The role of some non-enzymatic antioxidants spray on yield and quality of soybean under salt stress conditions

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ABSTRACT

A field experiment was conducted during the autumn season of 2022 at the College of Agricultural Engineering Sciences, University of Baghdad, to evaluate the role of spraying with glutathione and selenium on the growth, yield and quality of soybean under salt stress conditions in silty loam soil classified as Typic Torrifluvent. A split-split plot design in a randomized complete block arrangement with three replications was used. The main plots were assigned to saline water concentrations (1.2, 4, and 6 dSm^{-1}), while the subplots included glutathione concentrations (0, 50, and 100 mg L^{-1}) sprayed at 25, 50, and 75 days after planting. Sub-sub plots were assigned selenium concentrations (0, 25, and 50 mg L^{-1}) sprayed on the same dates.

The results showed a significant effect in the treatments of spraying glutathione, as glutathione at 50 mg L^{-1} achieved glutathione oxidase activity was 50.83 %, proline was 31.28 %, nitrogen, phosphorus and potassium in leaves 4.11 %, 0.37 %, 4.43 %, protein content in seeds was 20.38 %, and grain yield was 3.16 ton ha-1 . The spraying with selenium as Se1 was significantly difference in the treatments and achieved glutathione oxidase activity was 49.16 %, proline was 30.08 %, nitrogen, phosphorus and potassium was 3.86 %, 0.35 %, 4.42 %, protein content in seeds was 19.24 %, and grain yield was 2.95 ton ha^{-1}. Salinity level W_3 was significantly difference and gave enzyme glutathione oxidase activity was 76.70 %, proline was 34.47 %, nitrogen, phosphorus and potassium was 4.39 %, 0.35 %, 5.09 %, protein content in seeds was 20.31 %, yield 3.44-ton ha^{-1}.

Keywords: Glutathione; Selenium; Salt stress; proline; Soybean.

INTRODUCTION

Plants are exposed to different types of environmental stresses (biotic and abiotic), and salt stress is one of the most dangerous types of abiotic stresses affecting plant growth. Salt stress occurs when there is an increase in the concentration of dissolved salts in the soil, resulting in disturbance and imbalance in metabolic processes, ultimately leading to decreased growth and plant death [5,32,46]. Plants exhibit different degrees of sensitivity to salt stress, influenced by factors such as salts type, the length of exposure to salt stress, severity of stress, plant developmental stage, genetic makeup and interaction with other stress factors. When a plant is exposed to salt stress, the production of active oxygen species will increase, and to reduce the destructive effects of these types of oxygen, plant cells will in return stimulate the antioxidant system, which is divided into (enzymatic antioxidants and non-enzymatic antioxidants) [7,47].Worldwide, about 25–55% of irrigated land areas are affected by salt. The alarming issue is by 2050 up to 50% of agricultural land is expected to be affected by salinity [15,26].Glutathione containing non-protein thiol group and can act as an effective electron acceptor and donor for many biological reactions [45].

The tripeptide glutathione (GSH) is the most abundant peptide in plant tissues and plays multiple roles in cellular metabolism. It is a key compound in sulfur metabolism and one of the most important sulfotransferases in sulfur reduction. In addition, it acts as a potent reductant of reactive oxygen species. Glutathione is a non-enzymatic antioxidant capable of donating electrons via the electron transport chain. In this process, a hydrogen proton is donated and oxidized. Glutathione also participates in the formation of glutathione peroxidase, an antioxidant enzyme. Selenium is an essential component of this enzyme, enhancing its antioxidant properties. It gives off a hydrogen proton and is oxidized during the process. Additionally, glutathione also includes the antioxidant enzyme glutathione peroxidase in the recipe. Selenium is a presumptive component of this enzyme, enhancing its antioxidant properties [43].In addition to being essential as an antioxidant, it is responsible for antioxidant protection, regulating cell functions in terms of oxidation and reduction, and resisting various types of stress. [21].

