Study the applications of water deficiency levels and ascorbic acid foliar on growth parameters and yield of summer squash plant (*cucurbita pepo L.*)

Ebtessam Abd El-mouez Youssef*, Marwa Mahmoud Abd El-Baset, Ahmed Faris El-Shafie, Mohammed Morsy Hussein

(*Water Relations and Field Irrigation Dept., National Research Centre, Cairo, Egypt.*)

Abstract: Two field experiments study during 2015 and 2016 summer seasons on sandy loam soil under drip irrigation system by Nile river water, at the Agricultural Research and Production Station National Research Centre, El- Nubaria region, EL-Beheira Governorate, Egypt. This study focused on the applications of different water deficiency levels (100%, 80% and 60% of F.C. i.e. field capacity) and ascorbic acid (AsA) spraying foliar application with different concentrations (0, 50 and 100 ppm) as antioxidant on growth parameters and yield as well as photosynthetic pigments content of summer squash plants *(Cucurbitapepo* L.cv. Eskandrani). Results indicated that, decreasing water levels caused a significant reduction in the all tested growth and yield parameters, i.e., canopy weight, root weight, number of leaves, leaves fresh weight and leaf area as well as photosynthetic pigments content (total chl., and carotenoids), total yield, fruit weight and length. While increasing ascorbic acid spraying foliar application levels as antioxidant significantly increased the aforementioned parameters in the two seasons as compared with control. On the other hand, decreasing water levels caused a significant increasing in leaf proline content, leaf cell sap osmotic pressure, dry matter % and fruit TSS in the two growing seasons as compared with control.

Keywords: water stress, water deficiency, ascorbic acid, antioxidant, growth, yield, summer squash plant and *Cucurbita pepo*.

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1 Introduction

Summer squash (*Cucurbita pepo L.*) is one of the most important crop of the family cucurbitaceae and of highly polymorphic vegetable grown during summer, in tropical and subtropical condition (Tartoura et al., 2014). In Egypt, summer squash is one of the most popular vegetable crops (Ibrahim and Selim, 2010).

Egypt produced approximately 559600 ton, of squash, pumpkin and gourd with an average of 18.2 ton ha^{-1} (FAOSTAT, 2012).

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*** Corresponding author: E. A. Youssef,** Dr., Water Relations and Field Irrigation Dept., National Research Centre, Cairo, Egypt., 33 El-behooth St., Dokki 12622, Cairo, Egypt. Email: dr.ebtessamyoussef@yahoo.com. Tel: +2 01227227299, Fax: +20233370931.

Water supply is one of the most important factors which may greatly effect on the yield and quality of summer squash (Ahmet et al., 2004). Increasing irrigation frequency caused significant increases in plant water consumption and yield, whereas, an excessive irrigation level had a negative Water Relations and Field Irrigation Dept., National Research Centre., Dokki, Cairo, Egypt.

Deficit irrigation will play an important role in farm-level water management strategies, with consequent increases in the output generated per unit of water used in agriculture. In Egypt, it is necessary to produce the maximum yield and profit from a unit area by using available water efficiently because the existing agricultural land and irrigation water are rapidly diminishing. Therefore, it is essential to balance water requirements, water consumption and yield of summer squash.

Vitamins' could be considered as bio-regulator compounds which in low concentrations exerted a profound influence upon plant growth. Ascorbic acid is a vitamin known as growth regulating factor which influences many biological processes. It is currently considered to as a plant growth regulator due to its effect on cell division, differentiation and various growth factors. Ascorbic acid increases nucleic acid content, especially RNA and acts as co-enzyme in the enzymatic reactions by which carbohydrates, proteins are metabolized and involved in photosynthesis and respiration (Mazher, Azza et al., 2011; Masoud and El-Sahrawy, 2012).

Therefore, the aim of this study was to evaluate the effect of ascorbic acid spraying foliar application on growth and yield of Cucurbita plants grown under different water levels.

2 Materials and methods

2.1 The experimental site

The experiments were carried out at the Agricultural Research and Production Station, National Research Centre, under open field conditions at El-Nubaria region, EL-Beheira Governorate, Egypt. Two successive summer seasons of 2015 and 2016 to study the effect of different water levels and scorbic acid spraying foliar application with different concentrations on growth, some physiological aspects and yield of summer squash plants.

The soil of the experimental site is classified as sandy soil. Irrigation water was obtained from an irrigation channel (Nile water) going through the experimental area, with pH 7.3, and electrical conductivity of 0.37 dS m^{-1}, containing very suitable amount of cations and anions. Some of the physical, chemical properties of the soil and Irrigation water of the experimental site were estimated in the Soil laboratory, National Research Centre, at the beginning of the trial and are reported in Tables 1, 2 and 3 respectively.

2.2 Experimental design

The experimental design was split plot with three replications which include 9 treatments. The main plots were assigned to three levels of water applied (100%, 80% and 60% of F.C.). Subplots were ascorbic acid (AsA) spraying foliar application with different concentrations (0, 50, 100 ppm) as antioxidant. Each subplot area was 21 m^2 and contained 6 rows, 70 cm width and 5 m length. Each treatment was separated by two guard ridges.

