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Investigation on Yield Traits and Quality Properties of some Egyptian Cotton Genotypes Treated with Nano Titanium (TiO_2)

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Shimaa A. Shahat[*]; W. M. B. Yehia and Yasser, A. Abd El-Baset

Cotton Research Institute, Agricultural Research Center, Giza, Egypt.

ABSTRACT

Two field experiments were carried out at Sakha Agricultural Research Station, Agricultural Research Center, Kafr El-Sheikh, Egypt in 2017 and 2018 growing seasons, using Giza 94 and Giza 97 Egyptian cotton genotypes to investigate the effect of foliar application of nano titanium under three concentrations (25, 50 and 100ppm concentration of n-TiO_2) at two foliar application times (at the beginning of flowering and at the top of flowering) on yield, yield components and fiber quality. The experimental design was split plot design in three replicate. The obtained results indicated that titanium foliar treatments at the beginning of flowering recoded significant increase in yield characters except boll weight in both varieties compared to spraying at the top of flowering. Using 50ppm of nano titanium treatment improved significantly yield and yield component (No. of open boll/ plant, boll weight (g), seed index(g), seed cotton yield(g/plant), lint cotton yield (g/plant) and lint percentage%) compared to the control, 25ppm and 100ppm of n-TiO_2 treatments, however this improvement in fiber properties was practically of low magnitude in both varieties along the two seasons. The Effect of growing season on yield traits was insignificant in most cases while it was insignificant on all fiber properties of the two varieties. Chemical analysis of the seed produced from 100ppm treatment indicated that the residue amount of titanium in the seed is lower than the permitted limits specified by World Health Organization in food and feed products.

Keywords: Nano-titanium dioxide- foliar application - yield- cotton fiber quality

INTRODUCTION

Titanium (Ti) is considered a beneficial element for plant growth. Ti applied via roots or leaves at low concentrations has been documented to improve crop performance through stimulating the activity of certain enzymes, enhancing chlorophyll content and photosynthesis, promoting nutrient uptake, strengthening stress tolerance, and improving crop yield and quality Lyu *et al.* (2017). Furthermore, Cigler *et al.* (2010) concluded that the beneficial roles Ti plays in plants lie in its interaction with other nutrient elements primarily iron (Fe). Fe and Ti have synergistic and antagonistic relationships. When plants experience Fe deficiency, Ti helps induce the expression of genes related to Fe acquisition, thereby enhancing Fe uptake and utilization, subsequently improving plant growth. Lyu *et al.* (2017) added that Plants may have proteins that either specifically or nonspecifically binds with Ti. When Ti concentration is high in plants, Ti competes with Fe for ligands or proteins. The competition could be severe, resulting in Ti phytotoxicity. As a result, the beneficial effects of Ti become more pronounced during the time when plants experience low or deficient Fe supply. Li *et al.*, (2011) mentioned that, Ti has also been used as a beneficial element in China for crop production, since it improves plant health status at low concentrations but has toxic effects at high concentrations. The actions of Ti as a beneficial element to plants, including (1) participation in N fixation in the nodules of legumes; (2) influence plant metabolism by increasing absorption of other nutrient elements, such as Fe and Mg Dumon and Ernst, (1988); (3) involvement in redox system reactions (Ti^{4+} /Ti^{3+} with Fe^{3+} /Fe^{2+}) thus improving the Fe activity in plant tissues Carvajal *et al.*, (1995). or interacting with Fe in electron transport chain and decrease of the photo system II efficiency at a high Ti concentration Cigler *et al.*, (2010); (4) stimulation of enzymatic activities and photosynthesis Carvajal and Alcaraz, (1998). Bacilieri *et al.*, (2017) indicated that this element has a positive effect on crop phenological events such as germination, root formation, vegetative growth, maturation, protein synthesis, uptake of nutrients, activity of antioxidant enzymes and photosynthesis, as well as resistance to biotic or abiotic stress conditions and general crop health status. Carvajal and Alcaraz, (1998) and Bacilieri *et al.* (2017) added that Titanium boost the uptake of macro and micronutrients, enzymatic activity in plants, and consequently increase yield. Moreover, Botia *et al.*, (2002) reported that titanium improves yield of biomass, nutritional status of plants, stimulates enzymatic activity, increases photosynthesis, participates in the synthesis of proteins & chlorophyll, fruit quality and in the control of plant diseases. Hrubý *et al.*, (2002); Kuzel *et al.*, (2003), Eichert and Fernandez (2012) and Fallahi and Eichert, (2013) cleared that, Ti in both bulk and Nanoparticles has been applied as liquid form to above-ground plant parts, commonly known as foliar application. Leaf absorption initially is a nonselective and passive process driven by concentration gradients between the outside and inside of the leaf surface. Ti may enter the leaf apoplast through the same routes as Fe, i.e., stomata, cuticular cracks (cracks on the cuticular surface), ectodesmata, lenticels or aqueous pores Pandey *et al.* (2013). After arriving in the apoplast, Ti could

[*] **Corresponding author.**
E-mail address: shimaaabdrabou1981@yahoo.com
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be transported to symplast through the active process. The mechanism by which Ti crosses cell membranes is unknown; they assume that it could be similar to root absorption of Ti through Fe transporters.

Siddiqui *et al.* (2015). Mentioned that, nanoparticles (NPs) have unique physicochemical properties, *i.e*., high surface area, high reactivity, tunable pore size, and particle morphology. Nanoparticles can serve as "magic bullets", containing herbicides, nano-pesticide fertilizers, or genes, which target specific cellular organelles in plant to release their content. Wang *et al*. (2013) cleared that; Leaf absorption of TiO_2NPs to apoplast could be via the same paths as the bulk materials. Due to the size effects, however, small-diameter TiO_2NPs may gain access to symplast through direct penetration. NPL, (2002) and Frazer, (2014) stated that Ti, foliar fertilization can be beneficial because Ti supply via soil is not effective as this element is characterized by low mobility in soil and presents limited uptake by roots. Hong *et al.* (2005) and Yang *et al.* (2006) demonstrated that, TiO_2NPs increases light absorbance, hasten the transport and conversion of the light energy, protect chloroplasts from aging, and prolong the photosynthetic time of the chloroplasts. Kirschbaum (2011) cleared that Nano-anatase TiO_2 have a photocatalyzed characteristic and improves the light absorbance and the transformation from light energy to electrical and chemical energy, and also induces carbon dioxide assimilation. The exogenous application of TiO_2NPs improves net photosynthetic rate, conductance to water, and transpiration rate in plants Qi *et al.* (2013). Furthermore, Karami and Ali (2018) stated that, the n-$TiO_2$was found to aid in strengthening the antioxidant enzyme activities in barley plants. Additionally, n-TiO_2 can decrease the inhibition impacts of salinity stress by improving relative water content (RWC), chlorophyll content and net photosynthetic rate. Singh *et al*. (2021) mentioned that researchers are paying attention on developing some TiO_2-NP- based formulations to be used in agriculture to improve crop yield and quality and also to protect plants from various pests and pathogens and improve the plant performance under various abiotic stresses.