Selenium is a trace element that plays an effective role in increasing the antiviral activity of enzymes, acting as a cofactor for this purpose, especially the enzyme glutathione peroxidase, which participates in converting the toxic hydrogen peroxide compound H2O2 resulting from environmental stress into a molecule of H2O. Selenium also binds to amino acids, particularly methionine and cysteine, forming selenium proteins, which have the extraordinary ability to help cell membranes withstand stress and prevent the breakdown of plant protein metabolites. [19].Selenium is one of the most important nutrients at low concentrations and has a dual effect due to its participation as a cofactor in the nutritional metabolism of enzymatic and non-enzymatic antioxidants[39].One of its most important effects on plants is its role in the metabolism of secondary metabolites and its interaction with proteins and amino acids to produce mineral proteins characterized by an exceptional ability to withstand salt and water stress and prevent their degradation. In addition, selenium also participates in the formation of the rare amino acids selenocysteine and selenomethionine, which are considered among the newest and most effective antioxidants [42]. Soybean hummus (*Glycine max* L.) is of nutritional and industrial importance in most countries of the world. The interest in it comes because it is the only crop whose seeds contain all the essential amino acids for human and animal growth. Its seeds contain over 35% protein and over 22% oil content [46].

The aim is to study the role of spraying with glutathione and selenium on the growth, yield and quality of soybean under salt stress conditions.

MATERIALS AND METHODS

A field experiment conducted at the College of Agricultural Engineering Sciences, University of Baghdad, Jadirya during the autumn growing season of 2022, investigated the role of spraying with glutathione and selenium on the growth, yield and quality of soybean under salt stress conditions in Silty loam soil classified as Typic Torrifluvent according to the world classification Soil survey staff (2006). Using a randomized complete block design with split-split plots design with three replications. Soil samples were taken from 0-30 cm depth before planting for soil chemical, physical and fertility analysis (Table 1), and through the growing date of 90 days after soybean planting day. Soil samples were crushed and passed through 2 mm diameter sieve and then mixed. The main plots were devoted to the concentrations of the saline water at 1.2, 4 and 6 $dS.m^{-1}$ symbolized as W_1, W_2 and W_3. While the subplots were devoted to glutathione concentration sprayed on plants at rates 0, 50 and 100 mg L^{-1} symbolized as G_1, G_2 and G_3 which was applied on 25, 50, and 75 days of planted date. The sub–sub plots were devoted to Selenium concentration sprayed on plants at rates 0, 25 and 50 mg L^{-1} symbolized as Se_1, Se_2 and Se_3 which was applied on 25, 50, and 75 days of planted date.

Soybean seeds were sowed in 2 x 2 m plots. It included three rows. 2-3 seeds were planted in each hole, and then thinned after germination to one plant three weeks after planting. Nitrogen is added in two doses, the first at planting and the second at the flowering stage. Phosphorus and potassium are added at once at planting. The chlorophyll concentration in the leaves was measured using a Spad-502 Chlorophyll meter, manufactured by the Japanese company Minolta. Measurements were taken from five randomly selected plants from each experimental unit.

Table1. Physical, chemical and fertility properties of soil

EC	pH	O.M	$CaCO_3$	CEC	N	P	K	Texture
ds m^{-1}		%	g kg^{-1} soil	c mol c kg^1	mg kg^{-1} soil			
2.74	7.78	0.91	230	19.7	20.1	8.64	127.3	Silty loam

Results and discussion

3.1 Glutathione oxidase activity

The results are shown in table (2) significant difference in the treatments of spraying glutathione, as G_2 achieved glutathione oxidase activity was 50.83 % relative to control treatment G_3 was 44.16 %, this is ascribed to direct application of glutathione can led to enhance in the overall glutathione content within plant tissues, this can enhance the plant's ability to neutralize reactive oxygen species (ROS) and reduce oxidative stress, glutathione is involved in several enzymatic reaction, particularly those related to detoxification and antioxidation. Spraying glutathione may boost the activity of enzymes like glutathione peroxidase and glutathione s-transferase which are essential for maintaining cellular health and protecting against oxidative damage, By enhancing the availability of glutathione, plants may exhibit better tolerance to various environmental stresses such as drought, salinity and heavy metal exposure. This is due to the enhanced capacity to scavenge free radicals and repair damaged cells [34].

