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Website: http://www.aun.edu.eg/faculty_agriculture *E-mail: ajas@aun.edu.eg*

Response of Two Bread Wheat Cultivars to Foliar Spray by Salicylic and Ascorbic Acids under Water Stress Conditions

M.T. Said[*1] and A.M.A. Abd El-Moneem[2]

[1]Agronomy Department, Faculty of Agriculture, Assiut University, Assiut, Egypt

[2]Agronomy Department, Faculty of Agriculture (New valley branch), Assiut University, Assiut, Egypt

[*]Corresponding author: mtharwat@aun.edu.eg

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Abstract

Three field experiments were conducted at El-Wady El-Assiuty Experimental Farm, Agriculture Faculty, Assiut University, Assiut Governorate during 2013/2014 and 2014/2015 seasons to study the effect of foliar spray by antioxidant (salicylic and ascorbic acids) on the productivity of two bread wheat cultivars. Each experiment was subjected to one of three levels of evapotranspiration (100% or 75% or 50% of ET i.e. 4800, 3600 and 2400 m^3, respectively) including two factors i.e wheat cultivars (Masr1 and Shandaweel 1) and three treatments of antioxidant (100 ppm salicylic, 100 ppm ascorbic and 100 ppm salicylic + 100 ppm ascorbic) using randomized complete block design in split plot arrangement with three replications. The obtained results showed that all studied factors and their involved interactions had significant effects on most of studied traits in the two growing seasons. Thus, the highest mean values of grain yield (3.24 and 3.27-ton ha^{-1} in the first and second seasons, respectively) were obtained from Masr 1 cultivar under 75% ET with 100 ppm Salicylic acid as foliar spray, while, the highest mean values of WUE (1.24 and 1.17 kg m^{-3} in the first and second seasons, respectively) were obtained from Masr 1 cultivar irrigated by 50% ET and sprayed by 100 ppm ascorbic acid.

Keywords: *sprinkler irrigation, water stress, sandy soil, Triticum aestivum*

Introduction

Wheat is the most common crop in the world compared to other cereals especially in developing countries (Said *et al.,* 2015). There is a big gap between wheat production and its consumption in Egypt reached about 52.1% (FAO, 2013) and one of the possible ways to fill this gap is growing wheat in newly reclaimed soils. Usually, in this type of soils modern irrigation systems are used on behalf of surface irrigation as these systems can serve adequate amount of water, hence, additional agricultural area could be added then additional production could be gained. A reduction in grain yield of wheat could be occurred under limited irrigation, but it depends on the time, duration and the degree of the imposed soil moisture deficit (Singh *et al.,* 1991). For more serving water the amount of irrigation water should be reassessed depend on the region and climatic factors of the cultivated area. The previous studies on the impact of water deficit on the grain yield and water use efficiency (WUE) of wheat and corn revealed that in some cases, quality could be improved as well as grain and biological yields could be largely maintained, while substantially reduction in irrigation volume could be done (Yang *et al.,* 2000, Musick *et al.,* 1994, Zhang and Oweis, 1999,Yang *et al.,* 2000, Abdelraouf *et al*.,2013, Abd El-Waheda and Ali (2013) and Jiang *et al*., 2013). In addition, Kang *et al.* (2002) concluded that wheat could be efficiently grown over a large range of irrigation amounts and seasonal water use. The most common irrigation method for wheat in sandy soil is sprinkler irrigation as it can easily distribute the irrigation water uniformly especially in slow wind conditions. Furthermore, sprinkler irrigation is a technique for fertigation and accurately controlling irrigation time and water amount (Li and Rao, 2003).

Ascorbic acid (AA) is considered as one of the most effective growth regulators against a biotic stress (Conklin, 2001). AA not only acts as an antioxidant but the cellular levels of AA are correlated with the activation of complex biological defense mechanisms (Conklin & Barth, 2004). It has also been used to counteract the adverse effects of salt and drought stress in many crop plants and proposed functions in whole plant metabolism (Debolt *et al*., 2007 and Beltagi, 2008). Furthermore, experimental studies on different plants have shown that exogenous application of AA may reduce drought stress adverse effects and leading to a significant increment of growth and yield (Salama, 2009). Salicylic acid (SA) acts as an endogenous signal molecule responsible for inducing abiotic stress tolerance and regulating the physiological processes in plant (Shakirova *et al*., 2003, Gunes *et al.,* 2007).

According to this, the present study was undertaken to investigate the effect of foliar spray with antioxidants, i.e. ascorbic and salicylic acids on productivity as well as water use efficiency of two bread wheat cultivars grown under different levels of water stress.

Materials and Methods

This work was carried out at El-Wady El-Assiuty Experimental Farm, Agriculture Faculty, Assiut University, Assiut Governorate (lat. 27° 16' N, long 31° 34' and alt. 53 m asl) during 2013/2014 and 2014/2015 seasons to study the effect of foliar spray by salicylic and ascorbic acids on the productivity of two bread wheat cultivars as well as water use efficiency under three irrigation levels.

