O 42. THE ROLE OF SOME ANTIOXIDANTS FOLIAR APPLICATION ON BIO-CHEMICAL AND YIELD OF TWO WHEAT CULTIVARS GROWN UNDER SALINITY STRESS

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ABSTRACT: Salinity stress is one of adversely affect cereal crop yield and quality all over the world. Improving salt tolerance in wheat plants by breeding new cultivars and a foliar application of antioxidants as alleviating treatments to enhance plant production under salinity stress. The aim of this work was to study the role of some antioxidants foliar application on bio-chemical of two wheat (Triticum aestivum L.) cultivars grown under salinity stress. In a split–split plot design with three replicates. Factors were 2 soil types (normal and saline), 2 wheat cultivars (Sakha 95 and Misr 3), and 4 foliar spray treatments (control, 300 mg silicate potassium L-1, 200 mg ascorbic acid L-1 and 200 mg salicylic acid L-1). The effect was highly positive on the biochemical characteristics of wheat when a combination of foliar spray with 200 mg ascorbic acid L-1 with Sakha 95 under saline soil caused considerable increases in the chlorophyll content, peroxidase activity, catalase activity, grain yield and chemical analysis of grain (carbohydrates, P and K%). While the highest content of proline and protein were obtained with c.v Misr 3 + foliar spray by 200 mg ASA L-1. It can be concluded that using cv Sakha 95 and a foliar spray by the ASA is most effective ways for increasing wheat productivity under salinity stress condition.

Keywords: Cultivars Grown Under Salinity Stress

1. INTRODUCTION

Comprising 13.1% of world soils are salt-affected soils (FAO, 2021 b). Nearly 56% of irrigated soils are salt-affected at the Northan Egyptian Nile Delta (Aboelsoud *et al.,* 2022). Salt stress collectively inhibits cell division and expansion, as well as modulate the activity of some key enzymes, thus lastly reducing the seed reserves utilization (El-Hendawy *et al.,* 2019). Also, it has pronounced damaging effects on the physiological, morphological, and biochemical characteristics of the crop plants, including uptake of water and nutrients, germination, growth, photosynthesis, enzyme actions, and yield (Cisse *et al.,* 2019 and Arif *et al.,* 2020).

Wheat (*Triticum aestivum*) is considered one of the world's major cereals, especially in Egypt (FAO, 2020). The national production represents about 8.9 million Mg (2020-2021), and the total consumption increased to 20.6 million Mg due to the annual population growth, which is considered a high country in wheat imports (FAO, 2021 a).

The management of salt-affected soils, improving salt-tolerant crops, this triggered plant breeders to initiate breeding programs aimed at developing salt-tolerant crop cultivars (Ashraf and Munns 2022). Khedr *et al.,* (2023) noted that Sakha 95 and Misr 3 cultivars had no significant differences in chlorophyll content, proline, POD, CAT activity, wheat yield, and its attributes under salt stress.

The integrated and sustainable strategy to enhance salt tolerance in wheat by using the spray foliar application of antioxidants and growth regulators to mitigate the harmful effect of salinity on wheat yield and grain quality (El-Sabagh *et al.,* 2021). Under salt stress conditions, the foliar application of potassium silicate increases the enzymatic activities of antioxidants, thereby reducing the permeability of the plasma membrane and increasing the activity of the roots. This, in turn, enhances nutrient uptake (Ibrahim *et al.,* 2016), and improves plant growth (Ahmad *et al.,* 2013). Also Feghhenabi *et al.,* (2022) noted that the foliar spray by K2Sio3 increased catalase and peroxidase activities in wheat grown under saline conditions, which alleviated the oxidative damage of proteins and lipids. As same as the salicylic acid exogenously applied can maintain cellular detoxification through the regulation of antioxidant defense systems (El-Hawary *et al.,* 2023), regulation of plant physiological processes (Talaat and Shawky 2022). Furthermore, the application of SA enhanced antioxidant defensive or/and tolerance mechanisms which increased growth, pigment concentration, nutrient uptake and yield of wheat under salinity Stress (Noreen *et al.,* 2019). Iqbal *et al.,* (2022) showed that the exogenous application of 1.0 mM of salicylic acid (SA) positively influenced the 90% germination percentage, growth, biomass of plants, gas exchange attributes, photosynthetic rate, glycine betaine, MDA, carbohydrates, protein, and electrolyte leakage, antioxidant activities of enzymes and yield parameters of wheat under salinity stress. Also, ascorbic acid is one of the most important antioxidants in plants that alleviate different environmental stresses, furthermore, it has been found to enhance markedly the capacity of antioxidants and to improve protein metabolism to moderate oxidative stress (Akram *et al.,* 2017), which plays an important role in enhanced salt tolerance of wheat plant and improved shoot length, root weight, grain weight, and biochemical compounds e.g. chlorophyll, starch, fiber, ash, and fat (El-Kassas *et al.,* 2020). The foliar application of ascorbic acid increased the yield of the wheat crop (Osman and Nour Eldein 2017 and Ishaq *et al.,* 2021). The main objective of the present study is to use foliar antioxidant spray to alleviate hazards on biochemical characteristics and yield of wheat (*Triticum aestivum* L.) grown under stress condition.

2. MATERIALS AND METHODS

2.1. Experimental design and Treatments

In a split split–plot design with three replicates, a lysimeters experiment was carried out on two wheat cultivars (*Triticum aestivum* L., c.v Sakha 95 and Misr 3) during two successive seasons 2020/21 and 2021/22 at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, Egypt (31° 5'38.70" latitude N and 30°56'54.00" longitude E with an elevation 6 m above mean sea level). This study aimed to study the effect of foliar spraying with antioxidants on the productivity of wheat crop (*Triticum aestivum* L.) and reduce the harmful effect of salinity on biochemical characteristics and productivity of two cultivars of wheat (Sakha 95 and Misr 3) under salt stress condition. The main plots included 2 soil types (normal and saline), the sub-plots were randomly assigned to 2 wheat cultivars (Sakha 95 and Misr 3), and the sub-sub plots were to 4 foliar treatments: control, 300 mg silicate potassium L^{-1}, 200 mg ascorbic acid L^{-1} and 200 mg salicylic acid L^{-1}). Some soil properties as shown in Table 1.

The total lysimeters used were 48 plots (lysimeter area was 0.78 m^2), which had divided into 4 groups; each group includes 12 lysimeters. Two wheat cultivars (Sakha 95 and Misr 3) were graciously supplied by the Sakha Wheat Research Department, Field Crops Research Institute, Agricultural Research Center, Egypt; Names, pedigrees and Selection history are shown in Table 2.

Plants were irrigated every 30 days and all cultural practices were followed according to the recommendations of the Egyptian Ministry of Agriculture. All foliar application treatments were applied twice at 35 and 50 days after sowing.

Table 1. Soil test of the lysimeter experiment before two growing seasons.

Soil types	Lysimeters	pH	EC (dS m^{-1})	ESP	OM (%)	BD (Mg m^{-3})	Soil mechanical analysis (%)		
							Sand	Silt	Clay
Normal	Group 1	8	3.5	9.33	1.3	1.32	19.1	29.8	51.2
	Group 2	8	3.3	8.93	1.2	1.31	19.2	29.9	50.9
	Group 3	7.9	3.4	9.16	1.2	1.33	19.1	29.9	51.1
	Group 4	8.1	3.7	10.2	1.2	1.31	19.2	30	50.9
	Average	**8**	**3.5**	**9.41**	**1.2**	**1.32**	**19.1**	**29.9**	**51.0**
Saline	Group 1	8.3	8	15.4	1.2	1.36	18.6	29.1	52.2
	Group 2	8.3	8.2	15.6	1.2	1.34	18.9	29.5	51.6
	Group 3	8.3	8.1	15.9	1.2	1.33	18.8	29.4	51.8

	Group 4	8.3	7.9	15.4	1.2	1.36	18.7	29.2	52.1
	Average	**8.3**	**8.1**	**15.6**	**1.2**	**1.35**	**18.8**	**29.3**	**51.9**

* pH = Power Of Hydrogen, EC = Electrical Conductivity, ESP= Exchangeable Sodium Percentage, OM%= Organic matter content, BD= Bulk density

Table 2. Pedigrees and Selection history of the studied wheat cultivars

Cultivar	Pedigree&Selection history
Sakha 95	PASTOR//SITE/MO/3/CHEN/AEGILOPS SQUARROSA(TAUS)//BCN/4/WBLL1(CMSA01Y00158S-040P0Y-040M-030ZTM- 040SY-26M-0Y-0SY-0S).
Misr 3	ATTILA*2/PBW65*2/KACHU (CMSS06Y00582T-099TOPM-099Y-099ZTM-099Y-099M-10WGY-0B-0EGY).

2.2. Measurements and analysis

2.2.1. Soil analysis

Soil samples representing the surface of 30 cm were collected for analysis according to methods cited by Richards (1954), Vomocil (1957), Dewis and Fertias (1970), Hesse (1971), Cottenie *et al.,* (1982) and Page *et al.,* (1982).

2.2.2. Studied characteristics:

At the heading stage, 10 flag leaves were randomly selected from each plot to estimate the following characteristics:

2.2.2.1. Biochemical characteristics

Chlorophyll content (μg ml^{-1}):

Chlorophyll a and b were determined according to Moran (1982). The leaves were homogenized in N-N-dimethyl formamid and determined using the spectrophotometric technique

2.2.2.2. The content of some enzymes in the leaves

- Proline content of leaves (mg g^{-1}FW):
  Proline content was determined according to the method of Bates *et al.,* (1973) was perused UV-VIS Spectrophotometer at 520 nm.
- Catalase activity (CAT μmol min^{-1} g $protein^{-1}$) according to Lum *et al.,* (2014) on a UV-Vis spectrophotometer, the optical density was measured at 240 nm at 0 and 3 minutes.
- Peroxidase activity (POD μmol min^{-1} g $protein^{-1}$) according to (Jebara *et al.,* 2005 and Lum *et al.,* 2014). Absorbance was read at 436 nm on a UV-Vis spectrophotometer at 0 and 3 minutes.

2.2.3. Grain yield and its chemical analysis:

Grain yield was calculated by harvesting whole plants in each plot and air dried, then threshed and the grains at 13 % moisture were weighted in kg and converted to ton fed^{-1}. Grain samples were taken at random from each plot and grounded into a fine powder to pass through 2mm mesh for chemical analysis, i.e. crude carbohydrate content and crude protein (N%×5.75) was determined according to the procedures of the A.O.A.C. (1990) and expressed as a percentage of the dry weight of the sample. Both Na and K were estimated by a flame Photometer according to Jackson, 1967, and P was determined by using hydroquinine method and measured by a spectrophotometer at a 660 nm wavelength (Snell and Snell, 1967).

2.3. Statistical analysis

All statistical analysis was performed using analysis of variance technique by "MSTAT-C" (1990) computer software package and treatment means was compared with Duncan Multiple Range Test the treatments were compared at 0.01% level of significance Duncan (1955).

3. RESULTS

3.1. Biochemical characteristics

3.1.1. Chlorophyll content

Chlorophyll a, and b content in the flag leaf of wheat cultivar Sakha 95 and Misr 3 as affected by soil salinity and foliar spray, and their interaction in the 2020/21 and 2021/22 seasons are presented in Table (3). Data refer that the soil salinity resulted in a highly negative effect on chlorophyll content in both seasons. Soil salinity caused a marked reduction in chl. a (13.33 and 7.69 %), and chl. b (29.83 and 25.00%) compared with normal soil in the two seasons, respectively.

