, 26(3):270 – 277.

Smoleń, S., 2012. Foliar Nutrition: Current State of Knowledge and Opportunities. In: A. K. Srivastava (Ed.), Advances in Citrus Nutrition, DOI 10.1007/978-94-007-4171-3-4, Springer Science + Business Media, 41 – 58.

Snedecor, C.W. and W.G. Cochran, 1990. Stastical methods 7thed.Iowa State Univ. press. Ames Iowa. U.S.A.P.593.

Swietlik, D. and M. Faust, 1984. Foliar nutrition of fruit crops. Hort. Rev., 6: 287-355.

Stiles, W.C. and W.S. Reid, 1991. Orchard nutrition management. Cornell Cooperative Extension Bulletin 219.

Taiz, L., and E. Zeiger, 2002. Respiration and Lipid Metabolism. In Plant Physiology, 3rd ed., Sinauer Associates: Sunderland, MA, USA, 223-258.

Thippeshappa, G.N., C.S. Ravi, and Y.S. Ramesha, 2014 Influence of soil and foliar application of silicon on vegetative characters, fruit yield and nutrients content of sapota leaf. Res. Crop, 15: 626–630.

Toscano, P., G. Godino, T. Belfiore, and C. Bricolli-Bati, 2002. Foliar fertilization: A valid alternative for olive cultivar. Acta Hort., 594: 191-195.

Vijay, D.R., B.S. Beniwal and H. Saini, 2017. Effect of foliar application of potassium and its spray schedule on yield and yield parameters of sweet orange (Citrus sinensis Osbeck) cv. Jaffa. Journal of Applied and Natural Science, 9 (2): 786 -790.

Zagzog O.A. and F.M. Salem, 2017. Effect of potassium and boron fertilization on vegetative growth and mineral contents in leaves of Hayany date palm. Middle East Journal of Applied Sciences, 7(2):314-322.