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The role of vitamin E and calcium oxide nanoparticles in yield of wheat irrigated with saline water

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Abstract:

A field experiment was carried out during 2024 growing season ,to investigate the influence of foliar application of vitamin E and concentration of(0,100,200) mg.L⁻¹ in addition to Calcium oxide nanoparticles (0,50,100) mg.L⁻¹ on yield wheat parameters of to salt stress(Nacl)at three levels (0, 4, 8)ds.m⁻¹ .the experiment was conducted in factorial Randomized completely Blook Design (R.C.B.D) whith three replicates and means were compared Duncan s test at probability of 0.05. Results indicated that salt stress(Nacl) levels from 0 to 8 ds.m⁻¹ reduced significantly the average of growth yield parameters (Number of spikelets ,weight of 1000 grian , grian yield ,biological yield).Moreover , application of vitamin E and Calcium oxide nanoparticles increased significantly the average of growth yield parameters above,and had reduced the adverse effect of salt stress particularely 200 mg.l⁻¹ vitamin E and 100 mg.l⁻¹ Calcium oxide nanoparticles.

Keywords: wheat, Vitamin E, nano calcium, salt stress

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Introduction

Wheat (*Triticum aestivum* L.) it serves as the staple food for more than 35% of the world's population [1]. Wheat consider king of cereal crops because the grains have height percentage of carbohydrates and proteins estimated at approximately 70% and 20% respectively, in addition 3% fats, 2% fibers and many chemical compounds like vitamins (B and E) and secondary metabolites (flavonoids, alkaloids, phenolics, ect.) [2]. The grains are used as a raw

material in many food manufactures such as bread, biscuits, cakes, pastries and pasta [(3), while the straw is used as animal feed because they have 18% protein rich of amino acids such as lysine and tryptophan [4] Salt stress is considered one of the most detrimental environmental stresses, contributing significantly to increased agricultural production losses worldwide [5]. It leads to a series of morphological, physiological, and even molecular disturbances in plants, which negatively affect their growth, metabolism, and productivity [6]. Elevated concentrations of salts in irrigation water stimulate the overproduction of free radicals, including reactive oxygen species (ROS) and reactive nitrogen species (RNS). These reactive molecules induce lipid oxidation in unsaturated fatty acids of cellular membranes, causing membrane damage, chlorophyll degradation, reduced efficiency of photosynthesis and respiration, decreased carbohydrate and protein synthesis, and ultimately cell death [7] Vitamin E (Vit. E) or α -tocopherol play a vital role in protecting cells from oxidative stress, as they counteract the harmful effects associated with the accumulation of reactive oxygen species (ROS), which can lead to cellular damage [8] Vitamin E has many functions in plant cell such as: electron transport in photosystem, protect membrane from free radicals, increase tolerance to environmental stresses and delay senescence [9] Calcium oxide nanoparticles (CaO-NPs) have distinctive properties such as particles are small diameter with a large surface area, non-toxic and easily penetrated into plant tissues [10]. CaO NPs play a vital role in plant such as increase element absorption, cell wall structure, enhance germination, metabolic activity, and improve tolerance to various abiotic stresses (salinity, drought and heavy metals) [11]. The aim of research to choose the best treatment of Vit. E and CaO-NPs spraying to reduce salinity stress in wheat yield.

2. Material and methods

Soil preparation

An agricultural experiment was carried out in the garden of the College of Education for Pure Sciences/University of Diyala for the growing season (2024-2025) using plastic pots 5 kg capacity, To study the effect of salt stress (sodium chloride NaCl) at three levels (0, 4, 8) d.S.m⁻¹, three concentrations of both vit. E (0, 100 and 200 mg/L⁻¹) and CaO-Nps (0, 50 and 100 mg/L⁻¹) and interaction on some contents yield of wheat cv. Ajiba. The soil was brought from the nursery and mixed with soil and sifted with a 2 mm sieve. It was mixed well, filled in the pots and a sample was taken from it to know some physical and chemical properties. Table (1) shows the results of the analysis. Then, DAP fertilizer was added to the soil in the pots before planting at a rate of 3 gm/pot according to the fertilizer recommendation.

