

IMPACT OF CHEMICAL THINNING TO IMPROVE FRUIT CHARACTERISTICS OF DATE PALM CULTIVAR KHALAS

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ABSTRACT

A field study was conducted to observe the effects of chemical fruit thinning and their time of application on fruit yield and quality of date palm cv. Khalas at Date Palm Research Center of Excellence, King Faisal University, Saudi Arabia. Fourteen date palm trees were randomly selected for the experiment, which was laid out on two-factorial randomized complete block design having six replicates for each treatment. Factor-one comprised of the six chemical (ammonium thiosulphate at 1, 2, and 3% and ethephon at 100, 200 and 300ppm) excluding control, whereas the second factor was the time of application of these two chemical thinners (5 and 10 days after pollination). The findings of this study indicated that the chemical fruit thinning had definite effects on virtually all fruit quality characteristics. Early application of chemical thinners after 5 days of pollination, significantly decreased the total fruits drop percentage and enhanced number of retained fruits, bunch weight, yield per palm, fruit color, fruit weight and length, seed weight, TSS, total and reducing sugars. On the other hand, among chemical thinners, the application of ethephon at 300 ppm significantly improved previously mentioned parameters. Similarly, ethephon at 200 or ATS at 3% also showed promising results. It is therefore, concluded that the application of ethephon at 200 or 300ppm after 5 days of pollination influenced significantly regarding fruit yield and quality parameters of date palm cv. Khalas.

Keyword: *Phoenix dactylifera* L., ethephon, ammonium thiosulphate, fruit quality.

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تأثير الخف الكيميائي في تحسين الخصائص الثمرية لنخيل التمر صنف الإخلاص

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المستخلص

أجريت هذه التجربة لدراسة تأثير خف الثمار بالمواد الكيميائية، ووقت المعاملة على إنتاجية وجودة ثمار نخيل التمر صنف الإخلاص، وقد أجريت الدراسة في مركز التميز البحثي في النخيل والتمور - جامعة الملك فيصل - بالمملكة العربية السعودية. وقد تم اختيار أربعة عشر شجرة من نخيل التمر بشكل عشوائي للتجربة، طبقت تجربة عملية وفق تصميم القطاعات الكاملة العشوائية بستة مكررات. تضمنت التجربة عاملين، ثيوكبريتات الأمونيوم (1، 2، 3%)، الإيثفون (100، 200، 300 جزء في المليون) إضافة الى معاملة المقارنة. في حين كان العامل الثاني هو وقت الإضافة للمواد المستخدمة (5، 10 أيام بعد التلقيح). أظهرت النتائج تأثير واضح للخف الكيميائي على جميع خصائص جودة الثمار تقريباً. أيضاً بينت النتائج تفوق المعاملة في الموعد الاول (بعد 5 أيام من التلقيح) حيث كانت ذات تأثير معنوي في انخفاض نسبة تساقط الثمار الكلي، بالإضافة الي تحسين في نسبة الثمار المتبقية، وحسنت من وزن العنق، إنتاجية النخلة، لون الثمار، وزن الثمرة، وطول الثمرة، ووزن البذرة، المواد الصلبة الذائبة الكلية، السكريات الكلية، السكريات المختزلة. ومن جهة أخرى، وجد أن من بين المعاملات المستخدمة، أدى استخدام الإيثفون بتركيز 300 جزء في المليون إلى تحسن كبير في الخصائص المذكورة سالفاً. وبالمثل، أظهر استخدام الإيثفون بتركيز 200 جزء في المليون أو ثيوكبريتات الأمونيوم بتركيز 3% نتائج واعدة. ومن ثم، خلصت النتائج إلى أن تطبيق الإيثفون عند 200 أو 300 جزء في المليون بعد 5 أيام من التلقيح أثر بشكل كبير على محصول و جودة نخيل التمر صنف خلاص.

الكلمات المفتاحية: نخيل التمر، الإيثفون، ثيوكبريتات الأمونيوم، جودة الثمار.

