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ALLEVIATION THE ADVERSE EFFECTS OF SALINITY STRESS ON SOYBEAN CULTIVARS BY FOLIAR SPRAYING OF ARGININE

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ABSTRACT: The present study was carried out at the experimental farm of Tag El-Ezz Agricultural Research Station (30° 59\ N latitude, 31° 58\ E longitude´), Agricultural Research Center, Dakahlia Governorate, Egypt, to study the effect of foliar spraying of arginine on four soybean cultivars under salinity stress. This experiment was laid out in a split plot design with three replicates during the two successive summer seasons of 2020 and 2021. The main plots were occupied by four soybean cultivars (Giza 111, Giza 21, Giza 35 and Crawford), while subplots contained arginine treatments *i.e.* without spray (control), spray with arginine at 200 and 300 mg l^{-1} . The obtained results showed that, cultivars showed a wide range of variation in their salinity sensitivity where, Giza 111 gave the highest values of the most vegetative growth parameters *i.e.*, chlorophyll content, relative water content (RWC%), nutrients content in leaves, proline content as well as catalase and peroxidase enzymes activities, thus increased seed yield, seed nutrients, protein, carbohydrates and oil %. Concerning, foliar spraying of arginine ameliorate inhibitory effect of salinity on soybean cultivars in comparison to the control. The highest values of most studied vegetative growth parameters, yield and yield components were achieved by foliar spray of arginine at 300 mg l^{-1}. The interaction between soybean cultivars and foliar spraying of arginine revealed that, Giza 111 treated with arginine at 300 mg l^{-1} gave the highest values of growth, yield and yield components.

Key words: Soybean, Arginine, Salinity, growth, yield.

INTRODUCTION

Soybean (*Glycine max* L.) is the most economically important legume crop, it is not only a source of 70% from protein consumption in the world but also, it produce 29% from highly digestible oil (Ghassemi *et al*., 2009).

Soybean seeds contain 40% protein, 18-20% oil and 35% carbohydrates approximately (Teixeira *et al.*, 2020). It is important for human diets and animal feed where soybean oil contain high amounts of unsaturated fatty acids (Nickolic *et al*., 2009) and it considered a good protein source where it contains difference amino acids (Saad-Allah, 2015). Soybean seeds also consider a source of phospholipids, hormones and antioxidants (Ramana et al., 2012).

Soybean growth, development and productivity are affected by changing environments that induce abiotic stresses. Salinity stress is one of abiotic stresses that negatively affected on crops all over the world (Isayenkov, 2012). Salinity impact on different physiological and biochemical traits are affected via different ways *i.e.* reducing water uptake that cause osmotic stress, increasing rate of respiration (Hu and Schmidhalter, 2002), accumulation of Na^+ and Cl^- ions causing cytotoxicity, nutritional imbalance and excessive production of reactive oxygen species

(ROS) led to oxidative stress (Roy *et al.,* (2014). ROS caused damage to macromolecules, including proteins, lipids, nucleic acids, etc. Hasan *et al.,* (2020a). In order to avoid the toxic effects of ROS, plants have protection mechanisms that keep their concentrations much lower. These mechanisms include the antioxidant and glyoxalase systems, which respectively eliminate ROS (Hasanuzzaman *et al*., 2014). Soybean classified as a moderately salt sensitive crop, salinity reduce root nodules number, nitrogen fixation efficiency, growth and subsequently reduce yield (El Sabagh *et al*., 2016).

Amino acids are well known as bio-stimulant which has positive effects on plant growth and yield and significantly mitigates the injuries caused by abiotic stresses. Arginine is considered one of the essential amino acids which act as a precursor for polyamins (putrescine), nitric oxide and proline production (Winter *et al*., 2015). Putrescine is produced through decarboxylation of arginine by arginine decarboxylase enzyme (Abdul Qados 2010). Polyamins are important for different biological activities in plant via inhibition of lipid peroxidation, decreasing free radicals production, promoting cell division and enlargement and consequently protecting cell from oxidative damage (Alcázar *et al*., 2010).

Exogenous spraying of arginine stimulates growth, plant growth regulators, chlorophyll production and ameliorates salinity effect on plants (Hozayn *et al*., 2013). The simulative effect of arginine as polyamines precursor on growth and yield component may act as protective agent in plants adapted to extreme environment (Miller *et al*., 2007).

The objective of the present work is to reduce the harmful effects of salinity by foliar spraying of arginine on four soybean cultivars .

MATERIALS AND METHODS

An experiment was conducted during the two successive summer seasons 2020 and 2021 at the experimental farm of Tag El-Ezz Agricultural Research Station, Agricultural Research Center, Dakahlia governorate, Egypt, (located at 30^{o} 59$^{\backslash}$ N latitude, 31^{o} 58$^{\backslash}$ E longitude´) to study the effect of foliar spraying of arginine on growth, yield and its components as well as chemical composition of four soybean cultivars grown under saline soil. Seeds of soybean cultivars (Giza 111, Giza 21, Giza 35 and Crawford) were obtained from the Food Legumes Research Department, Ministry of Agriculture, Egypt. Random soil samples from the surface of the experimental soil (0-30 cm) were collected before planting. Some physical and chemical properties of the experimental soil were determined according to Page *et al*., (1982) and Klute (1986) as shown in Table (1).

Experiment description:

A split- plot design with three replicates were used in this work, where

I-The main: (soybean cultivars)
Giza 111, Giza 21, Giza 35 and Crawford.

II- The sub plots: (arginine spray)

- **Without spraying serve as control (Ar_0).**
- **Spraying arginine at 200 mg l^{-1} (Ar_1).**
- **Spraying arginine at 300 mg l^{-1} (Ar_2).**

Prior sowing, seeds of all cultivars were inoculated with the specific rhizobia which obtained from the Agricultural Research Center (ARC) as recommended. Seeds of soybean were sown in hills spaced 25 cm apart at both sides of the ridge. Each plot consisted of six ridges, 4 m long and 0.70m apart. The seeds were sown on 17th and 10st of May in the first and second season, respectively. Thinning was carried out at 15 days after

sowing to leave two plants per hill. With regard to the soil applied treatments, super phosphate [15.5 % P_2O_5] fertilizer was added to the soil during soil preparation at the rate of 15 kg P_2O_5 fad^{-1}. Nitrogen was added as urea (46.5 % N) at the rate of 15 kg N fad^{-1} and Potassium was added as potassium sulphate (48% K_2O) at the rate of 50 kg fad^{-1} according to recommendation by the Ministry of Agriculture and Soil Reclamation (MASR). The plants were sprayed with arginine twice at 45 and 70 days of planting with freshly prepared solutions at the rate (0, 200 and 300 mg l^{-1}). Meanwhile, untreated plants were sprayed with water and serve as a control.

A detailed description of name, pedigree, maturity group and origin of the tested soybean genotypes are presented in Table (2).

Table (1): Physical and chemical properties of the experimental soil during the two studied seasons 2020 and 2021.