Soil type of experimental site:

The mechanical and chemical analyses of the experimental sites of the soil are presented in Table 1.

Table 1. Some physical and chemical properties of experimental sites:

Properties	2013/2014	2014/2015
Mechanical analysis		
Sand	84.4	86.5
Slit	8.7	7.3
Clay	6.9	6.2
Soil type	Sandy	Sandy
Chemical analysis		
pH	8.34	8.26
Organic matter %	0.097	0.095
Total N%	0.018	0.019
Total $CaCO_3$%	20.26	19.85

Experimental design

Three separates experiments were done and each experiment was subjected to one of studied irrigation levels (100%, 75% and 50% of irrigation water requirements which covered evapotranspiration in this area). Each experiment was done using randomized complete block design using split plot arrangement with three replications. Three treatments of antioxidants, 100 ppm salicylic, 100 ppm ascorbic and 100 ppm salicylic + 100 ppm ascorbicplus control were arranged in main plots while, two bread wheat cultivars (Masr 1 and Shandaweel 1) were allocated in sub plots.

The experimental units were 5 x 5m and the amount of irrigation water requirements which covered the evapotranspiration in this area reached 4800 m^3 ha^{-1} according to Mohamed, 2007 and the studied irrigation levels were described as follows:

1. I_{50} as 50% of evapotranspiration added as sprinkler irrigation with 3-days intervals for 1 hour/irrigation after calculating the mean of sprinkler discharge.
2. I_{75} as 75% of evapotranspiration added as sprinkler irrigation with 3-days intervals for 1.5 hours/irrigation.
3. I_{100} as 100% of evapotranspiration added as sprinkler irrigation with 3-days intervals for 2 hours/irrigation.

The schedule of stress irrigation levels did not start until 25 days after sowing dates.

Agricultural practices

Sowing was done at December 2nd and 4th in 2013/2014 and 2014/2015 seasons, respectively, using hand drilling 15 cm apart using 150 kg ha^{-1} as a seeding rate and the preceding crop was sorghum in both seasons. All other cultural practices were done according to the standard recommendations for sowing wheat in this area.

Characteristics measurements

After maturity, a random sample of ten guarded stems from each sub plot was taken then plant height in cm, number of spikes m^{-2}, spike length in cm, spikelets number $spike^{-1}$ and 1000-kernel weight in g were measured. To determine biological and grain yields, one square meter was harvested and weighted then thrashed and converted to ton ha^{-1}.

Water use efficiency (WUE) values as kg grain m^{-3} of the applied water were calculated for different treatments according the equation described by Jensen (1983).

WUE = Grain yield (kg ha^{-1}) /water applied (m^3 ha^{-1})

Statistical analysis

Data were analyzed by MSTAT-C (1991) software package. Separate analysis of variance using randomized complete block design (RCBD) was carried out for each irrigation level. Bartlett's test for variance homogeneity was done following Snedecor and Cochran (1989), then combined analysis for data from all irrigation levels was also carried out for each year according to Gomez and Gomez (1984). Means were compared by revised Least Significant Difference (RLSD) at 5% level of significant (Steel and Torrie, 1981).

Results and Discussions

Effect of Irrigation Levels:

Data presented in Table 2 reveal that the investigated irrigation levels had significant effects on all studied traits in both seasons except spike length and number of spikes m^{-2} traits. Thus, the tallest wheat plants (74.42 and 77.17 cm), the highest mean values of spikelets spike^{-1} (16.25 and 18.08), seed index (27.52 and 30.94 g), and grain yield (2.13 and 2.56 ton ha^{-1}) in the first and second seasons, respectively were obtained from wheat plants subjected to 100 % evapotranspiration. While, the height mean values of biological yield (6.74 and 7.56 ton ha^{-1} in the first and second seasons, respectively) were obtained from wheat plants subjected to 75 and 100% evapotranspiration in the first and second seasons, respectively. On the other hand, the highest mean values of water use efficiency (0.76 and 0.79 kg m^{-3}) were recorded from 50% of evapotranspiration in the first and second seasons, respectively. The previous results can be ascribed by the role of water in physiological process and water stress at anthesis reduces pollination and thus less number of grains are formed per spike which results in the reduction of grain yield (Ashraf, 1998). Adequate water at or after anthesis period not only allows the plant to increase photosynthesis rate but also gives extra time to translocate the carbohydrate to grains (Zhang and Oweis, 1999) which improves grain size and thereby lead to increase grain yield. Also, Saini and Westgate (2000) reported that water stress initially affected kernel development, which resulting in a decrease in sink potential of kernel, and during the linear fill or its later stages of development, it inhibited the enzyme activity directly, thereby causing premature desiccation. Our results are in a good line with those obtained by Musick *et al.* (1994), Kang *et al.* (2002), Abdrabbo *et al*. (2016), Labuschagne *et al*. (2016), Tari (2016) and Zeleke and Nendel (2016).