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INTRODUCTION

Date palm (*Phoenix dactylifera* L.) has a wide range of agricultural and economical importance throughout human's history. It is a prominent crop in arid regions of North Africa and Middle East including Kingdom of Saudi Arabia (1). It can tolerate adverse environmental conditions of desert regions such as high temperature, drought and salinity (1, 2, 3). Saudi Arabia produces around 754,761 tons of dates from 69,799 ha area, whereas the production of Arab world of dates is about 80% of the total production of the world (4). Khalas is one of the important date palm cultivars across Saudi Arabia, specially, in Eastern Region. It is consumed at both Rutab and Tamar stages of development (5). Among improved cultural practices, fruit thinning of date palm is an important cultural practice to improve fruit quality such as physical characteristics as fruit retention, bunch weight, fruit weight, flesh weight, fruit length, diameter and chemical characteristics as total sugars, reducing and non-reducing sugars for domestic and international marketing. In addition, it reduces alternate bearing of some date palm cultivars (6, 7). Thinning can be done mechanically, manually and chemically methods (8, 9, 10). There are many chemical thinners available such as ethephon, naphthalene acetic acid, gibberellic acid, ammonium thiosulphate (ATS), which have been improved date palm fruit quality. Ethephon is known as plant growth regulator, which is almost stable in a solution with a pH below 4, however, at higher pH values, it breaks down to ethylene, hydrochloric and phosphatic ions. It provides ethylene to the plant tissue because the cell cytoplasm has a pH higher than 4 (11). The primary role of ethylene is to make changes in fruit texture, softening, colour, and other processes involved in ripening. It is also known as the aging hormone in plants. (12) reported that ethylene inhibited the synthesis and translocation of IAA within the fruits, thus reducing sink strength and ultimately inducing the separation area in the peduncle, which causes fruit drop (13). Early ethylene liberation is absorbed by interferes, which affect growth process (14). Increased ethephon spray concentrations, enhanced date palm fruit quality (15).

Similarly, ATS is commonly used as a blossom thinner for apple, which is effective on flowers that have reached anthesis at the time of treatment (16). Therefore, timing played a critical role for the success of ATS and other blossom desiccants. In order to achieve the target crop load, ATS must be applied when sufficient flowers are fertilized, which increased the fruit set percentage (17, 18). It effectively reduced fruit set when applied to pear trees (18). Similarly, the application of ATS at 1.5% was suggested an alternative to the hand thinning method in peach orchard (19). Keeping in view the importance of fruit thinners, the present investigation was planned to study the effect of different concentrations of ethephon and ATS applied at varied times after pollination of date palm cv. Khalas to enhance physio-chemical characteristics of the fruit.

MATERIALS AND METHODS

The present study was carried out at Date Palm Research Center of Excellence, King Faisal University, Al-Ahsa during 2017 and 2018 seasons. Fourteen, randomly selected uniform female date palm trees of cv. Khalas (10-years old) were chosen for the experiment. These trees were pollinated on the fourth day of spathe cracking with pollen grains, which were obtained from the male of the same source. All date palm trees were received same normal agricultural practices. Six spathes (replicates) per palm were kept for thinning treatments and any other emerging spathes were removed. Each spathe was covered with brown paper bags immediately after pollination to avoid contamination of any foreign pollen grain, which were removed after three weeks of pollination (at fruit set). The bags were temporary removed for the applications of Ethephon and ATS, which were sprayed after 5 and 10 days of pollination and were recovered immediately. The layout of the experiment was factorial in a randomized complete block design with six replicates for each treatment. The first factor included application time (after 5 or 10 days), whereas the second factor represented thinning treatments (spraying with ATS at 1, 2 and 3% or spraying with Ethephon at 100, 200 and 300ppm concentrations, in addition to control

i.e. without thinning). The detail of thinning treatments is given below:

Factor-A	Factor-B
Application after 5 days of pollination	Control (No thinning) Spraying with 1% ATS Spraying with 2% ATS Spraying with 3% ATS Spraying with 100ppm Ethephon Spraying with 200ppm Ethephon Spraying with 300ppm Ethephon
Application after 10 days of pollination	Control (No thinning) Spraying with 1% ATS Spraying with 2% ATS Spraying with 3% ATS Spraying with 100ppm Ethephon Spraying with 200ppm Ethephon Spraying with 300ppm Ethephon

