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Effect of GA_3, 6-benzylaminopurine and Boric Acid Spraying on Yield and Fruit Quality of Barhee Date Palm

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ABSTRACT

The present research was accomplished on (*Phonix dactylifera* L) CV. Barhee to investigate the effect of GA_3 at 100 ppm, 6-benzylaminopurine (BAP) at 100 ppm, Boric acid at 250 ppm and their mixture on fruit set, yield and fruit quality. Generally, spraying inflorescences of Barhee date palm with the mixture of 100 ppm GA_3 + 100 ppm BAP + 250 ppm Boric acid significantly increased fruit set, fruit retention bunch weight, yield and fruit quality in both seasons as compared with control and other treatments.

Key words: Barhee date palm, GA_3, 6-benzylaminopurine, Boric acid, yield, fruit quality.

Introduction

Date palm (*Phoenix dactylifera* L.) in one of the ancient domestic fruit trees in the Middle East countries and their fruits play an important role in the nutrition's pattern of many people. Egypt is considered among the top ten date producers, FAO (2012). Date palms could grow under unfavorable conditions where many of other fruits species could not grow. For this reason date palm is considered one of the suitable trees which could be cultivated in the new reclaimed desert regions. Arabian date palm cultivars grow successfully through Egypt (Ahmed *et al*., 1996 and Sayed 1999).

Many scientists studied the effect of some growth regulators on yield and fruit quality of date palm (Botes and Zaid, 1999). Proper application of plant growth regulators can increase quantitative, qualitative and economic output of date production in palm groves (Abdolali and Gholamreza, 2010).

Plant growth regulators such as gibberellins, auxins, cytokinins and abscisic acid have been successfully used in the orchard initiation and development (Nisha *et al*., 2012). Spraying bunches of date palm with the mixture of GA_3 at 50 ppm plus salicylic acid at 1000 ppm significantly increased fruit length, total soluble solids and total sugars, while decreased tannins in fruit as compared with other treatments including the untreated bunches (Merwad *et al*., 2015).

Cytokinin (BAP) stimulates protein synenthesis and participates in cell cycle control in a cell division (George *et at*., 2008). Cytokinin is proved to be very effective in improving fruiting of various crops through its benefit in enhancing cell enlargement, morphogenesis, development of plastids and stomatal aperture and in delaying the breakdown of chlorophyll, proteins and RNA. In addition, cytokinins as plant specific chemical messengers "hormones" participate in an essential role in the regulation of plant cell cycle and numerous developmental procedures, cytokinins were found out as factors that stimulate cell division as it exist in all plant tissues (Wasfy, 1995).

Spraying micronutrients improves fruit set, fruit retention and development as well as yield and fruit quality (Sarrwy *et al*., 2012 and Omar *et al*., 2014). Boron is involved in processes such as protein synthesis, transport of sugars and carbohydrate metabolism (Hansch & Mendel, 2009 and Harhash & Abdel-Nasser, 2010). The impact of some microelements, such as boron on dates yield and fruit quality seems to play an important role in achieving satisfactory fruit set and fruit quality (Etman *et al*., 2007 and Khayyat *et al*., 2007).

The objective of this study is to investigate the effect of some growth regulators spray such as GA_3, 6-benzylaminopurine (BAP) and Boric acid on yield and fruit quality of Barhee date palm.

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Material and Methods

This study was carried out during two successive growing seasons (2014 and 2015). Twenty one selected female uniform date palm (*Phoenix dactylifera* L.) of Barhee cultivar grown at a private orchard located at point of 63 kilo meters from Cairo- Alexandria Desert Road. The palms are grown in sandy soil and planted at 6 m a part. All palms were at similar age (10 years old), uniform in growth and subjected to the same management and cultural practices. Three bunches were pollinated from one male palm by inserting 10 fresh male strands into female spath in both seasons. Seven flower clusters were used on each palm and a palm was subjected to one of the following treatments:

(T_1) Control (treated with water only).
(T_2) 100 mg/L Gibberellic acid (GA_3)
(T_3) 100 mg/L 6- benzylaminopurine (BAP)
(T_4) 100 mg/L Boric acid
(T_5) 100 mg/L GA_3 + 100 mg/L Boric acid
(T6) 100 mg/L BAP + 100 mg/L Boric acid
(T7) 100 mg/L GA_3+ 100 mg/L BAP + 100 mg/L Boric acid

Solution of above concentration of growth regulators and Boric acid were prepared in a mixture of ethanol or NaOH: distilled water. Each palm was drilled with a hand drill. The experimental treatments were arranged in a randomized complete block design with three replicate (7 treatments x 3 replicates = 21 palms). Treatments were conducted at depressed period of fruit growth and one month after fruit set during two consecutive growing seasons. Clusters were protected from contamination by special practice.

The following measurements were carried out:

Fruit set

During the last week of June in each season fruit set percentage was determined using the following formula.

$$\text{Fruit set \%} = \frac{\text{Number of fruits setting on the strand}}{\text{Total number of flowers per stand}} \times 100$$

Fruit retained percentage

It was calculated using the formula of:

$$\text{Fruit retantion \%} = \frac{\text{Number of retained fruits}}{\text{Number of retained of fruit + number of flowers scars}} \times 100$$

Bunch weight and yield/palm (Kg)

In the two seasons, bunches were harvested at the mid-September at the peak of color development, and have been counted and weights (Kg) were recorded. Then, calculated the average of yield (Kg)/palm.

Fruit physical properties

Samples of 10 fruits were randomly taken form each bunch on the experimental palms. The fruit weight (g) and fruit dimensions (cm), flesh and seed weight (g), and fruit shap index were determined.

Fruit chemical properties

Preparation of sample for chemical analysis: Ten fruits from each treatment were divided into pieces and seeds were omitted. Fifty grams of pieces were mixed with 100 ml distilled water using

special electric mixer for extraction, then filtered and the filtrate was used for the determinations the following:

Total soluble solids percentage (TSS %) was determined by using hand refractometer. Total acidity percentage (TA %) was measured as malic acid and determined by (AOAC, 2000). Total sugars, reducing and non-reducing sugars percentages were determined according to AOAC (2000).

Experimental Design and Statistical Analysis:

The experiment was arranged in randomized complete block design with one tree plot of 3 replications each replicate with 2 clusters. Treatments means where compared using the new Duncan Multiple Range Test at 5% probability level (Snedecor and Cochran, 1980).

Results and Discussion

Fruit set

Results presented in Table (1) exhibited that fruit set percentage of Barhee date palm was significantly affected by different treatments as compared with control in both seasons. Foliar spray with the mixture of 100 ppm GA_3 + 100 ppm BAP + 250 ppm Boric acid (T_7), produced the highest fruit set percentage (85 and 83%), followed by spray with the mixture of 100 ppm BAP + 250 ppm Boric acid (T_6) since it was recorded (81 & 79.67 %) as well as T_3 recorded in this respect in the first and the second seasons, respectively. While, the lowest fruit set was obtained from control since this recorded (70.33% & 69.67%) in both experimental seasons, respectively. As for the effect of T_3 on fruit set, it was more effective than T_2 and the control and that in true in the two seasons. Generally, it in can be concluded that T_7 increased fruit set by (20.85 & 19.13%) form the control. These results may be due to the interaction with the mixture of GA_3+ BAP+ boric acid, which enhancing and improving fruit set.

The obtained results were nearly in the same line with obtained by (Etman *et al* 2007; Khayayat *et al*., 2007; Harhash and Abdel–Nasser, 2010; Soliman and Al-Obeed, 2011; El-Khayat and El–Noam, 2013; Omar *et al*., 2014 and Mostafa, 2015) who mentioned that the impact of some microelements, such as boron on dates yield and fruit quality seams to play an important role in achieving satisfactory fruit set and fruit quality. Khani *et al*. (2013) reported that, suits in major groups of plant hormone, gibberellins have an important role in plant flowering. On the other hand, (Abdolali and Gholamreza, 2010) mentioned that the application of GA_3, BAP or mixture of growth regulators did not affect fruit set percentage.