Raliya *et al*. (2015) reported that, in addition to root pathway, TiO_2-NPs can also enter the plants by means of leaves through foliar spray. The entry of TiO_2-NPs through aerial parts may involve stomata, lenticels and cuticle wounds or they may directly penetrate through the foliar cells then, translocated to other plant tissues along with the sugar and nutrients through phloem. Cox *et al*. (2016), Chaudhary and Singh (2020) added that impacts posed by TiO_2-NPs exhibit a dual characteristic, as it could be either toxic or beneficial due to various factors such as experimental conditions and features of targeted plants. Chao and Choi (2005) and Lei *et al.* (2007) demonstrated that, application of titanium dioxide (TiO_2) on food crops has promoted plant growth, increase the photosynthetic rate, reduce disease severity and enhance yield by 30%.

Wang *et al*., (2007) and Chen *et al*., (2011) mentioned that the lethal dose of TiO_2 is greater than 10g/kg and it has been approved as a food additive since 1996 by the Food and Drug Administration (FDA). The FDA and Environmental Protection Agency (EPA) have specified 50μg/kg body weight/day of nano-TiO_2 (nTiO_2) as a safe dose for humans. Furthermore, the European Commission's Scientific Committee on Food (SCF), the Joint Expert Committee on Food Additives of the Food and Agriculture Organization/ World Health Organization (JECFA), and the European Food Safety Authority (EFSA) demonstrated that TiO_2 is biologically inactive and Physiologically inert, exhibiting relatively low toxicity, thus posing low risk to humans.

The literature concerning the effect of titanium dioxide on cotton yield and lint and seed quality was poor, nevertheless, a research study about the effect of TiO_2 foliar application on growth and yield of Giza 94 Egyptian cotton variety conducted by El-Shimaa (2017) who found that exogenous application of nanoTiO_2 under different concentrations led to improve physiological, morphological and yield of cotton, she added that the best treatment was spraying cotton plants with 50 ppm. n TiO_2

Therefore, the main objective of this research is to study the influence nano titanium dioxide as foliar application on cotton yield, yield components and fiber quality.

MATERIALS AND METHODS

Two field experiments were carried out in 2017 and 2018 seasons at Sakha Agricultural Research Station, Kafr El-sheikh, Egypt, dependencies to Agricultural Research Center, Giza, Egypt. Using Two Egyptian LS cotton genotypes: Giza 94 and promising cotton cross {[(Giza 89 X Karshinky) X Giza 86] X Giza 94} (recently Giza 97) (*Gossypium barbadense L*.). The experimental design was split-plot design with three replicates. The two spraying times with titanium assigned for main-plots and their concentrations were assigned for sub-plots. Two times of foliar application treatments were applied; a) at the beginning of flowering and 60 days after planting and b) at the top of flowering, 15 days after the fist spray. Nano titanium dioxide (nTiO2) was used as foliar spraying in different concentrations (25, 50 and 100 ppm) besides control treatment was sprayed by tap water. TiO2 anatase, Nano powder 99.9% (metals basis), 32 nm APS powder, S.A. 45m/g, was provided by Alfa Aesar company (email: alfaaesar. eurosales@ thermofisher.com). The sub- plot area was 14.4 m2 and contained six ridges of 4.0 m long and 70 cm apart (56000 cotton plants/ feddan). The planting date was 30th April in both seasons. The preceding winter crop was Egyptian clover. Cotton planting was done by local method of dibbing 5 to 7 seeds in each hill by hand with 25 cm distance between hills. Thinning was conducted after 35 days of sowing to maintain better two plants per hill. The cultural practices including irrigation, application of fertilizers and insecticides etc. were conducted as recommended by Cotton Research Institute to maximize the cotton yield.

Soil samples were taken randomly from the experiment site before sowing at 0.30 m depth to determine physicochemical properties of experiment soil. Soil texture of the experimental site was clay. Soil chemical properties were determined according to standard methods outlined by Jackson (1973). Available manganese, iron, zinc and copper were determined using Atomic Absorption Spectrophotometer (AAS) after extracting the soil solution with DTPA as proposed by Lindsay and Norvell (1978). The averages of physicochemical properties of the experimental soil are shown in Table (1) (Average of the two seasons).

Table 1. Physicochemical properties of the experimental soil

Available macro Nutrients (ppm)	
N	62.40
P	6.15
K	293.40
Solution Ions (ppm)	
Fe	3.03
Mn	0.79
Zn	0.09
Cu	2.58
Chemical analysis	
PH	7.90
EC	3.48
SP %	70.00
Mechanical analysis	
Clay %	44.37
Silt %	31.05
Sand %	24.42

Traits studied:

A- Yield and yield components:

In both season, at harvest time, ten plants were randomly chosen from the two center ridges of each sup-plot to determine:

1) Boll weight (g). It was calculated from the following formula:

$$\textbf{Boll weight (g)} = \frac{\textbf{Seed cotton yield/plant (g)}}{\textbf{No. of open bolls/plant at harvest}}$$

2) Seed index (g). Determined from the average weight in grams of 100 seeds taken at random after ginning.
3) Lint percentage (%). It was calculated from ginning the seed cotton of the selected ten plants and applying the following formula:

$$\textbf{Lint percentage (\%)} = \frac{\textbf{Weight of lint cotton (g)}}{\textbf{Weight of seed cotton (g)}} \textbf{ x 100}$$

4) Seed cotton yield/plant (g). It was determined by dividing the seed cotton yield of the ten selected plants by ten
5) Lint cotton yield/plant (g). It was determined by dividing the lint cotton yield of the ten selected plants by ten

B- Fiber properties:

1- Upper half mean length (mm)
2- Length uniformity index (%)
3- Fiber strength (g/tex)
4- Micronaire reading
5- Fiber maturity ratio

The aforementioned fiber quality properties were determined at Cotton Technology Research Division, Cotton Research Institute, Giza, Egypt, at a constant relative humidity 65% (±2) and temperature 21C ° (±1) using HVI spectrum according to (ASTM-D-5867-05).