Soil characteristics	Seasons	
I. Physical properties:	2020	2021
Particle size distribution		
Sand	15.29	19.50
Silt	37.20	37.18
Clay	47.51	43.32
Soil Texture Class	Clayey	Clayey
II. Chemical properties:		
pH, [1:2.5 soil water suspension] *	8.01	8.00
EC, [soil past, dS m^{-1}] **	6.10	6.04
SSP %	60.97	61.62
SAR %	12.60	12.70
ESP %	14.90	14.75
Soluble cations (meq L^{-1})		
Ca^{2+}	8.82	8.79
Mg^{2+}	8.52	8.50
Na^{+}	37.24	37.22
K^{+}	6.5	5.89
Soluble anions (meq L^{-1})		
CO_3^{2-}	--	--
HCO_3^{-}	4.00	3.97
Cl^{-}	32.4	32.00
SO_4^{2-}	24.6	24.43
III. Available elements (mg kg^{-1})		
N	49.62	49.82
P	8.77	8.52
K	241.35	242.04

* Soil pH was determined in soil water suspension (1: 2.5) .

** Soil Electrical Conductivity (EC) and soluble ions were determined in saturated soil paste extract.
Where, SSP: soluble sodium percentage, SAR: sodium adsorption ratio, ESP: exchangeable sodium percentage

Table (2): The pedigree, maturity group, growth habit and origin of tested soybean cultivars.

Cultivars	Pedigree	Maturity group	Growth habit	Origin
Giza 21	Crawford x Celest iza 21 x Major	IV	Indeterminate	FCRI *
Giza 35	Crawford × Celest	III	Indeterminate	FCRI *
Giza 111	Crawford × Celest	IV	Indeterminate	FCRI *
Crawford	Williams× Columbus	IV	Indeterminate	USA**

* FCRI = Field Crops Research Institute, Giza, Egypt.
** USA = U. S. Regional Soybean Laboratory at Urbana, Illinois, and Stoneville, Mississipi.

Studied characteristics:

- **Growth parameters:**

Plant samples were collected from each plot at maximum vegetative growth stage for measurement of some growth parameters: [shoot length (cm), number of branches plant $^{-1}$, number of leaves branch^{-1}, leaf area (cm^2) and plant dry weight (g)].

- **Yield and yield components :**

At harvest a sample of ten guarded plants were randomly taken from each to measure : plant height (cm), no. of pods plant^{-1}, 100 seeds weight (g) and one meter square to calculated seed yield (Kg fad^{-1}) .

•Chemical analysis:

Representative plant samples were taken randomly from each plot to estimate the following traits:

- Relative water content (RWC %): After 50 days from sowing, leaf samples were collected and immediately weighed (fresh weight; FW) and transferred into sealed flasks then immersed in distilled water for 5 hrs. until fully turgid at 4^o C, surface swabbed and reweighed (turgid weight; TW). Then oven-dried at 70^o C for 48 hrs. and reweighed (dry weight; DW). then calculated according to the equation of Lazcano-Ferrat and Lovatt (1999) as follow:

$$\boldsymbol{RWC}\ (\%) = \frac{(\boldsymbol{FW}-\boldsymbol{DW})}{(\boldsymbol{TW}-\boldsymbol{DW})}\boldsymbol{X100}$$

- Photosynthetic pigment content in leaves: The total chlorophyll pigments were determined by reading the absorbance on spectrophotometer at 664 and 647 nm and concentration of photosynthetic pigments were calculated according to the equation mentioned by Moran (1982) as follow :

Chl. $_a$ = 12.7(O.D) 664 - 2.79(O.D) 647

Chl. $_b$ =20.7(O.D) 647- 4.62(O.D) 664

Where OD= optical density for absorbance

- Total N, P, K and Na (%) in leaves as well as seeds were determined according to the methods described by Buresh *et al*., (1982) and Chapman and Pratt (1961).

- Enzyme extraction: The leaf sample (500 mg) was frozen in liquid nitrogen and finely ground by pestle in a chilled motor, the frozen powder was added to 10 mL of phosphate buffer (pH 7.0). The homogenate was centrifuged at 15000 × g for 10 min at 4^o C and the supernatant was used as an enzyme source for catalase (CAT; EC 1. 11. 1. 6), peroxidase (POD; EC 1. 11. 1. 7).

- **Enzymatic assay:** Catalase activity (CAT) was determined according to the method described by Cakmak and Marschner (1992). The activity of peroxidase (POX) enzyme was assessed according to Kara and Mishra (1976).
- **Proline Assay:** Proline content of leaves was determined according to the method of Bates *et al*., (1973). Its absorbance was measured at 520 nm in a spectrophotometer. The content of proline was calculated from a standard curve in $mg.g^{-1}$ FW.
- **Seed oil %:** was determined by soxhelt apparatus using petroleum ether as a solvent as described by A.O.A.C (1995).
- **Protein (%):** was estimated by multiplying nitrogen percentage by the factor (6.25) according to A.O.A.C. (1990).
- **Total soluble carbohydrates (%):** were estimated by phenol-sulphuric acid method Dubois *et al*., (1956).
- **Nutrients uptake:** was determined according to the following formula

$$\text{Nutrients uptake (kg fad}^{-1}\text{)} = \text{NPK (\%) X yield (kg fad}^{-1}\text{) /100}$$

Statistical analysis

The obtained data were statistically analyzed and compared among means by computer programming methods (Stat graphics, v.4.2 software), as described by Snedecor and Cochran (1982).

RESULTS AND DISCUSSION

Plant growth parameters:

It is clear from Table (3) that, soybean cultivars significantly differed in vegetative growth parameters under salinity stress and foliar spraying of arginine during the two studied seasons. Data showed that, the highest shoot height was recorded by Giza 21(63.36 &65.40 cm) followed by Giza 111 (58.56&60.22 cm) then Giza 35 (52.74&53.96 cm) and Crawford (49.34&51.75 cm) during the two seasons, respectively. All other growth parameters recorded that Giza 111 gave the highest values of number of branches $plant^{-1}$ (21.98&22.17), number of leaves $branch^{-1}$ (53.0 &53.86), leaf area (41.80 &41.76 cm^2) and dry weight (7.51&7.63 g $plant^{-1}$). The differences among soybean cultivars in growth characteristics may be due to the differences in number of nodules formed on the root of the tested cultivars consequently, the growth of each cultivar may depended mainly on nitrogen fixation (Tawfic *et al.*, 1991). Similar result was obtained by EL-Harty *et al.*, (2010) who recorded that soybean cultivars had a wide range of variation in growth, yield as well as its attributes.

On the other hand, salinity negatively affected the vegetative growth parameters *i.e.* (shoot height, number of branches plant $^{-1}$, number of leaves branches $^{-1}$, leaf area and dry weight of plant). These results may be attributed to the reduction of water availability and increasing of ions toxicity as well as inhibition of cytokinesis and cell expansion (Agarwal *et al.*, 2015) and Saad-Allah, 2015). In response to the foliar spraying of arginine, data in Table (3) showed that arginine at 300 mg l^{-1} (Ar_2) could improve and alleviate salinity tolerance of the plant by increasing the abovementioned growth criteria as compared with corresponding controls. These results were in harmony with that indicated by Velikova *et al.*, (2000).

Arginine as a source of poly amines increased plant protection from salinity damage via enhancing antioxidants enzymes production, growth promoters thus consequently increasing vegetative growth of plant as well as the role of arginine in stimulating cell division and differentiation (Abd El-Samad *et al.*, 2011). In regard to the interaction between soybean cultivars and foliar spray of arginine, Giza 111 treated with arginine at 300 mg l^{-1} recorded the highest values of most studied vegetative growth attributes.

Table (3): Effect of foliar spray of arginine on vegetative growth parameters of four studied soybean cultivars under salinity stress during the two seasons.