Table 1 Some physical properties of the soil

Depth, cm	Particle size distribution, %				Texture class	θS % on weight basis			HC, cm h^{-1}	BD, g cm^{-3}	P, cm^3 voids cm^{-3} soil
	C. Sand	F. Sand	Silt	Clay		F.C.	P.W.P.	A.W			
0-15	8.4	77.6	8.5	5.5	Sandy	12	4.1	7.9	6.68	1.69	0.36
15-30	8.6	77.7	8.3	5.4	Sandy	12	4.1	7.9	6.84	1.69	0.36
30-45	8.5	77.5	8.8	5.2	Sandy	12	4.1	7.9	6.91	1.69	0.36
45-60	8.8	76.7	8.6	5.9	Sandy	12	4.1	7.9	6.17	1.67	0.37

Note: F.C.: Field Capacity, W.P.: Wilting Point, AW: Available Water, HC: Hydraulic conductivity, BD: Bulck density and P: Porosity.

Table 2 Some chemical properties of the soil

Depth, cm	pH 1:2.5	EC dS m^{-1}	Soluble Cations, meq L^{-1}				Soluble Anions, meq L^{-1}			
			Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^-	SO_4^{--}	Cl^-
0-15	8.3	0.35	0.50	0.39	1.02	0.23	0	0.11	0.82	1.27
15-30	8.2	0.36	0.51	0.44	1.04	0.24	0	0.13	0.86	1.23
30-45	8.3	0.34	0.56	0.41	1.05	0.23	0	0.12	0.81	1.23
45-60	8.4	0.73	0.67	1.46	1.06	0.25	0	0.14	0.86	1.22

Table 3 Some chemical properties of irrigation water

pH	EC, dS m^{-1}	Soluble cations, meq L^{-1}				Soluble anions, meq L^{-1}				SAR
		Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^-	SO_4^{--}	Cl^{--}	
7.3	0.37	0.76	0.24	2.6	0.13	0	0.9	0.32	2.51	4.61

2.3 Irrigation system description

Automatic drip irrigation system consists of Polyethylene Tank 5 m^3, centrifugal pump (0.75HP), screen filter 1.5" diameter, spring brass non-return valve 2", Pressure gauges, control valves and flow meter chemical injection equipment. Main line of a nominal diameter 63 mm /6 bar PVC pipeline convey water to sub main lines. Sub main line of a nominal diameter 32 mm, PVC pipeline, connected to solenoid valve, derived from the main line to feed the group of the laterals which represent a treatment. Laterals, it is 16 mm diameter PE tubes, with 30 cm apart, built in emitters of 4 L h^{-1} discharge at 1bar operating pressure. Distance between laterals was 70 cm.

Squash seeds (cv. Eskandrani) were sown on one side to each furrow at 40 cm distance between plants at the first of April in the two growing seasons. After 20 days from planting seeds were subjected to three levels of soil moisture. The first is irrigation after 60% depletion of F.C. i.e. normal water applied, the second is irrigation after 80% depletion of F.C. i.e. moderate water applied and the third is irrigation after 100% depletion of F.C. i.e. moisture stress. Ascorbic acid (AsA) concentrations were sprayed at 20, 30 days after planting. Plants were sprayed with a fine mist of ascorbic acid using a hand pressure sprayer, till run-off, with care being taken to cover all plant parts; no surfactants or other wetting agents were needed. The control plants were sprayed with water only.

Plants were fertilized with ammonium sulphate (20.6% N) at a rate of 75 N kg fed^{-1}, calcium super phosphate (16% P_2O_5) at rate of 40 kg P_2O_5 fed^{-1}, and potassium sulphate (48% K_2O) at a rate of 48 kg K_2O fed^{-1}, that were divided in two equal portions. The first portion of calcium super phosphate was added during seed bed preparation and the second portion was added with the first portion of N and K fertilizers which added at the fourth week after seed sowing and the second portion of N and K fertilizers was added at the eighth week after seeds sowing. Other agricultural practices were conducted according to recommendations (Ibrahim and Selim, 2010).

After 50 days from planting, five plants from each sub plot were randomly taken for measuring the vegetative growth parameters, i.e., canopy weight, leaves fresh weight and leaves dry mater percentage, photosynthetic pigments content in the 4^{th} leaf i.e., total chlorophyll and carotenoids (mg g^{-1} of fresh weight) were colorimetrically determined as outlined by Arnon (1949). Moreover, the proline content of fresh leaves was determined as (µg g^{-1} dry weight) following the method adopted by Bates et al. (1973). The leaf water relationship content was estimated following the method stated by Gosov (1960). Leaf area (cm^2) was determined using discs of the leaf blades according to Bremner and Taha (1966). The leaf osmotic pressure of the cell sap of leaf blades was determined following the method of Gosov (1960).

At the harvesting time, fruits of each plot were harvested by hand every 2-3 days and were classified as marketable fruits (3-4 cm in diameter and 13-16 cm in length) and non-marketable fruits (misshapen large and small fruits) in each harvest, thereafter, marketable and total fruit yield was determined as, ton fed^{-1}. Also, mean fruit weight was determined by dividing the total weight of the harvested fruit on the total number of fruits. At the seventh harvest, samples of five fruits were taken at random from each sub plot to determine total soluble solids percentage by refractomater.

The data of the experiments were subjected to statistical analysis as A split plot design with three replicates according to Snedecor and Cochran (1980).

3 Results and discussion

3.1 Growth parameters

The effect of water deficiency levels (100%, 80% and 60% of F.C.) and ascorbic acid (AsA) foliar spraying with different concentrations (0, 50, 100 ppm) on Cucurbita plants of canopy weight, root weight, number of leaves per plant, leaf fresh weight and leaf area is presented in Table 4.

