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The effect of glutathione and zinc oxide nanoparticles application and their interaction on some vegetative characteristics of *Vicia faba* L. exposed to salinity stress

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Abstract:

The field experiment was conducted at the Botanical Garden at the Department of Biology, College of Education of Pure Sciences (Ibn Al-Haitham), University of Baghdad and during the winter agricultural season 2019-2020 to study the effect of glutathione application at concentration of 0, 50, 100 $mg.L^{-1}$ and zinc oxide nanoparticles at concentration 0, 500, 1000 $mg.L^{-1}$ as well as their interaction in some of the vegetative characterstics of the faba bean plant exposed to different salinity concentrations 0, 5, 10,15 $dS.m^{-1}$.

The results showed a significant increase in the level of plant height, number of leaves, stem diameter, number of nodes when treated with glutathione, particularly concentration of 100 $mg.L^{-1}$, as well as a significant increase in the mean characteristic of plant height, stem diameter and number of nodes when treated with zinc oxide nanoparticles, particularly at concentration 1000 $mg.L^{-1}$, the plant's exposure to different concentrations of NaCl led to a significant decrease in the mean plant height, number of leaves, nodes, stem diameter, especially at the salinity concentration 15 $dS.M^{-1}$, while the treatment with glutathione, zinc oxide nanoparticles and different concentration from NaCl did not appear significant effect in the mean characteristic of the plant branches number. The duel and triple interactions recorded significant effect on the most characteristics.

Keywords:
Glutathione, Zinc oxide, Nanoparticles, *Vicia faba*, Salinity stress.

The effect of glutathione and zinc oxide nanoparticles application and their interaction on some vegetative characteristics of *Vicia faba* L. exposed to salinity stress

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***The research is based on a PhD dissertation.**

Introduction:

The faba bean is the crops that has high nutritional value and economic importance, which belongs to the Fabaceae family and contains many important nutrients including potassium, phosphorus, nitrogen and protein in addition to being used as green feed for animals, and spread agriculture in many parts of the world, including East Asia, China and the Mediterranean (Jezierny *et al*., 2010). The plant is exposed to different types of environmental stresses which may clearly affect most of the growth characteristics and plant's yield, including salinity stress, which increases and accumulates Na^+, Cl^- in cytoplasm cells, so the means of adapting the plant to salinity stress is to increase the size and number of cells to accumulate salinity ions (Flowers, 2004).

Saline stress causes increased concentration of salts in plant cell cytoplasm, which increases the osmotic stress of the plant and the accumulation of salinity ions hinders plant nutrition and nutrient absorption and thus negatively affects its growth and development (Miller *et al*., 2010).

The treatment of plants with glutathione may reduce the negative impact of salinity stress as a non-enzymatic antioxidant and acts as a co-enzyme as well as protect plant cells and tissues from the effect of negatively charged that produced from exposing the plant into the stress (Noctor *et al*., 2012). Zinc oxide nanoparticles plays a role in protecting the plant from the effects of environmental stress, as zinc oxide nanoparticles is an inorganic compound of a very small size and has a chemical formula ZnONPs and has many uses in the medical, cosmetic and pharmaceutical industries, as well as its role in increased movement and transport of nutrients within the plant, including N and P, which play a role in increasing plant content of proteins and dissolved carbohydrates (Pal *et al*., 2018).

Materials and Methods

The soil was prepared for cultivation during the winter planting season 2019-2020 in the Botanical Garden of the Department of Biology, College of Education for Pure Sciences (Ibn Al-Haitham), University of Baghdad, the experiment was designed in the method Randomized Complete Block Design (R.C.B.D) and three repeats, each of 36 experimental units, the length of the experimental unit 1 m and 1 m wide. The agriculture was carried out in the form of deep lines and by four lines of agriculture, and each line contained five holes, the distance between the lines 25 cm and the holes 20 cm and the seeds of the faba bean plant were cultivated on 15-10-2019 and the first cut was taken on 25-12-2019 as the vegetative growth characteristics were measured by the following:

1. Plant height (cm): The height of the plant from its contact area to the soil was calculated to the end of the peak and to three random plants and then calculated the rate for them.
2. The number of leaves (leaf.plant-1): According to three random plants and then according to their rate.
3. The number of branches of the main stem (branch.plant-1): according to the number of branches for three random plants and then by rate.
4. Stem diameter (thickness): Depending on the stem diameter rate of three random plants.
5. Number of nodes (node.plant-1): Depending on the mean number of nodes for three plants taken randomly from the middle line.

