

EFFECT OF NANO TITANIUM SPRAYING ON GROWTH AND PRODUCTIVITY OF ONION (*Allium cepa* L.)

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ABSTRACT

The field work was carried out at the Experimental Farm of the Desert Research Center, Balosa region, North Sinai Governorate, during winter season of 2014/2015. The experiment was conducted to investigate the effect of nano-TiO₂ at the rate of 1, 2 and 3 gm /L on growth, yield and chemical composition of onion variety Giza Red grown in sandy soil. Result revealed that growth parameters, chlorophyll contents, chemical contents, yield and its components increased with increasing nano-TiO₂ rate. No significant differences between nano-TiO₂ at the rates of 2 and 3 gm/L on bulb dry matter (%), total yield and nitrogen content.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important vegetable crops grown in the world. In Egypt, it is ranked as the third important vegetable crops after tomato and potato according to annual production (2024881 ton) FAO STAT (2012).

Nano particles is a new material with special physicochemical property, which stimulates plant growth, improves soil environment and promotes crop growth metabolism Lu *et al.* (2002). Nano particles (nano-scale particles = NSPs) are atomic or molecular aggregates with at least one dimension between 1 and 100 nm (Roco, 2003), that can drastically modify their physical–chemical properties compared to the bulk material (Nel *et al.*, 2006). Titanium dioxide (TiO₂) is a non-toxic, white pigment, for the use in manufacture of paints, plastics, paper, ink, rubber, textile, cosmetics, leather, and ceramics (Moore, 1997). Also, Barley (2003) reported that TiO₂ is considered to be non-toxic and harmless, that is approved for the use in food up to 1% of product final weight. Studies reported that nano-TiO₂ can promote plant photosynthesis and nitrogen metabolism and then greatly improve plant growth at a suitable concentration (Zheng *et al.*, 2005; Hong *et al.*, 2005; Yang *et al.*, 2007). Moreover, Yang *et al.* (2006) revealed that treated plant by nano-anatase TiO₂, Rubisco carboxylase activity was 2.67 times that of control. They also reported that the application of TiO₂ significantly reduced incidence of rice blast and tomato mould with a correspondent 20% increase in grain weight due to the growth promoting effect of TiO₂ nano-particles (NPL, 2002).

Dehkourdi *et al.* (2014) reported that pepper seeds soaked at four concentrations (3.5, 5.5, 7.5 and 9.5 percentage) nano-TiO₂ for 24 and 48

hour. The results showed that increase in the concentration of nano-anatase, caused to a significant increase in the percentage of germination, germination rate index, radicle and plumule length, fresh weight and vigor index of seedlings. The best concentration of nano-anatase was 7.5% nano-anatase. nano-TiO₂ could increase the water uptake and fertilizers due to increase nitrate reductase activity and also protected chloroplast from aging (Lu *et al.*, 2002 and Lee *et al.*, 2010).

Lei *et al.* (2007) found that nano-TiO₂ increases photosynthesis and plant growth of spinach and enhances absorption and transmission of the sun's energy to electron energy and activates chemical energy. Moreover, The research results of Moaveni *et al.* (2011) on effects of different nano titanium dioxide concentrations (0.01, 0.02, 0.03percent) and titanium dioxide (bulk) spray treatment on barley plants showed that traits of grain yield, number of ears and harvest index in all treatments of nano titanium dioxide application were more effective than the control treatment.

The aim of this study is to know the effect of nano-TiO₂ at the rate of 1, 2 and 3 gm /L on growth, yield and chemical composition of onion variety Giza Red grown in sandy soil.

MATERIALS AND METHODS

The field work was carried out at Baloza Station of the Desert Research Center, North Sinai Governorate, during the winter season of 2014/2015. The experiment was conducted to study the response of onion plants Giza Red cv. grown in sandy soil to nano titanium application as foliar spray in three rates *i.e.*, 1, 2 and 3 g/L and control treatment (spray with tap water). Complete randomized design with four replicates was used

The physical and chemical soil characteristics of the studied site were determined according to Page *et al.* (1982) and Klute (1986) respectively, as recorded in Table (1). The chemical analysis of irrigation water was carried out using the standard method of Page *et al.* (1982) and presented in Table (2).

