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Effects of Some Antioxidant Materials as a Foliar and Water Deficit Stress at Identify Growth Stages on Productivity of Wheat Crop

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ABSTRACT

Two field experiments were conduct at Sakha Agric. Res. Station,Kafer EL-Sheikh Governorate, Egypt during 2013/2014 and 2014/2015 seasons, to study the effects of foliar application of ascorbic and salicylic acid under water deficit stressat identify growth stages and its interaction on productivity of misr1 wheat cultivar. The split plot design with three replicates was used where the main plots included water stress (normal irrigation, water deficit stress attillering, heading, ripening stages), while ascorbic and salicylic acid applications (water spray, Asc 100 ppm, Asc 200 ppm, sal 100 ppm, sal 200 ppm, Asc 100 ppm + sal 100 ppm, Asc 200 ppm + sal 100 ppm, Asc 200 ppm + sal 200 ppm) were allocated at the sub plots. The obtained results were as follows:The normal irrigation recorded the highest signicficantly values in chlorophyll a, chlorophyll b, flage leaf area, plant height, spike length, number of spikes/m^2, number of grains/spike, grains weight/spike, 1000 grain weight, grain yeild/fed. and straw yeild/fed. characters without significantly differences with the treatment of water deficit stress at heading and ripening stages at chlorophyll ain both seasons, the normal irrigation did not significantly differed with the treatments of water deficit stress at tillering, heading and ripening stages in grains weight/spike, grain yeild and plant heighet characters respictively in the first season and with the treatments of water deficit stress atheading stage in number of grains/spike and spike length characters and at ripening stage in spike length character in the second season. The combinations between ascorbic acid and salicylic acid gave the greatest significantly values at the most of characters as soon as chlorophyll a, plant height, spike length, number of spikes/m^2, number of grains/spike, grains weight/spike, grain yeild/fed. and straw yeild/fed. characters compared with the other treatments in both seasons while the same trend was at chlorophyll b in the first season and at 1000 grain weight in the second season, the combination between ascorbic acid(200 ppm) and salicylic acid (200 ppm) only recorded the greatest significantly values offlage leaf area in both seasons and at 1000 grain weight andchlorophyll b in the first and second season respectivly, the combinations between ascorbic acid and salicylic acid under normal irrigation gave the highest significantly values of grain yield/fed. in both seasons without significantly differences with the same combinations under water deficit stress at heading stage in the first seasons. The normal irrigation received the greatest values of water applied (m^3/fed) and water consumption (m^3/fed) while treatments of water deficit stress at heading and ripening stages recorded the highest values of productivity of irrigation water (kg/m^3) and water productivity index (kg/m^3), the combinations between ascorbic acid and salicylic acid recorded the biggest values of water applied (m^3/fed), water consumption (m^3/fed), productivity of irrigation water (kg/m^3) and water productivity index (kg/m^3) characters compared with the other antioxidant treatments in both seasons. The combinations between ascorbic acid (200 ppm) and 100 ppm or 200 ppm salicylic acid at all water deficit stress treatments recorded the highest values of productivity of irrigation water (kg/m^3) and water productivity index (kg/m^3) compared with the other interactions, the lowest values of the previous characters were obtained from water spray at all water deficit stress treatments. It could be concluded that the combinations between ascorbic acid (200 ppm) and (100 ppm or 200 ppm) of salicylic acid as a foliar application under both normal irrigation and water deficit stress at heading stage producing the highest grain yield of Misr 1 wheat cultivar with increasing the productivity of irrigation water and water productivity index Under the conditions of this study.

Keywords: ascorbic acid, salicylic acid, water deficit stresses, Misr 1wheat cultivar, yield.

INTRODUCTION

Wheat crop owing a central role in world's food security.It is the principal food formore than one-fifth of human populace in the world. It is considered one of the most important strategically crop especially in Egypt (FAO, 2014).The national target in Egypt is increasing wheat productivity to fill the gap between the local consumption and production. The different abiotic stresses lead to decrease wheat productivity so, it is important to minimize these losses to face the increase in food requirements (Maswada and Abd El-Kader, 2016).

Response to water deficit stress related to the other factors such as duration, the intensity of stress, the developmental stage or growth of the plants. Plant growth reduces by water deficit stress through affecting various physiological processes, such as photosynthesis, translocation, nutrient metabolism and growth promoters (Azadeh *et al.*, 2014; Abdalla, 2011and Amin, *et al.*, 2009).Water deficit stress led to the plant will face the oxidative damage inevitably and can be resulted in producing reactive oxygen species (ROS), which are the result of incomplete reduction of oxygen and toxic for plant cells (Miyake, 2010), the reduction in fresh and dry biomass production resulted from water deficit stress on crop plants (Lisar *et al.*, 2012).

The antioxidant materials as soon as ascorbic acid and salicylic acid play an important role in the defense against oxidative stress. The recent results, using the transgenic plantsand mutants, confirmed the role of ascorbic acid in photosynthesis, the cycle of ascorbic acid in oxidative stress, but the amount of ascorbic acid was also increased in the plants under stress. The results of the studies of Malik *et al* (2015)showed that application of ascorbic acid under drought to overcome adverse effects of oxidative stress by maintaining growth, relative water content, osmotic adjustment through proline accumulation and by enhanced activity of antioxidant enzymes, Noreen *et al.*(2008) and Amirkhan *et al.*(2006) showed that ascorbic acid at the rate of (100 ppm) in wheat caused the reduction of adverse effects of drought stress. Farjam *et al.* (2015) showed that ascorbic acid application increased rate of biological WUE significantly as compared with control plants, application of salicylic acid led to significant increase in leaves protein content in complete drought stress condition, application of ascorbic acid at non-stress (control) condition resulted in the highest economical rate of WUE.

