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Spraying Maize with Salicylic and Ascorbic Acids to Improve Physiological Traits and Productivity Under Water Stress Conditions

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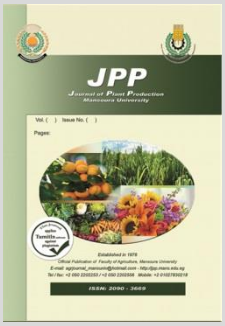

ABSTRACT

A field trial was performed at El-Gemmeiza Agricultural Research Station El-Gharbia Governorate, Egypt, which is situated between Latitude 30° 58′ 56″ N and Longitude 30° 57′ 8″ E during the two successive summer seasons of 2020 and 2021 to examine how salicylic (SA) and ascorbic (AA) antioxidants could mitigate the negative influences of water stress and their effects on physiological traits and yield of maize plants (Single Cross 168).Irrigation treatments were applied at 50, 65 and 80 % of available soil moisture depletion (AVSMD) and foliar spraying with SA and AA at the concentration of 100 or 200 ppm.Increasing soil moisture depletion up to 80 % of AVSMD, diminished significantly shoot dry weight plant^{-1}, plant height, leaf area index, leaf area duration, chlorophyll (chl.) a and b, leaf relative water content (LRWC), ear length, No. of grains row^{-1},100- grain weight and grain yield. Whereas, osmotic potential (OP) and chl. a/b increased significantly. Irrigation at 65 % of AVSMD significantly increased water use efficiency (WUE), chl. a and b compared to other irrigation levels. The foliar spraying of SA or AA (200 ppm) significantly increased most of the studied traits compared to untreated plants, except for OP and Chl. a/b which were significantly reduced by SA foliar spraying at 200ppm. It can be concluded that irrigation of maize plants at 65 % of AVSMD with foliar spraying with 200 ppm SA or AA activate maize plant´s growth and improved WUE also enhancing biosynthesis of photosynthetic pigments and then improving yield.

Keywords: *Zea Mays L, water stress, salicylic, ascorbic acids*

INTRODUCTION

Maize is one of three important major crops i.e. maize, wheat, and rice (FAO, 2019), and it is also an essential grain crop in Egypt, with approximately 2.7 million feddan dedicated to maize cultivation. Maize productivity increased from 1.5 tons /fed in 1988 to 3.3 tons /fed in the 2020 growing season. However, its production is limited by water shortage (Zhou *et al*., 2017), which can cause to yield decreases of 25-30%. (Ben-Ari *et al*., 2016).

There is no doubt that the problem of water scarcity has faced many countries in the world, especially Egypt after the construction of the Ethiopian dam. Water deficit has negative effects on some important physiological and biochemical processes. on plants and related factors, involving osmotic effects, reduced membrane integrity, photosynthetic activity, pigment content, transpiration rate, net assimilation rate, dry matter partitioning and stomatal conductance, etc (Li *et al*., 2019a and 2019b; Fracasso *et al*., 2016 and Song *et al*., 2018). These limitations directly inhibit plant growth and yields (Berger *et al*., 2016 and Jin *et al*., 2017).

Drought stress increased the formation of radical oxygen species (ROS) as a result of reduced light absorption and photosynthetic electron transport, which caused photooxidative deterioration to photosystems. (Yudina *et al*., 2020). Because of these damages, photosynthetic activity decreases and peroxidation in the cell membrane increases. At the same time plants have an antioxidant defense system and improved synthesis of antioxidants such as the ascorbate peroxidase, peroxidase, superoxide dismutase and catalase helps in inhibition of ROS created during drought stress (Hussain *et al.*, 2020 and Sohag *et al.*, 2020)

In previous studies Abu-Grab *et al.* (2019) on maize plants cleared that, irrigation at a rate of 50 % (AVSMD) increased leaf area index, crop growth rate, chlorophyll content, dry matter, relative water content, yield and yield component compared with irrigation at 80 % of AVSMD. Also, Kotb *et al.* (2021) noticed that reducing irrigation water from 3750 to 2250 m^3 fad^{-1}., significantly reduced leaf relative water content, total chlorophyll, 100-grain weight, and grain yield fad^{-1}, however significantly improved irrigation water use efficiency. Many reports cleared that the use of sufficient water irrigation every 8 days encouraged maize growth and productivity. (Ghazi and El-Sherpiny, 2021), 10 days (Abo El-Ezz and Haffez, 2019 and Gomaa *et al.*, 2021), 12 days (Ali and Abdelaal, 2020) and 14 days (Solieman *et al.*, 2019) as compared with prolonging irrigation intervals more than those periods.

Exogenous uses of plant growth regulators such as salicylic acid (SA) and ascorbic acid (AA) can play a significant role in increasing drought tolerance at different stages of plant growth. Salicylic acid, as a natural growth hormone, acts as a potential non-enzymatic antioxidant (Aldesuquy and Ghanem, 2015), regulating many biochemical processes in plants such as stomatal closure, ion uptake, and transpiration (Khan *et al.*, 2012), triggering chlorophyll biosynthesis and increasing photosynthesis and photosynthetic rate (Chattha *et al.*, 2015), also water uptake and ion transport, transpiration, and photosynthesis (Klessig *et al.*, 2018).

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Ascorbic acid, also known as vitamin C, is an essential antioxidant that regulates numerous plant biological processes such as cell division and differentiation, photosynthesis, respiration, and other metabolic activities where it controls the accumulation of ROS. (Moori and Eisvand, 2017 and Mittal *et al*., 2018). It has been observed that SA and AA mitigate the effects of water shortage. (El-Shafey, 2017).

The purpose of the present experiment was to evaluate the ability of SA and AA to mitigate the negative effects of water shortage and their impacts on the physiological and productivity traits of maize crop.

MATERIALS AND METHODS

A field trial was performed at El-Gemmeiza Agricultural Research Station El- Gharbia Governorate, Egypt, which is situated between Latitude 30° 58′ 56″ N Longitude 30° 57′ 8″ E during the two successive summer seasons of 2020 and 2021 to study the alleviation of the adverse effects of water stress by using some antioxidant materials on maize plants (Single Cross, 168 "SC 168"). The experimental unit area was 21 m^2 (4.2 × 5 m). Seeds of the tested maize experimental were provided by Maize Department, Field Crops Research Institute, Agriculture Research Center, Egypt. SC 168 was mechanically sown on the 26th and 29nd May in the first and second seasons respectively, as recommended for maize in the area. The soil of the experimental sites was silt clay loam in structure with pH value 7.81, organic matter 1.73 % and containing 32.7 ppm nitrogen, phosphor 8.3 ppm and potassium 380 ppm. The trial was implemented in a strip plot design with four replications, using irrigation treatments in the main plots and foliar spraying of SA and AA treatments in the sub plots., which sprayed twice after 30 and 45 days from planting. The treatments were as follows:

I - Main Plots (Irrigation Treatments)

A- Irrigation at 50 % of available soil moisture depletion (AVSMD) (I_1).

B- Irrigation at 65 % of AVSMD (I_2).

C- Irrigation at 80 % of AVSMD (I_3).