Table 2. Effect of irrigation levels on yield and its attributes traits of wheat.

Season	Irrigation	Plant height (cm)	Spike length (cm)	Spikes number m^{-2}	Spikelets number $spike^{-1}$	Seed index (g)	Biological yield (ton ha^{-1})	Grain yield (ton ha^{-1})	Water use efficiency (Kg m^{-3})
2013/ 2014	I_{50}	64.21	8.08	252.17	15.08	24.28	5.36	1.82	0.76
	I_{75}	72.75	8.71	255.83	15.58	25.80	6.74	2.11	0.58
	I_{100}	74.42	8.65	266.17	16.25	27.52	6.47	2.13	0.44
F Test		**	**NS**	**NS**	**	**	**	*	**
Rev L.S.D 0.05		**0.73**	**-**	**-**	**0.35**	**1.28**	**0.61**	**0.24**	**0.09**
2014/ 2015	I_{50}	66.25	9.50	302.69	17.25	27.57	5.61	1.90	0.79
	I_{75}	74.96	9.63	320.48	17.42	28.79	7.50	2.46	0.68
	I_{100}	77.17	9.77	307.39	18.08	30.94	7.56	2.56	0.53
F Test		**	**NS**	**NS**	**	**	**	**	**
Rev L.S.D 0.05		**0.54**	**-**	**-**	**0.37**	**1.04**	**0.68**	**0.58**	**0.11**

NS, * and ** means not significant, significant at 0.05 and 0.01 probability, respectively.

Effect of antioxidant foliar spray:

Exhibited data in Table 3 show that foliar spray of wheat plants by salicylic and /or ascorbic acid enhanced significantly all studied traits in both seasons except number of spikelets spike $^{-1}$ in the second season only as compared to control. Thus, the highest mean values of plant height (74.00 and 76.44 cm), spikes number m^{-2} (289.56 and 335.04), grain yield (2.37 and 2.57-ton ha^{-1}) and water use efficiency (0.70 and 0.75 kg m^{-3}) in the first and second seasons, respectively as well as the height mean value of biological yield (7.16 ton ha^{-1}) in the second season were obtained from plants sprayed by 100 ppm of ascorbic acid. While, the spike length and Spikelets number $spike^{-1}$ were increased by foliar spray at 100 ppm salicylic acid in both seasons. Furthermore, the obtained results revealed that spraying plants with ascorbic and salicylic acids together reduced significantly all studied traits except seed index in both seasons. Experimental studies on different plants have shown that exogenous application of AA may reduce water stress adverse effects and results in a significant increment of growth and yield (Salama, 2009). These findings are in harmony with those obtained by Shakirova *et al.*(2003), Debolt *et al.* (2007), Gunes *et al.*(2007) and Salama (2009).

Table 3. Effect of antioxidant foliar spray on yield and its attributes traits of wheat.

Season	Antioxidant	Plant Height (cm)	Spike length (cm)	Spikes number m^{-2}	Spikelets number $spike^{-1}$	Seed index (g)	Biological yield (ton ha^{-1})	Grain yield (ton ha^{-1})	Water use efficiency (Kg m^{-3})
2013/2014	Control	68.83	8.25	248.96	15.89	23.47	5.80	1.79	0.52
	Ascorbic 100 ppm	74.00	8.17	289.56	15.33	26.12	6.59	2.37	0.70
	Salicylic 100 ppm	71.44	9.06	257.11	16.33	26.88	6.61	2.08	0.63
	Ascorbic & Salicylic 100 ppm	67.56	8.44	236.59	15.00	27.00	5.76	1.84	0.54
F Test		**	**	**	*	**	**	**	**
Rev L.S.D 0.05		**0.70**	**0.50**	**16.50**	**0.83**	**0.73**	**0.32**	**0.17**	**0.06**
2014/2015	Control	71.00	9.31	303.60	17.44	27.08	6.44	2.08	0.60
	Ascorbic 100 ppm	76.44	9.58	335.04	17.56	28.49	7.16	2.57	0.75
	Salicylic 100 ppm	73.94	9.86	293.88	17.89	30.35	6.82	2.30	0.66
	Ascorbic & Salicylic 100 ppm	69.78	9.78	308.22	17.44	30.48	7.13	2.28	0.67
F Test		**	**	**	NS	**	*	**	**
Rev L.S.D 0.05		**0.29**	**0.22**	**16.06**	**-**	**1.18**	**0.45**	**0.20**	**0.07**

NS, * and ** means not significant, significant at 0.05 and 0.01 probability, respectively.