Treatments		Shoot height (cm)		No. of branches plant^{-1}		No. of leaves branch^{-1}		Leaf area (cm^2)		Dry weight (g plant^{-1})	
		2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Cultivars (C)											
Crawford		49.34	51.75	11.33	11.61	26.16	26.88	22.66	24.18	6.72	6.88
Giza 35		52.76	53.96	13.11	13.25	33.95	35.70	27.18	28.04	6.88	6.98
Giza 21		63.36	65.40	16.59	16.66	40.77	41.81	31.79	32.37	7.01	7.29
Giza 111		58.56	60.22	21.98	22.17	53.00	53.86	41.80	41.76	7.51	7.63
LSD at 0.05%		0.66	1.27	1.53	0.054	0.768	0.699	1.33	2.66	0.067	0.054
Arginine treatments (Ar)											
Ar_0		52.74	54.91	14.01	14.06	36.30	37.24	28.38	29.40	6.85	7.04
Ar_1		56.66	58.20	16.21	16.49	38.29	39.37	31.22	32.17	7.01	7.17
Ar_2		58.62	60.38	17.04	17.21	40.81	42.08	32.97	33.19	7.23	7.37
LSD at 0.05%		0.86	0.70	0.706	0.043	0.706	0.524	0.74	0.99	0.043	0.043
Interactions(CX Ar)											
Crawford	Ar_0	43.12	46.25	10.18	10.25	22.33	23.52	20.23	21.56	6.52	6.72
	Ar_1	51.62	53.42	11.50	12.10	25.50	26.34	22.60	24.80	6.74	6.80
	Ar_2	53.29	55.60	12.33	12.50	30.66	30.80	25.15	26.20	6.90	7.12
Giza35	Ar_0	50.40	51.80	12.50	12.62	32.25	33.50	26.20	27.12	6.65	6.83
	Ar_1	52.48	53.65	13.33	13.53	34.50	36.42	27.56	28.33	6.87	6.92
	Ar_2	55.36	56.43	13.50	13.60	35.10	37.18	27.80	28.67	7.12	7.20
Giza21	Ar_0	61.18	63.50	14.26	14.20	39.32	40.12	29.06	30.42	6.88	7.10
	Ar_1	63.42	65.42	17.52	17.68	40.66	41.33	32.74	33.56	6.92	7.32
	Ar_2	65.50	67.29	18.00	18.10	42.33	44.00	33.59	33.13	7.25	7.46
Giza111	Ar_0	56.23	58.12	19.12	19.20	51.32	51.82	38.03	38.53	7.36	7.52
	Ar_1	59.12	60.33	22.50	22.67	52.50	53.40	42.01	42.00	7.52	7.66
	Ar_2	60.33	62.23	24.33	24.66	55.18	56.36	45.37	44.76	7.65	7.73
LSD at 0.05%		1.73	1.41	1.41	0.086	1.40	1.04	1.48	1.99	0.087	0.086

Yield and yield attributes:

Data in Table (4) showed the yield and yield parameters *i.e.* (plant height, number of pods plant^{-1}, 100 seed weight) of four soybean cultivars that affected by foliar spraying of arginine under salinity stress. It is clear that, Giza 21 was the tallest plants (90.66& 94.56 cm) followed by Giza 111 (84.11&85.90 cm) then Giza 35(52.31&85.90 cm) and the shortest one is Crawford (77.18&77.39 cm) during the two growing seasons, respectively. Giza 111 recorded the highest values of number of pods plant^{-1} (127.46 &129.26), 100 seed weight (19.65&20.02 g) as well as seed yield (1889.52 and 1894.00 Kg fad^{-1}) in the two seasons, the lowest seed

yield values (1371.37 and 1376.03 Kg fad^{-1}) was achieved by Crawford. Similar results were obtained by Saad-Allah (2015). This may be due to the ability of Giza 111 to tolerate salinity stress more than other cultivars Sadak *et al*., (2020).

Salinity reduce all the previous studied criteria as well as seed yield, where it has an inhibitory effect on vegetative growth as shown in Table (3), these results are in harmony with those obtained by Agarwal *et al.*, (2015). Also, Abdul Qados (2010) concluded that reduction in seed yield under salinity may be attributed to negatively effect of salinity on growth, nutrients balance and chlorophyll content.

Foliar spraying of arginine has a significant impact on seed yield and yield attributes of all studied soybean cultivars. Foliar spraying of arginine (Ar_2) at rate of 300 mg l^{-1} achieved the highest values of plant height, number of pods plant^{-1}, 100 seed weight and seed yield, in the two seasons comparing with the control. These results may be due to the positive role of putrescine (the final product of arginine) in regulating growth, development and seed yield. Also, arginine has a vital role in promoting early flowering and fruiting of plant Liu *et al*., (2007), this result is in harmony with that concluded by Sadak *et al.*, (2015).

Regarding, the interaction between soybeans cultivars and foliar spraying of arginine, Giza 111 sprayed with arginine at the rate of 300 mg l^{-1} (Ar_2) achieved the highest values of seed yield and yield parameters under salinity stress.

Table (4): Effect of foliar spray of arginine on yield and yield attributes of four studied soybean cultivars under salinity stress in the two seasons.

Treatments		Plant height (cm)		No. of pods plant^{-1}		100 seed weight (g)		Seed yield (Kg fad^{-1})	
		2020	2021	2020	2021	2020	2021	2020	2021
Cultivars (C)									
Crawford		77.29	77.28	83.62	86.06	15.28	16.20	1371.37	1376.03
Giza 35		82.20	85.90	93.97	95.06	17.57	18.14	1401.71	1406.82
Giza21		90.77	94.56	103.17	111.34	18.22	19.33	1704.44	1709.10
Giza 111		84.22	85.90	127.46	129.26	19.65	20.02	1889.52	1894.00
LSD at 0.05%		3.85	1.33	2.17	5.47	0.033	0.054	7.76	6.45
Arginine treatments (Ar)									
Ar_0		82.64	84.00	98.75	101.75	17.24	17.78	1580.81	1586.55
Ar_1		83.46	86.26	102.11	105.39	17.81	18.63	1592.12	1597.23
Ar_2		84.60	87.46	105.32	108.99	17.99	18.86	1602.34	1605.67
LSD at 0.05%		1.99	1.73	1.73	4.37	0.043	0.043	3.56	4.30
Interactions (CX Ar)									
Crawford	Ar_0	71.25	74.26	81.32	83.33	4.85	15.22	1360.85	1366.97
	Ar_1	73.80	77.16	83.66	85.95	15.38	16.56	1372.67	1378.52
	Ar_2	79.21	80.75	85.90	88.25	15.62	16.83	1380.59	1382.62
Giza35	Ar_0	82.60	84.14	90.25	92.34	16.99	17.36	1392.08	1398.38
	Ar_1	85.14	86.22	94.33	94.66	17.76	18.42	1400.36	1405.42
	Ar_2	86.50	87.34	97.35	98.18	17.98	18.65	1412.70	1416.66
Giza21	Ar_0	87.14	92.36	99.25	104.50	17.76	18.93	1692.21	1698.56

	Ar_1	91.63	94.50	103.16	112.34	18.38	19.42	1705.19	1710.33
	Ar_2	93.22	96.82	107.12	117.20	18.52	19.65	1715.94	1718.42
Giza111	Ar_0	81.72	85.27	124.18	126.83	19.38	19.62	1878.11	1882.32
	Ar_1	84.36	87.18	127..30	128.62	19.72	20.14	1890.29	1894.6
	Ar_2	86.25	85.27	130.92	132.33	19.86	20.32	1900.16	1903.92
LSD at 0.05%		3.98	3.46	3.46	8.74	0.086	0.086	7.13	8.600

Chlorophyll content and Relative water content

It is evident from Table (5) that, chlorophyll content (Chl. $_{a.}$, Chl. $_{b}$ and chl. $_{a+b}$) as well as relative water content (RWC %) are significantly affected by foliar spraying of arginine in all studied soybean cultivars under salinity stress.