At harvest, thirty fruits from each replicate were taken to determine following physical and chemical properties: fruit retained percentage, bunch weight, yield per palm, fruit color (L^* , Hue angle and Chroma), fruit and seed size, pulp weight, pulp: seed ratio, total soluble solids (TSS), moisture content, total sugars, reducing sugars and non-reducing sugars (20). The data were statistically analyzed according to the factorial completely randomized block design of SAS software (21). In addition, least significant differences among means were calculated at 5% level of probability according to the Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

ata in Table 1 shows that the effect of different application time and plant thinners of significantly affected total fruit drop percentage, retained fruit percentage, bunch weight and yield per palm, however, their interaction was non-significant statistically except total fruit drop. Chemical thinners applied after 5 days of pollination had minimum total fruits drop percentage (42.1%) and maximum percentage of retained fruits (57.90%), bunch weight (5.92kg) and yield per palm (29.60kg). On the other hand, minimum total fruits drop percentage was recorded when ethephon at 200ppm was applied (36.0%) followed by ethephon at 300ppm application (36.2%) without significant difference. However, maximum retained fruit percentage (64%) was recorded when ethephon at 200ppm was applied followed by ethephon at 300ppm application (63.8%). Parameters such as, maximum bunch weight (6.98kg) and yield per palm (34.92kg) were higher when ethephon at 300ppm was applied, followed by ethephon at

200ppm treatment i.e. 6.75kg (bunch weight) and 33.75kg (yield per palm). The interaction data of total fruit drop showed significantly minimum fruits were dropped when ethephon at 200ppm or ethephon at 300ppm were sprayed after 5 or 10 days of pollination. Although interaction was non-significant, however, maximum retained fruit percentage (64.2%, ethephon at 200ppm), bunch weight (7.13kg, ethephon at 300ppm) and yield per palm (35.67kg, ethephon at 300ppm) were recorded when ethephon was applied after 5th days of pollination. Similarly, ATS at 3% applied after 5 days of pollination had 56.5% retained fruits, 5.85kg bunch weight and 29.25kg yield per palm. These parameters were recorded as minimum when no thinner was applied (control). A study conducted on pear, it was reported that too early or too late application of ATS did not enhance fruit set (18). More or less similar results were reported in date palm cvs. Khalas and Ruzeiz (22) and cv. Zaghoul (23). Time of thinner application had a significant effect on fruit color parameters (Table 1). The minimum L^* (31.5), maximum Chroma (20.4) and higher Hue angle (50.4) indicated that the Khalas fruit color was darker and brighter but less brown when fruit thinners were applied after 5 days of pollination and *vice versa*. Similarly, minimum L^* 31.0 (ATS applied at 3%) and 31.5 (ethephon applied at 300ppm) indicated darker fruit color, whereas maximum Chroma (21.3) and Hue angle (54.8) indicated brighter and less brown color when ATS applied at 2%). However, there was a non-significant difference in Chroma values. The statistically significant interaction data regarding fruit color showed that minimum L^* (24.2 and

27.0) were observed when the ATS at 3% and ethephon 300ppm were applied after 5 days of pollination and produced darker fruits. Whereas maximum Chroma (23.6) and Hue angle (61.8) indicated brighter and less brown color when ATS applied at 2%. The decrease in L* (difference in lightness and darkness) values decreased the b* (difference in yellow and blue) values as well that followed slight browning, which is attributed to non-enzymatic browning according to (24). Fruit whiteness is

known to be affected by physico-chemical properties and pretreatments (24). The observed values of Chroma and hue angle disagreed with the storage color of apple (25). The hue angle range was within the 90° region, which suggested that the fruit color was light brownish color that was an indication of a slow rate of occurrence of enzymatic browning (26).

Table 1. Effect of thinning treatments on total fruit drop, retained fruit, bunch weight, yield per palm, and fruit color of date palm cv. Khalas (2017 and 2018 seasons).

