9

Egypt. J. Agron. **Vol.40,** No. 2, pp. 119-132 (2018)

Seed Pre-soaking on Gibberellic Acid (GA3) Enhance Growth, Histological and Physiological Traits of Sugar Beet (*Beta vulgaris* L) under Water Stress

Enas Safaa Azab[#]

Agricultural Botany Department, Faculty of Agriculture, Suez Canal Universty, Ismailia, Egypt.

THE PRESENT study aimed to evaluate the effect of three levels of gibberellic acid solutions (50, 100 and 150 mg/L) on two sugar beet cultivars. (Farida and Sultan) under three field capacity (50 , 75 and 100%). This experiment was carried out at the Experimental Farm, Faculty of Agriculture, Suez Canal University, Ismailia, during the two growing successive seasons of 2013/14 and 2014/15. Results showed that all GA3 tested treatments statistically improved growth parameters, i.e., number of leaves, fresh and dry weights of leaves/plant, as well as, root yield, sucrose%, photosynthetic pigments (chlorophylls a, b and carotenoids), relative water content (RWC), leaf osmotic pressure (LOP) and the studied anatomical characters (thickness of mysophyll, thickness of midrib, thickness of palisade tissue, thickness of spongy tissue, average number of xylem vessels/vascular bundle, thickness of vascular bundle, thickness of collenchaymatous tissue and upper epidermis). Conclusively, this study indicates that, soaking seeds in GA3 solutions especially at 150 mg/L can decrease the effects of drought on growth and yield of sugar beet.

Keywords: Sugar beet, GA3, Anatomical characters, RWC, LOP, Chlorophyll.

Introduction

Sugar beet (*Beta vulgaris* L) is the second main source of sugar after sugar cane in the world. In Egypt, sugar beet cultivated area have been increased to 423,000 faddan in 2014. It produced 53.1% of the total amount of sugar production. This means that sugar beet has become the first source of sugar production compared to other sugar cane (Egyptian Society Sugar Technologists and Sugar Crops Research Institute, 2014).

Gibberellins (GAs) are plant phytohormones that regulate growth and effect various developmental processes, including stem elongation, germination, flowering, sex expression, and enzyme induction as α- amylase. Leopold & Kriendemann (1978)showed that GA3 has the capability of modifying the growth pattern of treated plants by affecting the DNA and RNA levels, cell division, cell expansionand biosynthetic pigments.

Exogenous application of gibberellic acid (GA3) in cotton plants cultivated under drought alleviated the effect of drought by improving the relative water content of leaves (Renu et al., 2004). Ghasempour et al. (2001) recorded that exogenous application of GA3 improved the protoplasmic drought tolerance of *Sporobolus stapfianus* cell under suspension culture. Moreover, GA3 improved tolerance under abiotic stress as drought by induction and increasing the endogenous levels of salicylic acid (Alonso-Ramirez et al., 2009).

Drought is one of most problems for agriculture in arid and semi-arid zones, which determines the success or failure of plants establishment (Gamze et al., 2005). Water stress affects on different levels of plant growth (morphologically, physiologically and histologically) and induces changes as, reduce germination, aerial organ growth reduction, decrease in dry biomass and growth rate (Huang, 1997). Under drought, photosynthetic efficiency is decreased as stomatal closure which restricts CO_2 uptake (Pantin et al., 2013 and Flexas & Medrano, 2002). Association of the photosynthetic activity a decrease of chlorophyll concentration as a consequence of membrane disturbances in the mesophyll cells (Cornic & Masacci,1996).

[#]Corresponding author email: enassafaa2010@hotmail.com

DOI: 10.21608/agro.2018.2944.1095

Extreme drought stress reduces the expression of genes that are important in protein synthesis and plant growth regulators. The proteins which are made in the plant will be disintegrate into amino acids during the drought stress, these amino acid lead to increase the concentration of substances in the plant, so the plant resistance against water stress increases (Kafi and Damghani, 2007). In general, plant hormones such as gibberellin lead to a change, release or probably produce regulator protein and as a result, the activity of this protein is only found in Aleurone cells which have received the hormonal message(Taiz & Zeiger, 2005).

The present paper aimed to study the effect of pre- soaking of seed with GA3 and water deficit on some growth characters, photosynthesis pigments (Chl. a, Ch. b and carotenoids), anatomical characters and yield of two sugar beet cultivars.

Materials and Methods

Two field experiments were conducted during the winter seasons of 2013/14 and 2014/15 at Experimental Farm, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt to study the effect of GA3 on behavior of two sugar beet (*Beta vulgaris* L) cvs, Farida and Sultan. Seed of both cultivars were obtained from Sugar Crops Institute Research, Agriculture Research Center, Giza, Egypt. Seeds were soaked for 10h in 50, 100 and 150mgL^{-1} of GA3 and distilled water (control treatment) as four treatments. Irrigation treatments application were imposed using 100%, 75% and 50% of the amount of daily irrigation were calculated by CROPWAT software version 7.0 (Smith, 1991) from agro-meterological data of the studied area, Eto (the reference evapotranspiration (mm/day)) and Kc (the crop coefficient). From this method, the amount of water that equivalent to 100%, 75% and 50% are 2059, 1544 and 1029m^3, respectively. The experimental sub-sub plot consisted of 5 ridges 5m in length and 60cm in width (area =15m^2) .

Growth characters

At 120 days after sowing, ten plants were taken randomly to record: Fresh and dry weights of shoot/plant (g) and number of leaves/plant.

Photosynthesis pigment content

The photosynthesis pigments (Chl. a, Chl. b and carotenoids) were determined in the 3rd leaf of sugar beet after 120 days from sowing. Every sample of leaves was collected and put it in ten ml acetone 85% in a dark bottle, and left to stand for 15h at room temperature, the sample was then filtered on glass wool into a 100ml volumetric flask, and made up to volume by 85% acetone solution. The optical density of the sample was then measured at wave length 440.5, 644 and 662nm using a Beckman DK-2 Spectrophotometer.

Chlorophyll a = (9.784 x E 662) – (0.99 x E 644) = mg g^{-1}D.Wt.

Chlorophyll b = (21.426 x E 644) – (4.65 x E 662) = mg g^{-1}D.Wt.

Carotenoids = (4.695 x E 440.5) – 0.268 (chlorophyll a+b) = mg g^{-1}D.Wt.

E = Optical density at the wave length indicated (Wettstein, 1957 and Fadl & Sari El- Deen , 1978).

Leaf osmotic pressure (LOP)

It was measured via two steps:

Firstly: Sample of leaves were taken randomly from each sub –sub plot and put in desiccators contains concentrated nitric acid and covered for 5min.

Secondly: The samples were squeezed to obtain the cell sap on the manual refractometer to determine total soluble solids (T.S.S). Osmotic pressure was calculated with the following formula according to Gosav (1960):

$$\text{O. P} = \text{T. S.S.} \times 1.013$$

Relative water content (RWC) of leaves

Leaf relative water content (RWC) was proposed as a better indicator of water status. RWC, through its relation to cell volume, may more closely reflect the balance between leaf water supply and transpiration rate. RWC was determined according to Schonfeld et al. (1988) for combined analysis for both seasons using the following equation:

$$\text{RWC}\,\% = \frac{\text{Fresh weight - dry weight}}{\text{Turgid weight - dry weight}} \times 100$$

Histological characters

Some characters of transverse sections of the leaf were estimated in the second season (2014-15) such as, thickness of mysophyll, thickness of midrib, thickness of palisade tissue, thickness of spongy tissue, average number of xylem vessels/ vascular bundle, thickness of vascular bundle, thickness of collenchaymatous tissue and upper epidermis. All measurements estimated in mµ.