II -Sub-plots (Foliar Spray of Salicylic and Ascorbic Acids)

1-Spraying water (control) (T_1)

2-Spraying 100 ppm salicylic acid (SA) (T_2)

3-Spraying 200 ppm salicylic acid (SA) (T_3)

4-Spraying 100 ppm ascorbic acid (AA) (T_4)

5-Spraying 200 ppm ascorbic acid (AA) (T_5)

Meteorological tables are important in cases of water stress for different crops due to their close relationship with the processes of transpiration and evaporation from the soil surface (Table, 1).

Table 1. Meteorological data in 2020 and 2021 growing season Month for El-Gharbia Governorate.*

Month	T - Max		T - Min		T- mean		Relative Humidity (%)	
	2020	2021	2020	2021	2020	2021	2020	2021
June	36.53	36.89	19.11	19.48	27.82	28.19	41.50	41.40
July	38.81	39.02	21.58	22.47	30.20	30.75	42.90	41.50
August	38.89	39.45	22.00	22.95	30.45	31.20	45.33	43.13
September	38.17	35.75	21.85	20.96	30.01	28.36	50.60	51.61

***Source: Water Requirement and Field irrigation Res., Dept.**

It should be noted that the water table measurements were 135 and 142 cm in 1st and 2nd seasons, respectively.

Growth and physiological traits:

Shoot dry weight (g. plant^{-1}):

At 80 days after sowing (DAS), five plants were selected at random from the two outer rows on either side of each plot and separated into their components, namely leaves, stems and ears, before being dried at 70 °C in a ventilated oven until constant weight to calculate the dry weight of the plant.

Leaf area index (LAI):

At 60 and 80 days after sowing (DAS) leaf area per plant was determined as follows: Individual leaf area= Leaf length × Leaf width × 0.73 (McKee, 1964).

LAI= leaf area per plant divided by ground area occupied by plant.

Leaf area duration (LAD; day):

From 60-80 DAS Leaf area duration was estimated by the formula given by Hunt (1978). $LAD = (LAI_1 + LAI_2) \times (t_2-t_1) \times 0.5$

Chlorophyll content of leaves

At 80 days after sowing, the fresh leaves content of Chlorophyll a and b (as mg/g fresh weight) was measured and calculated according to Moran. (1982).

Water Relation:

Leaf Relative water content (LRWC; %)

LRWC (%) was determined according to Salgado-Aguilar *et al*. (2020) as follows:

$$LRWC\ \% = (Fw- Dw) / (Tw- Dw) \times 100$$

Where

Fw, Dw and Tw are fresh weight, dry weight and turgid weight, respectively.

Osmotic potential (OP; bar) according to Gusev (1960) "OP" was estimated.

Water consumptive use (WCU):

Soil moisture was measured by taking soil samples at sowing time, just before irrigation, 48 hours after irrigation, and harvesting time using a regular auger. Duplicate soil representative samples were collected from depths of 0-20, 20-40, and 40-60 cm, and their moisture content was determined gravimetrically and presented in Table 2.

Table 2. Permanent wilting point, field capacity, bulk density and available moisture were determined for the experimental sit.

Soil layer depth (cm)	FC (w/w,%)		Wp (w/w,%)		Aw (%)		Bd (g.cm^{-3})	
	2020	2021	2020	2021	2020	2021	2020	2021
00 - 20	41.63	42.50	21.41	23.71	20.22	18.79	1.16	1.20
20 - 40	35.21	38.45	16.55	21.20	18.66	17.25	1.21	1.25
40 - 60	28.57	32.20	13.85	15.63	14.72	16.57	1.27	1.32

FC= Field capacity, Wp = water point, Aw = available water and Bd = bulk density.

According to Israelson and Hansen (1962), water consumptive use (WCU) was calculated by the following equation: $WCU (mm) = \theta_2 - \theta_1 / 100 \times BD \times D$

Where, θ_1 and θ_2 are soil moisture (%) by weight just before and 48 hr after each irrigation, BD is the soil bulk density and D is the effective root zone, (600 mm).

Plastic tubes perforated were put in the soil at a depth of 1.5 meters by auger for one replicate to ensure that water table measurements have not participated in water consumed by maize plants.

Water use efficiency (WUE):s

According to Vites (1965), water use efficiency was calculated for each treatment as equation follows:

$$WUE = \text{grain yield (kg fad}^{-1}\text{) / seasonal water consumption in } m^3 \text{ fad}^{-1}.$$

Days to tassling (DTT) and Days to silking (DTS):

In the first and second seasons, harvesting took place on 2/10/2020 and 7/10/2021, respectively. Five individual guarded plants were chosen at random from one row in each subplot at harvest time to determine:

Plant height (cm), Ear height on plant (cm), Ear length (cm), Number of rows /ear (mean of 10 cops per plot), Number of kernel row^{-1}, (mean of 10 cops per plot), 100-kernel weight (g) and Grain yield (GY) ard.fed^{-1}, was calculated from two ridge plants in each sub-plot.

According to Snedecor and Cochran (1980) data were statistically analyzed and treatment means were compared using the least significant difference test (LSD) at the 0.01 and 0.05 level of probability. Treatment means were compared by Duncan's multiple range test (Duncan's, 1955). The Bartlett test was used to evaluate the homogeneity of error variances, as described by Bartlett (1937). Because the test was not significant for all assessed traits, the results from the two seasons were combined. The findings were discussed based on of a combined analysis of the two seasons.

RESULTS AND DISCUSSIONS

Growth and growth analysis:

Data in Tables 3 & 4 showed the effect of water shortage and foliar spraying of SA or AS on shoot dry weight plant^{-1}, plant height, ear height plant^{-1} at 80 DAS, leaf area index at 60, 80 DAS and leaf area duration (60-80 DAS). Results of Tables 3 & 4 revealed that moisture stress had a significant impact on all growth parameters studied.

The maximum values of shoot dry weight plant^{-1} at 80 DAS, ear height as well as leaf area index at 60 and 80 DAS, leaf area duration (60-80 DAS), were achieved when maize plants irrigated at 50% of AVSMD followed by irrigated at 65 % of AVSMD with significant difference between such two treatments however, there was no significant difference among them in plant height. While, the lowest values in all mentioned traits were recorded for irrigation at 80 % of AVSMD treatment.

Table 3. Shoot dry weight, Plant height and Ear height of maize SC 168 as affected by water stress and foliar spraying of salicylic and ascorbic acids in 2020 and 2021 summer seasons.

