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EFFECT OF NANOPARTICLES AND ORDINARY ZINC OXIDE FERTILIZER AND HUMIC ACID ON GROWTH OF MAIZE *ZEA MAYS* L.

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Abstract

A pot experiment was carried out in the plastic house dedicated to the Department of Soil and Water Resources,using silty loam soil (SiL) collected from the Horticulture Fields Department / College of Agricultural Engineering Sciences / University of Baghdad. In order to study the effect of adding different levels of nano and ordinary zinc oxide fertilizer interaction with different levels of Humic acid (HA) to the soil and its effects on growth characteristics of *Zea mays* L. crop at the beginning stage of male inflorescence formation. The seeds of (*Zea mays* L.), Baghdad 3, were planted in the autumn season (2018-2019) by seven seeds in each pot and were reduced to three plants.pot^{-1} after two weeks of germination. The Randomized Complete Block Design (RCBD) was used in a three-replication factor experiment, the experiment included three factors: Zinc sources, zinc levels and Humic acid, as well as non-eddition treatment (control). The used fertilizers were mixed with soil by the following types and levels; ordinary ZnO (12 and 18) kg Zn.h^{-1} and ZnO nanoparticles (12 and 18) kg Zn.h^{-1} and Humic acid HA (0 and 60) kg HA.h^{-1}. While Phosphate fertilizer was added at the level of 80 kg P.h^{-1} in one dose before cultivation, Potassium fertilizer was added at the level of 120 kg K.h^{-1} and Nitrogen fertilizer at the level of 240 kg N.h^{-1} in two doses. The data were statistically analyzed and the least significant difference (LSD) was calculated to test the differences between treatments at a probability level of 0.05 using the Genstat program. The results showed that the addition of zinc oxide Nanoparticles fertilizer has led to a significant increase in the leaf area of the flag leaf and the shoot and root dry weight in the stage of male inflorescence by an increase of (5.47%, 3.77%, 5.40%) respectively. The addition of Humic acid resulted in a significant increase in the shoot and root dry weight by an increase of (15.15% and 29.66%) respectively. There was also a significant increase in the shoot and root dry weight from the addition of level 18 kg Zn.h^{-1} with an increase percentage of 8.71%, 9.69% respectively. The triple interactions showed a significant increase in the shoot dry weight trait as it achieved the highest weight at the Nano source and the level 18 kg Zn.h^{-1} for zinc oxide fertilizer and the concentration 60 kg.h^{-1} for the Humic acid with an increase of 49.91%.

Key words: zinc oxide, Humic acid, nanotechnology.

Introduction

The maize (*Zea mays* L.) belongs to the Poaceae family, which considered as one of the most important food and industrial cereal crops of this family. Corn grains containing high amounts of vitamin A equal approximately to twenty times that of wheat grains (Orhun, 2013), the yellow maize Cultivation has been distributed over northern, central and southern Iraq and its area reached to 76000 thousand hectares in the year 2016 and the average production was 3.42 mega gm.h^{-1} (Agricultural Statistics Directorate, 2017). However, Iraq's maize production is still below the average of developed countries, Therefore, methods and techniques should be used to increase productivity. Nanotechnology is one of the most modern discoveries of the 21st century, which is used in all fields of life. This technique is a distinct scientific method that involves the modification of the physical and chemical properties of the substance at the molecular or atomic level, which are between 1-100 *nm* and is the most accurate metric unit of measurement known so far (Ram *et al*., 2014). It has been used in many fields, including environmental engineering, textiles, biomedicine, construction and water resources and communication technology and food industry; there is also an opportunity to have a significant impact on the environment, economy, energy and agricultural systems (Veronica *et al*., 2015). Furthermore, Nano materials have been used in agriculture, where Nano fertilizer used instead of conventional fertilizers to meet the need of the

