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Evaluation of some sugarcane genotypes under drought condition

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ABSTRACT

A pot experiment was carried out at Agricultural Research Station, Agricultural Research Center, Giza Governorate, Egypt, (latitude 26° 31′N and longitude 31° 11′E) during 2019 and 2020 seasons to compare two sugarcane promising clones, with the commercial variety GT.54-9 (*Saccharum spp*. L.), under three irrigation water levels (60, 80 and 100% of IWL). A randomized completely design with five replications was used. Some growth traits such as shoot and root FW, root/shoot ratio, leaf area index (LAI), leaf area ratio (LAR), as well as the biochemical constituents like chlorophylls, carotenoids, proline, total soluble sugars, total amino acids, total soluble proteins and macronutrients such as.. N, P, K, Mg and Ca were assessed.

Results showed that, clone 2 had the desirable values for the studied traits more than commercial variety GT.54-9, while the clone1 recorded undesirable values for the studied traits compared to GT.54-9 under water deficit stress that be contributed. So could be select the clone 2 as anew promising variety in sugar cane cultivar with drought tolerance. In addition to, sugarcane studied clones not affected by increase the degree of IWL from 80 to 100%.

KEYWORDS: Drought, Growth, Osmoregulation, Sugarcane, Tolerant, Water deficit.

1. INTRODUCTION

Sugarcane crop (*Saccharum spp*.L.) is the second main source of sugar production in Egypt. It is cultivated only in El-Minia, Sohag, Qena and Aswan of south Egypt governorates with highly rising water requirements under climate changes conditions caused by high temperature disrupt physiological processes of sugarcane plants (Taha and Zohry, 2018). Global environmental changes like drought stress is one of the climatic phenomenon caused significant inhibiting for plant growth, development and productivity by affecting various morphological, physiological such as mineral nutrients uptake, enzymatic activities, photosynthesis, respiration and metabolic system (Farooq *et al.*, 2009; Silva *et al.*, 2011; Zhao *et al.*, 2013; Anjum *et al.*, 2017 and Ramadoss *et al.*, 2021).

Sugarcane is more sensitive to water deficit conditions especially during the tillering and grand growth stage thus limiting plant growth, development, osmotic potential, the photosynthetic rate and yield all over the world (Khonghintaisong *et al.*, 2018, Dos Santos *et al.*, 2019 and Hoang *et al.* 2019). Morphological and physiological characteristics as leaf area, root:shoot ratio, tillering, shoot biomass, chlorophylls and photosynthetic rate are useful indicators for drought tolerance in sugarcane varieties (Inman-Bamber *et al.*, 2005; Zhao *et al.*, 2013 and Dos Santos and Silva 2015).

In addition, drought tolerant plants using accumulation of carotenoids, total soluble sugars, proline and free amino acids or/and increased enzymatic antioxidants activity to maintain cells water balance and protect the photosynthetic pigments, enzymatic systems and cell membranes (Farooq et al., 2009, Abid et al., 2018 ; Dos Santos et al., 2019 and Ramadoss et al., 2021).

This study goals to gain an early selection of sugarcane promising clones to provide early knowledge about the promising clones which could be used in sugarcane breeding programs of drought tolerance. Thus, sugarcane two clones were tested under three water regimes to selection at early stage of growth compared with the commercial variety GT.54-9.

2. MATERIALS AND METHODS

The present study was carried out at Agricultural Research Station, Agricultural Research Center, Giza Governorate, Egypt, (latitude 26° 31′N and longitude 31° 11′E) during seasons of 2019 and 2020

Three genotypes of sugarcane hybrids complex (*Saccharum spp.* L.) include, clone 1 (Co.284 x CP.44-101), clone 2 (CP.57-617 x Co.617) and the cultivated variety GT.54-9 (NCo.310 x F.37-925) were tested under three irrigation water levels (IWL), well watered 100 %

(control treatment), 80 and 60 %. Irrigation treatments 60, 80 and 100 % of IWL were applied up to its level of field capacity in each one pot of each treatment received optimum moisture at growing medium according to Begum *et al.* 2012.

A randomized completely design with five replications was used (three genotypes × three irrigation levels. The plastic pots (60 x 60 cm in diameter with a drainage bottom hole), were filled by about 24 kg of the substrate of ratio 1:1 as sand and clay. On March 2019 and 2020, one cutting seed was planted in pot. All cultural applications were done when required to all plants in pots for natural growth till to the seedlings was ready to be treated at 60 days after planting.

