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# Effects of 5-Aminolevulinic acid (5-ALA) on fruit yield and quality of date palm cv, Khalas

# تأثير منظم النمو 5-Aminolevulinic acid على أنتاج وجودة نخيل البلح صنف خلاص

سليمان بن علي الخطيب، ر. أوكاوارا ، عبداللطيف بن علي الخطيب و إبراهيم العبدالهادي

**S. A. Al-Khateeb*; R. Okawara; A. A. Al-Khateeb and I. A. Al-Abdoulhady**

** Crops and Range Department, College of Agricultural and Food Sciences, King Faisal Univ. P.O. Box 420, Al-Hassa, 31982,*

**Abstract:** The effects of spraying 5-ALA on date palms in relation to chlorophyll biosynthesis and fruits yield and quality during the 1998/1999 seasons has been investigated. Fruits of Khalas cv. were sprayed with 5-ALA aqueous solutions of 0, 50, and 100 ppm two weeks after fruit setting. Spraying was applied biweekly for six weeks. The Fruit's chlorophyll content in the Khalal (green) stage was significantly increased with 5-ALA treatments. Fruit weight, fruit volume and fruit flesh percentage of the rutab (yellow) stage were significantly increased with 100 ppm 5-ALA. During tamer the stage, fruit volume was significantly increased with 5-ALA treatment, while fruit weight was not. Total and reducing sugars were significantly increased with 5-ALA treatment in the rutab stage, but not in the tamer stage.

**Keywords:** Date Palm, *Phoenix dactylifera*, Amino levulinic acid.

**المستخلص**: تأثير رش منظم النمو 5-ALA على نخيل البلح و ارتباطه بتخليق الكلوروفيل وأنتاجيه وجودة الثمار درست خلال الموسم 1998 / 1999. رشت ثمار نحيل البلح صنف خلاص مرحلة الخلال بمحلول مائي من منظم النمو 5-ALA بتركيزات صفر، 50 و 100 جزء في المليون بعد أسبوعين من عقد الثمار. وقد استمر الرش دوريا مرة كل أسبوعين لمدة 6 أسابيع . وأشارت نتائج الدراسة إلى أن تركيز الكلوروفيل في مرحلة الخلال زاد معنويا بزيادة تركيز منظم النمو 5-ALA، كما أن وزن الثمرة، حجم الثمرة، ونسبة اللحم بالثمرة في مرحلة الرطب زادت معنويا مع تركيز منظم النمو 5-100 ALA جزء في المليون . في مرحلة التمر، زاد حجم الثمرة معنويا بزيادة تركيز منظم النمو 5-ALA، إلا أن وزن الثمرة لم يتأثر. نسبة السكر الكلية والمختزلة زادت معنويا مع زيادة تركيز منظم النمو 5-ALA في مرحلة الرطب بينما لم تتأثر معنويا في مرحلة التمر.

**كلمات مدخلية**: منظم النمو، نخيل البلح، جودة نخيل، الكلوروفيل، خلال.

## Introduction

The Date Palm (*Phoenix dactylifera,* L.) is a major fruit tree of Saudi Arabia with a total production of about 830,000 tons date fruits (FAO, 2004). Cultivation of cv. Khalas date palm has tremendously increased in Saudi Arabia in recent years. This cultivar is well known for its high fruit quality. However, with the recent increase in its cultivation, several fruit quality problems have surfaced. Fruit size is considered one of the major factors that determine the income of the producers. Chemical spraying (Ethrel, $GA_3$, Ethephon, Naphthalene Acetic Acid) improved date palm fruit size and quality (El-Hamady *et al.*, 1983; El-Hamady *et al.*, 1992; Al-Khateeb *et al.*, 1993; Hussein *et al.*, 1996; Moustafa and Seif, 1996 and Moustafa *et al.*, 1996). However, chemical treatment, particularly $GA_3$ delayed fruit ripening and decreased total soluble solid and total sugar (Hussein *et al.*, 1996; Moustafa and Seif, 1996).