Salicylic acid was the organic compound in the plants, it affects the physiological activities in the plants, such as growth regulation, photosynthesis, nutrient uptake, plant water relations and mechanisms of plant resistance and tolerance to biotic and abiotic stresses (Hayat *et al.* 2010; Popova *et al.* 1997). Application of SA stimulated tolerance in plantsto many biotic and abiotic stress(Khan *et al.*, 2010). Amin *et al.* (2008) reported that foliar application of wheat plants (*Triticumaestivum L.*) CV. Gemmiza 10 with the combinations between salicylic acid at rate of 100 mg l-1 and ascorbic acid at rate of 200 or 400 mg l-1were more effective in increasing growth characters, yield and its components in addition to chlorophyll content in the leaves compared with untreated plants., Shirazi *et al.* (2014) studied the effect of four irrigation regimes ((no irrigation), 100 mm at 30 days after sowing (DAS), 200 mm (100 mm at 30 DAS + 100 mm at 45 DAS), and 300 mm (100 mm at 30 DAS + 100 mm at 45 DAS + 100 mm at 60 DAS)). They reported that the maximum grain yield was obtained from application of 200 mm (100 mm at 30 DAS + 100 mm at 45 DAS) irrigation treatment. Bakry *et al.* (2013).They found that highest grain yield resulted from water 80 % of irrigation requirement without significantly differences with the treatment of 100 % water irrigation. The greatest values of grain and straw yields/fad, protein content, plant height, spike length, seed index, number of spikelet's per spike and water use efficiency produced from Increasing foliar application levels of ascorbic acid.The interaction between 80% water irrigation requirements and 300 mg/L level of ascorbic acid as foliar application gave the highest values of grain, straw, protein yields /fad. and water use efficiency.

The aim of this investigation was study the effect of foliar application of ascorbic and salicylic acid under water deficit stress at identifies growth stages and its interaction on productivity of Misr1 wheat cultivar.

MATERIALS AND METHODS

Two field experiments were conduct at the Experimental Farm of Sakha Agricultural Research Station, at Kafr El-Sheikh Governorate, Agricultural Research Center, (ARC), Egypt during the two growing seasons, 2013/14 and 2014/15 respectively, to study the effect of foliar application of ascorbic and salicylic acid (water spray, Asc 100 ppm, Asc 200 ppm, sal 100 ppm, sal 200 ppm, Asc 100 ppm + sal 100 ppm, Asc 200 ppm + sal 100 ppm, Asc 200 ppm + sal 200 ppm)under water deficit stress at identify growth stages (normal irrigation,water deficit stress attillering, heading and ripening stages) and its interaction on productivity of Misr1 wheat cultivar and some water relations.

Split plot design was used in the two experiments, where the main plots included the water deficit stresses treatments and foliar application of ascorbic and salicylic acid treatments wasallocated in the sub plots. The sub plot area was 10.5 m2 (3 x 3.5 m) in both seasons. Foliar application of ascorbic and salicylic acid were done at 50 and 65 days after sowing, The mineral nitrogen fertilizer was applied in the form of urea (46.6 % N) in three doses, the first dose (20%) at sowing, which was incorporated in dry soil, the second dose (40%) was applied at the first irrigation and the third dose (40%) at the second irrigation. Before the sowing, the experimental soil was fertilized with 150 kg/fed. of calcium super phosphate (15.5% P2O5) during soil preparation. Before the soil preparation samples of soil was collected from (0-30cm layer) from the experimental sites in both seasons to for soil analysis which presented in Table (1).

Table 1. Soil analysis of the field experimental soil.

Season	EC_e (dS/m)	pH	Available (ppm)			Particle size distribution (%)			Texture class
			N	P	K	sand	silt	clay	
2013/14	1.97	7.79	20.12	10.64	341	21.1	27.1	51.8	clayey
2014/15	1.91	7.96	20.58	10.87	338				

Seed of the wheat cultivar Misr 1was sown at 22thand 27thof November in the first and second seasons, respectively. The preceding crop was corn in the two growing seasons. Seed was uniformly broadcasted at the rate of 60 kg/fed. The other cultural practices were applied as recommended by the Ministry of Agriculture.

At ripening stage the following traits were recorded: plant height (cm)and flag leaf area (cm^2). Ten flag leaves from each plot were collected when the flag leaf was fully expanded to measure flag leaf area by Leaf Area Meter (Li-Cor 3100, Lambda Instruments Co., USA). Chlorophyll a and b concentrations as mg/g fresh weight were done according to Lichtenthaler (1987). Leaves samples (0.5 g) were homogenized with acetone (90% v/v), filtered and made up to a final volume of 50 ml. Chlorophyll concentration was calculated spectrophotometerically from absorbance of extract at 663 and 645 nm.At harvest, the following traits were determined: spike length (cm), number of spikes /m^2, number of grains /spike, grain weight (g) /spik, weight of 1000-grains (g), grain yield (t/fed.) and straw yield (t/fed.).