In addition, the spraying with selenium as Se_1 was significantly difference in the treatments and achieved glutathione oxidase activity was 49.16 % relative to control treatment Se2 was 47.32 %, this is ascribed to selenium is a key component of the enzyme glutathione peroxidase, which is a selenium dependent antioxidant enzyme. Selenium spraying can enhance the activity of this enzyme, strengthening the plant's defenses against oxidative stress. [11,38,42].

Similarly, the salinity level in W3 was significantly different, with glutathione oxidase activity reaching 76.70% compared to 24.11% in the control treatment in W1. This is attributed to the significant effect of salt stress on plants, particularly on the concentration and activity of glutathione. Salt stress leads to increased production of reactive oxygen species (ROS) within plant cells, it causes oxidative stress, requiring the plant to enhance its natural defense mechanisms. In response to salt stress, the plant may increase glutathione production as part of its strategy to combat oxidative damage. [22,41].Regarding the interaction of spraying with glutathione, selenium and salinity, it gave the highest average value for glutathione oxidase activity, as the G1Se1W3 treatment achieved a rate of 92.30% compared to the control G3Se3W1 treatment, which reached 20.58%.

Table 2. Effect of some non-enzymatic antioxidants on glutathione oxidase activity under salt stress conditions

		W1	W2	W3	G * Se
G1	Se 1	21.21	34.25	92.30	49.25
	Se 2	24.95	35.03	80.70	46.90
	Se 3	25.88	44.60	82.83	51.11
G2	Se 1	24.73	47.83	80.67	51.08
	Se 2	26.28	48.07	78.47	50.94
	Se 3	22.82	47.90	80.70	50.47
G3	Se 1	25.27	44.13	72.07	47.16
	Se 2	25.29	42.63	64.43	44.12
	Se 3	20.58	44.90	58.10	41.19

LSD $_{0.05}$			9.95		5.66
					Average
W * G	**G 1**	24.02	37.96	85.28	49.09
	G 2	24.61	47.93	79.94	50.83
	G 3	23.71	43.89	64.87	44.16
LSD $_{0.05}$			6.32		3.54
					Average
W * Se	**Se 1**	23.74	42.07	81.68	49.16
	Se 2	25.51	41.91	74.53	47.32
	Se 3	23.10	45.80	73.88	47.59
LSD $_{0.05}$			6.15		3.29
Average W		24.11	43.26	76.70	
LSD $_{0.05}$			5.16		

3.2 Proline

The results of Table (3) indicate that there is a significant difference in the glutathione spray treatments, as G1 achieved a proline percentage of 31.28% compared to the control treatment G3, 23.18%. This is attributed to the fact that glutathione acts as an antioxidant and can help reduce oxidative stress, which may lead to increased proline production as part of the plant's response to enhance protection against environmental stresses. Although there are multiple mechanisms, including reducing oxidative stress and stimulating the production of osmotic substances. Proline is Known for its role in improving the plant's tolerance to various stresses by acting as an osmolyte that helps maintain water balance within cell and protects proteins and enzymes from damage. Spring glutathione may enhance this process by reducing oxidative damage and creating a favorable environment for enhanced proline concentration [20].

In addition, the spraying with selenium as Se_1 was significantly difference in the treatments and achieved proline was 30.08 % relative to control treatment Se_3 was 25.66 %, this is ascribed to selenium role in reducing oxidative stress by enhancing antioxidant enzymes, allowing the plant's to allocate more resources toward proline production as part of its stress response. Proline helps the plant's maintain water balance and protect cells from damage under harsh condition [17,30].

Similarly, salinity level W_3 was significantly difference and gave proline was 34.47 % relative to control treatment W_1 was 23.72 %, the concentration of proline often enhances significantly, this accumulation is a natural response by plant's to adapt to harsh condition, proline helps maintain cellular water balances, protects proteins from degradation.

In regard to the interaction of spraying glutathione, selenium and salinity gave the highest mean value of proline as $G_1Se_2W_3$ treatment achieved 44.40 % relative to control treatment $G_3Se_2W_1$ was 18.89 %.