Killing and fixation of leaf sample in 70% formalin acetic acid (F.A.A.) solution, dehydration and clearing with ethyl-alcohol and xylene, infiltration and embedding in pure parafine wax (M. P. 56-58°C) were carried out as described by Nassar & El-Sahhar (1998). Using a rotary microtome, sections of leaf (15µ) were obtained and stained with safranin and light green. Sections, in such cases were microscopically examined and analyzed with the image processing program Image. Anatomical examination and measurements were achieved using a Leica light Research Microscope model PN: DM 500/13613210 supplied with a digital camera.

Root and sugar yields/faddan (ton)

Root yield of each sub- sub plot was determined then root yield per faddan (ton) was calculated. sugar yield was calculated by multiplying sucrose% of each treatment by root yield per faddan. Sucrose percentage was determined by propol automatic polar meter on lead acetate extract of fresh macerated roots according to the method of Le-Docte (1927).

Statistical analysis

This study was analyzed by using appropriate analysis of variance (ANOVA) for three factorial experiments in split – split plot design with three replications. Whereas, water stress treatments were allocated in the main plot, while varieties in the sub plots and GA3 treatments in the sub-sub plots. Statistical analysis was done using the COSTAT programe for Window, version 6.311 (Cohort Software, Berkeley, CA, USA). The differences between means were compared using the least significant difference test (L.S.D) at 5% levels according to Snedecor & Cochran (1980).

Results and Discussions

Data in Tables 1, 2 and 3 showed that increasing drought stress (water regime) from 100 to 50% FC significantly decreased both fresh and dry weights of shoot/plant (FW, DW) as well as number of leaves/plant and that was true in both seasons. FW of leaves/plant decreased by 20.4% and 28.8% in 1st season and by 22.3% and 37.4% in 2nd season under drought treatments 100% (control treatment) compare to 75 or 50% FC, respectively. DW of leaves/plant decreased by 17.7% in 1st season and by 40.3% in 2nd season as water stress increased to 75% or 50% compared with control treatment. Also, number of leaves/plant decreased by 14.7% and 35.4% in the 1st season and by 32.2% and 49.1% in the 2nd season when drought treatments extended to 75% or 50% FC.

Farida cv. significantly surpassed Sultan cv. in FW and DW of leaves/plant as well as in number of leaves/plant and that was true in the two growing seasons (Tables 1, 2 and 3). It meaning that drought tolerant associated with genetic structure of plants and deferred according to varieties and cultivars.

Increasing GA3 level from 50mg/L to 100mg/L or 150mg/L significantly increased FW and DW of leaves/plant as well as number of leaves per plant. Also, all examined levels of GA3 superposed the control treatment that held true under both sugar beet cultivars in the two growing seasons (Tables 1, 2 and 3). However, FW treated by 150mg/L GA3 and exposed to drought 50% FC accumulated about (448g and 593g for Farida cv. 385g and 535g for Sultan cv. in 1st and 2nd seasons, respectively) surpassed the FW of either those plants which accumulated under 50mg GA3 and 75% FC treatment (395g and 483g for Farida cv. and 350g and 448g for Sultan cv. in the successive seasons, respectively) or those plants which untreated by GA3 and 100% FC (410g and 503g for Farida cv. and 287g and 450g for Sultan cv. in the two seasons, respectively).

DW of leaves/plants under 50% FC and treated with 150mg/L GA3 (66.7g and 71.7g for Farida cv. and 53.3g and 60g for Sultan cv. give equaled or superposed values of DW than those 100% FC and untreated with GA3 or those under 75% FC and treated with 50mg/L GA3 and true in the two growing seasons. On the other hand, number of leaves/plant which irrigated every 15 days and treated with 150mg/L GA3 recorded values equaled or surpassed those under 75% FC and untreated with GA3 and that was true for both sugar beet varieties in the seasons.

TABLE 1. Effect of GA3 and field capacity (FC) treatments on mean of leaves FW and DW of two sugar beet cultivars (Farida and Sultan) at 120 days from sowing during 2013/14 and 2014/15 seasons.

Var.	GA3 mg/L	FW of leaves (g)								DW of leaves (g)							
		2013/14				2014/15				2013/14				2014/15			
		FC %				FC %				FC %				FC %			
		100%	75%	50%	Mean	100%	75%	50%	Mean	100%	75%	50%	Mean	100%	75%	50%	Mean
Farida	Control	410	307	212	310	508	427	328	421	50.0	46.3	32.7	43.0	71.7	60.0	49.3	60.3
	50	497	395	290	394	643	483	400	509	65.0	53.3	36.7	52.0	80.0	69.3	50.0	66.4
	100	580	457	360	466	762	597	483	614	80.0	66.7	43.3	63.3	91.0	74.3	57.0	74.1
	150	670	503	448	540	957	702	593	751	107	83.3	66.7	86.0	133	81.0	71.7	95.2
	Mean	539	416	328	427	718	552	451	573	75.5	62.4	44.8	61.0	94.0	71.2	57.0	74.0
Sultan	Control	287	255	173	238	450	412	230	364	39.0	32.3	23.3	31.5	60.0	56.7	41.0	52.6
	50	463	350	240	351	568	448	372	463	60.0	50.0	35.0	48.3	80.0	61.7	50.0	64
	100	504	430	333	422	710	502	447	553	68.3	55.3	40.0	54.5	80.0	70.0	52.3	67.4
	150	603	495	385	494	810	637	535	661	86.7	70.0	53.3	70	100	80.0	60.0	80
	Mean	464	382	283	376	635	500	396	510	63.5	51.9	37.9	51.0	80.0	67.1	51.0	66.0
Mean		501	399	357		677	526	424		69.5	57.2	41.5		87	69.2	54	

L.S.D 2013/14 FC% = 4.7, GA3 = 5.0, Var = 3.2; L.S.D 2014/15 FC%.= 11.4, GA3= 6.9, Var.= 5.0; L.S.D. 2013/ 14 FC%.= 1.1, GA3= 1.22, Var.= 0.63; L.S.D. 2014/ 15 FC%= 2.1, GA3= 2.0, Var. = 1.03.

TABLE 2. Effect of GA3 and field capacity (FC%) treatments on mean of leaves numbers/plant of two sugar beet cultivars (Farida and Sultan) at 120 days from sowing during 2013/14 and 2014/15 seasons.