Table (1):- Some physical and chemical characters of the experimental soil.

Soil particles (g/ kg soil)	Organic matter	Ph	E.c Ds/m	texture	N	P	K
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Clay	Silt	sand	1.1	6.75	4	Sand Clay	17.8	22.4	117.8
22.5	28.25	49.26							

Preparation of Study Factors

The saline water was prepared using sodium chloride (NaCl) (table salt), using the following equation: $(640 \times W) = \text{weight of salt required to prepare the concentrate}$ [12]. The amount of sodium chloride required per liter of distilled water to achieve an electrical conductivity of (4,8) d.S .m⁻¹ was calculated using the above equation. The concentrations of vit.E and Cao-NP were prepared after preparing the stock solution by dissolving one gram of each of the above compounds in distilled water. The volume was brought to 1000 ml of distilled water. The required concentrations were then prepared according to the following dilution law: $c_2 \times v_2 = c_1 \times v_1$.

Agricultural operations

Wheat seeds were sown in pots on 20/11/2024. Sixteen seeds were planted in each pot at a depth of 1 cm. All treatments were irrigated with tap water until the emergence of the third to fourth leaf stage. Thereafter, irrigation was replaced with a sodium chloride solution. Irrigation was carried out according to plant requirements. Forty days after sowing, the plants were foliar-sprayed with two concentrations of vitamin E and nano-calcium oxide as previously mentioned. Spraying was conducted in the morning until complete wetting using a hand sprayer. A second foliar application was performed at the flowering stage. The plants (six plants per treatment) were harvested upon reaching full physiological maturity, indicated by complete drying of both spikes and vegetative parts, 150 days after sowing. The following yield components were subsequently determined to No. of spikelets (spikelet.plant⁻¹), weight of 1000 grain (g), grain yield (g) and biological yield (g).

Characteristics of Calcium oxide nano -particles

The results of X-ray diffraction (XRD) patterns of calcium oxide nanoparticles (CaONPs) were analyzed by identifying the peak locations. Peaks appeared at the following angles (2θ): 18.0027°, 28.7055°, 34.1147°, 42.9537°, 47.1481°, 50.8608°, 54.3512°, 59.4120°, 62.3631°, 64.1505°, and 71.180°, as shown in Figure (1). The diagram shows the crystalline nature of the material and its polycrystalline composition. The crystallite size (D_{av}) was calculated using the Scherrer equation, with the crystallite sizes ranging from 14–24 nanometers, confirming that the particles fall within the nanoscale range. The results also showed the presence of distinct peaks indicating the regular crystalline structure of calcium oxide. Comparing the peak locations with the JCPDS Card No. 36-1451 revealed a perfect match, indicating the purity of the sample and the absence of crystalline impurities.