Statistical analysis: The results were analyzed by the SAS program to compare the mean of all treatments with the lowest significant difference L.S.D. at a probability ratio of 0.05 (SAS, 2012).

Results and Discussion:

The results of table (1) indicated a significant decrease in the mean characteristic of plant height when treated with different concentrations of NaCl, particularly the saline concentration of 15 dS.m-1, which gave the lowest mean of 67.93 cm compared to the control treatment of 83.70 cm and a percentage decrease of 18.84%, this the effect of salinity on the rate of plant respiration, carbon metabolism and production of dry matter is due to the accumulation of salinity molecules, including Cl^-, Na^+ in plant cells and in large quantities, which increases the size of plant cells as a result of the accumulation of salts in them, which inhibits the process of cellular division and elongation of plant (Boudjabi *et al*., 2015). Therefore, the increase in the treatment of plants with salinity concentrations increases the rate of decline in plant height and these results are consistent with Dutta and Bera (2014), Zawde and Shanko (2017) and Perez-Labrada *et al.* (2019) on mung bean, chickpeas and tomatoes at respectively.

The results of the table also indicated a significant increase in the mean of this characteristic when treated with different concentrations of glutathione, as the concentration 100 $mg.L^{-1}$ gave the highest mean of this characteristic was 77.11 cm and a percentage increase of 5.71% compared to the control treatment of 72.94 cm and this is due to the role of glutathione increases the growth and development of plant cells as an antioxidant, and has a role in removing the harmful effect of reactive oxygen species, it increases the stability of cellular membranes as a reduced and regulating factor of plant growth, as well as its role in regulating the process of cellular division in the plant and increasing its tolerance to inappropriate oxidative conditions (Kocsy *et al*., 2013). This demonstrates the effective role of glutathione in increasing the growth and development of the plant, and these findings are consistent with the findings of El-Awadi *et al*. (2014) and Al-Hayani (2015) on wheat and mung bean plants at respectively.

The results of the table showed a significant increase in the mean height of the plant when treated with zinc oxide nanoparticles, particularly concentration of 1000 mg.L^{-1}, which gave the highest mean of 76.53 cm and a percentage increase of 6.78% compared to the control treatment of 71.67 cm, which may be due to the positive and effective role of zinc oxide nanoparticles because of the zinc element is a micronutrient for the plant and has a role in increasing the efficiency of photosynthesis because it is involved in the synthesis of chlorophyll molecule and a necessary component for the formation of tryptophan, which is involved in the synthesis of plant growth regulators, including: auxins IAA, which plays a role in increasing cellular division and differentiation process in the plant (Prasad et al., 2012). All of this is positively and effectively reflected in plant growth and increased height, and these findings are consistent with the findings of Laware and Roskar (2014), Tiwari (2017) and Carcia-Lopez *et al*. (2019) on onion, maize and pepper plants at respectively.

The results of the table also showed a significant effect of the dual interaction between NaCl and glutathione, giving the concentration 100 mg.L^{-1} of the glutathione and at the salinity concentration zero dS.m^{-1} the highest mean of 87.22 cm compared to the lowest mean of 65.78 cm at zero mg.L^{-1} concentration from glutathione and salinity concentration 15 dS.m^{-1}.