Var.	GA3 mg/L	Number of leaves / plant							
		2013/14				2014/15			
		FC%				FC%			
		100%	75%	50%	Mean	100%	75%	50%	Mean
Farida	Control	26.3	23.0	18.0	22.4	39.3	31.0	23.0	31.3
	50	29.0	25.0	20.7	25.0	45.0	33.3	25.0	34.4
	100	32.7	27.0	22.0	27.2	55.0	36.7	28.0	40.0
	150	48.7	40.7	26.3	38.6	83.3	45.3	33.7	54.1
	Mean	34.2	29.0	21.8	28.3	55.7	36.6	27.4	39.9
Sultan	Control	25.3	22.3	15.7	21.1	35.7	30.0	21.3	29.0
	50	27.3	23.7	19.3	23.4	41.7	31.7	24.0	32.5
	100	31.7	25.0	20.7	25.8	49.0	35.0	26.7	36.9
	150	35.0	31.0	22.7	29.6	66.7	39.3	30.0	45.3
	Mean	29.8	25.5	19.6	25.0	48.3	34.0	25.5	35.9
Mean		32.0	27.32	20.7	26.7	52.0	35.3	26.5	37.9

L.S.D 2013/14 FC% = 0.36, GA3 = 0.3, Var = 0.2; L.S.D 2014/15 FC%. = 0.71, GA3= 0.82, Var.= 0.41.

TABLE 3. Effect of GA3 and FC% treatments on root and sugar yield of two sugar beet cultivars (Farida and Sultan) at 120 days from sowing during 2013/14 and 2014/15 seasons.

Var.	GA3 mg/L	Root yield (ton/faddan)								Sugar yield (ton/faddan)							
		2013/2014				2014/2015				2013/2014				2014/2015			
		FC%				FC%				FC%				FC%			
		100%	75%	50%	Mean	100%	75%	50%	Mean	100%	75%	50%	Mean	100%	75%	50%	Mean
Farida	Control	9.80	5.80	5.00	7.00	25.0	18.3	15.9	19.7	1.90	1.00	1.00	1.30	3.20	2.40	2.10	2.57
	50	12.6	9.20	5.40	9.10	28.0	21.4	16.3	21.9	2.00	1.10	1.70	1.60	4.00	2.50	2.30	2.93
	100	13.6	11.1	6.40	10.4	29.8	28.4	23.3	27.2	2.30	1.60	1.80	1.90	4.30	3.40	3.40	3.70
	150	14.9	13.8	8.00	12.2	37.1	29.5	28.0	31.5	2.70	2.10	2.10	2.30	5.80	4.20	3.40	4.47
	Mean	12.8	10.0	6.20	9.70	30.0	24.4	20.9	25.1	2.23	1.45	1.65	1.78	4.33	3.13	2.80	3.42
Sultan	Control	7.50	4.90	5.30	5.90	24.5	18.6	16.3	19.8	1.10	1.00	1.20	1.10	2.40	2.30	2.20	2.30
	50	9.30	7.80	7.20	8.10	25.0	20.4	16.6	20.1	1.30	1.30	1.30	1.30	3.90	2.70	2.40	3.00
	100	10.5	8.30	8.40	9.10	28.0	21.3	18.0	22.4	1.60	1.60	1.40	1.53	4.30	3.60	2.70	3.53
	150	12.0	8.6	8.50	9.70	33.0	23.7	20.0	25.6	2.30	2.00	1.80	2.03	4.20	3.60	2.80	3.53
	Mean	9.83	7.40	7.35	8.20	27.6	21.0	17.7	22.1	1.58	1.48	1.43	1.49	3.70	3.05	2.53	3.09
Mean		11.3	8.70	6.78		28.8	22.7	19.3		1.91	1.47	1.69		4.02	3.09	2.27	

L.S.D 2013/14 FC% = 0.014, GA3 =0.30, Var = 0.05; L.S.D 2014/15 FC% = 0.25, GA3= 0.27, Var.= 0.15; L.S.D. 2013/ 14 FC% = 0.90, GA3 = 0.17, Var. = 0.09; L.S.D. 2014/ 15 FC%= 0.42, GA3= 0.46, Var. = 0.22.

The previous results were agreed with, Mohammadian et al. (2005) who reported that water stress affected root DW more than shoot DW in sugar beet. Also, Wu et al. (2014) found that drought reduced shoot FW and water content. Abbas (2013) show that GA3 increased shoot DW of Dill (*Anethum graveolens* L). Moreover, Kaya et al. (2006) stated that water stress reducedt he leaf dry weight, in maize. Shreelalitha et al. (2015) found that the GA3 acid enhanced the shoot growth and shoot DW in corn. Bayomi (2002) found that leaf growth was more sensitive to soil water deficit, which lead to regression of top yield in sugar beet.

Photosynthetic pigments concentration (mg/g DW)

It is clearly evident from Data illustrated in Fig 1, 2 and 3 that exposed plants to high level of drought (75 and 50%) reduced the amount of chlorophyll a, b (Chl. a, b) and total carotenoids and this result held result held true for both sugar beet cultivars in the two seasons. Sultan cv. was more affected by 50% FC (high level of stress) than Farida cv. concerning these traits. Increasing levels of GA3 enhanced the levels of photosynthetic pigments under the three FC levels compared with the 100% FC (control). These results were coordinated with Shaddad et al. (2013) who obvious that GA3 treatments improved the photosynthetic pigments and consequently the crop yield of two wheats cultivars. Cornic & Masacci (1996) explained that reduction soil water content caused stomatal closure which leading to a lower internal CO_2 concentration, as a result it limited the photosynthesis efficiency. Kaya et al. (2006) stated that water stress reduced chlorophyll concentration in maize and GA3 improved the water stress tolerance in maize plants by maintaining the membrane permeability, enhancement the chlorophyll concentration. In addition, Shreelalitha et al. (2015) found that the GA3 acid enhanced the carotenoids in the corn plants. Using of plant growth regulators as GA3 and cytokinin, stimulate increasing synthesis of photosynthetic pigments (Salehi Sardoei, 2014).

Relative water content (RWC) and leaf osmotic pressure (LOP)

Relative water content (RWC) and leaf osmotic pressure (LOP) were determined to give indication about the plant water status for the three factors of the experiment. Figure 4 and 5 showed significant differences between the sugar beet cultivars in RWC and LOP, whereas Farida cv. surpassed Sultan cv. in both traits. RWC reduced by increasing drought levels, but enhanced by increasing GA3 levels under drought stress. Wu et al. (2014) found that drought reduced water content.

Farida cv. maintained higher RWC under stress conditions results demonstrated that Farida was more drought tolerant than sultan cv. Moreover, it can be concluded that Farida cv. may tend to arise its RWC, by higher accumulation of solute and osmotic metabolites. Therefore, osmotic adjustment raises the RWC of plant under drought mentioned by Ritchie et al. (1990).

In contrast trend, osmotic pressure (Fig. 5) was increased by increasing drought levels and reduced by increasing GA3 levels under drought stress. These results are in harmony with those obtained by Kafi & Damghani (2007) and Ashraf & Iram (2002). Kusvuran (2012) cleared that osmotic potential and leaf water potential were decreased with drought stress. Kaya et al. (2006) stated that water stress reduced leaf (RWC) in maize and GA3 improved the water stress tolerance in maize plants by maintaining membrane permeability, and improve the (RWC) in leaves.

Root and sugar yields/faddan (ton)

Data in Table 3 showed that lengthen of water stress levels (from 100% to 75% or 50% FC) lead to significantly decrease in root yield/fad. Decreasing of root yield was by 23% and 40% in the 1st season and by 21.2% and 33% in the 2nd season, respectively.

