Effect of Chitosan Spraying on Growth and Fruiting of "Sakkoti" Date Palms Grown under Aswan Climatic Conditions

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Abstract

This study was conducted during 2019 & 2020 seasons to dissect the impact of spraying chitosan at 200, 400, 800 and 1600 ppm on growth, yield and fruit quality of "Sakkoti" date palms grown under Aswan climatic conditions. This experiment set up in a randomized complete block design with five treatments and three replications, palm each. Spraying the palms with chitosan at 200 to 1600 ppm had an announced promotion on all aspects of growth, yield and fruit quality compared to the control treatment (water spraying). The highest values of the studied growth and fruiting traits were obtained due to use the higher concentrations of chitosan. Using chitosan at concentrations higher (1600 ppm) failed to show measurable effects compared to use 800 ppm. Then, the best results with regard to growth, yield and fruit quality of "Sakkoti" date palms were obtained due to spraying the palms four times with chitosan at 800 ppm.

Key words: Chitosan, date palm, Sakkoti cultivar, yield, fruit quality.

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Introduction

Date palm (*Phoenix dactylifera* L.) is considered one of the leading fruit crops. In Egypt, it covers a large area that extended from Aswan to the North Delta; Egypt is considered the leading country in producing dates. The total number of females reached 14865631 palms and their yield reached about 1710603 ton. Aswan Governorate is considered to be one of the leading Egyptian Governorates in dry dates production (M.A.L.R., 2020). Sakkoti date palm is the most important cultivar of dry dates in Egypt. It can grow well under drastic environmental conditions. The variations in the soil types and orchard management have their influence on the characteristics of both tree growth and fruit quality (Selim *et al*., 1970). One of the principle problems in plant growth is abiotic stress which blocked plant growth and fruiting. Application of chitosan is one of the approaches to overcome the negative effect of abiotic stress and increase yield and quality of fruit crops (Barka *et al*., 2004). Chitosan is used as a fertilizer to develop seeds, roots, shoots, leaves, and fruits to improve plant production and provide disease protection (Dzung *et al*., 2011; Mondal *et al*., 2012 and Ibraheim and Mohsen, 2015). Moreover, using chitosan significantly improved the growth and yield through increasing efficiency of fruiting and improved the fruit quality and nutrients status of fruit (Abd El-Mawgoud *et al*., 2010 and Ali *et al*., 2011). Due to its unique qualities, chitosan is a natural, inexpensive and safe byproduct of chitin deacetylation that is utilized by numerous industries. Chitosan was tried in agriculture in the late 1980s when it became

commercially available in large amounts.

Antioxidant chitosan has been shown to promote plant development, ensure the safety of food goods and increase abiotic and biotic stress tolerance in a variety of horticulture products. As a value-delivery system for fertilizers, herbicides, pesticides, and micronutrients for crop growth promotion by balanced and sustained nutrition, chitosan nanoparticles have been synthesized recently (Malerba and Cerana, 2015 and 2016). Previous researchs demonstrated the critical importance of chitosan in promoting growth factors, as well as in boosting fruit yield and quality parameters (Ali *et al*., 2011; Mondal *et al*., 2012; Ibraheim and Mohsen, 2015; Ahmed *et al*., 2016 and Ayed, 2018). The goal of this study was to clarify the effect of chitosan spraying on yield and fruit quality of Sakkoti date palms grown under Aswan environmental conditions.

Materials and methods

This study was conducted during 2019 and 2020 seasons on 18 years Sakkoti date palms grown in a private date palm orchard where soil is silty clay and situated in Edfu district of Aswan Governorate, Egypt. Meteorological data in Aswan region during 2019 and 2020 seasons are presented in Table (1). These palms were characterized by regular bearing, uniform in vigor, healthy, good physical conditions, free from insects, diseases and damages. They planted at 7x7 meters apart and irrigated with well water through surface irrigation system.

Table (1): Monthly air temperature and relative humidity during the two seasons.