Giza 111 recorded the highest content of chl.$_{a}$, chl.$_{b}$, chl.$_{a+b}$ (0.147, 0.047& 0.194) during the first season and (0.148, 0.051 & 0.199) during the second season, also Giza 111 recorded the highest values of RWC (57.29& 58.79%) in the two seasons respectively, while the lowest values of chlorophyll content and RWC% were recorded by Crawford. Similar results were recorded by Abd El-Mohsen *et al.,* (2013), Ahmed *et al.*, (2007) and Soltan *et al*., (2018) which found that differences in partition and migration of photosynthate between cultivars and the endogenous hormones content.

Table (5): Effect of foliar spray of arginine on chlorophyll content and RWC of studied four soybean cultivars under salinity stress during the two seasons.

Treatments		Chl. $_{a}$ (mg .g fw^{-1})		Chl. $_{b}$ (mg .g fw^{-1})		Chl. $_{a+b}$ (mg .g fw^{-1})		RWC (%)	
		2020	2021	2020	2021	2020	2021	2020	2021
Cultivars (C)									
Crawford		0.086	0.092	0.029	0.033	0.115	0.125	35.62	37.39
Giza 35		0.113	0.120	0.037	0.040	0.150	0.160	41.32	42.76
Giza21		0.135	0.139	0.039	0.044	0.175	0.183	46.87	48.41
Giza 111		0.147	0.148	0.047	0.051	0.194	0.199	57.29	58.79
LSD at 0.05%		0.006	0.003	0.006	0.004	0.011	0.004	0.072	0.033
Arginine treatments (Ar)									
Ar_0		0.113	0.120	0.035	0.039	0.148	0.159	41.68	43.67
Ar_1		0.119	0.124	0.038	0.042	0.158	0.167	46.21	47.39
Ar_2		0.128	0.130	0.041	0.045	0.169	0.175	47.93	49.76
LSD at 0.05%		0.004	0.004	0.004	0.004	0.005	0.006	0.050	0.024
Interactions (CxAr)									
Crawford	Ar_0	0.077	0.087	0.026	0.030	0.103	0.117	32.67	33.20
	Ar_1	0.085	0.090	0.029	0.034	0.114	0.124	35.93	38.43
	Ar_2	0.097	0.100	0.032	0.036	0.129	0.136	38.26	40.56
Giza 35	Ar_0	0.102	0.115	0.034	0.038	0.136	0.153	39.14	40.72
	Ar_1	0.113	0.120	0.037	0.040	0.150	0.160	42.40	43.40
	Ar_2	0.126	0.125	0.040	0.043	0.166	0.168	42.43	44.18
Giza21	Ar_0	0.132	0.135	0.037	0.042	0.169	0.177	44.81	46.43

	Ar_1	0.135	0.140	0.040	0.045	0.175	0.185	47.66	48.82
	Ar_2	0.139	0.142	0.042	0.047	0.181	0.189	48.14	50.00
Giza111	Ar_0	0.143	0.145	0.044	0.047	0.187	0.192	50.13	54.33
	Ar_1	0.146	0.148	0.047	0.052	0.193	0.200	58.85	58.92
	Ar_2	0.152	0.153	0.050	0.054	0.202	0.207	62.89	63.12
LSD at 0.05%		0.008	0.009	0.008	0.009	0.011	0.012	0.100	0.049

Total chlorophyll (chlorophyll $_a$ & chlorophyll $_b$) is an important physiological symptom correlated with photosynthetic efficiency (Kirschbaum, (2011). Chlorophyll content were significantly decreased under salinity stress *via* different ways as stomatal closure, damage of chlorophyll molecules by ROS Kataria *et al.*, (2017). Also, El- Sabagh *et al*., (2015) found that salinity decreased chlorophyll content of soybean and this may be attributed to increasing activity of chlorophyllase enzyme that degrade chlorophyll and cause damage of chloroplast structure. Reduction of chlorophyll content was improved using foliar spraying of arginine at the rate of 300 mg l^{-1} in compassion to the control values. These results were found by Sadak *et al*., (2015) who showed that arginine decreased oxidative damage in photosynthetic apparatus, improved photosynthetic pigments and increased cell chlorophyll content (Hozayn *et al*., 2013).

RWC is an indicator for leaf dehydration Anjum *et al.*, (2011). Salinity decline RWC of soybean cultivars where salts accumulates around the root zone causing reduction in potential of root water, imbalance in osmotic pressure inside plant cells and thus decrease relative water content in leaves Otie *et al*., (2021). Reduction of leaf water content effects on hydrolytic enzymes synthesis that negatively affected on food reserves hydrolysis from storage tissues El-Sabagh *et al.*, (2016).

On the other hand, foliar spraying of arginine especially the highest concentration increased RWC % in leaves of different soybean cultivars in comparison to control (spray with water), this may be attributed to the change in ionic current density through cellular membrane that increase cell osmotic pressure and consequently enhance cell ability to absorb more water and increase relative water content (Winter *et al*., 2015).

Additionally, the effect of the interaction between soybeans cultivars and foliar spraying of arginine, Giza 111 sprayed with arginine at 300 mg l^{-1} (Ar_2) improved chlorophyll content as well as leaf relative water content %.

Antioxidant enzymes and proline

From data in Table (6) it is clear that, Giza 111 gave the highest values of proline as well as CAT and POD activities comparing with other cultivars, these results may be due to the ability of Giza 111 to tolerate salinity stress comparing to other cultivars according to El-Sabagh *et al*., (2015).

Concerning the effect of foliar spraying of arginine on proline content and antioxidant enzymes activities of the four soybean cultivars under salinity stress. The results showed that, foliar spraying of arginine enhance ability of plant to salinity tolerance through increasing proline production as well as increasing activities of CAT and POD enzymes, the highest values of proline and oxidative enzymes were achieved by foliar application of arginine (Ar_2) at rate of 300 mg l^{-1} comparing with control. The same result was obtained by Zeid (2009).

Proline as well as antioxidant enzymes are an important indicator for plant tolerance against salinity stress. Proline has a vital role in biological protection of macromolecules in plant protoplasm, osmotic adjustment and increasing stability of membrane Sadak *et al*., (2020), while, catalase (CAT) and peroxidase (POD) enzymes are antioxidant enzymes that produce by plant under salinity stress to protect cells against oxidative damage via reducing ROS radicals. CAT converts H_2O_2 to water and molecular oxygen that reduce free oxidative radicals (Hasanuzzaman *et al*., 2020).

Table (6): Effect of foliar spray of arginine on proline content and antioxidant enzymes activities on leaves of studied four soybean cultivars under salinity stress in the two seasons.