3.2 Canopy weight (F. W. g^{-1})

Data in Table 4 cleared significant differences between water deficiency levels in both seasons. The highest values were 340.18 and 312.42 g with 100% F.C., (i.e. field capacity) and the lowest values were 165.41 and 130.34 g for 60% F.C., respectively in the two experimental seasons.

Regarding AsA (i. e. Ascorbic acid) concentrations effect, it was cleared that canopy weight increased with AsA level being 186.26, 267.69 and 338.96 g for AsA 0, 50 and 100 ppm, respectively in the first season. The values in the second season were 159.62, 242.27 and 305.81 g for AsA 0, 50 and 100 ppm, respectively.

The interaction between water deficiency levels and ascorbic acid concentrations revealed highest values with 100% F.C × AsA 100 ppm being 435.24 and 376.68 g in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 60% F.C × AsA 0 ppm being 118.95 and 65.88 g in the first and the second seasons, respectively.

3.4 Root weight (F. W. / g)

Data presented in Table 4 reveal that the root weight was significantly decreased with increasing water levels. The highest values were 10.25 and 9.59 g with 100% F.C., and the lowest values were 4.92 and 4.34 g for 60% F.C., respectively in the two experimental seasons.

Regarding AsA concentrations effect, it was found that root weight increased with increasing AsA level (100% ppm) being 10.67 and 9.50 g, respectively in the two seasons.

Concerning the interaction effects in Table 4, it could be noticed that the highest values with 100% F.C × AsA 100 ppm being 14.25 and 12.25 g in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 60% F.C × AsA 0 ppm being 3.50 and 2.50 g in the first and the second seasons, respectively.

Table 4 Effect of water deficiency, ascorbic acid spraying and their interaction on some vegetative parameters of squash plants (seasons 2015-2016)

Treatments	Canopy weight, F. W. g^{-1}		Root weight, F. W. g^{-1}		No of leaves per plant		Leaf weight, F. W. g^{-1}		Leaf area, cm^2	
	First season									
100% F.C	340.18	A	10.25	A	21.33	A	13.07	A	94.12	A
80% F.C	287.31	B	8.33	B	19.2	B	12.27	B	88.31	B
60% F.C	165.41	C	4.92	C	16	C	8.47	C	61.03	C
AsA 0 ppm	186.26	C	5.5	C	16.53	C	9.24	C	66.53	C
AsA 50 ppm	267.69	B	7.34	B	18.67	B	11.75	B	84.59	B
AsA 100 ppm	338.96	A	10.67	A	21.33	A	13.03	A	93.79	A
100% F.C XAsA 0 ppm	250.41	e	7.5	d	19.2	d	10.69	c	76.99	c
100% F.C XAsA 50 ppm	334.89	c	9	c	20.8	c	13.2	b	95.04	b
100% F.C XAsA 100 ppm	435.24	a	14.25	a	24	a	14.86	a	107.01	a
80% F.C XAsA 0 ppm	189.41	g	5.5	ef	16	f	9.7	d	69.85	d
80% F.C XAsA 50 ppm	309.27	d	8.25	cd	19.2	d	13.2	b	95.09	b
80% F.C XAsA 100 ppm	363.26	b	11.25	b	22.4	b	13.29	b	95.73	b
60% F.C XAsA 0 ppm	118.95	i	3.5	g	14.4	g	6.77	e	48.76	e
60% F.C XAsA 50 ppm	158.91	h	4.75	f	16	f	8.14	d	58.63	d
60% F.C XAsA 100 ppm	218.39	f	6.5	e	17.6	e	10.17	c	73.23	c
	Second season									
100% F.C	312.42	A	9.59	A	19.9	A	12.87	A	92.63	A
80% F.C	264.95	B	7.83	B	18.67	B	11.63	B	83.76	B
60% F.C	130.34	C	4.34	C	14.93	C	7.16	C	51.52	C
AsA 0 ppm	159.62	C	5.09	C	15.3	C	8.55	C	61.56	C
AsA 50 ppm	242.27	B	7.17	B	17.95	B	11.06	B	79.64	B
AsA 100 ppm	305.81	A	9.5	A	20.27	A	12.37	A	89.02	A
100% F.C XAsA 0 ppm	234.24	e	7.5	d	17.6	d	10.91	d	78.56	d
100% F.C XAsA 50 ppm	326.36	c	9	c	19.73	c	13.56	b	97.64	b
100% F.C XAsA 100 ppm	376.68	a	12.25	a	22.4	a	13.78	a	99.24	a
80% F.C XAsA 0 ppm	178.73	g	5.25	ef	16	e	9.16	d	65.91	e
80% F.C XAsA 50 ppm	270.54	d	8	d	19.2	c	11.55	c	83.15	c
80% F.C XAsA 100 ppm	345.57	b	10.25	b	20.8	b	13.62	b	98.06	b
60% F.C XAsA 0 ppm	65.88	i	2.5	g	12.27	f	4.4	g	31.68	g
60% F.C XAsA 50 ppm	129.93	h	4.5	f	14.93	e	7.13	f	51.38	f
60% F.C XAsA 100 ppm	195.2	f	6	e	17.6	d	9.09	e	65.45	e

3.5 Number of leaves per plant

Examination of Table 4 reveals that the number of leaves per plant of irrigated plants with 60% of F.C., was the lowest in the two seasons in comparison with the control (irrigation with 100% of F.C.). The lowest values were 16.00 and 14.93 for 60% F.C., respectively in the two experimental seasons.