The results of the table also indicated a significant effect of the interaction between NaCl and zinc oxide nanoparticles, with the salinity concentration giving 0 dS.m^{-1} and 1000 mg.L^{-1} of the highest mean zinc oxide nanoparticles of 85.44 cm compared to the lowest value of this characteristic at 64.44 cm at the salinity concentration 15 dS.m^{-1} and zero mg.L^{-1} of zinc oxide nanoparticles. The results of the table also indicated a significant effect of the interaction between glutathione and zinc oxide nanoparticles, giving the concentration 100 mg.L^{-1} of glutathione and 1000 mg.L^{-1} of zinc oxide nanoparticles, the highest mean of this characteristic was 81.33 cm compared to the lowest value of 66.50 cm at zero mg.L^{-1} of glutathione and zinc oxide nanoparticles, this demonstrates their effective role in increasing the growth rate and height of the plant and eliminating the harmful effect of salinity.

The results of the table also showed a significant effect of the interaction between the three test factors, giving the concentration zero dS.m^{-1} of NaCl, 100 mg.L^{-1} of glutathione and zero mg.L^{-1} of the highest mean zinc oxide nanoparticles of this characteristic was 94.33 cm, which illustrates the role of glutathione and zinc oxide nanoparticles. The plant is added in removing the negative effect of the plant-exposed salinity stress, while the lowest mean of interaction between the three experiment factors at the salinity concentration 15 dS.m^{-1} and 0 mg.L^{-1} of glutathione and zinc oxide nanoparticles, which amounted to 61.67 cm, indicating the negative effect of salinity at the rate of plant height.

Table 1: The effect of glutathione, zinc oxide nanoparticles application and their interaction on the height (cm) of the faba bean plant exposed to salinity stress.

NaCl (dS.m^{-1})	Glutathione (mg.L^{-1})	ZnO nanoparticles (mg.L^{-1})			Glutathione × NaCl
		0	500	1000	
0	0	93.33	82.33	80.67	85.44
	50	88.33	64.62	82.33	78.44
	100	74.67	92.67	94.33	87.22
5	0	66.00	79.00	68.00	71.00
	50	68.00	66.67	81.67	72.11
	100	82.00	92.67	67.00	80.56
10	0	63.67	70.00	80.33	70.33
	50	66.33	67.33	66.00	66.56
	100	64.33	67.33	66.00	65.89
15	0	61.67	70.00	65.67	65.78
	50	63.67	71.00	89.33	74.67
	100	68.00	83.00	78.67	76.56
Mean ZnO nanoparticles		71.67	75.69	76.53	2.63
ZnO nanoparticles L.S.D (0.05)		1.31			
Dual interaction L.S.D (0.05)		4.56			

ZnO nanoparticles×NaCl

NaCl	ZnO nanoparticles (mg.L^{-1})			Mean of NaCl
	0	500	1000	
0	80.44	85.22	85.44	83.70
5	72.00	72.22	79.44	74.56
10	64.44	77.89	74.67	72.33
15	64.78	70.78	68.22	67.93
L.S.D (0.05)	2.68			1.52

Glutathione × NaCl

Glutathione	ZnO nanoparticles (mg.L^{-1})			Mean of Glutathione
	0	500	1000	
0	71.58	79.83	67.42	72.94
50	66.50	76.67	78.33	73.83
100	76.92	73.08	81.33	77.11
L.S.D (0.05)	2.28			1.31

The results of table (2) indicated a significant decrease in the mean number of leaves when treated with NaCl, particularly at the salinity concentration 15 dS.m^{-1}, which gave the lowest average of 8.81 leaf.plant^{-1}. This is due to the effect of salinity on the photosynthesis process and the inhibition of chlorophyll formation as well as its effect on the rate of absorption of the plant's absorption of the essential elements necessary for its growth and development as a result of the accumulation of salinity ions in plant cells (Dhookie *et al*., 2013), which clearly effects on the vegetative parts, especially the number of leaves, and these results are consistent with the findings of Abdul Qados (2010) on the faba bean plant with decreased rate was 24.95% compared to control which was 11.74 leaf.plant^{-1}.

