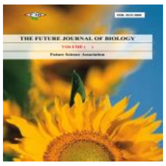

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Effect of Chitosan, Offshoot Age and Transplantation Date on Growth and Mineral Status of 'Barhi' Offshoots Grown Under Salinity Stress

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Abstract: This investigation was conducted during two successive seasons 2022 and 2023 on 'Barhi' one-year, two-years and three-year date palms offshoots, in addition two times of transplanting were examined (Early April and Early September). The bases of offshoots treated with chitosan, then the offshoots transplanted in large potted pots filled with medium of five parts sand and one-part clay. The offshoots were irrigated regally with 1600 ppm salinity water. The obtained results confirmed that under salinity stress, treated the base of 'Barhi' offshoots with chitosan at 0.2% is an effective and important to ensure the success of 'Barhi' offshoots and enhancing the vegetative parameters, leaf photosynthesis pigments, and macro uptick. Furthermore, the age and the transplantation date of 'Barhi' offshoots significantly effected of most vegetative parameters, root system parameters and leaf chemical composition. The obtained results also confirmed that the interaction between chitosan concentrations and offshoots age and its transplantation date was significant for all examined characters.

Key words: Barhi date palm, Chitosan, offshoots, mineral stats and growth.

1. Introduction

Date palm (*Phoenix dactylifera L.*) is an ancient crop of immense historical, cultural, and economic significance, particularly in arid and semi-arid regions. Fossil evidence and archaeological findings suggest that date palms have been cultivated in the Middle East and North Africa for more than 5,000 years (**Zaid and de Wet, 2002**). Taxonomically, the date palm belongs to the family *Palmaceae*, a large family of monocotyledonous flowering plants that includes numerous species adapted to arid and semi-arid climates. In Egypt, the date palm holds a special position not only as a source of nutrition but also as a cultural symbol associated with prosperity and resilience. Egypt leads the world in date production, contributing approximately 18% of global output (**FAO, 2022**). The cultivation of date palm in Egypt is geographically widespread, with significant concentrations in several governorates (**El-Kassas, 2019**). In Middle Egypt, governorates contribute about 18 % of the total Egyption date production. The cultivation here mainly focuses on semi-dry cultivars that are well-suited to the local environment. Farmers in these areas often rely on traditional farming methods (**Gomaa, 2017** and **Elsharabasy & Rizk, 2020**).

Chitosan acts as a natural defense activator, stimulating the plant's innate immune system by inducing the expression of defense related genes, activating systemic acquired resistance (SAR), and promoting the biosynthesis of phytoalexins compounds that inhibit the growth of invading pathogens (**Chandrkrachang, 2002 and Malerba & Cerana 2016**). Chitosan also plays a critical role in improving the structural properties of plant tissues, leading to increased mechanical strength and greater resistance to both biotic stresses and abiotic stresses (**Sharp 2013 and Hidamgmayum *et al.*, 2019**). chitosan not only reinforces cell walls physically but also chemically modifies plant metabolism by increasing the production of reactive oxygen species (ROS) and secondary metabolites, which further strengthen plant defense responses (**Chen *et al.*, 2003 and Hadwiger, 2013**).

The main object of this study was examined the effect of chitosan treatments as well as the age and transplantation date of 'Barhi' date palm offshoots on the root system, shoot system growth and mineral status offshoots.

2. Material and Methods

This investigation was conducted during two successive seasons 2022 and 2023 on seventy-two 'barhi' date palms offshoots. The offshoots were classified in three categories; the first group was one-year-old, the second group was two years old, and the third one was three years old at the time of separation and transplantation. The chosen offshoots in each group were selected from well-produced mother's palms, good physical conditions, uniform in vigour and free from insects and diseases, and. The present investigation was carried out under Rumana village in Al-Tur Region conditions – North Sinai Governorate.

