Effect of Some Plant Growth Regulators on Physiochemical Characteristics of Date Palm (*Phoenix dactylifera* L. cv. Kabkab) Fruit

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**Abstract:** An experiment was conducted to evaluate different plant growth regulators via trunk injection with distilled water as control, Gibberellic acid (100 mg/L), Naphthalene acetic acid (100 mg/L), Kinetin (100 mg/L) and their combination on fruit set and physiochemical properties of Kabkab date palm cultivar during two successive years (2008-2009). Results showed that NAA treatments significantly increased bunch weight, improved physical properties (fruit weight, height, diameter and size and flesh weight percentage) compared with untreated bunches and other treatments. However, total soluble solid, total and reducing sugars were decreased significantly by plant growth regulators treatments in fruit juice compared with the control in both seasons. Between treatments NAA alone showed the lowest total soluble solid, total and reducing sugars. Seed weight per fruit, acidity percentage and nonreducing sugars of both seasons were not affected significantly by applied treatments.

**Keywords:** Date palm · Fruit quality · *Phoenix dactylifera* L. · Plant growth regulators · Total soluble solid · Trunk injection

**INTRODUCTION**

Date palm (*Phoenix dactylifera* L.), a monocotyledonous and dioecious species belonging to the *Palmaeae* family, is widely cultivated in arid regions of the Middle East and North Africa. In Iran date palm distributed in warm climate area especially in south, southwest and southeast areas and is one of the main export crops of Iran. Producing high yield with best quality fruit related to many factors. The high land under date cultivation is in Iran is in Bushehr province, especially Dashestan region. This region is climatically apt to produce the most marketable date cultivar, 'Kabkab'. Area under cultivation of this cultivar has regularly increased in recent years because of its desirable taste, size and moisture and its important role to improve farmers' income. Many scientists studied the effect of some growth regulators on yield and fruit quality of date fruit. Fruit size is one important aspect of fruit quality especially for date palm. Small fruit size is one of the limiting factors in fruit marketing of many species such as date palm [1], Apple [2], Peach [3], Cherry [4], Citrus [5] and Loquat [6]. Consumers also prefer large fruits, making this a very important marketing consideration and the economic benefits from treatments capable of improving average fruit size are potentially very high. Several techniques were used to improve fruit size of date palm, such as hand bloom and fruit thinning [7,8]. However, the cost of hand thinning and the low potential for chemical bloom or fruitlet thinning allow using that technique. Using plant growth regulators via foliar spray on cluster or trunk injection is another technique. Proper application of plant growth regulators can increase quantitative, qualitative and economical output of date production in palm groves. Synthetic and natural plant bioregulators used extensively for the improvement of crop performance in some crops like citrus [9] and sweet cherry [10]. Synthetic auxins are effective on enhancing fruit growth. These auxins are known by their ability to increase the cell size [11], which enhance fruit growth in several fruit species such as citrus [5], Peach [3], Loquat [6] and Date Palm [12,13]. The most studies mentioned that a synthetic auxin is effective in increasing fruit size without thinning. Chemri is immature green colored stage of dates, which could differentiate in sub-stages. The first sub-stage is characterized by rapid increase in fruit size and weight, while fruit weight rate decreased in the second sub-stage "Depressed period" in comparison to the first sub stage. Application of
naphthalene acetic acid (NAA) between 50 to 200 ppm concentrations during the depressed period of fruit growth caused an increase in fruit size and weight and improved fruit quality in Zahdi and Sayer cv. [15] in Khenazi cv. [13] in Barhee cv. [12] and in Shabani cv. [14]. Application of gibberellic acid in combination with hand pollination increased fruit set percentage, pulp/seed ratio, average fruit weight and size [16]. Others found that the application of GA3 decreased the seed weight, fruit weight, pulp weight and total soluble solid (TSS) and delayed fruit maturation slightly or significantly [17-19]. Naphthalene acetic acid application on date palm trees reduced fruit yield per bunch, but increased fruit weight, dimensions, flesh weight percentage and total soluble solid percentage and reduced fruit ripening (%) [20]. Other auxin (2,4-DP) increased slightly Satsuma mandarin yield, but had no effect on fruit soluble solid contents (SSCs) [5]. The objectives of this study were to assess relative effectiveness of gibberellic acid, Naphthalene acetic acid, Kinetin and mixture of growth regulators on fruit set and fruit physicochemical properties, yield of Kabkab date palm trees in Dashtestan.