The results of the table also indicated a significant increase in the mean of this characteristic when treated with different concentrations of glutathione, particularly concentration of 100 mg.L^{-1}, which gave the highest mean was 10.47 leaf.plant^{-1} with an increase rate of 15.30% compared to the control treatment of 9.08 leaf.plant^{-1}. This demonstrates the role of glutathione as an adjunct to chemical reactions, detoxicity of oxidative processes and regulation of photosynthesis under various stress conditions to the plant (Salama and Al-Mutawa, 2009). Thus, the growth and production of the plant increases for the various vegetative parts, particularly the leaves, and these results are consistent with the results obtained by Al-Hayani (2015) on the mung bean plant. The results of the table showed that there was no significant effect of zinc oxide nanoparticles in the mean characteristic of the number of plant leaves. The results of the table also indicated a significant effect of the interaction between NaCl and glutathione. As the salinity concentration zero dS.m-1 and the concentration 50 mg.L^{-1} of glutathione was giving the highest mean for this characteristics was 12.44 leaf.plant^{-1} compared to the lowest mean of 7.67 leaf.plant^{-1} at salinity concentrations 15 dS.m^{-1} and zero mg.L^{-1} of glutathione.

The results of the table also indicated a significant effect of the interaction between NaCl and zinc oxide nanoparticles. As the salinity concentration zero dS.m-1 and the concentration of zinc oxide nanoparticles 1000 mg.L^{-1} was giving the highest mean of 12.89 leaf.plant^{-1} compared to the lowest mean of the characteristics was 8.44 leaf.plant^{-1} at the salinity concentration 15 dS.m^{-1} and the concentration zero mg.L^{-1} from zinc oxide nanoparticles. The results of the table indicated a significant effect of the dual interaction between glutathione and zinc oxide nanoparticles. As the concentration 100 mg.L^{-1} of glutathione and 1000 mg.L^{-1} of zinc oxide nanoparticles was giving the highest mean of this characteristic was 11.17

leaf.plant-1 compared to zero mg.L^{-1} concentration of glutathione and zinc oxide nanoparticles, which gave the lowest value of the characteristic at 8.33 leaf.plant^{-1}.

The results of the table also indicated a significant effect of the interaction between the three experiment factors in the mean of this characteristic, particularly at the salinity concentration zero dS.m-1 and (50, 100) mg.L^{-1} of glutathione and 100 mg.L^{-1} of zinc oxide nanoparticles, which gave the highest mean of 13.00 leaf.plant-1. This demonstrates the positive and effective role of glutathione and zinc oxide nanoparticles in increasing plant growth, photosynthesis efficiency and vegetative plant growth compared to the lowest mean of 7.00 leaf.plant^{-1} at the salinity concentration 15 dS.m^{-1} and the concentration zero mg.L^{-1} of both glutathione and zinc oxide nanoparticles.

Table 2: The effect of glutathione and zinc oxide nanoparticles application and their interaction on the leaves number (leaf.plant^{-1}) of the faba bean plant exposed to salinity stress.

NaCl (dS.m^{-1})	Glutathione (mg.L^{-1})	ZnO nanoparticles (mg.L^{-1})			Glutathione × NaCl
		0	500	1000	
0	0	9.67	11.67	12.67	11.33
	50	12.00	12.33	13.00	12.44
	100	12.67	8.67	13.00	11.44
5	0	8.67	8.33	8.33	8.44
	50	9.67	9.00	11.33	10.00
	100	11.67	10.00	11.67	11.11
10	0	8.00	10.67	8.00	8.89
	50	8.67	10.00	9.00	9.22
	100	9.33	9.00	9.00	9.11
15	0	7.00	7.67	8.33	7.67
	50	8.00	8.67	9.00	8.56
	100	11.00	11.67	8.00	10.22
Mean ZnO nanoparticles		9.69	9.81	10.11	1.15
ZnO nanoparticles L.S.D (0.05)		N.S			
Dual interaction L.S.D (0.05)		1.99			