During each season (2022 and 2023) the offshoots separated from their mothers palms in two dates (early April or early September), the bases of offshoots treated with chitosan, then the offshoots transplanted in large potted pots filled with medium of five parts sand and one part clay for one year. The physicochemical analysis of cultivation medium will be reported later in this chapter. One year after it was planted, the offshoots were removed and the deferent measurements were made. This work was repeated during the two experimental seasons on offshoots of the same description. The planted offshoots were irrigated regally with 1600 ppm salinity water. The pots were irrigated through surface system using ground well water contain 1600 ppm salinity. The pots were lines one meter between each two pots. The three groups of selected offshoots are subjected to similar and regular irrigation and fertilization practices that were commonly applied in the date palm offshoots.

2.1. Experimental work

Treated 'Barhi' offshoots with chitosan at different concentrations: 0.0 %, 0.05%, 0.1% and 0.2%, as well as the age (one, two, and three-years) and transplantation date (Aril and September) of offshoots were examined.

2.2. Experimental design and statistical analysis

Treatments were arranged in Randomized split plot design and each treatment was replicated four times, one offshoot per each. The obtained data were subjected to proper statistical analysis; by analysis of variance (ANOVA). Comparisons between means were made by least significant differences (L.S.D) at p= 0.05 (**Gomez & Gomez, 1984** and **Snedecore & Cochran, 1990)**.

The following parameters were achieved: 1) Roots number / offshoots: After a year of transplanting, the offshoots were takes off from the pots and the number of roots that grown in the base of offshoots were counted. **2)** Leaf numbers per offshoots and leaf morphological parameters: four full sized leaves per offshoots palm one leaf at each side (**Ibrahim, 2011**). The morphological measurements included the leaf length (cm), Leaflet area (cm2) according to **Ahmed and Morsy (1999)**, and then the leaf area (m^2) was calculated as a result of multiplying the number of leaflets/leaf by the surface area of leaflet. **3)** Determination of macro elements (N, P, and K) in leaves: A 6 adult leaflet per leaf chosen from the meddle part of leaf (three leaves per each side) was taken. According to **Martin-Preval *et al.* (1984)**. The samples were washed with tap water and then with distilled water, air-dried the dried in oven at 70 °C for 72 hrs. The samples were grounded, and so 0.5 g fine powder was digested using H_2SO_4 and H_2O_2 until clear solution was obtained (**Martin-Preval *et al.*, 1984**). Thereafter, contents of N. P, and K were determined (According to **Wild *et al.*, 1985 and Martin-Preval *et al.*, 1984**) as follows: Nitrogen: by using modified microkejldahl method. Phosphorus: by using colorimetric method, described by, at the base of measuring the optical density of phosphor-molibdo-vanadate complex by using Spectro-photometrically at wave length = 430 nm. Potassium: by flam-photometrically determination, using method outlined by **Martin-Preval *et al.* (1984)**.

3. Results and Discussion

3.1. Number of new leaves / offshoots

The results illustrated in Table (1) clearly demonstrated that, treating the Barhi *cv*. offshoots with chitosan at different concentrations (0.0%, 0.05%, 0.1%, and 0.2%) resulted in a significant increment in the number of new leaves produced by offshoots. This increment was parallel to the chitosan concentration used. However, the differences between the two highest concentrations were non-significant, neither in the first seasons nor in the second season. The age of the offshoots, as well as the transplanting date had a significant effect on the number of new leaves produced by the offshoots. It is clearly shows that two-year-old offshoots performed better results in this regard than those had one or three-years-old, as well as transplanting in April produced a higher number of new leaves per offshoots than transplanting in September. These data were true during the two experimental seasons.

It is clear from the results presented in Table (1) that the interaction between chitosan concentrations and offshoots age and its transplanting date was significant, during the two experimental seasons of this study. The two years old offshoots transplanted in April showed a significant improvement over those transplanted in September. Then, the highest number of new leaves per offshoots was produced by the two-years old offshoots treated with chitosan at 0.2%, in both experimental seasons. On the opposite side, untreated one-year old 'Barhi' offshoots which transplanted in September produced the lowest number of new leaves, during 2022 and 2023 respectively.