Month	2019				2020			
	Max. temp. °C	Min. temp. °C	Mean temp. °C	Relative humidity % (R.H)	Max. temp. °C	Min. temp. °C	Mean temp. °C	Relative humidity % (R.H)
Jan	25.6	8.2	16.90	42.8	27.8	9.6	18.7	46.8
Feb	28.4	12.3	20.35	37.8	29.3	12.2	20.75	47.9
Mar	31.2	13.8	22.50	38.0	33.4	13.9	23.65	27.5
Apr	34.8	18.7	26.75	30.6	36.9	17.6	27.25	23.9
May	41.1	22.7	31.90	19.8	40.9	22.2	31.55	18.7
Jun	46.7	28.0	37.35	18.9	47.7	27.9	37.8	16.4
July	47.6	29.3	38.45	20.9	45.2	28.8	37.0	24.6
Aug	48.6	32.9	40.75	21.7	45.5	27.6	36.55	23.4
Sept	48.4	30.5	39.45	24.1	44.5	29	36.75	27.0
Oct.	46.02	27.32	36.67	27.17	45.04	28.13	36.585	33.25

Source: Central Laboratory for Agricultural Climate, Agriculture Research Center, Giza, Egypt.

All the selected palms received the common and usual horticultural practices that already applied in the orchard. Bunches/leaf was adjusted to 1:8; pollination was uniformly performed in respect of sources, date and method to avoid residues of metaxinia. Hand pollination was carried out inserting five male strands into the female spathe after two days from spathe cracking. The number of female spathes per palm was adjusted to 10 spathes by removing excess earliest, latest and smallest ones.

The experiment included the following five treatments of chitosan application as follow:

1. Spraying the palms with chitosan at 200 ppm.
2. Spraying the palms with chitosan at 400 ppm.

3. Spraying the palms with chitosan at 800 ppm.
4. Spraying the palms with chitosan at 1600 ppm.
5. Spraying the palms with water (control).

Each treatment was replicated three times; one palm per each. Chitosan was sprayed four times since the beginning of growth, followed every two months. All chitosan concentration used were supplied with wetting agent substance namely triton B at 0.05 % (0.5 ml/l) and the palms were sprayed till runoff.

Preparation of chitosan – based solution:

Stock solution (2% w/v) of chitosan, was prepared by dissolving purified chitosan (low molecular weight chitosan was purchased from sigma chemical Co) in 0.5% (v/v) glacial acetic acid, under continues stirring and the pH was adjusted to 5.6 using 1N NaOH. The stock solution was sterilized at 121°C for 20 minute, and then lower concentrations (i.e 200, 400, 800 and 1600 ppm) were made by appropriate dilution with distillated water (Du *et al*., 1997).
The experimental treatments were arranged in a randomized complete block design with three replications, one palm for each.

The following parameters were determined to evaluate the effects of different chitosan concentration spraying on growth and fruiting of Sakkoti date palms.

1. Vegetative growth:

Four mature leaves around fruiting zone were chosen on each palm to determine, leaf length (cm); four leaflets were taken from middle part of each leaf to determine leaflet area (cm2) as follow:
Leaflet area = length x maximum width x 0.83, according to Shabana and Antoun (1980). Then, the leaf area and total surface area/palm was counted. In addition, total chlorophyll was determined in samples of five mature pinnae from the six-month-old leaf using a chlorophyll meter (Model: 2900 PDKL).

2. Yield and fruit quality:

The yield of the experimental palm was harvested through the first half of October in each season to determine the following measurements:

A. Yield components: i.e. fruit retention, bunch weight and yield/palm.

B. Fruit Physical Properties: Samples of 50 fruits per palm were taken to determine weight, size and flesh % of fruit and fruit moisture percentage.

C. Fruit Chemical Properties:

Ten date fruits from each treatment were divided into pieces and seeds were omitted. 50g of pieces were put in an electric mixer for extraction, and then filtered and the filtrate was used to determinations. Total soluble solids (TSS) as a percentage were recorded by using hand refractometer, acidity percentage as malic acid, total, reducing and non-reducing sugars percentage and total crude fiber % were determined according to A.O.A.C., 2000 and total soluble tannins % (Balbaa, 1981).

Statistical analysis:

The results were subjected to statistical analysis according to Snedecor and Cochran (1980) and Mead et al. (1993). Treatment means of the five treatments were compared using L.S.D test at 5 % level.