- **Productivity of irrigation water (PIW), Field water use efficiency (kg m^{-3}):**

PIWis considered an evaluation parameter of yield per unit of applied water.

PIW = Yield (kg/feddan) / Applied water (m^3/feddan).

- **Water productivity index (WP), Crop water use efficiency (Kg m^{-3}):**

WP as a measurement used to clarify variations in yield due to water consumptive use as it calculated according to Michael (1978) as follows:

WP = Yield (kg/feddan) /Water consumptive use (m^3/feddan).

The analysis of variance was carried out according to Gomez and Gomez (1984) for all collected data. Treatment means were compared by Duncan's Multiple Range test according to Duncan (1955). All statistical analysis was performed using analysis of variance technique by means of "MSTATC" computer software package.

RESULTS AND DISCUSSION

A. Growth characters:

Chlorophyll a, chlorophyll b, plant height, and flag leaf area of wheat at ripening stage as affected by foliar application of ascorbic and salicylic acid as well as water deficit stress at identify growth stage treatments during 2013/14 and 2014/15 seasons are presented in Table (2).

Data in table (2) show that water deficit stress at different growth stage showed that a significant differences in chlorophyll a and b in both seasons. Normal irrigation recorded the highest values of chlorophyll a and b compared with the other water deficit stress treatments without significantly differences with water deficit stress at heading and ripening stages in case of chlorophyll a in both seasons. The lowest values of chlorophyll a and b resulted from water deficit stress attillering stage in both seasons. Plant height and flag leaf area recorded the highest values under normal irrigation followed by the treatment of water deficit stress atripening stage in both seasons, without significant difference between the effect of normal irrigation treatment and water deficit stress atripening stage in respect to plant height. The lowest values of plant height and flag leaf area were recorded at water deficit stress attillering stage. These results were corresponded with those findings byAmin, *et al*., 2009, Abdalla, 2011 and Azadeh *et al*., 2014, which reported that plant growth reduced by water deficit stress through affecting various physiological and biochemical processes, such as photosynthesis, translocation, nutrient metabolism and growth promoters.

Table 2. Chlorophyll a, Chlorophyll b, flag leaf area (cm^2) and plant height (cm) of wheat as affected by foliar application of ascorbic and salicylic acid under water deficit stress at identify growth stage treatments and their interaction during 2013/14 and 2014/15 seasons.

Treatment	Chlorophyll a		Chlorophyll b		Flage leaf area (cm^2)		Plant height (cm)	
	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15
Water deficit stress(W.S):								
Normal irrigation	3.50 a	3.56 a	1.87 a	1.95 a	131.77 a	134.71 a	114.49 a	116.12 a
W.S at tillering	3.07 b	3.05 b	1.35 d	1.14 d	118.01 c	119.34 b	101.49 c	104.55 d
W.S at heading	3.42 a	3.24 a	1.61 c	1.57 c	118.89 bc	119.37 b	108.18 b	107.89 c
W.S at ripening	3.45 a	3.41 a	1.79 b	1.77 b	120.05 b	119.77 b	113.59 a	113.61 b
F-test	**	**	**	**	**	**	**	**
Antioxidant:								
Water (control)	2.87 d	2.79d	1.52 f	1.51 e	115.79 e	117.83 e	102.26 e	105.36 c
Asc 100 ppm	3.15 c	3.19 c	1.59 e	1.61 d	120.35 d	121.47 d	107.90 d	108.40 b
Asc 200 ppm	3.26 c	3.17 c	1.61 de	1.64 cd	121.18 cd	123.28 c	108.29 cd	110.26 ab
sal 100ppm	3.24 c	3.18 c	1.68 bc	1.70 bc	121.90 bcd	123.01 cd	110.83 ab	111.31 a
sal 200 ppm	3.26 c	3.23 c	1.65 cd	1.65 cd	121.93 bcd	122.80 cd	110.24 bc	111.17 a
Asc 100 ppm + sal 100 ppm	3.62 b	3.55 b	1.73 ab	1.73 b	122.84 bc	123.67 c	111.28 ab	112.12 a
Asc 200 ppm + sal 100 ppm	3.76 a	3.68 ab	1.73 ab	1.74 b	124.04 b	125.87 b	112.02 ab	112.68 a
Asc 200 ppm + sal 200 ppm	3.71 ab	3.72 a	1.76 a	1.80 a	129.3 a	128.47 a	112.67 a	113.o1 a
F-test	**	**	**	**	**	**	**	**
Interaction	**	**	**	**	**	**	**	Ns

At all tables:*, ** and Ns indicate p <0.05, <0.01 and not significant, respectively. Means of each treatment followed by the same letter are not significantly different at 5% level, according to Duncan's multiple range tests.

Asc 100 ppm and Asc 200 ppm (Ascorbic acid at rate 100 and 200 ppm) and sal 100ppmand sal 200 ppm (salicylic acid at rate 100 and 200 ppm).