ZnO nanoparticles×NaCl

NaCl	ZnO nanoparticles (mg.L^{-1})			Mean of NaCl
	0	500	1000	
0	11.44	10.89	12.89	11.74
5	10.00	9.11	10.44	9.85
10	8.67	9.89	8.67	9.07
15	8.44	9.33	8.67	8.81
L.S.D (0.05)	1.15			0.06

Glutathione × NaCl

Glutathione	ZnO nanoparticles (mg.L^{-1})			Mean of Glutathione
	0	500	1000	
0	8.33	9.58	9.33	9.08

50	9.58	10.00	10.58	10.06
100	11.17	9.83	10.42	10.47
L.S.D (0.05)			0.99	0.57

The results of table (3) showed no significant effect for NaCl in the mean characteristic of the plant branches number, as indicated by the absence of a significant effect of zinc oxide nanoparticles and glutathione in the mean of this characteristic and the triple interaction between the three experiment factors did not have a significant effect in the mean of this characteristic. The dual interaction between NaCl and glutathione had no significant effect on the mean of this characteristic, as well as the interaction between NaCl-zinc oxide nanoparticles and glutathione- zinc oxide nanoparticles had no significant effect on the mean of this characteristic.

Table 3: The effect of glutathione and zinc oxide nanoparticles application and their interaction on the branches number (branch.plant^{-1}) of the faba bean plant exposed to salinity stress.

NaCl (dS.m^{-1})	Glutathione (mg.L^{-1})	ZnO nanoparticles (mg.L^{-1})			Glutathione × NaCl
		0	500	1000	
0	0	2.33	2.33	2.67	2.44
	50	2.67	2.33	2.00	2.33
	100	2.67	2.00	2.00	2.22
5	0	1.67	2.00	2.00	1.84
	50	2.33	2.33	2.00	2.22
	100	2.67	1.67	2.00	2.11
10	0	2.00	2.00	2.00	2.00
	50	2.67	2.67	2.00	2.44
	100	2.00	2.33	2.00	2.11
15	0	1.33	2.00	2.00	1.78
	50	2.00	2.00	2.00	2.00
	100	2.33	2.00	2.00	2.11
Mean ZnO nanoparticles		2.22	2.25	2.14	N.S
ZnO nanoparticles L.S.D (0.05)				N.S	
Dual interaction L.S.D (0.05)				N.S	

ZnO nanoparticles×NaCl

NaCl	ZnO nanoparticles (mg.L^{-1})			Mean of NaCl
	0	500	1000	
0	2.56	2.22	2.22	2.33
5	2.22	2.00	2.00	2.07
10	2.22	2.33	2.00	2.18
15	1.89	2.00	2.00	1.96
L.S.D (0.05)			N.S	N.S

Glutathione × NaCl

Glutathione	ZnO nanoparticles (mg.L^{-1})			Mean of Glutathione
	0	500	1000	
0	1.83	2.08	2.16	2.03
50	2.42	2.33	2.00	2.25
100	2.42	2.00	2.00	2.06
L.S.D (0.05)			N.S	N.S

The results of the table (4) also indicated a significant decrease in the mean stem diameter characteristic when treated with different concentrations of NaCl, especially at the salinity concentration 15 $dS.m^{-1}$, which gave the lowest mean of this characteristic was 1.085 cm and a decrease rate of 38.21% compared to the control treatment of 1.756 cm. It returns to the degrading role of salinity in the growth rate of the plant and the formation of its vegetative parts through the effect of salinity in the osmotic stress of the soil solution, which affects the movement of dissolved, nourishing and absorbed elements through the root and all of this is reflected negatively in the overall vegetative characteristic of the plant, including the diameter of the stem (Boudjabi *et al*., 2015).

