Assiut J. Agric. Sci., 50 (4) 2019 (1-8) *ISSN: 1110-0486*
Website: *www.aun.edu.eg/faculty_agriculture/journals_issues_form.php* ***E-mail: ajas@aun.edu.eg***

Performance of Sunflower Genotypes under Different Zinc Oxide Nanoparticles Sizes

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Received on: 1/9/2019 **Accepted for publication on:** 3/9/2019

Abstract

This investigation was conducted to evaluate the productivity of certain number of sunflower genotypes under different treatments of Nanoparticles of Zinc Oxide (ZnO NPs). Seventeen sunflower lines (S_6 generation) were evaluated under three level of ZnO. Results indicate that Line 7 surpassed all the other genotypes in achene yield / plant and 100 achenes weight and occupied the fifth place for oil content. The highest mean values for all studied traits were obtained when plants were sprayed by 15 nm ZnO NPs, also spraying Zinc led to the early push of plants to flowering compared to plants that were not sprayed by it. Otherwise, the lowest achene yield obtained from Line 2 without ZnO NPs spray. Maximum oil content obtained from Line 7 when sprayed by 15 nm ZnO NPs. On the other hand, the minimum oil content obtained from Line 17 without ZnO NPs spray.

Keywords: *sunflower genotypes, Zinc nanoparticals, Zinc Oxide.*

Introduction

Vegetable oils are considered a food shortage in Egypt where the gap between production and consumption is greater than 90%. So, great emphasis must be given towards oil crops to decrease the gab in oil production.

Sunflower (*Helianthus annuus* L.) is one of the most important oil crops in the world (Demir *et al.*, 2006). Because of its moderate cultivation requirements and high oil quality, its acreage has increased in both developed and developing countries (Skoric, 1992). The cultivated area of sunflower in Egypt during 2017 season was about 6000 hectares with the total yield production of 20000 metric tons (FAO, 2018). Sunflower oil is highly demanded not only for human consumption, but also for chemical and cosmetic industries. So, sunflower is a potential crop that can shrink the gap between oil consumption and domestic production.

Zinc is an essential micronutrient for organisms and plays an important role in plant processes. Zinc is necessary for producing chlorophyll, pollen performance, fertility and germination, as well as for lipid metabolites, nucleic acid, RNA metabolism, stability and DNA simulation and gene expression regulation. Zinc plays an important role in cell proliferation and plant roughness. Zinc as a catalyzer, has an activating or building role in many enzymes in plants. Zinc is involved in the structure of more than 300 enzymes. (Cakmak *et al.* 2000, Prasad *et al.* 2012, Shukla *et al.* 2017 and Hafizi & Nasr, 2018).

Currently, nanotechnology is being used in agriculture for different purposes and under various conditions. Nanoparticles (NPs) may also be used as a source of essential plant nutrients. Nanoparticles of ZnO is applied on sunflower and check their effect on growth, yield and quality. (Janmohammadi *et al*. 2017 and Sabaghnia *et al.* 2018).

Obtaining lines and evaluating its under different conditions is an important tool for discovering new genotypes that can be used in breeding programs of sunflower to get new hybrids with good performance under different treatments (Adel and Talaat, 2018).

The objective of this research was to evaluate the productivity of sunflower genotypes under different zinc oxide nanoparticles sizes.

Material and Methods

This investigation was carried out to evaluate 17 genotypes of sunflower under different treatment of foliar spray of zinc oxide nanoparticles during two growing seasons 2017 and 2018 at the Agronomy Experimental Farm, Faculty of Agriculture, Assiut University. Sunflower genotypes were 17 S_6 lines derived from selfing of different cultivars (Table 1). Zinc nanoparticles treatment were control (water) and nanoparticles sizes (15 and 26 nm) at 200 ppm.

Table 1. Lines and its open pollinated cultivars.