The achieved results shows in Table (3) indicated that, Sakha 95 cultivar exceeded the Misr 3 cultivar in chlorophyll content in both seasons.

Foliar spraying by antioxidants resulted in a highly significant increase in chl a, and b content in the two seasons compared to control treatment (Table 3).

Application of ascorbic acid (ASA) produced the highest values of chl. a (13.34 and 14.51 µg ml^{-1}), followed by silicate potassium (10.92 and 13.24 µg ml^{-1}), and lowest one were obtained by control treatments (7.51 and 10.86 µg ml^{-1}) in the first and second seasons, respectively. Also, the results are similar for chl. b content. However, there was no significant difference between spraying salicylic acid and potassium silicate in the second season for each of chlorophyll content.

The attained results in Table (3) indicated that, the interactions between soil salinity and cultivars on chlorophyll content. It was found that there was an insignificant difference for chl. a in both seasons, and chl. b in the 1^{st} season. A significant difference in the second season for chl. b in the first season was found. The highest values of Sakha 95 cultivar were in the normal soil. Under the saline soil, Misr 3 gave the lowest mean values.

A positive significant difference was found due to the interactions between soil salinity and foliar spraying in chlorophyll content (Table 3). Chlorophyll (a) decreased by 25.98 and 22.91%, and chlorophyll (b) 35.80 and 15.54%.

Table (3) indicates the interactions between cultivars and foliar spraying of chlorophyll content, as it shows that there is a significant difference for chl. a and b in both seasons, but in the second season had insignificant difference in chlorophyll (a). The highest mean values of chlorophyll content were achieved with c.v Sakha 95 + ascorbic acid spray treatment, followed by c.v Misr 3 with ascorbic acid spray treatment; whiles c.v Misr 3 without foliar spray gave the lowest values.

Table 3. Biochemical characteristics of the two wheat cultivars as affected by soil salinity and foliar spraying with some antioxidants in 2020/21 and 2021/22 seasons.

Factors		Chl. a (µg ml^{-1})		Chl. b (µg ml^{-1})		Proline (mg g^{-1}FW)		POD (µmol min^{-1} g protein^{-1})		CAT (µmol min^{-1} g protein^{-1})	
Seasons		2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22
Soil salinity(A)											
Normal		10.97a	13.30a	4.57a	6.10a	0.250b	0.257b	2.27b	2.32b	0.148b	0.156b
Saline		9.68b	12.35b	3.52b	4.88b	0.257a	0.265a	2.42a	2.47a	0.156a	0.164a
F-test		**	**	**	**	**	**	**	**	**	**
Cultivars (B)											
Sakha 95		10.68a	13.15a	4.32a	5.89a	0.250b	0.256b	2.37a	2.43a	0.153a	0.161a
Misr 3		9.97b	12.50b	3.77b	5.10b	0.257a	0.266a	2.32b	2.37b	0.151b	0.159b
F-test		**	*	**	**	**	**	**	**	**	**
Foliar spray (C)											
Control		7.51d	10.86c	2.00d	4.26c	0.237d	0.240d	2.00d	2.02d	0.130d	0.136d
ASA		13.34a	14.51a	6.78a	7.66a	0.268a	0.281a	2.72a	2.79a	0.173a	0.182a
SA		9.55c	12.68b	3.08c	4.79bc	0.251c	0.257c	2.23c	2.28c	0.146c	0.152c
K_2SiO_3		10.92b	13.24b	4.32b	5.25b	0.257b	0.266b	2.44b	2.50b	0.160b	0.171b
F-test		**	**	**	**	**	**	**	**	**	**
Bilateral interaction											
Soil salinity (A)	**Cultivars (B)**										
Normal	Sakha 95	11.33	13.51	4.94	6.69a	0.247	0.254	2.3	2.36c	0.150b	0.158b
	Misr 3	10.62	13.09	4.19	5.51bc	0.253	0.26	2.25	2.29d	0.146c	0.154c
Saline	Sakha 95	10.04	12.79	3.7	5.08cd	0.253	0.259	2.45	2.49a	0.156a	0.165a
	Misr 3	9.33	11.91	3.34	4.68d	0.261	0.271	2.39	2.45b	0.155a	0.164a
F-test		ns	ns	ns	*	ns	ns	ns	**	**	*
Soil salinity(A)	**Foliar spray (C)**										
Normal	Control	8.37g	11.98e	2.30f	4.57de	0.231g	0.233f	1.91h	1.93h	0.127h	0.131
	ASA	14.23a	14.94a	8.03a	9.57a	0.263b	0.274b	2.66b	2.73b	0.169b	0.177
	SA	9.89e	12.82cd	3.27e	4.89cd	0.250e	0.256de	2.21f	2.25f	0.143f	0.148

	K_2SiO_3	11.40c	13.47bc	4.67c	5.38bc	0.256cd	0.265bc	2.32d	2.38d	0.155d	0.166
Saline	Control	6.65h	9.75f	1.69g	3.96e	0.244f	0.247e	2.09g	2.12g	0.133g	0.139
	ASA	12.44b	14.08b	5.53b	5.75b	0.273a	0.288a	2.78a	2.84a	0.177a	0.185
	SA	9.20f	12.55de	2.88e	4.70cd	0.253de	0.259cd	2.25e	2.31e	0.148e	0.156
	K_2SiO_3	10.44d	13.02cd	3.97d	5.12bcd	0.258c	0.266bc	2.57c	2.62c	0.164c	0.175
F-test		**	*	**	**	**	*	**	**	**	ns
Cultivars (B)	**Foliar spray (C)**										
Sakha 95	Control	7.99g	11.72	2.14e	4.54e	0.234g	0.236f	2.04g	2.06	0.13g	0.135g
	ASA	13.91a	14.82	7.49a	8.86a	0.261b	0.269b	2.75a	2.81	0.174a	0.183a
	SA	9.75e	12.73	3.19d	4.83de	0.250e	0.255d	2.24e	2.3	0.147e	0.155e
	K_2SiO_3	11.09c	13.32	4.45c	5.31c	0.256cd	0.265bc	2.47c	2.52	0.162c	0.172c
Misr 3	Control	7.03h	10	1.85e	3.98f	0.241f	0.245e	1.96h	1.98	0.130g	0.137g
	ASA	12.77b	14.21	6.07b	6.46b	0.275a	0.292a	2.69b	2.76	0.172b	0.180b
	SA	9.34f	12.63	2.96d	4.76e	0.253de	0.260cd	2.21f	2.25	0.144f	0.150f
	K_2SiO_3	10.75d	13.16	4.20c	5.19cd	0.258bc	0.266bc	2.42d	2.46	0.158d	0.169d
F-test		*	ns	*	**	**	**	**	ns	*	**

Note*: *and indicate a significant difference and **NS** indicates an insignificant difference at $P<0.01$. Different lowercase letters in the column indicate a significant difference between the treatments, while the same letters show no statistical difference at $P<0.01$ (Duncan's multiple range test).

Table 4. Interaction effect of soil salinity, wheat cultivars and foliar spray on biochemical characteristics in the 2020/21 and 2021/22 seasons.

Factors			Chl. a (µg ml^{-1})		Chl. b (µg ml^{-1})		Proline (mg g^{-1}FW)		POD (µmol min^{-1} g protein^{-1})		CAT (µmol min^{-1} g protein^{-1})	
	Seasons		2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22
Soil salinity(A)	**Cultivars (B)**	**Foliar spray (C)**										
Normal	Sakha 95	Control	8.71k	12.17fgh	2.5	4.60de	0.227m	0.227	1.96k	1.98m	0.129l	0.133j
		ASA	14.88a	15.42a	8.99	11.78a	0.260cd	0.268	2.67c	2.75c	0.170c	0.178c
		SA	10.12h	12.86defg	3.44	4.93de	0.249ij	0.254	2.21h	2.29i	0.145i	0.152g
		K_2SiO_3	11.61e	13.59bcde	4.84	5.46cde	0.254fghi	0.265	2.34f	2.41g	0.158f	0.168e
	Misr 3	Control	8.03l	11.79gh	2.1	4.54e	0.236l	0.239	1.85l	1.88n	0.124m	0.130j
		ASA	13.59b	14.47ab	7.06	7.36b	0.266b	0.28	2.64c	2.71d	0.167d	0.177cd
		SA	9.66i	12.78efg	3.1	4.85de	0.252ghi	0.257	2.20h	2.21j	0.142j	0.145h
		K_2SiO_3	11.19f	13.34bcde	4.5	5.30cde	0.257cdef	0.265	2.30g	2.34h	0.152g	0.164e
Saline	Sakha 95	Control	7.26m	11.27h	1.79	4.49e	0.241k	0.244	2.11i	2.14k	0.130l	0.137i
		ASA	12.95c	14.21bc	5.99	5.94c	0.262bc	0.271	2.83a	2.87a	0.178a	0.189a
		SA	9.38i	12.61efg	2.94	4.74de	0.252hi	0.255	2.27g	2.32hi	0.150h	0.157f
		K_2SiO_3	10.57g	13.06cdef	4.06	5.17cde	0.257defg	0.265	2.60d	2.65e	0.165de	0.176cd
	Misr 3	Control	6.03n	8.22i	1.6	3.42f	0.246jk	0.251	2.07j	2.09l	0.136k	0.143h
		ASA	11.94d	13.94bcd	5.07	5.56cd	0.284a	0.304	2.73b	2.81b	0.176b	0.183b
		SA	9.02j	12.49efg	2.82	4.67de	0.254efgh	0.263	2.23h	2.31i	0.146i	0.155fg
		K_2SiO_3	10.30gh	12.97def	3.89	5.07cde	0.259cde	0.266	2.54e	2.59f	0.164e	0.174d
F-test			*	*	ns	**	**	ns	**	**	**	**

Note*: *and indicate a significant difference and **NS** indicates an insignificant difference at *P<0.01*. Different lowercase letters in the column indicate a significant difference between the treatments, while the same letters show no statistical difference at *P<0.01* (Duncan's multiple range test).

The interactions between soil salinity, cultivars and foliar spraying of chlorophyll content, as the Table (4) indicated that there are positive affect chl. a, and b in both seasons, and there are insignificant difference in the 1st season of chlorophyll (b). The best treatment was ascorbic acid foliar spray with Sakha 95 under the influence of normal or salinity soil.

3.1.2. The content of some enzymes in the leaves:

The content of some enzymes in leaves was strongly affected by soil salinity. The saline soil increased considerably the values of proline, peroxidase activity (POD), and catalase activity (CAT) compared to normal soil (Table 3).

With regard to wheat cultivars, results in Table 3 revealed highly significant differences existed between Misr 3 and Sakha 95. Sakha 95 had a significantly higher activity of (POD) and (CAT) enzymes. While, the proline content was higher with Misr 3.

Foliar spraying treatments caused an observed increase in proline, (POD), and (CAT) activity compared to untreated plants (control). Ascorbic acid recorded the highest increase in the content of proline, (POD), and (CAT), followed by potassium silicate, while the lowest increase was obtained with salicylic acid.

The soil salinity × cultivars interaction is positive about the CAT content in both seasons. However, insignificant effects on proline content in both seasons and in the 1st season with POD, while in the 2nd season was highly significant as shown in Table 3.

Table (3) illustrates that, the interaction between soil salinity and foliar spray on the content of some enzymes in the leaves. Ascorbic acid more effective foliar spray treatment under normal and saline soil condition than that, the other foliar spray treatments (SA and K_2SiO_3).