Treatments		Shoot dry weight/plant (g) (80 DAS)			Plant height (cm)			Ear height (cm)		
		2020	2021	Comb.	2020	2021	Comb.	2020	2021	Comb.
Irrigation level										
I1		316.6 a	344.9 a	330.7 a	240.6 a	248.2 a	244.4 a	137.1 a	146.2 a	141.6 a
I2		289.9 b	326.3 a	308.1 b	233.0 a	241.2 a	237.1 a	131.1 a	138.8 b	134.9 b
I3		221.9 c	238.6 b	230.3 c	191.5 b	198.0 b	194.7 b	117.4 b	121.8 c	119.6 c
F. test		**	**	**	*	**	**	**	*	*
Foliar spraying of salicylic and ascorbic acids										
T1		249.2 d	274.0 c	261.6 d	214.4 b	223.5 b	219.0 c	123.5 c	131.7 b	127.6 c
T2		277.7 bc	306.3 b	292.0 bc	222.8 ab	229.0 ab	225.9 b	129.8 ab	136.1 ab	133.0 ab
T3		303.7 a	332.0 a	317.9 a	230.0 a	236.4 a	233.2 a	132.9 a	140.3 a	136.6 a
T4		265.0 cd	297.2 b	281.1 c	217.7 b	226.6 ab	222.1 bc	126.4 bc	133.4 ab	129.9 bc
T5		285.0 b	306.9 b	296.0 b	223.5 ab	230.1 ab	226.8 a	130.0 ab	136.3 ab	133.2 ab
F. test		**	*	**	*	*	*	*	*	*
Interaction										
I1	T1	292.6	324.7 bcd	308.7 de	237.0	245.5	241.3	134.0	143.8	138.9
	T2	314.6	340.5 abc	327.6 bcd	242.0	249.5	245.8	137.5	146.5	142.0
	T3	340.1	367.2 a	353.6 a	243.5	251.5	247.5	140.3	149.3	144.8
	T4	306.1	334.9 abc	320.5 cde	238.0	247.5	242.8	135.8	144.8	140.3
	T5	329.4	357.3 ab	343.3 ab	242.5	247.0	244.8	138.0	146.5	142.3
I2	T1	270.1	294.0 de	282.0 f	226.0	236.3	231.1	126.5	134.5	130.5
	T2	296.0	339.4 abc	317.7 de	234.0	241.0	237.5	131.3	138.5	134.9
	T3	321.2	362.5 a	341.9 abc	238.5	250.0	244.3	135.0	145.0	140.0
	T4	274.8	322.3 cd	298.5 ef	230.0	236.5	233.3	129.3	136.0	132.6
	T5	287.3	313.3 cd	300.3 ef	236.3	242.3	239.3	133.5	139.8	136.6
I3	T1	184.9	203.4 g	194.2 i	180.3	188.8	184.5	110.0	116.8	113.4
	T2	222.4	238.8 f	230.6 h	192.5	196.5	194.5	120.8	123.3	122.0
	T3	249.9	266.5 ef	258.2 g	208.0	207.8	207.9	123.5	126.5	125.0
	T4	214.0	234.3 fg	224.2 h	185.0	195.8	190.4	114.3	119.5	116.9
	T5	238.4	250.0 f	244.2 gh	191.8	201.0	196.4	118.5	122.8	120.6
F. test		NS	*	*	NS	NS	NS	NS	NS	NS

***.** indicate significant at 0.05 and 0.01 levels of probability, respectively.**

It could be pronounced that increasing the amount of water applied to maize plants allowed the soil to hold more moisture, which improved plant metabolism, increased plant development and greater dry matter production then plant height was lowered as a result of soil moisture depletion this could be attributed to the fact that water stress produced short plants. The current study is in full harmony with the results of Abo-Marzoka *et al*., 2016; Majid *et al*., 2017, Abo El-Ezz and Haffez, 2019 and Abdulnaser *et al*., 2021.

The reduction in plant height is typically caused by a reduction in the number of nodes as well as internode length. This decrease in growth could be attributed to decreased photosynthesis, suppressed cell division, and lowered cellular prolongation. (Korres *et al*., 2016).

Bangar (2019) observed that reducing leaf area is a drought avoidance strategy because decreasing leaf area resulted in reduced water loss through transpiration, and this reduction in leaf area is attributable to the inhibition of leaf growth by a decreased cell division rate, which resulted in a loss of cell turgidity. In the same trend, a reduction in soil moisture produces a decrease in leaf water content, which causes a decrease in turgor pressure of the guard cells due to stomata closure. (Deka, 2018).

Concerning the impact of foliar spraying of SA or AA, it has a positive effects on all mentioned traits. Where the foliar application of SA at 200 ppm resulted in a significantly increased in shoot dry weight plant^{-1} at 80 DAS, leaf area index (LAI) at 60 DAS and leaf area duration (LAD) from 60 to 80 DAS , followed by 200 ppm AA with significant differences between them The highest values of leaf area index (LAI) at 80 DAS and plant height were recorded when maize plant sprayed with 200 ppm SA or AA with insignificant differences between them. Ear height scored the highest value when sprayed plants with 200 ppm SA or AA and followed by 100 ppm SA with insignificant differences between them. The present results have coincided with Abdelnaser *et al.* (2021) who stated that 300 mg.L^{-1} SA recorded the highest values of plant height and leaf area index, which could be attributed to its stimulating role in vegetative growth as it is categorized as a stimulating plant hormone (Rush, 2002). moreover, it works to reduce the impact of abiotic stress on growth and the levels of plant hormones like auxins and cytokines, which affect cell expansion and division (Saklaabutdinova *et al*., 2003), As a consequence, leaf area index, plant height and leaf area increased. In addition, AA protects plant tissues from harmful oxidative damage by acting as a reductant. It has the ability for regulating several cellular processes, including cell division, differentiation, and elongation (Alamri *et al.,* 2018)

Table 4. Leaf area index(LAI) and Leaf area duration (LAD) of maize SC 168 as affected by water stress and foliar spraying of salicylic and ascorbic acids in 2020 and 2021 summer seasons.

Treatments		LAI at 60 day			LAI at 80 day			LAD		
		2020	2021	Comb.	2020	2021	Comb.	2020	2021	Comb.
Irrigation level										
I1		5.31 a	5.38 a	5.35 a	6.20 a	6.32 a	6.26 a	115.1 a	117.1 a	116. 1a
I2		4.99 b	5.08 b	5.04 b	5.79 b	6.00 b	5.89 b	107.8 b	110.8 b	109.3 b
I3		3.48 c	3.51 c	3.50 c	4.09 c	4.23 c	4.16 c	75.7 c	77.4 c	76.6 c
F. test		**	*	**	**	**	**	*	*	*
Foliar spraying of salicylic and ascorbic acids										
T1		4.32 d	4.37 c	4.35 d	5.07 c	5.24 c	5.15 d	93.9 c	96.1 c	95.0 d
T2		4.58 bc	4.68 b	4.63 bc	5.38 b	5.58 ab	5.48 bc	99.6 b	102.5 ab	101.1 bc
T3		4.93 a	5.01 a	4.97 a	5.64 a	5.75 a	5.70 a	105.7 a	107.6 a	106.7 a
T4		4.43 cd	4.53 bc	4.48 cd	5.26 bc	5.39 bc	5.32 cd	96.9 b	99.2 bc	98.1 cd
T5		4.70 ab	4.72 ab	4.71 b	5.44 ab	5.63 ab	5.54 ab	101.5 ab	103.5 ab	102.5 b
F. test		**	**	**	*	**	**	**	*	*
Interaction										
I1	T1	5.20	5.18	5.19	6.00 abc	6.20	6.10 bcd	112.0 abc	113.8	112.9 bcd
	T2	5.32	5.45	5.38	6.24 a	6.35	6.30 ab	115.6 ab	118.0	116.8 abc
	T3	5.47	5.62	5.54	6.39 a	6.46	6.43 a	118.6 a	120.8	119.7 a
	T4	5.23	5.28	5.26	6.14 ab	6.25	6.20 abc	113.7 ab	115.3	114.5 abcd
	T5	5.33	5.40	5.36	6.22 a	6.36	6.29 abc	115.5 ab	117.6	116.5 abc
I2	T1	4.68	4.77	4.72	5.56 c	5.69	5.63 f	102.4 d	104.6	103.5 f
	T2	4.98	5.07	5.03	5.75 bc	6.06	5.90 def	107.4 bc	111.3	109.3 def
	T3	5.36	5.55	5.45	6.08 ab	6.29	6.19 abc	114.4 ab	118.4	116.4 abc
	T4	4.82	4.97	4.90	5.65 bc	5.83	5.74 ef	104.8 cd	108.0	106.4 ef
	T5	5.13	5.06	5.09	5.91 bc	6.12	6.01 cde	110.3 abc	111.8	111.1 cde
I3	T1	3.09	3.17	3.13	3.65 f	3.82	3.74 i	67.4 g	69.9	68.6 j
	T2	3.45	3.52	3.48	4.15 de	4.32	4.23 gh	75.9 f	78.4	77.1 hi
	T3	3.97	3.85	3.91	4.46 d	4.51	4.48 g	84.3 e	83.6	83.9 g
	T4	3.25	3.33	3.29	3.98 ef	4.09	4.04 h	72.3 fg	74.2	73.2 ij
	T5	3.65	3.71	3.68	4.21 de	4.40	4.30 gh	78.6 ef	81.0	79.8 gh
F. test		NS	NS	NS	**	NS	*	*	NS	*