Increasing of GA3 level from 50 to 150mg/L GA3 gave significant increment of root yield/fad. Increment of root yield in Farida cv. was 30 to 74.3% in the first season and 11.2 to 59.9% in the 2nd season, respectively. Also, Sultan cv. in 1st season by 37.3% to 64.4% in the first season and by 4.5 to 29.3 in the second one compared with control.

Farida cv. surpassed Sultan cv. in root yield/fad by 18.3% in 1st season and by 13.5% in the 2nd. Data of sugar yield (ton/fad) gave the same trend of root yield/fad as affected by water stress, GA3 levels and varietal differences of sugar beet (Table3). The results were agreed with other (Caro & Cucci, 1986 and Sayfzadeh & Rashidi, 2010) who found that water stress in the early stage of sugar beet growth reduced root yield. Shaddad et al. (2013) found that GA3 treatments improved the crop yield in wheat. Carter et al. (1980) and Mahmoodi et al. (2008) found that soil water deficit decreased sugar yield and sugar concentrations in sugar beet. While Hoffmann (2010) concluded that the accumulation of compatible solutes in the storage root of beets under drought affected the sucrose content. Entessar & Abbas (2013) found that drought stress caused significant declines in dry matter accumulation, root yield, top yield, sugar yield. These declines were depending on the duration of drought. Increasing of drought period, increased stress severity. Physiologically, sucrose % may have increased as result of decreasing of water content in the roots. But sugar yield was more affected by root yield which more sensitive to drought (Javaheri et al., 2006 and Hoffmann, 2010)

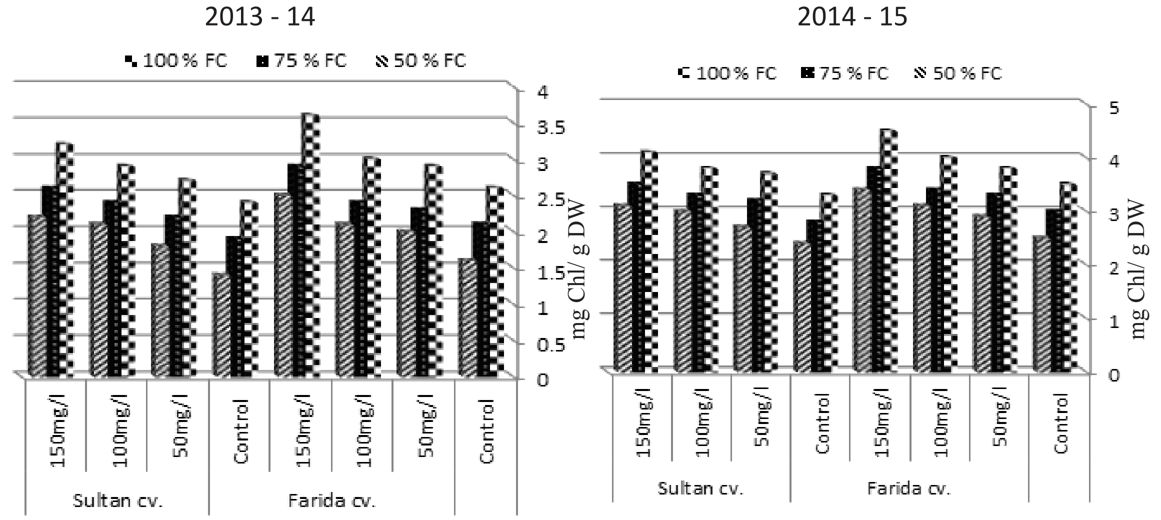


Fig 1. Effect of GA3 and FC% treatments on Chl a of two sugar beet cultivars (Farida and Sultan) at 120 days from sowing during 2013/14 and 2014/15 seasons.

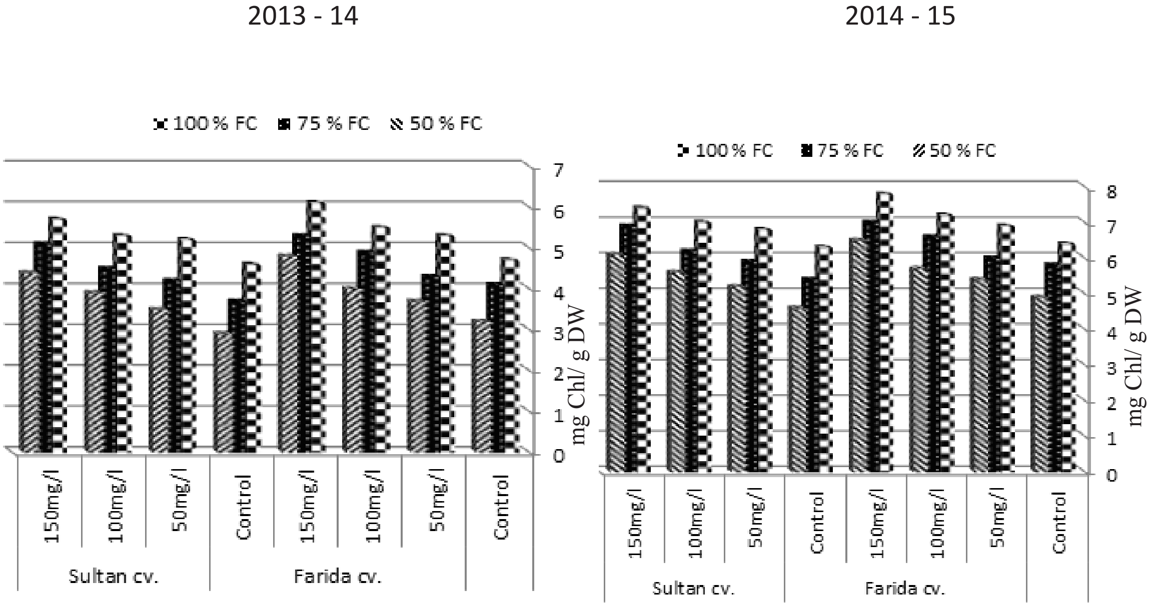


Fig 2. Effect of GA3 and FC% treatments on Chl b of two sugar beet cultivars (Farida and Sultan) at 120 days from sowing during 2013/14 and 2014/15 seasons.

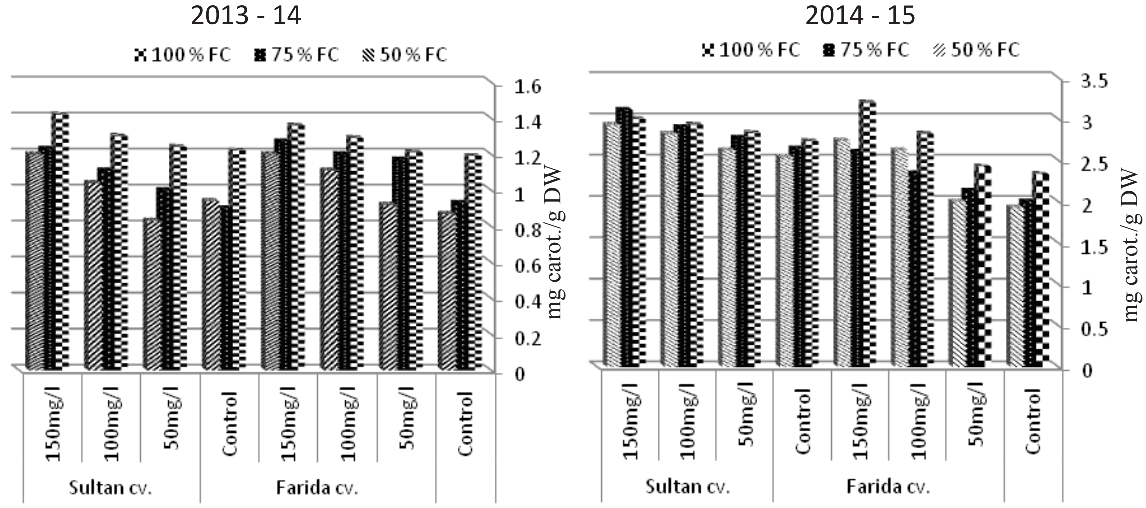


Fig 3. Effect of GA3 and FC% treatments on carotenoids of two sugar beet cultivars (Farida and Sultan) at 120 days from sowing during 2013/14 and 2014/15 seasons.