Treatments	Total fruits drop %	Retained fruits %	Bunch weight (kg)	Yield per palm (kg)	L* Value	Hue Angle	Chroma	
A: Application time:								
After 5 days	42.1 b	57.9 a	5.92 a	29.60 a	31.5 b	50.4 a	20.4 a	
After 10 days	43.4 a	56.6 b	5.71 b	28.55 b	34.5 a	48.3 a	19.3 b	
B: Thinning treatments:								
Control	50.1 a	49.9 e	4.58 g	22.92 g	33.1 ac	43.9 d	19.7 a	
ATS at 1%	46.8 b	53.2 d	4.89 f	24.46 f	35.2 a	47.6 cd	20.6 a	
ATS at 2%	44.7 c	55.3 c	5.49 e	27.43 e	34.8 ab	54.8 a	21.3 a	
ATS at 3%	44.2 c	55.8 c	5.77 d	28.88 d	31.0 c	48.8 bc	18.6 a	
Ethephon at 100ppm	41.3 d	58.7 b	6.23 c	31.17 c	32.3 bc	47.3 cd	19.3 a	
Ethephon at 200ppm	36.0 e	64.0 a	6.75 b	33.75 b	33.0 ac	50.3 bc	20.3 a	
Ethephon at 300ppm	36.2 e	63.8 a	6.98 a	34.92 a	31.5 c	52.8 ab	19.0 a	
C: Interaction A×B:								
After 5 days	Control	50.1 a	49.9 a	4.58 a	22.92 a	33.3 be	43.5 e	19.7 bd
	ATS at 1%	45.0 bc	55.0 a	5.00 a	25.00 a	35.3 ad	45.3 ce	22.8 a
	ATS at 2%	44.2 bc	55.8 a	5.64 a	28.20 a	37.0 ab	61.8 a	23.6 a
	ATS at 3%	43.5 bc	56.5 a	5.85 a	29.25 a	24.2 h	47.3 ce	19.1 cd
	Ethephon at 100ppm	40.2 d	59.8 a	6.33 a	31.67 a	34.2 ae	51.2 bc	21.5 ac
	Ethephon at 200ppm	35.8 e	64.2 a	6.90 a	34.50 a	29.5 fg	49.6 be	18.1 d
	Ethephon at 300ppm	36.0 e	64.0 a	7.13 a	35.67 a	27.0 gh	54.2 b	18.2 d
After 10 days	Control	50.1 a	49.9 a	4.58 a	22.92 a	32.8 cf	44.2 de	19.8 bd
	ATS at 1%	48.5 a	51.5 a	4.78 a	23.92 a	35.0 ad	49.9 be	18.4 d
	ATS at 2%	45.2 b	54.8 a	5.33 a	26.67 a	32.6 df	47.8 be	19.0 cd
	ATS at 3%	44.9 bc	55.1 a	5.70 a	28.50 a	37.8 a	50.4 bd	18.1 d
	Ethephon at 100ppm	42.5 cd	57.5 a	6.13 a	30.67 a	30.5 ef	43.4 e	17.1 d
	Ethephon at 200ppm	36.1 e	63.9 a	6.60 a	33.00 a	36.5 ac	51.0 bc	22.5 ab
	Ethephon at 300ppm	36.4 e	63.6 a	6.83 a	34.17 a	36.0 ad	51.4 bc	19.9 bd

Different letters in the same column means significantly different at 5% level of probability

Table 2 indicates that the fruit weight (7.62g), fruit length (27.3mm) and seed weight (0.772g) were statistically significant when chemical thinners were applied after 5 days of pollination. Similarly, maximum fruit weight (7.83g) and pulp weight (7.03g) were recorded when ethephon at 200ppm was applied followed by ethephon at 300ppm application i.e. 7.76g and 7.01g, respectively. Whereas maximum fruit length (30mm), fruit width (21.6mm) and pulp/seed ratio (9.36) were higher when ethephon at 300ppm was applied. Seed weight was maximum (0.815g) when ethephon at 100ppm was applied. The

interaction data of chemical thinners and their application time were non-significant apart from fruit weight, fruit width, pulp weight and pulp/seed ratio parameters. Maximum fruit weight (7.84g) was recorded when spray ethephon at 200ppm or at 300ppm were applied after 5 days of pollination. The highest value of pulp weight (7.05g) was obtained by 300 ppm when applied after 5 days of pollination. Similarly, maximum seed weight (0.82g) was observed when ethephon at 200ppm was applied after 5 days of pollination. However, pulp/seed ratio (9.72) was maximum when ethephon at 300ppm was

applied after 10 days of pollination. Similarly, ATS at 3% applied after 5 days of pollination had 7.70g fruit weight, 27.1mm fruit length, 21.5mm fruit width, 6.95g pulp weight and 9.18 pulp: seed ratio. Other significant parameters such as fruit length (31mm) and seed weight (0.820g) were recorded when ethephon at 300ppm was applied after 5 days of pollination. All these parameters were

minimum in control treatment. These results are in line with (27) and (22) who reported that the fruit weight was affected by thinning treatments. Regarding other physical fruit characteristics, more or less similar results were found by (28) who reported that the fruit characters were improved by the thinning treatments, which may be due to the present of limited number of fruits per bunch.