***.** indicate significant at 0.05 and 0.01 levels of probability, respectively.**

Regarding the interaction between water deficit and foliar spraying of SA or AA the results revealed that presence a significant difference on shoot dry weight plant^{-1} at 80 DAS, LAI at 80 DAS and LAD from 60-80 DAS. The maximum values of shoot dry weight plant^{-1} at 80 DAS, LAI at 80 DAS and LAD from 60-80 DAS were obtained when irrigated maize plants at 50 % of AVSMD with sprayed 200 ppm SA or AA followed irrigation at 65 % of AVSMD by spraying 200 ppm SA with there were no significant differences between former treatments. While, the lowest values for previous traits were observed when irrigated maize plants at 80 % of AVSMD with water spraying (control). In agreement with our results, Shemi *et al.* (2021) and Miller *et al.* (2010) revealed that the increase of ROS accumulation as a result of water-deficient conditions could damage the cell membrane and lead to consequently direct destruction of photosynthetic pigments, lipids, nucleic acids, proteins, in addition to cell structure, and finally cause the death of cells then loss of plant biomass. Similar results were obtained in our present study where the spraying application by SA and AA of maize plants alleviate ROS and this will be valuable effects for plants' tolerance to oxidative stresses.

Total chlorophyll of leaves:

Data in table 5 reveals that irrigation maize plants at 65% of AVSMD enhanced chlorophyll pigments a and b significantly more than other treatments, however chl. a/b ratio was reduced. In contrast, watered maize plants with 80% of AVSMD exhibited a significant increases in chl. a/b ratio compared to other treatments. In this respect (Abo El-Ezz and Haffez, 2019) reported that significant increase in chl. (a and b) associated with increasing irrigation every 11 days then decreased when maize plants irrigation every 15 days. This could be explained by the fact that longer irrigation intervals result in fewer leaves, poorer leaf development, and less photosynthesis. The current results were in agreement with Mafakheri (2010) who found that there were insignificant increase on chlorophyll *a*/*b* ratio under drought stress it may be to chlorophyll *b* is not more sensitive than chlorophyll *a* under drought stress. On the other side Shafiq *et al.* (2021) indicated that the chlorophyll a/b ratio remained unchanged under drought stress conditions.

The reduction in photosynthetic pigments under drought stress may be due to impaired biosynthesis or breakdown of chlorophyll pigments and related compounds (Bhuiyan *et al*., 2019). Bhargava (2013) added that reduction in leaf area, increased stomata closure and consequently reduced leaf cooling by evapotranspiration increases osmotic stress leading to damages to the photosynthetic apparatus are among the major constraints for photosynthesis. Reduced photosynthetic activity is caused by the loss of carbon dioxide uptake (Deepak, 2019), whose lower has been shown to affect Rubisco activity and reduction in function of nitrate reductase and sucrose phosphate synthase and the ability for ribulose bisphosphate (RuBP) production. These results are in direct in harmony with that reported by Eliaspour, 2021, Shemi *et al*., 2021, El-Sherpiny *et al*., 2020, Ghazi and El-Sherpiny, 2021.

Table 5. Chlorophyll A, Chlorophyll B and Chlorophyll A/ B of maize SC 168 as affected by water stress and foliar spraying of salicylic and ascorbic acids in 2020 and 2021 summer seasons.

Treatments		Chlorophyll a			Chlorophyll b			Chlorophyll a/b		
		2020	2021	Comb.	2020	2021	Comb.	2020	2021	Comb.
Irrigation levels										
I1		17.19 a	17.14 a	17.16 b	5.11 a	5.18 b	5.14 b	3.37 b	3.31 b	3.34 b
I2		17.49 a	18.18 a	17.84 a	5.29 a	5.54 a	5.41 a	3.31 b	3.28 b	3.29 b
I3		14.14 b	14.47 b	14.31 c	3.15 b	3.33 c	3.24 c	4.49 a	4.34 a	4.41 a
F. test		**	*	**	*	*	*	**	*	**
Foliar spraying of salicylic and ascorbic acids										
T1		14.97 d	15.56 c	15.26 d	3.95 c	4.07 d	4.01 d	3.79 a	3.82 a	3.81 a
T2		16.20 bc	16.71 b	16.45 bc	4.53 b	4.76 bc	4.65 bc	3.58 ab	3.51 bc	3.54 bc
T3		17.39 a	17.50 a	17.44 a	5.02 a	5.19 a	5.11 a	3.47 b	3.37 c	3.42 c
T4		15.94 c	16.35 b	16.15 c	4.39 b	4.57 c	4.48 c	3.63 ab	3.58 b	3.60 b
T5		16.88 ab	16.86 ab	16.87 b	4.69 ab	4.83 b	4.76 b	3.60 ab	3.49 bc	3.55 bc
F. test		**	**	**	*	**	**	*	*	*
Interaction										
I1	T1	16.35	17.08 cde	16.71 d	5.16	5.35 cd	5.25 cd	3.17	3.19 e	3.18 e
	T2	17.18	16.92 de	17.05 cd	4.90	5.17 de	5.04 de	3.51	3.27 e	3.39 e
	T3	18.21	17.53 bcd	17.87 b	5.39	5.58 bc	5.49 bc	3.38	3.14 e	3.26 e
	T4	16.47	16.82 de	16.64 d	4.83	4.82 e	4.82 e	3.41	3.49 e	3.45 e
	T5	17.73	17.34 bcd	17.54 bc	5.26	5.00 d	5.13 de	3.37	3.47 e	3.42 e
I2	T1	16.73	17.42 bcd	17.07 cd	4.40	4.43 f	4.41 f	3.80	3.94 d	3.87 d
	T2	17.34	18.42 ab	17.88 b	5.55	5.76 ab	5.66 ab	3.12	3.20 e	3.16 e
	T3	18.27	18.94 a	18.60 a	5.86	5.97 a	5.92 a	3.12	3.17 e	3.14 e
	T4	17.19	17.94 abcd	17.56 bc	5.23	5.69abc	5.46 bc	3.29	3.15 e	3.22 e
	T5	17.93	18.20 abc	18.06 ab	5.41	5.85 ab	5.63 ab	3.31	3.11 e	3.21 e
I3	T1	11.83	12.19 h	12.01 h	2.30	2.44 j	2.37 j	5.14	5.00 a	5.07 a
	T2	14.08	14.78 g	14.43 fg	3.14	3.36 hi	3.25 hi	4.49	4.40 bc	4.44 b
	T3	15.68	16.03 ef	15.85 e	3.80	4.03 g	3.92 g	4.13	3.98 cd	4.05 cd
	T4	14.16	14.31 g	14.23 g	3.12	3.21 i	3.16 i	4.54	4.46 b	4.50 b
	T5	14.98	15.05 fg	15.01 f	3.40	3.64 h	3.52 h	4.40	4.14 bcd	4.27 bc
F. test		NS	*	*	NS	**	*	NS	*	*