As for Boric acid 250 ppm (T_4) was more effective than the control on fruit set that is may be due to the effect of boron application on fruit drop.

The obtained results are in harmony with those reported by Khayyat *et al*. (2007) who mention that boron seems to play an important role in fruit set.

Table 1: The effect of GA_3, 6-benzylaminopurine (BAP), boric acid and their mixture spraying application on Fruit set (%), retention (%), bunch weight and yield of Barhee date palm during 2014 and 2015 seasons

Treatments	Fruit set (%)		Fruit retention (%)		Bunch weight (Kg)		Yield (Kg) /palm	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	70.33	69.67	47.6	46.7	12.5	12.9	112.5	115.8
100 ppm GA_3	75.76	74.67	51.2	49.7	14.0	14.2	126.0	127.8
100ppm BAP	80.33	79.00	54.2	53.0	15.1	15.9	136.2	143.4
250 ppm boric acid	78.00	76.67	49.0	45.3	13.6	14.1	122.7	126.6
GA_3 + boric acid	78.00	76.33	52.0	51.3	15.3	15.8	137.7	141.9
BAP + boric acid	81.00	79.67	56.0	54.3	15.8	15.9	142.2	145.9
GA_3 + BAP + boric acid	85.00	83.00	58.0	56.7	16.9	17.3	151.8	149.4
LSD 0.05	**2.1**	**2.0**	**1.7**	**1.13**	**0.51**	**0.32**	**4.6**	**2.9**

The mixture contains the same concentrations in the treatment alone.

Fruit retention

Data presented in Table (1) has taken the same trend of fruit set, which cleared that T_7 was more effective than the other treatments including control. The lowest fruit retention was recorded from GA_3 (T_2) and the control respectively. These results are in agreement with those obtained by (Desouky *et al*., 2007; Osman *et al*., 2011 and Merwad *et al*., 2015) who mentioned that spraying bunches of date palm with the mixture of GA_3 at 50 ppm plus salicylic acid at 1000 ppm significantly increased fruit retention. Sarrwy *et al*. (2012) and Omar *et al*. (2014) reported that spraying micro nutrients improves fruit set, fruit retention and development as well as yield and fruit quality.

Bunch weight and yield /palm

The obtained results indicated that, the bunch weight shows similar trend as the yield/palm. Bunch weight was significantly affected by different treatments in both seasons than the control. Spraying inflorescences of Barhee date palm with the combination of 100 ppm GA_3+ 100 ppm BAP + 250 ppm boric acid (T_7) resulted the highest bunch weight, followed by (T_6) and that is true in the two seasons respectively. It worth motioned; the T_3 and T_5 were obtained the same results in this regard in the 2nd season. The increment in bunch weight may be attributed to the increase in fruit weight. Abdolali and Gholamreza (2010) reported that plant growth regulator (PGRs) applications significantly increased bunch weight as compared with untreated control.

Palm yield affected by different treatments during 1st and 2nd seasons as presented showed in Table (1). Results indicated that PGRs applications significantly increased the palm yield. The enhancement effect of yield weight values was obtained with the mixture of 100 ppm GA_3+ 100 ppm BAP + 250 ppm Boric acid (T_7)., which increased the yield by (34.9 and 29.0 %), flowed by spraying inflorescences with T_6 which increased the yield by (26.4 and 26.0 %) from the control in the two seasons respectively. As for the comparison study between (T_5) and (T_6), it is clear from Table (1) that T_6 was more effective than T_5 in increasing fruit yield. Also, (T_3) was more effective than T_4 and T_2 and that is true in both seasons. It worth mentioned that PGRs is more effective than boric acid treatment alone. The pronounced increase in yield/palm due to T_7 spraying could be attributed to their effects in increasing fruit set and fruit retention.