Lines	Parent name of the line	Origin of the cultivar
Line 1	Maiak	Bulgaria
Line 2	Maiak	Bulgaria
Line 3	Bozolok	Russia
Line 4	Sakha 53	Egypt
Line 5	Giza 102	Egypt
Line 6	Giza 102	Egypt
Line 7	Bozolok	Russia
Line 8	Sakha 53	Egypt
Line 9	Maiak	Bulgaria
Line 10	Maiak	Bulgaria
Line 11	Maiak	Bulgaria
Line 12	Enosa	Russia
Line 13	Maiak	Bulgaria
Line 14	Maiak	Bulgaria
Line 15	Enosa	Russia
Line 16	Sakha 53	Egypt
Line 17	Maiak	Bulgaria

The experiment was carried out in randomized complete block design (RCBD) using strip plot arrangement with three replications. The sunflower genotypes were arranged vertically, while foliar applications were allocated horizontally and application time was after 30 days from sowing in both seasons.

The experimental unit was one row 3 m in length where row to row and plant to plant (on the row) distances were 60 cm and 30 cm, respectively. At the sowing time, two or three seeds were dibbled in each hill to facilitate better emergence and to provide uniform stand of plants and thinning was attended after two weeks from sowing to retain one healthy seedling per hill. Hoeing was done twice during the growth season to keep the plots free from weeds; first weeding was done when the seedlings were 5 cm high with 3-4 true leaves and the second was during vegetative growth when plants had 12 to 14 true leaves. The previous winter crop was wheat in both seasons. All other recommended cultural practices for sunflower crop were done in both seasons.

The mechanical and chemical analyses of the experimental soil are presented in Table 2.

Table 2. Some mechanical and chemical properties of the experimental soil.

Properties	2017	2018
Mechanical analysis:		
Sand	27.00	27.80
Slit	23.00	22.20
Clay	50.00	50.00
Soil type	Clay	Clay
Chemical analysis:		
pH	7.63	7.85
Organic matter %	1.80	1.70
Total N%	0.09	0.08

Measurement traits:

1- Plant yield and its attributes traits:

At flowering stage, we determined the following traits:

1. **Days to heading:** Number of days from sowing to 50% heading of plants in each plot.
2. **Plant height (cm):** It was determined from soil surface until the upper tip of plants as an average of 3 guarded plants which were taken randomly from the middle each experimental unit.
3. **Stem diameter (cm):** It was determined from as an average of three stems which were taken randomly from the middle each experimental unit using Vernier caliper.
4. **Head dimeter (cm):** Average of 3 random heads from guarded plants from each experimental unit using ruler.

At maturity stage, the following traits were determined:

1. **Achene weight plant^{-1}:** Average weight of achens from three random guarded plants from the middle of each experimental unit.
2. **Hundred achene weight (g):** The weight of 100-achens represented each experimental unit was weighted.

2- Quality traits:

1. **Oil content (%):** It was determined by soxhelt apparatus using petroleum ether (60-80 C° b_p) as a solvent according to the official method (AACC, 2000).

Statistical Analysis

All data collected were analyzed using Proc Mixed of SAS package version 9.2 (SAS 2008) and means were compared by Revised Least Significant Difference (R. LSD) at 5% level of significant (Steel & Torrie, 1981). Combined analysis was done after variance homogeneity test.

Results and Discussions

Mean squares of different traits (Table 3) show highly significant differences among genotypes, as well as among zinc treatments and interaction between them.

Table 3. Mean Squares of studied traits.

Source	DF	Days to heading	Plant height	Stem diameter	Head diameter	Weight of seeds /plant	Weight of 100 seeds	Oil content (%)
Season(S)	1	50165.76 **	28235.53*	24.88*	1153.31 *	6487.43 NS	26.37 NS	126.01 NS
Error A	4	35.59	3485.73	1.34	69.70	1031.01	11.03	183.82
Treatment(T)	2	78.30 *	52845.44**	20.06**	930.49 **	29063.13 **	228.79 **	2783.38 **
S x T	2	38.91 NS	161.74 NS	0.47*	4.37 NS	711.34 **	1.08 NS	24.02 NS
Error B	8	17.08	268.63	0.10	3.72	70.82	0.33	8.36
Genotype(G)	16	38.80 **	2384.54**	0.65**	42.50 **	2743.32 **	12.47 **	75.09 **
S x G	16	29.99 **	1750.83**	0.51**	39.14 **	1002.96 **	7.17 **	51.56 **
Error C	64	7.98	69.41	0.02	0.98	17.88	0.24	3.01
T x G	32	8.89 NS	255.54**	0.14**	2.52 **	143.48 **	1.36 **	14.82 **
S x T x G	32	4.68 NS	112.71*	0.14**	5.27 **	155.31 **	0.80 **	20.78 *8
Error D	128	6.19	73.09	0.02	0.88	20.74	0.32	2.81