With regard tothe effect of foliar application of ascorbic and salicylic acidon Chlorophyll a, chlorophyll b, flag leaf areaand plant height, Data presented in table (2) revealed that the combination between ascorbic acid and salicylic acid at rate of 200 ppm of each other recorded the greatest values at all previous characters without significant differences withthe treatment of Asc 200 ppm + Sal 100 ppm in most cases in the two seasons of study. The most of antioxidant treatment showed a significant increase in plant height compared with water spray treatment. Such effect of ascorbic and salicylic acid may be attributed to the important role, which the antioxidant plays against oxidative stress, Ascorbic acid plays an important role in photosynthesis.The promoting effects of ascorbic and salicylic acid on Chlorophyll a, chlorophyll b, flag leaf area and plant height of wheat were reported by Abdelaal, (2015a), which found that application of SA led to increase in wheat plant height and chlorophyll a and b concentrations under drought stress conditions. The increase in chlorophyll concentrations may be due to the role of SA through improvement the physiological processes such as photosynthesis and antioxidant activity as well as leaves longevity, Malik *et al* (2015) reported that ascorbic acid application under drought led to overcome adverse effects of oxidative stress by maintaining growth, Amin *et al* (2008) reported that foliar application of wheat plants (*Triticumaestivum L.*) cv. Gemmiza 10 with salicylic acid at the rate of 100 mg l^{-1}combined with ascorbic acid at 200 or 400 mg l^{-1} were more effective in increasing growth characters, yield and its components in addition to photosynthetic pigments content in the leaves compared with other treatments or untreated plants.

The interaction between foliar application of ascorbic and salicylic acid and water deficit stress at identify growth stage treatments show a significant effect on Chlorophyll a, Chlorophyll b, flag leaf area and plant height in both seasons, except that plant height in the second season, table (2).

B. Yield and its components:

Data presented in Tables (3, 4 and 5) show the effect of foliar application of ascorbic & salicylic acid and water deficit stress at identify growth stage treatments on yield and its components of wheat during 2013/14 and 2014/15 seasons as well as their interaction.

The data show that water deficit stress at different growth stages showed significant differences in spike length, number of spike/m^2, numberof grains /spike, grain weight /spike and 1000 grain weight in both seasons. Normal irrigation recorded the highest values of all mentioned characters without significant differences with water deficit stress at heading and ripening stages in respect to spike length in the second season; with water stress at heading stage in respect to no. of grains/spike in the second seasons as well as with water stress at tillering stage in respect to grain weight/spike in the first season. The lowest values of these characters were recorded under water stress at ripening stage in most cases in both seasons. These findings were in conformity with those obtained by Amin, *et al.*, (2009), Abdalla, (2011), Bakry *et al.*, (2013) and Azadeh *et al.*, (2014) which reported that water deficit stress reduces plant growth by affecting various physiological and biochemical processes, such as photosynthesis, respiration, translocation, ion uptake, carbohydrates, nutrient metabolism and growth promoters.

The results in Table (3 and 4) show that the effects of foliar application of ascorbic and salicylic acid on spike length, number of spike/m^2, number of grain /spike, grain weight /spike and 1000 grain weight were significant in the two seasons of study. Data presented in the two tables showed that the combination between ascorbic acid and salicylic acid at the rate of 200 ppm recorded the highest values of each other all previous characters in both seasons, without significant differences with other foliar application treatments in some cases of these characters. Such effect of antioxidant may be attributed to the important role in photosyn thesis. The promoting effects of ascorbic and salicylic acid on spike length, number of spike/m^2, number of grains /spike, grain weight /spike and 1000 grain weight of wheat were reported by several of authors, which explain the effects of antioxidants on growth characters and its reversion on yield components as soon as Abdelaal (2015a)which reported that application of SA increased growth characters under drought stress conditions. The increment in growth characters may be due to the active role of SA in increasing nutrient contents in plant as well as improvement the physiological processes such as photosynthesis and antioxidant activity as well as leaves longevity, Malik *et al.* (2015) reported that ascorbic acid application under drought to overcome adverse effects of oxidative stress by maintaining growth, Amin *et al.* (2008) reported that foliar application of wheat plants *Triticumaestivum L.*) cv. Gemmiza 10 with salicylic acid at 100 mg l^{-1} combined with ascorbic acid at 200 or 400 mg l^{-1} were more effective in increasing growth characters, yield and its components in addition to photosynthetic pigments content the leaves compared with other treatments or untreated plants.

Table 3. Spike length (cm), Number of spike/m^2, Number of grains /spike and grain weight /spike (g) of wheat as affected by foliar application of ascorbic and salicylic acid under water deficit stress at identify growth stage treatments and their interaction during 2013/14 and 2014/15 seasons.