MATERIALS AND METHODS

The experiment was carried out during two successive growing seasons (2008 and 2009), 15 selected female uniform date palm trees (Phoenix dactylifera L.) of Kabkab cultivar, grown in Department of Agriculture and Natural Resource, Persian Gulf University, the Iran were used. The trees were planted in sandy soil at 10 m apart. All the trees were of similar age (15 years old), uniform in growth, free from insects damage and diseases and were subjected to the same management and cultural practices. Date palm trees were pollinated on March 5-15/2008 and 2009, by placing five fresh male strands on female spadix (flower cluster) center. five flower clusters were used on each tree and a tree was subjected to one of the following treatments: 100 mg/l Gibberellic acid (GA3), 100 mg/l Naphthalene acetic acid (NAA), 100 mg/l Kinetin (Kin) and Mixture of growth regulators (100 mg/l GA3 + 100 mg/l NAA + 100 mg/l Kin) were selected as main treatments and compared with control treatments.

Solutions of above concentrations of growth regulators were prepared in a mixture of ethanol or NaOH distilled water. Each tree drilled with a hand drill 1.5 m height and 30 cm depth with 45 degree to down. Treatments were conducted at depressed period of fruit growth during two consecutive growing seasons (2008-2009). Clusters were protected from contamination by special practice. Ten strands were randomly selected per each replicate (5 bunches for each tree), from the 40-50 strands that composed a bunch, to determine following fruit characteristics in selected time:

Fruit Chemical Characters: Total soluble solids: The percentage of TSS was determined in the fruit juice using zice refractometer [21].

Fruit Acidity: Fruit acidity was determined according to A.O.A.C. [21] and the titrable acidity was calculated as citric acid [22].

Reducing Soluble Sugars: It was determined in the methanol extract according to Nelson and Somogy [23] and A.O.A.C. [21]. The percentage was calculated per dry weight.

Non-reducing Sugars: It was determined by the difference between total and reducing sugars.

Fruit Physical Characters: Samples of 50 fruits per each palm, 10 fruits were taken randomly from each bunch (replicate) to determine fruit weight, flesh weight, seed weight (g), fruit dimensions (length and diameter "mm"). fruit size (cm').

Percentage of fruit set at 45, 90 and 135 day after pollination (first, second and third stages of fruit development, respectively). Each bunch was tagged and labeled and the respective percentage of fruit set per selected strand was determined by counting the number of fruit and dividing it by the total number of the twigs on the respective strands.

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 (DMRMT) at 5% probability level.

RESULTS AND DISCUSSION

Bunch weight affected by different treatments during 2008 and 2009 seasons is presented showed in Table 1. Results indicated that PGRs application significantly increased the bunch weight as compared with untreated control. The highest bunch weight values were obtained
Table 1: Effect of GA3, NAA, Kin and mixture of growth regulators on fruit set (%), fruit length, bunch weight and fruit flesh (%) of Kabkab date palm trees during 2008 and 2009 in selected time

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<tbody>
<tr>
<td>Control</td>
<td>80%</td>
<td>74%</td>
<td>53%</td>
<td>39%</td>
<td>33%</td>
<td>33%</td>
<td>88%</td>
<td>90.1%</td>
<td>41.9%</td>
<td>40.2%</td>
</tr>
<tr>
<td>GA100</td>
<td>79%</td>
<td>70%</td>
<td>49%</td>
<td>40%</td>
<td>31.2%</td>
<td>32%</td>
<td>90%</td>
<td>89.3%</td>
<td>36.9%</td>
<td>36.8%</td>
</tr>
<tr>
<td>NAA 100</td>
<td>80.2%</td>
<td>75.2%</td>
<td>75.1%</td>
<td>65%</td>
<td>61a</td>
<td>91a</td>
<td>93.1%</td>
<td>45.3%</td>
<td>45.4%</td>
<td>18a</td>
</tr>
<tr>
<td>Kin 100</td>
<td>83a</td>
<td>74.4a</td>
<td>53.1b</td>
<td>41a</td>
<td>34.1b</td>
<td>37b</td>
<td>90a</td>
<td>89b</td>
<td>41.9%</td>
<td>43b</td>
</tr>
<tr>
<td>GA100+NAA 100+Kin 100</td>
<td>83.1a</td>
<td>75.2a</td>
<td>56b</td>
<td>39a</td>
<td>33.4b</td>
<td>32b</td>
<td>90.2a</td>
<td>90b</td>
<td>42.3%</td>
<td>41.2%</td>
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Means within columns followed by the same letter do not differ significantly (P = 5%): Duncan's multiple range test

Table 2: Effect of GA3, NAA, Kin and mixture of growth regulators on physical properties of Kabkab date palm fruit during 2008 and 2009 in selected time