***.** indicate significant at 0.05 and 0.01 levels of probability, respectively.**

Concerning the effect of foliar spraying by SA or AA on chl. a, b and a/b ratio are presented in Table 5. Results showed that chl .a and b were significantly increased with spraying maize plants at concentration 200 ppm SA but chl. a/b ratio was significantly decreased compared with untreated plants (control) at the same concentration. It may due to the role of SA as an antioxidant (Aldesuquy and Ghanem, 2015), which participates in the regulation of many biochemical processes in plants such as, stomatal closure, ion uptake, and transpiration (Khan *et al.*, 2012), triggered chlorophyll biosynthesis and promote photosynthesis and photosynthetic rate (Chattha *et al.*, 2015). Ahmad *et al.* (2014) demonstrated that foliar spraying of SA and AA significantly increased chl. b and decreased a/b ratio.

The interaction between water deficit and foliar spraying of SA and AA on chl. a, b and a/b ratio are presented in Table 5 were found to be significantly effect. The highest values of chl. a and b were recorded from (65% AVSMD) with foliar spraying by SA or AA at 200 ppm compared to other treatments. On the other side irrigation at 80% AVSMD with untreated plant (control) scored the highest value of chl. a/b ratio. Their results indicated that, water stress led to a reduction in chl. a, and b. while exogenous application of AS and AA acids alleviated the adverse effects of drought stress-induced reduction in growth, biomass and photosynthetic pigments. These results are directly in line with (Noman *et al.*, 2015)

Water Relations

Leaf relative water content (LRWC) and osmotic potential (OP)

Data in Table 6 illustrated that irrigation at 50 % of AVSMD leads to significant increase in LRWC. In the contrast, OP decreased significantly compared to irrigation at 80 % of AVSMD. Such findings showed that water status in plant cells was affected by water stress conditions. Our results are closed to those obtained by Yang *et al.* (2019), Meriem *et al.* (2021) and Kotb *et al.* (2021). According to Meriem *et al.* (2021), who found that water stress reduces soil water availability which leaves across xylems. This reduces leaf hydraulic conductance, which reduces water potential and diminished turgor pressure, as indicated by a low LRWC. In water-stressed conditions, a decreased leaf water potential and a high transpiration rate significantly reduce LRWC value.

As for foliar application of SA or AA, its significantly increased LRWC in maize plants leaves but at the same time its declined leaf osmotic potential (OP) compared with untreated plants (control) treatments. Spraying maize plants with SA or AA at 200 ppm give the highest value of LRWC and improved OP compared to other treatment. This increase in LRWC might be due to protective effects of exogenous application of SA or AA on membrane degradation in maize under drought conditions.

The interaction between irrigation treatments and foliar spraying of SA or AA recorded significant differences in LRWC and (OP) Table 6. Irrigation at 50% of AVSMD and sprayed with 100 and 200 ppm SA or 200 ppm AA achieved the maximum value of LRWC and improvement in OP value. In contrary irrigation at 80 % of AVSMD with untreated plants gave the worst values in LRWC and OP.

Table 6. **Leaf relative water content (LRWC), osomtic potential (OP), water consumptive use (WCU) and water use efficiency (WUE) of maize SC 168 as affected by water stress and foliar spraying of salicylic and ascorbic acids in 2020 and 2021 summer seasons.**

Treatments		LRWC			OP			WCU			WUE		
		2020	2021	Comb.	2020	2021	Comb.	2020	2021	Mean	2020	2021	Comb.
Irrigation levels													
I1		78.65 a	80.47 a	79.56 a	-13.17 c	-12.58 c	-12.88 c	2771	2823	2797	1.42 b	1.44 b	1.43 b
I2		73.62 b	75.87 b	74.75 b	-14.01 b	13.41 b	-13.71 b	2376	2429	2403	1.56 a	1.60 a	1.58 a
I3		65.29 c	67.15 c	66.22 c	-17.72 a	-19.02 a	-18.37 a	2012	2038	2025	1.48 ab	1.51 ab	1.49 b
F. test		**	**	**	*	**	**	-	-	-	*	*	*
Foliar spraying of salicylic and ascorbic acids													
T1		69.44 c	72.15 d	70.79 d	-16.45 a	-16.07 a	-16.26 a	2435	2500	2468	1.31 d	1.36 d	1.33 d
T2		72.78 abc	74.66 bc	73.72 bc	-14.94 b	-15.14 b	-15.04 b	2384	2415	2400	1.51 bc	1.51 bc	1.51 bc
T3		75.04 a	76.84 a	75.94 a	-14.03 c	-14.27 c	-14.15 c	2349	2388	2368	1.64 a	1.67 a	1.65 a
T4		71.27 bc	73.36 cd	72.31 cd	-15.29 b	-15.10 b	-15.19 b	2402	2447	2425	1.43 c	1.48 cd	1.45 c
T5		74.07 ab	75.46 ab	74.77 a	-14.13 c	-14.44 c	-14.28 c	2360	2401	2381	1.55 b	1.58 b	1.57 ab
F. test		**	*	**	*	*	*	-	-	-	*	**	*
Interaction													
I1	T1	76.01 cd	79.57 abc	77.79 bc	-14.08 e	-13.11	-13.59 efg	2808	2875	2842	1.31	1.37	1.34 hi
	T2	78.64 abc	81.04 ab	79.84 ab	-13.17 ef	-12.61	-12.89 gh	2783	2816	2800	1.45	1.42	1.43e fgh
	T3	80.52 a	82.50 a	81.51 a	-12.48 f	-12.00	-12.24 h	2720	2800	2760	1.54	1.54	1.54 bcdef
	T4	78.10 abc	79.34 abc	78.72 abc	-13.44 ef	-12.74	-13.09 fg	2780	2824	2802	1.34	1.40	1.37 ghi
	T5	80.00 ab	79.90 abc	79.95 ab	-12.69 f	-12.45	-12.57 gh	2762	2800	2781	1.47	1.48	1.47 cdefh
I2	T1	71.21 ef	73.84 de	72.53 e	-15.61 d	-14.07	-14.84 d	2428	2481	2455	1.35	1.43	1.39 fghi
	T2	73.59 de	75.95 cd	74.77 de	-14.10 e	-13.45	-13.77 ef	2372	2421	2397	1.60	1.61	1.60 abcd
	T3	76.74 bcd	77.88 bcd	77.31 bcd	-12.93 f	-12.82	-12.87 gh	2346	2380	2363	1.73	1.79	1.76 a
	T4	71.09 ef	74.53 cd	72.81 e	-14.22 e	-13.74	-13.98 e	2403	2456	2430	1.49	1.55	1.52 bcdefg
	T5	75.48 cd	77.16 bcd	76.32 cd	-13.22 ef	-13.00	-13.11 fg	2329	2409	2369	1.63	1.63	1.63 abc
I3	T1	61.10 i	63.03 g	62.06 i	-19.65 a	-21.04	-20.34 a	2070	2143	2107	1.25	1.27	1.26 i
	T2	66.11 g	67.00 f	66.55 fg	-17.55 bc	-19.36	-18.46 b	1997	2008	2003	1.48	1.51	1.49 bcdefgh
	T3	67.87 fg	70.15 ef	69.01 f	-16.68 cd	-18.00	-17.34 c	1981	1983	1982	1.64	1.66	1.65 ab
	T4	64.62 gi	66.23 f	65.42 g	-18.23 b	-18.81	-18.52 b	2024	2060	2042	1.45	1.48	1.46 defgh
	T5	66.73 g	69.33 f	68.03 fg	-16.48 cd	-17.87	-17.17 c	1988	1995	1992	1.56	1.62	1.59 bcde
F. test		**	*	**	*	NS	*	-	-	-	NS	NS	*