Treatment	Spike length(cm)		No. of spikes/m^2		No. of grains /spike		Grain wt /spik(g)	
	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15
Water deficit stress(W.S):								
Normal irrigation	15.72 a	15.51 a	397.50 a	399.21 a	85.54 a	82.83 a	3.51 a	3.57 a
W.S at tillering	11.75 d	12.97 b	357.29 c	364.88 d	63.13 d	62.96 c	3.34 a	2.61 d
W.S at heading	15.25 b	15.06 a	388.63 b	384.33 b	81.50 b	79.04 a	2.83 b	3.35 b
W.S at ripening	13.59 c	14.89 a	353.83 c	371.88 c	79.25 c	71.33 b	2.73 b	3.09 c
F-test	**	**	**	**	**	**	**	**
Antioxidant:								
Water (control)	12.83 d	13.05 f	351.00 e	346.58 e	69.17 e	66.00 c	2.80 d	2.82 f
Asc 100 ppm	13.55 c	14.018 e	357.83 e	362.33 d	73.58 d	70.92 bc	2.97 c	2.95 ef
Asc 200 ppm	13.48 c	14.48 de	366.08 d	362.58 d	76.75 c	73.58 ab	3.01 c	3.03 e
sal 100ppm	14.26 b	14.79 cd	378.33 bc	389.92 bc	78.50 bc	76.67 ab	3.12 bc	3.22 cd
sal 200 ppm	13.55 c	14.43 de	374.17 c	383 c	78.50 bc	74.67 ab	3.08 bc	3.09 de
Asc 100 ppm + sal 100 ppm	14.68 b	15.08 bc	392.50 a	394.42 ab	79.42 abc	75.83 ab	3.22 ab	3.28 bc
Asc 200 ppm + sal 100 ppm	14.91 ab	15.33 ab	385.25 ab	397.17 ab	80.92 ab	76.42 ab	3.29 a	3.38 ab
Asc 200 ppm + sal 200 ppm	15.36 a	15.79 a	389.33 a	404.58 a	82.00 a	78.25 a	3.31 a	3.44 a
F-test	**	**	**	**	**	**	**	**
Interaction	ns	ns	** ns	**	ns	ns	ns	ns

The interaction between water stress treatment and foliar application of ascorbic and salicylic acid significantly affected number of spike/m^2in both seasons and 1000 grain weight only in the first season, tables (3 and 4).

Data presented in table (4) show that water deficit stress at different growth stages recorded a highly significant differences in grain and straw yields in both seasons. Normal irrigation treatment recorded the highest values of grain and straw yields compared with the other water deficit stress treatments without significant differences with the treatment of water deficit stress at heading stage in respect of grain yield character in the first season. The treatment of water deficit stress atripening stage followed the normal irrigation in grain and straw yields in both seasons without significant differences with the treatment of water deficit stress at heading stage in most cases. The lowest values of grain and straw yields were obtained from the treatment of water deficit stress attillering stage in both seasons. Amin, *et al.*, (2009), Abdalla, (2011), Bakry *et al.*, (2013) and Azadeh *et al.*, (2014)reported that water deficit stress reduced plant growth by affecting various physiological and biochemical processes, such as photosynthesis, respiration, translocation, ion uptake, carbohydrates, nutrient metabolism and growth promoters, then it affect grain and straw yields of wheat. Shirazi *et al.* (2014) reported that the maximum grain yield was obtained from application of the tow irrigation treatments (100 mm at 30 DAS + 100 mm at 45 DAS).

Foliar application of ascorbic and salicylic acid significantly affected grain and straw yields in both seasons as shown in Table (4).The combinations between ascorbic acid and salicylic acid at the rate of 200 ppm of each other recorded the greatest grain and straw yields compared with the other treatments, without significant differences with the combination between ascorbic acid and salicylic at the rate of 200 ppm + 100 ppm, then the combination at the rate of 100 ppm + 100 ppm. The most of antioxidant treatment showed an increase ingrain and straw yields compared with water spray treatment (control), which recorded the lowest values. Such favorable effect of antioxidant on yield might have been resulted from the important role in photosynthesis, which increased vegetative growth under drought stress conditions, as soon as photosynthetic area, which resulted in more assimilates products and consequently increased dry matter accumulation and translocation of more photosynthesis to grain. These findings were in conformity with those obtained by Abdelaal (2015a)which reported that application of SA led to an increase in growth characters under drought stress conditions. The increment in growth characters may be due to the active role of SA in increasing nutrient contents in plants as well as improvement the physiological processes such as photosynthesis and antioxidant activity as well as leaves longevity. Malik *et al.* (2015) reported that ascorbic acid application under drought to overcome adverse effects of oxidative stress by maintaining growth. Amin *et al.* (2008) reported that foliar application of wheat plants (*Triticumaestivum L.*) cv. Gemmiza 10 with salicylic acid at the rate of 100 mg l^{-1} combined with ascorbic acid at the rate of 200 or 400 mg l^{-1} were more effective in increasing growth characters, yield and its components in addition to photosynthetic pigments content in the leaves compared with other treatments or untreated plants.

The interaction between water deficit stress at different growth stages and foliar application of ascorbic and salicylic acid significantly affected grain and straw yields during 2013/14 and 2014/15 seasons. as shown in table (4). Data presented in table (5) show that the different combinations of ascorbic and salicylic acid under normal irrigation treatment recorded the highest grain yield in both seasons. followed by the interaction between the treatment of water deficit stress atripening stage with the combination of ascorbic acid (200 ppm) and salicylic acid (200 ppm) in both seasons and the interaction between the treatment of water deficit stress at heading stage and the different combinations of ascorbic and salicylic acid in second season compared with the other treatments, the lowest values of grain yield were obtained from the interaction between water spray treatment and all water deficit stress treatments in both seasons. Shirazi *et al*, (2014) reported that the maximum grain yield was obtained from application of 200 mm in tow irrigation (100 mm at 30 DAS + 100 mm at 45 DAS), Bakry *et al.*, (2013) found that water irrigation requirement of (80 % IR) produced high grain yield per fad. and insignificantly out yielded the water irrigation requirements of (100 % IR). Increasing foliar application levels of ascorbic acid from 0 up to 300 mg/l significantly increased grain and straw yields per plant and per fad. as well as plant height, spike length and seed index.