* and ** means significant at 5% and 1% level of probability.

Performance of Genotypes

The significant differences among tested genotypes for all studied traits indicating that there is a wide genetic diversity among studied genotypes. The pervious results reflect that selfing can be used to obtain recombination in cross pollinated crops like sunflower as recorded by Ramanathan (2004), Encheva *et al.*, (2008), Alahdadi *et al*., (2011), Adel (2012) and Adel & Talaat (2018).

In the light of results in Table 4 we observed that the earliness flowering lines (78.00 day) were Line 3 and Line 12, but the latest flowering one was Line 17 (82.56 day). The shortest plant (117.64 cm) was obtained from Line 11, but the tallest one (156.17 cm) were obtained from Line 7. The highest achene yield /plant (65.64 g) was registered from Line 7 which occupied the fifth place for oil content (46.30%) and the heaviest 100 achene weight (7.62 g) was obtained from Line 14. The lowest oil content (40.20%) was recorded from Line 10, But the highest oil content (47.37%) was recorded from Line 15. These results were agreed with those obtained by Adel 2012 and Adel & Talaat 2018 whom found differences performance for sunflower lines obtained from selfing.

Effect of Zinc treatments:

In general, the obtained results showed that the addition of zinc foliar spray on the sunflower plants led to an increase in all the studied traits, which confirms the importance of zinc in plant biological processes and increase the net photosynthesis (Hafizi and Nasr, 2018).

Table 4. Effect of foliar spraying by ZnO NPs and genotypes on days to heading, plant height, stem diameter, head diameter, achene weight /plant, 100 achenes weight and oil content of sunflower.

