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Evaluating Water Stress Influence on Growth and Photosynthetic Pigments of Two Sugar Beet Varieties

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Abstract: A pot experiment was conducted in the greenhouse of the Water National Research Centre, Dokki, Cairo, over two successive seasons 2006 /07 and 2007/08 . study aimed to evaluate the influences of three irrigation [irrigation at 80 % of the maximum water holding capacity of the soil (W.H.C) i.e. normal water supply , 60 % of the moderate (W.H.C.) i.e. soil moisture stress and 40 % of the maximum (W.H.C) i.e. soil moisture stress] on growth and photosynthetic pigments of two Varieties of sugar beet plants. Variety FD(G2) surpassed the variety Cardova (G1) in plant height, number of leaves, root length and root diameter. However, of the increment in fresh root weight in Cardova (G1) more than FD99 (G2), the differences were not great enough to reach the level of significant. No significant differences were recorded for chlorophyll a and chlorophyll b concentration (in the leaves) between the two sugar beet Varieties. This was true for the concentration of carotenoids and total chlorophyll. Chlorophyll a : chlorophyll b ratio in Cardova (G1) exceeded that in FD99 (G2) ,however, the opposite was true for Chlorophyll a+ chlorophyll b; total carotenoids ratio. A negative relationship was observed between water stress treatments on plant height, number of green leaves, root length and leaves fresh weight. Plant height, root diameter, and fresh weight of roots and whole plant were slightly affected by drought. Chlorophyll a concentration increased with the first drought treatment (60 % W.H.C) and tended to decrease with 40 % W.H.C but still more than that in the leaves of control plants (80 % W.H.C). The values of chlorophyll b and carotenoids concentrations, its response to drought, were not significant. Data also pointed out that the two drought treatments exhibited approximately the same effect in the ratio of chlorophyll a + chlorophyll b. Leaves fresh weight was significantly affected by the interaction however, fresh weight was drastically depressed by drought and the 2nd treatment more effective than the 1st one. Meanwhile, FD99 (G2) leaves fresh weight was affected only by the 2nd treatment of drought. Plant height, number of green leaves, length and diameter of roots and whole plant were slightly affected but the differences were not significant. A progressive increase with drought was observed in Cardova (G1) treatments but FD99 (G2) was reversely responded. The concentration of chlorophyll a, chlorophyll b and carotenoids seemed to be equal.

Key words: Sugar beet-varieties-drought-growth-photosynthetic pigments.

INTRODUCTION

Low water availability is one of the major causes of crop reduction. The gap of sugar production extended in the last decades due to the increase in population and intern human consumption. In Egypt sugar cane production couldn't cover peoples demand and its cultivation needs high water requirements. Therefore the expansion in sugar beet cultivation is necessary to save water and increase sugar production. Sugar beet (*Beta vulgaris L.*) was found to be successful winter sugar crop in new cultivated lands and also tolerant to drought and salinity[2].

It had been denoted by Scott and Jaggard[22,18,13] that drought negatively affected the growth and yield of sugar beet plants. Also Havaux and Tardy[6,4] proved that drought affected chlorophyll status in plant cells and consequently photosynthetic process.

Therefore, this work was designed to study the effect of drought on growth characters and photosynthetic pigments concentration of two sugar beet Varieties.

MATERIALS AND METHODS

A pot experiment was conducted in the greenhouse of National Research Centre, Dokki, Cairo, over two growing seasons of 2006/07 and 2007/08, the study aimed to evaluate the influences of irrigation levels on growth and photosynthetic pigments of two sugar beet Genotypes.