Concerning the interaction of cultivars and foliar spray, the results in Table (3) show that there is a difference in the content of some enzymes in leaves of both cultivars. The highest proline content (0.275 and 0.292 mg g^{-1}FW) were observed with Misr 3 c.v + foliar spray by ASA. While, Sakha 95 with spraying ASA gave the highest mean values of POD (2.75 and 2.81µmol min^{-1} g $protein^{-1}$) and CAT (0.174 and 0.183 µmol min^{-1} g $protein^{-1}$). Insignificant differences in the POD content values in the second season were detected.

Under saline soil condition, the data in Table (4) show that the highest proline content values were obtained with Misr 3 c.v + foliar spray by ASA. While, the highest mean values of POD and CAT were recorded with Sakha 95 + ASA foliar spraying.

3.2. Grain yield and its chemical analysis:

3.2.1. Grain yield

Grain yield of the two wheat cultivars as affected by soil salinity and foliar spray, and their interaction in the 2020/21 and 2021/22 seasons are presented in Table (5). Data showed that the soil salinity resulted in a highly negative effect on grain yield in both seasons. Soil salinity caused a marked reduction in grain yield by 17.86 and 18.34% compared with normal soil in the two seasons, respectively.

The results indicated that, Sakha 95 cultivar exceeded the Misr 3 cultivar in grain yield in both seasons, which the grain yield increased an average of both seasons by 13%, respectively.

Foliar spraying treatments caused an observed increase in grain yield compared to untreated plants (control). Ascorbic acid recorded the highest increases in the grain yield, followed by potassium silicate, while, the lowest increase was obtained with salicylic acid Table (5).

The soil salinity × cultivars interaction is insignificant affect the grain yield of wheat in both seasons (Table 5).

Table (5) refers that the interaction between soil salinity and foliar spray on the grain yield. Ascorbic acid more effective foliar spray treatment under normal and saline soil conditions than that other foliar spray treatments (SA and K_2SiO_3).

Concerning the interaction of cultivars and foliar spray, the results in Table (5) show that there is a difference in the grain yield of both cultivars. The highest grain yield was observed with Sakha 95 c.v +

foliar spray by ASA. While, Misr 3 without spraying gives the lowest values.

For the interaction of soil salinity, cultivars and foliar spray, data shown in Table (6) indicate highly significant differences for grain yield in both seasons. The greatest values were obtained from foliar spray by ASA + Sakha 95 under the normal or /and saline condition.

3.2.2. Chemical analysis of grain:

Data presented in Tables (5 and 6) show the effect of soil salinity, wheat cultivars, foliar spray and their interaction on chemical analysis of grain wheat.

All Chemical analysis of grain, e.g. carbohydrates%, protein, Na%, P and K showed pronounced effects under salt stress (Table 5). Results reference that P and K were reduced and they had high significantly with salinity compared to unstressed condition (normal soil). While, the main values of carbohydrates, protein and Na% were highly significant increased with soil salinity in both seasons.

Table 5. Grain yield and chemical analysis of grains of the two wheat cultivars as affected by soil salinity and foliar spraying with some antioxidants in 2020/21 and 2021/22 seasons.

Factors		**Grain yield (ton fed^{-1})**		**Carbohedrat %**		**Protein%**		**Na%**		**P%**		**K%**	
Seasons		2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22
Soil salinity(A)													
Normal		1.98a	2.00a	72.59b	72.87b	9.56b	9.55b	1.17b	1.10b	0.378a	0.383a	0.951a	0.98a
Saline		1.68b	1.69b	73.86a	74.02a	11.00a	10.57a	1.26a	1.20a	0.368b	0.372b	0.874b	0.90b
F-test		**	**	**	**	**	**	**	**	**	**	**	**
Cultivars (B)													
Sakha 95		1.94a	1.96a	73.59a	73.78a	9.82b	9.75b	1.17b	1.11b	0.376a	0.380a	0.946a	0.96a
Misr 3		1.72b	1.73b	72.87b	73.11b	10.75a	10.38a	1.26a	1.19a	0.371b	0.375b	0.889b	0.92b
F-test		**	**	**	**	**	**	**	**	**	**	**	**
Foliar spray (C)													
Control		1.16d	1.19d	69.55d	70.74d	7.88d	7.66d	1.46a	1.37a	0.351d	0.356c	0.75d	0.76d
ASA		2.53a	2.54a	76.16a	76.19a	13.72a	12.57a	1.04d	0.97d	0.392a	0.395a	1.14a	1.18a
SA		1.67c	1.69c	72.65c	72.80c	8.70c	9.66c	1.23b	1.15b	0.371c	0.376b	0.83c	0.84c
K_2SiO_3		1.95b	1.98b	74.54b	74.06b	10.84b	10.36b	1.13c	1.10c	0.379b	0.383b	0.94b	0.98b
F-test		**	**	**	**	**	**	**	**	**	**	**	**
						Bilateral interaction							
Soil salinity (A)	**Cultivars (B)**												
Normal	Sakha 95	2.08	2.12	73.05c	73.2	9.17	9.13	1.15	1.08b	0.379	0.385	0.98a	1
	Misr 3	1.88	1.89	72.14d	72.54	9.96	9.97	1.19	1.12b	0.377	0.381	0.92b	0.95
Saline	Sakha 95	1.8	1.8	74.12a	74.36	10.46	10.36	1.2	1.14ab	0.372	0.375	0.89bc	0.92
	Misr 3	1.57	1.58	73.60b	73.68	11.55	10.79	1.33	1.25a	0.365	0.369	0.86c	0.88
F-test		ns	ns	*	ns	ns	ns	ns	*	ns	ns	**	ns
Soil salinity(A)	**Foliar spray (C)**												
Normal	Control	1.39g	1.42f	68.03h	69.80h	7.61f	7.06f	1.33b	1.24b	0.361f	0.367f	0.78f	0.80f
	ASA	2.77a	2.80a	75.84b	75.60b	12.23b	11.83b	1.01f	0.95d	0.396a	0.400a	1.20a	1.24a
	SA	1.70e	1.74e	72.26f	72.47f	8.15f	9.52d	1.21bcd	1.12c	0.374d	0.379d	0.84e	0.85e
	K_2SiO_3	2.04c	2.06c	74.25d	73.62d	10.28d	9.79d	1.12def	1.07cd	0.381c	0.385bc	0.98c	1.02c
Saline	Control	0.94h	0.96g	71.07g	71.69g	8.15f	8.26e	1.60a	1.49a	0.341g	0.345g	0.72g	0.72g
	ASA	2.29b	2.27b	76.49a	76.77a	15.21a	13.31a	1.08ef	1.00d	0.389b	0.389b	1.07b	1.11b
	SA	1.64f	1.64e	73.05e	73.13e	9.24e	9.79d	1.24bc	1.18bc	0.368e	0.374e	0.82ef	0.84e
	K_2SiO_3	1.86d	1.89d	74.83c	74.50c	11.41c	10.94c	1.14cde	1.12c	0.377cd	0.380cd	0.89d	0.94d
F-test		**	**	**	**	**	**	**	**	**	**	**	**
Cultivars (B)	**Foliar spray (C)**												
Sakha 95	Control	1.32f	1.35e	70.42g	71.37g	7.61f	7.06	1.33	1.27b	0.356d	0.361e	0.77	0.78
	ASA	2.73a	2.73a	76.38a	76.53a	12.63b	12.27	1.03	0.95e	0.394a	0.397a	1.17	1.22
	SA	1.69e	1.71d	72.76ef	73.00e	8.42de	9.52	1.22	1.14c	0.372c	0.377d	0.84	0.85
	K_2SiO_3	2.01c	2.05c	74.78c	74.23c	10.60c	10.13	1.12	1.08cd	0.380b	0.383c	0.96	1.01
Misr 3	Control	1.01g	1.03f	68.69h	70.11h	8.15ef	8.26	1.6	1.47a	0.346e	0.351f	0.73	0.73
	ASA	2.34b	2.34b	75.94b	75.84b	14.81a	12.87	1.06	1.00de	0.390a	0.392b	1.1	1.14
	SA	1.65e	1.66d	72.55f	72.60f	8.97d	9.79	1.24	1.16c	0.370c	0.375d	0.82	0.84
	K_2SiO_3	1.89d	1.91c	74.29d	73.89d	11.09c	10.6	1.14	1.11c	0.378b	0.382c	0.91	0.95
F-test		**	*	**	**	**	ns	ns	**	*	**	ns	ns

Note*: *and indicate a significant difference and **NS** indicates an insignificant difference at *P<0.01*. Different lowercase letters in the column indicate a significant difference between the treatments, while the same letters show no statistical difference at *P<0.01* (Duncan's multiple range test).

Table 6. Interactions between soil salinity, cultivars and foliar spray on grain yield and chemical analysis of grains during 2020/21 and 2021/22 seasons.

Factors			Grain yield (ton fed^{-1})		Carbohedrat %		Protein%		Na%		P%		K%	
Seasons			2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22
Soil salinity(A)	**Cultivars (B)**	**Foliar spray (C)**												
Normal	Sakha 95	Control	1.44h	1.47hi	69.29k	70.77l	7.06f	5.98f	1.29bc	1.24bc	0.360h	0.369ij	0.80fg	0.80hi
		ASA	3.05a	3.09a	76.03bc	75.69bc	11.68c	11.51b	1.00f	0.91f	0.398a	0.404a	1.26a	1.30a
		SA	1.72fg	1.77fg	72.36h	72.62hi	8.15e	9.25d	1.19cde	1.12bcde	0.374ef	0.380efgh	0.84ef	0.86g
		K_2SiO_3	2.09cd	2.13cd	74.52e	73.72f	9.79d	9.79cd	1.12def	1.04def	0.383cd	0.386cde	1.03c	1.06d
	Misr 3	Control	1.35hi	1.36ij	66.78l	68.82m	8.15e	8.15e	1.37b	1.24bc	0.362h	0.365j	0.77g	0.80hi
		ASA	2.50b	2.52b	75.64c	75.51c	12.77b	12.15b	1.02f	1.00ef	0.394ab	0.396b	1.14b	1.19b
		SA	1.68fg	1.70fg	72.16h	72.31ij	8.15e	9.79cd	1.24bcd	1.12bcde	0.373efg	0.378fgh	0.84ef	0.84gh
		K_2SiO_3	1.99d	2.00cde	73.97f	73.52f	10.76cd	9.79cd	1.12def	1.11cde	0.379de	0.384cdef	0.94d	0.99e
Saline	Sakha 95	Control	1.20i	1.23j	71.55j	71.97j	8.15e	8.15e	1.37b	1.29b	0.349i	0.354k	0.75gh	0.77i
		ASA	2.41b	2.37b	76.73a	77.36a	13.58b	13.04a	1.07ef	1.00ef	0.391b	0.391bc	1.08bc	1.14bc
		SA	1.66fg	1.65fgh	73.16g	73.37fg	8.70e	9.79cd	1.24bcd	1.16bcde	0.370fg	0.374ghi	0.84ef	0.84gh
		K_2SiO_3	1.92de	1.96de	75.04d	74.75d	11.41c	10.47c	1.12def	1.12bcde	0.377de	0.381defg	0.89de	0.95ef
	Misr 3	Control	0.67j	0.70k	70.59j	71.41k	8.15e	8.37e	1.82a	1.70a	0.332j	0.337l	0.69h	0.67j
		ASA	2.18c	2.17c	76.24b	76.17b	16.84a	13.58a	1.09def	1.00ef	0.387bc	0.388cd	1.06c	1.10cd
		SA	1.62g	1.62gh	72.94g	72.89fg	9.79d	9.79cd	1.24bcd	1.20bcd	0.366gh	0.373hi	0.80fg	0.84gh
		K_2SiO_3	1.80ef	1.82ef	74.61de	74.25e	11.41c	11.41b	1.16cdef	1.12bcde	0.376def	0.380efg	0.89de	0.92f
F-test			**	**	**	**	**	**	**	**	*	*	*	*

Note*: *and indicate a significant difference and **NS** indicates an insignificant difference at $P<0.01$. Different lowercase letters in the column indicate a significant difference between the treatments, while the same letters show no statistical difference at $P<0.01$ (Duncan's multiple range test).