Table 3. Effect of some non-enzymatic antioxidants on proline under salt stress conditions

		W1	**W2**	**W3**	**G * Se**
G1	**Se 1**	26.66	28.11	43.73	32.83
	Se 2	27.25	26.64	44.40	31.78
	Se 3	22.99	25.32	39.39	29.23
G2	**Se 1**	27.21	25.33	39.41	30.65
	Se 2	25.47	20.82	32.87	26.38
	Se 3	23.48	21.55	34.02	26.35
G3	**Se 1**	22.09	22.56	35.63	26.76
	Se 2	18.89	23.70	21.55	21.38
	Se 3	19.44	22.63	22.17	21.41

LSD $_{0.05}$			6.34		3.37
					Average
W * G	**G 1**	25.63	26.69	41.52	31.28
	G 2	25.39	22.56	35.43	27.79
	G 3	20.14	22.96	26.45	23.18
LSD $_{0.05}$			3.55		0.99
					Average
W * Se	**Se 1**	25.32	25.34	39.59	30.08
	Se 2	23.87	23.72	31.95	26.51
	Se 3	21.97	23.16	31.86	25.66
LSD $_{0.05}$			4.31		2.30
Average W		23.72	24.07	34.47	
LSD $_{0.05}$			3.62		

3.3 Nitrogen in leaves

Results of table (4) indicate a significant difference in the treatments of spraying glutathione, as G_3 achieved nitrogen in the leaves was 4.11 % relative to control treatment G_1 was 3.22 %, this is ascribed to glutathione can enhance plant's ability to absorb nitrogen from the soil by reducing oxidative stress and promoting root health, glutathione can boost root system activity, potentially leading to improved nitrogen uptake and higher nitrogen concentration in the leaves [1].

In addition, the spraying with selenium as Se_3 was significantly difference in the treatments and achieved nitrogen in the leaves was 3.86 % relative to control treatment Se_1 was 3.49 %, this is ascribed to selenium enhance the root ability to absorb nitrogen from the soil by improving root health and reducing oxidative stress, selenium can enhance the efficiency of the root system in absorbing nutrients including nitrogen, potentially leading to higher nitrogen concentration in the leaves [3,28,36].

Similarly, salinity level W_1 was significantly difference and gave nitrogen in the leaves was 4.39 % relative to control treatment W_3 was 2.97 %, this is ascribed to salt stress can decrease the ability of root to absorb nitrogen from soil. High salt concentration in the soil affects the water balance within the root, leading to a decrease in nitrogen uptake efficiency [4,37]. About the interaction of spraying glutathione, selenium and salinity gave the highest mean value of nitrogen as $G_3Se_3W_1$ treatment achieved 5.84 % relative to control treatment $G_1Se_1W_3$ was 2.22 %.

Table 4. Effect of some non-enzymatic antioxidants on nitrogen in leaves under salt stress conditions

		W1	**W2**	**W3**	**G * Se**
G1	**Se 1**	3.64	3.27	2.22	3.04
	Se 2	3.84	3.45	2.73	3.34
	Se 3	3.72	3.34	2.76	3.27
G2	**Se 1**	4.08	3.87	3.09	3.68
	Se 2	3.68	3.49	2.70	3.29
	Se 3	4.44	4.21	2.94	3.86
G3	**Se 1**	4.76	3.42	3.09	3.75
	Se 2	5.52	3.47	3.42	4.13
	Se 3	5.84	3.67	3.84	4.45
LSD $_{0.05}$			1.33		0.80
					Average
W * G	**G 1**	3.73	3.36	2.57	3.22
	G 2	4.06	3.38	2.91	3.61
	G 3	5.37	3.52	3.45	4.11

LSD $_{0.05}$		0.70			0.47
					Average
W * Se	**Se 1**	4.16	4.34	4.66	3.49
	Se 2	3.52	3.47	3.74	3.59
	Se 3	2.80	2.95	3.18	3.86
		0.71			0.47
Average		4.39	3.58	2.97	
LSD $_{0.05}$		0.34			

3.4 Phosphorus in leaves

Results of table (5) indicate a significant difference in the treatments of spraying glutathione, as G_3 achieved phosphorus in the leaves was 0.37 % relative to control treatment G_1 was 0.29 %, this is ascribed to glutathione might improve the internal transport of phosphorus from roots to leaves by supporting cellular functions and improving tissue health, glutathione can aid in the effective distribution of phosphorus throughout plants tissues leading to enhanced phosphorus concentration in the leaves [43].