Table 4. 1000 grain weight (g), Grain yield (kg/fed) and Straw yield (ton/fed.) of wheat as affected by foliar application of ascorbic and salicylic acid under water deficit stress at identify growth stage treatments and their interaction during 2013/14 and 2014/15 seasons.

Treatment	1000 grain weight (gm)		Grain yeild (kg/fed)		Straw yeild (t./fed.)	
	2013/1	2014/1	2013/1	2014/1	2013/	2014/1
Water deficit stress(W.S):						
Normal irrigation	45.97	48.09	3025.00	3101.5	3.41 a	3.77 a
W.S at tillering	41.33	34.47	2597.88	2448.4	2.81 c	2.70 c
W.S at heading	44.56	42.86	2967.44	2649.9	3.27 b	3.23 b
W.S at ripening	34.75	32.99	2878.69	2520	3.23 b	2.87
F-test	**	**	**	**	**	**
Antioxidant:						
Water (control)	39.22	36.47	2611.25	2502.8	2.75 e	2.81 d
Asc 100 ppm	39.70	37.95	2630.88	2551.1	2.89	2.91
Asc 200 ppm	41.17	38.49	2686.00	2584.1	3.04	2.97 c
sal 100ppm	41.18	39.98	2941..1	2739.3	3.27 b	3.18 b
sal 200 ppm	41.53	39.51	2867.38	2684.5	3.21	3.18 b
Asc 100 ppm + sal	42.48	40.35	3022.25	2782	3.38	3.34 a
Asc 200 ppm + sal	43.53	41.70	3072.88	2775.9	3.38	3.32 a
Asc 200 ppm + sal	44.44	42.36	3106.25	2820.1	3.52 a	3.44 a
F-test	**	**	**	**	**	**
Interaction	**	ns	*	*	*	**

Table 5. Grain yieldkg/fed. of wheat as affected by the interaction between foliar application of ascorbic & salicylic acid and water deficit stress at identify growth stage treatment during 2013/14 and 2014/15 seasons.

Water deficit stress (W.S) Antioxedant	Normal irrigation		W.S at tillering		W.S at heading		W.S at ripening	
	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15
Water (control)	2669.0 ij	2731.0 cde	2438.0 kl	2303.0 i	2616.5 ijk	2566.0 e-i	2721.5 hij	2411.0 ghi
Asc 100 ppm	2708.5 hij	2881.0 cd	2371.0 l	2306.5 i	2655.0 ij	2575.5 e-i	2789.0 f-i	2441.5 f-i
Asc 200 ppm	2799.0 f-i	2931.5 bc	2403.5 l	2347.0 hi	2743.5 g-j	2581.0 e-h	2798.0 f-i	2477.0 e-i
sal 100ppm	3131.5 a-d	3275.0 a	2664.0 ij	2466.5 e-i	3070.0 b-e	2693.0 c-f	2899.0 e-h	2522.5 e-i
sal 200 ppm	3044.0 b-e	3136.0 ab	2556.0 jkl	2456.0 e-i	2984.5 c-f	2647.0 d-g	2885.0 e-h	2499.0 e-i
Asc 100 ppm + sal 100 ppm	3251.5 ab	3356.5 a	2733.5 hij	2530.0 e-i	3187.5 abc	2703.0 c-f	2916.5 e-h	2538.5 e-i
Asc 200 ppm + sal 100 ppm	3305.5 a	3218.0 a	2795.0 f-i	2564.5 e-i	3240.5 ab	2710.5 c-f	2950.5 d-g	2610.5 e-h
Asc 200 ppm + sal 200 ppm	3291.0 a	3283.0 a	2822.0 f-i	2614.0 e-h	3242.0 ab	2723.5 cde	3070.0 b-e	2660.0 d-g

Table 6. Water applied (m^3/fed.), water consumption (m^3/fed.), Productivity of irrigation water (kg/m^3) , and water productivity index (kg/m^3) of wheat as affected by foliar application of ascorbic and salicylic acid under water deficit stress at identify growth stages during 2013/14 and 2014/15 seasons.

Treatment	Water applied (m^3/fed.)		Water consumtion (m^3/fed.)		Productivity of irrigation water (PIW)		Water productivity index (WP)	
	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15
Water deficit stress(W.S):								
Normal irrigation	1965.08	2353.41	1287.03	1254.46	1.539375	1.318	2.350	2.472
W.S at tillering	1697.41	1736.30	1113.06	1064.98	1.5305	1.410	2.334	2.299
W.S at heading	1869.25	1755.92	1209.10	853.88	1.5875	1.509	2.454	3.103
W.S at ripening	1850.50	1709.05	1215.34	847.99	1.555625	1.475	2.369	2.972
Antioxidant:								
Water (control)	1744.32	1881.45	1173.86	977.66	1.497	1.330	2.225	2.560
Asc 100 ppm	1714.21	1875.46	1157.96	982.51	1.53475	1.360	2.272	2.597
Asc 200 ppm	1723.45	1862.08	1143.47	986.96	1.5585	1.388	2.349	2.618
salicylic 100ppm	1918.86	1945.18	1263.91	1030.78	1.53275	1.408	2.327	2.658
salicylic 200 ppm	1845.75	1866.83	1199.49	975.03	1.553	1.438	2.391	2.753
Asc 100 ppm + sal100 ppm	1949.21	1894.45	1252.88	1002.52	1.5505	1.469	2.412	2.775
Asc 200 ppm + sal100 ppm	1947.33	1851.53	1231.74	978.46	1.578	1.499	2.495	2.837
Asc 200 ppm + sal 200 ppm	1916.26	1842.00	1220.77	973.96	1.621	1.531	2.545	2.896