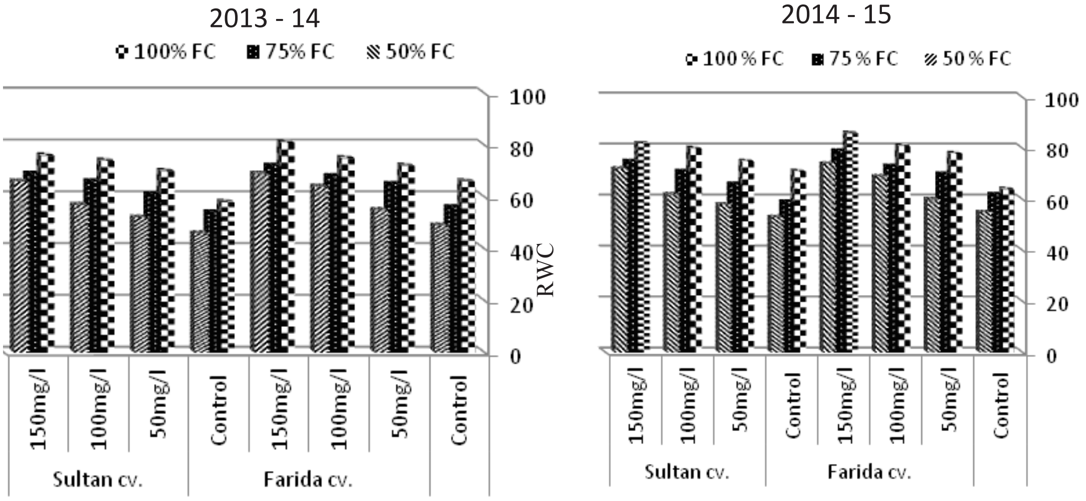


Fig. 4. Effect of GA3 and FC% treatments on relative water content (RWC) of two sugar beet cultivars (Farida and Sultan) at 120 days from sowing during 2013/14 and 2014/15 seasons.

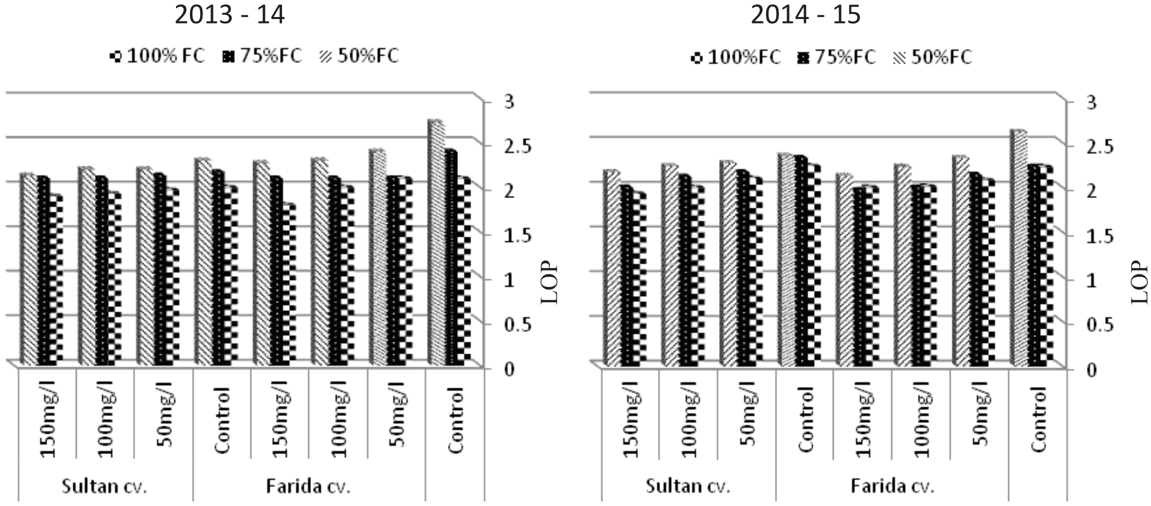


Fig 5. Effect of GA3 and FC% on treatments leaf osmotic pressure (LOP) of two sugar beet cultivars (Farida and Sultan) at 120 days from sowing during 2013/14 and 2014/15 seasons.

Anatomical characters

Measurements as, average of palisade tissue thickness and average of spongy tissue thickness, midrib (µm) average of midrib thickness, number of xylem vessels/main vascular bundle, thickness of collenchymatous tissue and upper epidermis and thickness of vascular bundle were illustrated in Table 4 and Plate 1, 2. Sugar beet (Farida and Sultan cvs.) grown under normal conditions (100%) gave the maximum values of mesophyll, midrib, thickness of collenchymatous tissue and thickness of vascular bundle. In contrary, increasing of water stress reduced all previous traits. On the other hand, number of xylem vessels/main vascular bundle (µm) was increased with lengthen drought levels. GA3 treatments (50, 100 and 150mg/L) was increased all anatomical measurements compared to control (untreated treatment) in both cultivars. Increasing of GA3 level to 150mg/L gave an increase palisade tissue by 48% and 33% in spongy tissue by 47.8% and by 39%, in midrib thickness by 32% and 11.9% in number of xylem vessels by 11% and 31.5% in thickness of collenchymatous tissue by 29% and 14.2% in thickness of vascular bundle by 33% and 20.1% compared with control for Farida and Sultan cvs., respectively. Briefly, 150mg/L GA3 treatment gave 100% FC approximately the same results at control treatment and sometimes superposed in some values as number of xylem vessels/main vascular bundle which is the one of important character related with drought tolerant. In this regard, Aldesuquy (1992) reported that GA3, had special effects on leaf anatomy and chloroplast structure in wheat. However, Abbas (2013) illustrated that GA3 decreased significantly vascular bundles thickness and vascular units diameter of Dillplant (*Anethum graveolens* L) under water stress. Also, Agamy (2004) and Xu et al. (2008) investigated the effect of some growth regulators on the anatomical characters of several plants and found a pronounce effects on thickness of epidermis and cortex and number and diameter of vascular bundles in sweet fennel. Under water stress, Bahrami et al. (2013) illustrated that the leaves thickness and xylem width could be considered key structural features of leaves that manage the ability of a safflower genotype to tolerate water deficit stress. Zhang et al. (2014) reported that drought stress reduced mesophyll cells and the cells in vascular structure in sugar cane plants. Sankar et al. (2013) showed that water deficit was very much reduced the thickness of the leaf, upper and lower epidermis and the number of cells per unit area in the palisade and spongy regions. The palisade and spongy layers of mesophylls were well-differentiated, and the cells are wide and long on peanut plants.