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plant from the necessary nutrient, increase production and to reduce the problem of harmful effects on soil and the environment. This has been encouraged by the fact that Nano fertilizers can be more effective in reducing soil contamination and other environmental hazards that can occur when other commercial fertilizers are used. The advantages available in Nano fertilizers are its high surface particle areas of and their density and interactions increment on the exchange surfaces of organic and mineral colloids (Ram *et al*., 2014). Nano technology may contribute in the manufacture of fertilizers by designing zinc fertilizers that can release zinc on demand and thereby prevent the zinc reactions with soil colloids and microorganisms that reduce zinc availability for crops (DeRosa *et al*., 2010). Zinc oxide is a high containing zinc fertilizer (Zn- 78%), which can provide sufficient amounts of zinc for the plant. At present, studies have been conducted on the use of zinc oxide Nanoparticles in fertilizing some crops on the scope of laboratory studies and pot experiments, where the Zinc oxide Nanoparticles have the ability to give better growth, high production rate and improve quality (Prasad *et al*., 2012). The high rang using of chemical fertilizers without following the fertilizer recommendation cause a significant damage to human health and the environment (Mustafa, 2018). Therefore, researchers resorted to the use of some methods to reduce the pollution of chemical fertilizers and the accumulation of nutrients in the soil, which cause plant toxicity and implement better and more successful and less costly methods through natural organic that improves different soil properties (Flayeh, 2017). Humic acid is one of the organic compounds “commercial economic product” with fast effectiveness that contains many elements, where it is humus substance are nutritious to the plant (Mohammad *et al*., 2014). Humic acid is used to reduce the harmful effect of mineral fertilizers in Soil (Mora *et al*., 2014), its substances have an effect on increasing the physiological activity of the plant and its impact on the growth and plant content of nutrient. Finally, the current study aims to investigate the effects of adding different levels of ordinary zinc oxide and zinc oxide Nanoparticles interact with different levels of Humic acid (HA) to the soil and its effects on the growth characteristics of yellow maize (*Zea mays* L).

Material and Methods of work

A pot experiment was carried out in a plastic house for the autumn season (2018-2019) using silty loam soil located at the level of soil aggregate (Typic torrifluvent), according to Soil survey staff, (2006). Surface soil samples (0-30 cm) were collected from the soil of one Horticulture Department Fields / College of Agriculture / University of Baghdad, randomly (Composite Sample) mixed to form a composite soil sample and air-dried, then sifted through a 4 mm diameter sieve and (20) kg of soil were added in each pot, which represents one experimental unit. A factorial experiment was carried out according to (RCBD) and included nine experimental treatments with three replicates, including comparative treatment that representing soil treatment only (without addition of Zn and Humic acid). Treatments were randomly distributed to 27 experimental units, while the statistical analysis was conducted according to (ANOVA Test) and the averages were compared with the least significant difference LSD at 0.05, then the statistical analysis was achieved by Statistical Analysis System-SAS, (2012) commercial software. Fertilizer sources were added with the following types and levels: ordinary ZnO (12 and 18) kg $Zn.h^{-1}$ and ZnO nanoparticles (12 and 18) kg $Zn.h^{-1}$, where table 1 shows the chemical properties of zinc nanoparticles and table shows some chemical properties of Humic acid HA (0 and 60) kg $HA.h^{-1}$. Nitrogen and potassium added at a constant level for all treatments, where Nitrogen was added in the form of Urea fertilizer (N 46%) at 240 kg $N.h^{-1}$ and potassium was added in the form of K_2SO_4 (K 41.5%) at 120 kg $K.h^{-1}$ with two equal doses. The first dose was mixed with soil before the cultivation and the second dose after 30 days of germination dissolving with irrigation water, moreover, Phosphorus was added in the form of triple super calcium phosphate fertilizer (P 20%) at the level of 80 kg $P.h^{-1}$ at one dose before cultivation mixing with the soil. The phosphate fertilizers and the first dose of Nitrogen and potassium fertilizers were mixed with the soil surface layer with a depth (0-15) cm before cultivation, the pot was planted with yellow corn seeds (Baghdad 3) in the autumn season (2018) by 7 seeds in each pot and

Table 1: Some chemical properties of used ZnO nanoparticles.