5-Amino levulinic acid (5-ALA) is a precursor of tetrapyrrole compounds such as chlorophyll, phycobilin, heme and vitamin B12 which exist in plants. Foliar spraying of 5-ALA at low concentrations improved the growth and yield by 10 – 60 % of crops such as radishes, kidney beans, barley, potatoes, garlic, rice and corn (Hotta *et al.*, 1997 a and b; Bingshan *et al.*, 1998; Yongin *et al.*, 2003; Al-Thabet, 2006; Al-Khateeb, 2006). However, in plants treated with 5-ALA at relatively high concentrations, more than 10 mM, herbicidal

properties of 5-ALA were well documented (Hotta *et al.*, 1997a). The Effects of 5-ALA in plants have been reported in relation to chlorophyll biosynthesis, photosynthesis activity and suppression of respiration (Hotta *et al.*, 1997a).

Treating the fruit of date palms at the khalal stage (green stage) is expected to show some of the abovememtioned effects. If this assumption is true, the contribution of the treated fruits to photosynthetic activity could be higher than untreated ones. Therefore, an accumulation of assimilates due to the increased activity of photosynthesis of treated fruits might positively affect the fruit size and chemical properties. Therefore the present study was planned to study the effects of spraying 5-ALA on the fruits of date palm in relation to chlorophyll biosynthesis, and fruits yield and quality.

## Materials and Methods

The study was carried out in 1998/1999 in Al-Hassa. Twelve uniform 25 years old vigorous palm trees "cv. Khalas" were selected. They were subjected to the normal agricultural practices and thinned to eight bunches/tree. Pollination was conduced using the same male parent for all experimental palm trees. Fruits were sprayed with 5-ALA aqueous solutions of 0, 50 and 100 ppm containing Tween 20 (0.1%). The spraying treatments were started two weeks after fruit setting with approximately 240 ml/tree of aqueous solution (approximately, 30 ml / bunch). Spraying was done biweekly in the early morning for a duration of six weeks. Samples from each tree (replicate) were randomly collected at the Khalal, rutab and tamer stages. A completely randomized block design with four replicates per treatment was used.

Chlorophyll was determined in the khalal stage after six weeks of spraying application. The Fruit's skin (the grin coat only) was taken by a cork borer and then homogenized in cold (4oC) 80 % v/v acetone in water. The homogenate was kept in the dark and centrifuged for 3.0 minutes to remove the fruit debris. The absorbance of the extract at 647 and 664 mm was taken using a spectrophotometer. For the accurate determination of chlorophyll a,b and the total, the extinction coefficients of Graan and Ort (1984) were used. Physical properties of rutab (two weeks after fruits become yellow in color) and tamer (four weeks after fruits become brown in color) were obtained, i.e. fruit length and diameter (cm), fruit weight (g), fruit size (cm3), fruit flesh (%), and fruit seed (%). Chemical properties including moisture (%), ash content, total sugars and reducing sugars were measured according to AOAC (1984). Collected data were subjected to analysis of variance (ANOVA). The SAS computer package (SAS Institute, 2001) has been used. Throughout, P=0.05 was used to define statistical significance.

## Results and Discussion

Total chlorophyll content and chlorophyll a and b at the khalal stage were significantly increased with ALA treatments (Fig. 1). There was no marked increase in chlorophyll a with increasing 5-ALA concentration from 50 to 100 ppm. However, 50 ppm 5-ALA treatment showed significantly the highest total chlorophyll and chlorophyll b concentrations. Since a slight drop in all chlorophyll types was noticed with the 100 ppm 5-ALA application, the 50 ppm 5-ALA concentration might have represented a physiological threshold level beyond which chlorophyll deteriorates. The increase in chlorophyll content has been reported in horse-radish treated with a low concentration of 5-ALA of less than 100 ppm, while respiration was suppressed in certain crops with higher levels of 5-ALA, more than 100 ppm (Hotta *et al.*, 1997a).