Table 1: Physical and chemical properties of the experimental soil.

Particle size distribution (%)			Texture soil	EC dS/m	pH	Available nutrients (Cations)					Available nutrients (Anions)			
Sand	Silt	Clay				Na %	P %	K %	Ca meg/l	Mg meg/l	CO ₃	HCO ₃ meg/l	Cl ⁻	SO ₄ ⁻
90	5	5	Sandy	1.37	8.20	4.78	0.42	0.54	3.65	4.40	-	3.85	3.3	6.5

Table 2. Chemical analysis of irrigation water.

pH	E.C. (ppm)	S.A.R	Soluble cations (me/l)				Soluble anions (me/l)			
			Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	CO ₃ ⁼	HCO ₃ ⁻	SO ₄ ⁼	Cl ⁻
7.45	1456	3.80	2.90	3.20	8.60	0.60	0.10	5.60	2.10	7.50

E.C.: Electrical conductivity, dSm⁻¹: decSiemen per meter, S.A.R: Sodium adsorption ratio, me/l: mille equivalent per liter

Organic manure was added at the rate of 30 m³/fed., while calcium super-phosphate (15.5% P₂O₅) at the rate of 300 kg /fed., were added during land preparation. Potassium sulphate (48% K₂O) at the rate of 200 kg/fed. fertilizer quantities were divided and applied within drip irrigation system starting after 60 days from transplanting to end of maturity, while Nitrogen fertilizer was added as ammonium sulphate (20.5% N) at the rate of 90 Kg(N/fed.), fertilizer quantities were divided and applied to the soil until 15 days from transplanting to until maturity. Onion seedlings were sown on ridge, in three lines and irrigated with drip irrigation system. The plots area was 32 m² which contained 4 rows, 8 m long and 1 m wide. Onion seedlings were planted on 1st of December. All agricultural practices for onion crop production were followed according to the recommendation of Egyptian Ministry of Agriculture.

Preparation of TiO₂ Nanoparticles

Titanium nanoparticles (TiO₂) were prepared by laser ablation of a Titanium plate (99.9% in purity) in 10 ml deionized water. Q-switched Nd:YAG (Quantel) pulse laser generating 8 ns pulses at the wavelength of 1064 nm with the repetition rate of 10 Hz and the energy density was 400 mJ cm⁻², was focused using a 100 mm focal length lens on the metal plate immersed in water according to **Siuzdak et al. (2014)**.

Characterization of TiO₂ Nanoparticles

Physicochemical properties of TiO₂ nanoparticles were characterized via TEM imaging Fig. (1). The images of the synthesized TiO₂ nanoparticles reveal a spherical shape and an average particle size of 19.5 to 20 nm.

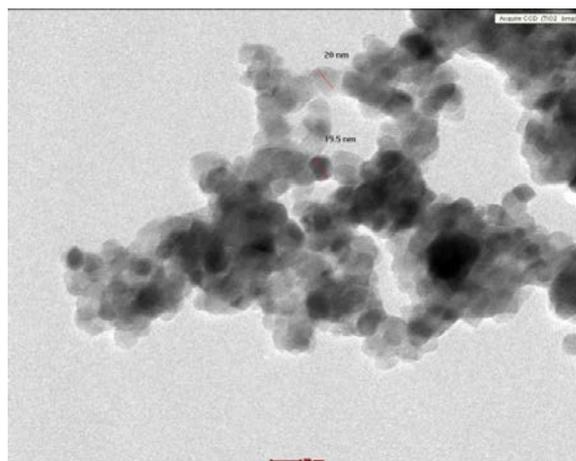


Fig. 1: TEM imaging of the prepared TiO₂ nanoparticles revealed a spherical shape of the particles, with an average size of 20 ±2.0 nm (inset shows electron diffraction pattern).

Growth parameters of vegetative growth:

After 100 days from transplanting, nine plants of each replicate were randomly taken for recording vegetative growth characteristics, (*i.e.*, plant height and weight, number of leaves/plant and percentage of dry weight of the aerial vegetative parts).