Phosphorus fertilizer was added once during seed-bed preparation as calcium super phosphate (15% P_2O_5) at the rate 30 kg P_2O_5/fed. Nitrogen fertilizer was applied as urea (46% N) at the rate of 100 kg N/fed, which was into one dose after the 60 days from planting. The other agricultural practices were done as recommended by Sugar Crops Research Institute.

2.1. Growth traits

At the end of experiment after 120 days from planting the samples were collected and measured of plant growth: shoot and root FW (g/plant), root/shoot ratio, leaf area index (LAI) and leaf area ratio (LAR). Were LAI was computed by using the Watson (1958) formula. LAR (cm^2/g) was calculated according to the Gardner 1985 formula.

2.2. Physiological parameters

2.2.1. Photosynthetic pigments (chlorophylls and carotenoids)

Photosynthesis pigments chlorophyll a (chl. *a*) plus chlorophyll b (chl. *b*), chl.*a/*chl.*b* ratio and carotenoids concentrations mg g^{-1} f.w. was measured following using the Shabala *et al*. (1998) and Lichtenthaler and Buschmann (2001) methods, respectively.

2.2.2. Determination of macronutrients

Half gram of the dried sugarcane leaves on 60 °C in a forced air oven for 72 h from each treatment at 120 days from planting were wet digested using H_2SO_4 and H_2O_2 mixture to determine N, P, K, Mg and Ca concentration. Micro-Kjeldahl method as described by Horneck and Miller (1998) for total N determination. The total concentration of P was determined by the molybdenum blue method described by Bernhart and Wreath (1955). Horneck and Hanson (1998) used to determine K concentration. The concentration of Mg and Ca were determined according to Stefánsson *et al*. (2007) method.

2.2.3. Osmolytes antioxidants (proline, total amino acids, soluble sugars and total soluble proteins)

The method of the aqueous sulfosalicylic acid and acid ninhydrin reagent as described by Bates *et al*. (1973) was used to assay the concentrations of proline (Pr) in leaves using a spectrophotometer at 520 nm. Total free amino acids (TFAA) concentrations in sugarcane leaves were analyzed using ninhydrin method described by Swamy (2008) using a spectrophotometer (Mapada UV 1200) at 570 nm. Total soluble sugars (TSS) were extracted from sugarcane leaves in 80 % hot ethanol and measured spectrophotometrically by anthrone reagent at 620 nm using glucose standard according to A.O.A.C. (2005) and Sadasivam and Manickam (2010), respectively. Total soluble protein (TSP) was determined in the leaf extracts of sugarcane genotypes using the method described by Bradford (1976) reading at 595 nm using bovine serum albumin as the standard.

2.3. Statistical analysis

Combined analysis of the two years was carried whenever homogeneity of variance was detected for the studied characters

Statistical analysis was over two years using RCD with five replications and mean values were compared using Duncan's (1955) multiple range test ($P < 0.05$ and $P < 0.01$) using the computer " CoStat " statistical analysis version 6.400 described by CoHort Software (1998).

3. RESULTS AND DISCUSSION

3.1. Growth traits

3.1.1. Shoot and root fresh weights

Data in Table (1) show that, the studied genotypes of sugarcane significantly differed in shoot and root fresh weights/plant. The highest and significant values of the previously mentioned traits were obtained with clone2, followed by the commercial variety GT.54-9 and clone1, respectively. It could be noted that, insignificant differences were observed between the commercial variety GT.54-9 and clone1 in root fresh weight/plant. The recorded results might be attributed to sugarcane genetic variability.

Sugarcane irrigated with 60 and 80% of irrigation water level (IWL) resulted in a significant reduce in shoot fresh weight/plant reached 15.4 and 38.8%, corresponding to a significant increase in root fresh weight/plant amounted to 9 and 18 %,

Table 1, Main effects for combined analysis of the two years of water irrigation levels (IWL) on vegetative growth and biochemical constituents of sugarcane genotypes.