The results of the table also indicated a significant increase in the mean of this characteristic when treated with glutathione, especially at 100 $mg.L^{-1}$, which gave the highest mean this characteristic of 1.578 cm and an increase rate of 84.34% compared to the control treatment of 0.856 cm, which shows the role of glutathione being as tripeptide amino acid and has a role in inhibiting the negative effect of free radicals and increasing the plant's antioxidant content, which increases plant vitality and efficiency in photosynthesis because it protects cellular parts of free radicals (Noctor *et al*., 2012), these findings are consistent with the findings of Al-Hayani (2015) on the mung bean plant.

The results of the table showed a significant increase in the mean stem diameter characteristic when treated with zinc oxide nanoparticles, particularly concentration of 1000 $mg.L^{-1}$, which gave the highest mean of 1.414 cm and an increase rate of 22.63% compared to the control treatment of 1.153 cm. This is due to the role of zinc oxide nanoparticles in increasing the rate of plant growth and the efficiency of the photosynthesis process because zinc is one of the essential nutrients that the plant needs to perform its vital activities in addition to being one of the elements that play a key role in the enzymatic synthesis of a number of enzymes, including carbonic anhydrase, which plays a key role in the photosynthesis of the plant (Prasad *et al*., 2012), this shows an effective effect in most vegetative parts of the plant, including the diameter of the stem.

The results of the table also indicated a significant effect of the interaction between NaCl and glutathione in the mean of this characteristic, as the salinity concentration zero $dS.m^{-1}$ and the concentration 100 $mg.L^{-1}$ of glutathione gave the highest mean of this characteristic 2.178 cm compared to the lowest mean of 0.600 cm at the salinity concentration 10 dS.m-1 and glutathione concentration of zero $mg.L^{-1}$.

The dual interaction between NaCl and zinc oxide nanoparticles also has a significant effect on the mean of this characteristic, the salinity concentration zero $dS.m^{-1}$ and 1000 $mg.L^{-1}$ of zinc oxide nanoparticles giving higher mean of 2.089 cm compared to the lowest mean of 0.833 cm at the salinity concentration 15 $dS.m^{-1}$ and the concentration zero $mg.L^{-1}$ from zinc oxide nanoparticles. The results of the table also indicated a significant effect of interaction between the glutathione and zinc oxide nanoparticles as the concentration 50 $mg.L^{-1}$ of glutathione and 1000 $mg.L^{-1}$ of zinc oxide nanoparticles gave the highest mean of this characteristic was 1.650 cm compared to the lowest mean of 0.508 cm at zero $mg.L^{-1}$ of glutathione and zinc oxide nanoparticles.

The results of the table also indicated a significant effect of the interaction between the three experiment factors in the mean of this characteristic, particularly at the salinity concentration zero $dS.m^{-1}$, the concentration of glutathione 100 $mg.L^{-1}$ and the concentration of zinc oxide nanoparticles 1000 $mg.L^{-1}$, which gave the highest mean of 2.567 cm compared to the lowest mean of 0.400 cm at the salinity concentration 15 $dS.m^{-1}$ and the concentration zero $mg.L^{-1}$ of both glutathione and zinc oxide nanoparticles, this shows the negative effect of salinity on the vegetative growth rate of the plant in its various parts.

Table 4: The effect of glutathione and zinc oxide nanoparticles application and their interaction on the stem diameter (cm) of the faba bean plant exposed to salinity stress.

NaCl ($dS.m^{-1}$)	Glutathione ($mg.L^{-1}$)	ZnO nanoparticles ($mg.L^{-1}$)			Glutathione × NaCl
		0	500	1000	
0	0	0.500	1.067	1.300	0.956
	50	2.267	1.733	2.400	2.133
	100	1.900	2.067	2.567	2.178
5	0	0.700	1.167	1.300	1.056
	50	1.167	1.467	1.500	1.378
	100	1.500	1.533	1.300	1.444
10	0	0.433	0.800	0.567	0.600
	50	1.333	1.267	1.333	1.311
	100	1.533	1.433	1.100	1.356
15	0	0.400	0.867	1.167	0.811
	50	0.700	1.267	1.367	1.111
	100	1.400	1.533	1.067	1.333
Mean ZnO nanoparticles		1.153	1.350	1.414	
ZnO nanoparticles L.S.D (0.05)				0.059	0.118
Dual interaction L.S.D (0.05)				0.205	