Treatment of 5-ALA had no significant effects on rutab fruit dimensions. Fruit weight, fruit volume and fruit flesh % were significantly increased with increasing concentrations of 5-ALA, while the seed fruit % was significantly reduced. The significant increase in rutab fruit weight with 5-ALA treatments may be attributed to the increase in flesh fraction under the same treatments. The fruit volume showed slight positive increases with 5-ALA spraying, while both fruit diameter and length did not. In this situation, it is not possible to establish a clear positive relation between fruit volume and the two dimensions. However, we can continuously assume that other unobserved factors may have affected the volume parameter in addition to the slight non-significant increases in fruit diameter and length. The increase in fruit weight and volume was approximately similar , i.e. 30 % more than control. Fruit dimensions of tamer were not significantly affected by 5-ALA treatments. Fruit volume was significantly increased with 5-ALA treatment, while fruit weight was not. Seed and fruit flesh % were not significantly affected by 5-ALA treatment (Table 1). It is quite possible that fruits at this stage may have reached a stable physiological maturation that can not be changed by 5-ALA or any other hormonal treatments. Moreover, the 5-ALA effects are more possibly pronounced at the rutab stage of the fruit. Hussein *et al.* (1996) reported that GA3 treatment significantly increased fruit weight,

volume, length and thickness, but there was no definite trend for seed weight in Zaghlolo date cv. Similar effects had been reported by Moustafa and Seif (1996). The proper time of chemical application during fruit or flower development to obtain certain desirable characters of fruits have been well investigated (e.g., El-Hammady *et al.*, 1992; Al-Khateeb *et al.*, 1993). Total and reducing sugars were significantly increased in the rutab stage with the application of 5-ALA, but there was no significant difference in non-reducing sugar content. As was the case in chlorophyll, 50 ppm 5-ALA yielded significantly the highest total and reducing sugars. Liangju *et al.* (2004) found that spraying 5-ALA increased the total soluble solid content of apple fruits. This possibly indicates an active photosynthesis rate and/or reducing respiration rate with this concentration. Ash content was significantly reduced with increasing 5-ALA concentration. Moisture content was significantly lower with 50 ppm 5-ALA, but there was no significant difference between control and 100 ppm 5-ALA. The reduction in moisture content with 5-ALA treatment indicates an increase in dry matter of fruits which raises the possibility of higher photosynthetic activity of fruits at the khalal stage. The improved photosynthesis efficiency of the khalal stage might possibly to the accumulation of assimilates which might explain the increase in the dry matter content of fruits. Total and non-reducing sugars in the tamer stage were not much altered with 5-ALA, but there was an increase in reducing sugars with 5-ALA treatment and this increase was significant and best with 50 ppm 5-ALA. Similar to the rutab stage, ash content significantly decreased with 5-ALA treatment. Moisture content was not significantly changed with 5-ALA treatment. However, there was a clear trend of an increase in moisture content. This increase in moisture content may explain the significant increase in fruit volume of tamer. Although, there was no significant effect of 5-ALA on fruit weight, a 20% increase in fruit weight was obtained compared to 22% in fruit volume. It is worth mentioning that an increase in fruit volume and weight of tamer might be obtained due to the flesh fraction. Mustafa and Seif (1996) and Hussein *et al.* (1996) reported that total sugar % has been reduced with GA3 treatment. However, Hussein *et al.*, (1996) reported an increase in total and reducing sugars in the Zaghlol date treated with cycocel.

Despite the consistent increasing trend, fruit yield (kg/tree) was not significantly affected (Fig. 2). Yield is a combined factor of fruit number, size, weight and other related variables; Mushtaq *et al.*, 2004). In our study, 5-ALA has improved fruit weight and volume at the rutab stage. It is quite probable that increasing fruit size or weight reduces fruit number, as has often been shown in certain fruit crops (El-Hamady *et al.*, 1992; Mushtaq *et al.*, 2004). Improvement in fruit size is becoming detrimental in the cmarketing of date fruits and highly preferred by consumers.