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The Treatments Were as Follows:

a)- Irrigation regimes: [irrigation at 80 % of the maximum water holding capacity of the soil (W.H.C) i.e. normal water supply , 60 % of the moderate (W.H.C.) i.e. soil moisture stress and 40 % of the maximum (W.H.C) i.e. soil moisture stress]

b- Varieties: Cardova (G1) and FD99 (G2)

The experiment included 6 treatments which were the combination of three irrigation regimes and two sugar beet Varieties. The experimental design was factorial in randomized complete blocks with 8 replicates. Metallic ten pots of 35 cm in diameter and 50 cm in depth were used. Each pot contained 30 Kg of air dried clay loam soil (the soil moisture with 44 % at water holding capacity). The inner surface of the pots were coated with three layers of bitumen to prevent direct contact between the soil and metal. In this system, 2 kg of gravel (Particles about 2-3 cm in diameter), to assure the movement of water from the base and upward. Seeds of sugar beet (*Beta vulgaris L.*) varieties Cardova (G1) and FD99 (G2) and were sown on the 25th and 30th of November in the first and second seasons respectively. Plants were thinned once 15 and 30 days after sowing where two plants / pot were left. Calcium super phosphate (15.5 % P205) and potassium sulfate (48.5 % k20) in the rate of 3.0 and 1.50 g/pot were added before sowing. Ammonium sulfate (20.5 % N) in the rate of 6.86 g / pot was added in two equal portions, once at 21 days from sowing and the second two weeks later).

Cholorophylls and carotenoids were determined according to the method described by Von Wettstein[24].

All collected data were subjected to the proper statistical analysis as described by Snedecor and Cochran[21].

RESULTS AND DISCUSSION

Growth:

a)-Genotypes: Data in Table (1) indicated that genotype FD99 (G2) surpassed genotype Cardova (G1) in plant height, number of leaves, root length and root diameter. However, the increment in fresh root weight in Cardova (G1)was more than FD99 (G2), the differences were not great enough to reach the level of significance. Al-Naas[3] reported some differences among sugar beet Genotypes in root diameter and root length, Foliage characters, fresh and dry weights. Kandil, *et al*[7] found that Pleno variety surpassed significantly other notypes(Aramis and Kawe mire) in root length, dry weight of Foliage and whole plant dry weight. Abd El-Wahab *et al*[2] grew five sugar beet varieties and found significant differences among varieties sin root diameter while it was highly significant for root weight/plant. The highest values were recorded for Foliage c.v. in root diameter and Kawenmira and Pleno in root weight/plant. Concerning Foliage weight/plant in the 1st season, the highest value was recorded for Farda cultivar without significant difference with Pleno cv.They added also, that in the 2nd season, the highest Foliage weight/plant was recorded by Foliage cv., but it differs significantly only with Pleno. Cv. Also, genotypes differences were detected by many authors: Ober[15,12,18].

b)-Water Regime: Negative significant results were obtained under water regime treatments for, number of green leaves, root length and Foliage fresh weight. Plant height, root diameter, and fresh weight of roots and whole plant were not significantly affected by water limitation.

This effect may be due to the negative effect on water adjustment in plant tissues[8,11], Medrano, *et al*[11] stated that many photosynthetic parameters (e.g. electron transport rate, carboxylation efficiency, intrinsic water-use efficiency, respiration rate in the light, etc.) were also more strongly correlated with stomatal conductance than with water status itself.

c)-Interaction: The interactive effect of varieties differences and water stress was observed in Table (3). Leaves fresh weight was significantly depressed by drought especially the second treatment as compared to the first one. Meanwhile, in FD99 (G2) eaves fresh weight was affected only by the second water stress treatment. Plant height, number of green leave, length and diameter of roots and whole plant were slightly affected but the differences were not significant.

On subjecting sugar beet to drought and water scarce, the selection and breeding drought tolerance of varieties was the proper target to avoid drought damage[13,14].

The varietal differences in drought tolerance were detected by many authors: Ober, *et al*[13]. Pidgeon, *et al*[18] who reported that genotypes were classed according to their intercept (yield potential under low-stress conditions). Ober *et al*[16] mentioned that there was a general trend for rapidly growing plants to show more relative growth inhibition, in part because large plants consumed more of the water in the limited pot volume. Separating the entries by growth rate under well-watered conditions minimizes the chances of identifying one entry as a ‘drought-tolerant’ genotype only because it has a low growth rate under all conditions.

Table 1: Growth characters of two sugar beet varieties(average of two growing .