***.** indicate significant at 0.05 and 0.01 levels of probability, respectively.**

Seasonal water consumptive use (WCU)

Data in table (6) indicated that WCU ranged from 2025 to 2797 m^3 fed^{-1} for the average of both seasons under study. The highest value of WUC was observed when maize plants were irrigated at 50 % of AVSMD, followed by irrigation at 65 % of AVSMD, while the lowest value was obtained under irrigation at 80 % of AVSMD . Irrigation at 50 % of AVSMD recorded higher water consumption which due to an abundance of soil moisture, and plants tend to grow without water deficit. These results could be related to increasing water irrigation, provided more soil moisture available for extraction by plant roots. The present results agreed with the findings by Ewis *et al.* (2016) and Abd El-Latif *et al*. (2016) who demonstrated that the increase in water consumption by plants depended on plant growth stage and availability of soil moisture in the root zone.

In terms of the impact of foliar application by SA or AA on WCU. The results showed that spraying maize plants at 200 ppm SA recorded the lowest value of WCU (2368 m^3 fad^{-1}).

The interaction between irrigation treatments and foliar spraying of SA or AA achieved the minimum value of WCU when plants were irrigated at 80 % of AVSMD with spraying at 200 ppm SA.

Water use efficiency (WUE)

Table 6 demonstrated that WUE achieved the maximum value when plants were irrigated at 65 % of AVSMD followed by those irrigated at 80 % of AVSMD with insignificant difference between them, while irrigated at 50 % of AVSMD given the minimum value of WUE. irrigation at 65% and 80 % of AVSMD reduced WCU by 14.09, 27.60 % and improved WUE by 11.39 and 7.60 %, respectively compared with irrigation at 50 % treatment. The current findings disagree with the results obtained by Gomaa *et al.* (2021) who found that irrigation every 20 days recorded the highest value of WUC compared to irrigation every 15 or 10 days .

In connection with the effect of foliar application of SA or AA on WUE. Results illustrated that spraying 200 ppm SA achieved the highest value of WUE (1.65 m^3 fad^{-1}) compared to other treatments. These antioxidant enzymes can reduce photo-oxidative stress, scavenge ROS, maintain the integrity of the chloroplast membrane, and ultimately, increase the photosynthetic rate in crop plants, which improves WUE and plant production.

The interaction between irrigation treatments and foliar spraying of SA or AA displayed significant differences in WUE (Table 6). Irrigation at 65% of AVSMD and sprayed with 200 ppm of SA or AA achieved the maximum value of WUE but irrigation at 50 % of AVSMD with untreated plants gave the lowest value.

Days to tasselling and silking

Data given in Table (7) indicate that irrigation treatments had a significant effect on tasselling and silking time. Irrigation of maize plants at 50 or 65 % of AVSMD were differ insignificantly between them in days to tasselling and silking than that irrigation at 80 % of AVSMD. our findings were agreed with Abu-Grab *et al.* (2019) and El-Gamal *et al.* (2021) who illustrated that each increases in soil moisture stress up to 80 % of AVSMD leads to significant earlier visibility of tasseling and silking, that reducing time to tasselling and silking to escape from water deficit conditions.

Regarding the effect of foliar spray of SA or AA, results cleared that days to tasselling and silking were significantly increased by spraying maize plants with 200 ppm SA followed by spraying 100 ppm SA compared to control treatment.

The interaction between water shortage treatments and foliar spraying of SA or AA exhibited a significant effect on days to tasselling and silking. The maximum value of days to tasselling and silking was obtained when plants were watered at 50 % or 65 % of AVSMD and SA (200 ppm) was sprayed.

Table 7. **Days to tasseling and days to silking of maize SC 168 as affected by water stress and foliar spraying of salicylic and ascorbic acids in 2020 and 2021 summer seasons.**

Treatments		Day to 50% tasseling			Day to 50% silking		
		2020	2021	Comb.	2020	2021	Comb.
Irrigation levels							
I1		61.20 a	62.75 a	61.98 a	63.42 a	65.01 a	64.22 a
I2		61.13 a	61.90 a	61.52 a	63.23 a	64.21 a	63.72 a
I3		59.13 b	60.20 b	59.67 b	60.95 b	62.26 b	61.61 b
F. test		**	**	**	*	**	**
Foliar spraying of salicylic and ascorbic acids							
T1		59.40 d	60.85 c	60.13 d	61.37 d	63.12 d	62.24 d
T2		60.77 b	61.82 b	61.29 b	62.87 b	64.00 b	63.43 b
T3		61.70 a	62.60 a	62.15 a	63.87 a	64.87 a	64.37 a
T4		60.10 c	61.17 bc	60.63 c	62.20 c	63.37 cd	62.78 c
T5		60.47 b	61.65 b	61.06 b	62.37 c	63.78 bc	63.08 b
F. test		*	**	**	**	**	**
Interaction							
I1	T1	60.50 cd	62.50 bcd	61.50 c	62.70 d	64.80 bc	63.75 c
	T2	61.50 b	63.50 b	62.50 b	63.70 bc	65.70 ab	64.70 b
	T3	62.50 a	64.00 a	63.25 a	64.80 a	66.30 a	65.55 a
	T4	61.00 c	61.50 de	61.25 c	63.20 cd	63.70 cd	63.45 c
	T5	60.50 cd	62.25 cd	61.38 c	62.70 d	64.55 c	63.63 c
I2	T1	59.50 ef	60.75 e	60.13 de	61.50 ef	62.95 de	62.23 d
	T2	61.75 b	61.75 de	61.75 c	63.95 b	64.05 c	64.00 c
	T3	62.50 a	63.00 bc	62.75 ab	64.80 a	65.55 ab	65.18 a
	T4	60.50 cd	62.00 cd	61.25 c	62.70 d	64.30 c	63.50 c
	T5	61.40 b	62.00 cd	61.70 c	63.20 cd	64.20 c	63.70 c
I3	T1	58.20 g	59.30 g	58.75 g	59.90 h	61.60 f	60.75 f
	T2	59.05 fg	60.20 fg	59.63 ef	60.95 fg	62.25 ef	61.60 e
	T3	60.10 de	60.80 ef	60.45 d	62.00 e	62.75 de	62.38 d
	T4	58.80 g	60.00 fg	59.40 fg	60.70 g	62.10 ef	61.40 e
	T5	59.50 ef	60.70 ef	60.10 de	61.20 fg	62.60 ef	61.90 de
F. test		*	**	**	*	*	*