Genotype	Shoot fresh weight (g/plant)	Root fresh weight (g/plant)	Root: Shoot ratio	Leaf area index	Leaf are ratio (cm^2/g)
Clone1	16.00 c	15.00 b	1.04 a	0.96 c	20.53 b
Clone2	31.90 a	24.50 a	0.77 b	2.10 a	23.42 a
GT.54-9	25.60 b	15.10 b	0.62 c	1.35 b	18.59 c
Irrigation water levels					
100 % (control)	29.90 a	18.20 b	0.61 c	1.63 a	26.19 a
80 % IWL	25.30 b	20.00 a	0.85 b	1.53 b	19.54 b
60 % IWL	18.30 c	16.40 c	0.98 a	1.15 c	16.82 c

Genotype	Total chlorophyll (mg/ g f.w)	Chlorophyll a: b ratio	Carotenoids (mg/ g f.w)	Proline (mg/ g f.w)	Total amino acids (mg/ g f.w)
Clone1	0.09 c	4.00 a	2.95 a	0.37 a	6.88 c
Clone2	0.22 b	1.60 b	2.67 b	0.33 b	7.31 b
GT.54-9	0.29 a	1.40 c	1.99 c	0.26 c	12.40 a
Irrigation water levels					
100 % (control)	0.28 a	2.70 a	3.14 a	0.24 c	7.55 b
80 % IWL	0.19 b	2.30 b	2.33 b	0.32 b	9.42 a
60 % IWL	0.13 c	2.10 c	2.14 c	0.39 a	9.64 a

Genotypes	Total sugars	Total soluble protein	N	P	K	Mg	Ca
Clone1	14.53 a	67.36 b	11.94 b	1.04 b	6.34 b	2.99 b	4.13 a
Clone2	14.80 a	72.92 a	13.94 a	1. 49 a	7.40 a	3.63 a	4.58 a
GT.54-9	15.18 a	78.13 a	13.93 a	1.48 a	7.21 a	3.97 a	4.76 a
Irrigation water levels							
100 % (control)	12.27 b	82.29 a	15.83 a	1.61 a	7.52 a	3.71 a	5.31 a
80 % IWL	15.89 a	72.22 b	12.37 b	1.34 b	7.08 a	3.69 a	4.26 b
60 % IWL	16.35 a	63.89 c	11.62 b	1.06 c	6.36 b	3.19 b	3.90 b

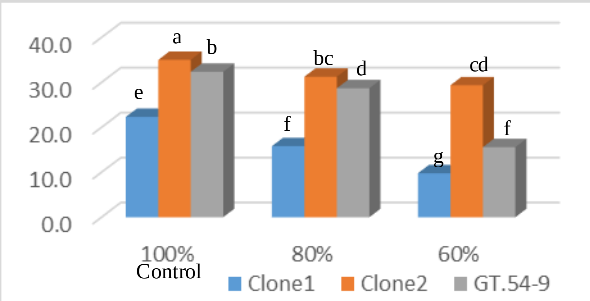
* Means followed by different letters are significantly different at $P \leq 0.05$ level; according to Duncan's multiple range test.

respectively, as compared to that given with 100% of IWL. These results coincide with those of Abd El-Raheem (2018), and Hoang *et al.* (2019) and Gaber *et al.* (2021) for sugarcane plants.

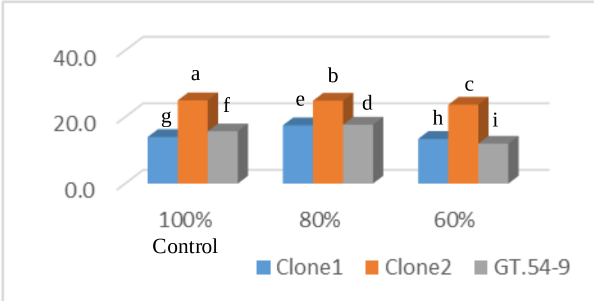
These significantly decreases in the shoot weight of drought stressed sugarcane may attribute to that, water deficit reduced the photosynthetic rate comparing to non-stressed plants (Farooq *et al.* 2009 and Hoang *et al.*, 2019). Because that, water deficit stress is highly affected on sugarcane by the intense growth stage dos Santos *et al.*, (2019). The limited vegetative growth and development by drought stress may be due to water shortage inhibiting cells division and elongation (Anjum *et al.*, 2017). Therefore, Farooq *et al.*, (2009) reported that, water is necessary for plant nutrients uptake and transportation.

The significant interaction between irrigation levels and three sugarcane genotypes (Figure 1, A & B) showed huge response for shoot and root fresh weights. These observations may be back to different tolerance response of various genotypes. Under full irrigation water conditions (100 % of IWL), clone 2 ranked in the first genotype and had highest values of root FW/plant overpassed the commercial variety which came in the second rank under 80 % of IWL. Using water level 60 %, clone 1 showed the lowest shoot fresh weight meanwhile, the commercial variety GT.54-9 came in the last rank for root fresh weight by 60 % IWL. Consequently, our results indicated that, clone 2 could represent a good genotype for drought stress tolerant.