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<tbody>
<tr>
<td>Control</td>
<td>0.81a</td>
<td>0.87a</td>
<td>36.97e</td>
<td>36.84a</td>
<td>20.4d</td>
<td>20.4d</td>
<td>10.3a</td>
<td>10.3e</td>
<td>8.31c</td>
<td>8.92c</td>
</tr>
<tr>
<td>GA100</td>
<td>0.91a</td>
<td>0.84a</td>
<td>41.93b</td>
<td>40.25b</td>
<td>22.33c</td>
<td>22.2e</td>
<td>13.05d</td>
<td>13.2e</td>
<td>9.01b</td>
<td>9.4b</td>
</tr>
<tr>
<td>NAA 100</td>
<td>0.83a</td>
<td>0.8a</td>
<td>45.9a</td>
<td>45.4a</td>
<td>27.27a</td>
<td>27.2a</td>
<td>18.57a</td>
<td>18.21a</td>
<td>12.4a</td>
<td>12.31a</td>
</tr>
<tr>
<td>Kin 100</td>
<td>1.16a</td>
<td>1.1a</td>
<td>41.93b</td>
<td>43b</td>
<td>23.1c</td>
<td>22.4c</td>
<td>14.17c</td>
<td>14.07c</td>
<td>10.1b</td>
<td>9.7b</td>
</tr>
<tr>
<td>GA100+NAA 100+Kin 100</td>
<td>1.14a</td>
<td>1.02a</td>
<td>42.33b</td>
<td>41.25b</td>
<td>25.6b</td>
<td>24.1b</td>
<td>17.57b</td>
<td>16.77b</td>
<td>11.3a</td>
<td>11.03a</td>
</tr>
</tbody>
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Means within columns followed by the same letter do not differ significantly (P = 5%): Duncan’s multiple range test

Table 3: Effect of GA3, NAA, Kin and mixture of growth regulators on chemical properties of Kabkab date palm fruit during 2008 and 2009 in selected time

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<tbody>
<tr>
<td>Control</td>
<td>17.89a</td>
<td>17.41a</td>
<td>8.48a</td>
<td>8.68a</td>
<td>26.37a</td>
<td>26.09a</td>
<td>0.44a</td>
<td>0.42a</td>
<td>77a</td>
<td>84a</td>
</tr>
<tr>
<td>GA100</td>
<td>17.31a</td>
<td>17.3a</td>
<td>7.91a</td>
<td>8.43a</td>
<td>25.22a</td>
<td>25.73a</td>
<td>0.45a</td>
<td>0.40a</td>
<td>75ab</td>
<td>82b</td>
</tr>
<tr>
<td>NAA 100</td>
<td>13.21c</td>
<td>13.51c</td>
<td>7.15a</td>
<td>7.89a</td>
<td>20.36c</td>
<td>20.4c</td>
<td>0.41a</td>
<td>0.41a</td>
<td>72c</td>
<td>70d</td>
</tr>
<tr>
<td>Kin 100</td>
<td>16.41a</td>
<td>17.33a</td>
<td>8a</td>
<td>7.88a</td>
<td>24.41b</td>
<td>25.21a</td>
<td>0.44a</td>
<td>0.42a</td>
<td>76ab</td>
<td>82b</td>
</tr>
<tr>
<td>GA100+NAA 100+Kin 100</td>
<td>15b</td>
<td>15.8b</td>
<td>7.21a</td>
<td>7.1a</td>
<td>22.21b</td>
<td>22.9b</td>
<td>0.46a</td>
<td>0.43a</td>
<td>72c</td>
<td>77ab</td>
</tr>
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</table>

Means within columns followed by the same letter do not differ significantly (P = 5%): Duncan’s multiple range test