***.** indicate significant at 0.05 and 0.01 levels of probability, respectively.**

Yield and yield components

Data presented in Tables 8 and 9 show the effect of water deficit and foliar spraying of SA or AS at 100 and 200 ppm and their interaction on yield and yield components.

There are significant and gradual reductions in each of ear length, No. of rows ear^{-1}, No. of kernels rows^{-1}, 100- grain weight and grain yield by increasing the level of soil moisture depletion from 50% to 80% of AVSMD. The maximum values of ear length, No. of rows ear^{-1}, No. of kernels rows^{-1}, 100- grain weight and grain yield were obtained from plants irrigated at 50% of AVSMD followed by plants watered at 65 % of AVSMD with a significant difference between them. It's worth to mentioning that declined irrigation rate from 50% to 65% of AVSMD displayed reducing No. of kernels rows^{-1}, 100-grains and grain yield by 4.93, 6.54 and 5.24 % respectively. These values reached 33.65, 18.29 and 24.65 % when maize plants were irrigated at 80 % AVSMD.

The reduction in yield and yield components obtained may be due to exposing plants to water deficit that causes to decline in growth parameters expressed (shoot dry weight, LAI, LAD, plant height and ear height). In addition in the physiological constituents in the leaves chl.(a, b) and LRWC that former discussed in Tables 3, 4, 5, and 6. The present study agreed with Gabr *et al.* (2018), Shinoto *et al.* (2018), El-Sherpiny *et al.* (2020), Ali and Abdelaal (2020), Ghazi and El-Sherpiny (2021), Salgado-Aguilar *et al.* (2020) and Gomaa *et al.* (2021). Gholami and Zahedi (2019) stated that water shortage caused a drop in photosynthetic efficiency, net assimilation production, water and mineral uptake by the root, all of which caused a negative impact on the development and vegetative growth of olive genotypes.

As for foliar spraying of SA and AA, data presented in Tables 8&9 showed that ear length, No. of kernels rows^{-1}, 100-kernels weight and grain yield of maize plants were significantly improved with foliar spraying antioxidants of SA and AA. The highest values of ear length and grain yield were recorded when plants were sprayed by 200 ppm SA followed by spraying 200 ppm AA with significant difference between such two treatments. The maximum values of No. of kernels rows^{-1} and 100-kernels weight were scored when plants were sprayed with 200 ppm SA followed by 200 ppm AA, without significant difference between the two treatments. Comparing with the untreated plants the increases in No. of kernels rows^{-1}, 100-kernels weight and grain yield of maize plants were 13.70, 10.40 and 16.08 %[1], respectively. The present results were harmony with findings of Shemi *et al.* (2021) who explained the drought stress (50% field capacity) significantly reduced LRWC, chlorophyll contents concentration, yield, and yield components compared with well water conditions (85% field capacity) might be due to the increases in production of ROS (H_2O_2 and O_2) that led to oxidative damage to the membranes, lipids and chlorophylls, and finally decreases plant biomass accumulation.

Table 8. **Ear length, number of rows ear^{-1} and number of kernels row^{-1} of maize SC 168 as affected by water stress and foliar spraying of salicylic and ascorbic acids 2020 and 2021 summer seasons.**

Treatments		Ear length (cm)			No. of rows ear-1			No. of kernels row-1		
		2020	2021	Comb.	2020	2021	Comb.	2020	2021	Comb.
Irrigation levels										
I1		23.09 a	24.25 a	23.67 a	16.03 a	16.18 a	16.10 a	45.82 a	43.41 a	44.61 a
I2		21.06 b	22.04 b	21.55 b	15.00 a	15.36 a	15.18 b	43.51 a	41.31 a	42.41 b
I3		15.94 c	17.24 c	16.59 c	13.68 b	13.80 b	13.74 c	28.76 b	30.44 b	29.60 c
F. test		**	*	**	*	*	*	*	**	**
Foliar spraying of salicylic and ascorbic acids										
T1		18.72 d	19.49	19.11 d	14.20 c	14.58	14.39	36.45 c	35.53 b	35.99 c
T2		19.98 c	21.34	20.66 bc	14.87 abc	15.12	14.99	39.33 b	38.81 a	39.07 b
T3		21.67 a	22.81	22.24 a	15.69 a	15.53	15.61	41.81 a	40.02 a	40.92 a
T4		19.44 cd	20.38	19.91 cd	14.58 bc	14.88	14.73	38.98 b	38.33 a	38.65 b
T5		20.35 bc	21.85	21.10 b	15.15 ab	15.45	15.30	40.23 ab	39.26 a	39.75 ab
F. test		*	NS	*	*	NS	NS	*	**	**
Interaction										
I1	T1	22.31	23.18	22.74	15.60	15.90	15.75	44.38	41.33 c	42.85 bc
	T2	23.14	24.33	23.73	16.08	16.15	16.11	45.53	43.88 ab	44.70 abc
	T3	24.00	25.65	24.83	16.38	16.40	16.39	47.90	44.40 a	46.15 a
	T4	22.49	23.05	22.77	15.85	16.13	15.99	45.18	43.33 abc	44.25 abc
	T5	23.54	25.05	24.29	16.23	16.33	16.28	46.11	44.13 ab	45.12 ab
I2	T1	19.02	20.75	19.89	14.31	14.80	14.55	40.38	38.35 d	39.36 d
	T2	20.98	22.35	21.66	15.00	15.45	15.23	43.78	41.68 bc	42.73 bc
	T3	23.60	23.40	23.50	15.66	15.80	15.73	45.61	43.15 abc	44.38 abc
	T4	20.11	21.45	20.78	14.76	15.15	14.96	42.85	41.05 c	41.95 cd
	T5	21.62	22.25	21.93	15.26	15.60	15.43	44.91	42.33 abc	43.62 abc
I3	T1	14.84	14.55	14.70	12.69	13.05	12.87	24.60	26.90 f	25.75 f
	T2	15.83	17.35	16.59	13.54	13.75	13.65	28.70	30.88 e	29.79 e
	T3	17.41	19.38	18.39	15.04	14.38	14.71	31.93	32.50 e	32.21 e
	T4	15.72	16.65	16.19	13.14	13.38	13.26	28.90	30.60 e	29.75 e
	T5	15.91	18.25	17.08	13.98	14.43	14.20	29.69	31.33 e	30.51 e
F. test		NS	NS	NS	NS	NS	NS	NS	*	*