Table (1). Effect of chitosan treatments, offshoots age and transplantation date as well as their interactions on new leaves number / offshoot of Barhi date palm, during 2022 and 2023 seasons

Treatments	2022					2023				
	Chito. 0.0%	**Chito. 0.05%**	**Chito. 0.1%**	**Chito. 0.2%**	**Mean A**	**Chito. 0. 0%**	**Chito. 0.05%**	**Chito. 0.1%**	**Chito. 0.2%**	**Mean A**
April 1 year	5.3	8.5	11.3	12.3	**9.4**	6.9	8.7	9.7	9.9	**8.8**
April 2 years	7.5	11.3	13.7	14.5	**11.8**	11.3	13.1	14.3	18.3	**14.3**
April 3 years	8.3	9.5	11.5	13.7	**10.8**	10.5	12.5	16.5	17.5	**14.2**
September 1 year	4.7	7.7	9.3	8.5	**7.6**	5.5	7.5	11.5	10.3	**8.7**
September 2 years	5.7	8.5	11.7	10.3	**9.1**	9.7	11.3	13.7	14.5	**12.3**
September 3 years	6.5	8.7	10.7	9.7	**8.9**	8.7	11.5	14.5	15.7	**12.6**
Mean B	**6.3**	**9.0**	**11.3**	**11.5**		**8.8**	**10.7**	**13.4**	**14.4**	
LSD at 5%	**A= 1.3 ; B= 1.1 ; AB= 1.6**					**A= 1.4 ; B= 1.3 ; AB= 1.9**				

3.2. Leaf length (cm)

Data listed in Table (2) shows the effect of treating 'Barhi' date palm offshoots with chitosan at different concentrations (0.0%, 0.05%, 0.1% and 0.2%), as well as its age and their transplanting date on the average leaf length (cm) during 2022 and 2023 seasons on the lengths of leaves produced per offshoots. The results clearly show that, treating the Barhi cv. offshoots with chitosan at different concentrations (0.0%, 0.05%, 0.1%, and 0.2%) resulted in a significant increment in the length of leaf (cm). This increment was parallel to increasing chitosan concentration. However, the differences between the two highest chitosan concentrations were non-significant, neither in the first seasons nor in the second season.

The age of the offshoots and its transplanting date also had a significant effect on the average length of leaf of Barhi offshoot. The results show that, three-years-old offshoots performed better in this regard than one- or two-years-old ones, as well as transplanting in April produced a higher leaf length (cm) than transplanting in September. These data were true during the two experimental seasons.

The obtained results (Table 2) clearly showed that, the interaction between chitosan treatments and offshoots age and its transplanting date was significant during the two experimental seasons of this study. Three-year old offshoots transplanted in April present the best leaf length compared to the other treatments. On the opposite side, untreated one-year old 'Barhi' offshoots transplanted in April produced the lowest leaf length, during 2022 and 2023 respectively.

Table (2). Effect of chitosan treatments, offshoots age and transplantation date on leaf length (cm) of 'Barhi' date palm, during 2022 and 2023 seasons

Treatments	2022					2023				
	Chito. 0.0%	**Chito. 0.05%**	**Chito. 0.1%**	**Chito. 0.2%**	**Mean A**	**Chito. 0.0%**	**Chito. 0.05%**	**Chito. 0.1%**	**Chito. 0.2%**	**Mean A**
April 1year	133	154	170	175	**158**	135	157	173	172	**159**
April 2 years	155	173	190	187	**176**	161	178	189	180	**177**
April 3 years	167	169	193	195	**181**	173	179	191	185	**181**
September 1 year	133	144	169	160	**150**	141	140	163	164	**152**
September 2 years	149	155	188	180	**168**	153	162	178	179	**168**
September 3 years	150	159	178	182	**167**	163	162	182	183	**173**
Mean B	**147**	**159**	**181**	**180**		**154**	**162**	**180**	**177**	
LSD at 5%	**A= 8 ; B= 9 ; AB= 13**					**A= 9 ; B= 7 ; AB= 10**				

3.3. Leaflet area (cm^2)

The obtained data during the two experimental seasons as illustrated in Table (3) displayed that, all the chitosan treatments was capable to increase significantly the leaflet area of Barhi offshoots (cm^2) compared to untreated offshoots, these findings were true during the two experimental seasons. The stimulation of leaflet area (cm^2) was parallel related to the chitosan concentrations. However, the offshoots received 0.2% chitosan present higher leaflet area than those received 0.05% or 0.1%, during the two experimental seasons respectively.