With regard to the effect of spraying with AsA concentrations, data indicate that, the number of leaves per plant increased with AsA level being 16.53, 18.67 and 21.33 for AsA 0, 50 and 100 ppm, respectively in the first season. The values in the second season were 15.30, 17.95 and 20.27 for AsA 0, 50 and 100 ppm, respectively.

The interaction between water deficiency levels and ascorbic acid concentrations revealed highest values with 100% F.C × AsA 100 ppm being 24.00 and 22.40 in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 60% F.C × AsA 0 ppm being 14.40 and 12.27 in the first and the second seasons, respectively.

3.6 Leaf weight (F. W. g^{-1})

Data in Table 4 cleared significant differences between water deficiency levels in both seasons. The highest values were 13.07 and 12.87 g with 100% F.C., and the lowest values were 8.47 and 7.16 g for 60% F.C., respectively in the two experimental seasons.

Regarding AsA concentrations effect, it was cleared that canopy weight increased with AsA level being 9.24, 11.75 and 13.03 g for AsA 0, 50 and 100 ppm, respectively in the first season. The values in second season were 8.55, 11.06 and 12.37 g for AsA 0, 50 and 100 ppm, respectively.

The interaction between water deficiency levels and ascorbic acid concentrations revealed highest values with 100% F.C × AsA 100 ppm being 14.86 and 13.78 g in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 60% F.C × AsA 0 ppm being 6.77 and 4.40 g in the first and the second seasons, respectively.

3.7 Leaf area (cm^2)

The results in Table 4 reveal that the total leaf area per plant significantly increased with decreasing water levels. The highest values were 94.12 and 92.63 cm^2 with 100% F.C., and the lowest values were 61.03 and 51.52 cm^2 for 60% F.C., respectively in the two experimental seasons.

As for AsA concentrations effect, it was cleared that total leaf area increased with AsA level being 66.53, 84.59 and 93.79 cm^2 for AsA 0, 500 and 100 ppm, respectively in the first season. The values in second season were 61.56, 79.64 and 89.02 cm^2 for AsA 0, 50 and 100 ppm, respectively.

The interaction between water deficiency levels and ascorbic acid concentrations revealed highest values with 100% F.C × AsA 100 ppm being 107.01 and 99.24 cm^2 in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 60% F.C × AsA 0 ppm being 48.76 and 31.68 cm^2 in the first and the second seasons, respectively.

These results are in harmony with those results obtained by Uday et al. (2001), Metwally (2011), Kassab et al. (2012). They revealed that, growth characteristics generally improved with the increased in total water applied during growing period.

Kramer and Boyer (1995) reported that the growth of plants is controlled by rates of the cell division and enlargement and by the supply of organic and inorganic compounds required for the synthesis of new protoplasm and cell walls. Cell enlargement is particularly dependent on at least a minimum degree of cell turgor, and stem and leaf elongations are quickly checked or stopped by water deficits.

Ascorbic acid increased nucleic acid contents, especially RNA and protein content. It also affected the synthesis of enzymes, and proteins. In addition, it acts as co-enyme in metabolic changes. Generally, ascorbic acid had positive effects on growth parameters by increasing carbohydrates and content of macronutrients (N, P and K) in plants (Aria et al., 2010; Mazher et al., 2011; and Hafez et al., 2011).

Smirnoff and Wheeler (2000) reported that ascorbic acid is an abundant component of plants. It reaches a concentration of over 20 mm in chloroplasts and occurs in all cell compartments including cell wall. It was suggested that ascorbic acid functions in photosynthesis, as an enzyme cofactor. Abdel et al. (2009), indicated that application of ascorbic acid significantly increased all growth parameters.

3.8 Squash leaves contents of total chlorophyll, carotenoids, proline and osmotic pressure

The effect of water levels (100%, 80% and 60% of F.C.) and ascorbic acid (AsA) foliar spraying with different concentrations (0, 50, 100 ppm) on Cucurbita leaves contents of total chlorophyll, carotenoids, proline and osmotic pressure is presented in Table 5.

3.9 Leaf total chlorophyll content (mg g^{-1} leaf F.W.)

Data in Table 5 recorded that, the content of leaf total chlorophyll was decreased by the gradually increasing in water levels in the two growing seasons. The highest values were 1.64 and 1.61 mg g^{-1} with 100% F.C., and the lowest values were 1.54 and 1.55 mg g^{-1} for 60% F.C., respectively in the two experimental seasons.

Also, the effect of AsA concentrations, it was indicated that leaf total chlorophyll content increased with AsA level being 1.55, 1.58 and 1.65 mg g^{-1} for AsA 0, 50 and 100 ppm, respectively in the first season. The values in second season were 1.55, 1.57 and 1.61 mg g^{-1} for AsA 0, 50 and 100 ppm, respectively.

Table 5 Effect of water deficiency, ascorbic acid spraying and their interaction on leaf pigments and proline of squash plants (seasons 2015-2016)