These results are agreed with Nisha *et al*. (2012) who reported that the application of BAP increased the percentage of in florescence production induced earlier flowering and flowers produced. Moreover, PGRs such as gibberellins, auxins, cytokinins and abscisic acid have been successfully used in the orchid cut flower industry for many purposes including for flower initiation and development. Samy and Nabil (2015) concluded that bio stimulants amino acids mixture treatments had a positive effect on yield and fruit quality. George, 2008 found that Cytokinin (BAP and Kin) stimulate protein synthesis and participate in cell cycle control in cell division. Spraying micro nutrients improves yield and fruit quality (Sarrwy *et al*., 2012 and Omar *et al*., 2014). Adequate boron nutrition is critical not only for obtaining higher yield but also for fruit quality (Abd El-Fatah *et al*., 2008).

Fruit physical properties

Fruit weight

The present results indicated that, all growth regulators treatments caused significant in average of Barhee fruit weight compared with control in both seasons of study (Table 2). The heaviest fruit weight was detected by foliar spray with the mixture of (T_7) followed by (T_6). It was (53.3 & 48.5 %) and (36.7 & 34.3 %) from the control in the two seasons respectively. The lowest fruit weight was recorded from control. Generally speaking, the fruit weight was lower with the application of 100 ppm GA_3 than the other treatments; it was (12.2 & 13.1 %) from the control, in the two seasons respectively. It may be due to the effect of GA_3 100 ppm (T_2) alone.

Such as results nearly, are in agreement with those obtained by Kamal (1995) who noticed that fruit weight was generally increased by GA_3 treatments at 100-200 ppm than the control. Ghazzawy (2013) mentioned that GA_3 had significant effect in increasing fruit weight than BA followed by NAA

250 ppm as compared the control. On the other hand, El-Kassas (1993) and Hussein *et al*. (1993) who mentioned that the application of GA_3 decreased fruit weight than the control. Regarding to the effect of foliar spraying boric acid (T_4), in Table (2) there increase significant differences between it and the control on fruit weight. This result may be due to the role and the mode of action for boric acid, the obtained result in this respect agree with that found by Abd El-Fatah *et al*. (2008) who mentioned that boric acid application achieved about 11% increase in fruit weight during the two seasons.

Flesh weight

Results presented in Table (2) cleared that fruit flesh weight increased significantly affected by differed treatments as compared with control. The mixture of plant growth regulator + boric acid (T_7) this study scored statically the highest value of fruit flesh weight, it was obtained (13 & 13.8 g) followed by T_6 since it was recorded (11.5 & 12.4 g) in the first and second seasons, consecutively. The obtained results are nearly of those of Soliman and Al-Obeed, 2011 who noticed that flesh weight increased by the high concentration of boric acid. Amini *et al*., 2013 showed that the highest flesh weight was seen in benzyl adenine 250 ppm in distillated water.

Table 2: The effect of GA_3, 6-benzylaminopurine (BAP), boric acid and their mixture spraying application on Fruit physical properties of Barhee date palm during 2014 and 2015 seasons

Treatments	Fruit weight (g)		Flesh weight (g)		Seed weight (g)		Fruit length (cm)		Fruit diameter (cm)		Fruit shap index	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	9.0	9.9	8.0	8.7	1.0	1.2	3.5	3.4	2.1	1.9	1.7	1.8
100 ppm GA_3	10.1	11.2	9.2	10.2	0.9	1.0	4.1	3.9	2.2	2.1	1.9	1.9
100ppm BAP	11.0	12.0	10.0	11.1	1.0	0.9	4.3	4.2	2.3	2.2	1.9	1.9
250 ppm boric acid	10.2	11.5	9.3	10.5	0.9	1.0	3.8	3.7	2.2	2.1	1.7	1.8
GA_3 + boric acid	11.8	12.7	11.0	11.8	0.8	0.9	4.3	4.1	2.3	2.2	1.9	1.9
BAP + boric acid	12.3	13.3	11.5	12.4	0.8	0.9	4.5	4.4	2.4	2.3	1.9	1.9
GA_3 + BAP + boric acid	13.8	14.7	13.0	13.8	0.8	0.9	4.8	4.6	2.4	2.5	2.0	1.8
LSD 0.05	**0.6**	**0.37**	**0.56**	**0.36**	**0.08**	**0.07**	**0.13**	**0.16**	**NS**	**0.11**	**0.06**	**0.1**