TABLE 4. Effect of GA3 and FC% treatments on anatomical characters of two sugar beet cultivars (Farida and Sultan) during 2014/ 15 season.

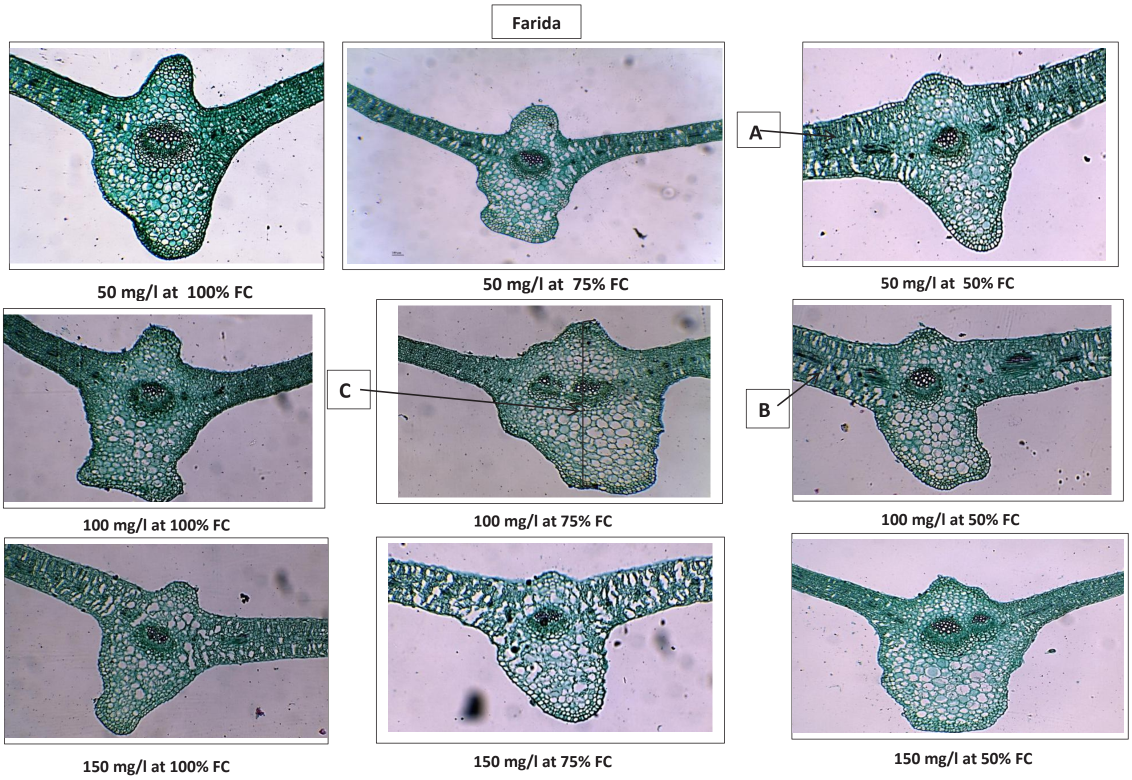
Var.	GA3 mg/L	Average of palisade tissue thickness (µm)				Average of spongy tissue thickness (µm)				Average of midrib thickness (µm)			
		100% FC	75 %FC	50% FC	Mean	100% FC	75 %FC	50% FC	Mean	100% FC	75 %FC	50% FC	Mean
Farida	Control	137	127	103	122	93.0	65.0	50.0	69.0	1027	1060	853	980.0
	50	120	130	116	122	73.0	70.0	77.0	73.0	1086	1107	950	1047
	100	143	137	120	133	103	90.0	63.0	85.0	1186	1297	1040	1174
	150	210	150	183	181	130	90.0	87.0	102	1307	1347	1240	1298
	Mean	152	136	130	139	100	79.0	69.0	82.0	1151	1202	1020	1124
Sultan	Control	130	120	83.0	111	70.0	70.0	43.0	61.0	1147	1037	990	1058
	50	150	120	110	127	83.0	70.0	57.0	70.0	1190	1053	1020	1087
	100	140	130	113	128	97.0	83.0	60.0	80.0	1267	1090	1033	1130
	150	160	160	123	148	103	90.0	63.0	85.0	1300	1133	1120	1184
	Mean	145	132	107	128	88.3	78.3	55.8	74.0	1226	1078	1040	1114
Mean		149	134	118		94.2	78.7	62.4		1188	1140	1030	

L.S.D FC%= 2.3, GA3 = 2.2, Var = 1.03; L.S.D FC% = 1.7, GA3= 1.3, Var.= 0.68; L.S.D FC%. = 1.3 , GA3 = 1.5, Var. = 0.63.

TABLE 4. Cont.

Var.	GA3 mg/L	Number of xylem vessels/main vascular bundle (µm)				Thickness of collenchymatous tissue and upper epidermis (µm)				Thickness of vascular bundle (µm)			
		100% FC	75 %FC	50% FC	Mean	100% FC	75 %FC	50% FC	Mean	100% FC	75 %FC	50% FC	Mean
Farida	Control	15.0	19.0	19.7	17.9	363	290	223	292	243	212	200	218
	50	16.0	19.0	20.7	18.6	300	310	260	290	300	226	210	245
	100	17.3	20.0	21.0	19.4	310	347	275	310	300	260	220	260
	150	18.0	20.0	21.7	19.9	440	353	340	377	310	280	280	290
	Mean	16.6	19.5	20.8	75.8	353	325	274	317	288	244	227	253
Sultan	Control	18.3	19.3	19.3	19.0	333	320	300	317	223	210	210	214
	50	19.7	21.0	21.7	20.8	350	323	310	327	250	223	210	228
	100	20.0	21.3	21.7	21.0	380	332	310	340	250	230	220	233
	150	23.7	25.3	26.0	25.0	397	350	340	362	310	240	222	257
	Mean	20.4	21.7	22.2	21.5	365	331	315	336	258	226	215	233
Mean		18.5	20.6	21.5		359	328	294		273	235	221	

L.S.D FC% = 6.4, GA3 = 4.5, Var = 2.5; L.S.D FC% = 0.13, GA3= 0.16, Var.= 0.08; L.S.D FC% = 1.77 , GA3 = 2.18, Var.= 1.36.