Treatments		Proline (µmol.g^{-1} fw)		CAT (Δ Abs 564 min^{-1} g^{-1} protein)		POD (Δ Abs 564 min^{-1} g^{-1} protein)	
		2020	2021	2020	2021	2020	2021
Cultivars (C)							
Crawford		13.46	13.71	69.93	71.99	1.63	1.71
Giza 35		15.36	15.84	74.97	76.00	2.37	2.47
Giza21		17.25	17.61	79.25	80.88	2.84	3.03
Giza 111		19.11	19.50	83.93	86.38	3.49	3.52
LSD at 0.05%		0.085	0.204	0.037	0.063	0.007	0.063
Arginine treatments (Ar)							
Ar_0		15.67	16.29	75.75	77.03	2.31	2.44
Ar_1		16.30	16.61	76.92	78.89	2.52	2.69
Ar_2		16.91	17.10	78.39	80.52	2.91	2.91
LSD at 0.05%		0.035	0.170	0.037	0.035	0.007	0.043
Interactions (CxAr)							
Crawford	Ar_0	12.83	13.20	68.76	70.24	1.34	1.46
	Ar_1	13.48	13.62	69.93	72.33	1.56	1.65
	Ar_2	14.09	14.33	71.10	73.42	1.97	2.03
Giza 35	Ar_0	14.75	15.42	73.41	74.33	1.99	2.15
	Ar_1	15.35	15.89	74.60	76.26	2.20	2.52
	Ar_2	15.98	16.23	76.91	77.42	2.92	2.74
Giza21	Ar_0	16.63	17.33	78.07	79.42	2.63	2.86
	Ar_1	17.27	17.58	79.26	80.56	2.84	3.06
	Ar_2	17.87	17.92	80.43	82.67	3.06	3.18
Giza 111	Ar_0	18.50	19.22	82.78	84.13	3.27	3.32
	Ar_1	19.12	19.36	83.90	86.42	3.49	3.56
	Ar_2	19.73	19.92	85.13	88.60	3.71	3.70
LSD at 0.05%		0.070	0.072	0.074	0.070	0.014	0.086

Under salinity ROS production is more than plant ability to remove them that cause oxidative damage. Arginine as an amino acid enhance salt tolerance by increasing POD and CAT activities that decline ROS levels and ameliorate cell oxidative damage (Golezani and Noori, 2011). The accumulation of the proline in plant tissues in response to different abiotic stresses may play an important role against oxidative damages (Alia *et al*., 2001). In regard to the interaction between soybeans cultivars and arginine treatments, Giza 111 treated with arginine at 300 mg l^{-1} (Ar_2) gave the highest values of proline and anti-oxidative enzymes.

NPK and Na% in Leaves:

Data in Table (7) recorded the effect of arginine on N,P and K (%) in leaves of four soybean cultivars under salinity stress.

Giza 21 recorded highest values of N and P in leaves (5.44, 5.52, 0.402 & 0.406%) in the two growing seasons, respectively. This result is in harmony with that indicated by Soltan *et al.*, (2018) and Safina *et al.*, (2018). While, Giza 111 gave the highest values of K (3.04 & 2.97 %) and the lowest values of Na (0.846& 0.863%) as well as K:Na ratio (3.52 & 3.54) in two growing seasons. These results may be due to the Giza 111 was less affected by salinity stress than other cultivars El-Sabagh *et al.*, (2016) and EL-Harty *et al.*, (2010).

Salinity significantly increase the concentration of Na in soybean leaves, while N, P and K contents decrease. These results are in harmony with that recorded by Essa (2002). The decline in N, P and K % in leaves may be due to the impact of salinity on nutrients availability and their translocation through plant, causing excessive concentration of Na^+ and Cl^- ions that led to imbalance nutrients due to the interference of these ions with other elements, reducing water absorption and nutrients mobility to root cells as well as reducing their translocation from roots to shoots (Golezani *et al.*, 2011). On the other hand salinity increase Na ions concentration in root zone and enhance its absorption by plant as a result of osmotic pressure Ramana *et al*., (2012).

It is clear that arginine had a positive effect on NPK % in leaves and the highest values of N, P and K as well as reduction of Na^+ were recorded by foliar spraying of arginine (Ar_2) at 300 mgl^{-1}. Arginine foliar spraying ameliorate salinity effect *via* promoting N, P and K accumulation in levels and decline Na^+ ions content, which constrains its excessive accumulation in plant cytosol and maintain ion balance Sadak *et al*., (2015).

The interaction between soybeans cultivars and foliar spraying of arginine, the results showed that, Giza 111 sprayed with arginine at 300 mg l^{-1} (Ar_2) increased nutrients K concentration in leaves, decline Na content as well as K: Na ratio. While, the highest percentage of N and P recorded by Giza 21 sprayed with arginine at 300 mg l^{-1} (Ar_2).

Table (7): Effect of foliar spray of arginine on nutrients concentration on leaves of studied four soybean cultivars under salinity stress in the two seasons.

Treatments		N (%)		P (%)		K (%)		Na (%)		K:Na ratio	
		2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Cultivars (C)											
Crawford		5.31	5.36	0.364	0.366	2.16	2.26	1.203	1.22	1.80	1.85
Giza 35		5.39	5.46	0.380	0.382	2.61	2.64	1.103	1.16	2.37	2.27
Giza21		5.44	5.52	0.402	0.406	2.80	2.83	0.990	1.03	2.83	2.73
Giza 111		5.28	5.32	0.344	0.345	2.97	3.04	0.846	0.863	3.52	3.54
LSD at 0.05%		0.009	0.033	0.003	0.005	0.046	0.028	0.038	0.009	0.100	0.051
Arginine treatments (Ar)											
Ar_0		5.32	5.38	0.365	0.366	2.57	2.63	1.07	1.10	2.47	2.45
Ar_1		5.36	5.42	0.373	0.376	2.64	2.69	1.03	1.07	2.63	2.59
Ar_2		5.39	5.45	0.380	0.381	2.69	2.75	1.00	1.03	2.80	2.75
LSD at 0.05%		0.048	0.049	0.005	0.004	0.049	0.045	0.049	0.053	0.125	0.142
Interactions (CxAr)											
Crawford	Ar_0	5.28	5.32	0.357	0.356	2.11	2.21	1.23	1.25	1.71	1.77
	Ar_1	5.32	5.37	0.366	0.369	2.19	2.27	1.20	1.22	1.82	1.86
	Ar_2	5.35	5.40	0.371	0.373	2.20	2.30	1.18	1.20	1.87	1.91

Giza 35	Ar_0	5.37	5.42	0.370	0.371	2.57	2.62	1.14	1.20	2.25	2.18
	Ar_1	5.40	5.47	0.383	0.385	2.62	2.60	1.11	1.17	2.36	2.22
	Ar_2	5.42	5.50	0.389	0.390	2.66	2.70	1.06	1.12	2.51	2.41
Giza21	Ar_0	5.40	5.48	0.395	0.400	2.72	2.75	1.02	1.07	2.66	2.57
	Ar_1	5.45	5.52	0.402	0.408	2.80	2.84	0.99	1.04	2.83	2.73
	Ar_2	5.48	5.56	0.389	0.412	2.88	2.90	0.96	1.00	3.00	2.89
Giza 111	Ar_0	5.25	5.0	0.338	0.340	2.88	2.94	0.89	0.90	3.24	2.27
	Ar_1	5.28	5.32	0.344	0.344	2.98	3.08	0.85	0.87	3.51	3.54
	Ar_2	5.31	5.35	0.351	0.352	3.05	3.12	0.80	0.82	3.82	3.81
LSD at 0.05%		0.097	0.099	0.153	0.008	0.099	0.090	0.099	0.106	0.251	0.285

NPK and Na% in Seeds.