Water relations:

Data of total water applied (m3/fed.), water consumption (m3/fed.), Productivity of irrigation water (PIW) and water productivity index (WP) in both seasons are presented in Table (7). The obtained results clearly show that the treatment of normal irrigation received the highest values of total water applied (m3/fed.) and water consumption (m3/fed.) while, the treatment of water deficit stress at heading and ripening stages recorded the greatest values of Productivity of irrigation water (PIW) and water productivity index (WP),These results are in accordance with those obtained by Bakry *et al.*, (2013) study the effect of drought stress (100 % IR, 80 % IR and 60 % IR) on yield and irrigations water use efficiency of wheat they found that water irrigation requirement of (80 % IR) produced the highest irrigations water use efficiency and high grain yield per fad.

Table 7. Productivity of irrigation water (PIW) and water productivity index (WP) of wheat as affected by the interaction between foliar application of ascorbic and salicylic acid and the treatments of water deficit stress at identify growth stages during 2013/14 and 2014/15 seasons.

Factors	Productivity of irrigation water (PIW) (Kg m-3)							
	Water deficit stress							
	Normal irrigation		Drought at tillering		Drought at heading		Drought at ripening	
Antioxidant	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15
Water (control)	1.493	1.223	1.454	1.327	1.526	1.38	1.515	1.391
Asc 100	1.562	1.254	1.461	1.350	1.587	1.427	1.529	1.410
Asc 200	1.544	1.258	1.506	1.380	1.653	1.514	1.531	1.399
sal 100	1.514	1.283	1.511	1.398	1.571	1.525	1.535	1.427
salc 200	1.516	1.276	1.577	1.420	1.563	1.556	1.558	1.500
Asc 100 + sal 100	1.520	1.392	1.568	1.432	1.537	1.534	1.577	1.516
Asc 200 + sal 100	1.576	1.414	1.573	1.457	1.571	1.571	1.592	1.555
Asc 200 +sal 200	1.590	1.443	1.594	1.517	1.692	1.566	1.608	1.598

Factors	Water productivity index (Kg m^{-3})							
	Water deficit stress							
	Normal irrigation		Drought at tillering		Drought at heading		Drought at ripening	
Antioxidant	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15
Water (control)	2.238	2.299	2.170	2.133	2.275	2.932	2.215	2.876
Asc 100	2.268	2.324	2.205	2.195	2.338	2.968	2.277	2.899
Asc 200	2.323	2.326	2.221	2.224	2.47	3.033	2.382	2.89
sal 100	2.329	2.397	2.283	2.256	2.312	3.045	2.384	2.932
sal200	2.385	2.597	2.364	2.330	2.433	3.153	2.380	2.933
Asc 100 + sal 100	2.389	2.600	2.406	2.371	2.531	3.198	2.323	2.931
Asc 200 + sal 100	2.409	2.589	2.433	2.398	2.574	3.247	2.563	3.114
Asc 200 +sal 200	2.462	2.647	2.590	2.485	2.701	3.251	2.425	3.199

Regarding to the effect of foliar application of ascorbic and salicylic acid on water relations in both seasons showing in Table (7). Data revealed that the combination between ascorbic (200 ppm) and salicylic acid (200) recorded the highest Productivity of irrigation water (PIW) and water productivity index (WP) compared with the other treatments. Similar results were obtained by Malik *et al*(2015) reported that ascorbic acid application under drought to overcome adverse effects of oxidative stress by relative water content, osmotic adjustment through proline accumulation and by enhanced activity of antioxidant enzymes, Farjam *et al*(2015) showed that ascorbic acid application increased rate of biological water use efficiency significantly as compared with control plants Such effect of ascorbic and salicylic acid could be its involved in various physiological processes in plants, such as growth regulation, photosynthesis, nutrient uptake, plant water relations and mechanisms of plant resistance and tolerance to biotic and abiotic stresses which play a rolein the defense against oxidative stress.

Data presented in Table 8 showed that the effect of interaction between foliar application of ascorbic & salicylic acid and the treatments of water deficit stress at identify growth stages on Productivity of irrigation water (PIW) and water productivity index (WP) during 2013/14 and 2014/15 seasons. It could be concluded that the combination between both salicylic and ascorbic acid with water deceit stress treatments recorded the highest values of Productivity of irrigation water (PIW) and water productivity index (WP) during 2013/14 and 2014/15 seasons compared with the other interaction. Similar results were obtained by Bakry *et al.*, (2013) reported that the interaction between the water irrigation requirements of (80% IR) and (300 mg/L) foliar application level of ascorbic acid gave the highest values of grain and yields per fad. and water use efficiency.