It is clear from the obtained data that differed the age of offshoots (one, two and three years) and its transplantation date (April and in September) significantly was followed by stimulating the leaflet area. Three-years old offshoots transplanted in September produced higher leaflet area (cm^2) than the others, in both experimental seasons.

Regarding the interaction between chitosan concentrations and offshoots age and its transplantation date was significant for leaflet area (cm^2) in both seasons (Table 3). The highest leaflet area was obtained when the three-year offshoots received chitosan at 0.2% and transplanting in September. Contrary untreated one-year offshoots which transplanted in April present the least leaflet area, these data were true during 2022 and 2023 seasons.

Table (3). Effect of chitosan treatments, offshoots age and transplantation date on leaflet area (cm^2) of Barhi date palm, during 2022 and 2023 seasons

Treatments	2022					2023				
	Chito. 0.0%	Chito. 0.05%	Chito. 0.1%	Chito. 0.2%	Mean A	Chito. 0.0%	Chito. 0.05%	Chito. 0.1%	Chito. 0.2%	Mean A
April - 1 year	141.5	155.7	165.5	171.5	**158.6**	144.1	150.2	169.3	171.2	**158.7**
April - 2 years	149.5	165.7	188.7	179.9	**170.1**	142.1	155.7	173.2	175.0	**161.5**
April - 3 years	146.4	169.9	185.8	178.4	**169.8**	148.7	158.2	177.4	181.3	**166.4**
September- 1 year	139.5	158.5	166.9	173.3	**159.6**	151.2	129.4	166.5	174.5	**155.4**
September - 2 years	144.7	171.1	177.5	181.1	**168.6**	155.5	171.3	177.5	183.7	**172.0**
September - 3 years	149.5	177.4	179.4	183.3	**172.4**	159.7	170.1	182.2	187.3	**174.8**
Mean B	**145.2**	**166.3**	**176.3**	**177.9**		**150.2**	**155.3**	**174.4**	**178.8**	
LSD at 5%	**A= 5.2 ; B= 6.2 ; AB= 9.1**					**A= 5.0 ; B= 4.6 ; AB= 6.7**				

3.4. Leaf area (m^2)

Change in leaf area (m^2) of Barhi cv. offshoots present in Table (4) in relation to chitosan treatments (0.0%, 0.05%, 0.1% and 0.2%), age of offshoot (one, two and three years) and transplantation date (April and September) of the adult leaves, during 2022 and 2023 seasons, shows that

One can state that significant differences on leaf area were observed among the two factors "chitosan treatments and age of offshoots and its transplantation date. It is worth to mention that Increased the concentration used of chitosan from 0.05% to 0.2% had a significant promotion on leaf area. These data were true during the two experimental seasons (2022 and 2023). However, non-significant differences were observed between the two highest concentrations (0.1% and 0.2%), as shown in Table (4).

Among the effect of age and transplantation date, during the two experimental seasons, it was capable to enhance significantly the leaf area (m^2). However, three-years old offshoots transplanted in September produced the highest leaf area. On the opposite side the one-year old offshoots transplanted in September present the lowest leaf area, these findings were true in both 2022 and 2023 experimental seasons.

All combined applications of the two factors (chitosan concentration as well as offshoots age and transplantation date) shows more effective on leaf area of 'Barhi' date palm offshoots than each factor alone. Furthermore, treated the three-year old offshoots with 0.2% chitosan and transplanted it in September shows more effective in enhancing leaf area and produced the highest leaf area rather than the other treatments. On the opposite side, lowest leaf area was obtained from untreated one-year old offshoots which transplanted in September. These findings were true during the two experimental seasons.