Yield parameters and its components:

At harvesting stage (150 days from transplanting date), a sample of 20 onion plants randomly taken from each experimental plot for yield characteristics, *i.e.*, neck and head diameter, average bulb fresh weight, and percentage dry matter of bulb were recorded. In addition, total yield (ton/fed.) and percentage of marketable yield

Chemical component:

Three samples of onion bulb from each subplot were taken and oven dried at 70°C until stable weight then grinded to fine particles and used to determine chemical contents such as mineral contents (N, P and K), Phosphorus was determined using the colorimetric method for phosphorus content using spectrophotometer according to Cottenie *et al.*(1982), Total nitrogen was determined using the modified micro Kjeldahl method, Potassium percentage was measured using flame photometer method as described by Brown and Lilliland (1964).

Statistical analysis:

All data were statistically analyzed according to the technique of analysis variance (ANOVA) in randomized block design and the least significant difference (LSD) at 5 % was used to compare the deference between the means of treatment values to as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth parameters:

The obtained data present in Table (3) revealed that there were significantly differences between water treatments. The highest values on plant height, plant weight, No. of leaves chlorophyll content and shoot dry matter percentage were recorded with nano-TiO₂ at the rate of 3gm/L, no significant differences on plant height and shoot dry matter percentage between all nano-TiO₂ treatments.

The positive effect of titanium dioxide (nano) can improve structure of chlorophyll and better capture of sunlight, can facilitate manufacture of pigments and transformation of light energy to active electron and chemical activity and increases photosynthetic efficiency, stimulates rubisco actives and also increases photosynthesis and nitrogen metabolism which reflect on improve growth this results agreed with those obtained by (Hong *et al.*, 2005, Zheng *et al.*, 2005 and Yang *et al.*, 2007).

Table 3. Effect of nano titanium spraying on plant height, plant weight, No. of leaves, chlorophyll and shoot dry matter (%) of onion plants during 2014/2015 growing season.

Characters Spray treat.	Plant height (cm)	Plant weight (gm)	No. of leaves	Chlorophy ll	Shoot dry (%)
Control	80.96	151.69	7.55	52.21	16.62

Nano-TiO ₂ 1gm/L	99.37	219.53	9.30	51.49	19.37
Nano-TiO ₂ 2gm/L	100.43	213.37	11.55	60.78	20.05
Nano-TiO ₂ 3gm/L	105.69	253.04	13.30	68.94	20.95
L.S.D at 0.05%	13.84	20.57	1.87	2.81	1.79

Bulb and yield parameters:

It was quite evident from Tables (4) and Fig. (2) that spraying with nano-TiO₂ at the rate of 3gm/L significantly improved neck and bulb diameters, bulb weight and dry matter percentage, total yield and marketable yield percentage than control treatment. No significant differences between nano TiO₂ at the rates of 2 and 3 gm/L on bulb dry matter (%) and total yield. The positive effect of titanium dioxide (nano) may be due to its role in increase the water uptake and fertilizers due to increase nitrate reductase activity and also protected chloroplast from aging. This results in the same line with those obtained by (Lu *et al.*, 2002 and Lee *et al.*, 2010). Also, application of TiO₂ nanoparticles on food crops has been reported to promote plant growth, increase the photosynthetic rate, reduce disease severity and enhance yield by 30% (Chao and Choi, 2005 and Dehkourdi *et al.*, 2014)