Model	ZINC OXIDE
APS (nm)	50
Purity (%)	> 99.9
Specific Surface area ($m2g^{-1}$)	100
Volume density (gcm-3)	0.30-0.45
Density (gcm-3)	5.60
Crystal form	Cube
Color	White

Table 2: Some chemical properties of Humic Acid used in the cultivation.

Total Organic Matter	%70
Total Humic Acid (As Dry Basis)	%80
Potassium (As K_2O Dry Basis)	%10
Moisture	%15
pH	9 – 11

Table 3: Some chemical and physical properties of soil study before the cultivation.

Properties		Value	Unit
pH value		7.46	-
Electrical Conductivity (EC)		2.13	ds.m^{-1}
Cation Exchange Capacity (CEC)		17.0	cmol. Charge. Kg^{-1}soil
Organic matter		12.1	gm.kg^{-1}soil
Gypsum		1.08	
Carbonate minerals		251	
Dissolved cation ions	Calcium	2.49	cmol. Charg.L^{-1}
	Magnesium	1.83	
	Potassium	0.10	
	Sodium	2.45	
Dissolved negative ions	Carbonates	Nil	
	Bicarbonate	0.34	
	Sulfates	1.06	
	Chlorine	1.58	
Available elements	Nitrogen	51.3	mg.kg^{-1}soil
	Potassium	136	
	Phosphorus	10.8	
	Zinc	8.13	
Field capacity		25.3	%
Total Zinc		168	mg.kg^{-1}soil
Soil separators	Sand	360	gm.kg^{-1}
	Silt	520	
	Clay	120	
Texture		Silty loam soil (SiL)	

were reduced to 3 plants.pot^{-1} after two weeks of germination. The bush was removed from each pot and the corn stem borer *Sesamia Cretica* L. was controlled twice by diazinon pesticide (10%), the first are preventive control after the formation of 4-5 leaves and the second control ten days after the first control (Ministry of Agriculture, 2006). Treatments were irrigated immediately after planting with the preservation of humidity by (80%) of the calculated available water amount for calculating the percentage of humidity in a laboratory at the permanent wilting point, field capacity and the continuation of irrigation after depleting (50%) of available water (gravimetric method) to return humidity to (80%) of the available water. Some growth characteristics were measured such as: Plant height, leaf area, shoot dry weight, root dry weight).

A samples of soil were taken before cultivation, then mixed to form a composite sample, air-dried, milled and sifted through a 2mm diameter sieve, where Some of its chemical and physical properties were estimated before the cultivation as shown in table 3. The average height of the plant (cm) for three plants was calculated from the soil surface to the first Internode of the male inflorescence (Al- Sahoki, 1990). As well as, the average leaf area of three plants in each pot in the male inflorescence stage was calculated according to the following equation (Thomas, 1975) leaf area = leaf length × Center width × Correction factor (0.75). The vegetative part of the three plants were collected in each pot in the male inflorescence stage and the three cultivated plants were cut off and the vegetative part was isolated from the root part of the three plants from each pot. The root was isolated from the surrounding soil, free from any soil residue by washing it with distilled water, the shoot and root were washed with tap water, then with distilled water and dried and placed in perforated paper bags, then placed in an oven at a temperature of (65°C) until the weight is stable. The dry weight was measured with a sensitive balance for both shoot and root in the male inflorescence stage.