Effect of wheat cultivars:

Data in Table 4illustrate that the two bread wheat cultivars differed significantly in all studied traits in the two growing seasons. Masr 1 cultivar surpassed Shandaweel 1 in all studied traits except spike length and spikelets number $spike^{-1}$.The differences between the two cultivars are mainly due to the interaction between their genetic make up during growth periods and to the environmental factors prevailing during development which was suitable for Masr 1 cultivar than the other one. Morover, superiority of Masr 1 cultivar in grain yield can be ascribed to the superiority in yield attributes such as number of spikes m^{-2} and seed index. Ibrahim *et al.* (2016) stated that the studied wheat genotypes varied significantly for yield and its components. since, Giza -168 and Sakha-93 cultivars surpassed the other tested cultivars in spike length, number of grain $spike^{-1}$ and grain yield. The results of current study are in harmony with those recorded by Abdrabo *et al.* (2016) Zeleke and Nendel (2016).

Table 4. Effect of wheat cultivars on yield and its attributes traits of wheat.

Seasons	Cultivar	Plant Height (cm)	Spike length (cm)	Spikes Number m^{-2}	Spikelets number $spike^{-1}$	Seed index (g)	Biological yield (ton ha^{-1})	Grain yield (ton ha^{-1})	Water use efficiency (Kg m^{-3})
2013/2014	Masr1	70.75	8.25	259.04	15.44	27.45	6.25	2.15	0.66
	Shan1	70.17	8.71	257.07	15.83	24.29	6.13	1.89	0.54
F Test		*	**	NS	NS	**	NS	**	**
2014/2015	Masr1	73.17	9.24	312.22	17.22	31.17	6.93	2.45	0.73
	Shan1	72.42	10.03	308.15	17.94	27.04	6.85	2.16	0.61
F Test		*	**	NS	**	**	NS	**	**

NS, * and ** means not significant, significant at 0.05 and 0.01 probability, respectively.

Effect of the interactions:

Concerning the first order interaction between irrigation levels and antioxidant foliar spray, the data presented in Tables 5 and 6reveal that the most studied traits were affected significantly by the previous interaction in both seasons. Thus, the highest mean values of grain yield (2.78 and 2.96 ton ha^{-1} in the first and second seasons, respectively) were obtained from the plants irrigated with 75% ET and sprayed by 100 ppm ascorbic acid.

The illustrated data in Table 7reveal that the first order interaction between irrigation levels and cultivars had a significant influence on all studied traits in the two growing except spike length in the second season and spikelets number $spike^{-1}$ in both growing seasons. Since, the highest mean values of plant height (78.25 and 80.42 cm in the first and second seasons respectively) were obtained from Shandaweel 1 cultivar irrigated by 100% ET. Here too, the highest mean values of spikes number m^{-2} (301.11 and 349.22 in the first and second seasons, respectively) were registered from Masr 1 cultivar irrigated by 75 and 50 % ET in the first and second seasons, respectively. While, Shandaweel 1 cultivar irrigated by 100 % ET gave the highest mean values of spikeletes number $spike^{-1}$(16.83 and 18.50 in the first and second seasons, respectively). Otherwise, Masr 1 cultivar irrigated by the 100% ET gained the highest mean values of seed index (28.33 and 32.47 g in the first and second seasons, respectively). Also, the highest grain yield (2.61 and 3.08ton ha^{-1} in the first and second seasons, respectively) were recorded from Masr 1 cultivar irrigated by 75% ET. Furthermore, Masr 1 cultivar subjected to the lowest amount of irrigated water (50% of ET) produced the highest mean values of water use efficiency (WUE) which reached about 0.89 and 0.88 in the first and second seasons, respectively.

Table 5. Effect of the interaction between irrigation levels and antioxidant foliar spray on plant height, spike length, number of spikes per plant, spikelet number per spike.

Season	Antioxidant	Plant height (cm)			Spike length (cm)			Spikes number m^{-2}			Spikelets number $spike^{-1}$		
		I_{50}	I_{75}	I_{100}	I_{50}	I_{75}	I_{100}	I_{50}	I_{75}	I_{100}	I_{50}	I_{75}	I_{100}
2013/2014	Control	57.00	71.33	78.17	7.75	8.25	8.75	258.22	249.56	239.11	14.33	16.00	17.33
	Ascorbic 100 ppm	71.50	76.50	74.00	7.83	8.50	8.17	280.44	292.89	295.33	14.67	15.67	15.67
	Salicylic 100 ppm	66.67	74.83	72.83	8.58	9.25	9.33	234.22	257.11	280.00	16.33	15.67	17.00
	Ascorbic & Salicylic 100 ppm	61.67	68.33	72.67	8.17	8.83	8.33	235.78	223.78	250.22	15.00	15.00	15.00
F test		**			NS			NS			NS		
Rev L.S.D 0.05		1.21			-			-			-		
2014/2015	Control	58.17	73.17	81.67	9.08	9.00	9.83	314.22	284.81	311.78	16.00	17.67	18.67
	Ascorbic 100 ppm	73.33	78.83	77.17	9.33	10.00	9.42	327.33	344.44	333.33	17.33	17.33	18.00
	Salicylic 100 ppm	69.83	76.83	75.17	9.92	9.50	10.17	290.96	316.22	274.44	18.00	17.67	18.00
	Ascorbic & Salicylic 100 ppm	63.67	71.00	74.67	9.67	10.00	9.67	278.22	336.44	310.00	17.67	17.00	17.67
F Test		**			**			**			*		
Rev L.S.D 0.05		0.50			0.38			30.43			1.27		

NS, * and ** means not significant, significant at 0.05 and 0.01 probability, respectively.