Table (4). Effect of chitosan treatments, offshoots age and transplantation date on leaf area (m^2) of Barhi date palm, during 2022 and 2023 seasons

Treatments	2022					2023				
	Chito. 0.0%	Chito. 0.05 %	Chito. 0.1%	Chito. 0.2%	Mean A	Chito. 0.0%	Chito. 0.05 %	Chito. 0.1%	Chito. 0.2%	Mean A
April - 1year	1.34	1.63	1.87	1.97	**1.70**	1.31	1.59	2.05	2.04	**1.74**
April - 2 years	1.57	1.93	2.39	2.34	**2.06**	1.44	1.85	2.27	2.26	**1.96**
April - 3 years	1.20	2.22	2.47	2.41	**2.08**	1.59	2.07	2.39	2.48	**2.13**
September - 1 year	1.21	1.60	1.75	1.92	**1.62**	1.29	1.28	1.85	1.97	**1.60**
September - 2 years	1.55	1.93	2.14	2.26	**1.97**	1.54	1.57	2.18	2.33	**1.91**
September - 3 years	1.66	2.18	2.21	2.27	**2.09**	1.71	2.09	2.31	2.45	**2.14**
Mean B	**1.42**	**1.91**	**2.14**	**2.19**		**1.68**	**1.75**	**2.18**	**2.26**	
LSD at 5%	**A= 0.08 ; B=0.10 ; AB= 0.15**					**A=0.7 ; B=0.09 ; AB= 0.131**				

The role of chitosan in enhancing vegetative growth of date palm offshoots can attribute to the following reasons: it plays a critical role in improving the structural properties of plant tissues. It has been shown to enhance the deposition of cellulose and lignin in cell walls, leading to increased mechanical strength and greater resistance to both biotic stresses and abiotic stresses **(Sharp, 2013)**. Chitosan not only reinforces cell walls physically but also chemically modifies plant metabolism by increasing the production of reactive oxygen species and secondary metabolites, which further strengthen plant defense responses. The ability of chitosan to fortify cell wall integrity is crucial in enhancing plant resilience, especially under challenging environmental conditions **Hadwiger** (**2013**). Another important aspect of chitosan's application being biodegradable, non-toxic, and derived from natural sources such as crustacean shells, chitosan represents an eco-friendly. It decomposes naturally into harmless byproducts **(Sharp, 2013)**. Research conducted by **El Hadrami & Al-Khayri (2012)** and **Ayed (2018)** emphasized that chitosan based treatments significantly improve vegetative growth and yields as well as reduce the need for synthetic pesticides and fertilizers. Chitosan coatings form a semi-permeable film on the surface of produce, which regulates gas exchange, reduces water loss, and acts as a barrier to microbial invasion **(Dutta *et al.*, 2009).** Furthermore, soil applications of chitosan have been linked to improved soil microbial health, stimulating beneficial microorganisms that promote nutrient cycling and plant growth (**Rinaudo, 2006**). **El-Hadrami & Al-Khayri (2012)** have documented the stimulatory effects of chitosan on the vegetative development of date palms, foliar spraying of chitosan significantly increased offshoots height, number of leaves per offshoots, and overall plant vigor, this primitive role may be due to its ability to enhance nutrient uptake, stimulate endogenous hormone production, and activate defense related genes. On the other side, the age of offshoots at the time of planting is a crucial factor influencing their vegetative development, establishment success, and subsequent fruiting performance (**Hussien, 2005; Al-Khateeb, 2008 and Ibrahim, 2010**). The physiological and morphological characteristics of offshoots vary significantly with age, it is essential for achieving optimal growth and productivity. Younger seedlings may establish more quickly due to their active growth status, but they may also be more vulnerable to environmental stresses. Conversely, older seedlings often possess a more developed root system and greater stored energy reserves, enhancing their survival and vigor under field conditions.

The obtained results in the present study shows some variation or inconsistency in the effect of offshoots age and transplanting date on vegetative growth parameters, but most of this characters consolidate of the two years old offshoots. Several studies have investigated the relationship between seedling age and growth parameters in date palms by **Al-Mulla *et al.* (2015)** they confirmed that, offshoots aged between 12 and 20 months exhibited superior vegetative growth compared to younger or much older counterparts. These seedlings showed higher rates of production, greater leaf area development, and thicker trunk diameters. It was suggested that the stimulation of growth attained during this age range allowed for efficient photosynthesis and resource allocation toward both root and shoot development.