NS: not significant. The mixture contains the same concentrations in the treatment alone.

Seed weight

Our data in Table (2) suggest that seed weight of Barhee date palm was decreased significantly affected by different treatments in both seasons. The highest seed weight was recorded from the control (1.0 & 1.2 g). Meanwhile the lowest seed weight was recorded (0.8 & 0.9g) from (T_5, T_6 and T_7) in the two seasons respectively.

These results may be due to the mode of action and the effect of the interaction between GA_3, 6-benzylaminopurine (BAP) and Boric acid. The obtained results in this experiment were agreement with that found by Kim and Miller (2008), Pan and Xu (2010) and Nisha *et al*. (2012). Moreover, Sarrwy *et al*. (2012) reported that the highest seed weight % was obtained by control treatment, whereas the lowest seed weight with recorded by the spraying 500 ppm boric acid mixed with 2 % calcium nitrate.

Fruit dimensions

From the date in Table (2), Barhee fruit length and diameter has taken the same trend of fruit weight and that is true in the two seasons of study. Results in Table (2) cleared that Barhee fruit diameter in the first season was not significantly affected by different treatments as compared with control.

Such results are in harmony with those of Attalla *et al*. (2007), Soliman and Al-Obeed (2011), Sarrwy *et al*. (2012), Ghazzawy (2013), Mostafa (2015) and Merwad *et al.* (2015) on different date

palm CVS. who decided that fruit weight, diameter and length were increased with all growth regulator as compare with the control. Anita *et al*. (2015) found that the most length and diameter in plants were obtained by applying benzyl adenine and salicylic acid while the lowest length was related to control. Hamidimoghadam *et al*. (2014) reported that simultaneous using of GA $_{4+7}$ and BA causes an increase in diameter of Tulip flowers.

Fruit shape Index

Tabulated data demonstrate that fruit shape index ranged from (1.7 to 2.0) in the first season and between (1.8 to 1.9) in the second season. Sarrwy *et al*. (2012) found that the highest fruit shape index was obtained 1.94 by spraying with 500 ppm boric acid + 2% calcium.

Fruit chemical properties

Total acidity and total soluble solids

From Table (3) data cleared that treatments (T_2 and T_3) had the lowest parameter value on total acidity % flowed by control and the other treatments, that is true in the two seasons of the investigation. Generally, there are no significant results between the other treatments (T_4, T_5, and T6) on acidity in the two seasons. It means that GA_3 treatment has a positive effect on fruit quality and more effective in reducing acidity. As for total soluble solids (TSS %) the data in Table 3 indicated that T_7 had the best effect in increasing TSS % than the other treatments including control.

The above mentioned results are in harmony with obtained Harhash and Abdel-Nasser, 2010 who included that boron spraying significantly reduce acidity and increase TSS%. On the other hand, Ghazzawy (2013) found that the application of GA_3 decreased TSS % and delayed fruit maturation slightly and others founded that significantly.