Treatments	Leaf total chlorophyll content (mg g^{-1} of leaf F. W.)	Leaf carotenoids content (mg g^{-1} of leaf F. W.)	Leaf proline content (μg g^{-1} of leaf D. W.)	Leaf cell sap osmotic pressure (atm.)
First season				
100% F.C	1.64 A	0.64 A	29.81 C	4.75 C
80% F.C	1.59 B	0.59 B	37.99 B	5.18 B
60% F.C	1.54 C	0.52 C	59.09 A	6.43 A
AsA 0 ppm	1.55 B	0.52 C	54.43 A	6.19 A
AsA 50 ppm	1.58 B	0.57 B	41.12 B	5.42 B
AsA 100 ppm	1.65 A	0.65 A	31.32 C	4.75 C
100% F.C XAsA 0 ppm	1.57 d	0.56 d	40.07 e	5.56 c
100% F.C XAsA 50 ppm	1.59 c	0.62 c	30.31 g	4.74 d
100% F.C XAsA 100 ppm	1.75 a	0.72 a	19.03 i	3.95 f
80% F.C XAsA 0 ppm	1.54 d	0.51 e	53.58 c	5.69 c
80% F.C XAsA 50 ppm	1.58 c	0.58 d	34.94 f	5.12 d
80% F.C XAsA 100 ppm	1.64 b	0.68 b	25.43 h	4.74 e
60% F.C XAsA 0 ppm	1.53 e	0.5 f	69.64 a	7.33 a
60% F.C XAsA 50 ppm	1.53 e	0.51 e	58.13 b	6.41 b
60% F.C XAsA 100 ppm	1.56 d	0.55 d	49.49 d	5.56 c
Second season				
100% F.C	1.61 A	0.62 A	34.05 C	4.75 C
80% F.C	1.58 B	0.59 B	46.34 B	5.37 B
60% F.C	1.55 C	0.52 C	70.61 A	6.64 A
AsA 0 ppm	1.55 B	0.53 C	66.66 A	6.59 A
AsA 50 ppm	1.57 B	0.56 B	51.17 B	5.42 B
AsA 100 ppm	1.61 A	0.64 A	33.17 C	4.75 C
100% F.C XAsA 0 ppm	1.58 c	0.57 d	49.97 e	5.56 c
100% F.C XAsA 50 ppm	1.59 c	0.59 c	38.13 g	4.74 d
100% F.C XAsA 100 ppm	1.67 a	0.7 a	14.06 i	3.95 e
80% F.C XAsA 0 ppm	1.55 d	0.54 e	69.63 c	6.26 b
80% F.C XAsA 50 ppm	1.58 c	0.57 d	41.65 f	5.12 c
80% F.C XAsA 100 ppm	1.61 b	0.65 b	27.73 h	4.74 d
60% F.C XAsA 0 ppm	1.53 e	0.5 f	80.37 a	7.95 a
60% F.C XAsA 50 ppm	1.54 d	0.51 e	73.73 b	6.41 b
60% F.C XAsA 100 ppm	1.57 d	0.56 d	57.71 d	5.56 c

The interaction between water deficiency levels and ascorbic acid concentrations revealed highest values with 100% F.C × AsA 100 ppm being 1.75 and 1.67 mg g^{-1} in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 60% F.C × AsA 0 ppm being 1.53 and 1.53 mg g^{-1} in the first and the second seasons, respectively.

3.10 Leaf carotenoids content (mg g^{-1} leaf F.W.)

Data in Table 5 cleared significant differences between water deficiency levels in both seasons. The highest values were 0.64 and 0.62 mg g^{-1} with 100% F.C., and the lowest values were 0.52 and 0.52 mg g^{-1} for 60% F.C., respectively in the two experimental seasons.

Regarding AsA concentrations effect, it was cleared that leaf carotenoids contentincreased with increasing AsA level being 0.52, 0.57 and 0.65 mg g^{-1} for AsA 0, 50 and 100 ppm, respectively, in the first season. The values in second season were 0.53, 0.56 and 0.64 mg g^{-1} for AsA 0, 50 and 100 ppm, respectively.

The interaction between water deficiency levels and ascorbic acid concentrations revealed highest values with 100% F.C × AsA 100 ppm being 0.72 and 0.70 mg g^{-1} in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 60% F.C × AsA 0 ppm being 0.50 and 0.50 mg g^{-1} in the first and the second seasons, respectively.

3.11 Leaf proline content (μg g^{-1} leaf D.W.)

From the given data in Table 5 it could be concluded that, decreasing soil moisture level lead to increase of proline metabolism, which is a typical mechanism of biochemical adaptation subjected to stress condition. The highest values were 59.09 and 70.61 μg g^{-1} with 60% F.C., and the lowest values were 29.81 and 34.05 μg g^{-1} for 100% F.C., respectively in the two experimental seasons.

As regards the effect of AsA concentrations, it was obtained that proline decreased with the highest concentration of AsA.

The interaction between water deficiency levels and ascorbic acid concentrations revealed highest values with 60% F.C × AsA 0 ppm being 69.64 and 80.37 μg g^{-1} in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 100% F.C × AsA 100ppm being 19.03 and 14.06 μg g^{-1} in the first and the second seasons, respectively.

3.12 Leaf cell sap osmotic pressure (atm.)

The present data in Table 5 show that the osmotic pressure of the cell sap exhibited a remarkable increase with increasing the soil moisture stress. The highest values were 6.43 and 6.64 atm., with 60% F.C. and the lowest values were 4.75 and 4.75 atm., for 100% F.C., respectively in the two experimental seasons.

Regarding AsA concentrations effect, it was founded that the osmotic pressure of the cell sap decreased with AsA level being 6.19, 5.42 and 4.75 atm., for AsA 0, 50 and 100 ppm, respectively in the first season. The values in second season were 6.59, 5.42 and 4.75 atm., for AsA 0, 50 and 100 ppm, respectively.

As for the interaction between different treatments, the data of the interaction among the two studied factors showed that the highest values with 60% F.C × AsA 0 ppm being 7.33 and 7.95 atm., in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 100% F.C × AsA 100 ppm being 3.95 and 3.95 atm., in the first and the second seasons, respectively.