Results and Discussion

Plant height (cm)

Table 4, showed that there was no significant increase in plant height from the addition of zinc oxide Nanoparticles in the male inflorescence stage; also, there was also no significant increase in plant height from the addition of the Humic acid. As well as, there was no significant increase at the male inflorescence stage with different level nanoparticles, ordinary zinc oxide levels of zinc oxide. The interaction between the average source of ordinary fertilizer and the addition of Humic acid achieved a significant increase in plant height amounted 113.59 cm compared to an average of 112.61 cm with non-addition of Humic acid by an increase of 0.87%. Bilateral interaction between the average sources of fertilizer and Humic acid did not achieve a significant increase in the plant height trait at the male inflorescence stage. As well as, the bilateral interaction between average sources and the levels and the triple interaction was not significant. The significant increase in plant height of the male inflorescence stage can be attributed to the fertilizer Zinc containing, which is important in increasing the photosynthesis process, improving plant growth and its positive role in activating enzymes. It's also responsible for the formation of amino acid tryptophan, which manufactures indole acetic acid IAA which necessary for elongation and cell division and thus leads to an increase in plant height (Hafeez *et al.*, 2013). The role of Zinc mentioned above, in addition to

Table 4: Effect of ordinary and Nanoparticles Zinc oxide fertilizers and their levels and Humic acid on plants height cm.plant^{-1} in the male inflorescence stage for maize.

Fertilizer sources	Zinc levels Kg Zn.h^{-1}	Humic acid levels Kg HA.h^{-1}		Average sources × levels
		0	60	
ord-ZnO	12	144.67	152.33	148.50
	18	148.50	153.11	150.81
Average sources × Humic acid		146.59	152.72	149.66
Nano-ZnO	12	145.22	155.31	150.27
	18	152.85	155.91	154.38
Average sources × Humic acid		149.04	155.61	152.33
Average Humic acid		147.81	154.17	150.99
Control		130.50		
Fertilizer sources		Zinc levels kg Zn.h^{-1}		Average sources
		12	18	
ord-ZnO		148.50	150.81	149.66
Nano-ZnO		150.27	154.38	152.33
Average levels		149.39	152.60	150.99
Humic acid levels kg HA.h^{-1}		Zinc levels kg Zn.h^{-1}		Humic acid average
		12	18	
0		144.95	150.68	147.81
60		153.82	154.51	154.17
Average levels		149.39	152.60	150.99

Treatments	Sources	Levels	Humic acid	Sources X levels	Sources X Humic acid	levels X Humic acid	Sources X levels X Humic acid
$L.S.D_{0.05}$	N.S	N.S	N.S	N.S	N.S	N.S	N.S

the role of Humic acid, which has a hormonal effect that effects on the cellular wall and cell protoplasm in addition to respiration and photosynthesis and various enzymatic reactions. This was lead to rapid cell division and growth and stimulates hormone activity such as auxins and gibberellins that stimulates the growth and expansion of stem cells and thus affects the increase in plant height (Ponds, 2016 and Olaetxea *et al*., 2016; Gomaa *et al*., 2014).

Leaf area (cm^2)

Table 5, showed a significant increase in the leaf area of flag leaf from the addition of zinc oxide Nanoparticles, which its average was 444.39 cm^2 compared to an average of 421.34 cm^2 with the addition of ordinary zinc oxide by an increase of 5.47%. While it did not achieve a significant increase in this trait, when adding Humic and the levels and both bilateral and triple interaction. The significant increase in leaf area trait may be due to the role of zinc oxide Nanoparticles fertilizer in increasing leaf area due to the large surface area of zinc Nanoparticles and it's high solubility and effective concentration, good activity, increased intensity and increased its reactions on the surfaces of organic and mineral colloids are easy to spread. Therefore, the zinc concentration in the soil increases, then transferred from the root to the leaves because zinc is important in the effectiveness of enzymes involved in metabolism that are associated with respiration and water absorption. As well as, its importance in regulating the sugars consumption and increasing the energy required for chlorophyll production and photosynthesis is responsible for the formation of amino acid tryptophan (Hafeez *et al*., 2013; Ain *et al*., 2016).

