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Influence of Some Stimulative Substances and Planting Density on Olive Fruit Characteristics Cv. (Toffahi) under Soil Salinity

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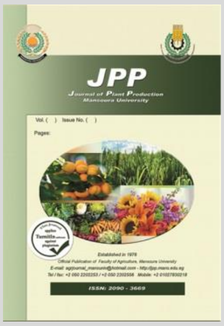

ABSTRACT

This experiment was carried out during two successive seasons (2021 and 2022) to study the influence of different stimulative substances (Proline at 150 ppm, Fulvic acid at 50 ppm, Glutamic acid at 500 ppm, Nano-chitosan at 50 ppm and potassium Silicate at 1000 ppm) with two types of planting density (normal 5*6 m and intensive (3*5 m) and their interactions on productivity and fruit characteristics of 21 years old of Toffahi olive trees grown in saline sandy soil and irrigated with a drip system in a private orchard located at Fayed city, Ismailia, Egypt. The results showed that spraying trees with nano-chitosan or potassium silicate enhanced fruit physical characteristics (fruit and pulp weight, fruit dimension, fruit hardness and dry matter). Whereas, trees treated with nano-chitosan or proline recorded the highest productivity in both seasons. In addition, fulvic acid acquired the highest ripening degree (coloring index) .Conversely in the fruit chemical properties, no apparent effect of treatments from1st season to 2nd season in each of acidity and proline. As for to the type of planting density effect, it obviously superiority of normal plant density.

Keywords: Olive, planting density, simulative substances, soil salinity.

INTRODUCTION

Olive (*Olea europaea* L.) is one of the oldest known cultivated trees in the world going as far as 8000 years ago. Olive has spread in the Mediterranean basin, which is still the major region of olive production. It considered one of the crops tolerant to different environmental conditions such as heat and drought, so its cultivation is widespread in most of the desert areas in Egypt.

The climate change lead to a decrease in the economic return in many crops, including olives. Hence the importance of vertical and horizontal expansion to confront these variables and increase the agricultural economic return. Intensive cultivation is considered one of the methods of vertical expansion by increasing the number of plants planted per unit area in order to improve productivity and raise the efficiency of using available resources (irrigation and fertilization) while reducing costs by reducing dependence on labor force and the use of agricultural mechanization in the performance of various agricultural operations (Papachatzis et al., 2011). The success of different agricultural systems in olive orchard depends on good management of irrigation and fertilization processes to control the strength of tree growth and productivity, in addition to choosing the appropriate cultivar for the planting distance used (Rallo et al., 2013 and Diez et al., 2016). In spite of the fact that intensive cultivation of olives began decades ago, the research that dealt with the intensification of olive varieties used for table purposes is very rare.

Salinity is considered one of the most important factors that affect the productivity of fruit trees in general (Boussadia *et al.*, 2023). Increasing of salt stress is one of the major problems in large areas of cultivated land in Egypt. The growth rates and productivity of plants in general and olive trees in particular are affected by high levels of salinity (Abd El-Hady *et al*., 2003; Chartzoulakis, 2005 and Regni *et al.*, 2019).

Stimulative substances are natural or synthetic substances applied to plants to enhance nutritional efficiency, abiotic stress tolerance and crop quality (Carolina and Helena, 2020). Among these substances, amino acids, chitosan, and silicates showed efficiency in raising plants tolerance to salt stress. Foliar application of amino acids is decisive to plants; it considered as considered as main component in the formation of proteins which are important for stimulation of cell growth. Similarly, it acts as a buffer, which helps to maintain favorable pH value within the plant cell. Amino acids can directly or indirectly influence physiological processes within plants. Moreover, the exogenous application of amino acids has been reported to modulate the growth, yield and fruit quality of pears and grapevine (Rai, 2002, Ahmed and Abd El-Hameed, 2003 and Khan et al., 2012). Chitosan is a polysaccharide containing randomly distributed beta 1-4 linked deacetylated unit and acetylated unit (Rinaudo, 2006 and Zagzog et al., 2017). Chitosan works to narrow the openings of the stomatal, which increases the plant's efficiency in resisting pathogens and stress in general. Foliar application of chitosan decreased transpiration and increased water use efficiency, growth parameters and yield of many crops (Gornik et al., 2008; Ahmed et al., 2016; Malerba and Cerana, 2016; Sajid et al., 2020 and Khalil and Badr eldin, 2021). The application of chitosan raises the enzymatic activity in the nitrogen metabolism and enhances the transportation of nitrogen in the functional leaves which increases plant growth and productivity (Mondal et al., 2013).