The results presented in Table (5) introduced significant differences in the chemical analysis of grain across in both seasons. Sakha 95 cultivars significantly surpassed Misr 3 in carbohydrates%, P and K. While, Misr 3 produced more protein and Na% than Sakha 95.

Foliar spraying was accompanied by a significant increase in selected chemical analysis of grain than that of untreated plants (control). Application of ascorbic acid (ASA) produced increasing the mean values of carbohydrates (9.50 and 7.70%), protein (74.11 and 64.10%), P (11.68 and 10.96%) and K (52.00 and 55.26%) in the 1st and 2nd seasons, respectively. While, the mean values of Na% were decreased by 28.77 and 29.20% in both seasons compared with control (untreated plants).

Table (5) indicates the interactions between soil salinity and cultivar in chemical analysis of grain, where it was found that there were insignificant affects the carbohydrates and K in the 2nd season and also, the P and protein no significant differences in both seasons. In general, the mean values of carbohydrates and Na% content were increased with Misr 3 under saline soil, while Sakha 95 cultivars significantly exceed Misr 3 in K% under different salinity conditions (Table 5).

The application of ASA recorded the best treatment for counteracting salinity stress in terms of the chemical analysis of grain. Highly significant differences were found in the first and two seasons due to the interactions between soil salinity and foliar spray in the all chemical analysis (Table 5).

Concerning the interaction of soil salinity and foliar spraying, the results in Table (5) show that there is a highly significant difference for all chemical analysis in both seasons. Foliar spray with ascorbic acid under salinity stress condition increased carbohydrates and protein compared the unstressed condition, while, P and K were increased under normal than that saline soil. Na% decreased significantly under unstressed and salinity stress conditions.

Regarding the combinations between cultivars and foliar spray, the data illustrated in Table (5) clearly indicate that antioxidants foliar application, especially ascorbic acid with Sakha 95 gave a highest mean values of carbohydrates (76.38 and 76.53 %) and P (0.394 and 0.397%). While the highest mean values of protein and Na content with Misr 3 + ascorbic acid spray or/and without spray treatments.

The interactions between soil salinity and cultivars and foliar spraying, as shown in Table (6). The highest mean values of protein content were produced with Misr 3 + ascorbic acid foliar sprays under saline soil, and Na% in both seasons were achieved with Misr 3 + control (untreated plants) under saline soil. While the maximum carbohydrates, P and K% were obtained with ascorbic acid foliar spray + Sakha 95 under normal soil.

4. DISCUSSION

Chlorophyll content:

Data showed that the soil salinity resulted in a highly negative effect on Chlorophyll content (a, b and t). The decrease in the content of photosynthetic pigments might be attributed to damage to protein complexes and/or chlorophyll molecules Siddiqui *et al.,* (2018). ASA Foliar spraying treatments caused an observed increase in Chlorophyll content (a and b) compared to untreated plants (control). These results agreed with Azzedine *et al.,* (2011) found that applying ascorbic acid was improving chlorophyll under saline stress. Also, Siddiqui *et al.,* (2018) noted that ascorbic acid significantly improved the accumulation of chlorophyll content in wheat plants under non-stress and stress conditions. Interactions between soil salinity and cultivars on chlorophyll content were found that the highest values of Sakha 95 cultivars were under un-stress condition, while Misr 3 gave the lowest mean values under salt stress condition. These findings are in agreement, Abd El-Hamid *et al.,* (2020), Genedy and Eryan (2022), Elsawy *et al.,* (2023) and Khedr *et al.,* (2023), which they specified that the Sakha 95 cultivars exceeded Misr3 cultivar in chlorophyll contents. Foliar spray by ascorbic acid declined the salinity stress on chlorophyll content more efficiently than the other foliar spray treatment.

The interactions between soil salinity and foliar spraying resulted in a decrease in chlorophyll content, due to salinity stress under control treatment in the two seasons, respectively. The interactions between cultivars and foliar spraying of chlorophyll content indicated that, the behavior of foliar spraying of chlorophyll content differed for cultivars to another. Regarding the interactions between soil salinity, cultivars and foliar spraying of chlorophyll content (a and b), the effect of the second order interaction on that trait was significant in both seasons, except, Chl. b in the first season, indicated that these treatments are dependable on each others in their influence on this character.

The content of some enzymes in the leaves:

The content of some enzymes in leaves was strongly affected by soil salinity. These results agreed with the result obtained by Lee *et al.,* (2001) and Khedr *et al.,* (2023) they observed that under saline stress, plants induce an excess of reactive oxygen species (ROS) which causes oxidative stress of lipid cell membranes. The soil salinity × cultivars interaction is a positive effect on the content of some enzymes in the leaves. It seems that, the first order did not affected by changing the other environment. These agreed with Genedy and Eryan (2022) and Khedr *et al.,* (2023).

Concerning the interaction between soil salinity and foliar spray on the content of some enzymes in the leaves. The results indicated that, foliar spray by AsA was effective under non-stress and salt sress condition. In agreement with the findings of Abbasi and Faghani (2015), Desoky and Merwad (2015), and Hassan and Bano (2016) they refer that the application of ascorbic acid increments proline in plants under saline conditions for wheat. Also Agami (2014), Hassan and Bano (2016) and Gerami *et al.,* (2019) found that under salt-stressed conditions, the ascorbic acid application led to an increase in CAT and POD activities. Concerning the interaction effect of soil salinity, wheat cultivars and foliar spray on the content of some enzymes in the leaves, the results showed that the highest proline content values were obtained with Misr 3 cultivar + foliar spray by (ASA). While, the highest mean values of (POD) and (CAT) were recorded with Sakha 95 cultivar + spraying by ascorbic acid. The results were agreeing with data obtained by Mandhania et al., (2012) found that the activities of catalase activity (CAT) increased with increasing the salt stress in both salt tolerant and salt sensitive wheat cultivars.

Grain yield:

Data showed that the soil salinity resulted in a highly negative effect on grain yield in both seasons, which caused a marked reduction in grain yield compared with normal soil. The results agreed with Hasan *et al.,* (2015) and Nadeem *et al.,* (2020) which indicated a negative effect of salinity on grain yield. In addition, losses in grain weight due to saline stress are due to pollen sterility, reduced production of assimilates, and reduced partitioning to economical parts (grains) of plants (Dadshani *et al.,* 2019). The results indicated that, Sakha 95 cultivar exceeded the Misr 3 cultivar in grain yield in both seasons. It seems that, wheat yields had affected by among cultivar to another. Foliar spraying treatments caused an observed increase in grain yield compared to untreated plants (control). Ascorbic acid recorded the highest increases in the grain yield. This result agreed with El-Awadi *et al.,* (2014) found that the treatment of wheat plants with foliar spraying of ascorbic acid resulted in an increase in the grain yield.

The soil salinity × cultivars interaction is positive affect the grain yield of wheat. Those findings agreed with Abd El-Hamid *et al.,* (2020), Genedy and Eryan (2022), Elsawy *et al.,* (2023) and Khedr *et al.*, (2023). Ascorbic acid more effective foliar spray treatment under normal and saline soil conditions than that other foliar spray treatments. These results agreement with Fawy and Attia (2013) and Bakry *et al.,* (2013) and they mention that application of ascorbic acid spray led to increases in grain yield under stress condition. It seems that, soil salinity affected by changing foliar spray treatments.

Concerning the interaction of cultivars and foliar spray, the results showed that the highest grain yield were observed with Sakha 95 c.v + foliar spray by ascorbic acid (ASA). It seems that, wheat cultivars had affected by changing foliar spray treatments. The interaction of soil salinity, cultivars and foliar spray, data indicated that the greatest values of grain yield were obtained from foliar spray by ascorbic acid (ASA) + Sakha 95 under the saline condition. These significant interactions among these characters indicated that, these factors are dependable on each of the others in their in influences.

Chemical analysis of grain:

The chemical analysis of grains was strongly affected by soil salinity. It may be due to the salinity increases the percentage of Na produced from soil salts such as NaCl, which in turn works to increase the osmotic pressure in the plant and thus an increase in electrical conductivity. The results agreed with Zhong *et al.,* (2016) who noted the salt stress affects caused the metabolism of carbohydrates and the translocation that causes the build-up of starch and sugars (*et al.,* 2016). Also, the increase in total carbohydrate content under salinity stress is consistent with results found by Hassan and Bano (2016), Zhong *et al.,* (2016) and Mohamed *et al.,* (2018). Also, the soil salinity led to increased protein and Na content, this may be related to the relatively stable nitrogen metabolism under salt stress, which might contribute to the higher protein concentration (Abd El-Hamid *et al.,* 2020). While Na uptake causes a decrease in P and K uptake by wheat plants, The results agreed with Nadeem *et al.,* (2020) who noted the negative impact of salinity on nutrient content in wheat plants. Foliar spraying by (AsA) caused an observed increase in carbohydrates, P, K and protein content compared to untreated plants (control). While it led to decreased Na. It seems that, the first order affected by changing the foliar spray.

The soil salinity × cultivars interaction a highly negative effect on the chemical analysis of grain. Zheng *et al.,* (2009) referred that the protein content of cultivars under study increased as salt concentration increase. The results indicated that, Misr 3 produced more protein and Na%. While Sakha 95 cultivars significantly surpassed Misr 3 in carbohydrates%, P and K. The data showed also the exceed Sakha 95 than Misr 3 under unstressed and salinity stress conditions. These results agreed with Abd El-Hamid *et al.,* (2020) and Ibrahim *et al.,* (2022). The results of this study agree with the results obtained by Abd El-Hamid *et al.,* (2020) and Elsawy *et al.,* (2023). The results indicated that, the attitude of these traits differed from cultivar to another. Concerning the interaction of soil salinity and foliar spraying, the results showed that foliar spraying by ascorbic acid recorded the best treatment for withstanding salt stress. Results agreed with Ishaq *et al.,* (2021). This result may be due to the effectiveness of the antioxidant system in the removal of ROS from plants and the maintenance of ion homeostasis (Athar and Ashraf 2008). Also, Azza *et al.,* (2011) stated that the promoting effect of ascorbic acid on total carbohydrates may be due to their important role in the biosynthesis of chlorophyll molecules which in turn affected total carbohydrate content. For the interactions between cultivars and foliar spray are positive effect on the chemical analysis of grain. It seems that, wheat cultivars had affected by changing foliar spray treatments, except, protein content in the first season, P% in the second season and K% in both seasons. Regarding interactions between soil salinity, cultivars, and foliar spray of the chemical analysis of grain, it showed that the highest results were in favor of Sakha 95 with ascorbic acid under un-stress and salt stress condition except, protein and Na% were achieved with Misr 3 + (AsA) foliar spray or/ and untreated plant under saline soil. It indicated that these treatments are dependable on each others in their influence on these traits.

5. CONCLUSIONS

It can conclude that the foliar spraying using ascorbic acid at a rate of 200 mg L^{-1} is most effective ways for increasing wheat productivity and alleviate the damage effects of salinity on the wheat plants. Therefore, it is recommended to plant Sakha 95 cultivars, due to its superiority tolerance to salinity as well as foliar spraying using ascorbic acid.