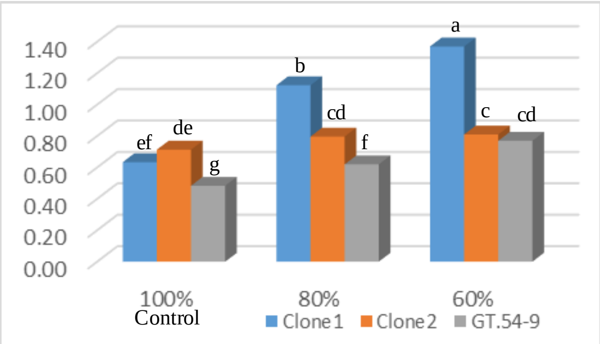
In sugarcane, the inhibited stalk and leaf growth and enhanced deep large roots are the first morphological adaptation after sugarcane plants exposed to minor or moderate water deficit conditions (Anjum *et al.*, 2017). Likewise, under water deficit conditions roots become clumped and hence the facility of water uptake (Couso and Fernandez, 2012).



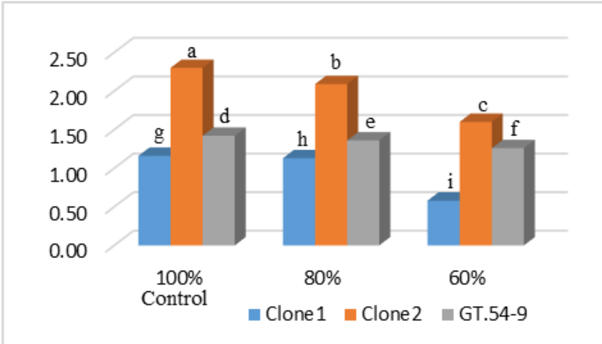
A) Shoot fresh weight



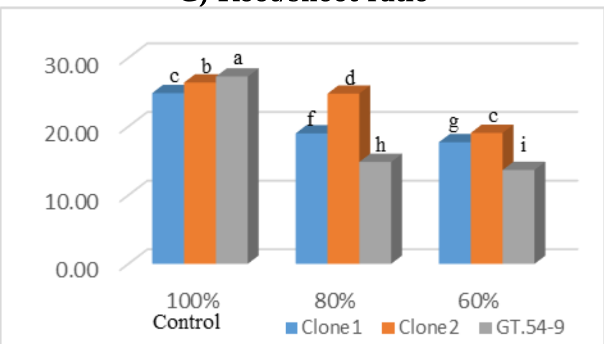
B) Root fresh weight



C) Root/shoot ratio



D) LAI



E) LAR

Fig 1. Interaction effects for combined analysis of the two years of irrigation levels (IWL) and sugarcane genotypes on shoot, root fresh weight, root/shoot ratio, LAI and LAR of sugarcane genotypes.

* Means followed by different letters are significantly different at P ≤ 0.05 level; according to Duncan's multiple range test.

3.1.2. Root: shoot ratio

Means of root: shoot ratio reveal significant variances among all studied genotypes varied from 0.62 to 1.04. The higher root/shoot ratio was found in clone 1, this mean that root FW was heavier than shoot FW. Vice versa, the cultivated variety GT.54-9 had the last rank in root/shoot ratio. In means as overall of the three irrigation levels, the root/shoot ratio was increased significantly by reducing IWL from 100% to 60 % (Table 1).

Irrigation levels x sugarcane genotypes interaction, was significant (Fig.1,c). The first and second rank of root: shoot ratio was recorded with clone1 under the stressed irrigation levels 60% and 80% IWL, respectively, this due to a decrease of shoot fresh weight against the increase in root fresh weight. On the other hand, the cultivated variety GT.54-9 gave the last rank of root: shoot ratio at normal water level (100% IWL), these result caused by an increase in shoot fresh weight against a decrease of root fresh weight.

Similar result was obtained by Kaya *et al.* (2006), who reported that, the larger root: shoot ratios of maize seedlings are attributed to a greater decrease in root growth than shoot growth under water deficit stress. Also, the root length of sugarcane cultivars increased after exposed to early water deficit so, the higher root/shoot ratio could be suggested as a key strategy for drought tolerance Khonghintaisong *et al.* (2018). This results are also, supported by Anjum *et al.* (2017) who suggested that, plants can adapt to drought stress through some morphological modifications i.e. expand roots area and higher root/ shoot ratios for enhancing water uptake, water status and reduce water loss.