Silicon is one of the abundant elements in the soil next to oxygen, comprises 27.2 % of soil weight and 3-17% in its solution (Greenwood and Earnshaw, 1997 and Sommer *et al*.,

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2006). Moreover, it plays an important role in increasing plant growth and enhancing withstanding of fruit crops to biotic and abiotic stresses, nutrient uptake, plant pigments, preserving plant water balance, sustaining photosynthetic activity, and maintaining erectness of plant leaves under high transpiration rates (Mir *et al.*, 2022 and Xu *et al*., 2023).

The objective of this work aims to study the effect of some simulative substances via amino acid (Proline, Fulvic and Glutamic acids), Nano-chitozan and Silicate potassium on growth and productivity of intensive olive trees in soil salinity.

MATERIALS AND METHODS

The experiment was carried out during two successive seasons of 2021 and 2022 on thirty-six mature trees of Toffahi olive cultivar. The trees were 21 years old grown in a private orchard at Sarabium, Ismailia Governorate, situated (30.435421508569423) N latitude, (32.15477538658834) E longitude. Olive trees were cultivated at 5 x 6 and 3 x 5 m in sandy soil under drip irrigation. The selected trees received the normal horticulture practices. The experiment designed in a split plot design, consisted of 6 treatments. Every treatment contained 6 trees as replicates.

The physical and chemical properties of the experimental soil were tabulated according to (Black *et al.*, 1975; Chapman and Pratt, 1975; Page *et al.*, 1982) in Tables (1&2). The water analyses of main source supply (subterranean well) are given in Table 3

Table 1. The physical properties of the soil experiment analyzed before treatment.

Depth cm	Sand %	Clay%	Silt %	organic matter (%)
0-30 cm	95.60	1.60	2.80	0.23

Table 2. The chemical properties of the soil experiment analyzed before treatment.

Depth Cm	pH	ECe dS m^{-1}	available N (Mg kg^{-1}soil)	available P (Mg kg^{-1}soil)	available K (Mg kg^{-1}soil)
0-30	8.02	3.51	20.7	12.2	90.5

Table 3. The chemical analysis of the used irrigation water

Characters	EC dSm^{-1}	pH	Cations (meq/l)				Anions (meq/l)				SAR
			Ca^{2+}	Mg^{2+}	Na^{2+}	K^{2+}	CO_3^-	HCO_3^-	Cl^-	SO_4^{2-}	
Value	10.50	7.91	10.4	14.2	75.1	5.3	0.00	37.9	32.7	34.4	21.41

The selected trees received the following treatments at full bloom and after 4 weeks:

1. Control (water spray).
2. Proline 150 ppm.
3. Fulvic acid 50 ppm.
4. Glutamic acid 500 ppm.
5. Nano- chitosan 50 ppm.
6. Potassium Silicate 1000 ppm.

At the harvest date in mid-September, 150 fruits per replication were randomly selected to determine the fruit's physical attributes and chemical constituents. The responses of the tested olive trees to treatments were evaluated through the following parameters:

Fruit physical characteristics:

- Fruit and pulp weights (g) were determined by using electric balance and the average weight each of them was calculated.
- Fruit dimensions (cm) were measured and fruit shape index was determined (length / diameter).
- Fruit firmness (hardness) (kg/m^2) was calculated by using a push-pull dynamometer on opposite sides.
- Fruit dry weight (g) was measured by weighing the samples after drying in a forced air oven at 150 C for 42 h.
- Color index of ripening: Table olives are classified according to ripeness degree (green to yellow). Fruit samples (100 fruit) were picked in mid-September and randomly sorted into 3 color categories related to green olive table based on the color chart categories in Table (4)

Table 4. Categories of color fruits.

Olive color	score	Number of olives	Calculation
Deep Green Skin Color	0	N_1	$0 \times N_1$
Yellow or Yellow-Green Skin Color	1	N_2	$0 \times N_2$
Yellow-Green with Less than Half of the Olive with Reddish Spots or Violet Skin Color	2	N_3	$0 \times N_3$

The total number of olives in each category was counted and recorded. The following equation was there applied to determine the maturity index:

$$CI = \frac{o \ x \ n_1 + 1 \ x \ n_2 + 2 \ x \ n_3}{100}$$

Where,

CI is color index and (n) is the number of fruits in each the group (Cillidag, 2013).

- Productivity (Ton/Fed). The productivity was calculated by multiplying the number of trees/ Fed by the yield of one tree.

Fruit chemical properties:

- Fruit acidity percentage: as Malic acid (mg/100 g fruit juice) (A.O.A.C., 2000).
- Total phenol content (mg/ g fruit) was determined according the method that described by Vazquez- Roncero *et al.* (1973).
- Light intensity (cd/m^2) was estimated at 1.5 m above the soil at 4 random locations by a luxmeter (LX-101) two times a day (0900 to 1000 h, 1200 to 1300 h).

