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Research Article

Enhancing Fruit Set and Productivity in Date Palm (*Phoenix Dactylifera* L.) Berhi Cultivar Using Boron and Potassium

Hussein J. Shareef

Date Palm Research Centre, University of Basrah, Basrah, Iraq

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Abstract: 'Berhi' is one of the most important cultivars not only in Iraq, but in all regions interested in planting date palm as a commercial crop. The influence of pollens sources with boric acid and potassium sulphate (2 and 4 g) on fruit set and yield of 'Berhi' cultivar was estimated in the experiment. Results indicated that addition of boron or potassium by mixing with pollens sources of Al-Ghannami Al-Akhdar or Al-Khikri Al-Adi male clones significantly increased fruit set, fruit weight, a percentage of fruit ripening, bunch weight and total yield and decreased fruit drop compared to both two treatments control the cultivars. Also, application of 4 g boron with pollen of 'Al-Ghannami Al-Akhdar' cultivar showed the greatest values of fruit traits. Our results revealed that mixture of boric acid or potassium sulphate had a positive effect on improving date palm 'Berhi' fruit set, yield and fruit quality and the mixture should be introduced as new method for its sufficient pollination.

Keywords: pollinating, boric acid, potassium sulfate, mixed method, male cultivars

INTRODUCTION

Date palm (*Phoenix dactylifera*, L.) is an important fruit crop in arid and semi-arid regions of the world. Date palm is a major fruit tree in Iraq and public and private sector take an interest in its cultivation.

'Berhi' is one of the most important cultivars not only in Iraq but in all regions of date palm cultivation. Many investigators suggested the effect of elements in pollen grains germination and pollen tube growth in Date Palm, such as boron and potassium[1, 2, 3, 4, 5, 6]. One of the serious problems facing date palm growers in different regions is fruit set and low fruit quality[4]. The source of pollen had a significant effect on the levels of free gibberellins and free IAA during fruit development of Hillawi cultivar, with fruits produced by the pollen Khikri having the highest level, as compared with fruit produced by the pollen Ghannami Akhdar[7, 8]. One of the best tools for date palm reproductive potential studies is the direct application of nutrient elements on inflorescences and fruits[9]. Spraying micronutrients improves fruit set, fruit retention, and development as well as total yield and fruit quality[5]. A serious problem facing the date palm growers through the different regions is fruit set and fruit retention. Nutrients, such as boron and potassium on dates yield and fruit quality seems to play an important role in achieving satisfactory fruit set and fruit quality[10,11]. Boron affects on many functions of the plant such as hormone movement, salt absorption, flowering and fruiting process, pollen germination, and direction of pollen tube growth. It is also involved in processes such as protein synthesis, transport of sugars, and carbohydrate metabolism[12]. Applying the potassium element generally improves growth, yield and fruit quality of some date palm cultivars[13]. It has a role in controlling cell water content and carbohydrates biosynthesis and mobilization in plant tissues, consequently, carbohydrates play a serious role in fruit set and retention [11, 14, 15]. Potassium is an important solute in expanding cells, and expansive growth is very sensitive to K+ deficiency. Also, .potassium is needed for the enlargement of fruit[16]. Potassium activates the enzymes involved in sugar biosynthesis and helps in translocation of sugars[17]. Many investigators studied the effect of potassium and/or boron spraying on fruit set, yield and fruit quality of many crops. Al-Hamoudi[18], reported that spraying of 'Berhi' with potassium sulphate or boric acid significantly increasing fruit retention, physical and chemical fruit parameters. Spraying date palm inflorescences with boric acid and/or calcium nitrate had a significant effect on fruit set, yield, and fruit physical and chemical characteristics of 'Amhat' [5]. Whereas Shareef *et al.*[19] found that spraying 'Hallawi' inflorescences with 1 and 2% potassium sulfate had not a significant effect on fruit set. 'Berhi 'cultivar is one of the most important cultivars in Iraq, however, fruit set is frequently impaired. The main aim of this study was to investigate the effects of boric acid or potassium sulphate mixed with pollen (dry method) on fruit set and yield characteristics of date palm 'Berhi'.

MATERIAL AND METHOD

Plant material and treatments: The experiment was carried out during the growing season 2013 on 15 years old 'Berhi' cultivar grown on clay soil (EC 10.34 dS m^{-1}) at Abu-Al-Khaseeb in private orchards in Basrah, 17 km south of Basrah, Iraq. Thirty trees, uniform in size and vigor as far as possible were selected. The trees were subjected to the standard farm management, as pruning, irrigation, fertilization and manuring. Nine bunches left for each tree, and artificial pollination on the 1st of April. The pollen grains were taken from the male clones Al-Ghannami Al-Akhdar (A) and Al-Khikri Al-Adi (B), as powder mixed with treatments of H_3BO_3 and K_2SO_4 and inflorescences bagging with brown paper for 2 weeks to avoid the metaxenic effects.