Determination of the residual amount of titanium in the produced cotton seeds:

Since the high doses of n Tio_2 may have toxic effects on human and animals and the cotton seeds are used in extracting oil for food and making seed cake for feed, samples of the seeds produced from the high concentration foliar application treatment 100ppm n-Tio_2 were sent and tested in The Regional Center for Food & Feed, using Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) [optima 2000 DV-Perkin Elmer, Germany instrument and applying Titanium stander stock solution 1000ppm from Sigma-Aldrich for Calibration Curve to determine the residual amount of titanium in the cotton seeds of the two studied varieties.

Statistical analysis:

The obtained data were subjected to Analysis of variance and LSD 5% test was employed to compare the different means of each studied character. The analysis of variance and LSD test were carried out according to Snedecor and Cochoran (1986). Data of each variety was analyzed separately.

RESULTS AND DISCUSSION

A-yield and yield components:

Results in Table (2) and Table(3) showed that the effect of titanium concentrations, time of foliar application, growing seasons and their interactions on yield and yield components characters of the two Egyptian LS cotton varieties; G.94 and G.97 was statistically significant except the effect of growing season which was not significant in most cases in the two varieties.

Effect of growing season:

Data in Table (2) and Table (3) indicated that, in G.94 and G.97, both seasons showed insignificant differences in all the studied yield traits except in seed index of G.94 where 2018 season showed higher seed index than 2017 and showed higher values of seed and lint cotton yield/plant and lint % in G.97

Effect of foliar application times:-

Results in Table (2) and Table (3) cleared that, foliar application of n-Tio_2 at the beginning of flowering recorded higher values of cotton yield and its components of the two varieties in both seasons compared to the treatment at the top of flowering except the difference between the two spraying times in boll weight in both seasons and lint %in 2017 which was not significant.

In case of G.94, foliar application of n-Tio2 at the beginning flowering surpassed the spraying of TiO_2 at the top of flowering in all the studied yield traits. It recorded 18.0 and 17.5 for No.of open bolls/plant, recorded 4.0 and 4.1g for boll weight, 12.6 and 12.9g for seed index, 72.2 and 72.0 g for seed cotton yield/plant, 28.77 and 29.07g for lint cotton yield/plant and recorded 39.57 and 40.13% for lint % in both seasons respectively, While spraying n-TiO_2 at the top of flowering recorded 15.7 and 14.60 boll for No.of open bolls/plant, recorded 3.9 and 4.0gfor boll weight, 12.13 and 12.23g for seed index, 60.90 and 58.8 g for seed cotton yield/plant, 23.9 and 23.23g for lint cotton yield/plant and recorded 39.17 and 39.47% for lint % in both seasons respectively.

Concerning G.97, it showed the same trend of G.94 indicating that foliar application of n-Tio_2 at the beginning of flowering showed higher values of yield traits than the spraying of n-Tio_2 at the top of flowering to be 16.4 and 16.8 for No. of open bolls/plant, 11.63 and 12.0 g for seed index, 64.7 and 67.0g for seed cotton yield/plant, 25.2 and 26.6g for lint cotton yield/plant and 38.8 and 39.5% for lint percentage in both season respectively, While the spraying of n-Tio2 at the top of flowering recorded 15.20 and 16.14No. of open bolls/plant, 11.4g in both season for seed index,59.17 and 62.73g for seed cotton yield/plant, 22.81 and 24.33g for lint cotton yield/plant and 38.5 and 38.7% in both season respectively. These results agreed with Al-Shimaa (2017), Qi *et al*. (2013) and Carvajal and Alcaraz, (1998) who mentioned that, the Increase in yield traits levels when treated with nano-sized titanium dioxide may due to the photocatalyst ability of the nano-sized titanium dioxide, which leads to an increased photosynthetic rate. Titanium nanoparticles improved yield and yield components.

Effect of nano-Tio2 concentrations on yield and its components of Giza 94 and Giza 97 cotton genotypes.

The results indicated that, concentrations of nano Tio_2, affected significantly most of yield and yield components characters; (No. of open bolls/ plant, boll weight, seed index, seed cotton yield, lint cotton yield and lint %) of the two varieties in both seasons.

Concerning G.94, The results presented in Table (2) cleared that using of 50 ppm concentration of n-TiO_2 as a foliar application at the beginning flowering showed the highest values of most yield traits. In 2018 season, it recorded20.9 for No.of open bolls/plant, recorded 4.3g for boll weight, 13.4gfor seed index and recorded 89.7g for seed cotton yield/ plant,38.0gfor lint cotton yield/ plant and recorded 42.4% for lint percentage. While, in 2017 season, it recorded 20.2 for No.of open bolls/plant, recorded 4.3g for boll weight, 13.2g for seed index and recorded 87.0g for seed cotton yield/ plant, 36.5g for lint cotton yield/ plant and recorded 42.0% for lint percentage. The control treatment significantly produced the lowest values of the above traits in both seasons; being14.7 and 14.9 for No.of open bolls/plant, 3.6 and 3.62g for boll weight, 10.2 and 10.7g for seed index, 52.9 and 54.0g for seed cotton yield/plant, 16.5 and 16.9g for lint cotton yield/plant in the first and second season, respectively, whereas, the lowest values of lint % were obtained from 100ppm concentration treatment at the top flowering being 37.6 and 38.0% in both season respectively.

The superiority ratios in 2018 season, between the medium concentration (50ppm) to the control and both of low concentration (25ppm) and high concentration (100ppm) at the beginning flowering amounted to 40.1,33.9, and 30.6% for No.of open boll/plant, 18.8,7.5, and 7.5 % for boll weight, while being25.2, 5.5, and 8.9 %for seed index, being 66.1, 44.2, and 40.2 % for seed cotton yield/plant, 80.5, 56.4 and 52.6% for lint cotton yield/plant and 8.8, 8.4 and 9.0% for lint % respectively

Similar results were noticed in 2017 season, the superiority ratios of n-Tio2 medium concentration (50ppm) to the control and both of low concentration (25ppm), and high concentration (100ppm) at the beginning flowering were; 37.5, 18.8, and 20.9%for No. of open bolls/plant, 19.44, 7.5 and 16.22 % for boll weight, 29.4, 4.76 and 10.0% for seed index, 64.5, 28.13 and 40.8%for seed cotton yield/plant,79.3, 38.8 and 55.3% for lint cotton yield/plant and 9.1, 8.5 and 10.5% for lint%, as compared to control and foliar sparing by n-TiO_2 concentration 25, 100 ppm treatments at the beginning flowering respectively.