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O 42. THE ROLE OF SOME ANTIOXIDANTS FOLIAR APPLICATION ON BIO-CHEMICAL AND YIELD OF TWO WHEAT CULTIVARS GROWN UNDER SALINITY STRESS

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ABSTRACT: Salinity stress is one of adversely affect cereal crop yield and quality all over the world. Improving salt tolerance in wheat plants by breeding new cultivars and a foliar application of antioxidants as alleviating treatments to enhance plant production under salinity stress. The aim of this work was to study the role of some antioxidants foliar application on bio-chemical of two wheat (Triticum aestivum L.) cultivars grown under salinity stress. In a split–split plot design with three replicates. Factors were 2 soil types (normal and saline), 2 wheat cultivars (Sakha 95 and Misr 3), and 4 foliar spray treatments (control, 300 mg silicate potassium L-1, 200 mg ascorbic acid L-1 and 200 mg salicylic acid L-1). The effect was highly positive on the biochemical characteristics of wheat when a combination of foliar spray with 200 mg ascorbic acid L-1 with Sakha 95 under saline soil caused considerable increases in the chlorophyll content, peroxidase activity, catalase activity, grain yield and chemical analysis of grain (carbohydrates, P and K%). While the highest content of proline and protein were obtained with c.v Misr 3 + foliar spray by 200 mg ASA L-1. It can be concluded that using cv Sakha 95 and a foliar spray by the ASA is most effective ways for increasing wheat productivity under salinity stress condition.

Keywords: Cultivars Grown Under Salinity Stress

1. INTRODUCTION

Comprising 13.1% of world soils are salt-affected soils (FAO, 2021 b). Nearly 56% of irrigated soils are salt-affected at the Northan Egyptian Nile Delta (Aboelsoud *et al.,* 2022). Salt stress collectively inhibits cell division and expansion, as well as modulate the activity of some key enzymes, thus lastly reducing the seed reserves utilization (El-Hendawy *et al.,* 2019). Also, it has pronounced damaging effects on the physiological, morphological, and biochemical characteristics of the crop plants, including uptake of water and nutrients, germination, growth, photosynthesis, enzyme actions, and yield (Cisse *et al.,* 2019 and Arif *et al.,* 2020).

Wheat (*Triticum aestivum*) is considered one of the world's major cereals, especially in Egypt (FAO, 2020). The national production represents about 8.9 million Mg (2020-2021), and the total consumption increased to 20.6 million Mg due to the annual population growth, which is considered a high country in wheat imports (FAO, 2021 a).

The management of salt-affected soils, improving salt-tolerant crops, this triggered plant breeders to initiate breeding programs aimed at developing salt-tolerant crop cultivars (Ashraf and Munns 2022). Khedr *et al.,* (2023) noted that Sakha 95 and Misr 3 cultivars had no significant differences in chlorophyll content, proline, POD, CAT activity, wheat yield, and its attributes under salt stress.

The integrated and sustainable strategy to enhance salt tolerance in wheat by using the spray foliar application of antioxidants and growth regulators to mitigate the harmful effect of salinity on wheat yield and grain quality (El-Sabagh *et al.,* 2021). Under salt stress conditions, the foliar application of potassium silicate increases the enzymatic activities of antioxidants, thereby reducing the permeability of the plasma membrane and increasing the activity of the roots. This, in turn, enhances nutrient uptake (Ibrahim *et al.,* 2016), and improves plant growth (Ahmad *et al.,* 2013). Also Feghhenabi *et al.,* (2022) noted that the foliar spray by K2Sio3 increased catalase and peroxidase activities in wheat grown under saline conditions, which alleviated the oxidative damage of proteins and lipids. As same as the salicylic acid exogenously applied can maintain cellular detoxification through the regulation of antioxidant defense systems (El-Hawary *et al.,* 2023), regulation of plant physiological processes (Talaat and Shawky 2022). Furthermore, the application of SA enhanced antioxidant defensive or/and tolerance mechanisms which increased growth, pigment concentration, nutrient uptake and yield of wheat under salinity Stress (Noreen *et al.,* 2019). Iqbal *et al.,* (2022) showed that the exogenous application of 1.0 mM of salicylic acid (SA) positively influenced the 90% germination percentage, growth, biomass of plants, gas exchange attributes, photosynthetic rate, glycine betaine, MDA, carbohydrates, protein, and electrolyte leakage, antioxidant activities of enzymes and yield parameters of wheat under salinity stress. Also, ascorbic acid is one of the most important antioxidants in plants that alleviate different environmental stresses, furthermore, it has been found to enhance markedly the capacity of antioxidants and to improve protein metabolism to moderate oxidative stress (Akram *et al.,* 2017), which plays an important role in enhanced salt tolerance of wheat plant and improved shoot length, root weight, grain weight, and biochemical compounds e.g. chlorophyll, starch, fiber, ash, and fat (El-Kassas *et al.,* 2020). The foliar application of ascorbic acid increased the yield of the wheat crop (Osman and Nour Eldein 2017 and Ishaq *et al.,* 2021). The main objective of the present study is to use foliar antioxidant spray to alleviate hazards on biochemical characteristics and yield of wheat (*Triticum aestivum* L.) grown under stress condition.

2. MATERIALS AND METHODS

2.1. Experimental design and Treatments

In a split split–plot design with three replicates, a lysimeters experiment was carried out on two wheat cultivars (*Triticum aestivum* L., c.v Sakha 95 and Misr 3) during two successive seasons 2020/21 and 2021/22 at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, Egypt (31° 5'38.70" latitude N and 30°56'54.00" longitude E with an elevation 6 m above mean sea level). This study aimed to study the effect of foliar spraying with antioxidants on the productivity of wheat crop (*Triticum aestivum* L.) and reduce the harmful effect of salinity on biochemical characteristics and productivity of two cultivars of wheat (Sakha 95 and Misr 3) under salt stress condition. The main plots included 2 soil types (normal and saline), the sub-plots were randomly assigned to 2 wheat cultivars (Sakha 95 and Misr 3), and the sub-sub plots were to 4 foliar treatments: control, 300 mg silicate potassium L^{-1}, 200 mg ascorbic acid L^{-1} and 200 mg salicylic acid L^{-1}). Some soil properties as shown in Table 1.

The total lysimeters used were 48 plots (lysimeter area was 0.78 m^2), which had divided into 4 groups; each group includes 12 lysimeters. Two wheat cultivars (Sakha 95 and Misr 3) were graciously supplied by the Sakha Wheat Research Department, Field Crops Research Institute, Agricultural Research Center, Egypt; Names, pedigrees and Selection history are shown in Table 2.

Plants were irrigated every 30 days and all cultural practices were followed according to the recommendations of the Egyptian Ministry of Agriculture. All foliar application treatments were applied twice at 35 and 50 days after sowing.

Table 1. Soil test of the lysimeter experiment before two growing seasons.

Soil types	**Lysimeters**	**pH**	**EC ($dS\ m^{-1}$)**	**ESP**	**OM (%)**	**BD ($Mg\ m^{-3}$)**	**Soil mechanical analysis (%)**		
							Sand	Silt	Clay
Normal	Group 1	8	3.5	9.33	1.3	1.32	19.1	29.8	51.2
	Group 2	8	3.3	8.93	1.2	1.31	19.2	29.9	50.9
	Group 3	7.9	3.4	9.16	1.2	1.33	19.1	29.9	51.1
	Group 4	8.1	3.7	10.2	1.2	1.31	19.2	30	50.9
	Average	**8**	**3.5**	**9.41**	**1.2**	**1.32**	**19.1**	**29.9**	**51.0**
Saline	Group 1	8.3	8	15.4	1.2	1.36	18.6	29.1	52.2
	Group 2	8.3	8.2	15.6	1.2	1.34	18.9	29.5	51.6
	Group 3	8.3	8.1	15.9	1.2	1.33	18.8	29.4	51.8

	Group 4	8.3	7.9	15.4	1.2	1.36	18.7	29.2	52.1
	Average	**8.3**	**8.1**	**15.6**	**1.2**	**1.35**	**18.8**	**29.3**	**51.9**

* pH = Power Of Hydrogen, EC = Electrical Conductivity, ESP= Exchangeable Sodium Percentage, OM%= Organic matter content, BD= Bulk density

Table 2. Pedigrees and Selection history of the studied wheat cultivars

Cultivar	Pedigree&Selection history
Sakha 95	PASTOR//SITE/MO/3/CHEN/AEGILOPS SQUARROSA(TAUS)//BCN/4/WBLL1(CMSA01Y00158S-040P0Y-040M-030ZTM- 040SY-26M-0Y-0SY-0S).
Misr 3	ATTILA*2/PBW65*2/KACHU (CMSS06Y00582T-099TOPM-099Y-099ZTM-099Y-099M-10WGY-0B-0EGY).

2.2. Measurements and analysis

2.2.1. Soil analysis

Soil samples representing the surface of 30 cm were collected for analysis according to methods cited by Richards (1954), Vomocil (1957), Dewis and Fertias (1970), Hesse (1971), Cottenie *et al.,* (1982) and Page *et al.,* (1982).

2.2.2. Studied characteristics:

At the heading stage, 10 flag leaves were randomly selected from each plot to estimate the following characteristics:

2.2.2.1. Biochemical characteristics

Chlorophyll content (μg ml^{-1}):

Chlorophyll a and b were determined according to Moran (1982). The leaves were homogenized in N-N-dimethyl formamid and determined using the spectrophotometric technique

2.2.2.2. The content of some enzymes in the leaves

- Proline content of leaves (mg g^{-1}FW):
  Proline content was determined according to the method of Bates *et al.,* (1973) was perused UV-VIS Spectrophotometer at 520 nm.
- Catalase activity (CAT μmol min^{-1} g $protein^{-1}$) according to Lum *et al.,* (2014) on a UV-Vis spectrophotometer, the optical density was measured at 240 nm at 0 and 3 minutes.
- Peroxidase activity (POD μmol min^{-1} g $protein^{-1}$) according to (Jebara *et al.,* 2005 and Lum *et al.,* 2014). Absorbance was read at 436 nm on a UV-Vis spectrophotometer at 0 and 3 minutes.

2.2.3. Grain yield and its chemical analysis:

Grain yield was calculated by harvesting whole plants in each plot and air dried, then threshed and the grains at 13 % moisture were weighted in kg and converted to ton fed^{-1}. Grain samples were taken at random from each plot and grounded into a fine powder to pass through 2mm mesh for chemical analysis, i.e. crude carbohydrate content and crude protein (N%×5.75) was determined according to the procedures of the A.O.A.C. (1990) and expressed as a percentage of the dry weight of the sample. Both Na and K were estimated by a flame Photometer according to Jackson, 1967, and P was determined by using hydroquinine method and measured by a spectrophotometer at a 660 nm wavelength (Snell and Snell, 1967).

2.3. Statistical analysis

All statistical analysis was performed using analysis of variance technique by “MSTAT-C” (1990) computer software package and treatment means was compared with Duncan Multiple Range Test the treatments were compared at 0.01% level of significance Duncan (1955).

3. RESULTS

3.1. Biochemical characteristics

3.1.1. Chlorophyll content

Chlorophyll a, and b content in the flag leaf of wheat cultivar Sakha 95 and Misr 3 as affected by soil salinity and foliar spray, and their interaction in the 2020/21 and 2021/22 seasons are presented in Table (3). Data refer that the soil salinity resulted in a highly negative effect on chlorophyll content in both seasons. Soil salinity caused a marked reduction in chl. a (13.33 and 7.69 %), and chl. b (29.83 and 25.00%) compared with normal soil in the two seasons, respectively.

The achieved results shows in Table (3) indicated that, Sakha 95 cultivar exceeded the Misr 3 cultivar in chlorophyll content in both seasons.