The treatments were as following:

1. Co. A: control treatment pollinated only pollen grain (A)
2. B2A: pollinated by 50 g pollen grain (A) + 2 g H_3BO_3

3. B4A: pollinated by 50 g pollen grain (A) + 4 g H_3BO_3
4. K2A: pollinated by 50 g pollen grain (A) + 2 g K_2SO_4
5. K4A: pollinated by 50 g pollen grain (A) + 4 g K_2SO_4
6. Co.B: control treatment pollinated only pollen grain (B)
7. B2B: pollinated by 50 g pollen grain (B) + 2 g H_3BO_3
8. B4B: pollinated by 50 g pollen grain (B) + 4 g H_3BO_3
9. K2B: pollinated by 50 g pollen grain (B) + 2 g K_2SO_4
10. K4B: pollinated by 50 g pollen grain (B) + 4 g K_2SO_4

It was grinding elements by electric mill then mixed with pollen grain according to concentrations.

Measurements:

Fruit set (%): Fruit set was calculated every two weeks using the following equation:

Fruit set (%) = (No. of retained fruits on the strand/No. of retained fruits + No. of flowers scars on the same strand) ×100

To determine the total yield at harvest, each bunch was weighed separately using weighing balance and was expressed in kilogram (kg) with nine bunches for each tree.

Fruit drop (%): The number of nods and retained fruits in fifteen strands per each treatment were recorded in kimmri stage to the end of Khalal stage. The percentage of fruit drop was calculated using the following formula:

Total number of retained fruits (%) = (The number of empty scars / Number of flowers Contracting + the number of sites drop flowers and flowers non-Contracting) ×100

Determination of weight (g): At the beginning of the Rutab stage, bunch weight was recorded and 150 fruits per bunch were randomly collected and immediately transported to the laboratory for measurements. Fruit weight (g) was recorded.

Ripening fruit (%): The Ripening fruit percentage was determined by equation:

Ripening fruit (%) = (No. of mature fruits (Rutab) /Total fruits number) ×100

Experimental design and statistical analysis: The experiment was designed in a complete block randomized model with three replicates per treatment. One way ANOVA was run using the SAS program version 6 (flexera software CO.). Means were compared using (RLSD) at $P \leq 0.05$.

RESULTS

Fruit set (%): An addition of boron or potassium, significantly increased fruit set compared to both two treatments of cultivars (**Table 1**). Application of 4g boron with pollen grain (A) showed the highest percentage of fruit set (67.73 %). Whereas the control of pollen grain of (B) gave the lowest percentage (44.69 %). The differences in two type of pollen grain were significant compared to the control and all treatments, The pollen grain (A) showed the greatest percentage of fruit set than pollen grain (B). Moreover, boron application showed significantly increased fruit set as using with (B) (57.84 %).

Fruit drop (%): Also, data in **Table 1** showed that boron at 4g with pollen grain (A) decreased significantly fruit drop compared to the control and some other treatments, as recorded (32.27 %) whereas control of pollen grain of (B) recorded (55.31 %). The application of boron significantly decreased fruit drop by treatments of 4 g + 50 g pollen grain to (A) and (B).

Fruit weight (%): The weight of fruits obtained in control treatment was the lowest compared to all treatments in both sources of pollen grain (**Table 1**). Application of 4 g boron to pollen grain (A) and pollen grain of (B) increased fruit weight compared to other treatments. However, application of boron and potassium improved fruit weight significantly compared to control.

Fruit ripening (%): Data in **Table 1** showed that boron at 4g with pollen grain (A) increased significantly the percentage of fruit ripening compared to the control and some other treatments and showed the greatest percentage of fruit ripening (33.03 %). whereas control of pollen grain of (B) recorded (20.71%), the Application of boron and potassium significantly increased the percentage of fruit ripening in particular concentrations of 4 g + 50 g pollen grain.

Bunch weight (kg bunch^{-1}): All treatments increased bunch weight, compared to the control in both two sources of male pollen grain (**Table 1**). As with fruit weight, the application of 4 g boron increased bunch weight in source (A) and (B) (14.57, 13.97 kg bunch^{-1}), respectively. Also, the application of 4 g potassium increased bunch weight in source (A) and (B) (12.96, 13.11 kg bunch^{-1}), respectively, compared with the control at both two pollen grain sources.

Total yield (kg tree $^{-1}$): All treatments significantly increased total yield compared to the two control, in both sources of pollen grain (**Table 1**). Treatment with 4 g boron to both two pollen grain (A) and pollen grain of (B) significantly increased total yield (131.13, 125.73 kg tree $^{-1}$), respectively, compared to other treatments.