Table 2. **Effect of growing season, foliar application time, concentration of nano TiO_2 and their interactions on yield traits and its components of G.94 variety.**

Treatment / Trait	No. of opened bolls/plant		Boll weight (g)		Seed index (g)		Seed cotton yield/plant (g)		Lint cotton yield/plant (g)		Lint %	
Seasons	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
Seasonsaverage	**16.22**	**15.78**	**3.88**	**3.96**	**11.80**	**12.13**	**63.15**	**62.55**	**24.84**	**24.81**	**39.1**	**39.5**
LSD at 5%	N.S		N.S		0.13		N.S		N.S		N.S	
Foliar application time												
At start of flowering stage	17.97	17.50	4.00	4.10	12.60	12.93	72.20	72.00	28.77	29.07	39.57	40.13
At the top of flowering stage	15.70	14.57	3.87	4.03	12.13	12.23	60.90	58.77	23.90	23.23	39.17	39.47
LSD at 5%	0.85	0.72	N.S	N.S	0.24	0.25	1.60	1.32	1.34	1.00	N.S	0.50
Titianium dioxide (TiO_2) concentration (ppm)												
Control	14.7	14.9	3.6	3.62	10.2	10.7	52.9	54.00	20.36	21.05	38.5	39.0
25 ppm of nano TiO_2	16.70	14.30	4.00	4.00	12.40	12.60	66.80	57.10	25.70	22.00	38.50	38.50
50 ppm of nano TiO_2	17.90	18.50	4.20	4.20	12.70	13.00	75.30	77.50	31.50	32.60	41.80	42.10
100 ppm of nanoTiO_2	15.60	15.40	3.70	4.00	11.90	12.20	57.60	61.60	21.80	23.60	37.80	38.30
LSD at 5%	0.80	0.68	0.21	0.18	0.30	0.27	1.50	1.20	1.30	0.8	0.60	0.48
Interaction effect												
25 ppm of nano TiO_2												
At start of flowering stage	17.00	15.60	4.00	4.00	12.60	12.70	67.90	62.20	26.30	24.30	38.70	39.10
At the top of flowering stage	16.80	13.00	3.90	4.00	12.10	12.40	65.70	52.00	25.10	20.10	38.20	38.70
50 ppm of TiO_2												
At start of flowering stage	20.20	20.90	4.30	4.30	13.20	13.40	87.00	89.70	36.50	38.00	42.00	42.40
At the top of flowering stage	15.90	15.90	4.00	4.10	12.60	12.10	63.60	65.30	26.50	27.20	41.70	41.70
100 ppm of TiO_2												
At start of flowering stage	16.70	16.00	3.70	4.00	12.00	12.30	61.80	64.00	23.50	24.90	38.00	38.90
At the top of flowering stage	14.40	14.80	3.70	4.00	11.70	12.20	53.40	59.00	20.10	22.40	37.60	38.00
T LSD at 5%	1.1	0.98	0.32	0.28	0.35	0.38	1.80	1.50	1.55	1.31	0.72	0.65
The superiority of 50 ppm treatment of n-TiO_2 vs the control, 25ppm and 100ppm treatments												
Control	37.47	40.11	19.44	18.78	29.41	25.23	64.46	66.11	79.27	80.52	9.13	8.77
25ppm of n-TiO_2 At start of flowering stage	18.82	33.97	7.50	7.50	4.76	5.51	28.13	44.21	38.78	56.38	8.53	8.44
100ppm of n-TiO_2 At start of flowering stage	20.96	30.63	16.22	7.50	10.00	8.94	40.78	40.16	55.32	52.61	10.53	9.00

Regarding G.97 cotton variety, the results presented in table (3) showed nearly the same trend of G.94 indicating that foliar application treatment of 50 ppm of n-Tio_2 at the beginning flowering exhibited the highest values of most of yield traits. The recorded mean values in 2018 season were18.8 for No. of open bolls/plant, 4.1g for boll weight; 12.2g for seed index, 77.2g for seed cotton yield/ plant, 31.9g lint cotton yield/ plant and 41.3% for lint percentage, while recorded in 2017 season, 18.0 for No. of open bolls/plant, 4.1g for boll weight , 11.9g for seed index, 74.0 g for seed cotton yield/ plant, 29.9g for lint cotton yield/ plant and recorded 40.4% for lint percentage. Cotton plants of G.97 variety which received 100ppm concentration of nano Tio_2 treatment at the top flowering significantly produced the lowest values of most traits in both seasons, It recorded 13.0 and 12.8 for No.of open bolls/plant, 52.1 and 51.0g for seed cotton yield/plant, 19.5 and 19.0g for lint cotton yield/plant and recorded 37.4 and 37.3% for lint % in the first and the second season respectively.

The superiority ratios of the medium concentration 50ppm n-Tio_2 at the beginning flowering to the control and both of low concentration (25ppm) and high concentration (100ppm) amounted to18.99, 10.6 and 27.9% for No.of open boll/plant, 2.5, 2.5 and 7.9% for boll weight, 7.02, 4.3 and 1.7% for seed index, 22.2, 13.53 and 38.6% for seed cotton yield/plant, 28.1, 19.5 and 50.5% for lint cotton yield/plant and 4.8, 5.4 and 8.4% for lint % as compared to the control treatment and the other two concentrations; 25, 100 ppm respectively.

Similar results were noticed in 2017 season. The superiority ratios of n-Tio_2 50ppm concentration foliar application to the control, 25 ppm and 100 ppm concentrations were16.1, 11.1 and 20.0% for No. of open bolls/plant; 5.1, 5.1 and7.9% for boll weight,7.2, 5.3 and 1.7% for seed index, 22.7, 17.5 and, 29..8% for seed cotton yield/plant, 29.4, 23.1 and 39.7% for lint cotton yield/plant and 5.5, 4.9, 7.7% for lint%, respectively.

Table 3. Effect of growing season, foliar application time, concentration of nano TiO_2 and their interactions on yield traits and its components of G.97 variety.