Varieties	Plant height(cm)	No.of leaves/plant	Root		Fresh seasons):			Dry weight(g):		
			Length cm	Diam.cm	Root	Foliage	Whole plant	Root	Foliage	Whole plant
G1	36.43	16.23	18.10	5.29	214.43	137.90	352.33	10.76	9.04	19.80
G2	42.50	18.23	21.77	6.24	196.20	186.30	382.50	13.80	8.69	22.49
LSDat5%	4.68	N.S	N.S	0,26	N.S	N.S	N.S	N.S	N.S	N.S

G1 : Cardova G2 :FD99

Table 2: Growth characters of sugar beet as affected by irrigation regimes. (average of two growing seasons).

Irrigation regimes	Plant height(cm)	No.of leaves/plant	Root		Fresh weight(g):			Dry weight(g):		
			Length cm	Diam.cm	Root	Foliage	Whole plant	Root	Foliage	Whole plant
Irrigation at 80% W.H.C	44.15	22.35	22.85	6.35	205.8	225.9	431.7	10.91	5.30	16.21
Irrigation at 6% W.H.C	38.00	14.85	19,30	5.75	219.7	152.5	372.2	14.89	7.57	22.46
Irrigation at 4% W.H.C	36.20	14.50	17.65	5.20	190.5	108.0	298.5	11.05	13.74	24.79
L.S.D.at 5%	N.S	4.32	2.96	N.S	N.S	23.0	N.S	2.44	6.74	4.08

Table 3: Growth characters of two sugar beet Genotypes as affected by irrigation regimes (average of two growing seasons).

Varieties	Irrigation regimes	Plant height(cm)	No.of leaves/plant	Root		Fresh weight(g):			Dry weight(g):		
				Length cm	Diam. cm	Root	Foliage	Whole plant	Root	Foliage	Whole plant
G1	Irrigation at 80 % W.H.C	42.3	22.7	21.7	6.47	173.3	250.7	424.0	11.45	3.54	14.99
	Irrigation at 60 % W.H.C	35.3	13.7	16.3	5.33	292.0	101.0	393.0	12.42	6.18	18.60
	Irrigation at 40 % W.H.C	31.7	12.3	16.3	4.07	178.0	62.0	240.0	8,40	17.41	25.81
G2	Irrigation at 80 % W.H.C	46.0	22.0	24.0	6.23	238.3	201.0	439.3	10.36	7.05	17.41
	Irrigation at 60 % W.H.C	40.7	16.0	22.3	6.17	147.3	204.0	351.3	17.35	8.95	26.30
	Irrigation at 40 % W.H.C	40.7	16.7	19.0	6.33	203.0	154.0	357.0	13.70	10.07	23.77
L.S.D.at 5%		N.S	N.S	N.S	N.S	N.S	32.6	N.S	4.22	N.S	7.08

Ober, *et al*[13] stated that specific objective were to assess the degree of genotypic diversity for drought tolerance, characterize genotypic differences in response to drought and identified sources of germplasm with greater drought tolerance than current commercial varieties. Ober, *et al*[14] concluded that there were significant genotypic differences for stomatal conductance, succulence index, specific leaf weight, and osmotic adjustment, but not for photosynthetic rate, relative water content of total use.

Photosynthetic Pigments:

a)-Varieties Differences: No significant differences were detected in chlorophyll a and chlorophyll b concentration (in the leaves) between the two sugar beet Varieties. This was true for the concentration of carotenoids and total chlorophyll. Chlorophyll a : chlorophyll b ratio in Cardova (G1) exceeded those in FD99 (G2),however, the opposite was true for Chlorophyll a+ chlorophyllb; total carotenoids ratio (Table 4).

Manirannan, *et al*[9] studied the differences in chlorophyll in genotypes. Ober, *et al*[13,14,1] reported the genotypes s differences in chlorophyll status in plants. Also, Kandel, *et al*[7] revealed that photosynthetic pigments content in sugar beet leaves after 90 days from sowing, significantly affected by Varieties.

b)-Water Regime: Data in Table (5) indicated that chlorophyll a concentration increased with the water stress or treatment and tended to decrease with prolonging the period of drought but still more than that in the leaves of control plants. The values of

Table 4: Photosynthetic pigments concentration of two sugar beet Genotypes(average of two growing seasons).