Table 3: The effect of GA_3, 6-benzylaminopurine (BAP), boric acid and their mixture spraying application on Fruit chemical properties of Barhee date palm during 2014 and 2015 seasons

Treatments	Total acidity (%)		Total soluble solids (%)		Reducing Sugars (%)		Non reducing Sugars (%)		Total Sugars (%)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	0.44	0.43	28.9	29.2	16.3	15.2	7.4	7.8	23.7	23.0
100 ppm GA_3	0.42	0.40	29.5	30.2	16.6	17.8	7.8	8.3	24.4	26.1
100ppm BAP	0.44	0.43	30.6	31.2	17.8	17.5	7.6	8.0	25.4	25.5
250 ppm boric acid	0.45	0.44	29.3	29.7	16.8	17.0	7.7	8.1	24.5	25.1
GA_3 + boric acid	0.45	0.44	29.7	31.4	17.5	17.6	8.3	8.2	25.8	25.8
BAP + boric acid	0.45	0.44	30.3	31.9	18.6	18.4	8.1	8.6	26.7	27.0
GA_3 + BAP + boric acid	0.46	0.44	31.5	32.7	18.8	19.5	8.5	8.7	27.3	28.2
LSD $_{0.05}$	**0.03**	**0.01**	**0.84**	**0.55**	**0.22**	**0.55**	**0.01**	**0.25**	**0.26**	**0.55**

The mixture contains the same concentrations in the treatment alone.

Reducing sugars

Table 3 showed that, the reducing sugars percentage was significantly affected by different treatments as compared with control in both seasons. The enhancement effect of T_7 clearly appeared on reducing sugars (%) it was (18.8 & 19.5 %), followed by foliar spray with T_6 since it was (18.6 & 18.4 %) in the first and second season, respectively. The lowest values were obtained from control since it was 16.3 & 15.2 % in both seasons.

The increasing in reducing sugars content could be due to necessity of PGR and mineral element for synthesis of sugar products and photosynthesis. The obtained results in this experiment were agreement with that found by Saleh, 2009 on Piarom date palm. Soliman and Al-Obeed, 2011 mentioned that spraying 0.6 % H_3Bo_3 + 2g/L sugar and spraying 8 % H_3Bo_3 + 1g/L sugar increased reducing sugars percentage than the other treatments.

Non-reducing sugars

Data in Table 3 demonstrates that all tasted treatments increased non-reducing sugars % and has the similar trend as reducing sugars as compared with the control treatment, and that is true in both seasons. The obtained results were nearly in the same line with obtained by Harhash and Abdel-Nasser, 2010 who notice that boron spraying significantly increased fruit chemical characteristics i, e. reducing, non-reducing compared with the control. Also, Sarrwy *et al*., 2012 reported that, concerning the non-reducing sugars, the highest percentage was detected by spraying boric acid at 500 ppm combined with calcium nitrate at 2 % where the lowest percentage was observed at control.

Total sugars

As for total sugar contents, resulted in Table (3) show that fruit content of total sugars significantly affected by different treatments of foliar spray in the two seasons. Foliar spray with the mixture of 100 ppm GA_3 + 100 ppm BAP + 250 ppm boric acid gave the highest fruit contents of total sugar percentage (27.3 & 28.2 %), followed by foliar spray with the mixture of 100 ppm BAP + 250 ppm boric acid since it was (26.7 & 27.0 %) in the first and second seasons consecutively. While, the lowest content of total sugars was obtained by control treatment (23.7 & 23.0 %) in both seasons of study.

Our results may be due to the interaction between the mode of actions of GA_3, BAP and boric acid. These results are in harmony with those obtained on date palms since spray GA_3 at 150 ppm increased total soluble solids and total sugars percentage (Ahmed *et al.*, 2010, Mostafa, 2015 and Merwad *et al*., 2015). In addition boron is involved in processes such as protein synthesis transport of sugars and carbohydrate metabolism (Hansch and Mendel, 2009).

Conclusion

Generally, it could be concluded that spraying inflorescences of Barhee date palm with the mixture of 100 ppm GA_3 + 100 ppm BAP + 250 ppm boric acid had played an important role and gave the best treatment for improving fruit set, fruit retention, bunch weight and fruit quality followed by spraying the mixture of 100 ppm BAP + 100 ppm boric acid under this experiment conditions.

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