Treatment / Trait	No. of opened bolls/plant		Boll weight (g)		Seed index (g)		Seed cotton yield/plant (g)		Lint cotton yield/plant (g)		Lint %	
Seasons	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
Average season	15.80	16.49	3.92	3.93	11.50	11.67	61.92	64.85	24.00	25.47	38.63	39.10
LSD at 5%	N.S		N.S		N.S		1.21		1.0		0.44	
Foliar application time												
At start of flowering stage	16.40	16.83	3.93	3.97	11.63	11.97	64.67	66.97	25.20	26.60	38.80	39.53
At the top of flowering stage	15.20	16.14	3.90	3.90	11.37	11.37	59.17	62.73	22.81	24.33	38.46	38.67
LSD at 5%	0.60	0.55	N.S	N.S	0.18	0.22	1.64	1.41	1.42	1.1	N.S	0.66
Titianium dioxide (TiO_2) concentration (ppm)												
Control	15.50	15.80	3.90	4.00	11.10	11.40	60.30	63.20	23.10	24.90	38.30	39.40
25 ppm of nano TiO_2	16.20	17.40	3.80	3.90	11.20	11.50	61.70	67.90	23.70	26.50	38.30	39.00
50 ppm of nano TiO_2	17.55	18.31	3.95	4.00	11.70	12.00	69.50	73.35	27.91	29.85	40.14	40.65
100 ppm of nanoTiO_2	14.00	13.70	3.90	3.90	11.60	12.45	54.60	53.40	20.50	20.10	37.50	37.70
LSD at 5%	0.82	0.71	N.s	N.S	0.20	0.24	1.46	1.38	1.29	1.30	0.54	0.42
Interaction effect												
25 ppm of nano TiO_2												
At start of flowering stage	16.20	17.00	3.90	4.00	11.30	11.70	63.00	68.00	24.30	26.70	38.50	39.20
At the top of flowering stage	15.50	17.80	3.90	3.80	11.10	11.30	60.40	67.70	23.00	26.20	38.10	38.70
50 ppm of TiO_2												
At start of flowering stage	18.00	18.80	4.10	4.10	11.90	12.20	74.00	77.20	29.90	31.90	40.40	41.30
At the top of flowering stage	17.11	17.82	3.80	3.90	11.50	11.80	65.00	69.50	25.92	27.80	39.88	40.00
100 ppm of TiO_2												
At start of flowering stage	15.00	14.70	3.80	3.80	11.70	12.00	57.00	55.70	21.40	21.20	37.50	38.10
At the top of flowering stage	13.00	12.80	4.00	4.00	11.50	11.00	52.10	51.00	19.50	19.00	37.40	37.30
LSD at 5%	1.22	1.1	N.S	N.S	0.32	0.33	1.86	1.61	1.55	1.42	0.76	0.80
The superiority of 50 ppm treatment of n-TiO_2 vs the control, 25ppm, and 100ppm treatments												
Control	16.13	18.99	5.13	2.50	7.21	7.02	22.72	22.15	29.44	28.11	5.48	4.82
25ppm of TiO_2 At start of flowering stage	11.11	10.59	5.13	2.50	5.31	4.27	17.46	13.53	23.05	19.48	4.94	5.36
100ppm of TiO_2 At start of flowering stage	20.00	27.89	7.89	7.89	1.71	1.67	29.82	38.60	39.72	50.47	7.73	8.40

These results are in line with Lyu *et al.* (2017), Al-Shimaa (2017), Qi *et al.* (2015), Yang *et al.* (2006) and Hong *et al.* (2005) who reported that the increase in growth, yield and yield components traits may due to the positive effects of titanium in different cellular mechanisms. Titanium nanoparticles helped the water absorption and improved growth. Furthermore, TiO_2NPs increases light absorbance, hasten the transport and conversion of the light energy, protect chloroplasts from aging, and prolong the photosynthetic time of the chloroplasts. Moreover, tio2 participate in the synthesis of proteins &chlorophyll could ultimately reflect as improved biomass and yield of treated plants.

B- Fiber properties:-

Mean values of fiber quality properties; upper half mean, fiber uniformity index, Fiber strength, micronaire reading and maturity ratio for the two Egyptian cotton genotypes G.94 and G.97 as affected by growing season, time of foliar application with n-Tio_2, concentrations, and their interaction are presented in Table (4) and Table (5). The results indicated that the differences between the mean values of all the studied fiber quality properties pertaining the effect of growing season and the effect of spraying times were not statistically significant. Whilst, the effect of n-TiO_2 concentrations and their interactions were statically significant in both varieties.

Effect of growing season:

Data in Table (4) and Table (5) indicated that, in G.94 and G.97, both seasons showed insignificant differences in all the studied fiber quality. Both seasons recorded nearly similar means for fiber properties with slight insignificant increase in favor of 2018 season, meanwhile the recorded means of fiber traits of the two varieties were very close to be 33.5 mm for upper half mean length of the two varieties, 85.6% and 85.5 %for length uniformity index for Giza 94 and Giza 97, 42.5 g/tex for length strength in both varieties, 4.4 and 4.3 for micronaire value, and 0.94 and 0.93 for maturity ratio in both varieties respectively.

Effect of foliar application times:-

The results in Table (4) and Table (5) showed that the differences between foliar spray with nano titanium at the beginning of flowering and the spraying at the top of flowering were not statistically significant for all fiber quality properties of the two cotton varieties along the two seasons.

In both of G.94 and Giza 97, foliar application of n-Tio_2 at both of the spraying times showed nearly similar means for the different fiber properties with slight insignificant increase in favor of the spraying of TiO_2 at the beginning of flowering in most of the studied fiber quality properties. Both spraying times recorded 33.5 and 33.6mm for upper half mean length of the two varieties, 85.6 and 85.4 % for length uniformity index, 42.6 and 42.7 g/tex for fiber strength, recorded 4.4 and 4.3for micronaire value and 0.94 and 0.93 for maturity ratio in both of Giza 94 and Giza 97 respectively. Karami and Ali (2018), Lyu *et al.* (2017), Al-Shimaa (2017), Bacilieri, (2017) revealed that titanium element has a positive effect on crop phonological events such as germination, root formation, vegetative growth, maturation, protein synthesis, uptake of nutrients, activity of antioxidant enzymes and photosynthesis, as well as resistance to biotic or abiotic stress conditions and general crop health status, all of these effects can influence and reflect on fiber quality.

Effect of nano-Tio2 concentrations on fiber quality of Giza 94 and Giza 97 cotton genotypes.