Impact of foliar spraying of arginine on seed nutrients (N, P, K and Na %) of different soybean cultivars under salinity stress was tabulated in Table (8). The results showed that, Giza 21 gave the highest values of N (5.42 &5.48 %) and P (0.362 &0.364%) during the two studied seasons, respectively. The same result was obtained by Morsy *et al.*, (2016) and Safina *et al*., (2018) who concluded that soybean varieties are genetically differentiated and Giza 21 cultivar is a good source of important minerals for human diet and could be used as nutes. On the other hand, Giza 111 gave the highest values of K % in seeds as well as K: Na ratio, but it achieved the lowest value of N, P and Na content, this result is in harmony with that obtained by Safina *et al*., (2018) and Soltan *et al.,* (2018). Also, Crawford cultivar recorded the highest Na content in seeds, these results are in harmony with El-Sabagh *et al.*, (2015).

Table (8): Effect of foliar spraying of arginine on NPK and Na % of studied four soybean cultivars under salinity stress in the two respective seasons.

Treatments		N (%)		P (%)		K (%)		Na (%)		K:Na	
		2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Cultivars (C)											
Crawford		5.29	5.35	0.328	0.330	2.08	2.09	0.993	1.00	2.09	2.08
Giza 35		5.37	5.44	0.344	0.347	2.21	2.24	0.890	0.894	2.49	2.50
Giza21		5.42	5.48	0.362	0.364	2.38	2.39	0.776	0.780	3.09	3.08
Giza 111		5.25	5.27	0.308	0.314	2.55	2.57	0.670	0.673	3.84	3.82
LSD at 0.05%		0.033	0.054	0.017	0.003	0.066	0.033	0.038	0.023	0.175	0.048
Arginine treatments (Ar)											
Ar_0		5.30	5.35	0.330	0.334	2.25	2.28	0.870	0.876	2.67	2.68
Ar_1		5.34	5.38	0.335	0.339	2.31	2.33	0.830	0.837	2.88	2.88
Ar_2		5.36	5.42	0.341	0.343	2.35	2.36	0.797	0.802	3.08	3.05
LSD at 0.05%		0.049	0.043	0.077	0.004	0.035	0.049	0.049	0.009	0.205	0.070
Interactions (CxAr)											
Crawford	Ar_0	5.26	5.30	0.324	0.326	2.03	2.05	1.02	1.036	1.99	1.97
	Ar_1	5.30	5.35	0.329	0.330	2.07	2.10	0.990	1.011	2.09	2.07
	Ar_2	5.33	5.40	0.333	0.335	2.14	2.14	0.970	0.974	2.21	2.19
Giza 35	Ar_0	5.35	5.42	0.339	0.344	2.18	2.20	0.930	0.935	2.41	2.35

	Ar_1	5.38	5.44	0.344	0.348	2.21	2.25	0.880	0.884	2.48	2.54
	Ar_2	5.40	5.47	0.349	0.350	2.24	2.27	0.860	0.863	2.58	2.63
Giza21	Ar_0	5.38	5.45	0.356	0.358	2.31	2.35	0.792	0.823	2.82	2.85
	Ar_1	5.43	5.48	0.362	0.364	2.39	2.40	0.780	0.784	3.06	3.06
	Ar_2	5.46	5.52	0.370	0.370	2.46	2.44	0.730	0.733	3.38	3.32
Giza 111	Ar_0	5.23	5.24	0.302	0.310	2.50	2.53	0.710	0.710	3.52	3.56
	Ar_1	5.26	5.28	0.308	0.315	2.56	2.58	0.670	0.672	3.83	3.83
	Ar_2	5.28	5.30	0.315	0.318	2.61	2.60	0.630	0.638	4.15	4.07
LSD at 0.05%		0.099	0.086	0.014	0.009	0.076	0.099	0.099	0.018	0.382	0.140

Salinity caused a significant decline in N, P and K content. The reduction in N content may be attributed to the interference between NO^{3-} and Cl^-. While, phosphorus content decrease as a result of reduction in phosphate availability and this due to the low solubility of Ca and P minerals Bakhoum *et al*., (2019). On the other hand, increasing of Na^+ ions as a result of salinity interfere with K^+ ion at root zone that effect on integrity of root membrane and alter elemental selectivity Sadak *et al*., (2015). Foliar spraying of arginine (Ar_2) at 300 mgl^{-1} had a significant increasing effect of N (5.36&5.42%), P (0.362&0.364%) and K (2.35&2.36%) as well as K: Na ratio (3.08&3.05) and caused the lowest values of Na (0.797&0.802%). This result may be related to that all arginine products polyamines *i.e.* putrescine, spermine and spermidin have a vital role in cation-anion balance in plant via stabilizing membrane under salinity (Hozayn *et al*., (2013). Salt stress disturbs intracellular ion homeostasis of plants, which leads to growth inhibition Very *et al*., (1998). Arginine treatments caused significant increases in N, P, and K content in soybean plants under salinity. The interaction between soybean cultivars and foliar spraying of arginine, the results showed that, Giza 111 treated with arginine at 300 mg l^{-1} recorded the highest values of P, K % and K:Na ratio and the lowest values of Na %.

Despite, Giza 111 recorded the lowest percentage of N and P, but it recorded the highest values of NPK uptake, where N (92.44&93.71), P (5.82&5.94) and K (40.68&40.68) as shown in Table 9 . While, Crawford recoded the highest values of Na uptake (13.61&43.85). On the other hand, Arginine treatments at 300 mgl^{-1} (Ar_2) recorded the highest values of NPK uptake during the two studied seasons. The interaction between soybean cultivars and foliar spraying of arginine shown in Figs. (1,2,3&4). The results showed that, Giza 21 treated with arginine at 300 mg l^{-1} achieved the highest uptake of P .

Table (9): Effect of foliar spraying of arginine on N P K and Na uptake (Kg fad.-1) of studied four soybean cultivars under salinity stress in the two respective seasons.

Treatments	Nutrients uptake (Kg fad^{-1})							
	N		P		K		Na	
	2020	2021	2020	2021	2020	2021	2020	2021
Cultivars (C)								

Crawford	**72.63**	**73.61**	**4.50**	**4.54**	**28.52**	**28.84**	**13.61**	**13.85**
Giza 35	**75.36**	**76.57**	**4.81**	**4.89**	**30.98**	**30.98**	**13.23**	**13.32**
Giza21	**92.44**	**93.71**	**5.82**	**5.94**	**40.68**	**40.68**	**12.65**	**12.74**
Giza 111	**99.65**	**99.78**	**6.17**	**6.21**	**48.31**	**48.31**	**12.46**	**12.57**
LSD at 0.05%	**0.076**	**0.054**	**0.054**	**0.057**	**0.083**	**0.066**	**0.153**	**0.066**
Arginine treatments (Ar)								
Ar_0	**84.35**	**84.85**	**5.20**	**5.29**	**36.00**	**36.10**	**13.50**	**13.64**
Ar_1	**85.02**	**85.98**	**5.32**	**5.40**	**37.22**	**37.36**	**12.96**	**13.12**
Ar_2	**85.69**	**86.92**	**5.46**	**5.50**	**38.15**	**38.16**	**12.50**	**12.60**
LSD at 0.05%	**0.070**	**0.043**	**0.043**	**0.048**	**0.099**	**0.099**	**0.070**	**0.099**