3.1.3. Leaf area Index (LAI) and Leaf area ratio (LAR)

Data cleared in Table 1, showed significant differences in the values of LAI and LAR (cm^2 g^{-1}) for sugarcane two promising clones and GT.54-9. The best genotypes ranked by clone 2, which recorded the highest LAI and LAR however, the last LAI was for clone 1. The commercial variety (GT.54-9) gave the second rank for LAI and the last for LAR. The levels of water mandatory under this study cleared ~~a~~ significant values of LAI, in addition, the results pointed to decrease LAI and LAR ranked by increasing the level of water deficit from 80 % to 60 % of IWL respectively, comparing to the normal water level (100 %).

Obtained results in Figure (1, D & E) cleared that, all tested genotypes significantly varied in LAI and LAR values by different irrigation water levels. In this regard, clone 2 recorded the first rank over than rest of genotypes, where it had highest values of LAI when irrigated by 100 % IWL. On the other hand, clone one got in the last rank for LAI when stressed plant by 60 % of IWL. The enhanced LAI and LAR of clone 2 resulting from the increase in shoot FW may be due to its more drought stress tolerance. On the contrary, the first and last LAR values were produced by GT.54-9 variety under 100 and 60 % of IWL, respectively. Same trends were cleared by Begum *et al.*, 2012, Zhao, *et al.* 2013, Hoang *et al.* 2019 and Gaber *et al.* 2021 showed that the leaf area reduced in drought stressed plants compared with the well watered plants so, this trait might be grateful for improving drought tolerance in sugarcane. Same results in barley verities were observed by Hellal *et al.*, (2020). Drought stress hamper plant growth and developmental processes including leaf area, leaves number and dry matter production, due to impaired cells elongation and division by limited turgor (Anjum *et al.*, 2017).

3.2. Physiological indices

3.2.1. Photosynthetic pigments

Table.1 cleared that, data of overall total chlorophylls, chl. a: b ratios and carotenoids were significantly differences under using water deficit treatments at 80 % and 60 % of IWL comparing to control (the level of 100 %) as well as the three sugarcane genotypes. Water deficit treatments had a negative influence on photosynthetic pigments contents. The highest of chl.a + chl.b concentration was observed with GT.54-9 variety followed by clone 2, meanwhile, clone 1 had the first rank in chl. a: b ratio and carotenoids concentration and clones 2 in the second rank then lastly ranked the commercial variety GT.54-9. The superiority of variety GT.54-9 over the two clones in total chlorophylls content might be back to genetic variability, in addition to that the synthesis of chlorophyll a was higher than chl.b, under water deficit stress. Moreover, accumulated higher amount of carotenoids in clone 1 aimed to keep the photosynthetic pigments under drought stress.

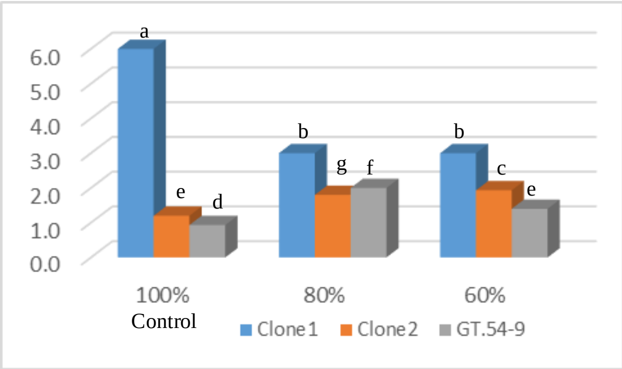
Significantly differences were detected between the irrigation levels and three sugarcane genotypes (figure, 2, A, B and C). From (figure, 2, B) the commercial variety was the best than other genotype where it recorded the highest pigments values of total chlorophylls (chl.a + chl.b.) followed by clone 2 under all IWL treatments. About, clone 1 had the first rank in carotenoids content and clones 2 got in the second rank then lastly ranked the commercial variety under all IWL treatments (figure, 2, C). It could be clear, from (figure, 2, A) the full water level 100 % produced the first rank of chlorophyll a: b ratio of clones 1, whereas, the same clone got in the second rank at both two stressed 80 and 60% of IWL with an insignificant differences. The increases in chl. a/b ratio may be back to decrease in chl.*b* concentration by increase of water stress. Reducing leaf photosynthetic pigments under water deficit is associated with the significant reduction in leaf area index in (Fig 1. D).