Results

1. Vegetative growth:

Data presented in Tables (2 & 3) show the effect of spraying chitosan on some vegetative growth of Sakkoti date palm during 2019 and 2020 seasons. It is obvious from the data that the results took a similar trend during the two studied seasons. In general view, data showed that spraying chitosan significantly increased leaf growth traits and total chlorophyll content compared unsprayed one (control). The promotion was significantly related to the increase in concentrations of chitosan applied 200 to 1600 ppm. No significant increases on these studied leaf characteristics were recorded due to the higher concentrations namely 800 to 1600 ppm. From economical point of view the best results with regard to leaf features were obtained due to spray chitosan at 800 ppm. Under such promised treatment, leaf length (358.67 & 412.33 cm), total surface area/palm (203.37 & 229.65 m2) and total chlorophyll contents (87.32 & 90.11 SPAD value), respectively. Then, the increment percentage of leaf length over control were attained (6.11 & 27.53), total surface area/palm (159.40 & 143.02%) and total chlorophyll (11.61 & 12.13%) due to spray chitosan at 800 ppm during the two studied seasons. So it could be concluded that spraying chitosan was beneficial improvement of growth and vigor of palm.

Table (2): Effect of chitosan spraying on leaf characteristics of Sakkoti date palm during 2019 and 2020 seasons.

Treat.	Leaf length (cm)		Leaflet area (cm^2)		Leaf area (m^2)		Total surface area/palm (m^2)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	338.00B	323.33C	63.83D	69.23D	1.29C	1.43D	78.4D	94.5D
Chitosan 200 ppm	344.00B	350.00B	96.23C	98.83C	1.98B	2.03C	128.63C	137.83C
Chitosan 400 ppm	361.00B	363.33B	114.4B	122.4B	2.56A	2.59B	173.97B	192.3B
Chitosan 800 ppm	358.67AB	412.33A	119.8AB	131.77AB	2.52A	2.81AB	203.37A	229.65A
Chitosan 1600 ppm	385.33A	426.6A	125.52A	140.4A	2.72A	3.03A	231.43A	260.36A
L.S.D. at 5%	**31.98**	**26.98**	**8.43**	**9.81**	**0.29**	**0.25**	**32.11**	**35.02**

Table (3): Effect of chitosan spraying on total chlorophyll and yield components of Sakkoti date palm during 2019 and 2020 seasons.

Treat.	Total chlorophylls (SPAD)		Fruit retention %		Bunch weight (kg)		Yield/palm (kg)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	78.23C	80.36C	30.27C	31.1C	5.96C	6.55C	59.60C	65.54C
Chitosan 200 ppm	82.55B	84.95B	32.95B	33.27B	7.41B	7.83B	74.18B	78.33B
Chitosan 400 ppm	83.56B	86.39B	34.18B	34.3B	8.21B	8.36B	82.11B	83.62B
Chitosan 800 ppm	87.32AB	90.11A	37.35A	37.8A	9.34A	9.43AB	93.38A	94.33A
Chitosan 1600 ppm	88.77A	91.35A	38.2A	38.77A	9.66A	9.63A	96.63A	96.30A
L.S.D. at 5%	**3.88**	3.59	**1.56**	**2.10**	**1.18**	**1.22**	**8.81**	**7.89**

2. Yield components:

Data presented in Table (3) show the effect of spraying chitosan on yield components of Sakkoti date palm during 2019 and 2020 seasons. It is obvious from the data that the results took a similar trend during the two studied seasons. Data exhibits that spraying chitosan applications significantly increased, fruit retention, bunch weight and yield/palm compared to unsprayed one (control). The promotion was significantly related to the increase in concentrations of chitosan applied 200 to 1600 ppm. However no significant promotion on these studied yield components was observed among the higher two concentrations namely, 800 and 1600 ppm using. From economical point of view the best results with regard to fruit retention, bunch weight and yield per palm were obtained due to spray chitosan at 800 ppm. Under such promised treatment, bunch weight reached 9.34 & 9.43 kg and yield/palm were 93.38 & 94.33 kg/palm during the two studied seasons, respectively. The lowest bunch weight (5.96 & 6.55 kg) and yield/palm (59.60 & 65.54 kg/palm) during the two studied seasons, respectively. Then, the increment percentage of bunch weight over control was attained (56.71 & 43.97%) due to spray chitosan at 800 ppm during the two studied seasons.