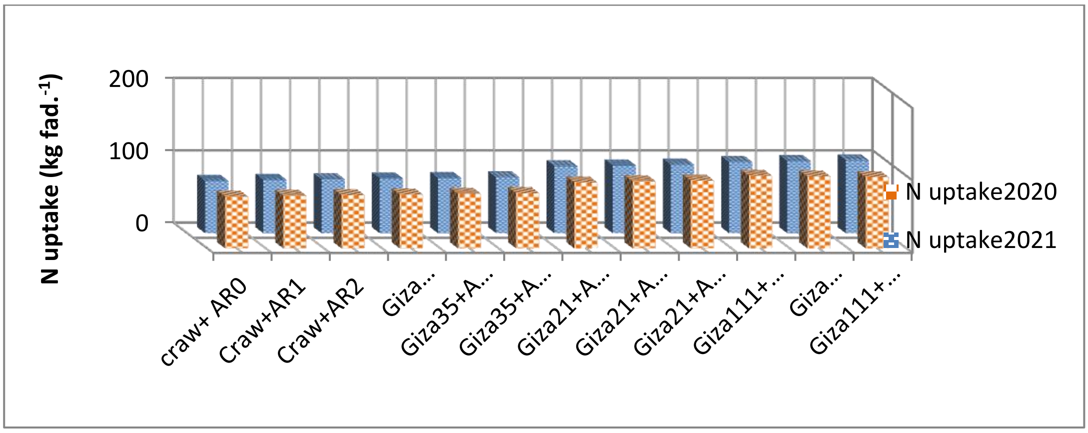

Fig. (1): Interaction effect of arginine foliar rates and different soybean cultivar on seed N uptake (Kg fad^{-1}) under salinity stress in two seasons.

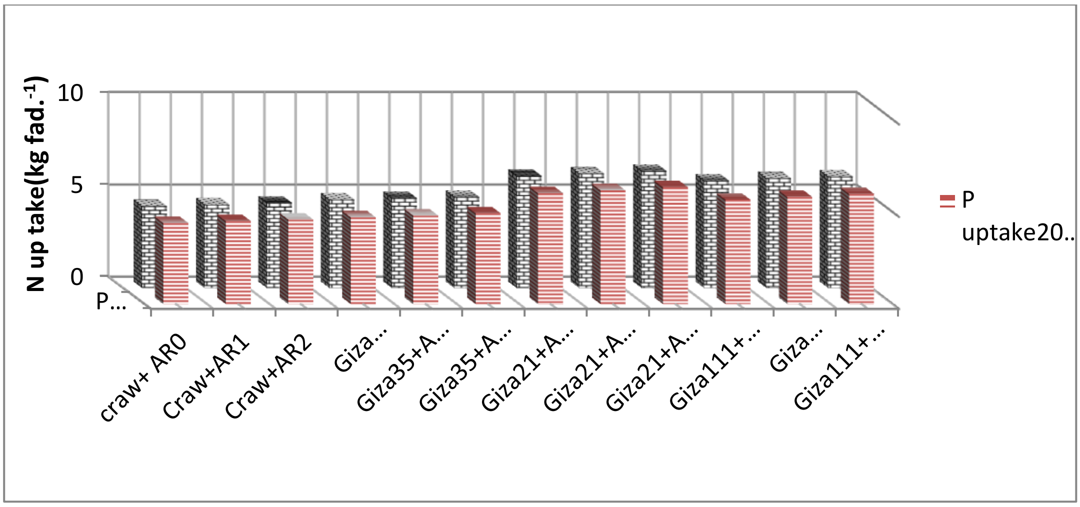

Fig. (2): Interaction effect of arginine foliar rates and different soybean cultivar on seed P uptake (Kg fad^{-1}) under salinity stress in two seasons.

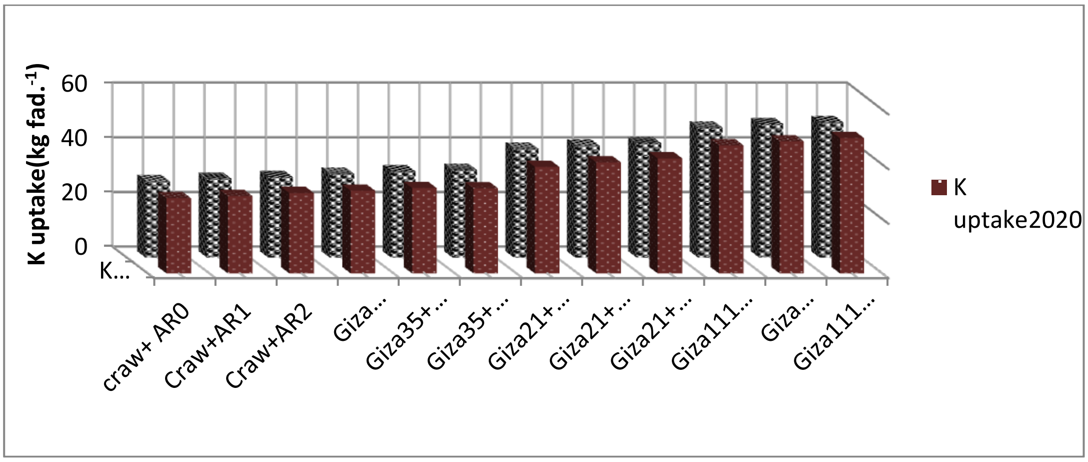

Fig. (3): Interaction effect of arginine foliar rates and different soybean cultivar on seed K uptake (Kg fad^{-1}) under salinity stress in two seasons.

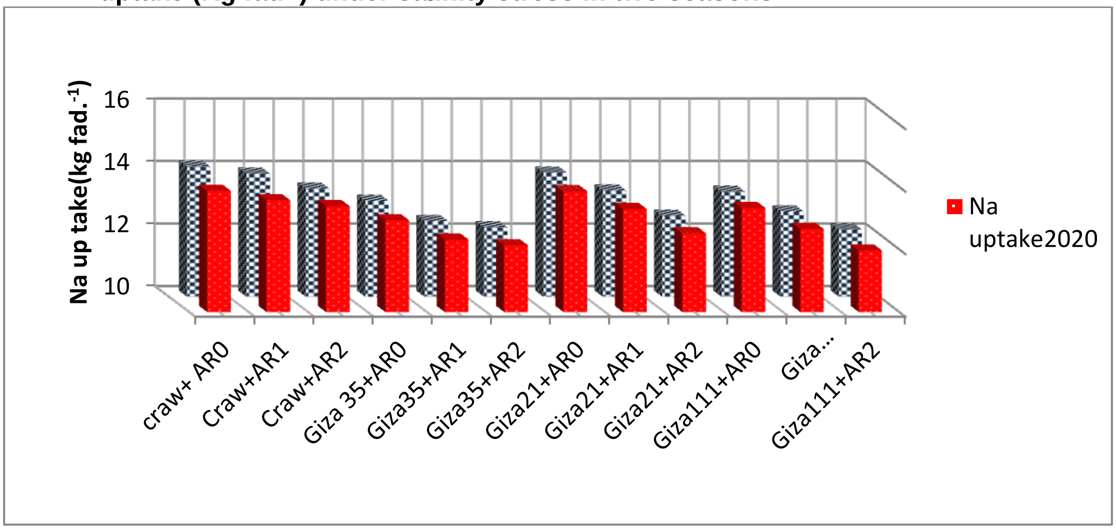

Fig. (4): Interaction effect of arginine foliar rates and different soybean cultivar on seed Na uptake (Kg fad^{-1}) under salinity stress.