Table 2. Effect of thinning treatments on fruit physical properties of date palm cv. Khalas (2017 and 2018 seasons).

Treatments	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Pulp weight (g)	Seed weight (g)	Pulp/seed ratio	
A: Application time:							
After 5 days	7.62 a	27.3 a	20.6 a	6.85 a	0.772 a	8.96 a	
After 10 days	7.53 b	26.8 b	20.4 a	6.78 a	0.750 b	9.12 a	
B: Thinning treatments:							
Control	7.15 d	24.2 g	17.0 d	6.45 e	0.700 g	9.26 ab	
ATS at 1%	7.46 c	25.6 f	20.6 c	6.72 d	0.735 e	9.16 ab	
ATS at 2%	7.57 bc	26.6 e	20.8 bc	6.84 bd	0.733 f	9.33 ab	
ATS at 3%	7.68 ab	26.9 d	21.1 ac	6.92 ac	0.763 c	9.07 ab	
Ethephon at 100ppm	7.57 bc	27.6 c	21.2 ac	6.75 cd	0.815 a	8.29 c	
Ethephon at 200ppm	7.83 a	28.5 b	21.4 ab	7.03 a	0.798 b	8.81 b	
Ethephon at 300ppm	7.76 a	30.0 a	21.6 a	7.01 ab	0.750 d	9.36 a	
C: Interaction A×B:							
After 5 days	Control	7.16 a	24.2 i	16.9 a	6.43 a	0.723 j	8.89 a
	ATS at 1%	7.50 a	25.9 g	20.5 a	6.78 a	0.723 j	9.38 a
	ATS at 2%	7.60 a	26.8 e	20.7 a	6.85 a	0.743 i	9.22 a
	ATS at 3%	7.70 a	27.1 e	21.5 a	6.95 a	0.757 g	9.18 a
	Ethephon at 100ppm	7.70 a	27.8 d	21.1 a	6.89 a	0.813 c	8.47 a
	Ethephon at 200ppm	7.84 a	28.4 c	21.6 a	7.02 a	0.820 a	8.56 a
	Ethephon at 300ppm	7.84 a	31.0 a	22.0 a	7.05 a	0.783 d	9.00 a
After 10 days	Control	7.14 a	24.2 i	17.1 a	6.46 a	0.677 l	9.62 a
	ATS at 1%	7.42 a	25.4 h	20.5 a	6.67 a	0.747 h	8.94 a
	ATS at 2%	7.55 a	26.4 f	20.8 a	6.83 a	0.723 j	9.45 a
	ATS at 3%	7.66 a	26.8 e	20.7 a	6.89 a	0.770 f	8.95 a
	Ethephon at 100ppm	7.43 a	27.5 d	21.3 a	6.62 a	0.817 b	8.10 a
	Ethephon at 200ppm	7.81 a	28.6 c	21.2 a	7.04 a	0.777 e	9.06 a
	Ethephon at 300ppm	7.68 a	29.0 b	21.1 a	6.97 a	0.717 k	9.72 a

Different letters in the same column means significantly different at 5% level of probability