Foliar spraying by antioxidants resulted in a highly significant increase in chl a, and b content in the two seasons compared to control treatment (Table 3).

Application of ascorbic acid (ASA) produced the highest values of chl. a (13.34 and 14.51 µg ml^{-1}), followed by silicate potassium (10.92 and 13.24 µg ml^{-1}), and lowest one were obtained by control treatments (7.51 and 10.86 µg ml^{-1}) in the first and second seasons, respectively. Also, the results are similar for chl. b content. However, there was no significant difference between spraying salicylic acid and potassium silicate in the second season for each of chlorophyll content.

The attained results in Table (3) indicated that, the interactions between soil salinity and cultivars on chlorophyll content. It was found that there was an insignificant difference for chl. a in both seasons, and chl. b in the 1st season. A significant difference in the second season for chl. b in the first season was found. The highest values of Sakha 95 cultivar were in the normal soil. Under the saline soil, Misr 3 gave the lowest mean values.

A positive significant difference was found due to the interactions between soil salinity and foliar spraying in chlorophyll content (Table 3). Chlorophyll (a) decreased by 25.98 and 22.91%, and chlorophyll (b) 35.80 and 15.54%.

Table (3) indicates the interactions between cultivars and foliar spraying of chlorophyll content, as it shows that there is a significant difference for chl. a and b in both seasons, but in the second season had insignificant difference in chlorophyll (a). The highest mean values of chlorophyll content were achieved with c.v Sakha 95 + ascorbic acid spray treatment, followed by c.v Misr 3 with ascorbic acid spray treatment; whiles c.v Misr 3 without foliar spray gave the lowest values.

Table 3. Biochemical characteristics of the two wheat cultivars as affected by soil salinity and foliar spraying with some antioxidants in 2020/21 and 2021/22 seasons.

Factors		**Chl. a (µg ml^{-1})**		**Chl. b (µg ml^{-1})**		**Proline (mg g^{-1}FW)**		**POD (µmol min^{-1} g protein^{-1})**		**CAT (µmol min^{-1} g protein^{-1})**	
Seasons		2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22
Soil salinity(A)											
Normal		10.97a	13.30a	4.57a	6.10a	0.250b	0.257b	2.27b	2.32b	0.148b	0.156b
Saline		9.68b	12.35b	3.52b	4.88b	0.257a	0.265a	2.42a	2.47a	0.156a	0.164a
F-test		**	**	**	**	**	**	**	**	**	**
Cultivars (B)											
Sakha 95		10.68a	13.15a	4.32a	5.89a	0.250b	0.256b	2.37a	2.43a	0.153a	0.161a
Misr 3		9.97b	12.50b	3.77b	5.10b	0.257a	0.266a	2.32b	2.37b	0.151b	0.159b
F-test		**	*	**	**	**	**	**	**	**	**
Foliar spray (C)											
Control		7.51d	10.86c	2.00d	4.26c	0.237d	0.240d	2.00d	2.02d	0.130d	0.136d
ASA		13.34a	14.51a	6.78a	7.66a	0.268a	0.281a	2.72a	2.79a	0.173a	0.182a
SA		9.55c	12.68b	3.08c	4.79bc	0.251c	0.257c	2.23c	2.28c	0.146c	0.152c
K_2SiO_3		10.92b	13.24b	4.32b	5.25b	0.257b	0.266b	2.44b	2.50b	0.160b	0.171b
F-test		**	**	**	**	**	**	**	**	**	**
Bilateral interaction											
Soil salinity (A)	**Cultivars (B)**										
Normal	Sakha 95	11.33	13.51	4.94	6.69a	0.247	0.254	2.3	2.36c	0.150b	0.158b
	Misr 3	10.62	13.09	4.19	5.51bc	0.253	0.26	2.25	2.29d	0.146c	0.154c
Saline	Sakha 95	10.04	12.79	3.7	5.08cd	0.253	0.259	2.45	2.49a	0.156a	0.165a
	Misr 3	9.33	11.91	3.34	4.68d	0.261	0.271	2.39	2.45b	0.155a	0.164a
F-test		ns	ns	ns	*	ns	ns	ns	**	**	*
Soil salinity(A)	**Foliar spray (C)**										
Normal	Control	8.37g	11.98e	2.30f	4.57de	0.231g	0.233f	1.91h	1.93h	0.127h	0.131
	ASA	14.23a	14.94a	8.03a	9.57a	0.263b	0.274b	2.66b	2.73b	0.169b	0.177
	SA	9.89e	12.82cd	3.27e	4.89cd	0.250e	0.256de	2.21f	2.25f	0.143f	0.148

	K_2SiO_3	11.40c	13.47bc	4.67c	5.38bc	0.256cd	0.265bc	2.32d	2.38d	0.155d	0.166
Saline	Control	6.65h	9.75f	1.69g	3.96e	0.244f	0.247e	2.09g	2.12g	0.133g	0.139
	ASA	12.44b	14.08b	5.53b	5.75b	0.273a	0.288a	2.78a	2.84a	0.177a	0.185
	SA	9.20f	12.55de	2.88e	4.70cd	0.253de	0.259cd	2.25e	2.31e	0.148e	0.156
	K_2SiO_3	10.44d	13.02cd	3.97d	5.12bcd	0.258c	0.266bc	2.57c	2.62c	0.164c	0.175
F-test		**	*	**	**	**	*	**	**	**	ns
Cultivars (B)	**Foliar spray (C)**										
Sakha 95	Control	7.99g	11.72	2.14e	4.54e	0.234g	0.236f	2.04g	2.06	0.13g	0.135g
	ASA	13.91a	14.82	7.49a	8.86a	0.261b	0.269b	2.75a	2.81	0.174a	0.183a
	SA	9.75e	12.73	3.19d	4.83de	0.250e	0.255d	2.24e	2.3	0.147e	0.155e
	K_2SiO_3	11.09c	13.32	4.45c	5.31c	0.256cd	0.265bc	2.47c	2.52	0.162c	0.172c
Misr 3	Control	7.03h	10	1.85e	3.98f	0.241f	0.245e	1.96h	1.98	0.130g	0.137g
	ASA	12.77b	14.21	6.07b	6.46b	0.275a	0.292a	2.69b	2.76	0.172b	0.180b
	SA	9.34f	12.63	2.96d	4.76e	0.253de	0.260cd	2.21f	2.25	0.144f	0.150f
	K_2SiO_3	10.75d	13.16	4.20c	5.19cd	0.258bc	0.266bc	2.42d	2.46	0.158d	0.169d
F-test		*	ns	*	**	**	**	**	ns	*	**

Note*: *and indicate a significant difference and **NS** indicates an insignificant difference at $P<0.01$. Different lowercase letters in the column indicate a significant difference between the treatments, while the same letters show no statistical difference at $P<0.01$ (Duncan's multiple range test).

Table 4. Interaction effect of soil salinity, wheat cultivars and foliar spray on biochemical characteristics in the 2020/21 and 2021/22 seasons.

Factors			Chl. a ($\mu g\ ml^{-1}$)		Chl. b ($\mu g\ ml^{-1}$)		Proline ($mg\ g^{-1}FW$)		POD ($\mu mol\ min^{-1}\ g\ protein^{-1}$)		CAT ($\mu mol\ min^{-1}\ g\ protein^{-1}$)	
	Seasons		2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22
Soil salinity(A)	**Cultivars (B)**	**Foliar spray (C)**										
Normal	Sakha 95	Control	8.71k	12.17fgh	2.5	4.60de	0.227m	0.227	1.96k	1.98m	0.129l	0.133j
		ASA	14.88a	15.42a	8.99	11.78a	0.260cd	0.268	2.67c	2.75c	0.170c	0.178c
		SA	10.12h	12.86defg	3.44	4.93de	0.249ij	0.254	2.21h	2.29i	0.145i	0.152g
		K_2SiO_3	11.61e	13.59bcde	4.84	5.46cde	0.254fghi	0.265	2.34f	2.41g	0.158f	0.168e
	Misr 3	Control	8.03l	11.79gh	2.1	4.54e	0.236l	0.239	1.85l	1.88n	0.124m	0.130j
		ASA	13.59b	14.47ab	7.06	7.36b	0.266b	0.28	2.64c	2.71d	0.167d	0.177cd
		SA	9.66i	12.78efg	3.1	4.85de	0.252ghi	0.257	2.20h	2.21j	0.142j	0.145h
		K_2SiO_3	11.19f	13.34bcde	4.5	5.30cde	0.257cdef	0.265	2.30g	2.34h	0.152g	0.164e
Saline	Sakha 95	Control	7.26m	11.27h	1.79	4.49e	0.241k	0.244	2.11i	2.14k	0.130l	0.137i
		ASA	12.95c	14.21bc	5.99	5.94c	0.262bc	0.271	2.83a	2.87a	0.178a	0.189a
		SA	9.38i	12.61efg	2.94	4.74de	0.252hi	0.255	2.27g	2.32hi	0.150h	0.157f
		K_2SiO_3	10.57g	13.06cdef	4.06	5.17cde	0.257defg	0.265	2.60d	2.65e	0.165de	0.176cd
	Misr 3	Control	6.03n	8.22i	1.6	3.42f	0.246jk	0.251	2.07j	2.09l	0.136k	0.143h
		ASA	11.94d	13.94bcd	5.07	5.56cd	0.284a	0.304	2.73b	2.81b	0.176b	0.183b
		SA	9.02j	12.49efg	2.82	4.67de	0.254efgh	0.263	2.23h	2.31i	0.146i	0.155fg
		K_2SiO_3	10.30gh	12.97def	3.89	5.07cde	0.259cde	0.266	2.54e	2.59f	0.164e	0.174d
F-test			*	*	ns	**	**	ns	**	**	**	**

Note*: *and indicate a significant difference and **NS** indicates an insignificant difference at $P<0.01$. Different lowercase letters in the column indicate a significant difference between the treatments, while the same letters show no statistical difference at $P<0.01$ (Duncan's multiple range test).

The interactions between soil salinity, cultivars and foliar spraying of chlorophyll content, as the Table (4) indicated that there are positive affect chl. a, and b in both seasons, and there are insignificant difference in the 1st season of chlorophyll (b). The best treatment was ascorbic acid foliar spray with Sakha 95 under the influence of normal or salinity soil.

3.1.2. The content of some enzymes in the leaves:

The content of some enzymes in leaves was strongly affected by soil salinity. The saline soil increased considerably the values of proline, peroxidase activity (POD), and catalase activity (CAT) compared to normal soil (Table 3).

With regard to wheat cultivars, results in Table 3 revealed highly significant differences existed between Misr 3 and Sakha 95. Sakha 95 had a significantly higher activity of (POD) and (CAT) enzymes. While, the proline content was higher with Misr 3.

Foliar spraying treatments caused an observed increase in proline, (POD), and (CAT) activity compared to untreated plants (control). Ascorbic acid recorded the highest increase in the content of proline, (POD), and (CAT), followed by potassium silicate, while the lowest increase was obtained with salicylic acid.

The soil salinity × cultivars interaction is positive about the CAT content in both seasons. However, insignificant effects on proline content in both seasons and in the 1st season with POD, while in the 2nd season was highly significant as shown in Table 3.

Table (3) illustrates that, the interaction between soil salinity and foliar spray on the content of some enzymes in the leaves. Ascorbic acid more effective foliar spray treatment under normal and saline soil condition than that, the other foliar spray treatments (SA and K_2SiO_3).