Table 6. Effect of the interaction between irrigation levels and antioxidant foliar spray on seed index, biological yield, grain yield, water use efficiency.

Season	Antioxidant	Seed index (g)			Biological yield (ton ha^{-1})			Grain yield (ton ha^{-1})			Water use Efficiency (Kg m^{-3})		
		I_{50}	I_{75}	I_{100}	I_{50}	I_{75}	I_{100}	I_{50}	I_{75}	I_{100}	I_{50}	I_{75}	I_{100}
2013/2014	Control	22.54	21.21	26.65	4.37	5.94	7.08	1.57	1.62	2.18	0.66	0.45	0.45
	Ascorbic 100 ppm	26.31	26.78	25.27	6.11	7.35	6.33	2.09	2.78	2.24	0.87	0.77	0.47
	Salicylic 100 ppm	23.02	29.30	28.32	6.02	7.54	6.27	1.94	2.48	1.83	0.81	0.69	0.38
	Ascorbic & Salicylic 100 ppm	25.28	25.92	29.82	4.93	6.13	6.21	1.68	1.55	2.30	0.70	0.43	0.48
F Test		**			**			**			**		
Rev L.S.D 0.05		1.30			0.57			0.30			0.10		
2014/2015	Control	28.10	24.19	28.96	4.70	6.85	7.77	1.66	2.11	2.46	0.69	0.59	0.51
	Ascorbic 100 ppm	27.41	28.58	29.48	6.07	7.93	7.50	2.06	2.96	2.68	0.86	0.82	0.56
	Salicylic 100 ppm	25.64	33.87	31.54	5.45	8.05	6.97	1.70	2.82	2.38	0.71	0.78	0.50
	Ascorbic & Salicylic 100 ppm	29.14	28.53	33.78	6.23	7.18	8.00	2.15	1.97	2.72	0.90	0.55	0.57
F Test		**			**			**			**		
Rev L.S.D 0.05		2.06			0.80			0.36			0.13		

NS, * and ** means not significant, significant at 0.05 and 0.01 probability, respectively.

Table 7. Effect of the interaction between irrigation levels and cultivars on yield and its attributes traits of wheat.

Season	Irrigation	Cultivar	Plant height (cm)	Spike length (cm)	Spikes number m^{-2}	Spikelets Number $spike^{-1}$	Seed index (g)	Biological yield (ton ha^{-1})	Grain yield (ton ha^{-1})	Water use efficiency (Kg m^{-3})
2013/2014	I_{50}	Masr1	64.25	8.21	228.11	15.00	27.23	5.77	2.14	0.89
		Shan1	64.17	7.96	276.22	15.17	21.34	4.94	1.50	0.62
	I_{75}	Masr1	77.42	8.67	301.11	15.67	26.78	7.59	2.61	0.72
		Shan1	68.08	8.75	210.56	15.50	24.83	5.90	1.60	0.45
	I_{100}	Masr1	70.58	7.88	247.89	15.67	28.33	5.38	1.68	0.35
		Shan1	78.25	9.42	284.44	16.83	26.70	7.56	2.59	0.54
F Test			**	**	**	NS	**	**	**	**
Rev L.S.D 0.05			**0.74**	**0.45**	**15.86**	**-**	**0.64**	**0.36**	**0.18**	**0.05**
2014/2015	I_{50}	Masr1	66.17	9.29	349.22	16.67	30.58	5.96	2.11	0.88
		Shan1	66.33	9.71	256.15	17.83	24.57	5.27	1.68	0.70
	I_{75}	Masr1	79.42	9.21	302.33	17.33	30.44	8.48	3.08	0.86
		Shan1	70.50	10.04	338.63	17.50	27.14	6.52	1.85	0.51
	I_{100}	Masr1	73.92	9.21	285.11	17.67	32.47	6.35	2.15	0.45
		Shan1	80.42	10.33	329.67	18.50	29.41	8.76	2.96	0.62
F Test			**	NS	**	NS	*	**	**	**
Rev L.S.D 0.05			**0.98**	**-**	**27.37**	-	**1.54**	**0.53**	**0.24**	**0.07**

NS, * and ** means not significant, significant at 0.05 and 0.01 probability, respectively.