***,** indicate significant at 0.05 and 0.01 levels of probability, respectively.**

Table 9. **100- kernels weight and grain yield of maize SC 168 as affected by water stress and foliar spraying of salicylic and ascorbic acids in 2020 and 2021 summer seasons.**

Treatments		100- kernels weight (g)			Grain yield (ard/fed.)		
		2020	2021	Comb.	2020	2021	Comb.
Irrigation levels							
I1		40.07 a	39.20 a	39.63 a	28.12 a	29.08 a	28.60 a
I2		38.04 a	36.04 b	37.04 b	26.43 b	27.77 a	27.10 b
I3		31.12 b	33.63 c	32.38 c	21.22 c	21.88 b	21.55 c
F. test		**	**	**	*	**	**
Foliar spraying of salicylic and ascorbic acids							
T1		34.29 b	34.55 c	34.42 c	22.79 d	24.34 c	23.56 d
T2		36.58 a	36.49 ab	36.54 ab	25.66 b	25.96 b	25.81 bc
T3		38.05 a	37.95 a	38.00 a	27.36 a	28.30 a	27.83 a
T4		35.96 ab	35.48 bc	35.72 bc	24.36 c	25.72 b	25.04 c
T5		37.16 a	36.97 ab	37.07 ab	26.11 b	26.91 b	26.51 b
F. test		**	*	**	*	*	**
interaction							
I1	T1	39.00	38.25 abc	38.63 ab	26.37	28.21 bcd	27.29 bc
	T2	40.08	39.15 ab	39.61 a	28.79	28.52 abcd	28.65 ab
	T3	41.03	40.33 a	40.68 a	29.89	30.89 a	30.39 a
	T4	39.90	38.85 ab	39.38 ab	26.57	28.21 bcd	27.39 bc
	T5	40.33	39.40 ab	39.86 a	29	29.57 abcd	29.28 ab
I2	T1	36.01	33.78 efg	34.89 cd	23.46	25.39 de	24.42 de
	T2	38.00	35.75 cde	36.88 bc	27.04	27.76 cd	27.40 bc
	T3	39.35	37.70 abc	38.52 ab	28.92	30.47 ab	29.70 ab
	T4	37.82	35.55 de	36.68 bc	25.57	27.17 d	26.37 cd
	T5	39.02	37.43 bcd	38.22 ab	27.16	28.08 cd	27.62 bc
I3	T1	27.85	31.63 g	29.74 f	18.53	19.43 g	18.98 g
	T2	31.67	34.58 ef	33.12 de	21.16	21.6 fg	21.38 f
	T3	33.78	35.83 cde	34.80 cd	23.27	23.55 ef	23.41 ef
	T4	30.15	32.05 fg	31.10 ef	20.95	21.77 f	21.36 f
	T5	32.14	34.09 eg	33.12 de	22.18	23.07 ef	22.63 ef
F. test		NS	**	*	NS	*	*

***,** indicate significant at 0.05 and 0.01 levels of probability, respectively.**

while the foliar spraying of SA had a positive impact in improvement of drought-tolerance in maize which it attributed to increase in LRWC, Chl. a, Chl. b and mitigate the damaging effects of water deficit on plants. Also, Kotb *et al*. (2021) reported that the beneficial effect of SA and AA on increasing grain yield could be attributed to their important roles in increasing enzyme activity and photosynthetic pigment content, which, in turn, increases plant metabolism and thus yield attributes such as ear length and number of kernels rows^{-1}, 100 grain weight and consequently increase grain yield fad^{-1} of maize plants.

The interaction effect between water deficient and foliar spray of SA and AA on yield and its components appeared to be significant on No. of kernels rows^{-1}, 100-kernels weight and grain yield. The highest values of No. of kernels rows^{-1}, 100- grain weight and grain yield were noticed when plants irrigated at 50 % of AVSMD and sprayed by 200 ppm SA. On the aforementioned traits, irrigation at 65% of AVSMD with 200 ppm SA spraying did not significantly differ from irrigation at 50% of AVSMD with 200 ppm SA.

CONCLUSION

Our results illustrated that drought stress had adverse effect on physiological traits and productivity of maize plants. while SA and AA plays vital role in protecting plant tissues from harmful oxidative damage by acting as reductant drought conditions. So it can be concluded that irrigation maize plants at 65 % of ASMD with foliar spraying with 200 ppm SA or AA stimulated the growth of maize plants and enhanced biosynthesis of photosynthetic pigments and then improved yield.

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الرش الورقى للذرة الشامية بحمض السالسيليك والاسكوربيك لتحسين الصفات الفسيولوجية والانتاجية تحت ظروف الاجهاد المائى

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الملخص

أجريت تجربة ميدانية في محطة البحوث الزراعية بالجميزة محافظة الغربية ، مصر ، الواقعة بين خط العرض 30 ° 58 ′56 شمالاً وخط الطول 30 ° 57 ′ 8 شرقاً خلال موسمي الصيف لعامي 2020 و2021 لدراسة كيف يمكن لبعض مضادات الأكسدة(حمض السالسيليك والاسكوربيك) أن تخفف الآثار السلبية للإجهاد المائي وتأثيرها على الصفات الفسيولوجية والانتاجية لمحصول الذرة الشامية (هجين فردى 168). وكانت معاملات الري المستخدمة هى الري عند فقد 50 و 65 و 80٪ من الماء الميسر. وكان الرش الورقي بحمضي الساليسيلك أوالأسكوربيك عند تركيز 100 و 200 جزء في المليون. أظهرت نتائج البحث إن زيادة الاجهاد المائي حتى 80٪ من الماء الميسر أدي إلى انخفاض معنوي في الوزن الجاف للنبات، ارتفاع النبات, دليل مساحة الأوراق، فترة بقاء الأوراق، محتوى الكلوروفيل أ, ب المحتوى المائي النسبي بالأوراق، طول الكوز، عدد السطور في الكوز، عدد حبوب فى السطر, وزن الـ 100 حبة, محصول الحبوب، بينما كانت هناك زيادة معنوية في الجهد الاسموزي ونسبة الكلوروفيل أ / ب. وقد أدى الري عند فقد65 ٪ من الماء الميسر الى زيادة معنوية فى كفاءة استخدام المياه والكلوروفيل أ و ب مقارنة بمستويات الرى الأخرى. أدى الرش الورقي بحمضي الساليسيلك أو الأسكوربيك (200 جزء في المليون) إلى زيادة معنوية فى معظم الصفات المدروسة مقارنة بالنباتات غير المعاملة, ماعدا الجهد الاسموزي ونسبة الكلوروفيل أ / ب اللذان انخفضا بالرش بحمض الساليسيلك عند 200 جزء فى المليون. يمكن أن نخلص الى أن رى نباتات الذرة عند فقد65٪ من الماء الميسر مع الرش الورقي بـ 200 جزء في المليون من حمضى الساليسيليك أو الأسكوربيك حفز نمو نباتات الذرة وحسن كفاءة استخدام الماء وأيضًا شجعت التخليق الحيوي للأصباغ الضوئية ومن ثم تحسين المحصول.