J. Plant Production, Mansoura Univ., Vol. 6 (11): 1803 -1810 , 2015

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

El Sagan, M.A.[1] and M.S. Khater[2]

1-Plant Production Department, Desert Research Center, Cairo, Egypt.

2-National Institute of Laser Enhanced Science (NILES), Cairo University, Egypt.

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-TiO_2 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-TiO_2 rate. No significant differences between nano-TiO_2 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 (TiO_2) 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 TiO_2 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-TiO_2 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 TiO_2, Rubisco carboxylase activity was 2.67 times that of control. They also reported that the application of TiO_2 significantly reduced incidence of rice blast and tomato mould with a correspondent 20% increase in grain weight due to the growth promoting effect of TiO_2 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-TiO_2 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-TiO_2 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-TiO_2 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-TiO_2 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 (spary 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	HCO3 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% P_2O_5) at the rate of 300 kg /fed., were added during land preparation. Potassium sulphate (48% K_2O) 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 m^2 which contained 4 rows, 8 m long and 1 m wide. Onion seedlings were planted on 1^{st} of December. All agricultural practices for onion crop production were followed according to the recommendation of Egyptian Ministry of Agriculture.

Preparation of TiO_2 Nanoparticles

Titanium nanoparticles (TiO_2) 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 TiO_2 Nanoparticles

Physicochemical properties of TiO_2 nanoparticles were characterized via TEM imaging Fig. (1). The images of the synthesized TiO_2 nanoparticles reveal a spherical shape and an average particle size of 19.5 to 20 nm.

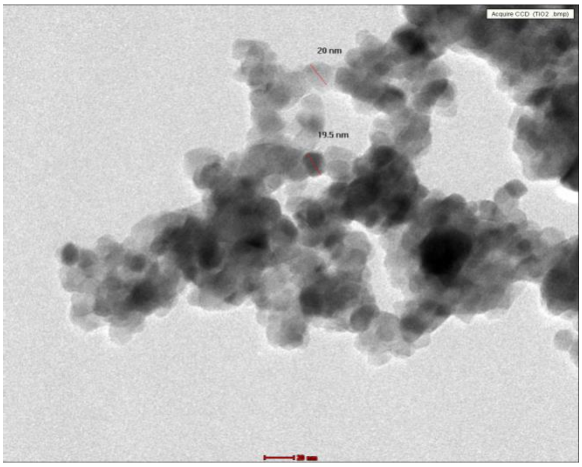


Fig. 1: TEM imaging of the prepared TiO_2 nanoparticles revealed a spherical shape of the particles, with an average size of 20 ±2.0 nm (inset shows electron diffraction pattern).

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 70ºC 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-TiO_2 at the rate of 3gm/L, no significant differences on plant height and shoot dry matter percentage between all nano-TiO_2 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).

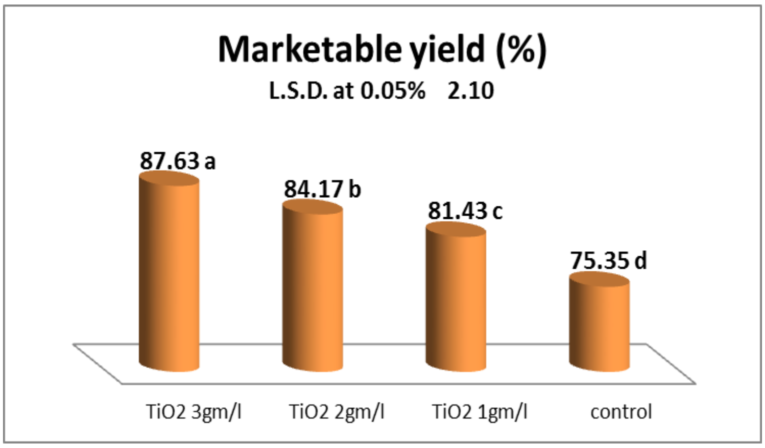
Table 3. Effect of nano titanium spraying on plant height, plant weight, No. of leaves, chlorophyll and shoot dry matter (%) of onion plants during 2014/2015 growing season.

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-TiO_2 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 TiO_2 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 TiO_2 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)



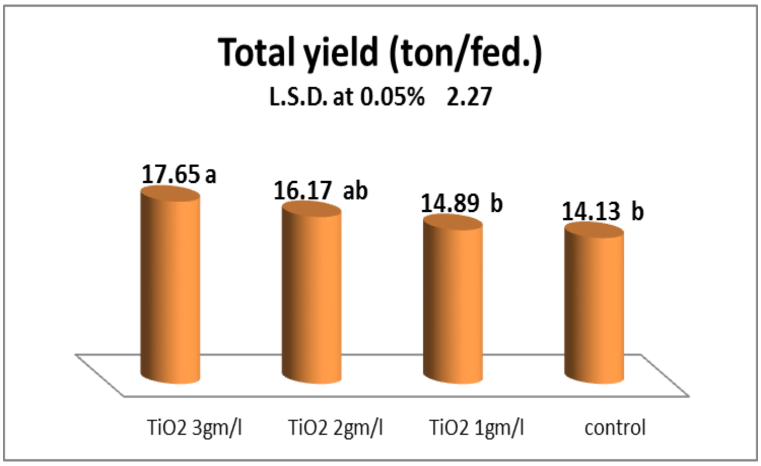


Fig. 2. Effect of nano titanium spraying on total yield and marketable yield percentage of onion plants during 2014/2015growing season

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 TiO_2 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 TiO_2 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

REFERENCES

Barley, R. (2003). The Smaller the Better (Long but Interesting). Reason Newsl., 1 5 pp.