Statistical analysis:

All collected data will be analyzed with analysis of variance (ANOVA) procedure using the Co Stat Statistical Software. Differences between means were compared by using Duncan (1958).

RESULTS AND DISCUSSION

Fruit and pulp weight (g)

Dealing with the specific effect of the two investigated factors (planting density and stimulative substances) and their interaction on the average fruit and pulp weight of Toffahi Olive cv., the perusal data in Table 5 showed a significant difference between the means of trees that grown under normal plant density and intensive plant density. Whereas, the highest fruit and pulp weight were recorded from olive trees that were grown under normal plant density as opposed to intensive plant density in both tested seasons respectively. These findings go in the same line with those obtained by Guerfel *et al.,* 2010, Larbi *et al.,* 2012, Diez *et al.,* 2016 and Tous, 2018 on olive. They illustrated that olive fruits weight/tree were increased at low plant densities. This effect may be due to an increase in the rates of photosynthesis in trees grown under normal density as a result of good lighting which leads to an increase in the amount of carbohydrates stored in the fruits. Also, paucity of the competition between trees at normal plant densities for nutrients helps in increasing carbohydrate formation rates and improving yield characteristics (Laužikė *et al.,* 2020 and Haque and Sakimin, 2022).

Table 5. Influence of some stimulative substances and planting density on fruit and pulp weight of Toffahi Olive cultivar during 2021 and 2022 seasons.

Treatment	Frist season			Second season		
	Plant density		Mean	Plant density		Mean
	Normal	Intensive		Normal	Intensive	
	Fruit weight (g)					
Control	8.62 g	7.24 h	7.93 D	10.37 g	8.89 h	9.63 D
Proline	11.26 a	9.28 e	10.27 B	14.78 a	11.46 ef	13.12 B
Fulvic acid	10.25 c	8.88 f	9.56 C	13.46 c	11.38 f	12.42 C
Glutamic acid	10.98 b	9.34 e	10.16 B	14.81 a	11.83 e	13.32 AB
Nano- chitosan	10.94 b	9.88 d	10.41 A	14.04 b	12.59 d	13.32 AB
Potassium Silicate	11.23 a	9.78 d	10.51A	14.79 a	12.29 d	13.54 A
Mean	10.55 A	9.07 B		13.71 A	11.41 B	
	Pulp weight (g)					
Control	7.70 g	6.39 h	7.04 E	9.35 f	7.93 g	8.64 D
Proline	10.11 a	8.32 f	9.21 BC	13.40 a	10.36 e	11.88 B
Fulvic acid	9.18 d	7.88 g	8.53 D	12.17 c	10.21 e	11.19 C
Glutamic acid	9.88 bc	8.33 f	9.11 C	13.49 a	10.60 e	12.05 AB
Nano- chitosan	9.76 c	8.84 e	9.30 AB	12.61 b	11.38 d	12.00 AB
Potassium Silicate	9.96 ab	8.77 e	9.37 A	13.20 a	11.13 d	12.17 A
Mean	9.43 A	8.09 B		12.37 A	10.27 B	

Values have the same letter are not significantly different at 5% level using Duncan's New Multiple Range Test

In regards to the effects of stimulative substances, data revealed differences among tested treatments in both studied seasons. Nano-chitosan and potassium silicate attained the highest weight of fruit (10.41 and 10.51 g), (13.32 and 13.54 g) and pulp (9.30 and 9.37 g), (12.00 and 12.17 g) in the two seasons respectively, partnership with glutamic treatment in the second season. On the contrary, the least weight of fruit (7.93 g and 9.63 g) and pulp (7.04 g and 8.64 g) was scored by control treatment. The positive effect of nano-chitosan is attributed to its role in enhancing the photosynthesis process which contributed in plant growth and development, and an increase in the metabolic activity of some important enzymes (Sajid *et al*., 2020 and El- bolok and Kasem, 2023). Similarly, numerous studies demonstrated the effectiveness of potassium silicate in enhancing fruit weight (El-Gioushy (2016) on orange, El Kholy *et al*. (2018) on loquat, Enas *et al.* (2018) on date palm, Aly *et al*. (2019) on mango, Abd El-Aziz *et al.* (2021) on peach, Hussien and Kassem (2021) on fig). The beneficial effect of silicon in plants is due to its enhancement of enzymatic activity and photosynthesis, improvement of K^+/Na^+ ratio which help leaves to avoid Na^+ toxicity and maintained higher chlorophyll retention (Abdel-Hameed, 2012; Meena *et al.,* 2014). Moreover, silicon increased soluble substances in plant tissues, and promotion of the antioxidant defense mechanism of plants (Sahebi *et al.,* 2015). Also, potassium helps plants to adapt water shortages by controlling the opening and closing of stomata therefore it helps in controlling the process of photosynthesis and the formation of carbohydrates (Hasanuzzaman *et al.,* 2018). Moreover, Kumari *et al.* (2021) mentioned that potassium reduces salinity damage in plants by alleviating osmotic stress, strengthening the activity of antioxidant enzymes, and improving nitrogen utilization efficiency in plants which helps maintain crop yields during stress conditions.