With NAA in both seasons. The increment in bunch weight may be attributed to the increase in fruit weight (Table 2). These results are in agreement with those obtained by many researchers on several date palm cultivars [12-14]. Application of GA3, Kin or mixture of growth regulators did not effect fruit set percentage of Kabkab date palm trees at all three stages of fruit development (45, 90 and 135 DAP) during two successive growing seasons (2008, 2009). Naphthalene acetic acid increased significantly fruit set % at the second or third stage of fruit development during first or first and second growing seasons, respectively as compared with control or other treatments (Table 1). The fruit set (%) of Kabkab date palm tended to be high in the first stage of fruit development, then progressively decreased with fruit age throughout the two growing successive seasons. Injection of GA3 or kin on Kabkab date palm had no significant effect on fruit flesh percentage at different stages of fruit development (data not shown) during two successive growing seasons respectively. Naphthalene acetic acid showed the highest fruit flesh percentage during first and second seasons, respectively compared with the control and other treatment (Table 1). The results could concluded that the NAA treatment was more effective on fruit flesh percentage of Kabkab date palm trees compared with the other treatments. The results are in agreement with Mustafa and Sif, [18] who found that the NAA treatments increased fruit flesh weight % of date palm trees. Results also indicated that the synthetic growth regulator NAA might be used for improvement of various important fruit characteristics, when the fruits treated at depressed period of growth. Between
treatments Naphthalene acetic acid treatments significantly increased the fruit size compared to the control during 2008 and 2009 seasons. Also, injection mixture of growth regulators increased significantly fruit weight during the first and second growing season and showed significant difference with control treatment. The trend was found to be the same as in fruit weight. Seed weight did not affected by PGRs treatments (Table 2). Application of NAA alone or in mixture increased fruit size, due to the enhanced strength of the sink for carbohydrate. The increase in cell size following auxin application possibly indicates its ability to mobilize carbohydrate uptake and thus enlarge the cells considerably. Another possibility is that the auxins increase the elasticity of the cell wall, thereby enabling its enlargement [24]. As a result of cell enlargement the rate of fruit growth, eventually leading to an increased yield of large fruit. These results are in harmony with the findings of many workers for several date cultivars [12,13]. They found that NAA increased date fruit growth and improved fruit physical properties. The same phenomenon was recently reported by Stern et al. [2] in plam. They found that NAA stimulate cell enlargement in the fruit mesocarp, which in turn, caused improvement in fruit size and total yield. Fruit dry matter percentage of Kabkab date palm was affected by PGRs. But these effects was not significant in comparison with the control (data not shown). Results shown in Table 3 illustrated that the total soluble solids (TSS) in fruit juice of Kabkab were decreased by PGRs treatments in both seasons (Table 3). Naphthalene acetic acid treatments decreased TSS in fruit juice as compared with the control in both seasons. Aljuburi et al. [25] reported that application of Naphthalene acetic acid or mixture of growth regulators treatments reduced significantly total soluble solid (oBx) of Heriz fruit at the third or fourth stage of fruit development during second and third or first and third growing seasons, respectively as compared with the control. Also, GA treatment increased the TSS compared to the control. But, was not significant at first growing season. The results of GA treatment are similar to that obtained by Rom. [26] and Facteau, [10] who found that the GA treatment decreased TSS accumulation in sweet cherry fruit in one of two years, or had no effect on TSS of Blackberry fruits. The acidity percentage was not significantly affected by PGRs treatments in both seasons (Table 3). The highest fruit acidity percentage in fruit juice was recorded in the control in both seasons as compared with PGRs treatments. Percentages of total and reducing sugars in fruit juice decreased significantly by NAA treatment of compared with the control in both seasons. The highest contents of total and reducing sugars in fruit juice were in the control. However, the non-reducing sugars percentages in fruit juice were not affected significantly in both seasons (Table 3). The lowest contents of TSS, total and reducing sugars in fruit treated by NAA application. This could attributed to the dilution effect of increase in fruit weight and size and high yield per bunch. In addition, an increase in the moisture percentage occurred. These results are in agreement with those obtained by Aljuburi et al. [12-13], Aljuburi et al. [25] and Aboutalebi and Beharoznam [14]. Regarding the effect of results, data of both seasons indicated that the highest values of fruit yield and quality were obtained with NAA treatment. Thus, it is recommended to injection the trunk the bunches during depressed period of fruit growth with 100 ppm NAA to obtain best yield with high fruit physical characteristics (weight, volume, height, diameter and flesh %) which affected TSS and sugars contents of Kabkab date palm cultivars. Naphthalene acetic acid treatment increased significantly fruit yield of Kabkab trees by 48 or 57 % during first or second growing season respectively as compared with the control (Data not shown). The results of NAA treatments are similar to that obtained by Alubiri et al. [25], who found that the NAA treatment increased significantly the average yield of Barhee date palm trees. The results of NAA treatments are in contrast to the results obtained by Moustafa et al. [20], who reported that the NAA treatments reduced the average yield of date palm trees. These differences in results might be due to the differences in NAA concentrations, cultivar had been used and to environmental conditions, under which the experiment was done. The results also showed that the yield of Kabkab date palm trees were higher for most treatments during the first growing season followed by third and second growing seasons, with exception of NAA and mixture treatments, which had higher yield/tree during first or second growing season respectively. The data suggested that NAA may be more effective in increasing Kabkab date palm trees yield than other treatments under Dashtestan condition of the Iran.

ACKNOWLEDGEMENT

The authors wish to express their thanks to Persian Gulf Research Center and Mr. D. Hidari, Mr. A. Dabbaleh, Roostami and H. Esfandiar for helpful comments and providing the necessary facilities during the course of this work.
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