3. Fruit characteristics:

Data in Tables (4, 5 & 6) measurably indicate that subjecting Sakkoti date palms growing under Aswan environmental condition to the chitosan significantly responsible for improving fruit quality in terms of increasing weight, volume and fruit flesh% of fruit as well as T.S.S.% and sugar contents and decreasing moisture %, total crude fibre % and total soluble tannins compared to the control. The promotion on both physical and chemical characteristics of the fruits was significantly in proportional to the increase concentrations of chitosan sprayed from 200 to 1600 ppm. Increasing concentrations of applied from 800 to 1600 ppm had no significant promotion on fruit characteristics. The highest fruit weight was (9.51 & 9.16) and (9.71 & 9.31g), against (7.19 & 7.31g) due to spray chitosan at 800 or 1600 ppm untreated ones during the two studied seasons, respectively. The corresponding flesh % was (90.12 & 90.63) and (90.77 & 90.38), respectively. Then the corresponding increment percentage of fruit weight attained to (32.27 & 25.31) and (35.05 & 27.36%), respectively. Moreover, the highest total soluble solids was (73.4 & 74.8) and (74.5 & 75.2), against (66.2 & 66.8%) due to spray chitosan at 800 or 1600 ppm compared to water during the two studied seasons respectively. Hence, the increment percentage of TSS due to chitosan spraying over water spraying attained (10.88 & 11.98) and (12.54 & 12.57%), respectively. Therefore the best results with regard to quality parameters were obtained due to spray the palms four times with chitosan at 800 to 1600 ppm. From economic via, the best results for yield and fruit quality

due to spray chitosan at 800 ppm, since no significantly increased due to increase the spraying concentrations from 800 to 1600 ppm.

Table (4): Effect of chitosan spraying on physical properties of Sakkoti date palm during 2019 and 2020 seasons.

Treat.	Fruit weight (g)		Fruit size (cm^3)		Flesh %		Moisture %	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	7.19C	7.31C	7.33C	7.69C	85.37C	85.77C	13.31	13.48
Chitosan 200 ppm	8.48B	8.36B	9.51B	9.95B	87.37B	88.63B	12.16	12.31
Chitosan 400 ppm	8.81B	8.78B	9.85B	10.30B	88.33B	88.77B	11.14	11.08
Chitosan 800 ppm	9.51A	9.16AB	10.88A	11.38A	90.12AB	90.63A	11.29	10.96
Chitosan 1600 ppm	9.71A	9.31A	11.18A	11.69A	90.77A	90.38AB	10.89	10.78
L.S.D. at 5%	**0.68**	**0.56**	**0.48**	**0.39**	**1.90**	**1.71**	**0.85**	**0.98**

Table (5): Effect of chitosan spraying on soluble solids and sugar contents of Sakkoti dates during 2019 and 2020 seasons.

Treat.	T.S.S. %		Total sugars %		Reducing sugars %		Non-reducing sugars %	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	66.2D	66.8E	57.15C	57.65C	40.48C	39.87C	16.67C	17.78B
Chitosan 200 ppm	69.2C	70.4C	58.7B	59.36B	41.41BC	40.99B	17.29B	18.37B
Chitosan 400 ppm	72.4B	73.2B	60.10B	60.35B	42.72B	42.10B	17.38B	18.25B
Chitosan 800 ppm	73.4AB	74.8A	62.17A	62.51A	44.24A	43.49A	17.92A	19.02A
Chitosan 1600 ppm	74.5A	75.2A	62.2A	62.56A	44.22A	43.52A	17.98A	19.03A
L.S.D. at 5%	**1.95**	**1.49**	**1.48**	**1.66**	**0.72**	**1.04**	**0.46**	**0.41**

Table (6): Effect of chitosan spraying on some chemical juice contents of Sakkoti dates during 2019 and 2020 seasons.

Treat.	Total acidity %		Crude fibre %		Soluble tannins %	
	2019	2020	2019	2020	2019	2020
Control	0.223A	0.216A	1.71A	1.68A	0.799A	0.768A
Chitosan 200 ppm	0.171B	0.168B	1.36B	1.32B	0.697B	0.673B
Chitosan 400 ppm	0.163BC	0.156BC	1.25C	1.20C	0.598C	0.573C
Chitosan 800 ppm	0.149C	0.146BC	1.11D	1.13D	0.631C	0.611C
Chitosan 1600 ppm	0.134C	0.135C	1.08D	1.11D	0.623C	0.597C
L.S.D. at 5%	**0.021**	**0.026**	**0.06**	**0.05**	**0.050**	**0.042**