3.5. Root numbers per offshoots

The obtained data illustrated in Table (5) shows that the number of new roots per offshoot varied significantly in both experimental seasons. It is clear that, such increase was gradually enhanced parallel with the increase in the chitosan concentration. However, the offshoots treated with chitosan at 0.2% present highest number of roots per offshoot. Whereas, increasing the concentration of chitosan from 0.1% to 0.2% led to slight and non-significant increase in the number of roots per offshoot. These findings were true during the two experimental seasons. Regarding the effect of age and transplantation date, the obtained results shows that the two-year old offshoots pronounced a higher numbers of roots than those produced by one year or three years. In the same context, regardless the age of offshoots, the offshoots transplanted in April showed a remarkable and significant superiority over those transplanted in September. Furthermore, the two-years old offshoots transplanted in April produced the highest number of roots per offshoot in both experimental seasons. Contrary, one-year-old offshoots that were transplanted in September produced the lowest numbers of roots, in both experimental seasons.

Regarding the interaction between chitosan concentrations and offshoot age and its transplantation date, it was significantly in the two experimental seasons as illustrated in Table (5). It is clear that treated two years-old ‘Barhi’ offshoots with chitosan at 0.2% and transplanted in April produced the higher roots number compared to the untreated offshoots or other chitosan treatments combined with other ages and transplantation date.

The obtained data was harmony with the results obtained by: **Rinaudo (2006); Badawy & Rabea (2011)**; **El Hadrami & AlKayri (2012)**; **Zahra *et al.* (2012)**; **Mondal *et al.* (2015); Xing *et al.* (2015); Kumaraswamy *et al.* (2018),** and **Abdel-Aziz *et al.* (2018).**

Table (5). Effect of chitosan treatments, offshoots age and transplantation date of number of roots / offshoots of Barhi date palm, during 2022 and 2023 seasons

Treatments	2022					2023				
	Chito. 0.0%	Chito. 0.05 %	Chito. 0.1%	Chito. 0.2%	Mean A	Chito. 0.0%	Chito. 0.05 %	Chito. 0.1%	Chito. 0.2%	Mean A
April - 1 year	9.3	15.1	18.7	20.3	**15.9**	7.3	15.4	21.3	23.5	**16.9**
April - 2 years	15.5	25.3	28.3	29.5	**24.6**	13.3	18.5	30.5	32.3	**23.7**
April -3 years	11.3	20.3	21.5	24.5	**19.4**	11.7	17.3	24.5	26.7	**20.1**
September - 1 year	6.7	11.5	15.3	16.3	**12.5**	9.5	13.7	18.7	21.5	**15.9**
September -2 years	9.9	17.7	23.5	25.7	**19.2**	10.5	14.5	24.9	27.9	**19.5**
September - 3 years	9.3	15.7	19.9	21.5	**16.7**	10.7	13.3	19.5	22.5	**16.5**
Mean B	**9.8**	**17.6**	**21.2**	**22.9**		**11.3**	**15.5**	**23.2**	**25.7**	
LSD at 5%	**A= 4.2 ; B= 5.5 ; AB= 7.9**					**A= 4.4 ; B= 6.5 ; AB= 8.3**				

The apparent effect of chitosan on enhancing the root system of ‘Barhi’ offshoots can be explained as follows: chitosan-treated offshoots exhibited improved tolerance to soil salinity and drought stress. This enhanced stress tolerance is attributed to the improved root system, which enables the plant to access deeper soil layers for water and nutrients during periods of scarcity **El Hadrami & Alkayri (2012)**. Furthermore, chitosan has been shown to activate defense related genes in plants, which help improve their ability to withstand biotic stresses caused by pathogens and pests **Shu (2015)**. The ability of chitosan to improve root system development also contributes to increased stress tolerance in date palms. Date palms are typically grown in arid and semi-arid regions where water scarcity, soil salinity, and high temperatures are common stressors. Chitosan application can enhance the root system's efficiency in water and nutrient absorption (**Ibrahim, 2011**). The mechanisms by which chitosan affects root growth and development are still being investigated. However, it is believed that chitosan affects various physiological processes that contribute to improved root system development. One of the key mechanisms is the stimulation of plant hormones, especially auxins, which are critical for root initiation and elongation. In addition to auxins, chitosan has been shown to increase the levels of cytokinin, which promote cell division and branching in the roots **(Abdel-Aziz *et al.*, 2017)**. Another mechanism is the enhancement of soil microbial activity in the rhizosphere. Chitosan acts as a natural elicitor that stimulates the growth of beneficial microorganisms, which in turn improve nutrient cycling and availability in the soil (**Abd El-Aziz, 2020**).