According to the interaction between planting density and stimulative substances, the tabulated data stated that proline or potassium silicate treatments under normal plant density achieved the highest fruit and pulp weight in both seasons shared with glutamic treatment in the second season. Meanwhile, the control treatment recorded the least one in all plant density during two studied seasons. The other combination gives in between values.

Fruit dimensions (cm)

Data in Table (6) demonstrate the significant influence of stimulative substances, planting density and their interaction on fruit dimensions of the tested olive fruits during 2021 and 2022 seasons; dimensions (length and diameter) ranged from (2.49 to 2.86 cm) for fruit length, (2.25 to 2.63 cm) for fruit diameter in the first season and from (2.62 to 3.05 cm) for fruit length, (2.41 to 2.84 cm) for fruit diameter in the second one.

With respect to the planting density (normal and intensive) the normal planting density was adequate to give high values of fruit length and diameter in both tested seasons. The same trend was stated by Dhiman *et al.,* 2018 on apple. This effect may be due to an increase in the rates of photosynthesis in trees grown under normal density as a result of good lighting which leads to an increase in the amount of carbohydrates stored in the fruits. Also, paucity of the competition between trees at normal plant densities for nutrients helps in increasing carbohydrate formation rates and improving yield characteristics (Laužikė *et al.,* 2020 and Haque and Sakimin, 2022).

Regarding the effects of simulative substances on olive fruit length and diameter, it was noticed that the uppermost fruit dimensions were obtained in the first and second season in most cases throw using proline, Nano-chitosan and potassium silicate treatments share with glutamic treatment in the second season. As well as, control treatment recorded the least values in the two seasons under study. Generally, it could be summarized that, these stimulative substances regulate osmotic pressure within the cells, causes an increase in the availability and absorption of water and important nutrients, which in turn maintains turgor pressure and increased cell size (Sajid *et al*., 2020; Hussien and Kassem, 2021; Eisaa *et al*., 2023 and Torresa *et al*., 2023).

Table 6. Influence of some stimulative substances and planting density on fruit dimensions of Toffahi Olive cultivar during 2021 and 2022 seasons.

Treatment	Frist season			Second season		
	Plant density		Mean	Plant density		Mean
	Normal	Intensive		Normal	Intensive	
			Fruit length (cm)			
Control	2.56 ^{e}	2.49 ^{f}	2.53 ^{D}	2.68 ^{g}	2.62 ^{g}	2.65 ^{C}
Proline	2.85 ^{a}	2.68 ^{cd}	2.77 ^{A}	3.03 ^{a}	2.83 ^{e}	2.93 ^{A}
Fulvic acid	2.76 ^{b}	2.59 ^{e}	2.67 ^{C}	3.00 ^{ab}	2.76 ^{f}	2.88 ^{B}
Glutamic acid	2.77 ^{b}	2.65 ^{d}	2.71 ^{B}	2.96 ^{bc}	2.89 ^{d}	2.93 ^{A}
Nano-chitosan	2.86 ^{a}	2.72 ^{bc}	2.79 ^{A}	3.01 ^{ab}	2.92 ^{cd}	2.96 ^{A}
Potassium Silicate	2.83 ^{a}	2.70 ^{c}	2.77 ^{A}	3.05 ^{a}	2.82 ^{e}	2.93 ^{A}
Mean	2.77 ^{A}	2.64 ^{B}		2.96 ^{A}	2.807 ^{B}	
			Fruit diameter (cm)			
Control	2.36 ^{h}	2.25 ^{i}	2.30 ^{C}	2.52 ^{f}	2.41 ^{g}	2.46 ^{C}
Proline	2.63 ^{a}	2.47 ^{fg}	2.55 ^{A}	2.83 ^{ab}	2.63 ^{e}	2.73 ^{Ab}
Fulvic acid	2.51 ^{ef}	2.44 ^{g}	2.48 ^{B}	2.74 ^{cd}	2.67 ^{de}	2.70 ^{B}
Glutamic acid	2.56 ^{cd}	2.40 ^{h}	2.48 ^{B}	2.84 ^{a}	2.63 ^{e}	2.73 ^{Ab}
Nano- chitosan	2.61 ^{ab}	2.49 ^{f}	2.55 ^{A}	2.78 ^{bc}	2.71 ^{cd}	2.75 ^{A}
Potassium Silicate	2.59 ^{bc}	2.53 ^{de}	2.56 ^{A}	2.82 ^{ab}	2.69 ^{d}	2.75 ^{A}
Mean	2.55 ^{A}	2.43 ^{B}		2.75 ^{A}	2.62 ^{B}	