In addition, the spraying with selenium as Se_3 was significantly difference in the treatments and achieved phosphorus was 0.35 % relative to control treatment Se_1 was 0.30 %, this is ascribed to selenium help plant maintain phosphorus in the leaves by boosting cellular defenses and reducing the impact of stress, selenium helps mitigate damage to phosphorus uptake and utilization activating related enzymes and boosting the plant stress resistance [28,36].

Similarly, salinity level W_1 was significantly difference and gave phosphorus was 0.35 % relative to control treatment W_3 was 0.29 %, this is ascribed to high salt concentration in the soil after the water potential around the roots which impairs the roots ability to transport phosphorus and other nutrients. This disruption in nutrient transport can lead to a reduced availability of phosphorus for the plant's, resulting in lower phosphorus levels in the leaves [18,27]. About the interaction of spraying glutathione, selenium and salinity gave the highest mean value of phosphorus as $G_2Se_2W_1$ treatment achieved 0.47 % relative to control treatment $G_1Se_1W_3$ was 0.20 %.

Table 5. Effect of some non-enzymatic antioxidants on phosphorus in leaves under salt stress conditions

		W1	**W2**	**W3**	**G * Se**
G1	**Se 1**	0.31	0.34	0.20	0.29
	Se 2	0.33	0.24	0.24	0.27
	Se 3	0.35	0.36	0.27	0.33
G2	**Se 1**	0.40	0.38	0.30	0.36
	Se 2	0.47	0.32	0.28	0.36
	Se 3	0.29	0.35	0.32	0.32
G3	**Se 1**	0.44	0.34	0.28	0.35
	Se 2	0.42	0.35	0.35	0.37
	Se 3	0.38	0.37	0.36	0.37
LSD $_{0.05}$		0.10			0.06
					Average
W * G	**G 1**	0.33	0.31	0.24	0.29
	G 2	0.39	0.35	0.30	0.35
	G 3	0.41	0.35	0.33	0.37
LSD $_{0.05}$		0.04			0.03
					Average

W * Se	**Se 1**	0.33	0.31	0.26	0.30
	Se 2	0.36	0.35	0.29	0.33
	Se 3	0.38	0.36	0.32	0.35
LSD 0.05			0.05		0.03
Average W		0.35	0.34	0.29	
LSD 0.05			0.02		

3.5 Potassium in leaves

Results of table (6) indicate a significant difference in the treatments of spraying glutathione, as G_3 achieved potassium in the leaves was 4.43 % relative to control treatment G_1 was 4.29 %, this is ascribed to spring glutathione contribute to better internal transport of nutrients, including potassium by supporting the vascular system and internal nutrients, glutathione helps in the efficient movement of potassium from roots to leaves. Addition to glutathione help reduce the negative effect of competition between potassium and other nutrients by improving overall nutrient balance within the plant [23].

In addition, the spraying with selenium as Se_3 was significantly difference in the treatments and achieved potassium was 4.42 % relative to control treatment Se_1 was 4.30 %, this is ascribed to selenium boost the activity of enzymes involved in potassium metabolism and storage. Enhanced enzyme activity can contribute to higher potassium levels in the leaves. Addition to selenium improves health of plant tissues by reducing oxidative stress and protecting cells. Healthier tissues can utilize nutrients like potassium more effectively, which can lead to enhanced potassium levels in the leaves [13].