Regarding to the interaction between antioxidant foliar spray and cultivars, data exhibited in Tables 8 and 9show that all studied traits were affected significantly by the previous interaction in the two growing seasons except spike length in both seasons and spikelets number spike^{-1} in the first season only. As, the highest mean values of grain yield (2.52 and 2.70 ton ha^{-1}) and WUE (0.80 and 0.83 kg m^{-3}) in the first and second seasons, respectively were obtained from Masr1 cultivar sprayed by 100 ppm ascorbic acid.

Table 8. Effect of the interaction between antioxidant foliar spray and wheat cultivars on plant height, spike length spikes number per m^2 and spikelet number per spike.

Season	Antioxidant	Plant height (cm)		Spike length (cm)		Spikes number m^{-2}		Spikelets number spike^{-1}	
		Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1
2013/2014	Control	66.67	71.00	8.00	8.50	237.78	260.15	15.89	15.89
	Ascorbic 100 ppm	75.78	72.22	7.89	8.44	288.15	290.96	15.00	15.67
	Salicylic 100 ppm	71.78	71.11	8.94	9.17	266.52	247.70	16.33	16.33
	Ascorbic & Salicylic 100 ppm	68.78	66.33	8.17	8.72	243.70	229.48	14.56	15.44
F Test		**		NS		*		NS	
Rev L.S.D 0.05		0.95		-		21.9		-	
2014/2015	Control	69.00	73.00	9.00	9.61	282.96	324.25	17.67	17.22
	Ascorbic 100 ppm	78.56	74.33	9.28	9.89	344.59	325.48	17.22	17.89
	Salicylic 100 ppm	73.89	74.00	9.50	10.22	301.48	286.27	17.22	18.56
	Ascorbic & Salicylic 100 ppm	71.22	68.33	9.17	10.39	319.85	296.59	16.78	18.11
F Test		**		NS		*		*	
Rev L.S.D 0.05		1.13		-		38.5		0.94	

NS, * and ** means not significant, significant at 0.05 and 0.01 probability, respectively.

Table 9. Effect of the interaction between antioxidant foliar spray and wheat cultivars on seed index, biological yield, grain yield and water use efficiency.

Season	Antioxidant	Seed index (g)		Biological yield (ton ha^{-1})		Grain yield (ton ha^{-1})		Water use efficiency (Kg m^{-3})	
		Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1
2013/2014	Control	24.68	22.25	5.13	6.47	1.65	1.93	0.46	0.58
	Ascorbic 100 ppm	29.66	22.58	6.82	6.37	2.52	2.21	0.80	0.60
	Salicylic 100 ppm	27.15	26.61	7.14	6.08	2.31	1.85	0.72	0.53
	Ascorbic & Salicylic 100 ppm	28.30	25.71	5.91	5.60	2.10	1.59	0.65	0.43
F Test		**		**		**		**	
Rev L.S.D 0.05		0.74		0.42		0.21		0.06	
2014/2015	Control	29.18	24.99	5.86	7.02	1.96	2.19	0.54	0.65
	Ascorbic 100 ppm	33.43	23.55	7.42	6.91	2.70	2.43	0.83	0.66
	Salicylic 100 ppm	30.76	29.95	7.42	6.22	2.67	1.93	0.78	0.54
	Ascorbic & Salicylic 100 ppm	31.30	29.66	7.02	7.25	2.45	2.11	0.75	0.59
F Test		**		**		**		**	
Rev L.S.D 0.05		1.60		0.65		0.31		0.08	

NS, * and ** means not significant, significant at 0.05 and 0.01 probability, respectively.

Concerning to the second order interaction, the presented data in Tables from 10 to 13 show that the all studied traits were affected significantly by the interaction between irrigation levels, wheat cultivars and antioxidant foliar spray in the two growing seasons. The highest mean values of plant height (86.00 and 88.67 cm in the first and second seasons respectively) were recorded from Shandaweel 1 cultivar irrigated by 100 % ET and control. While the highest mean values of spike length (9.83 and 11.00 cm in the first and second seasons, respectively) were obtained from Shandaweel 1 cultivar irrigated by 100 % ET and control. Here too, the highest mean values of grain yield (3.24 and 3.77ton ha^{-1}in the first and second seasons, respectively) were obtained from Masr 1 cultivar irrigated by 75% ET and sprayed by 100 ppm salicylic acid while, the highest mean values of WUE (1.24 and 1.17 kg m^{-3}in the first and second seasons, respectively) were obtained from Masr 1 cultivar irrigated by 50% ET and sprayed by 100 ppm ascorbic acid.

Table 10. Effect of interaction between antioxidant foliar spray, irrigation levels and wheat cultivars on plant height and spike length.