These results are in harmony with Silva *et al.* 2007, Begum *et al.* 2012; Zhao, *et al.* 2013; dos Santos and Silva 2015 and Gaber *et al.* 2021 observed that water deficit reduced the level of chlorophylls and carotenoids in sugarcane leaves so they obtained that drought tolerant sugarcane genotypes accumulated higher concentrations of photosynthetic pigments. Our results supported by the findings of Kaya *et al.*, (2006) on maize.

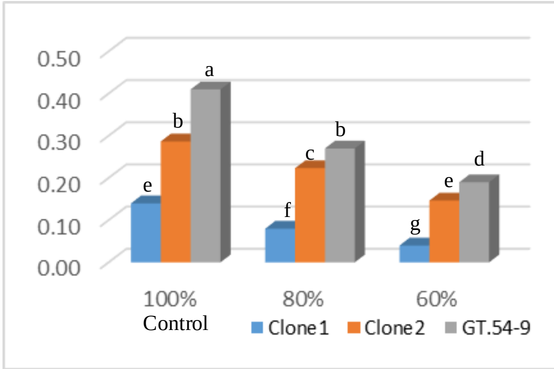
3.3. Antioxidants (proline, total amino acids, total soluble sugars and total soluble proteins)

3.3.1. proline

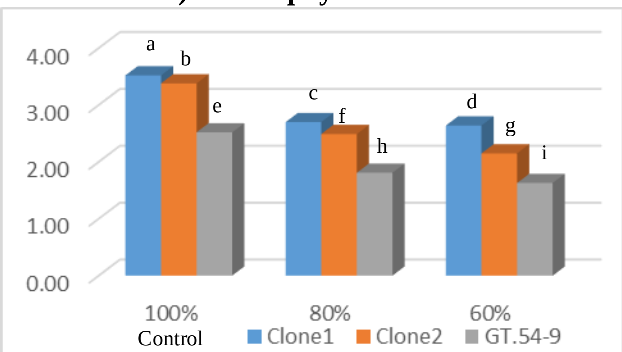
Data documented in Table, 1 showed a significant variance in leaf proline content of the tested sugarcane genotypes. The genotypes ranked from high to low as clone 1, clone 2 and GT.54-9, respectively. The data showed that, these variances may be due to the genetic variability between genotypes. Water deficit stress had positive impact on proline concentration which significantly increased by reducing water levels treatments from 100 to 60 % of IWL.



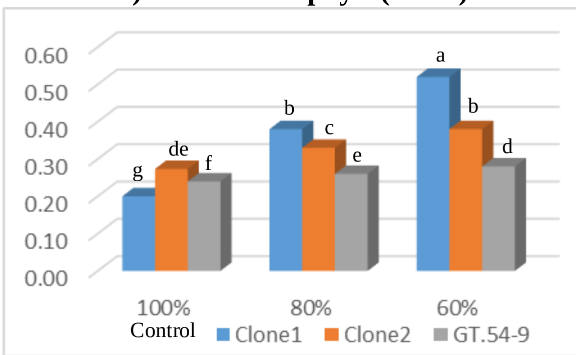
A) Chlorophyll a:b ratio



B) Total chlorophyll (a + B)



C) Carotenoids content



D) Proline content

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Fig 2. Interaction effects for combined analysis of the two years of irrigation levels (IWL) and sugarcane genotypes on chl. a:b ratio, total chlorophylls (a+b), carotenoids and proline concentrations of sugarcane genotypes.

* Means followed by different letters are significantly different at $P \leq 0.05$ level; according to Duncan's multiple range test

Highest proline content was recorded with clone 1 by the interaction with 60% IWL, as compared to that given with 80 % of IWL, meanwhile the lowest concentration of proline was found under well watered 100% of IWL (Figure, 2 D).

Similar results showed on various crops by Kaya *et al.* 2006; Sultan *et al.* 2012; dos Santos and Silva 2015; Abid *et al.*, 2018; Bezerra *et al.*, 2019; Hellal *et al.*, 2020, Gaber *et al.* 2021 and Ramadoss *et al.*, 2021 considered that proline as important antioxidant compatible osmolyte solute accumulated within the plant tissues to protect plant organelles and development its tolerance under water deficit stress. Increased the accumulation of proline in plants by drought might attribute to synthesis higher proline and regulated genes (Bayoumi *et al.*, 2008).