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تأثير الرش ببعض مضادات الاكسدة والاجهاد المائى عند مراحل نمو محددة على انتاجية محصول القمح

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أجريت تجربتان حقليتان بالمزرعة البحثية بمحطة البحوث الزراعية بسخا بمحافظة كفر الشيخ - مصر خلال موسمى 2013/ 2014 و 2014/ 2015 لدراسة تأثير الرش بحمض الاسكوربيك وحمض السلسليك والاجهاد المائى عند مراحل نمو محددة والتفاعل بينهما على انتاجية صنف القمح مصر 1 وقد استخدم تصميم القطع المنشقه فى ثلاث مكررات فى تنفيذ الدراسة حيث اشتملت القطع الرئيسية على معاملات الاجهاد المائى (الرى المنتظم، الاجهاد المائى (اسقاط رية) عند مراحل التفريع ، الطرد ، النضج) بينما فى القطع الشقيه قد وزعت معاملات الرش بحمض الاسكوربيك والسلسليك (الرش بالماء ، حمض الاسكوربيك 100، ppm200 ، حمض السلسليك 100، ppm 200 ، حمض الاسكوربيك ppm 100 + حمض السلسليك ppm100 ، حمض الاسكوربيك ppm200+ حمض السلسليك 100أو ppm 200) و كانت النتائج المتحصل عليها كما يلى :- سجلت معاملة الرى المنتظم القيم الاعلى معنوية في صفات كلورفيل أ ، كلورفيل ب ، ومساحة الورقة العلم ، ارتفاع النبات ، وطول السنبلة ، وعدد السنابل/م^2، عدد الحبوب / سنبلة ، وزن الحبوب / سنبلة ، وزن الالف حبة ، محصول الحبوب / فدان ، محصول القش / فدان وبدون اختلافات معنوية مع معاملة الاجهاد المائى عند مرحلتي الطرد والنضج في صفات كلورفيل أ في كلا الموسمين ، ولم تختلف معاملة الري المنتظم مع معاملات الاجهاد المائي عند مراحل التفريع الطرد والنضج في صفات وزن الحبوب / السنبلة ومحصول الحبوب/فدان وارتفاع النبات على التوالي في الموسم الاول ومع معاملات الاجهاد المائي عند مرحلة الطرد في صفات عدد الحبوب/ سنبلة وطول السنبلة وفي صفة طول السنبلة عند مرحلة النضج في الموسم الثاني فقط. سجلت التواليف بين حمض الاسكوربيك والسلسليك القيم الاعلى معنوية في معظم الصفات مثل كلورفيل أ ، ارتفاع النبات ، طول السنبلة ، عدد السنابل /م^2 ، عدد الحبوب / السنبلة ، وزن الحبوب / السنبلة، محصول الحبوب / فدان ، محصول القش / فدان بالمقارنة بالمعاملات الاخرى في كلا الموسمين وفى نفس الاتجاه كانت صفة كلورفيل ب في الموسم الاول وصفة وزن الالف حبة في الموسم الثاني وقد سجلت التوليفة بين حمض الاسكوربيك (ppm200) وحمض السلسيلك (ppm200) القيم العظمى لصفات مساحة الورقة العلم في كلا الموسمين وصفة ووزن الالف حبة وكلورفيل (ب) في الموسم الاول والثاني على التوالي .فى حين سجل التفاعل بين تواليف حمض الاسكوربيك والسلسليك مع الري المنتظم القيم الاعلى معنوية لصفة محصول الحبوب/ فدان في كلا الموسمين بدون اختلافات معنوية مع نفس التواليف من حمض الاسكوربيك والسلسليك مع الاجهاد المائي عند مرحلة الطرد في الموسم الاول . قد استقبلت معاملة الري المنتظم اعلى كمية من المياة المضافة (م^3/فدان) ، والاستهلاك المائي (م^3/فدان) بينما اظهرت معاملات الاجهاد المائي عند مرحلتي الطرد والنضج تفوقا فى انتاجية مياة الري (كجم/م^3) ودليل انتاجية المياة (كجم/م^3) وقد سجلت التواليف بين حمض الاسكوربيك والسلسليك اعلى القيم فى صفات كمية المياه المضافة ، الاستهلاك المائى ، وانتاجية مياه الرى ، ودليل انتاجية المياة بالمقارنة بمضادات الاكسدة الاخرفى كلا الموسمين. قد سجلت معاملة (حمض الاسكوربيك ppm200 + حمض السلسليك 100أو ppm 200) اعلى انتاجية لمياه الرى و ودليل انتاجية المياة عند كل معاملات الاجهاد المائى، وقد اعطت معاملة الرش بالماء اقل القيم فى كل الصفات السابقة عند كل معاملات الاجهاد المائى. من النتائج السابقة وتحت ظروف هذه الدراسة يمكن نستخلص ان اضافة تواليف من حمض الاسكوربك(بتركيز 200 جزء فى المليون) + حمض السلسليك (بتركيز 100 او 200 جزء فى المليون) رشا تحت ظروف الرى المنتظم او الاجهاد المائى عند مرحلة الطرد (اسقاط ريه) قد اعطت اعلى إنتاجية من محصول القمح (صنف مصر 1) مع زيادة قيمة كلا من انتاجية مياه الرى ودليل انتاجية مياه الرى (كجم/م^3) .