Table 1. Effect of Boron and Potassium on Fruit set, Fruit drop, Fruit weight, Bunch weight, Ripening Fruit and total yield

Treatments	Fruit set (%)	Fruit drop (%)	Fruit weight (g)	Ripening fruit (%)	Bunch weight (kg bunch^{-1})	Total yield (kg tree^{-1})
$Co._A$	51.23 ^{cd}	48.76 ^{bc}	9.44 ^{c}	20.81 ^{f}	12.41 ^{f}	103.47 ^{f}
B_{2A}	57.99 ^{b}	42.00 ^{cd}	9.90 ^{bc}	27.53 ^{cde}	12.72 ^{de}	114.51^{e}
B_{4A}	67.73 ^{a}	32.27 ^{e}	10.58 ^{a}	33.03 ^{a}	14.57 ^{a}	131.13 ^{a}
K_{2A}	59.87 ^{b}	40.12 ^{d}	9.62 ^{c}	26.23 ^{de}	12.63 ^{e}	113.67 ^{e}
K_{4A}	56.14 ^{b}	43.85 ^{cd}	9.62 ^{c}	29.37 ^{bc}	12.96 ^{cd}	116.67 ^{d}
$Co._B$	44.69 e	55.31 ^{a}	9.56 ^{c}	20.71 ^{f}	12.59 ^{e}	103.83 ^{f}
B_{2B}	51.06 ^{cd}	48.93 ^{bc}	9.77 ^{c}	25.45 ^{e}	12.70 ^{de}	114.33 ^{e}
B_{4B}	57.84 ^{b}	42.15 ^{cd}	10.17 ^{b}	31.60 ^{ab}	13.97 ^{b}	125.73 ^{b}
K_{2B}	49.37 ^{d}	50.62 ^{b}	9.65 ^{c}	26.90 ^{de}	12.70 ^{de}	114.36 ^{e}
K_{4B}	54.69 ^{c}	45.30 ^{c}	9.94 ^{bc}	28.53 ^{cd}	13.11 ^{c}	118.05 ^{c}
R.L.S.D. P ≤ 0.05	4.46	4.5	0.39	2.34	0.29	1.29

DISCUSSION

Results of fruit set showed that the application of boron and potassium had a pronounced effect on fruit set %. Also, application of 4 g boron with 50 g pollen grain (A) significantly increased fruit set compared to both two treatments control of male cultivars (A) and (B). However, these treatments decreased significantly fruit drop. These results may lead us to confirm the importance of boron and potassium on fruit set, drop fruit, and development, and eventually total fruit yield.

In this regard, previous findings indicated that increasing fruit set due to boron may be attributed to its role in maintaining high pollen viability, germination, and pollen tube elongation [4,6, 12, 20]. Increasing fruit yield due to boron or potassium may be attributed to their effect an increasing fruit set. Also, the application of boron and potassium impact significantly on fruit weight, bunch weight subsequently total yield. Moreover, application of 4 g boron with 50 g pollen grain (A) significantly increased fruit weight, bunch weight and subsequently the total yield compared to both two treatments control of male cultivars (A) and (B). Increasing fruit physical character may be attributed to the improvement of fruit growth and uptake of both K and B nutrients that accelerate metabolic processes. A similar finding was reported by Khayyat *et al*[11], Desouky *et al.*,[1] Harhash and Abdel-Nasser[6], Shahin[14], Sarrwy *et al.*[5] and omar *et al.*[6].

Boron and potassium with both two pollen grain cultivars (A) and (B) increased significantly the percentage of fruit ripening. Boron has the main role in many processes especially transport of sugars and carbohydrate metabolism[12]. Moreover, boric acid causes cell division or nucleic acid synthesis within fruit growth and development period and consequently fruit growth improves[11]. Potassium is essential for fruit enlargement and in some plants cause cell turgidity supplementally by reducing carbohydrates[21].

The improvement occurred in the fruit retention percentage and quality could be attributed to the effects of nutrients on carbohydrate influx or plant growth regulators synthesis in growing fruits. Differences in fruit weight between fruit produced by the two pollens are probably[20] related to differences in the levels of free IAA and free gibberellins which would influence the process of cell division and cell elongation and affecting fruit growth, through their effect on the mobilization of assimilates toward the fruit in a process known as the hormone-directed transport[7, 8].

Lichtenzveig *et al*.[22] reported that differences in the time to fruit ripening might be due to variable growth rates of pollen tubes. Thus, the source of pollen is an important variable to consider in order improving fruit quality and ripening time. However, in our results source of pollen grain (A) increased significantly fruit set and decreased fruit drop compared with the source of pollen grain (B), whereas had not significant differences in fruit weight, bunch weight, fruit ripening and total yield. Boron and potassium have been considered to be functional in the transport of carbohydrates and translocation of sugar[21, 23].

CONCLUSIONS

Boron and potassium played an important role in fruit set, fruit retention, and development and cause efficient yield and quality improvement. Our results revealed that mixture of boric acid and potassium sulphate had a positive effect such as a new method to enhancing pollination of date palm ‘Berhi’ cultivar and increase of fruit set, yield, and fruit quality. However, it could be concluded that the promising treatment is boric acid at 4g gave the highest values concerning fruit set, fruit retention, bunch weight and fruit physical and ripening of fruit.

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Corresponding author: Hussein J. Shareef

Date Palm Research Centre, University of Basrah, Basrah, Iraq