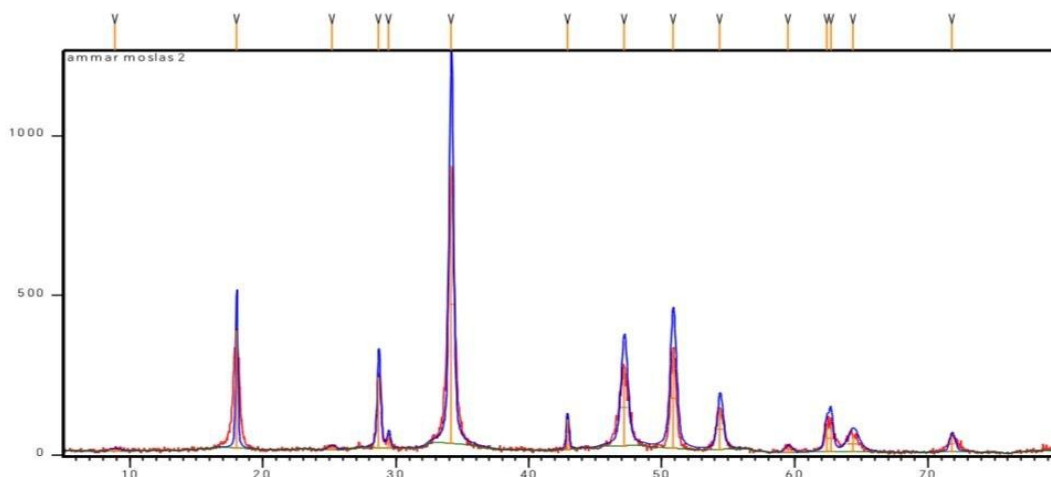


Figure (1) X-ray photometry of calcium oxide nanoparticles

Statistical analysis

factorial experiment was conducted using a Randomized Complete Block Design (R.C.B.D.). The results were statistically analyzed using SPSS. The differences between the means were compared using Duncan’s multiple range test at a probability level of 0.05 and P value.

3. Result and Discussion

Number of spikelets (spikelet.plant⁻¹)

Table (2) showed that there were significant differences among the mean of salinity (NaCl) levels in spikelets number and when increased from 0 to 8dS.m⁻¹ that decreased from 32.89 to 25.67spikelet.plant⁻¹. while the foliar spraying both vitamin E, and CaO-NPs gave a significant increase especially in higher concentration (200 and 100mg.l⁻¹) (30.70 and 31.33spikelet.plant⁻¹) respectively compared with control. A significant difference was found at the three interactions among studied factors. Plants irrigated with the tap water and sprayed with 200 mg.l⁻¹ Vit.E and 100mg.l⁻¹ CaO-NPs was superior to give the highest of the spikelets number 37.67 spikelet.plant⁻¹ and differed significantly from other plants, while the lowest spikelets number in plants irrigated with 8dS.m⁻¹ and non-sprayed with vitamin and nanoparticles gave 21.00 spikelet.plant⁻¹. This confirms the harmful effect of salt stress on decrease spikelets number, but plants sprayed with Vit.E (200mg. l⁻¹) and CaO-NPs (100mg.l⁻¹) with the same level of saline previous (8dS.m⁻¹) gave 30.67 spikelet.plant⁻¹.

Table (2): Effect of NaCl, Vit.E, CaO-NPs and interaction on No. of spikelets (spikelet.plant-1)

NaCl ds.m ⁻¹	0	Ca-ONP ^s			Average NaCl
		0	50	100	
0	0	28.00 f	31.00 d	32.67 c	28.89 A
	100	29.67 e	33.67 c	35.33 b	
	200	32.67 c	35.33 b	37.67 a	

4	0	23.00 l	26.33 h	27.67 fg	27.41 B
	100	25.00 lj	26.67 gh	30.67 de	
	200	25.67 hi	28.33 f	33.33b	
8	0	21.00 m	23.67 ki	25..67 de	25.67 C
	100	22.67 l	26.33 h	28.33 f	
	200	24.33 jk	28.33 f	30.67 de	
Average vit.E	0	26.56 C			
	100	28.70 B			
	200	30.70 A			
Average Ca-ONPs	0	25.78 C			
	50	28.85 B			
	100	31.33 A			

Weight of 1000 Grain

The results in Table (3) showed a significant decrease in the mean weight of 1000 grains with increasing salinity levels. At the level of 8 dS m⁻¹, the lowest weight of 35.26 g was recorded compared to 47.13 g at 0 dS m⁻¹. while the foliar spraying both vitamin E, and CaO-NPs gave a significant increase especially in higher concentration (200 and 100mg.l⁻¹) (42.28g and 42.74 g) respectively compared with control. A significant difference was found at the three interactions among studied factors. Plants irrigated with the tap water and sprayed with 200 mg.l⁻¹ Vit.E and 100mg.l⁻¹ CaO-NPs was superior to give the highest weight of 1000 grains 51.48 g and differed significantly from other plants, while the lowest weight of 1000 grains in plants irrigated with 8dS.m⁻¹ and non-sprayed with vitamin and nanoparticles gave 31.30 g. This confirms the harmful effect of salt stress on decrease weight of 1000 grian , but plants sprayed with Vit.E (200mg. l⁻¹) and CaO-NPs (100mg.l⁻¹) with the same level of saline previous (8dS.m⁻¹) gave 40.02 g