Hafez et al. (2011) shown that, AsA levels 200 and 400 ppm enhanced the production of proline than the control at the end of the experiment. Level 400 ppm was superior in increasing proline content.

Shun and Mohammed (2014) shown that, chlorophyll and carotenoids decreased significantly with increasing irrigation intervals to 14 and 21days, this reduction was recovered by addition of 200 ppm AsA which caused significant increase in chlorophyll and carotenoids compared to their corresponding controls. On the other hand, proline content was significantly increased by increasing interval days of irrigation to 14 and 21 days compared to control. Application of 200 ppm AsA caused significant increase in proline content in plants irrigated every 3 and 7 days compared to their corresponding control.

3.13 Squash leaves water relation:

The effect of application water regimes deficiency (100%, 80% and 60% of F.C.) and ascorbic acid (AsA) foliar spraying with different concentrations (0, 50, 100 ppm) on Cucurbita leaves water relation is presented in Table 6.

3.14 Leaf free water content (%)

Data in Table 6 recorded that, significant differences between water deficiency levels in both seasons. The highest values were 68.18% and 65.07% with 100% F.C., and the lowest values were 56.94% and 52.97% for 60% F.C., respectively in the two experimental seasons.

Table 6 Effect of water deficiency, ascorbic acid spraying and their interaction on leaf water, leaf dry matter content and leaf cell sap osmotic pressure of squash plants (seasons, 2015-2016)

Treatments	Leaf free water content, %	Leaf bound water content, %	Leaf total water content, %	Leaf dry matter content, %
		First season		
100% F.C	68.18A	17.35C	85.53A	14.47C
80% F.C	63.82B	20.35B	84.17B	15.83B
60% F.C	56.94C	24.45A	81.39C	18.61A
AsA 0 ppm	57.67C	24.49A	82.16C	17.84A
AsA 50 ppm	61.61B	21.87B	83.48B	16.52B
AsA 100 ppm	69.65A	15.81C	85.46A	14.54C
100% F.C XAsA 0 ppm	59.06d	25.59a	84.65c	15.35d
100% F.C XAsA 50 ppm	65c	20.13e	85.13b	14.87e
100% F.C XAsA 100 ppm	80.48a	6.34g	86.82a	13.18f
80% F.C XAsA 0 ppm	57.95d	23.81c	81.76e	18.24b
80% F.C XAsA 50 ppm	63.03c	21.78d	84.81c	15.19d
80% F.C XAsA 100 ppm	70.48b	15.47f	85.95b	14.05e
60% F.C XAsA 0 ppm	56e	24.07b	80.07f	19.93a
60% F.C XAsA 50 ppm	56.81e	23.68c	80.49f	19.51a
60% F.C XAsA 100 ppm	58d	25.62a	83.62d	16.38c
		Second season		
100% F.C	65.07A	19.41C	84.48A	15.52C
80% F.C	59.46B	23.96B	83.42B	16.58B
60% F.C	52.97C	27.13A	80.1C	19.9A
AsA 0 ppm	53.41C	27.61A	81.02C	18.98A
AsA 50 ppm	57.77B	24.59B	82.36B	17.64B
AsA 100 ppm	66.32A	18.31C	84.63A	15.37C
100% F.C XAsA 0 ppm	55.79d	27.26a	83.05d	16.95d
100% F.C XAsA 50 ppm	61.11c	23.15c	84.26c	15.74e
100% F.C XAsA 100 ppm	78.31a	7.82e	86.13a	13.87f
80% F.C XAsA 0 ppm	53.33d	28.04a	81.37f	18.63b
80% F.C XAsA 50 ppm	58.92c	24.8b	83.72d	16.28d
80% F.C XAsA 100 ppm	66.14b	19.03d	85.17b	14.83e
60% F.C XAsA 0 ppm	51.11e	27.52a	78.63g	21.37a
60% F.C XAsA 50 ppm	53.28d	25.82b	79.1g	20.9a
60% F.C XAsA 100 ppm	54.51d	28.07a	82.58e	17.42c

Regarding AsA concentrations effect, it was indicated that leaf free water content increased with AsA level being 57.67%, 61.61% and 69.65% for AsA 0, 50 and 100 ppm, respectively in the first season. The values in second season were 53.41%, 57.77% and 66.32% for AsA 0, 50 and 100 ppm, respectively.

As for the interaction between water deficiency levels and ascorbic acid concentrations revealed highest values with 100% F.C × AsA 100 ppm being 80.48% and 78.31% in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 60% F.C × AsA 0 ppm being 56.00% and 51.11% in the first and the second seasons, respectively.

3.15 Leaf bound water content (%)

From the given data in Table 6 it could be concluded that decreasing soil moisture level led to increase of leaf bound water content. The highest values were 24.45% and 27.13% with 60% F.C., and the lowest values were 17.35% and 19.41% for 100% F.C., respectively in the two experimental seasons.

As regards the effect of AsA concentrations, it was obtained that, leaf bound water content decreased with the highest concentration of AsA.

The interaction between water deficiency levels and ascorbic acid concentrations revealed highest values with 100% F.C × AsA 0 ppm being 25.59% and 27.26% in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 100% F.C × AsA 100 ppm being 6.34% and 7.82% in the first and the second seasons, respectively.

3.16 Leaf total water content (%)

Examination of Table 6 revealed that, the water content of irrigated plants with 60% of F.C., was the lowest in the two seasons (81.39% and 80.10% for 60% F.C.) in comparison with the control (irrigation with 100% of F.C.).