Values have the same letter are not significantly different at 5% level using Duncan's New Multiple Range Test

The interaction between the two factors of study clearly indicates that, all studied fruit dimensions significantly increased when the trees were planted under normal density compared to control treatments that acquired the least one. Proline, Nano-chitosan and potassium silicate recorded the highest values of fruit length, shared with fulvic acid under normal density in the second season. Similarly, there is a vast variability in fruit diameter among simulative substances under normal density, whereas, proline treatment attained the highest value in both seasons, but other treatments differ from season to another.

Fruit hardness (g/m^3) and dry weight (g)

Data in Table (7) showed that, fruit hardness (g/m^3) and dry weight (g) were gradually affected by plant density in both seasons. In regards to the plant density effect, it was noticed that normal density had a higher superiority to trees planted intensively which gave the highest fruit hardness (345.17 and 347.44 g/m^3) and dry weight (0.218 and 0.295 g) in the 1st and 2nd seasons, respectively. This could be explained by more carbohydrate availability by improved light penetration and reduces competition among trees for nutrients in wider spacing (Zhang *et al*., 2015 and Dhiman *et al*., 2018).

With respect to the effect of stimulative substance, the tested silicate potassium treatment significantly increased fruit hardness (362.50 and 363.83 g/m^3) and dry weight (0.222 and 0.304 g) in both seasons respectively. Otherwise, the control treatment recorded the lowest values during two studied seasons.

Table 7. Influence of some stimulative substances and planting density on fruit hardness (kg/m^3) and dry weight (g) of Toffahi Olive cultivar during 2021 and 2022 seasons.

Treatment	Frist season			Second season		
	Plant density		Mean	Plant density		Mean
	Normal	Intensive		Normal	Intensive	
			Fruit hardness (kg/m2)			
Control	285.33 ^{gh}	273.33 ^{h}	279.33 ^{E}	300.17 ^{g}	280.67 ^{h}	290.42 ^{F}
Proline	368.33 ^{b}	312.67 ^{ef}	340.50 ^{B}	372.67 ^{b}	324.33 ^{e}	348.50 ^{B}
Fulvic acid	315.00 ^{ef}	292.67 ^{fgh}	303.83 ^{D}	319.67 ^{e}	300.83 ^{g}	310.25 ^{E}
Glutamic acid	343.00 ^{cd}	300.00 ^{fg}	321.50 ^{C}	342.17 ^{d}	307.50 ^{fg}	324.83 ^{D}
Nano-chitosan	361.33 ^{bc}	301.00 ^{fg}	331.17 ^{Bc}	358.33 ^{c}	313.17 ^{ef}	335.75 ^{C}
Potassium Silicate	398.00 ^{a}	327.00 ^{de}	362.50 ^{A}	391.67 ^{a}	336.00 ^{d}	363.83 ^{A}
Mean	345.17 ^{A}	301.11 ^{B}		347.44 ^{A}	310.42 ^{B}	
			Fruit dry weight (g)			
Control	0.166 ^{h}	0.153 ^{i}	0.160 ^{D}	0.204 ^{f}	0.192 ^{f}	0.198 ^{D}
Proline	0.230 ^{c}	0.202 ^{e}	0.216 ^{B}	0.305 ^{b}	0.266 ^{de}	0.285 ^{B}
Fulvic acid	0.208 ^{de}	0.189 ^{g}	0.199 ^{C}	0.287 ^{c}	0.260 ^{e}	0.274 ^{C}
Glutamic acid	0.232 ^{bc}	0.196 ^{f}	0.214 ^{B}	0.325 ^{a}	0.267 ^{de}	0.296 ^{A}
Nano- chitosan	0.235 ^{b}	0.209 ^{d}	0.222 ^{A}	0.318 ^{ab}	0.281 ^{c}	0.300 ^{A}
Potassium Silicate potassium	0.239 ^{a}	0.205 ^{de}	0.222 ^{A}	0.331 ^{a}	0.276 ^{cd}	0.304 ^{A}
Mean	0.218 ^{A}	0.192 ^{B}		0.295 ^{A}	0.257 ^{B}	

Values have the same letter are not significantly different at 5% level using Duncan's New Multiple Range Test

Dealing with the interaction effect between plant density and stimulative substance, it was noticed that the interaction between normal plant distant and silicate recorded significantly the highest values of fruit hardness (398.00 and 391.67 g/m^3) and dry weight (0.239 and 0.331 g). Meanwhile, the interaction between intensive plant density and control treatment recorded the least values in fruit hardness and fruit dry weight.