Based on the variance analysis of all fiber quality data, the differences in fiber quality measurements due to the effect of nano Tio2 concentrations; 25, 50 and 100ppm application treatments were statistically significant

In regard to G.94 variety, the results in table (4) cleared that using of 50 ppm concentration of n-TiO_2 as a foliar application at the beginning of flowering showed noticeable and statistically significant improvement inmost of fiber properties means compared to the control and the other two concentrations. It recorded 34.3mm for upper half mean, 86.8 % for length uniformity index, 44.0g/tex for fiber strength, 4.6 for micronaire value and 0.95for maturity ratio in 2018 season, while in 2017 season, it recorded 34.0mm for upper half mean; 86.5 % for length uniformity index, 44.0g/tex for fiber strength, 4.5 for micronaire reading and 0.94for maturity ratio. On the other hand, cotton plants which received tap water (control treatment) significantly produced the lowest mean values of fiber quality traits to be 33.1mm for upper half mean length, 84.4% for length uniformity index, 42.2 g/tex for fiber strength, 4.3 for micronaire reading and 0.93 for maturity ratio in 2018 season. And recorded 33.0mm for upper half mean length, 84.3 % for fiber uniformity index, 42.0 g/tex for fiber strength, 4.2 for micronaire reading and 0.92 for maturity ratio in 2017 season. The obtained results cleared that the difference between the control and both of 25ppm and100ppm concentrations of n-TiO_2 treatments were practically of low magnitude although of their statistical significance in some cases.

The increase in mean values of fiber quality traits pertaining 50ppm concentration of n-TiO_2 at the beginning flowering treatment ranged from 2.21 % in length uniformity index in 2017 to 7.14 % in micronaire reading in 2017compared to the control treatment while this improvement ranged from 0.12 % in length uniformity index in 2018 season to 4.65 % in micronaire value in 2017 compared to 25ppm treatment of n Tio_2,and ranged from 012 % in length uniformity index in 2017 season to 4.65 in micronaire value in 2017 season compared to 100ppm treatment. 50 ppm of nTio_2 showed in general, nearly the same trend and approximately similar values of improvement in fiber quality values as compared to the control and the other two concentrations of Tio2 treatments.

Table 4. Effect of growing season, foliar application time, concentration of nano TiO_2 and their interactions on fiber quality properties of G.94 variety.

Treatment / Trait	Upper half mean length (mm)		Length uniformity index (%)		Fiber strength (g/tex)		Micronaire reading		Maturity ratio	
Seasons	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2017**
Average season	33.40	33.60	85.50	85.80	42.50	42.50	4.40	4.40	0.94	0.94
LSD at 5%		N.S		N.S		N.S		N.S		N.S
Foliar application time										
At start of flowering stage	33.50	33.70	86.20	86.30	42.70	42.70	4.40	4.50	0.93	0.94
At the top of flowering stage	33.60	33.60	85.70	85.80	42.60	42.50	4.40	4.40	0.94	0.94
LSD at 5%	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
Titianium dioxide (TiO_2) concentration(ppm)										
Control	33.00	33.10	84.30	84.40	42.00	42.20	4.20	4.30	0.92	0.93
25 ppm of nano TiO_2	33.20	33.60	85.30	86.20	42.10	42.30	4.40	4.40	0.94	0.94
50 ppm of nano TiO_2	33.90	34.00	85.80	86.40	43.30	43.90	4.50	4.60	0.94	0.95
100 ppm of nanoTiO_2	33.50	33.80	86.50	86.10	42.00	42.00	4.30	4.30	0.94	0.94
LSD at 5%	0.20	0.22	0.28	0.29	0.51	0.48	0.06	0.07	0.01	0.01
Interaction effect										
25 ppm of nano TiO_2										
At start of flowering stage	33.20	33.50	85.50	86.90	42.2	42.10	4.30	4.40	0.93	0.94
At the top of flowering stage	33.10	33.60	85.00	85.40	42	42.50	4.40	4.30	0.95	0.94
50 ppm of TiO_2										
At start of flowering stage	34.00	34.30	86.50	86.80	44	44.00	4.50	4.60	0.94	0.95
At the top of flowering stage	33.80	33.70	85.30	86.00	42.6	43.80	4.40	4.50	0.94	0.94
100 ppm of TiO_2										
At start of flowering stage	33.20	33.60	86.40	85.70	42	42.00	4.30	4.40	0.93	0.94
At the top of flowering stage	33.80	33.50	86.20	86.40	42	41.80	4.30	4.40	0.94	0.94
LSD at 5%	0.41	0.44	0.35	0.37	0.64	0.57	0.1	0.1	0.02	0.01
The superiority of 50 ppm treatment of n-TiO_2 vs the control, 25ppm and 100ppm treatments										
Control (tap water)	3.03	3.63	2.21	2.96	4.76	4.27	7.14	6.98	2.37	2.35
25ppm of TiO_2 At start of flowering stage	2.41	2.39	1.17	0.12	4.27	4.51	4.65	4.55	1.08	1.06
100ppm of TiO_2 At start of flowering stage	2.41	2.08	0.12	1.40	4.76	4.76	4.65	4.55	1.08	1.06

As for G.97 genotype, the treatment of spraying 50 ppm concentration of n-TiO2 at the beginning flowering during 2018 season showed the highest mean values of all the studied fiber quality properties being, 34.8mmin upper half mean length, 86.6 % in fiber uniformity index, 44.0g/tex, in fiber strength, being4.6 in micronaire value and being 0.95 in maturity ratio, while recorded in 2017 season34.5mm for upper half mean length, 86.3 %for length uniformity index, 44.0 g/tex for fiber strength, 4.5 for micronaire value and 0.95 for maturity ratio. The control treatment showed the same trend of G.94 where exhibited the lowest values of most traits in both seasons to be 33.5 mm in upper half mean length, 86.1 % in length uniformity, 42.3 g/tex in fiber strength, 4.3 in micronaire value and 0.92 in maturity ratio. The control treatment showed slightly lower values for fiber quality properties in 2017 season. The differences in fiber quality measurements between the control and the other two concentrations 25 and 100 ppm treatments were practically of low magnitude

The improvement in fiber quality traits of Giza 97 pertaining 50ppm concentration of n-TiO_2 at the beginning flowering treatment ranged from 0.58 % in uniformity index in 2017 to 6.19 % in micronaire value in 2017 compared to the control treatment. While this improvement ranged from 2.97 % in length uniformity index in 2017 season to 7.14 % in micronaire value in 2017 compared to 25ppm treatment of n Tio_2 and ranged from 1.76 % to length uniformity index in 2017 to 12.5 % in micronaire value in 2017 compared to 100ppm treatment.

It is obvious from the obtained results that length uniformity of the two varieties showed the lowest improvement in fiber quality properties while micronaire value showed the highest improvement in fiber quality of the studied varieties; however fiber length and strength showed moderate improvement when sprayed with 50ppm of $nTio_2$ at the beginning of flowering on the other hand the improvement in fiber quality properties due to the 50 ppm foliar application of n Tio_2 was not as high as in case of the cotton yield and yield components.