3.6. Effect on leaf macro nutrients

Data presented in Tables (6, 7 & 8) shows the effect of different chitosan concentrations (0.0%, 0.05%, 0.1% and 0.2%) as well as of offshoots age (one, two, and three years) and transplantation date (April and September) of 'Barhi' date palm, during 2022 and 2023 seasons. Regarding the leaves N contents, chitosan treatments have a positive and significant effect on Nitrogen percentage. This increment was parallel with to chitosan concentration (table 6). However, the highest Nitrogen contents were obtained from the offshoots received 0.2%. On the opposite side, untreated one present the lower Nitrogen contents in both experimental seasons respectively. Furthermore, leaves Nitrogen contents varied significantly in relation to the age of offshoots and its transplantation date. One-year offshoots transplanted in April presented higher Nitrogen content compared to other ages and transplantation date. Contrary, untreated three-year offshoots transplanted in September present lower Nitrogen continents (1.66% and 1.66%) in their leaves compared to other ages and transplantation date, this finding were true during the two experimental seasons.

Concerning the leaves phosphorus contents, varying the age of offshoots and its transplantation date failed to change the leaves phosphorus contents significantly, neither in the first seasons nor in the second one (Table 7). On the other side, treated different ages 'Barhi' offshoots with chitosan (at 0.05%, 0.1% and 0.2%) was Capable to enhancing the leaf phosphorus contents significantly. All chitosan concentrations were capable to cause a significant increase in leaves phosphorus contents during the two experimental seasons, except the lowest concentration (0.05%) during the first season only. This positively enhancement was parallel with increasing chitosan concentration. The interaction between chitosan treatments and offshoots age and its transplantation date was significant in both experimental seasons. Three-year 'Barhi' offshoots treated with chitosan at 0.2% and transplanted in September present the highest Phosphorus contents in their leaves. However, non-significant differences were observed between the three-years offshoots treated with 0.02% chitosan and two-years treated with the similar concentration in the first year and those have two years transplanted in April in the second season.

Regarding the potassium contents of 'Barhi' offshoots, Table (8) present the effect of chitosan concentration, age of offshoots and its transplantation date on leaves Potassium %, during 2022 and 2023 seasons. The obtained data shows that, all chitosan treatments as well as the age and transplantation date treatments were capable in enhancing the leaf Potassium contents in the leaves of 'Barhi' offshoots, during the two experimental seasons. Gradual increase of chitosan concentration (0.0%, 0.05%, 0.1% and 0.2%) significantly enhanced the leaves Potassium contents, during both experimental seasons. this increment was paralleled with the concentration used. However, the offshoots received 0.2% present the higher K% in their leaves, contrary untreated offshoots present the lowest Potassium contents, and these data were true during 2022 and 2023 seasons. The same table shows that offshoots age and transplantation date significantly affected the leaves potassium contents.

However, the offshoots transplanted in April shows higher potassium contents in their leaves rather than those transplanted in September.

The interaction was significant in the two experimental seasons. However, the maximum values of potassium were obtained when the two-year offshoots received 0.2% chitosan and transplanted in April. Contrary, the lowest Potassium contents were obtained from un-treated one-Year offshoots transplanted in September.

Table (6). Effect of chitosan treatments, offshoots age and transplantation date on leaf N % of 'Barhi' date palm, during 2022 and 2023 seasons