ZnO NPs (Zn) / Genotypes (G)	Days to heading				Plant Height (cm)				Stem Diameter (cm)				Head Diameter (cm)			
	control	15 nm ZnO NPs	26 nm ZnO NPs	**Mean**	**control**	15 nm ZnO NPs	26 nm ZnO NPs	**Mean**	**control**	15 nm ZnO NPs	26 nm ZnO NPs	**Mean**	**control**	15 nm ZnO NPs	26 nm ZnO NPs	**Mean**
Line 1	78.50	80.83	82.83	**80.72**	122.50	148.17	135.67	**135.44**	1.03	1.70	1.33	**1.36**	13.17	18.94	15.50	**15.87**
Line 2	81.00	81.33	80.83	**81.06**	110.00	159.17	132.17	**133.78**	1.17	1.87	1.37	**1.47**	12.17	17.08	14.67	**14.64**
Line 3	79.33	77.50	77.17	**78.00**	133.33	168.50	149.83	**150.56**	1.35	2.07	1.80	**1.74**	14.42	20.50	17.42	**17.44**
Line 4	80.67	78.17	78.83	**79.22**	125.50	180.00	153.33	**152.94**	1.43	2.25	1.82	**1.83**	15.42	21.25	18.75	**18.47**
Line 5	80.83	77.50	77.50	**78.61**	122.50	162.50	141.25	**142.08**	1.30	1.80	1.46	**1.52**	13.08	19.63	16.63	**16.45**
Line 6	79.00	75.50	77.83	**77.44**	107.50	148.83	128.33	**128.22**	1.27	2.12	1.57	**1.65**	12.67	20.33	16.50	**16.50**
Line 7	80.83	78.83	80.83	**80.17**	121.67	184.17	162.67	**156.17**	1.65	2.70	2.25	**2.20**	15.58	22.33	18.08	**18.67**
Line 8	81.17	77.67	79.00	**79.28**	113.67	158.75	137.50	**136.64**	1.18	2.27	1.62	**1.69**	14.42	20.17	17.67	**17.42**
Line 9	81.50	79.83	80.17	**80.50**	105.50	148.50	136.67	**130.22**	1.17	2.18	1.65	**1.67**	14.00	22.50	19.92	**18.81**
Line 10	82.83	80.83	81.33	**81.67**	100.17	151.67	130.50	**127.44**	1.08	2.08	1.57	**1.58**	12.25	18.17	15.00	**15.14**
Line 11	82.50	78.83	78.17	**79.83**	96.17	135.50	121.25	**117.64**	0.93	2.38	1.75	**1.69**	12.06	18.42	14.92	**15.13**
Line 12	79.50	77.83	76.67	**78.00**	105.00	158.33	125.83	**129.72**	1.10	1.83	1.60	**1.51**	14.08	20.75	18.42	**17.75**
Line 13	82.33	79.33	80.83	**80.83**	132.17	191.67	154.67	**159.50**	1.22	2.33	1.88	**1.81**	17.83	21.75	19.33	**19.64**
Line 14	82.50	81.33	81.67	**81.83**	110.00	179.50	147.00	**145.50**	1.50	1.98	1.70	**1.73**	15.00	21.33	18.00	**18.11**
Line 15	81.33	80.83	77.50	**79.89**	112.50	148.33	125.50	**128.78**	1.27	1.93	1.62	**1.61**	13.67	19.33	16.67	**16.56**
Line 16	82.17	81.33	80.33	**81.28**	118.33	148.98	138.00	**135.11**	1.18	2.63	1.70	**1.84**	11.83	17.58	14.92	**14.78**
Line 17	82.00	83.33	82.33	**82.56**	116.17	153.67	138.83	**136.22**	1.22	1.98	1.43	**1.54**	13.83	18.08	15.92	**15.94**
Mean	**81.06**	**79.46**	**79.64**	**80.05**	**114.86**	**160.37**	**138.76**	**138.00**	**1.24**	**2.12**	**1.65**	**1.67**	**13.85**	**19.89**	**16.96**	**16.90**
R.LSD (G)	**1.87**				**4.86**				**0.08**				**0.58**			
R.LSD (Zn)	**1.40**				**4.89**				**0.09**				**0.58**			
R.LSD (G x Zn)	-				**10.07**				**0.15**				**1.16**			

Table 4. Cont.