Coloring index of ripening and productivity (Ton/Fed)

The data in table (8) reveals the effect of planting density and stimulative substances and their interactions on the ripeness degree and productivity/area in the two seasons. It had been stated that the coloring index generally ranged from 1.75 to 0.98 in the first season and from 2.24 to 0.80 in the second one. While the productivity of olive trees (ton/fed) ranged from 5.60 to 13.72 ton/fed and from 5.13 to 12.13 ton/fed in the 1st and 2nd seasons.

As for the effect of planting density, the highest coloring index (1.46 and 1.70) was obtained from olive trees grown under intensive plant density in both tested seasons, compared with olive trees grown under normal plant density. Meanwhile, normal plant density recorded the highest values of productivity/area (10.93 and 9.29 ton/fed).

Concerning the effect of stimulative substances, data showed that fulvic acid gave the highest values of coloring index (1.42 and 1.71) in the two seasons respectively, and without significant differences with proline treatment in the second season only. The effect of amino acids on fruit colour may play a significant role in the formation of chlorophyll, which in turn influences the amount of carbohydrates present (Abo-Elmagd *et al.,* 2015).

Similarly, the highest productivity (ton/fed) was obtained from olive trees treated by proline (11.64 and 10.27 ton/fed) and Nano- chitosan (11.48 and 10.36 ton/fed) in both seasons respectively. Otherwise, control treatment recorded the least coloring index and productivity in both seasons. The positive effect of proline application on fruit productivity has been reported by Caronia *et al.* (2010) and Okba *et al.* (2022).

In addition, the interaction between planting density and stimulative substances was significant and clearly indicates that, proline or fulvic acid treatments under intensive plant density give highest coloring index in both seasons. Meanwhile, the highest fruit productivity was obtained from trees cultivated in normal plant density and treated by Nano-chitosan in both seasons.

Table 8. Influence of some stimulative substances and planting density on the coloring index of ripening and productivity (Ton) of Toffahi Olive cultivar during 2021 and 2022 seasons.

Treatment	Frist season			Second season		
	Plant density		Mean	Plant density		Mean
	Normal	Intensive		Normal	Intensive	
	Color index					
Control	1.09 ef	0.73 h	0.91 D	0.80 g	1.02 f	0.91 E
Proline	0.97 g	1.73 a	1.35 B	1.10 ef	2.18 a	1.64 AB
Fulvic acid	1.10 e	1.75 a	1.42 A	1.18 de	2.24 a	1.71 A
Glutamic acid	1.28 d	1.40 bc	1.34 B	1.54 c	1.58 bc	1.56 BC
Nano-chitosan	1.15 e	1.44 b	1.30 B	1.32 d	1.72 b	1.52 C
Potassium Silicate	0.98 fg	1.33 cd	1.16 C	1.22 de	1.48 c	1.35 D
Mean	1.04 B	1.46 A		1.19 B	1.70 A	
	productivity (ton/fed)					
Control	8.21 g	5.60 i	6.91 E	6.44 g	5.13 h	5.78 D
Proline	12.37 b	10.92 d	11.64 A	10.64b	9.89 bc	10.27 A
Fulvic acid	9.47 f	6.72 h	8.10 D	7.79ef	6.07 gh	6.93 C
Glutamic acid	10.31 e	8.40 g	9.36 C	8.82de	7.65 f	8.24 B
Nano- chitosan	13.72 a	9.24 f	11.48 A	12.13a	8.59 def	10.36 A
Potassium Silicate potassium	11.48 c	9.99 e	10.73 B	9.94bc	9.52 cd	9.73 A
Mean	10.93 A	8.48 B		9.29 A	7.81 B	

Values have the same letter are not significantly different at 5% level using Duncan's New Multiple Range Test

Fruit chemical properties

Olive trees planted at normal density displayed significantly higher fruit acidity (0.127 and 0.360) in both seasons, respectively, and phenols 0.123 in first season, while the highest phenols in olive fruit were recorded by intensive plant density in second season only (Table 9).

Table 9. Influence of some stimulative substances and planting density on fruit chemical properties of Toffahi Olive cultivar during 2021 and 2022 seasons.