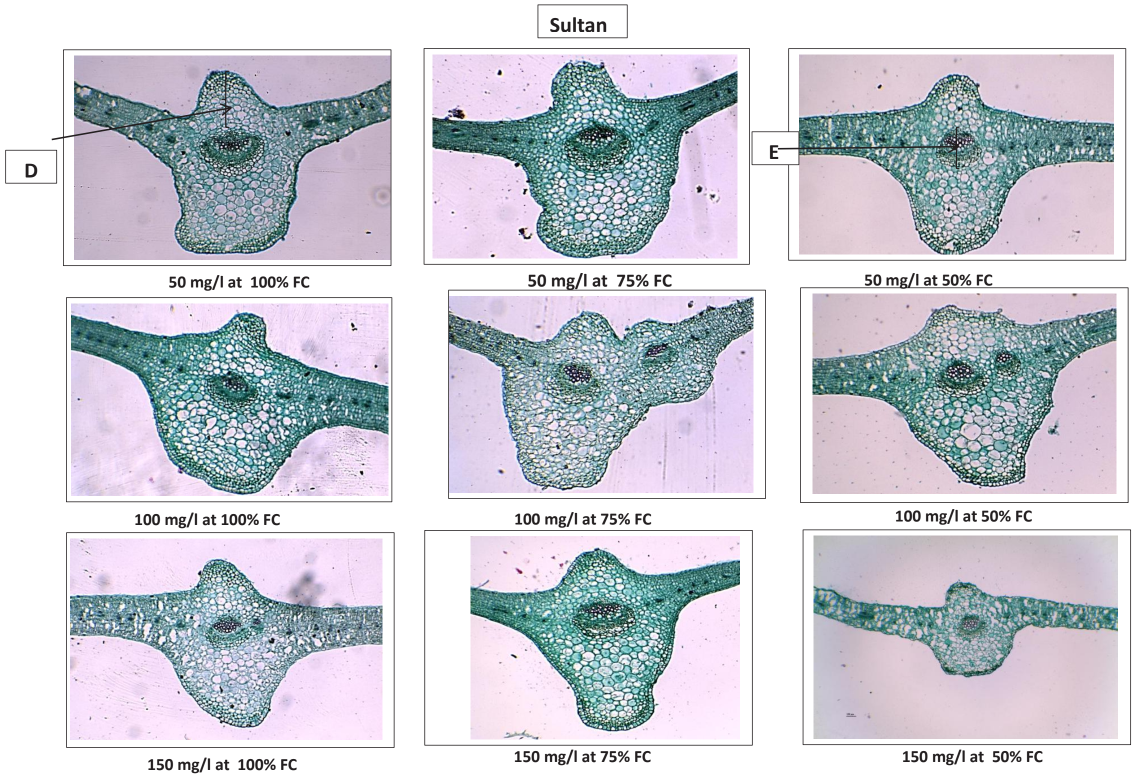


50 mg/l at 100% FC; 50 mg/l at 75% FC; 50 mg/l at 50% FC

100 mg/l at 100% FC; 100 mg/l at 75% FC; 100 mg/l at 50% FC

150 mg/l at 100% FC; 150 mg/l at 75% FC; 150 mg/l at 50% FC

Plate 1. Cross sections of leaves of sugar beet Farida cv. under GA3 and FC% treatments during 2014/2015 season. A: Palisade tissue thickness (µm), B: Spongy tissue thickness (µm) and C: Midrib thickness (µm). Bar=100µm.



50 mg/l at 100% FC
50 mg/l at 75% FC
50 mg/l at 50% FC
100 mg/l at 100% FC
100 mg/l at 75% FC
100 mg/l at 50% FC
150 mg/l at 100% FC
150 mg/l at 75% FC
150 mg/l at 50% FC

Plate 2. Cross sections of leaves of sugar beet Sultan cv. under GA3 and FC% treatments during 2014/2015 season. D:Thickness of collechymatous tissue and upper epidermis (µm) and E: Thickness of vascular bundle (µm). Bar=100µm.

Conclusion

It could be concluded that pre-soaking of seed of *Beta vulgaris* cvs. Farida and Sultanin with GA3 solutions enhanced plant growth parameters, photosynthetic pigments, anatomical characters and yields of root and sugar. Moreover, 150 mg/L GA3 treatment gave the best results under normal and drought conditions.

References

Abbas, M.K. (2013) Effect of foliar fertilizer and some growth regulators on vegetative and anatomical characters of Dill (*Anethum graveolens* L). *Middle-East Journal of Scientific Research,* **13**(6), 803-811.

Aldesuquy, H.S. (1992) Growth and pigment content of Wheat as influenced by the combined effects of salinity and growth regulators. *Biol. Plant J.* **34**, 275-283.

Agamy, R.A. (2004) Effect of mineral and/ orbiofertilizers on morphological and anatomical characters, chemical constituents and yield of sweetfennel (*Foeniculum vulgare* Mill. cv. Dulce) plants grown in calcareous soil. *Egypt. J. Appl. Sci.* **19**(3), 55-75.

Alonso-Ramirez, A., Rodriguez, D., Reyes, D., Jimenez, A.J., Nicolas, G., Lopez-Climent, M., Gomez-Cadenas, A. and Nicolas, C. (2009) Evidence for a role of gibberellins in salicylic acid-modulated early plant responses to abiotic stress in *Arabidopsis* seeds. *Plant Physiology*, **150**, 1335-1344.

Ashraf, M. and Iram, A. (2002) Optimization and influence of seed priming with salts of potassium or calcium in two spring wheat cultivars differing in salt tolerance at the initial growth stages. *Agro. Chimica*. **46,** 47-55.

Bahrami, F., Arzani, A. and Amini, H. (2013) Leaf anatomical characteristics in safflower genotypes as affected by drought stress. *Acta Biologica Szegediensis*, **57**, 39-42.

Bayomi, Y.A. (2002) Sugar beet leaf growth and yield response to soil water deficit. *African Crop Science Journal,* **10**(1), 51-66.

Caro, A.D. and Cucci, G. (1986) Four year experiment on spring-seeded sugar beet irrigation and harvest time in southern Italy. *Irrigation,* **33**(3), 21-25.

Carter, J.N., Jensen, M.E. and Travellers, D.J. (1980) Effect of mid- tolate- season water stress on sugar beet growth and yield. *Agronomy Journal,* **72**, 806-815.

Cornic, G. and Masacci, A. (1996) Leaf photosynthesis under droughtstress. In: "*Photosynthesis and the Environment*". Baker, N.R. (Ed.), pp 347–366. Kluwer Academic Publishers, Dordrecht.

Egyptian Society Sugar Technologists and Sugar Crops Research Institute (2014).

Entessar, A. and Abbas, F. (2013) The effect of length during drought stress on sugar beet (*Beta vulgaris* L) yield and quality. *Persian Gulf Crop Protection,* **2**, 35-43.

Fadl, M.S. and Sari El- Deen, S.A. (1978) Effect of N-benzyl adenine on photosynthesis pigments and total soluble sugars of olive seedling grown under saline condition. *Egypt. J. Hort*. **6**(2),169-183.

Flexas, J. and Medrano, H. (2002) Drought-inhibition of photosynthesis in C3 plants: Stomatal and non-stomatal limitation revisited. *Ann. Bot.* **89**,183-189.

Gamze, O., Mehmet, D.K. and Mehmet, A. (2005) Effects of salt and drought stresses on germination and seedling growth of pea (*Pisum sativum* L.). *Turk. J. Agri.* **29**, 237-242.

Ghasempour, H.R., Anderson, E.M. and Gaff, D.F. (2001) Effects of growth substances on the protoplasmic drought tolerance of leaf cells of the resurrection grass *Sporobolus stapfianus*. *Australian J. Plant Physiol*. **28**(11), 1115-1120.

Gosav, N.A. (1960) "*Some Methods in Studying Plant Water Relation*". Leningrad. Acad. Sci. USSR.

Hoffmann, C.M. (2010) Sucrose accumulation in sugar beet under drought stress. *Journal of Agronomy and Crop Science,* **196**, 243-252.