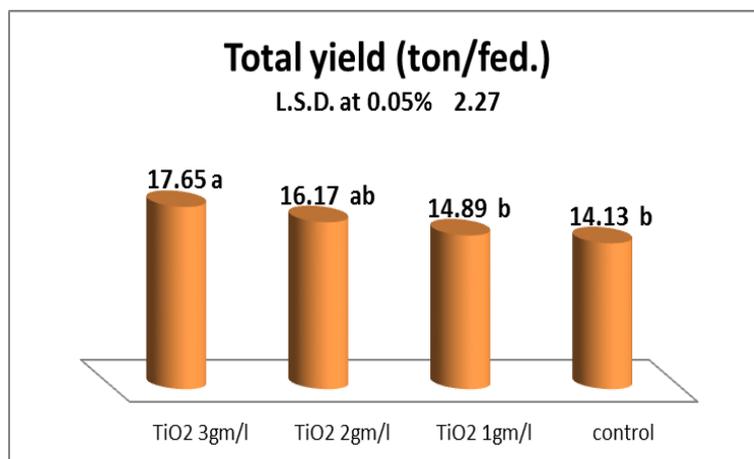
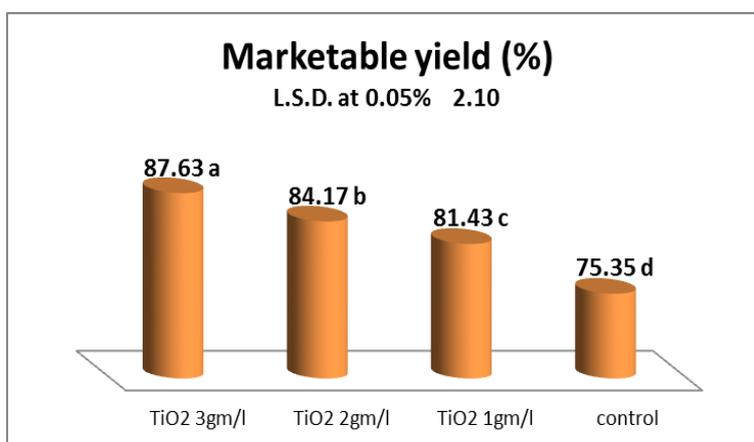


Fig. 2. Effect of nano titanium spraying on total yield and marketable yield percentage of onion plants during 2014/2015growing season

Table 4. Effect of nano titanium spray on neck diameters, bulb diameters, bulb weight (gm) and bulb dry matter (%) of onion plants during 2014/2015growing season

Characters Spray treat.	Neck diameters (cm)	Bulb diameters (cm)	bulb weight (gm)	Bulb dry matter (%)
Control	1.60	5.09	125.09	18.22
Nano-TiO ₂ 1gm/L	2.25	5.64	142.34	19.05
Nano-TiO ₂ 2gm/L	2.00	6.57	168.52	20.05
Nano-TiO ₂ 3gm/L	2.25	7.84	211.37 a	21.45
L.S.D at 0.05%	0.369	0.743	29.09	1.61

Chemical constituents:

It is clear that from Table (5) plants which were sprayed with nano TiO₂ at the rates of 3gm/l attained significantly high nutrients content in terms of which represented by nitrogen, phosphorus compared with control treatment, no significant differences between with nano TiO₂ at the rates of 2 and 3gm/l on nitrogen content. N-Tio2 could increase the water uptake and fertilizers due to increase nitrate reductase activity and also protected chloroplast from aging (Lu *et al.*, 2002 and Lee *et al.*, 2010).

Table 5. Effect of nano titanium spray on N, P and K (%) of onion plants during 2014/2015 growing season.

Characters .	N %	P %	K %
Control	1.81	0.384	0.337
Nano-TiO ₂ 1gm/L	2.54	0.454	0.370
Nano-TiO ₂ 2gm/L	2.40 a	0.446	0.297
Nano-TiO ₂ 3gm/L	2.88	0.542 a	0.376
L.S.D at 0.05%	0.676	0.058	NS

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تأثير الرش بالنانو تيتانيوم على نمو وإنتاجية البصل
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إجريت تجربة حقلية بمحطة بحوث بالوظة – التابعه لمركز بحوث الصحراء بمحافظة شمال سيناء خلال الموسم الشتوى 2015/2014 لدراسة تأثير الرش بجزيئات التيتانيوم المتناهية فى الصغر بتركيزات 1 ، 2 و 3 جرام/لتر على النمو والمحصول والمحتوى الكيمايى للبصل صنف جيزا احمر تحت ظروف الأراضى الرملية . أظهرت النتائج زيادة فى النمو والمحصول ومكوناته والمحتوى الكيمايى بزيادة تركيز الرش بالتيتانيوم المتناهى فى الصغر . ولم يسجل فرق معنوى بين معاملى التيتانيوم بتركيز 2 و 3 جرام /لتر فى نسبة المادة الجافة للرؤوس ، المحصول الكلى ونسبة النيتروجين .