Treatments	2022					2023				
	Chito. 0.0%	Chito. 0.05 %	Chito. 0.1%	Chito. 0.2%	Mean A	Chito. 0.0%	Chito. 0.05 %	Chito. 0.1%	Chito. 0.2%	Mean A
April -1 year	1.77	1.80	1.88	1.91	**1.84**	1.78	1.84	1.92	1.95	**1.87**
April-2 years	1.73	1.77	1.80	1.82	**1.78**	1.72	1.78	1.82	1.84	**1.79**
April-3 years	1.64	1.71	1.77	1.78	**1.73**	1.66	1.70	1.77	1.79	**1.73**
September 1 year	1.70	1.75	1.79	1.80	**1.76**	1.72	1.75	1.80	1.81	**1.77**
September-2 years	1.64	1.70	1.74	1.75	**1.71**	1.64	1.70	1.72	1.74	**1.70**
September-3 years	1.60	1.65	1.69	1.71	**1.66**	1.60	1.66	1.69	1.70	**1.66**
Mean B	**1.67**	**1.73**	**1.78**	**1.80**		**1.68**	**1.74**	**1.79**	**1.81**	
LSD at 5%	**A= 0.05 ; B= 0.06 ; AB= 0.08**					**A= 0.06 ; B= 0.06 ; AB= 0.08**				

Table (7). Effect of chitosan treatments, offshoots age and transplantation date on leaf P% of 'Barhi' date palm, during 2022 and 2023 seasons

Treatments	2022					2023				
	Chito. 0.0%	Chito. 0.05%	Chito. 0.1%	Chito. 0.2%	Mean A	Chito. 0.0%	Chito. 0.05%	Chito. 0.1%	Chito. 0.2%	Mean A
April -1year	0.23	0.25	0.27	0.27	**0.25**	0.24	0.26	0.27	0.26	**0.26**
April-2 years	0.23	0.24	0.27	0.29	**0.25**	0.24	0.27	0.27	0.27	**0.26**
April-3 years	0.25	0.25	0.26	0.28	**0.26**	0.24	0.27	0.26	0.28	**0.26**
September-1 year	0.22	0.26	0.27	0.28	**0.25**	0.24	0.27	0.27	0.27	**0.26**
September-2 years	0.24	0.26	0.27	0.29	**0.26**	0.24	0.28	0.26	0.27	**0.26**
September-3 years	0.24	0.25	0.26	0.29	**0.26**	0.23	0.27	0.27	0.28	**0.26**
Mean B	**0.24**	**0.25**	**0.27**	**0.0.28**		**0.24**	**0.27**	**0.27**	**0.28**	
LSD at 5%	**A= NS ; B= 0.02 ; AB= 0.03**					**A= NS ; B=0.02 ; AB= 0.03**				

Table (8). Effect of chitosan treatments, offshoots age and transplantation date on K% of 'Barhi' date palm, during 2022 and 2023 seasons

Treatments	2022					2023				
	Chito. 0.0%	Chito. 0.05%	Chito. 0.1%	Chito. 0.2%	Mean A	Chito. 0.0%	Chito. 0.05%	Chito. 0.1%	Chito. 0.2%	Mean A
April -1year	1.4	1.7	1.6	1.7	**1.6**	1.4	1.6	1.7	1.7	**1.6**
April-2 years	1.3	1.6	1.7	1.8	**1.6**	1.4	1.5	1.7	1.8	**1.6**
April-3 years	1.4	1.3	1.6	1.8	**1.5**	1.3	1.4	1.6	1.7	**1.5**
September-1 year	1.2	1.3	1.6	1.6	**1.4**	1.3	1.4	1.5	1.6	**1.5**
September-2 years	1.3	1.4	1.4	1.5	**1.4**	1.3	1.6	1.6	1.6	**1.5**
September-3 years	1.3	1.5	1.7	1.7	**1.6**	1.2	1.5	1.6	1.7	**1.5**
Mean B	**1.3**	**1.5**	**1.6**	**1.7**		**1.3**	**1.5**	**1.6**	**1.7**	
LSD at 5%	**A= 0.1 ; B= 0.2 ; AB= 0.3**					**A=0.1 ; B=0.2 ; AB= 0.3**				

4. Conclusion

Based on the obtained results we can confirm that under salinity stress, treated the base of 'Barhi' offshoots with chitosan at 0.2% is an effective and important to ensure the success of 'Barhi' offshoots and enhancing the vegetative parameters, leaf photosynthesis pigments, and macro uptick. Furthermore, the age and the transplantation date of 'Barhi' offshoots significantly effected of most vegetative parameters, root system parameters and leaf chemical composition. The obtained results also confirmed that the interaction between chitosan concentrations and offshoots age and its transplantation date was significant for all examined characters.

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