Table (3): Effect of NaCl, Vit.E, CaO-NPs and their interaction on weight of 1000 grian

NaCl ds.m ⁻¹	0	Ca-ONP ^s			Average NaCl
		0	50	100	
0	0	45.16 h	46.48 f	47.88 d	47.91 A
	100	46.35 g	47.9 d	49.74 b	
	200	47.24 e	48.92 c	51.48 a	
4	0	35.50 s	37.56 o	35.50 s	38.92 B
	100	37.19 p	39.21 l	37.19 p	
	200	37.93 n	40.22 j	31.93 n	
8	0	31.30 x	33.90 v	31.30 x	35.26 C
	100	33.12 w	35.12 t	33.12 w	
	200	34.74 u	36.21 q	34.74 u	

Average vit.E	0	39.13 C
	50	40.68 B
	100	42.28 A
Average Ca-ONPs	0	38.37 C
	100	40.68 B
	200	42.28 A

Grian yield

The results in Table (4) showed that the mean grain yield decreased significantly with increasing sodium chloride concentration in irrigation water compared to the control treatment irrigated with tap water only. The lowest yield was 5.85 g at 8 dS m⁻¹ salinity, while the highest was 8.11 g in the control treatment. while the foliar spraying both vitamin E, and CaO-NPs gave a significant increase especially in higher concentration (200 and 100mg.l⁻¹) (6.69g and 7.07g) respectively compared with control. A significant difference was found at the three interactions among studied factors. Plants irrigated with the tap water and sprayed with 200 mg.l⁻¹ Vit.E and 100mg.l⁻¹ CaO-NPs was superior to give the highest grains yield 10.42 g and differed significantly from other plants, while the lowest grains yield in plants irrigated with 8dS.m⁻¹ and non-sprayed with vitamin and nanoparticles gave 5.17 g. This confirms the harmful effect of salt stress on decrease grian yield, but plants sprayed with Vit.E (200mg. l⁻¹) and CaO-NPs (100mg.l⁻¹) with the same level of saline previous (8dS.m⁻¹) gave 7.04 g.

Table (4): Effect of NaCl, Vit.E, CaO-NPs and their interaction on Grian yield

NaCl ds.m ⁻¹	0	Ca-ONP ^s			Average NaCl
		0	50	100	
0	0	7.01 K	7.62 g	8.21 d	47.91 A
	100	7.51 l	7.98 e	8.87 b	
	200	7.92 f	8.23 c	10.42 a	
4	0	5.67 v	6.23 q	6.60 n	38.92 B
	100	5.91 s	6.71 m	7.02 k	
	200	6.33 p	6.98 l	7.55 h	
8	0	5.17 y	5.51 w	5.91 s	35.26 C
	100	5.49 x	5.81 t	6.51 o	
	200	5.79 u	6.03 r	7.04 j	
Average vit.E	0	5.97 c			
	50	6.52 B			
	100	6.69 A			
Average Ca-ONPs	0	5.89 C			
	100	6.52 B			

	200	6.69 A	
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Biological Yield

The results in Table (5) showed that increasing sodium chloride concentrations from 0 to 8 dS m⁻¹ caused a decrease in the mean biological yield of wheat plants. The mean value declined from 19.60 g to 15.31 g, representing a reduction of 21%.

However, foliar application of both vitamin E and CaO nanoparticles (CaO-NPs) resulted in a significant increase in biological yield, particularly at higher concentrations (200 and 100 mg L⁻¹), where the values reached 16.76 g and 17.23 g, respectively, compared to the control. A significant difference was observed among the three-way interactions of the studied factors. Plants irrigated with tap water and sprayed with 200 mg L⁻¹ vitamin E and 100 mg L⁻¹ CaO-NPs produced the highest biological yield (22.52 g), showing a significant superiority over other treatments. In contrast, the lowest biological yield (14.19 g) was recorded in plants irrigated with 8 dS m⁻¹ and not treated with either vitamin E or nanoparticles.