Discussion

One of the principle problems in fruit is abiotic stress, which blocked plant growth and fruiting. Application of chitosan is one of the approaches to overcome the negative effect of abiotic stress and increase yield and quality of fruit crops (Barka *et al*, 2004). Chitosan products are proposed as substrate to control the release of agrochemicals (fertilizers and pesticides). The chelating properties of chitosan also make it an excellent source of macro and micronutrients (Divya and Jisha, 2018 and Rahman *et al*., 2018). Chitosan have positive effects on increasing vegetative growth and development which increased key enzymes activates of nitrogen metabolism and enhanced the transportation of nitrogen in the functional leaves leading to improved vegetative growth development which tree nutritional status (Gornik *et al*. 2008). Chitosan can be used as a treatment for mineral contaminator soil

(Sheikha and AL-Malki, 2011). It is not only decrease pollution and costs, but also nourishing the plant (Delphine *et al*., 2005). The use of chitosan helps to induce drought resistance and improves the efficiency of water use (Hassnain *et al*., 2020). Due to its biological activities and mode of action, it is considered as an antimicrobial compound and can be used against microorganisms and as an inducer of the plant defense mechanisms. It also helps stimulate plant immune systems, plant growth, and plant protection against various insects, pests, diseases, and microorganisms. Chitosan effects on fruit physiology and agronomic traits have been highly studied using different concentrations of chitosan in a variety of fruits (Sofy *et al*., 2020). Recent years have witnessed the discovery that using chitosan pre and post harvesting was very effective in enhancing growth, yield and fruit quality parameters in different fruit crop species. Thus, using chitosan leads to improve the vegetative growth, increase the yield and improve the fruit quality. These results are in agreement with those obtained by Ghasemnezhad and Shiri (2010), Ali *et al*. (2011), El- Miniawyet al. (2013), Hadwiger (2013), Shao *et al*. (2015), Malerba and Cerana (2016), Hossain and Iqbal (2016), Zagzog *et al*. (2017) and Ayed (2018) emphasized the beneficial effects of using chitosan on improving growth and fruit quality of fruit crops.

Conclusion

On the light of previous results, it could be concluded that spraying the Sakkoti date palms grown under Aswan region conditions four times with chitosan at 800 ppm, to obtained high yield with best dates quality.

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تأثير رش الشيتوزان علي نمو وإثمار نخيل البلح السكوتي النامية تحت ظروف أسوان المناخية

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[٣]كلية الزراعة والموارد الطبيعية– جامعة أسوان

الملخص العربي

أجريت هذه الدراسة خلال موسمي ٢٠١٩ و ٢٠٢٠ علي نخيل البلح صنف السكوتي المنزرعة في منطقة أدفو بمحافظة أسوان – وذلك لدراسة تأثير رش الشيتوزان علي النمو والمحصول وخصائص الثمار. وكان تصميم التجربة بنظام القطاعات كاملة العشوائية تحتوي علي خمسة معاملات وثلاثة مكررات. وقد تم إجراء عملية الرش أربع مرات خلال موسم النمو بداية من النمو وكل شهرين. ويمكن تلخيص النتائج كالتالي، سببت جميع معاملات الرش زيادة معنوية في صفات النمو الخضري ونسبة الثمار الباقية ووزن السوباطة ووزن المحصول/نخلة مقارنة بمعاملة الكنترول (رش ماء). أدي الرش بأي من تركيزات الشيتوزان إلي زيادة معنوية في وزن وحجم الثمار ونسبة اللحم ونقص نسبة الرطوبة وكذلك تحسين معنوي في خصائص الثمار الكيميائية من حيث زيادة محتوي الثمار من المواد الصلبة الذائبة والسكريات مع نقص الحموضة ونسبة التانينات ونسبة الألياف مقارنة بمعاملة الكنترول. ومن الناحية الاقتصادية كانت أفضل المعاملات نتيجة الرش بالشيتوزان بتركيز ٨٠٠ جزء في المليون. وعليه ينصح بالرش بالشيتوزان ٨٠٠ جزء في المليون وذلك لتحسين النمو الخضري وبالتالي إنتاج محصول عال ذو خصائص ثمرية جيدة لنخيل البلح السكوتي تحت ظروف أسوان.

الكلمات الدالة: شيتوزان، نخيل التمر، صنف السكوتي، المحصول، جودة الثمار