Shoot dry weight (gm.plant^{-1})

Table 6, showed a significant increase in the dry weight of shoot from the addition of zinc oxide Nanoparticles in the male inflorescence stage, where its average reached 166.72 gm.plant^{-1} compared to an average of 160.67 gm.plant^{-1} with the addition of ordinary zinc oxide with an increase of 3.77%. There was a significant increase in the dry weight of shoot from the addition of Humic acid, where its average reached 175.22 gm.plant^{-1} compared to an average of 152.17 gm.plant^{-1} without the addition of Humic with an increase of 15.15%. The effect of the average concentrations of zinc oxide Nanoparticles and ordinary fertilizer has shown a significant increase in dry weight from the addition of level 18 kg Zn.h^{-1} where its average amounted 170.53 gm.plant^{-1} compared to the level of 12 kg Zn.h^{-1} which reached 156.86 gm.plant^{-1} with an increase of 8.71%.

Table 5: Effect of ordinary and Nanoparticles Zinc oxide fertilizers and their levels and Humic acid on leaf area of flag leaf cm^2.plant^{-1} in the male inflorescence stage of maize.

Fertilizer sources	**Zinc levels Kg Zn.h^{-1}**	**Humic acid levels Kg HA.h^{-1}**		**Average sources × levels**
		0	**60**	
ord-ZnO	12	399.99	415.12	407.56
	18	440.00	430.21	435.11
Average sources × Humic acid		420.00	422.70	421.34
Nano-ZnO	12	433.31	446.16	439.74
	18	439.98	458.08	449.03
Average sources × Humic acid		436.60	452.10	444.39
Average Humic acid		428.32	437.39	432.86
Control		388.48 *		
Fertilizer sources		Zinc levels kg Zn.h^{-1}		Average sources
		12	18	
ord-ZnO		407.56	435.11	421.34
Nano-ZnO		439.74	449.03	444.39
Average levels		423.65	442.05	432.86
Humic acid levels kg HA.h^{-1}		Zinc levels kg Zn.h^{-1}		Humic acid average
		12	18	
0		416.65	439.99	428.32
60		430.64	444.15	437.40
Average levels		423.65	442.07	432.86

Treatments	Sources	Levels	Humic acid	Sources X levels	Sources X Humic acid	levels X Humic acid	Sources X levels X Humic acid
L.S.D$_{0.05}$	20.08	N.S	N.S	N.S	N.S	N.S	N.S

The Bilateral interaction between the average source of Nano fertilizer and Humic acid showed a significant increase in the addition of Humic acid and reached 177.17 gm.plant^{-1} compared to the non-addition of Humic acid where its average amounted 156.28 gm.plant^{-1} with an increase of 13.37%. Bilateral interaction between average source of ordinary fertilizer and Humic acid its average reached 173.28 gm.plant^{-1} compared with non-addition Humic acid, which reached 148.06 gm.plant^{-1} with an increase of 17.03%. The Bilateral interaction between average source and the levels showed a significant increase in the dry weight of shoot reached 171.50 gm.plant^{-1} at the Nano source and the level interaction 18 gm.plant^{-1}compared to 12 kg Zn.h^{-1} which its average reached 161.94 gm.plant^{-1} with an increase of 5.90%. The ordinary source exceeded at a level of 18 kg Zn.h^{-1} and its average reached 169.56 gm.plant^{-1} compared to the level of 12 kg Zn.h^{-1}, reached 151.78 gm.plant^{-1} with an increase of 11.71%. Bilateral interaction between levels and Humic acid was significant, where the level interaction 18 kg Zn.h^{-1} for fertilizer and the second level of Humic acid (60 kg.h^{-1}) 180 gm.plant^{-1} compared to the interaction of level 12 kg Zn.h^{-1} for fertilizer and Humic acid addition which its average reached 170.45 gm.plant^{-1}, gave an increase of 5.60%. While at the interaction of level 18 kg, Zn.h^{-1} without the addition of Humic its average reached to 161.06 gm.plant^{-1} compared to the level of 12 kg Zn.h^{-1} which its average reached to 143.28 gm.plant^{-1} with an increase of 12.41%. The triple interaction showed a significant increase in the shoot dry weight trait of achieving the highest weight at the Nano source and the level of 18 kg Zn.h^{-1} and the concentration of 60 kg.h^{-1} for Humic acid by 181.56 gm.plant^{-1}, compared to the control that achieved the lowest value its average reached 121.11 gm.plant^{-1} with an increase of 49.91%. The significant increase in the shoot dry weight trait of the shoot when adding Nano source and the level 18 kg Zn.h^{-1} and Humic acid in addition to the bilateral interaction between (sources with Humic acid) and (sources with levels), in addition to the triple interaction. It may be attributed to that the Nano fertilizer have the required qualities for using in planting, in terms of reducing the loss of fertilizers when used, as well as, the arrival rapid and its effect to what normal molecules did not reach such as high solubility, effective concentration, good efficiency leads to an increase in the used nutrients efficiency. Thus, it is easily absorbed by the plant (Monreal *et al*., 2016 and Al- Wakeel, 2013). Zinc oxide Nanoparticles fertilizer provides a large area for different metabolic reactions in the plant, which