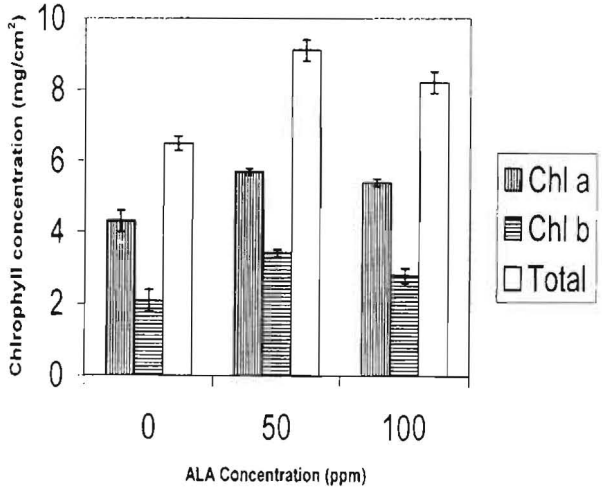


**Fig. 1.** Chlorophyll content in Khalal stages of cv.Khalas as affected by ALA treatments. Bars =LSD (5%).

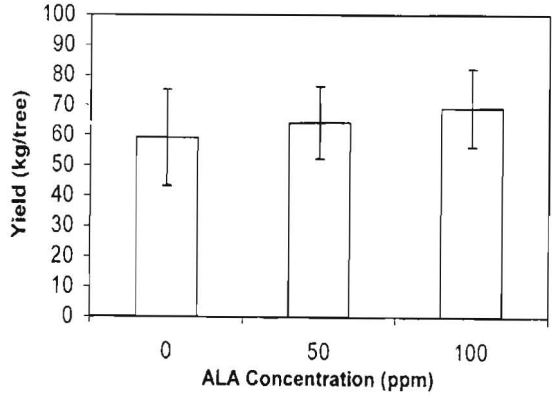


**Fig. 2.** Tamer yield (kg/tree) in cv. Khalas as affected by ALA treatments. Bars =LSD (5%).

**Table 1.** Fruit and seed physical properties of Khalas cv. " Rutab stages and Tamer" as affected by ALA treatments.

| ALA Concentration (ppm) | Weight (g) | Volume ($cm^3$) | Flesh fruit (%) | Seed fruit (%) | Diameter (cm) | Length (cm) |
|---|---|---|---|---|---|---|
| Rutab | | | | | | |
| 0 | 8.81 | 8.5 | 88.2 | 11.8 | 2.13 | 3.18 |
| 50 | 10.10 | 9.9 | 89.8 | 10.2 | 2.19 | 3.33 |
| 100 | 11.49 | 11.1 | 90.1 | 9.9 | 2.24 | 3.42 |
| F.Test | * | * | * | * | N.S | N.S |
| LSD (5%) | 2.27 | 2.58 | 1.7 | 1.7 | --- | --- |
| Tamer | | | | | | |
| 0 | 5.88 | 5.9 | 87.7 | 12.3 | 1.91 | 3.1 |
| 50 | 6.33 | 6.4 | 88.7 | 11.1 | 1.91 | 3.1 |
| 100 | 6.75 | 7.2 | 89.2 | 10.8 | 1.93 | 3.2 |
| F.Test | N.S | * | N.S | N.S | N.S | N.S |
| LSD (5%) | --- | 0.9 | --- | --- | --- | --- |

**Table 2.** Chemical properties (%) of Khalas "Rutab and Tamer" stages as affected by ALA treatments.

| ALA concentration (ppm) | Moisture | Ash | Reducing sugars | Non red. sugars | Total sugars |
|---|---|---|---|---|---|
| Rutab | | | | | |
| 0 | 64.0 | 0.98 | 24.3 | 1.6 | 25.9 |
| 50 | 58.3 | 0.93 | 30.6 | 2.0 | 32.6 |
| 100 | 62.8 | 0.82 | 26.9 | 1.5 | 28.4 |
| F.Test | * | * | * | N.S | * |
| LSD (5%) | 5.2 | 0.09 | 4.1 | --- | 4.2 |
| Tamer | | | | | |
| 0 | 6.9 | 1.78 | 70.1 | 4.3 | 74.4 |
| 50 | 7.7 | 1.57 | 71.6 | 4.2 | 75.8 |
| 100 | 8.3 | 1.58 | 70.5 | 4.2 | 74.7 |
| F.Test | N.S | * | * | N.S | N.S |
| LSD (5%) | --- | 0.17 | 1.3 | --- | --- |

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