Varieties	Photo synthetic pigments content (mg/dm^2)					
	Chl.a	Chl.b	Carot.	Chl.a+Chl.b	Chl.a:Chl.b	Chl.a:Chl.b: Carotenoids
G1	5.890	5.039	1.835	10.929	1.169	5.956
G2	8.706	4.245	2.764	12.951	2.051	4.686
L.S.D.at5%	N.S	N.S	N.S	N.S	--------	--------

Table 5: Photosynthetic pigment of sugar beet as affected by irrigation regimes (average of two growing seasons).

Irrigation regimes	Photo synthetic pigments content (mg/dm^2)					
	Chl.a	Chl.b	Carot.	Chl.a+Chl.b	Chl.a:Chl.b	Chl.a:Chl.b: Carotenoids
Irrigation at 80 % W.H.C	6.856	4.138	2.216	10.995	1.656	4.962
Irrigation at 60% W.H.C	8.153	4.848	2.068	12.961	1.696	6.267
Irrigation at 40% W.H.C	7.386	4.909	2.616	12.302	1.483	4.703
L.S.D.at 5%	1.376	0.865	N.S	2.075	-------	

chlorophyll b and carotenoids concentrations, in response to drought, were not significant. Data also pointed out that the two water stress treatments exhibited approximately the same effect on the ratio of chlorophyll a + chlorophyll b. Obtained data is in harmony with those obtained by Salt marsh, *et al*[20]. Furthermore, Yanqiong, *et al*[25] found that the content of chlorophyll, free proline and soluble sugars showed an increase, whereas evaporation ratio, WSD, RWC and cytolemma osmosis showed a decrease under drought stress. Matsumoto, *et al*[10] concluded that a low leaf chlorophyll concentration imposed a restriction on the opening capacity of the stomata. The stomatal conductance variability depended markedly on chlorophyll function; the degree of dependence was almost equal to that on solar radiation or vapor pressure deficit. Manirannan, *et al*[9] detected the depression of chlorophyll a and b and total chlorophyll in *Helianthus annuus L.* plants under water stress .

c)-Interaction: The interactive effect of water stress and Varieties differences on photosynthetic pigments were presented in Table (6). The data clearly shown a progressive increase with water stress treatment FD99 (G2)reversely responded. The concentration of chlorophyll a, chlorophyll b and carotenoids seemed to be equal. Rolando and Little[19] revealed that seedling physiology was assessed by shoot water potential, stomatal conductance and chlorophyll fluorescence.

Neoumerous studies had been conducted to investigate the interactive effect of drought and varietal differences on photosynthetic pigments of sugar beet Van der Beek and Hoffman[23].

Abdul Jaleel, *et al*[1] noticed that there was a significant reduction in the photosynthetic pigment contents in both *Catharanthus roseus* Varieties. The Rosea variety was more affected due to water deficit

Table 6: Photosynthetic pigments of two sugar beet Genotypesas affected by irrigation regimes (average of two growing seasons).

Varieties	Irrigation regimes	Photosynthetic pigments content (mg/dm^2)					
		Chl.a	Chl.b	Carot.	Chl.a+Chl.b	Chl.a:Chl.b	Chl.a:Chl.b: Carotenoids
G1	80 % W.H.C	3.833	4.127	1.438	7.955	0.930	5.532
	60 % W.H.C	6.361	5.281	1.840	11.642	1.205	6.327
	40 % W.H.C	7.477	5.764	2.228	13.191	1.309	5.921
G2	80 % W.H.C	9.878	4.156	2.993	14.034	2.377	4.68
	60 % W.H.C	8.945	4.334	2.295	13.279	2.064	5.786
	40 % W.H.C	7.294	4.244	3.003	11.538	1.719	3.842
LSD5%		N.S	N.S	N.S	2.934	--------	--------

when compared to Alba variety. Also Oukarroum, *et al*[17] and Christen, *et al*[5] detected the interactive effects of genotypes s differences and drought in chlorophyll.

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