Table 6: Effect of ordinary and Nanoparticles Zinc oxide fertilizers and their levels and Humic acid on shoot dry weight gm.plant^{-1} in the male inflorescence stage of maize.

Fertilizer sources	**Zinc levels Kg Zn.h^{-1}**	**Humic acid levels Kg HA.h^{-1}**		**Average sources × levels**
		0	**60**	
ord-ZnO	12	135.45	168.11	151.78
	18	160.67	178.44	169.56
Average sources × Humic acid		148.06	173.28	160.67
Nano-ZnO	12	151.11	172.78	161.94
	18	161.44	181.56	171.50
Average sources × Humic acid		156.28	177.17	166.72
Average Humic acid		152.17	175.22	163.69
Control		121.11 *		

Fertilizer sources	Zinc levels kg Zn.h^{-1}		Average sources
	12	18	
ord-ZnO	151.78	169.56	160.67
Nano-ZnO	161.94	171.50	166.72
Average levels	156.86	170.53	163.69

Humic acid levels kg HA.h^{-1}	Zinc levels kg Zn.h^{-1}		Humic acid average
	12	18	
0	143.28	161.06	152.17
60	170.45	180.00	175.22
Average levels	156.86	170.53	163.69

Treatments	Sources	Levels	Humic acid	Sources X levels	Sources X Humic acid	levels X Humic acid	Sources X levels X Humic acid
L.S.D$_{0.05}$	2.20	2.20	2.20	3.16	N.S	3.16	4.47

increases the photosynthesis percentage and produces a large amount of dry matter. This is consistent with (Qureshi *et al*., 2018). The significant increase in the shoot dry weight of when increasing the concentration due to that the fertilizer contains zinc, which have an important role in the metabolic processes that are related with respiration, water absorption. As well as, chlorophyll formation, photosynthesis and the enzymes effectiveness, which involved in metabolism, as it increases cells elongation, leaf area, plant height and thus increasing the plant dry weight (Vitti *et al*., 2014; Morales-Díaz *et al*., 2017). The dry weight of the plant also increases with the addition of Humic acid, as it increases the nutrients readiness in the soil. Therefore forming a good root increases the absorption of major and minor nutrients and water in the plant and effect on the respiration and photosynthesis process and thus carbohydrates and proteins are manufactured that are distributed in the plant tissues and then increases the plant dry weight (Olaetxea *et al*., 2016; Zandonadi *et al*., 2016).