With regard to the effect of spraying with ascorbic acid, data indicate that AsA level of 100 ppm significantly increased water content in the two seasons comparing with control.

As for the interaction affect, Table 6 revealed that the highest values with 100% F.C × AsA 100 ppm being 86.82% and 86.13% in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 60% F.C × AsA 0 ppm being 80.07% and 78.63% in the first and the second seasons, respectively.

3.17 Leaf dry matter content (%)

Data in Table 6 cleared significant differences between water deficiency levels in both seasons. The highest values were 18.61 and 19.90% with 100% F.C., and the lowest values were 14.47% and 15.52% for 60% F.C., respectively in the two experimental seasons.

Regarding AsA concentrations effect, it was cleared that leaf dry matter content (%) decreased with AsA level being 17.84%, 16.52% and 14.54% for AsA 0, 50 and 100 ppm, respectively in the first season. The values in second season were 18.98%, 17.64% and 15.37% for AsA 0, 50 and 100 ppm, respectively.

The interaction between water deficiency levels and ascorbic acid concentrations revealed highest values with 60% F.C × AsA 0 ppm being 19.93% and 21.37% in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 100% F.C × AsA 100 ppm being 13.18% and 13.87% in the first and the second seasons, respectively.

The collected data in the present investigation show that the decrease of soil moisture caused a decrease in leaf free water and leaf total water content and increase in leaf bound water and leaf dry matter. Similar results were reported by several investigators. Ali et al. (1999) indicated that soil drying decreased leaf growth, thereby reducing leaf water status in addition to accumulation of organic solutes to osmotic adjustment which in turn inhibited the incorporation of small substrate molecules into the polymers needed to grow new cells. In the same connection Abdel-Mawgoud et al. (2005) on green bean also reported that increased irrigation rate increases water availability in the root zone resulting in improving plant water status and better stomatal conductance which eventually reflects on photo- assimilates production.

Youssef (2013) on gladiolus plants reported that decreasing water levels caused decreasing leaves water content.

Zhwan and Mohammed (2014) found that water deficiency levels for 14, 21 days interval were significantly decrease leaves water content. The AsA application could alleviate the harm effect of drought through enhancement plant water content.

3.18 Squash yield and fruit characteristics

The effect of application water regimes deficiency (100%, 80% and 60% of F.C.) and ascorbic acid (AsA) foliar spraying with different concentrations (0, 50, 100 ppm) on Cucurbita yield and fruit quality is presented in Table 7.

3.19 Total yield (ton fed^{-1})

It is clear from Table 7 that, the total yield significant increased with increasing water supply. The highest values were 11. 62 and 10.84 ton fed^{-1}., with 100% F.C., and the lowest values were 6. 68 and 5.69 ton fed^{-1}., for 60% F.C., respectively in the two experimental seasons.

Regarding AsA concentrations effect, it was cleared that total yield increased with AsA level being 7.27, 9.57 and 11.59 ton fed^{-1}, for AsA 0, 50 and 100 ppm, respectively, in the first season. The values in second season were 6.52, 8.85 and 10.65 ton fed^{-1}., for AsA 0, 50 and 100 ppm, respectively.

The interaction between water deficiency levels and ascorbic acid concentrations revealed highest values with 100% F.C × AsA 100 ppm being 14.31 and 12.66 ton fed^{-1}., in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 60% F.C×AsA 0 ppm being 5.36 and 3.86 ton fed^{-1} in the first and the second seasons, respectively.

3.20 Fruit weight (g)

Data in Table 7 indicated that significant differences between water deficiency levels in both seasons. The highest values were 129.74 and 128.73 g with 100% F.C., and the lowest values were 77.98 and 70.24 g for 60% F.C., respectively in the two experimental seasons.

As regarding AsA concentrations effect, it was cleared that fruit weight increased with AsA level being 92.48, 98.83 and 127.91 g for AsA 0, 50 and 100 ppm, respectively in the first season. The values in second season were 87.07, 98.66 and 117.88 g for AsA 0, 50 and 100 ppm, respectively.

The interaction between water deficiency levels and ascorbic acid concentrations revealed highest values with 100% F.C × AsA 100 ppm being 148.05 and 140.61 g in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 60% F.C × AsA 0 ppm being 57.75 and 52.00 g in the first and the second seasons, respectively.

3.21 Fruit length (cm)

Data in Table 7 cleared significant differences between water deficiency levels in both seasons. The highest values were 13.99 and 14.23 cm with 100% F.C., and the lowest values were 12.04 and 11.64 cm for 60% F.C., respectively in the two experimental seasons.

Regarding AsA concentrations effect, it was cleared that fruit length increased with AsA level being 12.38, 13.21 and 14.06 cm for AsA 0, 50 and 100 ppm, respectively in the first season. The values in second season were 12.16, 12.88 and 14.26 cm for AsA 0, 50 and 100 ppm, respectively.

The interaction between levels of water deficiency and ascorbic acid concentrations revealed highest values with 100% F.C × AsA 100 ppm being 14.60 and 15.67 cm in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 60% F.C × AsA 0 ppm being 11.07 and 10.77 cm in the first and the second seasons, respectively.