Concerning the interaction of cultivars and foliar spray, the results in Table (3) show that there is a difference in the content of some enzymes in leaves of both cultivars. The highest proline content (0.275 and 0.292 mg g^{-1}FW) were observed with Misr 3 c.v + foliar spray by ASA. While, Sakha 95 with spraying ASA gave the highest mean values of POD (2.75 and 2.81μmol min^{-1} g $protein^{-1}$) and CAT (0.174 and 0.183 μmol min^{-1} g $protein^{-1}$). Insignificant differences in the POD content values in the second season were detected.

Under saline soil condition, the data in Table (4) show that the highest proline content values were obtained with Misr 3 c.v + foliar spray by ASA. While, the highest mean values of POD and CAT were recorded with Sakha 95 + ASA foliar spraying.

3.2. Grain yield and its chemical analysis:

3.2.1. Grain yield

Grain yield of the two wheat cultivars as affected by soil salinity and foliar spray, and their interaction in the 2020/21 and 2021/22 seasons are presented in Table (5). Data showed that the soil salinity resulted in a highly negative effect on grain yield in both seasons. Soil salinity caused a marked reduction in grain yield by 17.86 and 18.34% compared with normal soil in the two seasons, respectively.

The results indicated that, Sakha 95 cultivar exceeded the Misr 3 cultivar in grain yield in both seasons, which the grain yield increased an average of both seasons by 13%, respectively.

Foliar spraying treatments caused an observed increase in grain yield compared to untreated plants (control). Ascorbic acid recorded the highest increases in the grain yield, followed by potassium silicate, while, the lowest increase was obtained with salicylic acid Table (5).

The soil salinity × cultivars interaction is insignificant affect the grain yield of wheat in both seasons (Table 5).

Table (5) refers that the interaction between soil salinity and foliar spray on the grain yield. Ascorbic acid more effective foliar spray treatment under normal and saline soil conditions than that other foliar spray treatments (SA and K_2SiO_3).

Concerning the interaction of cultivars and foliar spray, the results in Table (5) show that there is a difference in the grain yield of both cultivars. The highest grain yield was observed with Sakha 95 c.v +

foliar spray by ASA. While, Misr 3 without spraying gives the lowest values.

For the interaction of soil salinity, cultivars and foliar spray, data shown in Table (6) indicate highly significant differences for grain yield in both seasons. The greatest values were obtained from foliar spray by ASA + Sakha 95 under the normal or /and saline condition.

3.2.2. Chemical analysis of grain:

Data presented in Tables (5 and 6) show the effect of soil salinity, wheat cultivars, foliar spray and their interaction on chemical analysis of grain wheat.

All Chemical analysis of grain, e.g. carbohydrates%, protein, Na%, P and K showed pronounced effects under salt stress (Table 5). Results reference that P and K were reduced and they had high significantly with salinity compared to unstressed condition (normal soil). While, the main values of carbohydrates, protein and Na% were highly significant increased with soil salinity in both seasons.

Table 5. Grain yield and chemical analysis of grains of the two wheat cultivars as affected by soil salinity and foliar spraying with some antioxidants in 2020/21 and 2021/22 seasons.

Factors		**Grain yield (ton fed^{-1})**		**Carbohedrat %**		**Protein%**		**Na%**		**P%**		**K%**	
Seasons		2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22
Soil salinity(A)													
Normal		1.98a	2.00a	72.59b	72.87b	9.56b	9.55b	1.17b	1.10b	0.378a	0.383a	0.951a	0.98a
Saline		1.68b	1.69b	73.86a	74.02a	11.00a	10.57a	1.26a	1.20a	0.368b	0.372b	0.874b	0.90b
F-test		**	**	**	**	**	**	**	**	**	**	**	**
Cultivars (B)													
Sakha 95		1.94a	1.96a	73.59a	73.78a	9.82b	9.75b	1.17b	1.11b	0.376a	0.380a	0.946a	0.96a
Misr 3		1.72b	1.73b	72.87b	73.11b	10.75a	10.38a	1.26a	1.19a	0.371b	0.375b	0.889b	0.92b
F-test		**	**	**	**	**	**	**	**	**	**	**	**
Foliar spray (C)													
Control		1.16d	1.19d	69.55d	70.74d	7.88d	7.66d	1.46a	1.37a	0.351d	0.356c	0.75d	0.76d
ASA		2.53a	2.54a	76.16a	76.19a	13.72a	12.57a	1.04d	0.97d	0.392a	0.395a	1.14a	1.18a
SA		1.67c	1.69c	72.65c	72.80c	8.70c	9.66c	1.23b	1.15b	0.371c	0.376b	0.83c	0.84c
K_2SiO_3		1.95b	1.98b	74.54b	74.06b	10.84b	10.36b	1.13c	1.10c	0.379b	0.383b	0.94b	0.98b
F-test		**	**	**	**	**	**	**	**	**	**	**	**
Bilateral interaction													
Soil salinity (A)	**Cultivars (B)**												
Normal	Sakha 95	2.08	2.12	73.05c	73.2	9.17	9.13	1.15	1.08b	0.379	0.385	0.98a	1
	Misr 3	1.88	1.89	72.14d	72.54	9.96	9.97	1.19	1.12b	0.377	0.381	0.92b	0.95
Saline	Sakha 95	1.8	1.8	74.12a	74.36	10.46	10.36	1.2	1.14ab	0.372	0.375	0.89bc	0.92
	Misr 3	1.57	1.58	73.60b	73.68	11.55	10.79	1.33	1.25a	0.365	0.369	0.86c	0.88
F-test		ns	ns	*	ns	ns	ns	ns	*	ns	ns	**	ns
Soil salinity(A)	**Foliar spray (C)**												
Normal	Control	1.39g	1.42f	68.03h	69.80h	7.61f	7.06f	1.33b	1.24b	0.361f	0.367f	0.78f	0.80f
	ASA	2.77a	2.80a	75.84b	75.60b	12.23b	11.83b	1.01f	0.95d	0.396a	0.400a	1.20a	1.24a
	SA	1.70e	1.74e	72.26f	72.47f	8.15f	9.52d	1.21bcd	1.12c	0.374d	0.379d	0.84e	0.85e
	K_2SiO_3	2.04c	2.06c	74.25d	73.62d	10.28d	9.79d	1.12def	1.07cd	0.381c	0.385bc	0.98c	1.02c
Saline	Control	0.94h	0.96g	71.07g	71.69g	8.15f	8.26e	1.60a	1.49a	0.341g	0.345g	0.72g	0.72g
	ASA	2.29b	2.27b	76.49a	76.77a	15.21a	13.31a	1.08ef	1.00d	0.389b	0.389b	1.07b	1.11b
	SA	1.64f	1.64e	73.05e	73.13e	9.24e	9.79d	1.24bc	1.18bc	0.368e	0.374e	0.82ef	0.84e
	K_2SiO_3	1.86d	1.89d	74.83c	74.50c	11.41c	10.94c	1.14cde	1.12c	0.377cd	0.380cd	0.89d	0.94d
F-test		**	**	**	**	**	**	**	**	**	**	**	**
Cultivars (B)	**Foliar spray (C)**												
Sakha 95	Control	1.32f	1.35e	70.42g	71.37g	7.61f	7.06	1.33	1.27b	0.356d	0.361e	0.77	0.78
	ASA	2.73a	2.73a	76.38a	76.53a	12.63b	12.27	1.03	0.95e	0.394a	0.397a	1.17	1.22
	SA	1.69e	1.71d	72.76ef	73.00e	8.42de	9.52	1.22	1.14c	0.372c	0.377d	0.84	0.85
	K_2SiO_3	2.01c	2.05c	74.78c	74.23c	10.60c	10.13	1.12	1.08cd	0.380b	0.383c	0.96	1.01
Misr 3	Control	1.01g	1.03f	68.69h	70.11h	8.15ef	8.26	1.6	1.47a	0.346e	0.351f	0.73	0.73
	ASA	2.34b	2.34b	75.94b	75.84b	14.81a	12.87	1.06	1.00de	0.390a	0.392b	1.1	1.14
	SA	1.65e	1.66d	72.55f	72.60f	8.97d	9.79	1.24	1.16c	0.370c	0.375d	0.82	0.84
	K_2SiO_3	1.89d	1.91c	74.29d	73.89d	11.09c	10.6	1.14	1.11c	0.378b	0.382c	0.91	0.95
F-test		**	*	**	**	**	ns	ns	**	*	**	ns	ns

Note*: *and indicate a significant difference and **NS** indicates an insignificant difference at *P<0.01*. Different lowercase letters in the column indicate a significant difference between the treatments, while the same letters show no statistical difference at *P<0.01* (Duncan's multiple range test).

Table 6. Interactions between soil salinity, cultivars and foliar spray on grain yield and chemical analysis of grains during 2020/21 and 2021/22 seasons.

Factors			Grain yield (ton fed^{-1})		Carbohedrat %		Protein%		Na%		P%		K%	
	Seasons		2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22	2020/21	2021/22
Soil salinity(A)	**Cultivars (B)**	**Foliar spray (C)**												
Normal	Sakha 95	Control	1.44h	1.47hi	69.29k	70.77l	7.06f	5.98f	1.29bc	1.24bc	0.360h	0.369ij	0.80fg	0.80hi
		ASA	3.05a	3.09a	76.03bc	75.69bc	11.68c	11.51b	1.00f	0.91f	0.398a	0.404a	1.26a	1.30a
		SA	1.72fg	1.77fg	72.36h	72.62hi	8.15e	9.25d	1.19cde	1.12bcde	0.374ef	0.380efgh	0.84ef	0.86g
		K_2SiO_3	2.09cd	2.13cd	74.52e	73.72f	9.79d	9.79cd	1.12def	1.04def	0.383cd	0.386cde	1.03c	1.06d
	Misr 3	Control	1.35hi	1.36ij	66.78l	68.82m	8.15e	8.15e	1.37b	1.24bc	0.362h	0.365j	0.77g	0.80hi
		ASA	2.50b	2.52b	75.64c	75.51c	12.77b	12.15b	1.02f	1.00ef	0.394ab	0.396b	1.14b	1.19b
		SA	1.68fg	1.70fg	72.16h	72.31ij	8.15e	9.79cd	1.24bcd	1.12bcde	0.373efg	0.378fgh	0.84ef	0.84gh
		K_2SiO_3	1.99d	2.00cde	73.97f	73.52f	10.76cd	9.79cd	1.12def	1.11cde	0.379de	0.384cdef	0.94d	0.99e
Saline	Sakha 95	Control	1.20i	1.23j	71.55j	71.97j	8.15e	8.15e	1.37b	1.29b	0.349i	0.354k	0.75gh	0.77i
		ASA	2.41b	2.37b	76.73a	77.36a	13.58b	13.04a	1.07ef	1.00ef	0.391b	0.391bc	1.08bc	1.14bc
		SA	1.66fg	1.65fgh	73.16g	73.37fg	8.70e	9.79cd	1.24bcd	1.16bcde	0.370fg	0.374ghi	0.84ef	0.84gh
		K_2SiO_3	1.92de	1.96de	75.04d	74.75d	11.41c	10.47c	1.12def	1.12bcde	0.377de	0.381defg	0.89de	0.95ef
	Misr 3	Control	0.67j	0.70k	70.59j	71.41k	8.15e	8.37e	1.82a	1.70a	0.332j	0.337l	0.69h	0.67j
		ASA	2.18c	2.17c	76.24b	76.17b	16.84a	13.58a	1.09def	1.00ef	0.387bc	0.388cd	1.06c	1.10cd
		SA	1.62g	1.62gh	72.94g	72.89fg	9.79d	9.79cd	1.24bcd	1.20bcd	0.366gh	0.373hi	0.80fg	0.84gh
		K_2SiO_3	1.80ef	1.82ef	74.61de	74.25e	11.41c	11.41b	1.16cdef	1.12bcde	0.376def	0.380efg	0.89de	0.92f
F-test			**	**	**	**	**	**	**	**	*	*	*	*

Note*: *and indicate a significant difference and **NS** indicates an insignificant difference at *P<0.01*. Different lowercase letters in the column indicate a significant difference between the treatments, while the same letters show no statistical difference at *P<0.01* (Duncan's multiple range test).