Similarly, the salinity level in W1 was significantly different, with potassium content at 5.09% compared to the control treatment, W3, which was 3.63%. This is attributed to the fact that salt stress disrupts the ionic balance within plant cells due to the accumulation of salts in the soil. High salt concentrations also increase the accumulation of toxic ions such as sodium and chloride, which hinders potassium uptake and reduces its effectiveness in the leaves. Salt stress often leads to increased water loss from plants due to its impact on water balance in cells. Water deficiency can impair a plant's ability to transport potassium to the leaves, contributing to low potassium levels. [14,35].

In regards to the interaction of spraying glutathione, selenium and salinity gave the highest mean value of potassium as $G_3Se_3W_1$ treatment achieved 5.73 % relative to control treatment $G_1Se_1W_3$ was 3.23 %.

Table 6. Effect of some non-enzymatic antioxidants on potassium in leaves under salt stress conditions

		W1	**W2**	**W3**	**G * Se**
G1	**Se 1**	5.00	4.50	3.23	4.30
	Se 2	5.20	3.90	3.87	4.32
	Se 3	4.90	4.57	3.83	4.43
G2	**Se 1**	4.93	4.37	3.63	4.31
	Se 2	5.17	4.23	3.60	4.33
	Se 3	4.83	4.63	3.40	4.23
G3	**Se 1**	5.30	4.17	3.87	4.44
	Se 2	4.70	4.40	3.67	4.26
	Se 3	5.73	4.46	3.57	4.59
LSD 0.05			1.55		0.90
					Average
W * G	**G 1**	4.98	4.41	3.49	4.29
	G 2	5.03	4.32	3.70	4.35
	G 3	5.24	4.34	3.70	4.43
LSD 0.05			0.97		0.59

					Average
W* Se	Se 1	5.02	4.17	3.71	4.30
	Se 2	5.08	4.34	3.63	4.35
	Se 3	5.16	4.55	3.54	4.42
LSD $_{0.05}$		0.90			0.51
Average W		5.09	4.35	3.63	
LSD $_{0.05}$		0.69			

3.6 Protein content in seeds

Results of table (7) indicate a significant difference in the treatments of spraying glutathione, as G_3 achieved protein content in seeds was 20.38 % relative to control treatment G_1 was 16.71 %, this is ascribed to glutathione improve the synthesis of amino acids, which are the building blocks of proteins by boosting the production and availability of amino acids within the plant's, glutathione lead to enhance in protein content in the seeds [23,31].

In addition, the spraying with selenium as Se_2 was significantly difference in the treatments and achieved protein content in seeds was 19.24 % relative to control treatment Se_1 was 17.76 %, this is ascribed to selenium plays a crucial role in boosting the plant antioxidant defense system by reducing oxidative stress, selenium helps preserve the integrity of proteins and enzymes necessary for protein production in seeds, potentially leading to higher protein content [16].

Similarly, salinity level W_1 was significantly difference and gave protein content in seeds was 20.31 % relative to control treatment W_3 was 14.43 %, this is ascribed to that under saline stress conditions, plant face significant challenges in maintaining their physiological balance. To overcome these difficult circumstances, plants are compelled to divert a substantial portion of their energy towards enhancing their natural defenses. This includes the production of antioxidants and other protective compounds that help safeguard cells from damage caused by oxidative stress and increased salt concentration [44].

In regards to the interaction of spraying glutathione, selenium and salinity gave the highest mean value of protein content in seeds as $G_3Se_2W_1$ treatment achieved 27.19 % relative to control treatment $G_1Se_1W_3$ was 10.80 %.

Table 7. Effect of some non-enzymatic antioxidants on protein content in seeds under salt stress conditions

		W1	W2	W3	G * Se
G1	Se 1	19.56	16.98	10.80	15.78
	Se 2	14.90	20.88	13.50	16.42
	Se 3	15.96	21.61	16.65	18.07
G2	Se 1	21.68	18.36	12.26	17.43
	Se 2	19.70	25.18	15.86	20.25
	Se 3	22.10	19.82	14.73	18.88
G3	Se 1	17.09	25.51	17.60	20.07
	Se 2	27.19	21.20	14.73	21.04
	Se 3	24.64	21.69	13.78	20.04
LSD $_{0.05}$		5.41			2.84
					Average
W * G	G 1	16.80	19.82	13.65	16.71
	G 2	19.63	21.12	14.28	18.34
	G 3	22.97	22.80	15.37	20.38
LSD $_{0.05}$		3.41			1.92
					Average
W * Se	Se 1	19.44	20.28	13.55	17.76