Brown, J. D. and O. Lilliland (1964). Rapid determination of potassium and sodium in plant material and soil extracts by flame photometer. Proc. Amer.Soc. Hort. Sci., 48: 341-346.

Chao, S. H. L. and H. S. Choi (2005). Method for providing enhanced photosynthesis. Korea Research Institute of Chemical Technology, Jeonju, South Korea. Buletin 10pp

Cottenie, A.; Verloo M. L. Kickens; G.Velghe and R. Camerlynck (1982). Chemical analysis of plants and soils. Laboratory of Analytical and Agrochemistry. State University, Ghent Belgium, pp: 63.

Dehkourdi E. H., C. Mehrangiz; H. Hamidreza; H. Mahboobe (2014). The effect of anatase nanoparticles (TiO_2) on pepper seed germination (*Capsicum annum* L.). International J.of Biosciences, 4 (5):141-145.

FAO STAT (2012). An on-line and multilingual databases currently containing over one million time-series records covering international statistics.

Gomez, K. A. and Gomez, A. A. (1984). "Statistical Procedures for the Agricultural Researches". John Wiley and Son, Inc. New York.

Hong F.; J. Zhou; C. Liu; F.Yang; C. Wu; L. Zheng and P.Yang (2005). Effects of Nano-TiO_2 on photochemical reaction of chloroplasts of spinach. Biological Trace Element Research, 105:269–279.

Klute, A. J. (1986). Methods of Soil Analysis. No. (9), Part 1 - Physical and Mineralogical Methods. Am. Soc., Agron., Inc. Soil. Sci., Mad., Wisc., U.S.A.

Lee, C.W.; S. Mahendra; K. Zodrow;, D. Li; Y. Tsai; J. Braam and P. J. J. Alvarez (2010) Developmental phytotoxicity of metal oxide nanoparticles to Arabodopsis thaliana. Environ. Toxicol. Chem., 29:669-675.

Lei Z, Mingyu S., Chao L., Liang C., Hao H., Xiao W., Xiaoqing L., Fan Y., Fengqing G. and H. Fashui (2007). Effects of nanonatase Tio2 on photosynthesis of spinach chloroplasts under different light illumination. Biol Trace Elem Res. J., 119:68–76

Lu, C. M., Zhang, C. Y., Wen, J. Q., Wu, G. R. and M. X. Tao (2002). Research of the effect of nanometer material on germination and growth enhancement of Glycine max and its mechanism. Soybean Science, 21(3):168-171.

Moaveni P., Talebi A., Farahani A., Maroufi H. and K. Maroufi (2011). Study of TiO_2 nano particles spraying effect on the some physiological prameters in barley (*Hordem Vulgare* L.). Adv Environ Biol., 5(7):1663–1667.

Moore D. (1997). Key issues in medium term outlook for titanium and zircon resource. Outlook Conference, Canberra, 4–6 Feb. 1997, 23 pp.

Nel A, Xia T, Madler L and N.Li (2006). Toxic potential of materials at the nanolevel. Science, 31:622–627.

NPL (Nano-Plant Technology) (2002). Method of accelerating metabolism and growth of plant using the corpuscular of Titanium Dioxide. A handbook. Sun Plus Corp., Korea.

Page, A. L., Miller R. H.and D. R. Keeney (1982). Methods of soil analysis. No. (9), Part 2. Chemical and Microbiological Properties. Am. Soc., Agron., Inc. Soil. Sci., Mad., Wisc., U.S.A.

Roco M. C. (2003). Nanotechnology: convergence with modern biology and medicine. Curr Opin Biotechnol 14, 337–346.

Siuzdak, K., M. Sawczak, M. Klein, G. Nowaczyk, S. Jurga and A. Cenian (2014). Preparation of platinum modified titanium dioxide nanoparticles with the use of laser ablation in water. Royal Society of Chemistry, 6.

Yang F., Liu C., Gao F., Su M.,Wu X., Zheng L., Hong F. and P. Yang (2007). The improvement of spinach growth by nano-anatase TiO2 treatment is related to nitrogen photoreduction. Biological Trace Element Research, 119: 77–88.

Zheng L.; F. Hong; S. Lu and C. Liu (2005). Effect of nano-TiO_2 on strength of naturally aged seeds and growth of spinach. Biological.

تاثير الرش بالنانو تيتانيوم على نمو وإنتاجية البصل

محمد عبد المعطى السجان [١] و محمد سليمان خاطر [٢]
١ قسم الانتاج النباتى – مركز بحوث الصحراء – القاهرة - مصر
٢ المعهد القومى لليزر- جامعة القاهرة - مصر

إجريت تجربة حقلية بمحطة بحوث بالوظة – التابعه لمركز بحوث الصحراء بمحافظة شمال سيناء خلال الموسم الشتوى ٢٠١٥/٢٠١٤ لدراسة تأثير الرش بجزيئات التيتانيوم المتناهية فى الصغر بتركيزات ١ , ٢ و٣ جرام/لتر على النمو والمحصول والمحتوى الكيميائى للبصل صنف جيزا احمر تحت ظروف الأراضى الرملية .

أظهرت النتائج زيادة فى النمو والمحصول ومكوناتة والمحتوى الكيميائى بزيادة تركيز الرش بالتيتانيوم المتناهى فى الصغر . ولم يسجل فرق معنوى بين معاملتى التيتانيوم بتركيز ٢ و ٣ جرام /لتر فى نسبة المادة الجافة للرؤوس ، المحصول الكلى ونسبة النيتروجين .