Root dry weight (gm.plant^{-1})

Table 7, showed a significant increase in the root dry weight by adding zinc oxide Nanoparticles in the male inflorescence stage, where its average reached to 11.33 gm.plant^{-1} compared to an average of 10.75 gm.plant^{-1} with the addition of ordinary zinc oxide with an increase of 5.40%. There was an a significant increase in the root dry weight by adding Humic acid where the average weight reached 12.46 gm.plant^{-1} compared with an average of 9.61 gm.plant^{-1} without adding Humic by 29.66%. The average levels effect of ordinary and Nanoparticles zinc oxide fertilizer the table has shown a significant increase in the root dry weight when adding the level 18 kg Zn.h^{-1} where its average reached 11.55 gm.plant^{-1} compared to the level of 12 kg Zn.h^{-1}, its average 10.53 gm.plant^{-1} with an increase of 9.69%. Bilateral interaction between the levels and Humic acid was significantly, as the root dry weight at the level 18 kg Zn.h^{-1} for fertilizer with the presence of Humic acid 12.72 gm.plant^{-1} compared to the level 12 kg Zn.h^{-1} for fertilizer and with the presence of Humic acid, which its average reached 12.21 gm.plant^{-1} with an increase of 4.18%. Furthermore, at the level of 18 kg Zn.h^{-1} and with the addition of Humic its average 10.38 gm.plant^{-1} compared to the level of 12 kg Zn.h^{-1}, which its average 8.84 gm.plant^{-1} with an increase of 17.42%. The triple interaction was not significant in the dry weight trait of root. The addition of zinc oxide Nanoparticles fertilizer and increased levels and the addition of Humic acid as well as when the bilateral interaction between (Humic

Table 7: Effect of ordinary and Nanoparticles Zinc oxide fertilizers and their levels and Humic acid on Dry Weight of Root gm^{-1} in the Stage of Male Nora Formation of Maize.

Fertilizer sources	**Zinc levels Kg $Zn.h^{-1}$**	**Humic acid levels Kg $HA.h^{-1}$**		**Average sources × levels**
		0	**60**	
ord-ZnO	12	8.53	11.94	10.24
	18	9.99	12.52	11.25
Average sources × Humic acid		9.26	12.23	10.75
Nano-ZnO	12	9.15	12.48	10.81
	18	10.77	12.91	11.84
Average sources × Humic acid		9.96	12.70	11.33
Average Humic acid		9.61	12.46	11.04
Control		6.31		

Fertilizer sources	Zinc levels kg $Zn.h^{-1}$		Average sources
	12	18	
ord-ZnO	10.24	11.25	10.75
Nano-ZnO	10.81	11.84	11.33
Average levels	10.53	11.55	11.04

Humic acid levels kg $HA.h^{-1}$	Zinc levels kg $Zn.h^{-1}$		Humic acid average
	12	18	
0	8.84	10.38	9.61
60	12.21	12.72	12.47
Average levels	10.53	11.55	11.04

Treatments	Sources	Levels	Humic acid	Sources X levels	Sources X Humic acid	levels X Humic acid	Sources X levels X Humic acid
$L.S.D_{0.05}$	0.38	0.38	0.38	N.S	N.S	0.54	N.S

and the levels) achieved a significant increase in the dry weight trait the root. It can be attributed to the role of ordinary and Nanoparticles zinc oxide fertilizer with increased levels of zinc addition, caused that the fertilizer contains zinc, which has an important role in stimulating plant growth and metabolic processes that are related with respiration and water absorption. As well as, the formation of chlorophyll, photosynthesis, enzymes effectiveness, which involved in the metabolism, root cells development and its permeability of wood, responsible for the auxin hormone which stimulates the plant growth and thus increasing the growth and penetration of roots and then increases the root dry weight (Morales-Díaz *et al*., 2017; Rahman *et al*., 2017). The zinc oxide Nanoparticles fertilizer has a high solubility, effective concentration and good efficiency, thus easily absorbed by the plant and provides a large area for different metabolic reactions of the plant, provides a large area for different metabolic reactions in the plant, which increases the photosynthesis percentage and leads to efficient root formation and increases root penetration in soil. Thus, releasing CO_2, which reacts with water to form carbonic acid, then decreasing the pH, increasing the readiness of zinc added to the soil, increasing the efficiency of the roots and producing a large amount of dry matter for the root.

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