	Se 2	20.59	22.42	14.70	19.24
	Se 3	20.90	21.04	15.05	19.0
LSD 0.05		2.63			1.85
Average W		20.31	21.25	14.43	
LSD 0.05		1.73			

3.7 Grain Yield

Results of table (8) indicate a significant difference in the treatments of spraying glutathione, as G_3 achieved grain yield was 3.16 ton ha^{-1} relative to control treatment G_1 was 2.56 ton ha^{-1} this is due to one of the important roles of glutathione in the plant, as it prevents, reduces, or regulates oxidation resulting from the vital processes taking place in the plant during growth and development from cell division and elongation to aging and death (Kasote et al., 2015), this is consistent with [8,40].

In addition, the spraying with selenium as Se_3 was significantly difference in the treatments and achieved grain yield was 2.95 ton ha^{-1} relative to control treatment Se_1 was 2.81 ton ha^{-1}, this is ascribed to Selenium acts as an antioxidant in plants, helping them to mitigate the damaging effects of reactive oxygen species (ROS) caused by environmental stresses such as drought, heat, salinity, and heavy metal toxicity. By reducing oxidative stress, selenium can protect cellular components and maintain optimal plant function, which can lead to increased grain yield. [6,9,25,33].

Similarly, salinity level W_1 was significantly difference and gave grain yield was 3.44ton ha^{-1} relative to control treatment W_3 was 2.57 ton ha^{-1}, this is ascribed to salinity affects crop productivity through several mechanisms including water stress, ionic toxicity, and nutritional imbalances. hose impacts lead to reduced productivity and quality, making salinity management a priority in agricultural research to achieve crop sustainability and increase food security. [2,12].

Regarding the interaction between glutathione, selenium and salinity, the grain yield was given by G3Se3W1 with 3.83 tons gain-1 compared to the control G1Se1W3 which was 1.95 tons ha-1.

Table 8. Effect of some non-enzymatic antioxidants on grain yield under salt stress conditions

		W1	W2	W3	G * Se
G1	Se 1	3.26	2.34	1.95	2.51
	Se 2	3.11	2.29	2.41	2.61
	Se 3	3.30	2.22	2.17	2.56
G2	Se 1	3.34	2.37	2.52	2.74
	Se 2	3.67	2.29	3.04	3.00
	Se 3	3.49	2.74	2.48	2.91
G3	Se 1	3.54	2.99	2.99	3.17
	Se 2	3.37	2.64	2.77	2.93
	Se 3	3.83	3.27	3.05	3.38
LSD 0.05		0.59			0.35
					Average
W * G	G 1	3.23	2.28	2.17	2.56
	G 2	3.50	2.47	2.68	2.88
	G 3	3.58	2.96	2.94	3.16
LSD 0.05		0.30			0.20
					Average
W * Se	Se 1	3.38	2.56	2.49	2.81
	Se 2	3.39	2.41	2.74	2.85
	Se 3	3.54	2.74	2.54	2.95

LSD $_{0.05}$	0.31			0.21
Average W	3.44	2.60	2.57	
LSD $_{0.05}$	0.14			

CONCLOSION

The study showed that spraying glutathione and selenium significantly improved plant performance under saline conditions. Glutathione at a concentration of 100 mg L^{-1} showed significant effects, improving enzyme activity, leaf nutrient content, and grain yield. Selenium spraying at a concentration of 25 mg L^{-1} also showed a significant positive effect on plant, leaf nutrient content, and grain yield. Salinity concentrations at 6 $dS.m^{-1}$, despite its challenging conditions, resulted in the highest glutathione oxidase activity and grain yield, highlighting the potential adaptability of soybean plants with proper treatment. These findings emphasize the effectiveness of foliar applications in mitigating the adverse effects of salinity stress on soybean growth, nutrient in the leaves and yield.

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