ZnO nanoparticles×NaCl

NaCl	ZnO nanoparticles ($mg.L^{-1}$)			Mean of NaCl
	0	500	1000	

0	**1.556**	**1.622**	**2.089**	**1.756**
5	**1.122**	**1.389**	**1.367**	**1.293**
10	**1.100**	**1.167**	**1.000**	**1.089**
15	**0.833**	**1.222**	**1.200**	**1.085**
L.S.D (0.05)			**0.118**	**0.068**

Glutathione × NaCl

Glutathione	**ZnO nanoparticles (mg.L^{-1})**			**Mean of Glutathione**
	0	**500**	**1000**	
0	**0.508**	**0.975**	**1.083**	**0.856**
50	**1.367**	**1.433**	**1.650**	**1.483**
100	**1.583**	**1.642**	**1.508**	**1.578**
L.S.D (0.05)			**0.102**	**0.059**

The results of table (5) indicated a significant decrease in the mean number of nodes at different concentrations of NaCl, as the salinity concentration 15 dS.m^{-1} gave the lowest mean of 8.30 nodes.plant-1 with a rate decrease of 33.11% compared to the control treatment of 12.41 nodes.plant^{-1}. The exposure of the plant to salinity stress increases the accumulation of salinity ions, including Cl^{-}, Na^{+} and these ions have a clear negative effect on photosynthesis enzymes, chlorophyll pigments and carotene, which negatively affects the growth rate of the plant represented by the length of the stem and the number of leaves and nodes on the main stem because of the salinity ions draw water from the cytoplasm to the intercellular spaces affecting the size of plant cells and causing them to break down (Parida *et al*., 2002).

The results of this table also indicated a moral increase in the mean of this characteristic when treated with different concentrations of glutathione, particularly the concentration of 100 mg.L^{-1}, which gave the highest mean of 10.28 nodes.plant^{-1} with an increase rate of 15.63% compared to the control treatment of 8.89 node.plant^{-1}. This is because glutathione is an antioxidant with the defensive function of plant components from the damage caused by environmental stress as it contributes to the development of plant growth by regulating the process of cellular division and increasing plant tolerance for different oxidative conditions, which increases plant efficiency and increases effective photosynthesis pigments (Pyngrope *et al*., 2013). The role of glutathione in promoting plant growth, efficiency and growth of its various vegetative parts, including the plant nodes, is thus evident.

The results of the table also showed a significant increase in the mean number of nodes when treated with different concentrations of zinc oxide nanoparticles, particularly concentration of 1000 mg.L^{-1}, which gave the highest mean of 10.28 nodes. plant^{-1} with an increase rate of 12.24% compared to the control treatment of 9.11 nodes.plant-1 due to the role of zinc as a nutrient of the plant and a catalyst for photosynthesis of the plant, which contributes to increasing the stability of cellular membranes and increasing the rate of photosynthesis in the plant as well as entering into the synthesis of special enzymes for the formation of plant auxins stimulating plant growth and formation of its vegetative parts (Bouis, 2013). The results of this table also showed no significant effect on the interaction between NaCl- zinc oxide nanoparticles, NaCl-Glutathione, zinc oxide nanoparticles-Glutathione and between the three experiment factors.

Table 5: The effect of glutathione and zinc oxide nanoparticles application and their interaction on the plant nodes (node.plant^{-1}) of the faba bean plant exposed to salinity stress.