3.3.2. Total free amino acids (TAA)

For concentrations of total amino acids recorded significant increase in leaves of sugarcane colons. The commercial variety GT.54-9 recorded the highest significant concentration while, clone 1 was the last rank for total amino acids (Table 1). Total amino acids concentration was higher in drought stressed plants at 60 % and 80% than 100 % of IWL. Means values of total free amino acids were different significantly by irrigation water levels and sugarcane genotypes interaction. In this regard, the most effective genotype clone 2 that recorded the highest concentration of total free amino acids 14.40 and 12.95 mg/g f.w. in leaves of drought stressed plants by 60 % and 80 % of IWL treatments respectively while, the lowest concentration of total free amino acids 5.23 mg/ g f.w. was recorded in clone 2 under 100 % of IWL (Table 2).

Plants can develop it osmotic adjustment through the accumulation of amino acids. The higher accumulation of total amino acids in drought stressed plants were observed by Abid *et al.*, (2018) on wheat and by Medeiros *et al.*, (2013) and dos Santos *et al.*, (2019) on in sugarcane and Hellal *et al.*, (2020) on barely varieties.

Table 2. Interaction effects for combined analysis of the two years of irrigation water levels (IWL) and sugarcane genotypes on some macronutrients and osmolytes concentrations.

IWL treatments	Genotype	Macronutrients (mg/ g d.w.)					Osmolytes (mg/ g f.w)		
		N	P	K	Mg	Ca	TAA	TSS	TSP
100 % (control)	Clone1	14.92	1.17[e]	6.98	3.58	4.75	9.87[c]	10.65[i]	75.50
	Clone2	16.67	1.73[b]	7.62	4.07	5.75	5.23[i]	13.87[g]	87.50
	GT.54-9	15.87	1.88[a]	7.92	4.20	5.38	7.55[f]	12.27[h]	80.73
80 % IWL	Clone1	10.78	1.02[h]	6.45	3.32	4.04	7.95[e]	16.06[d]	66.15
	Clone2	12.67	1.38[d]	7.43	3.83	4.41	12.95[b]	16.71[b]	78.13
	GT.54-9	13.62	1.59[c]	7.27	3.73	4.28	7.35[g]	14.90[e]	72.40
60 % IWL	Clone1	10.08	0.91[i]	5.55	2.63	3.55	8.76[d]	14.47[f]	57.29
	Clone2	12.43	1.12[f]	6.53	3.12	4.08	14.40[a]	18.18[a]	68.75
	GT.54-9	12.33	1.10[g]	6.95	3.17	4.02	5.75[h]	16.40[c]	65.63
P ≤ 0.05 level		**NS**	*	**NS**	**NS**	**NS**	*	*	**NS**

* Means followed by different letters are significantly different at P ≤ 0.05 level; according to Duncan's multiple range test.
NS = Non significant

3.3.3. Total soluble sugars (TSS)

Regarding, means of total soluble sugars concentrations were insignificant increase in leaves of sugarcane colons, the genotypes ranked from high to low as GT.54-9, clone 2 and clone 1. However, significant linear increases were produced under water deficit treatments 80 and 60 % compared to the control 100 % (Table 1). For the interaction between sugarcane clones and levels of irrigation water was significant. In this regard, the clone 2 recorded the highest concentrations of total soluble sugars were 18.18 mg/ g f.w. under 60 % whereas, the lowest concentration was 10.65 mg/ g f.w. for clone 1 under 100 % of IWL (Table 2). These results indicate that clone 2 accumulated higher amounts of soluble sugars for drought tolerance.

Similar result was obtained by Dos Santos and Silva, (2015) and Garcia *et al.*, (2020) indicated that, water deficit increased sugar concentration in tolerant sugarcane cultivars. According to Marcos *et al.*, (2018) and dos Santos *et al.*, (2019) sugarcane plants accumulated higher soluble sugars under drought compared to non-stressed plants. As well, carbohydrates accumulation in stressed sugarcane plants Medeiros *et al.*, (2013). Same trend was found in wheat by Abid *et al.*, (2018). Also, Ramadoss *et al.*, (2021) suggested that accumulation of oligosaccharides and sugar alcohols have significant crucial roles in acclimatization and tolerance during abiotic stress i.e. drought. Begum *et al.*, (2012) suggested different opinion about the reducing sugars which consider as passive correlated with the sugarcane drought tolerant.