These results confirm the detrimental effect of salt stress in reducing biological yield. Nevertheless, plants subjected to the same salinity level (8 dS m⁻¹) but treated with vitamin E (200 mg L⁻¹) and CaO-NPs (100 mg L⁻¹) showed an improved yield of 17.74 g.

Table (5): Effect of NaCl, Vit.E, CaO-NPs and their interaction on Biological Yield

NaCl ds.m ⁻¹	0	Ca-ONP ^s			Average NaCl
		0	50	100	
0	0	17.81 f	18.94 e	19.79 e	47.91 A
	100	18.62 e	19.55 cd	20.78 b	
	200	19.43 d	19.86 cd	22.52 a	
4	0	14.88 lm	16.23 l	16.31 i	38.92 B
	100	15.42 jk	16.56 hi	16.70 ghi	
	200	16.85 gh	16.99 gh	17.74 f	
8	0	14.19 n	14.83 lm	15.50 jk	35.26 C
	100	14.70 m	15.83 jkl	16.28 i	
	200	15.13 klm	15.65 j	17.06 g	
Average vit.E	0	15.61 C			
	50	16.44 B			
	100	16.76 A			
Average Ca-ONPs	0	15.52 C			
	100	16.16 B			
	200	17.23 A			

The results presented in Tables (2, 3, 4, and 5) demonstrated a reduction in the number of spikelets, the weight of 1000 grains, grain yield, and biological yield with the increase in

sodium chloride levels. This decrease is attributed to the role of irrigation water salinity in raising soil salinity, which negatively affects plant growth through the osmotic effect of the soil solution. This osmotic stress reduces the ability of plant roots to absorb water, thereby inhibiting the photosynthetic process [13]. The reduction in photosynthetic products increases the competition between the flag leaf and the spike for dry matter resources [14]. Moreover, the high concentration of sodium chloride reduces the duration required for grain filling, which leads to a decrease in grain weight and consequently affects wheat yield [15]. α -Tocopherol plays a protective role by scavenging reactive oxygen species (ROS). It exerts its antioxidant function by donating a hydrogen atom to lipid peroxy radicals, thereby terminating the chain propagation of lipid peroxidation. This mechanism protects the acyl groups of unsaturated fatty acids from oxidative degradation and consequently preserves the structural integrity and stability of cellular membranes [16], while, an increase in yield traits was observed with foliar application of vitamin E and nano-calcium. This increase is attributed to the role of vitamin E in enhancing plant tolerance to salt stress, as it contributes to improving spikelet fertility and increasing floral clusters. Moreover, it plays an active role in stabilizing cellular membranes, thereby enhancing the absorption of water and essential nutrients such as nitrogen, phosphorus, and potassium, while reducing the uptake of sodium and chloride. These processes collectively promote vigorous vegetative growth that supports the reproductive development of the plant [17]. In addition, vitamin E facilitates the translocation of assimilated sugars from the leaves to the grains in the spikes, which leads to grain filling, increased grain number and weight, and enhanced accumulation of carbohydrates, ultimately improving yield components [18]. Furthermore, vitamin E protects the photosynthetic apparatus from oxidative damage, thereby significantly increasing the photosynthetic pigments in the leaves [19], which in turn contributes to enhancing physiological processes such as the regulation of plant growth and metabolism [20]. Nano-calcium also plays a role in enhancing chlorophyll content, increasing photosynthetic activity, and promoting plant growth [21]. In addition, it contributes to improving the translocation of nutrients within the plant and enhances metabolic activities [22]. Foliar application of nano-calcium increases the plant's ability to absorb calcium, as it decomposes into carbon dioxide, making it more available and consequently leading to enhanced photosynthesis and improved yield [23].

Conclusions

We conclude from the experimental results that the treatment with increasing concentrations of sodium chloride affected the yield traits of the wheat cultivar Ajiba. Spraying the vegetative parts of the plant with vitamin E and nano-calcium enhanced all vegetative growth traits, particularly when applying the combination of 200 mg. L⁻¹ vitamin E and 100 mg. L⁻¹ nano-calcium.

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