Seed protein, carbohydrates and oil %

With respect to seed quality, the data in Table (10) revealed that protein, carbohydrates and oil % have significant response in all cultivars of soybean in the two seasons. Data showed that Giza 111 recorded the highest percentage of seed oil (20.88 & 21.06 %) and carbohydrates (35.65 & 35.67 %) in the two seasons, respectively. Similar results were obtained by El-Sabagh *et al*., (2016) which found that Giza 111 is the least sensitive cultivar to salinity. On the other hand, the highest values of protein (33.89 and 34.43%) was obtained by Giza 21 and the lowest one (32.85 and 32.95%) was achieved by Giza 111 These results are in line with Morsy *et al*., (2016) and Soltan *et al*., (2018).

Data in Table (10) recorded a significant effect of arginine foliar spraying treatments on protein, carbohydrates and oil % of different soybean cultivars under salinity stress. The highest values were achieved with foliar spraying of arginine (Ar_2) 300 mg l^{-1}. These results are in the same line with Hozayn *et al.,* (2013) and Minocha *et al*., (2014).

Ghassemi *et al.*, (2011) found that, salinity decline protein, carbohydrates and oil content, this reduction may be due to inhibition of nitrogen absorption, negative effect of salinity on nitrogen metabolism in plant, weakening of protein-pigment-lipid complex and inhibition of enzymes activity.

Arginine play a vital role in promoting physiological process in plant *via* Promoting chlorophyll production, stimulating enzymes activities, building protein and carbohydrates as well as formation polyamines (the end product of arginine) that stimulate plant growth, yield and protect plant against salinity stress (Winter *et al.*, 2015).

Concerning the interaction between soybeans cultivars and arginine the results showed that, Giza 21 treated with arginine at 300 mg l^{-1} (Ar_2) recorded the highest values of protein while, the highest values of carbohydrates and oil % were recorded by Giza 111 sprayed with arginine at 300 mg l^{-1} (Ar_2) during the two seasons.

Table (10): Effect of arginine foliar application rates on protein, carbohydrates and oil content on seeds of different soybean cultivars under salinity stress in the two seasons.

Treatments		Protein (%)		Carbohydrates (%)		Oil (%)	
		2020	2021	2020	2021	2020	2021
Cultivars (C)							
Crawford		33.10	34.27	33.44	33.61	19.21	19.32
Giza 35		33.60	33.02	34.27	34.37	19.95	20.02
Giza21		33.89	34.43	34.96	35.11	20.41	20.54
Giza 111		32.85	32.95	35.65	35.67	20.88	21.06
LSD at 0.05%		0.208	0.339	0.052	0.057	0.131	0.038
Arginine treatments(Ar)							
Ar_0		33.15	33.45	34.31	34.41	19.75	19.95
Ar_1		33.39	33.67	34.62	34.77	20.24	20.31
Ar_2		33.54	33.89	34.81	34.90	20.35	20.45
LSD at 0.05%		0.312	0.270	0.040	0.042	0.092	0.049
Interactions (CxAr)							
Crawford	Ar_0	32.87	33.12	33.18	33.32	18.36	18.76
	Ar_1	33.12	33.43	33.46	33.73	19.65	19.52
	Ar_2	33.31	33.75	33.70	33.80	19.64	19.70
Giza 35	Ar_0	33.43	33.87	33.96	34.06	19.77	19.82
	Ar_1	33.62	34.00	34.42	34.50	19.94	20.06
	Ar_2	33.75	34.18	34.44	34.55	20.15	20.20
Giza21	Ar_0	33.62	34.06	34.71	34.86	20.25	20.36
	Ar_1	33.93	34.25	34.97	35.14	20.48	20.57
	Ar_2	34.12	34.50	35.21	35.33	20.52	20.70
Giza 111	Ar_0	32.68	32.75	35.42	35.40	20.64	20.86
	Ar_1	32.87	33.00	35.65	35.71	20.91	21.12
	Ar_2	33.00	33.12	35.90	35.92	21.10	21.20
LSD at 0.05%		0.624	0.540	0.080	0.084	0.185	0.099

Conclusion

This study recorded that the foliar spraying of arginine at 300 mg l^{-1} with

Giza111 was the most effective treatment to enhance vegetative growth, chlorophyll content, leaf relative water content, proline content and the activities of antioxidant enzymes (CAT and POD) as well as improve seed yield, seed content of oil and carbohydrates under salinity stress. Therefore, we can concluded that the foliar spraying of arginine at 300 mg l^{-1} had a beneficial role in ameliorating the adverse effect of salinity stress on physiological and yield of soybean cultivars especially Giza 111 cultivar.

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التخفيف من الآثار السلبية لإجهاد الملوحة في أصناف فول الصويا عن طريق الرش الورقي بالأرجينين

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الملخص العربى

أجريت هذه الدراسة بالمزرعة التجريبية بمحطة بحوث تاج العز الزراعية ،مركز البحوث الزراعية بمحافظة الدقهلية ، لدراسة تأثير الرش الورقي بالأرجينين على أربعة أصناف من فول الصويا تحت اجهاد الملوحة. نفذت هذه التجربة بتصميم القطع المنشقة بثلاث مكررات خلال موسمي الصيف المتتاليين 2020 و 2021. احتوت القطع الرئيسية على أربعة أصناف من فول الصويا وهى جيزة 111 ، وجيزة 21 ، وجيزة 35 ، وكروفورد ، بينما احتوت القطع المنشقة على ثلاث معاملات للرش الورقى بالأرجينين. الكنترول ، رش بالأرجينين بمعدل 200 و 300 مجم لتر −1، و أظهرت النتائج المتحصل عليها أن:

- الأصناف أظهرت تبايناً واسعاً في حساسيتها للملوحة حيث أعطت جيزة 111 أعلى قيم لمعظم معاملات النمو الخضرى مثل محتوى الكلوروفيل ، محتوى الماء النسبى بالاوراق ، محتوى المغذيات المختلفة ، محتوى الحمض الأمينى البرولين وكذلك أنشطة إنزيمات الكاتلاز والبيروكسيديز ، وبالتالي زيادة محصول البذور ومحتوى البذور من البروتين والكربوهيدرات ونسبة الزيت.

- فيما يتعلق بالرش الورقي بالحمض الامينى الأرجينين للتقليل من اثار اجهاد ملوحة التربية على نمو ومحصول أصناف فول الصويا تحت الدراسة ، تم تحقيق أعلى قيم لمعظم صفات النمو الخضري والفسيولوجى المدروسة ، ومكونات المحصول والمحصول عن طريق الرش الورقي للأرجينين عند 300 مجم لتر -1. كما أظهر التفاعل بين أصناف فول الصويا والرش الورقي للأرجينين أن صنف جيزة 111 المعاملة بالأرجينين عند 300 مجم لتر -1 أعطت أعلى قيم للنمو والحاصل ومكوناته.

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