Season	Trait	Plant height (cm)						Spike length(cm)					
	Irrigation	I_{50}		I_{75}		I_{100}		I_{50}		I_{75}		I_{100}	
	Antioxidant	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1
2013/2014	Control	49.67	64.33	80.00	62.67	70.33	86.00	7.83	7.67	8.50	8.00	7.67	9.83
	Ascorbic 100 ppm	71.67	71.33	86.00	67.00	69.67	78.33	8.17	7.50	8.83	8.17	6.67	9.67
	Salicylic 100 ppm	71.67	61.67	73.00	76.67	70.67	75.00	9.00	8.17	8.83	9.67	9.00	9.67
	Ascorbic & Salicylic 100 ppm	64.00	59.33	70.67	66.00	71.67	73.67	7.83	8.50	8.50	9.17	8.17	8.50
F test		**						**					
Rev L.S.D 0.05		1.47						1.00					
2014/2015	Control	50.33	66.00	82.00	64.33	74.67	88.67	9.17	9.00	9.17	8.83	8.67	11.00
	Ascorbic 100 ppm	74.00	72.67	87.67	70.00	74.00	80.33	9.50	9.17	9.67	10.33	8.67	10.17
	Salicylic 100 ppm	74.00	65.67	75.00	78.67	72.67	77.67	9.33	10.50	9.33	9.67	9.83	10.50
	Ascorbic & Salicylic 100 ppm	66.33	61.00	73.00	69.00	74.33	75.00	9.17	10.17	8.67	11.33	9.67	9.67
F test		**						**					
Rev L.S.D 0.05		1.96						0.79					

NS, * and ** means not significant, significant at 0.05 and 0.01 probability, respectively.

Table 11. Effect of the interaction between antioxidant foliar spray, irrigation levels and wheat cultivars on spikes number per m2 and spikelet number per spike.

Season	Trait	Spikes number m^{-2}						Spikeletsnumber spike^{-1}					
	Irrigation	I_{50}		I_{75}		I_{100}		I_{50}		I_{75}		I_{100}	
	Antioxidant	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1
2013/2014	Control	235.56	280.89	312.44	186.67	165.33	312.89	15.00	13.67	16.33	15.67	16.33	18.33
	Ascorbic 100 ppm	247.56	313.33	354.67	231.11	262.22	328.44	14.33	15.00	16.33	15.00	14.33	17.00
	Salicylic 100 ppm	220.44	248.00	265.78	248.44	313.33	246.67	17.00	15.67	15.00	16.33	17.00	17.00
	Ascorbic & Salicylic 100 ppm	208.89	262.67	271.56	176.00	250.67	249.78	13.67	16.33	15.00	15.00	15.00	15.00
F test		**						**					
Rev L.S.D 0.05		32.80						1.67					
2014/2015	Control	363.11	265.33	200.00	369.63	285.78	337.78	16.33	15.67	18.33	17.00	18.33	19.00
	Ascorbic 100 ppm	393.33	261.33	327.56	361.33	312.89	353.78	17.00	17.67	17.67	17.00	17.00	19.00
	Salicylic 100 ppm	299.11	282.81	339.11	293.33	266.22	282.67	18.33	17.67	16.33	19.00	17.00	19.00
	Ascorbic & Salicylic 100 ppm	341.33	215.11	342.67	330.22	275.56	344.44	15.00	20.33	17.00	17.00	18.33	17.00
F test		**						**					
Rev L.S.D 0.05		62.14						1.45					

NS, * and ** means not significant, significant at 0.05 and 0.01 probability, respectively.

Table 12. Effect of the interaction between antioxidant foliar spray, irrigation levels and wheat cultivars on seed index and biological yield.

Season	Trait	Seed index(g)						Biological yield(ton ha^{-1})					
	Irrigation	I_{50}		I_{75}		I_{100}		I_{50}		I_{75}		I_{100}	
	Antioxidant	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1
2013/2014	Control	23.58	21.50	22.68	19.74	27.78	25.52	2.45	6.28	7.03	4.85	5.89	8.27
	Ascorbic 100 ppm	31.90	20.71	28.90	24.67	28.18	22.37	7.94	4.28	7.57	7.13	4.96	7.70
	Salicylic 100 ppm	25.28	20.76	31.32	27.28	24.84	31.80	6.62	5.42	9.33	5.75	5.47	7.07
	Ascorbic & Salicylic 100 ppm	28.17	22.38	24.21	27.63	32.53	27.10	6.09	3.77	6.42	5.85	5.23	7.19
F test		**						**					
Rev L.S.D 0.05		1.27						0.71					
2014/2015	Control	28.47	27.74	27.92	20.46	31.14	26.77	3.02	6.38	7.99	5.72	6.57	8.97
	Ascorbic 100 ppm	33.38	21.44	31.14	26.01	35.76	23.20	7.70	4.43	8.11	7.75	6.45	8.54
	Salicylic 100 ppm	28.56	22.73	36.10	31.63	27.61	35.48	6.11	4.79	10.11	5.99	6.05	7.89
	Ascorbic & Salicylic 100 ppm	31.92	26.36	26.61	30.46	35.38	32.18	7.00	5.46	7.71	6.64	6.35	9.64
F test		**						**					
Rev L.S.D 0.05		2.82						1.11					

NS, * and ** means not significant, significant at 0.05 and 0.01 probability, respectively.