The results presented in Table (5) introduced significant differences in the chemical analysis of grain across in both seasons. Sakha 95 cultivars significantly surpassed Misr 3 in carbohydrates%, P and K. While, Misr 3 produced more protein and Na% than Sakha 95.

Foliar spraying was accompanied by a significant increase in selected chemical analysis of grain than that of untreated plants (control). Application of ascorbic acid (ASA) produced increasing the mean values of carbohydrates (9.50 and 7.70%), protein (74.11 and 64.10%), P (11.68 and 10.96%) and K (52.00 and 55.26%) in the 1^{st} and 2^{nd} seasons, respectively. While, the mean values of Na% were decreased by 28.77 and 29.20% in both seasons compared with control (untreated plants).

Table (5) indicates the interactions between soil salinity and cultivar in chemical analysis of grain, where it was found that there were insignificant affects the carbohydrates and K in the 2^{nd} season and also, the P and protein no significant differences in both seasons. In general, the mean values of carbohydrates and Na% content were increased with Misr 3 under saline soil, while Sakha 95 cultivars significantly exceed Misr 3 in K% under different salinity conditions (Table 5).

The application of ASA recorded the best treatment for counteracting salinity stress in terms of the chemical analysis of grain. Highly significant differences were found in the first and two seasons due to the interactions between soil salinity and foliar spray in the all chemical analysis (Table 5).

Concerning the interaction of soil salinity and foliar spraying, the results in Table (5) show that there is a highly significant difference for all chemical analysis in both seasons. Foliar spray with ascorbic acid under salinity stress condition increased carbohydrates and protein compared the unstressed condition, while, P and K were increased under normal than that saline soil. Na% decreased significantly under unstressed and salinity stress conditions.

Regarding the combinations between cultivars and foliar spray, the data illustrated in Table (5) clearly indicate that antioxidants foliar application, especially ascorbic acid with Sakha 95 gave a highest mean values of carbohydrates (76.38 and 76.53 %) and P (0.394 and 0.397%). While the highest mean values of protein and Na content with Misr 3 + ascorbic acid spray or/and without spray treatments.

The interactions between soil salinity and cultivars and foliar spraying, as shown in Table (6). The highest mean values of protein content were produced with Misr 3 + ascorbic acid foliar sprays under saline soil, and Na% in both seasons were achieved with Misr 3 + control (untreated plants) under saline soil. While the maximum carbohydrates, P and K% were obtained with ascorbic acid foliar spray + Sakha 95 under normal soil.

4. DISCUSSION

Chlorophyll content:

Data showed that the soil salinity resulted in a highly negative effect on Chlorophyll content (a, b and t). The decrease in the content of photosynthetic pigments might be attributed to damage to protein complexes and/or chlorophyll molecules Siddiqui *et al.,* (2018). ASA Foliar spraying treatments caused an observed increase in Chlorophyll content (a and b) compared to untreated plants (control). These results agreed with Azzedine *et al.,* (2011) found that applying ascorbic acid was improving chlorophyll under saline stress. Also, Siddiqui *et al.,* (2018) noted that ascorbic acid significantly improved the accumulation of chlorophyll content in wheat plants under non-stress and stress conditions. Interactions between soil salinity and cultivars on chlorophyll content were found that the highest values of Sakha 95 cultivars were under un-stress condition, while Misr 3 gave the lowest mean values under salt stress condition. These findings are in agreement, Abd El-Hamid *et al.,* (2020), Genedy and Eryan (2022), Elsawy *et al.,* (2023) and Khedr *et al.,* (2023), which they specified that the Sakha 95 cultivars exceeded Misr3 cultivar in chlorophyll contents. Foliar spray by ascorbic acid declined the salinity stress on chlorophyll content more efficiently than the other foliar spray treatment.

The interactions between soil salinity and foliar spraying resulted in a decrease in chlorophyll content, due to salinity stress under control treatment in the two seasons, respectively. The interactions between cultivars and foliar spraying of chlorophyll content indicated that, the behavior of foliar spraying of chlorophyll content differed for cultivars to another. Regarding the interactions between soil salinity, cultivars and foliar spraying of chlorophyll content (a and b), the effect of the second order interaction on that trait was significant in both seasons, except, Chl. b in the first season, indicated that these treatments are dependable on each others in their influence on this character.

The content of some enzymes in the leaves:

The content of some enzymes in leaves was strongly affected by soil salinity. These results agreed with the result obtained by Lee *et al.,* (2001) and Khedr *et al.,* (2023) they observed that under saline stress, plants induce an excess of reactive oxygen species (ROS) which causes oxidative stress of lipid cell membranes. The soil salinity × cultivars interaction is a positive effect on the content of some enzymes in the leaves. It seems that, the first order did not affected by changing the other environment. These agreed with Genedy and Eryan (2022) and Khedr *et al.,* (2023).

Concerning the interaction between soil salinity and foliar spray on the content of some enzymes in the leaves. The results indicated that, foliar spray by AsA was effective under non-stress and salt sress condition. In agreement with the findings of Abbasi and Faghani (2015), Desoky and Merwad (2015), and Hassan and Bano (2016) they refer that the application of ascorbic acid increments proline in plants under saline conditions for wheat. Also Agami (2014), Hassan and Bano (2016) and Gerami *et al.,* (2019) found that under salt-stressed conditions, the ascorbic acid application led to an increase in CAT and POD activities. Concerning the interaction effect of soil salinity, wheat cultivars and foliar spray on the content of some enzymes in the leaves, the results showed that the highest proline content values were obtained with Misr 3 cultivar + foliar spray by (ASA). While, the highest mean values of (POD) and (CAT) were recorded with Sakha 95 cultivar + spraying by ascorbic acid. The results were agreeing with data obtained by Mandhania et al., (2012) found that the activities of catalase activity (CAT) increased with increasing the salt stress in both salt tolerant and salt sensitive wheat cultivars.

Grain yield:

Data showed that the soil salinity resulted in a highly negative effect on grain yield in both seasons, which caused a marked reduction in grain yield compared with normal soil. The results agreed with Hasan *et al.,* (2015) and Nadeem *et al.,* (2020) which indicated a negative effect of salinity on grain yield. In addition, losses in grain weight due to saline stress are due to pollen sterility, reduced production of assimilates, and reduced partitioning to economical parts (grains) of plants (Dadshani *et al.,* 2019). The results indicated that, Sakha 95 cultivar exceeded the Misr 3 cultivar in grain yield in both seasons. It seems that, wheat yields had affected by among cultivar to another. Foliar spraying treatments caused an observed increase in grain yield compared to untreated plants (control). Ascorbic acid recorded the highest increases in the grain yield. This result agreed with El-Awadi *et al.,* (2014) found that the treatment of wheat plants with foliar spraying of ascorbic acid resulted in an increase in the grain yield.

The soil salinity × cultivars interaction is positive affect the grain yield of wheat. Those findings agreed with Abd El-Hamid *et al.,* (2020), Genedy and Eryan (2022), Elsawy *et al.,* (2023) and Khedr *et al.*, (2023). Ascorbic acid more effective foliar spray treatment under normal and saline soil conditions than that other foliar spray treatments. These results agreement with Fawy and Attia (2013) and Bakry *et al.,* (2013) and they mention that application of ascorbic acid spray led to increases in grain yield under stress condition. It seems that, soil salinity affected by changing foliar spray treatments.

Concerning the interaction of cultivars and foliar spray, the results showed that the highest grain yield were observed with Sakha 95 c.v + foliar spray by ascorbic acid (ASA). It seems that, wheat cultivars had affected by changing foliar spray treatments. The interaction of soil salinity, cultivars and foliar spray, data indicated that the greatest values of grain yield were obtained from foliar spray by ascorbic acid (ASA) + Sakha 95 under the saline condition. These significant interactions among these characters indicated that, these factors are dependable on each of the others in their in influences.

Chemical analysis of grain:

The chemical analysis of grains was strongly affected by soil salinity. It may be due to the salinity increases the percentage of Na produced from soil salts such as NaCl, which in turn works to increase the osmotic pressure in the plant and thus an increase in electrical conductivity. The results agreed with Zhong *et al.,* (2016) who noted the salt stress affects caused the metabolism of carbohydrates and the translocation that causes the build-up of starch and sugars (*et al.,* 2016). Also, the increase in total carbohydrate content under salinity stress is consistent with results found by Hassan and Bano (2016), Zhong *et al.,* (2016) and Mohamed *et al.,* (2018). Also, the soil salinity led to increased protein and Na content, this may be related to the relatively stable nitrogen metabolism under salt stress, which might contribute to the higher protein concentration (Abd El-Hamid *et al.,* 2020). While Na uptake causes a decrease in P and K uptake by wheat plants, The results agreed with Nadeem *et al.,* (2020) who noted the negative impact of salinity on nutrient content in wheat plants. Foliar spraying by (AsA) caused an observed increase in carbohydrates, P, K and protein content compared to untreated plants (control). While it led to decreased Na. It seems that, the first order affected by changing the foliar spray.

The soil salinity × cultivars interaction a highly negative effect on the chemical analysis of grain. Zheng *et al.,* (2009) referred that the protein content of cultivars under study increased as salt concentration increase. The results indicated that, Misr 3 produced more protein and Na%. While Sakha 95 cultivars significantly surpassed Misr 3 in carbohydrates%, P and K. The data showed also the exceed Sakha 95 than Misr 3 under unstressed and salinity stress conditions. These results agreed with Abd El-Hamid *et al.,* (2020) and Ibrahim *et al.,* (2022). The results of this study agree with the results obtained by Abd El-Hamid *et al.,* (2020) and Elsawy *et al.,* (2023). The results indicated that, the attitude of these traits differed from cultivar to another. Concerning the interaction of soil salinity and foliar spraying, the results showed that foliar spraying by ascorbic acid recorded the best treatment for withstanding salt stress. Results agreed with Ishaq *et al.,* (2021). This result may be due to the effectiveness of the antioxidant system in the removal of ROS from plants and the maintenance of ion homeostasis (Athar and Ashraf 2008). Also, Azza *et al.,* (2011) stated that the promoting effect of ascorbic acid on total carbohydrates may be due to their important role in the biosynthesis of chlorophyll molecules which in turn affected total carbohydrate content. For the interactions between cultivars and foliar spray are positive effect on the chemical analysis of grain. It seems that, wheat cultivars had affected by changing foliar spray treatments, except, protein content in the first season, P% in the second season and K% in both seasons. Regarding interactions between soil salinity, cultivars, and foliar spray of the chemical analysis of grain, it showed that the highest results were in favor of Sakha 95 with ascorbic acid under un-stress and salt stress condition except, protein and Na% were achieved with Misr 3 + (AsA) foliar spray or/ and untreated plant under saline soil. It indicated that these treatments are dependable on each others in their influence on these traits.

5. CONCLUSIONS

It can conclude that the foliar spraying using ascorbic acid at a rate of 200 mg L^{-1} is most effective ways for increasing wheat productivity and alleviate the damage effects of salinity on the wheat plants. Therefore, it is recommended to plant Sakha 95 cultivars, due to its superiority tolerance to salinity as well as foliar spraying using ascorbic acid.

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