Huang, B. (1997) Drought resistance mechanisms of seven warm season turf grass under surface soil drying. *Crop Sci.* **37**, 1858-1863.

Javaheri, M.A., Najafinezhad, H. and Azad Shahraki, F. (2006) Study of autumn sowing of sugar beet in Orzouiee area (Kerman province). *Pajouhesh Sazandegi*, **71**(2), 85-93.

Kafi, M. and Damghani, A. (2007) "*Mechanisms of Plants Resistance to Environmental Stresses*" (translation). Ferdowsi University of Mashhad Publications, p 467.

Kaya, C., Tuna, A.L. and Alves, A.A.C. (2006) Gibberellic acid improves water deficit tolerance in maize plants. *Acta Physiologlae Plantarum,* **28** (4), 331-337.

Kusvuran, S. (2012) Effects of drought and salt stresses on growth, stomatal conductance, leaf water and osmotic potentials of melon genotypes (*Cucumis melo* L). *African Journal of Agricultural Research,* **7**(5), 775-781.

Le-Docte (1927) Commercial determination of sugar beet in the beet root using the sacks. Le-Docte process. *Int. Sugar. J.* **29**, 488-492.

Leopold, A.C. and Kriendemann, P.E. (1978) "*Plant Growth and Development*". MC Graw-Hill Book, N.Y., p545.

Mahmoodi, R., Maralian, H. and Aghabarati, A. (2008) Effects of limited irrigation on root yield and quality of sugar beet (*Beta vulgaris* L). *African Journal of Biotechnology*, **7**(24), 4475-4478.

Mohammadian, R., Moghadam, M., Rahimian, H. and Sadeghian, S.Y. (2005) Effect of early season drought stress on growth characteristics of sugar beer genotypes. *Turk. J. Agric. For.* **29**, 357-368.

Nassar, M.A. and El-Sahhar, K.F. (1998) "*Botanical Preparations and Microscopy (Microtechnique)*". Academic Bookshop, Dokki, Giza, Egypt, 219pp (In Arabic).

Pantin, F., Monnet, F., Jannaud, D., Costa, J.M., Renaud, J., Muller, B., Simonneau, T. and Genty, B.B. (2013) The dual effect of abscisic acid on stomata. *New Phytol.* **619**, 67-72.

Renu, M., Goswami, C.L. and Kumar, B. (2004) Hormonal response of osmoregulation in cotton under water logging and drought. *J. Cotton Research and Development*, **18**(1), 70-77.

Ritchie, S.W., Nguyen, H.T. and Holaday, A.S. (1990) Leaf water content and gas-exchange parameters of two wheat genotypes differing in drought resistance. *Crop Sci.* **30**, 105-111.

SalehiSardoei, A. (2014) Response of application gibberellic acid (GA3) and benzyladenine (BA) to *Dizigotheeca elegantissima* Plants. *International Journal of Advanced Biological and Biomedical Research,* **2**(3), 615-621.

Sankar, B., Karthishwaran, K. and Somasundaram, R. (2013) Leaf anatomical changes in peanut plants in relation to drought stress with or without paclobutrazol and abscisic acid. *Journal of Phytology,* **5**, 25-29.

Sayfzadeh, S. and Rashidi, M. (2010) Effect of drought stress on antioxidant enzyme activities and root yield of sugar beet (*Beta vulgaris*). *American-Eurasian J. Agric. Environ. Sci.* **9**(3), 223-230.

Schonfeld, M.A., Johnson, R.C., Carver, B.F. and Mornhinweg, D.W. (1988) Water relations in winter wheat as drought resistance indicators.*Crop Sci*. **28**, 536-541.

Shaddad, M.A.K., Abd El- Samad, H.M. and Mostafa, D. (2013) Role of gibberellic acid (GA3) in improving salt stress tolerance of two wheat cultivars. *International Journal of Plant Physiology and Biochemistry,* **5**(4), 50-57.

Shreelalitha, S., Sridhar, K. and Sukesh, S. (2015) Seed dormancy and germination in two wild genotypes of Sesbania of the southwest mangroves in India. *Journal of Agricultural Technology*,**11**(4), 895-902.

Smith, M. (1991) "*CROPWAT: Manual and Guidelines*". FAO of UN, Rome.

Snedecor, G.W. and Cochran, W.G. (1980) Statistical sugar beet cultivars to *Cercospora* leaf spot disease. *Crop. Sci.* **18**, 39-42.

TaizL, and Zeiger, E. (2005) "*Plant Physiology*", pp. 462-560, (4th ed). Sinaver Associates, Inc. Publishers. Sunderland, Massachusetts.

Wettstein, D.V. (1957) Chlorophyll-latale und der sub mikroskopische for meuechsh der plastiden. *Expr. Cell. Res*. **12**, 427-433.

WU, G-Q., Wang, C.M., Su, Y.Y., Zhang, J.J., Feng, R.J. and Liang, N. (2014) Assessment of drought tolerance in seedlings of sugar beet (*Beta vulgaris* L) cultivars using inorganic and organic solutes accumulation criteria. *Soil Science and Plant Nutrition*, **60**, 565-576.

Xu, Z., Wang, Q.M., Guo, Y.P., Guo, D.P., Shaha, G.A., Liua, H. and Mao, A. (2008) Stem-swelling and photosynthate partitioning in stem mustard are regulated by photoperiod and plant hormones. *Environ. Exp. Bot*. **62**, 160-167.

Zhang, F.J., Zhang, K.K., Du, C.Z., Li, J., Xing, Y.X., Yang, L.T. and Yang, R.L. (2014) Effect of drought stress on anatomical structure and chloroplast ultrastructure in leaves of sugarcane. *Sugar Tech.* **17**, 41-48.

(*Received* 16/ 2/2018;
accepted 10/ 5/2018)

تأثير نقع البذور قبل الزراعة في حمض الجبرلليك والجفاف على بعض صفات النمو والصفات الهستولوجية والفسيولوجية على نبات بنجر السكر

إيناس صفاء إبراهيم عزب
قسم النبات الزراعى - كلية الزراعة - جامعة قناة السويس - الإسماعيليه - مصر.

تهدف هذه الدراسة لتقييم تأثير نقع بذور بنجر السكر قبل الزراعة فى ثلاث مستويات من حمض الجبرلليك وهى (50، 100 و150 ملليجرام/لتر) والبذور كانت لصنفين هما (Farida و Sultan) تحت ثلاث مستويات من الري (100% و 75% و50% من السعة الحقلية) بمزرعة كلية الزراعة جامعة قناة السويس. أوضحت النتائج أن حمض الجبرلليك يقوم بتحسين تحمل نباتات بنجر السكر لظروف الجفاف وذلك من خلال دراسة بعض صفات النمو (عدد الأوراق والوزن الغض والجاف للأوراق/نبات) وأيضا محصول الجذر والسكر وصبغات التمثيل الضوئى (كلوروفيل أ وب والكاروتينيدات) والمحتوى المائى للاوراق RWC والضغط الأسموزى للأوراق والصفات الهستولوجية. بإختصار نقع البذور فى حمض الجبرلليك قبل الزراعة خاصة فى تركيز 150 ملليجرام/لتر يقلل التأثير الضار للجفاف على نمو ومحصول بنجر السكر.