ZnO NPs (Zn) / Genotypes (G)	Achene Weight /plant				100 Achenes Weight				Oil content %			
	control	15 nm ZnO NPs	26 nm ZnO NPs	Mean	control	15 nm ZnO NPs	26 nm ZnO NPs	Mean	control	15 nm ZnO NPs	26 nm ZnO NPs	Mean
Line 1	16.32	32.31	26.90	**25.18**	4.82	8.38	7.43	**6.87**	39.15	46.65	41.42	**42.41**
Line 2	14.63	51.71	32.46	**32.93**	5.06	7.45	6.07	**6.19**	41.28	47.23	44.08	**44.20**
Line 3	37.93	79.49	59.12	**58.84**	5.85	9.09	7.80	**7.58**	41.38	51.94	47.17	**46.83**
Line 4	30.30	83.09	56.66	**56.68**	5.76	8.88	6.96	**7.20**	38.90	53.05	47.03	**46.33**
Line 5	21.96	58.70	43.44	**41.36**	4.59	8.01	6.97	**6.52**	39.44	52.61	46.14	**46.06**
Line 6	29.62	59.97	43.01	**44.20**	6.63	8.28	7.46	**7.45**	40.26	48.51	44.80	**44.52**
Line 7	42.46	89.97	64.48	**65.64**	5.35	8.59	7.91	**7.28**	43.43	48.87	46.60	**46.30**
Line 8	28.36	61.59	45.14	**45.03**	5.88	8.58	6.95	**7.14**	38.23	49.27	45.57	**44.35**
Line 9	32.33	68.99	52.28	**51.20**	4.76	8.39	7.15	**6.77**	37.35	46.02	41.77	**41.72**
Line 10	17.02	39.43	29.87	**28.77**	3.59	7.10	4.49	**5.06**	36.00	45.19	39.42	**40.20**
Line 11	21.85	65.09	36.74	**41.23**	5.39	7.53	6.14	**6.36**	39.04	50.19	43.96	**44.40**
Line 12	36.23	62.16	49.23	**49.21**	4.80	9.41	7.32	**7.18**	40.74	54.57	45.09	**46.80**
Line 13	44.82	78.86	60.40	**61.36**	6.46	8.62	7.51	**7.53**	39.49	51.68	43.74	**44.97**
Line 14	45.71	79.48	58.78	**61.32**	6.55	8.55	7.75	**7.62**	40.42	50.21	47.19	**45.94**
Line 15	31.24	63.34	44.35	**46.31**	5.86	8.96	6.94	**7.25**	40.84	53.72	47.54	**47.37**
Line 16	21.37	46.50	31.45	**33.11**	4.53	7.39	5.62	**5.85**	38.53	47.92	43.60	**43.35**
Line 17	20.71	45.93	34.40	**33.68**	3.31	6.88	4.64	**4.95**	35.80	50.21	41.04	**42.35**
Mean	**28.99**	**62.74**	**45.22**	**45.65**	**5.24**	**8.24**	**6.77**	**6.75**	**39.43**	**49.87**	**44.48**	**44.59**
R.LSD (G)	**2.47**				**0.29**				**1.03**			
R.LSD (Zn)	**2.51**				**0.17**				**0.86**			
R.LSD (G x Zn)	**4.91**				**0.64**				**1.85**			

Data in Table 4 shows that the highest mean values for all studied traits were obtained when plants sprayed by 15 nm ZnO NPs except days to heading, also, Zinc led to the early push of plants to flowering compared to plants that were not sprayed with zinc. The obtained results with respect to the effect of zinc on growth and yield correspond to the obtained results by Munir *et al*, (2018) and Hafizi & Nasr, (2018).

Effect of the interaction between genotypes and zinc treatments:

The interaction between genotypes and zinc treatments was highly significant for all studied traits except days to heading. These results reflect that the response of genotypes was varied under different sizes of ZnO NPs. The highest mean value for achene yield /plant (89.97 g) was obtained from Line 7 when sprayed by 15 nm ZnO NPs, but the lowest achene yield (14.63 g) was obtained from Line 2 without ZnO NPs spray. Moreover, the maximum oil content was obtained from Line 12 when sprayed by 15 nm ZnO NPs, while, the minimum oil content was obtained from Line 17 without ZnO NPs spray.

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اداء تراكيب وراثية من دوار الشمس تحت احجام مختلفة من أكسيد الزنك النانومترى

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الملخص

أجريت هذه الدراسة بهدف تقييم عدد من التراكيب الوراثية لدوار الشمس تحت احجام مختلفة من أكسيد الزنك النانزمترى. سبعة عشر سلالة من دوار الشمس (الجيل السادس من التلقيح الذاتي) تم تقييمهم تحت ثلاث احجام من أكسيد الزنك في الصورة النانومتريه (صفر ، ١٥ و ٢٦ نانومتر). أوضحت النتائج ان السلالة رقم ٧ تفوقت على جميع التراكيب الوراثية في محصول الثمار للنبات ووزن ال ١٠٠ ثمرة بينما احتلت هذه السلالة المرتبة الخامسة من حيث نسبة الزيت .اعلى قيم لجميع الصفات المدروسة تم الحصول عليها عند رش النباتات بحجم ١٥ نانومتر من أكسيد الزنك. اعلى نسبة زيت تم الحصول عليها من السلالة رقم ٧ عند رشها بحجم ١٥ نانومتر من أكسيد الزنك. بينما اقل نسبة زيت تم الحصول عليها من السلالة رقم ١٧ في حالة عدم رشها بأكسيد الزنك.