Treatment	Frist season			Second season		
	Plant density		Mean	Plant density		Mean
	Normal	Intensive		Normal	Intensive	
	Fruit acidity (mg/100 g fruit juice)					
Control	0.128 f	0.155 a	0.142 B	0.367 f	0.384 d	0.376 C
Proline	0.108 i	0.113 h	0.111 B	0.378 e	0.397 c	0.388 A
Fulvic acid	0.136 d	0.087 j	0.112 D	0.401 b	0.350 g	0.376 C
Glutamic acid	0.150 c	0.114 gh	0.132 C	0.267 j	0.229 k	0.248 E
Nano-chitosan	0.153 b	0.133 e	0.143 A	0.405 a	0.366 f	0.386 B
Potassium Silicate	0.085 k	0.115 g	0.100 F	0.340 h	0.320 i	0.330 D
Mean	0.127 A	0.120 B		0.360 A	0.341 B	
	Phenols (mg/ g)					
Control	0.115 c	0.105 e	0.110 D	0.298 h	0.299 g	0.299 D
Proline	0.114 c	0.114 c	0.114 C	0.242 k	0.388 c	0.315 C
Fulvic acid	0.136 a	0.108 d	0.122 A	0.279 i	0.475 a	0.377 B
Glutamic acid	0.129 b	0.109 d	0.119 B	0.424 b	0.352 d	0.388 A
Nano- chitosan	0.130 b	0.114 c	0.122 A	0.330 e	0.216 l	0.273 F
Potassium Silicate	0.135 a	0.109 d	0.122 A	0.315 f	0.275 j	0.295 E
Mean	0.123 A	0.113 B		0.314 B	0.334 A	

Values have the same letter are not significantly different at 5% level using Duncan's New Multiple Range Test

The effect of stimulative substances on the chemical properties of olive fruits varied during the two years of the study. The highest fruit acidity in first season was recorded by Nano-chitosan treatment, while, proline treatment gave the highest fruit acidity in the second one.

The interaction between treatments (density and stimulative substance) were significant in the two seasons, whereas the lowermost fruit acidity and phenols were obtained in the first season throw using the normal density and proline treatment. The uppermost fruit acidity was obtained by treatments (intensive density and control). While, the olive trees planted at normal density and treated by fulvic acid gave the highest phenol content in olive fruits. In the second season the uppermost fruit acidity was obtained by the interaction treatment (normal density + nano-chitosan). Whereas, the uppermost value of phenol was obtained by treatment (olive planted in intensive density and fulvic acid application).

Light intensity

The results presented in Table (10) demonstrate the effect of simulative substances and planting density and their interaction on light intensity among olive trees under study. The light intensity among olive trees was significantly affected with plant density, the normal olive density recorded the higher most light intensity among olive trees in different times during the day (86803 and 83611 cd/m^2) at 12 pm and (33550 and 33648 cd/m^2) at 4 pm in both seasons respectively.

Table 10. Influence of some simulative substances and planting density on light intensity at different time between olive trees cv. (Toffahi).

Treatment	Frist season			Second season		
	Plant density		Mean	Plant density		Mean
	Normal	Intensive		Normal	Intensive	
	Light intensity 12 pm (cd/m^2)					
Control	81437 ^{c}	58050^e	69743 ^{C}	66995 ^{b}	52262 ^{c}	59628^B
Proline	85412 ^{b}	60012 ^{e}	72712 ^{B}	90312 ^{a}	56237 ^{bc}	73274 ^{A}
Fulvic acid	89487 ^{a}	60800 ^{de}	75143 ^{A}	87137 ^{a}	52812 ^{c}	69974 ^{A}
Glutamic	89687 ^{a}	61087 ^{de}	75387 ^{A}	85925 ^{a}	55600 ^{bc}	70763 ^{A}
Nano-chitosan	87162 ^{ab}	63512 ^{d}	75337 ^{A}	85512 ^{a}	54100 ^{c}	69806 ^{A}
Potassium Silicate	87637 ^{ab}	60875 ^{de}	74256^{AB}	85787 ^{a}	57425 ^{bc}	71606 ^{A}
Mean	86803 ^{A}	60723 ^{B}		83611 ^{A}	54739 ^{B}	
	Light intensity 4 pm (cd/m^2)					
Control	32050 ^{b}	11712 ^{e}	21881 ^{C}	37822 ^{a}	7925 ^{f}	22873^{BC}
Proline	32812 ^{ab}	12950 ^{de}	2288 ^{BC}	37712 ^{a}	11812 ^{de}	24762 ^{A}
Fulvic acid	34850 ^{a}	13250 ^{de}	22912^{BC}	32002 ^{b}	10262 ^{ef}	21132 ^{D}
Glutamic	34600 ^{ab}	10975 ^{e}	23925^{AB}	30835 ^{b}	11912 ^{de}	21373^{CD}
Nano- chitosan	32662 ^{ab}	17712 ^{c}	25187 ^{A}	31045 ^{b}	15812 ^{c}	23428^{AB}
Potassium Silicate	34325 ^{ab}	14375 ^{d}	24350 ^{B}	32475 ^{b}	13317 ^{d}	22896^{BC}
Mean	33550 ^{A}	13496 ^{B}		33648 ^{A}	11840 ^{B}	