NaCl (dS.m^{-1})	Glutathione (mg.L^{-1})	ZnO nanoparticles (mg.L^{-1})			Glutathione × NaCl
		0	500	1000	
0	0	12.00	10.00	14.00	12.00
	50	12.00	13.00	13.00	12.67
	100	11.67	14.00	12.00	12.56
5	0	7.67	9.00	8.33	8.33
	50	8.67	10.00	10.33	9.67
	100	10.00	10.67	11.67	10.78
10	0	8.00	8.33	8.00	8.11
	50	8.00	8.67	10.33	9.00
	100	9.33	8.00	10.00	9.11
15	0	7.00	6.67	7.67	7.11
	50	8.00	10.33	9.00	9.11
	100	7.00	10.00	9.00	8.67
Mean ZnO nanoparticles		9.11	9.89	10.28	N.S
ZnO nanoparticles L.S.D (0.05)				0.73	
Dual interaction L.S.D (0.05)				N.S	

ZnO nanoparticles×NaCl

NaCl	ZnO nanoparticles (mg.L^{-1})			Mean of NaCl
	0	500	1000	
0	11.89	12.33	13.00	12.41
5	8.78	9.89	10.11	9.59
10	8.44	8.33	9.44	8.74
15	7.33	9.00	8.56	8.30
L.S.D (0.05)			N.S	0.84

Glutathione × NaCl

Glutathione	ZnO nanoparticles (mg.L^{-1})			Mean of Glutathione
	0	500	1000	
0	8.67	8.50	9.50	8.89
50	9.17	10.50	10.67	10.11
100	9.50	10.67	10.67	10.28
L.S.D (0.05)			N.S	0.73

Conclusion:

Exposing the plant to the concentration of 15 dS.m^{-1}of NaCl has a negative effect on the characteristics of the plant, including its height, number of leaves and nodes in terms of the number of branches, but the spraying of the plant with glutathione and ZnO nanoparticles, particularly 100 and 1000 mg.L^{-1}, has a positive role in reducing the effect of salinity. The duel and triple interaction have a significant effect on some of the appearance qualities in terms of having no significant effect on the number of plant branches.

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تأثير الرش بالكلوتاثيون واوكسيد الزنك النانوي وتداخلهما في بعض الصفات الخضرية لنبات الباقلاء *Vicia faba* L. المعرض للإجهاد الملحي

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المستخلص:
أجريت التجربة الحقلية في الحديقة النباتية لقسم علوم الحياة، كلية التربية للعلوم الصرفة (ابن الهيثم) وخلال الموسم الزراعي الشتوي 2019-2020 لدراسة تأثير الرش بالكلوتاثيون وبالتراكيز 0، 50، 100 ملغم.لتر$^{-1}$ واوكسيد الزنك النانوي وبالتراكيز 0، 500، 1000 ملغم.لتر$^{-1}$ وتداخلهما في بعض الصفات الخضرية لنبات الباقلاء المعرض لتراكيز مختلفة من الملوحة وهي 0، 5، 10، 15 ديسيمينز.م$^{-1}$. أظهرت النتائج وجود زيادة معنوية في مستوى صفة ارتفاع النبات وعدد الأوراق وقطر الساق وعدد العقد عند المعاملة بالكلوتاثيون ولاسيما التركيز 100 ملغم.لتر$^{-1}$، كما حصلت زيادة معنوية في متوسط صفة ارتفاع النبات وقطر الساق وعدد العقد عند المعاملة باوكسيد الزنك النانوي ولاسيما التركيز 1000 ملغم.لتر$^{-1}$، كما أن تعرض النبات لتراكيز مختلفة من NaCl أدت إلى حصول انخفاض معنوي في متوسط صفة ارتفاع النبات وعدد الأوراق والعقد وقطر الساق ولاسيماعند التركيز الملحي 15 ديسيمنز.م$^{-1}$ في حين لم تكن للمعاملة بالكلوتاثيون واوكسيد الزنك النانوي وتراكيز مختلفة من NaCl أي تأثير معنوي في متوسط صفة عدد الأفرع النباتية.

الكلمات المفتاحية : الكلوتاثيون، اوكسيد الزنك، الجسيمات النانوية، الباقلاء، الاجهاد الملحي.

ملاحظة : هل البحث مستل من رسالة ماجستير او اطروحة دكتوراه ؟ نعم : √ كلا :