These results are in line with Al-Shimaa (2017), Bacilieri *et al*. (2017), Karami and Ali (2018) who reported that, Titanium improves yield of biomass, nutritional status of plants, stimulates enzymatic activity, accelerates the uptake of nutrients, increases photosynthesis, and participates in the synthesis of proteins & chlorophyll quality and in the control of plant diseases. All of this effects can led to improvement and increase in yield and yield components traits, hence reflected in different degrees on fiber quality properties

The residual effect of nano titanium in the cotton seedof G.94 and G.97 Genotypes:

The residual effect of titanium was tested in seeds obtained from the cotton plants treated with 100ppm n-Tio2 foliar application (the highest concentration). The results indicated that the residues amount of titanium was 0.4 ppm for Giza 94 and 0.31 ppm for Giza 97 compared to 0.04ppm for the control, and this amount does not have any toxic effect with respect to the limits specified and permitted by the World Health Organization and the Food and Drug Organization Chen *ei al*., (2011) and Wang *et al*., (2007) came to similar findings.

Table 5. Effect of growing season, foliar application time, concentration of nano TiO_2 and their interactions on fiber quality properties of G.97 variety.

Treatment / Trait	Upper half mean length (mm)		Length uniformity index (%)		Fiber strength (g/tex)		Micronaire reading		Maturity ratio	
Seasons	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Average season	33.40	33.70	85.30	85.60	42.40	42.70	4.25	4.33	0.93	0.93
LSD at 5%		N.S		N.S		N.S		N.S		N.S
Foliar application time										
At start of flowering stage	33.50	33.80	85.20	85.30	42.50	43.00	4.25	4.35	0.92	0.93
At the top of flowering stage	33.50	33.70	85.50	85.60	42.40	42.90	4.25	4.35	0.92	0.93
LSD at 5%	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
Titianium dioxide (TiO_2) concentration(ppm)										
Control	32.90	33.50	85.50	86.10	41.70	42.30	4.10	4.30	0.91	0.92
25 ppm of nano TiO_2	32.90	33.20	84.70	85.00	42.00	42.30	4.20	4.40	0.93	0.93
50 ppm of nano TiO_2	34.50	34.80	86.30	86.60	43.90	44.00	4.50	4.50	0.94	0.94
100 ppm of nanoTiO_2	33.20	33.40	84.80	85.10	41.60	42.10	4.00	4.20	0.92	0.92
LSD at 5%	0.21	0.20	0.24	0.25	0.40	0.31	0.07	0.08	0.01	0.01
Interaction effect										
25 ppm of nano TiO_2										
At start of flowering stage	32.90	33.20	83.80	84.10	42.40	42.70	4.20	4.40	0.92	0.93
At the top of flowering stage	32.90	33.10	85.50	85.80	41.60	41.90	4.10	4.30	0.93	0.93
50 ppm of TiO_2										
At start of flowering stage	34.50	34.80	86.30	86.60	44.00	44.00	4.50	4.60	0.95	0.95
At the top of flowering stage	34.40	34.70	86.30	86.60	43.70	44.00	4.40	4.60	0.94	0.94
100 ppm of TiO_2										
At start of flowering stage	33.00	33.30	84.80	85.10	41.90	42.20	4.00	4.20	0.92	0.92
At the top of flowering stage	33.30	33.50	84.70	85.00	41.20	42.00	4.00	4.20	0.91	0.91
LSD at 5%	0.49	0.43	0.39	0.36	0.51	0.55	0.14	0.15	0.02	0.02
The superiority of 50 ppm treatment of n-TiO_2 vs and the control,25ppm, and 100ppm treatments										
Control (tap)water	4.86	3.88	0.94	0.58	5.52	4.02	9.76	6.98	4.40	3.26
25ppm of TiO_2 At start of flowering stage	4.86	4.82	2.98	2.97	3.77	3.04	7.14	4.55	3.26	2.15
100ppm of TiO_2 At start of flowering stage	4.55	4.50	1.77	1.76	5.01	4.27	12.50	9.52	3.26	3.26

CONCLUSION

From the obtained results it could be concluded that:

Nano titanium foliar treatments at the beginning of flowering improved significantly cotton yield and most of yield components compared to spraying at the top of flowering. Using 50ppm of nano titanium treatment improved significantly yield and its components, however this improvement in fiber properties was practically of low magnitude.Chemical analysis of the seed produced from 100ppm treatment indicated that the residue amount of titanium in the seed is lower than the permitted limits specified by World Health Organization in food and feed products, therefore it is safe to use Nano titanium foliar treatments to improve cotton yield.

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دراسه علي صفات المحصول و الجوده لبعض التراكيب الوراثيه للقطن المصري المعامل بالنانو تيتانيوم

شيماء عبد ربه شحات، وليد محمد بسيوني يحيي و ياسر عبدالهادي عبد الباسط
معهد بحوث القطن– مركز البحوث الزراعية - الجيزة - مصر