Values have the same letter are not significantly different at 5% level using Duncan's New Multiple Range Test

As for foliar application effect. In first season the higher most significant values of light intensity at 12 pm were recorded among olive trees treated with glutamic (75387 cd/m^2) without a significant difference with those trees treated by nano-chitosan, fulvic acid and silica-potassium, meanwhile proline application achieved the higher most values in the second one (73274 cd/m^2) without significant differences with other foliar application in compere with the control.

The effect of the treatments differed somewhat during the daytime. The highest significant values of light intensity in the first season were recorded during the olive trees at 4 pm in the trees treated with nano-chitosan (25187 cd/m^2) without significant differences with those treated with glutamic. While, the treatments of proline and nano- chitosan gives the higher most light intensity in the second one (24762 cd/m^2) and (23428 cd/m^2) respectively.

As for the effect of interaction, results show significant effects for treatments used in the study. The lower most statistically light intensity at 12 pm was among control x intensive plant density (58050 and 52262 cd/m^2) in first and second season, respectively. On the other hand, glutamic x normal plant density achieved the higher most light intensity (89687 cd/m^2) in the first season. The application of proline x normal plant density recorded the highest light intensity in the second one and without significant differences with those recorded by other foliar application x normal plant density.

CONCLUSION

Results of the present study showed considerable variation in morphological and chemical fruit characteristics as the effect of two investigated factors (planting density and stimulative substances). The results showed that spraying trees with Nano-chitosan or potassium silicate enhanced fruit physical characteristics (fruit and pulp weight, fruit dimension, fruit hardness and dry matter). Whereas, trees treated with Nano-chitosan or proline recorded the highest productivity in both seasons. In addition, Fulvic acid acquired the highest ripening degree (coloring index). Conversely, in the fruit chemical properties, there were no apparent effect of treatments from1st season to 2nd season in each of acidity and proline. In regards to the type of planting density effect, it noticed the superiority of normal plant density than intensive.

Finally, it can be concluded that spraying Toffahi Olive trees planted under normal density with simulative substances potassium silicate or Nano- chitosan was the best treatment in terms of fruit characteristics and productivity to raise its efficiency in resisting salt conditions.

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تأثير بعض المواد المحفزة والكثافة النباتية على صفات ثمار الزيتون صنف التفاحي تحت ملوحة التربة

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الملخص

أجريت هذه التجربة خلال موسمين متتاليين (2021 و2022) لدراسة تأثير المواد المحفزة المختلفة (البرولين بتركيز 150 جزء في المليون، وحمض الفولفيك بتركيز 50 جزء في المليون، وحمض الجلوتاميك بتركيز 500 جزء في المليون، والنانو-شيتوزان بتركيز 50 جزء في المليون، وسيليكات البوتاسيوم بتركيز 1000 جزء في المليون) مع نوعين من الكثافة النباتية (عادية 5*6 م ومكثفة 3*5 م) و التفاعل بينهما على إنتاجية وخصائص ثمار أشجار الزيتون صنف التفاحي عمر 21 سنة المزروعة في تربة رملية مالحة والمروية بنظام التنقيط في مزرعة خاصة تقع في مدينة فايد بالإسماعيلية ، مصر. أظهرت النتائج أن رش الأشجار بالنانو-شيتوزان أو سيليكات البوتاسيوم أدى إلى تحسين الخصائص الفيزيائية للثمار (وزن الثمار واللب، وأبعاد الثمار، وصلابة الثمار والمادة الجافة). في حين سجلت الأشجار المعالجة بالنانو-شيتوزان أو البرولين أعلى إنتاجية في كلا الموسمين. بالإضافة إلى ذلك، احرز حمض الفولفيك أعلى درجة النضج (مؤشر اللون) . وعلى العكس من ذلك في الخواص الكيميائية للثمار لم يكن للمعاملات من الموسم الأول إلى الموسم الثاني تأثير واضح في كلاً من الحموضة والبرولين. أما بالنسبة لتأثير نوع الكثافة النباتية فمن الواضح تفوق الكثافة النباتية العادية.