Data in Table 3, shows that the TSS (69.5 Brix) was statistically significant when chemical thinners were applied after 5 days of pollination, whereas fruit moisture content (16.5%) was significantly higher after 10 days of thinners application. There was a non-significant effect of different time of thinner application on sugar contents. Similarly, maximum TSS (69.8-69.9 Brix) was estimated in all ATS and ethephon treatments as average compared to control (63.4 Brix). There was a non-significant effect of thinner concentrations on fruit moisture content (16.0-16.6%). Sugar contents were significantly affected by different thinner concentrations i.e. total sugars (69.0%) and reducing sugars (66.6%)

were higher when ethephon at 200ppm was applied followed by ethephon at 300ppm application, however, non-reducing sugars (2.67%) was higher when ethephon at 100ppm was applied. The interaction of chemical thinners and their time of application were significant apart from TSS and moisture content variables. Maximum TSS (75.1 Brix) and moisture content (17.4%) were recorded when ethephon at 300ppm was applied after 5 days of pollination. Although the sugar contents were non-significant, however, maximum total sugars (69.4%) and reducing sugars (66.9%) were observed when ethephon at 200ppm was applied after 5 days of pollination. All these parameters were

minimum in control treatment. Previous studies showed that the fruit quality including the TSS of Hallway dates was much improved by different chemical treatments (29). The increase in sugar content by the application of

ethephon may be due to the increased carbohydrates and other metabolites accumulated in the fruits. These results are in agreement with the studies of (22, 23, 30, 31).

Table 3. Effect of thinning treatments on fruit chemical properties of date palm cv. Khalas (2017 and 2018 seasons).

Treatments	TSS (Brix)	Moisture content %	Total sugars %	Reducing sugars %	Non-reducing sugars %	
A: Application time:						
After 5 days	69.5 a	16.0 b	67.3 a	65.1 a	2.18 a	
After 10 days	67.7 b	16.5 a	67.0 a	64.7 a	2.28 a	
B: Thinning treatments:						
Control	63.4 c	16.6 a	65.0 c	62.6 d	2.43 ab	
ATS at 1%	69.8 a	16.4 a	65.8 c	63.8 c	1.98 b	
ATS at 2%	69.9 a	16.4 a	67.2 b	65.1 b	2.12 b	
ATS at 3%	69.8 a	16.2 a	67.3 b	65.3 b	2.03 b	
Ethephon at 100ppm	67.4 b	16.1 a	67.8 b	65.1 b	2.67 a	
Ethephon at 200ppm	69.8 a	16.0 a	69.0 a	66.6 a	2.40 ab	
Ethephon at 300ppm	69.8 a	16.1 a	67.9 b	65.9 ab	1.97 b	
C: Interaction A×B:						
After 5 days	Control	63.7 fg	16.6 b	65.0 a	62.6 a	2.43 a
	ATS at 1%	71.0 b	16.5 bc	66.3 a	64.7 a	1.60 a
	ATS at 2%	69.7 bd	15.3 e	67.2 a	65.2 a	2.03 a
	ATS at 3%	69.2 cd	15.6 de	67.4 a	65.3 a	2.13 a
	Ethephon at 100ppm	67.5 e	15.6 de	67.3 a	64.9 a	2.40 a
	Ethephon at 200ppm	70.1 bc	16.8 b	69.4 a	66.9 a	2.50 a
	Ethephon at 300ppm	75.1 a	17.4 a	68.1 a	66.2 a	1.90 a
After 10 days	Control	63.2 g	16.6 bc	65.0 a	62.6 a	2.43 a
	ATS at 1%	68.6 de	16.2 cd	65.3 a	62.9 a	2.37 a
	ATS at 2%	70.1 bc	16.4 c	67.3 a	65.1 a	2.20 a
	ATS at 3%	70.5 bc	16.5 cd	67.2 a	65.3 a	1.93 a
	Ethephon at 100ppm	67.4 e	16.6 bc	67.9 a	65.4 a	2.47 a
	Ethephon at 200ppm	69.6 cd	16.3 bd	68.8 a	66.3 a	2.50 a
	Ethephon at 300ppm	64.5 f	15.2 e	67.6 a	65.6 a	2.03 a

Different letters in the same column means significantly different at 5% level of probability

The findings of present study concluded that the chemical fruit thinning of date palm cv. Khalas had positive effects on almost all fruit quality attributes. As already stated, that the time of chemical thinning also played an important role not only to maintain the fruit load but also improve fruit quality. Hence, it is concluded that the application of ethephon at 200 or 300ppm after 5 days of pollination contributed significantly in order to improve fruit quality and appearance of date palm cv. Khalas. The other fruit thinner (ATS) can also be used at 3%, which also exhibited good results. Further research is needed to study in detail all the physical and chemical characteristics of date fruit under different managing practices.

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