أقيمت تجربتان حقليتان بمحطة التجارب الزراعية بسخا (بمحافظه كفر الشيخ) التابعة لمركز البحوث الزراعية موسمي ٢٠١٧ , ٢٠١٨ بهدف دراسة تأثير الرش الورقي بالنانو تيتانيوم داي اكسيد بثلاثة تركيزات ٢٥ ، ٥٠ ، ١٠٠ جزء في المليون علي المحصول ومكوناته وصفات الجوده للصنفين جيزه ٩٤ و جيزه ٩٧ وكذلك تقدير كمية التيتانيوم المتبقية بالبذرة الناتجة بعد المعاملة وما اذا كانت سامة للانسان والحيوان، وتمت الزراعه في ٣٠ ابريل في كلا الموسمين .وتم الرش بالنانو تيتانيوم في ميعادين الاول عند بدايه التزهير(بعد ٦٠ يوم من الزراعه) الثانية عند قمه التزهيربعد اسبوعين من الميعاد الاول. استخدم تصميم القطع المنشقه مره واحده في ثلاث مكررات. وتتلخص اهم النتائج في الاتي: كان تأثير موسم الزراعة علي صفات المحصول والجودة لكلا الصنفين غير معنوي احصائيا فيما عدا زيادة وزن ١٠٠ بذرة للصنف جيزة ٩٤ وزيادة محصول الزهر والشعر ونسبة التيلة في الصنف جيزة ٩٧ موسم ٢٠١٨ - اوضحت النتائج ان الرش الورقي في مرحله بدايه التزهير في كلا الموسمين سجل زيادة معنوية في متوسطات كل الصفات المحصوليه عدا صفة وزن اللوزة عن الرش الورقي للنانو تيتانيوم في قمه التزهير.في كلا الصنفين في موسمي الزراعة بينما لم تتأثر صفات جودة التيلة المدروسة معنويا بميعاد الرش الورقي بالنانو تيتانيوم في كلا الصنفين - حقق التركيز ٥٠ جزء في المليون من النانوتيتانيوم زياده معنويه في الصفات المحصوليه ومكوناتها وبعض صفات الجوده ولم يكن هناك فرق معنوي بين التركيز ٢٥ و ١٠٠ جزء في المليون ومعاملة الكنترول في معظم الحالات - سجل الرش الورقي بتركيز ٥٠ جزء في المليون في بدايه التزهير اعلي متوسطات للصفات المحصوليه لكلا الصنفين في كلا الموسمين. حيث سجل الصنف جيزه ٩٤ (٢٠,٢ و ٢٠,٩ لوزه) لعدد اللوز المتفتح علي النبات و(٤,٣ جرام لكلا الموسمين) لصفه وزن اللوزه و (١٣,٤ و ١٣,٢ جرام) لوزن ال١٠٠ بذره، (٨٧,٠ و ٨٩,٧ جرام/النبات) لمحصول القطن الزهر/النبات و (٣٦,٥ ، ٣٨,٠ جرام/النبات) لمحصول القطن الشعر/النبات و (٤٢,٠و ٤٢,٤ ٪) لنسبه الشعر الشعرفي موسمي ٢٠١٧ , ٢٠١٨ علي التوالي بينما سجلت معاملة الكنترول (١٤,٩ لوزه) لعدد اللوز المتفتح علي النبات و(٤,٦٢ جرام) لصفه وزن اللوزه و (١٠,٧ جرام) لوزن ال١٠٠ بذره، (٥٤,٠ جرام/النبات) لمحصول القطن الزهر/النبات و ٢١,٠٥ جرام/النبات) لمحصول القطن الشعر/النبات و ٣٩,٠ ٪) لنسبه الشعر الشعرلهذه الصفات في موسم٢٠١٨ واخد التركيب الوراثي جيزه ٩٧ نفس الاتجاه حيث سجلت هذه المعاملة (١٨,٠ و ١٨,٨ لوزه) لعدد اللوز المتفتح علي النبات و (١١,٩ و ١٢,٢ جرام) لوزن ال١٠٠ بذره، (٧٤,٠ و ٧٧,٢ جرام/النبات) لمحصول القطن الزهر و (٢٩,٩ ، ٣١,٩ جرام/النبات) لمحصول القطن الشعر و(٤٠,٤ و ٤١,٣ ٪) لنسبه الشعرفي موسمي ٢٠١٧ , ٢٠١٨ علي التوالي بينما سجلت معاملة الكنترول (١٥,٨ لوزه) لعدد اللوز المتفتح علي النبات و(٤,٠ جرام) لصفه وزن اللوزه و (١١,٤٠ جرام) لوزن ال١٠٠ بذره، (٤٣,٢ جرام/النبات) لمحصول القطن الزهر/النبات و(٢٤,٩ جرام/النبات) لمحصول القطن الشعر/النبات و (٣٩,٤ ٪) لنسبه الشعر لهذه الصفات في موسم ٢٠١٨. -سجل الرش الورقي بتركيز ٥٠ جزء في المليون في بدايه التزهير اعلي متوسطات لصفات جودة التيلة في الصنف جيزة ٩٤ حيث سجل طول التيلة (٣٣,٩ ، ٣٤,٠ مم) و (٨٦,٥ و ٨٦,٨) لمعامل انتظام الطول و (٤٤,٠ و ٤٤,٠ جرام/تكس) لمتانه التيلة و(٤,٥ و ٤,٦) لقراءه الميكرونيرو(٠,٩٤ و ٠,٩٥) لنسبة النضج لكلا الموسمين علي الترتيت بينما سجلت معاملة الكنترول (٣٣,١٠ مم) لطول التيله و (٨٤,٤) لمعامل انتظام الطول و (٤٢,٢ جرام/تكس) لمتانه التيلة و(٤,٣) لقراءه الميكرونيرو (٠,٩٣) لنسبة النضج لنفس الصفات في موسم ٢٠١٨. واتخذ الصنف جيزه ٩٧ نفس الاتجاه حيث سجلت هذه المعاملة (٣٤,٥ و ٣٤,٨ مم) لطول التيلة و (٨٦,٣ و ٨٦,٦ %) لمعامل انتظام طول التيلة و (٤٤,٠ و ٤٤,٠ جرام/تكس) لمتانه الالياف و(٤,٥ و ٤,٦) لقراءه الميكرونير و (٠,٩٥ و ٠,٩٥) لنسبة النضج بينما سجلت معاملة الكنترول (٣٣,٥مم) لطول التيله و (٨٦,١٠)لمعامل انتظام الطول و (٤٢,٣ جرام/تكس) لمتانه التيلة و(٤,٣) لقراءه الميكرونيرو(٠,٩٢) لنسبة النضج لنفس الصفات في موسم ٢٠١٨ . كانت الفروق بين معاملتي الرش الورقي بالنانو تيتانيوم بتركيز ٢٥ وتركيز ١٠٠ جزء في المليون ومعاملة الكنترول غير معنوية إحصائيا في معظم صفات المحصول والجودة. بينت النتائج ان تأثير الرش بالنانو تيتانيوم خصوصا معاملة الرش بتركيز ٥٠ جزء في المليون كان كبيرا وواضحا علي صفات المحصول ومكوناته بينما كان هذا التأثير هامشيا علي صفات الجودة رغم معنويته إحصائيا في بعض الحالات تبين من تحليل بذره الصنفين الناتحه من معامله الرش الورقي بتركيز ١٠٠ جزء في المليون بالمعمل المركزي للاغديه والاعلاف بمركز البحوث الزراعيه ان نسبه عنصر التيتانيوم في البذوه هي ٠,٤ و ٠,٣١ جزء في المليون في بذره الصنيفين جيزه ٩٤ و جيزه ٩٧ مقابل ٠,٠٤ جزء في المليون في عينات الكنترول وهي نسبه اقل من الحد المسموح به اغذيه الانسان والحيوان والمحدد بمعرفه منظمه الصحه العالميه مما يدل علي ان التركيزات المستخدمه لم تترك اثر سام في البذره الناتجه من الصنفين.