Table 7 Effect of water deficiency, ascorbic acid spraying and their interaction on total yield, fruit weight, fruit length, fruit diameter and fruit TSS of squash plants (seasons 2015-2016)

Treatments	Total yield, ton fed^{-1}	Fruit weight, g	Fruit length, cm	Fruit diameter, cm	Fruit Tss, %
			First season		
100% F.C	11.62A	129.74A	13.99A	3.38A	4.33C
80% F.C	10.13B	111.50B	13.61A	2.99A	5.06B
60% F.C	6.68C	77.98C	12.04B	2.49A	6.17A
AsA 0 ppm	7.27C	92.48C	12.38C	2.79B	5.89A
AsA 50 ppm	9.57B	98.83B	13.21B	2.77B	5.39B
AsA 100 ppm	11.59A	127.91A	14.06A	3.28A	4.28C
100% F.C XAsA 0 ppm	9.08c	129.16c	13.40b	3.57a	5.00d
100% F.C XAsA 50 ppm	11.47b	112.00d	13.97b	2.92a	5.00d
100% F.C XAsA 100 ppm	14.31a	148.05a	14.60a	3.63a	3.00f
80% F.C XAsA 0 ppm	7.36e	90.53e	12.67c	2.71a	6.00b
80% F.C XAsA 50 ppm	10.75c	105.94d	13.67b	2.85a	5.00d
80% F.C XAsA 100 ppm	12.28b	138.04b	14.50a	3.42a	4.17e
60% F.C XAsA 0 ppm	5.36g	57.75g	11.07d	2.12a	6.67a
60% F.C XAsA 50 ppm	6.50f	78.55f	12.00c	2.55a	6.17b
60% F.C XAsA 100 ppm	8.18d	97.65e	13.07b	2.79a	5.67c
			Second season		
100% F.C	10.84A	128.73A	14.23A	3.30A	4.67C
80% F.C	9.50B	104.65B	13.41B	2.87B	5.17B
60% F.C	5.69C	70.24C	11.64C	2.35B	6.50A
AsA 0 ppm	6.52C	87.07C	12.16B	2.69B	6.11A
AsA 50 ppm	8.85B	98.66B	12.88B	2.84B	5.50B
AsA 100 ppm	10.65A	117.88A	14.26A	2.98A	4.72C
100% F.C XAsA 0 ppm	8.63c	125.10b	13.27b	3.50a	5.33d
100% F.C XAsA 50 ppm	11.23b	120.49c	13.77b	3.20a	5.00e
100% F.C XAsA 100 ppm	12.66a	140.61a	15.67a	3.14a	3.67g
80% F.C XAsA 0 ppm	7.06d	84.12e	12.43c	2.59a	6.00c
80% F.C XAsA 50 ppm	9.65c	109.57d	13.53b	2.98a	5.00e
80% F.C XAsA 100 ppm	11.78b	120.25c	14.27a	3.04a	4.50f
60% F.C XAsA 0 ppm	3.86f	52.00g	10.77d	2.00a	7.00a
60% F.C XAsA 50 ppm	5.68e	65.94f	11.33c	2.33a	6.50b
60% F.C XAsA 100 ppm	7.52d	92.78e	12.83c	2.72a	6.00c

3.22 Fruit diameter (cm)

Data in Table 7 showed that significant differences between the levels of water deficiency in both seasons. The highest values were 3.38 and 3.30 cm with 100% F.C., and the lowest values were 2.49 and 2.35 cm for 60% F.C., respectively in the two experimental seasons.

Regarding AsA concentrations effect, it was cleared that fruit diameter increased with AsA level being 2.79, 2.77 and 3.28 cm for AsA 0, 50 and 100 ppm, respectively in the first season. The values in second season were 2.69, 2.84 and 2.98 cm for AsA 0, 50 and 100 ppm, respectively.

The interaction between levels of water deficiency and ascorbic acid concentrations were insignificant.

3.23 Fruit Tss (%)

Data in Table 7 founded that significant differences between the water deficiency levels in both seasons. The highest values were 6.17% and 6.50% with 60% F.C., and the lowest values were 4.33% and 4.67% for 100% F.C., respectively in the two experimental seasons.

Regarding AsA concentrations effect, it was cleared that fruit Tss decreased with AsA level being 5.89%, 5.39% and 4.28% for AsA 0, 50 and 100 ppm, respectively in the first season. The values in second season were 6.11%, 5.50% and 4.72% for AsA 0, 50 and 100 ppm, respectively.

The interaction between water deficiency levels and ascorbic acid concentrations revealed highest values with 60% F.C × AsA 0 ppm being 6.67% and 7.00% in the first and second seasons, respectively. On the other hand, the lowest values came from the interaction 100% F.C × AsA 100 ppm being 3.00% and 3.67% in the first and the second seasons, respectively.

Maksoud et al. (2009) on olive trees stated that ascorbic acid as antioxidants appears to be a powerful tool for improving yield, fruit weight of olive trees (Chemlali cv.) planted in calcareous soil.

Ibrahim and Selim (2010) show that decreasing irrigation intervals caused significant increases in total fruit yield and marketable yield in the two summer seasons. Bakry et al. (2013) and Rizwan et al. (2011) were reported same results about increasing of yield by ascorbic acid application. Zhwan and Mohammed (2014) found that the combination between irrigation interval with 200 ppm AsA increased yield of wheat. These results are in harmony with those results obtained by Metwally (2011), Alahdadi et al. (2011), Kassab et al. (2012) and Ebrahim et al. (2014).

4 Conclusion

The above-mentioned results indicated that water stress by decreasing the amount of added water adversely affected growth parameters and yield of plants. On reverse, ascorbic acid application via leaves was beneficially affected plant growth and yield. Therefore, it could be concluded that, spraying and used the vitamin c enhancing the drought tolerance of squash plants under water stress conditions.

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