Table 13. Effect of the interaction between antioxidant foliar spray, irrigation levels and wheat cultivars on grain yield and water use efficiency.

Season	Trait	Grain yield(ton ha^{-1})						Water use efficiency(Kg m^{-3})					
	Irrigation	I_{50}		I_{75}		I_{100}		I_{50}		I_{75}		I_{100}	
	Antioxidant	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1	Masr1	Shan1
2013/2014	Control	0.92	2.23	2.10	1.15	1.93	2.42	0.38	0.93	0.58	0.32	0.40	0.50
	Ascorbic 100 ppm	2.98	1.19	3.04	2.52	1.54	2.94	1.24	0.50	0.84	0.70	0.32	0.61
	Salicylic 100 ppm	2.33	1.56	3.24	1.71	1.38	2.28	0.97	0.65	0.90	0.48	0.29	0.47
	Ascorbic & Salicylic 100 ppm	2.34	1.02	2.06	1.03	1.89	2.71	0.97	0.42	0.57	0.29	0.39	0.56
F test		**						**					
Rev L.S.D 0.05		0.36						0.11					
2014/2015	Control	1.01	2.32	2.74	1.48	2.14	2.77	0.42	0.97	0.76	0.41	0.45	0.58
	Ascorbic 100 ppm	2.81	1.31	3.26	2.66	2.04	3.31	1.17	0.54	0.90	0.74	0.43	0.69
	Salicylic 100 ppm	1.99	1.42	3.77	1.86	2.26	2.50	0.83	0.59	1.05	0.52	0.47	0.52
	Ascorbic & Salicylic 100 ppm	2.64	1.67	2.55	1.39	2.16	3.27	1.10	0.69	0.71	0.39	0.45	0.68
F test		**						**					
Rev L.S.D 0.05		0.52						0.14					

NS, * and ** means not significant, significant at 0.05 and 0.01 probability, respectively.

These findings can be attributed to the adverse role of salicylic and ascorbic acids agents abiotic stress occurs from shortage of irrigation water at 50 and 75% ET.

Conclusion

From the previous results the investigator recommended that in such kind of environments, Masr 1 cultivar subjected to 75% ET and sprayed by 100 ppm salicylic acid gaved the highest grain yield and saved 25% of irrigation water which could be used for increasing wheat cultivation land.

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استجابة صنفين من قمح الخبز للرش الورقي بحامضى الاسكوربيك والسالساليك تحت ظروف الاجهاد المائي

محمد ثروت سعيد[١] واحمد محمد احمد عبد المنعم[٢]

[١]قسم المحاصيل– كلية الزراعة – جامعة اسيوط – اسيوط – مصر

[٢]قسم المحاصيل – كلية الزراعة(فرع الوادي الجديد) – جامعة اسيوط اسيوط - مصر

الملخص

لدراسة تأثير الرش الورقي بمضادات الاكسدة (حامض الاسكوربيك وحامض السالسيلك) علي انتاجية صنفين من قمح الخبز تحت ثلاث مستويات من الري. تم اجراء ثلاث تجارب منفصلة في مزرعة الوادي الاسيوطي التابعة لكلية الزراعة جامعة أسيوط خلال الموسمين ٢٠١٣-٢٠١٤ و ٢٠١٤- ٢٠١٥ باستخدام نظام الري بالرش. تعرضت كل تجربة من التجارب الثلاث لاحد مستويات الري (٥٠ أو ٧٥ أو ١٠٠ % من النتح-بخر). صممت كل تجربة باستخدام القطاعات كاملة العشوائية بترتيب القطع المنشقة مرة واحدة بثلاث مكررات حيث تم وضع الرش بمضادات الاكسدة (كنترول ؛ ١٠٠ جزء في المليون حامض اسكوربيك ؛ ١٠٠ جزء في المليون حامض سالساليك و ١٠٠ جزء في المليون حامض اسكوربيك + ١٠٠ جزء في المليون حامض سالساليك). وكانت أهم النتائج المتحصل عليها هي أن جميع عوامل الدراسة وكذلك التفاعلات بينها قد اثرت معنويا في معظم الصفات محل الدراسة لكلا الموسمين. كذلك تم الحصول علي اعلي متوسطات لمحصول الحبوب (٣,٢٤ و ٣,٧٧ طن للهكتار خلال الموسم الاول والثاني علي التوالي) من زراعة الصنف مصر ١ تحت مستوي الري ٧٥% من النتح-بخر والرش الورقي بحامض السالساليك بتركيز ١٠٠ جزء في المليون بينما تم الحصول علي اعلي متوسطات لكفاءة استخدام الماء (١,٢٤ و ١,١٧ كجم /م[٣] في الموسم الاول والثاني علي التوالي) من زراعة الصنف مصر ١ تخت مستوي ري ٥٠% من النتح-بخر والرش الورقي بحامض الاسكوربيك بتركيز ١٠٠ جزء في المليون.