3.3.4. Total soluble proteins (TSP)

Linear significant reduction for leaf soluble proteins were resulted with both of sugarcane colons and reducing water irrigation level treatments 80 and 60 % compared to the control 100 % (Table 1). In this concern, the commercial GT.54-9 variety and 100 % of IWL got the first rank. About means of the irrigation water levels x three sugarcane genotypes interaction (Table 2) was insignificant. The highest value of total soluble protein was 87.50 µg/g f.w. in leaves of clone 2 under 100 % of IWL, whereas clone 1 irrigated with 60 % of IWL recorded the lowest concentration of the total soluble protein 57.29 µg/g f.w. The commercial cultivated variety GT.54-9 got the moderate performance of total soluble protein concentrations under all studied IWL treatments. High soluble protein is importance for sugarcane tolerance to drought conditions.

These results are in line with those mentioned by Dos Santos and Silva, (2015), who observed that water deficit stress reduced the soluble proteins concentrations in sugarcane cultivars. Likewise, in wheat the total soluble protein decreased under drought stress versus non-stressed plants, Abid *et al.*, (2018). In this regard, Bayoumi *et al.*, (2008) obtained that, leaf protein become useful trait in plant drought tolerance. Opposite trend protein concentration was reported by Medeiros *et al.*, (2013) and Dos Santos *et al.*, (2019).

3.4. Macronutrients

Data recorded in Table 1 showed significant differences in N, P, K and Mg between clone 2 and GT.54-9) compared to clone1. In this regard, the second clone had the first rank for values of N, P and K, as well as, the commercial variety got the first rank for Mg and Ca concentrations whereas, clone 1 recorded the last rank in these nutrients. In over all means of irrigation levels, macronutrients N, P, K, Mg and Ca were significantly decreased under reduce irrigation water levels from 100 to 60 % of IWL.

Regarding, the irrigation water levels x sugarcane genotypes interaction in Table (2) was insignificant for means of N, K, Mg and Ca while, gave significant decrease for the P concentration. The most effective genotypes are clone 2 and GT.54-9 that recorded higher concentrations of all macronutrients in leaves comparing with clone 1, which recorded the lowest values of these nutrients under all water levels IWL (Tables 1 & 2).

These results are in good agreement with Silva *et al.*, 2017 who found that N, P and K concentrations were reduced in sugarcane tissues respectively by drought. As well as, the leaf K and Ca concentrations decreased in maize seedlings grown under water deficit stress Kaya *et al.* (2006). Nutrients uptake and transportation within plant requires basically normal water supply (Farooq *et al.*, 2009). Moreover, Silva *et al.* (2011) indicated that, drought stress inhibiting the transpiration, active uptake and membranes permeability which reduced nutrients uptake and its translocation from the roots to shoots. Higher N, P and K concentrations could be suggested as a strategy for sugarcane drought tolerance (Silva *et al.*, 2017).

4. CONCLUSION

Water deficit stress 80 and 60 of IWL reduced the vegetative growth traits and the endogenous biochemical constituents' chlorophylls, total soluble proteins, N, P, K, Ca and Mg of some sugarcane genotypes. On the base of enhancing the photosynthetic pigments, proline, soluble sugar, total amino acids, N, P, K, Mg and Ca we can recommend that clone 2 and GT.54-9 as drought tolerant while, the clone 1 was more drought sensitive.

5. REFERENCE

AOAC (2005). Official Methods of Analysis of AOAC International, Ed 18th. Association of Official Analytical Chemists, Washington, D.C., USA.

Abd El-Raheem KM (2018). Effect of some soil amendment on physiological traits and productivity of sugar beet under water stress in sandy soil in Egypt and Morocco. M. Sc. Thesis, African studies Institute, Cairo, Univ.

Abid M, Ali S, Qi LK, Zahoor R, Tian Z, Jiang D, Snider JL, Dai T (2018). Physiological and biochemical changes during drought and recovery periods at tillering and jointing stages in wheat (*Triticum aestivum L.*). Scientific Reports, 8: 4615 1- 18.

Anjum SA, Ashraf U, Zohaib A, Tanveer M, Naeem M, Ali I, Nazir U, Tabassum T (2017). Growth and developmental responses of crop plants under drought stress: a review. Zemdirbyste-Agriculture, 104 (3): 267–276.

Bates LS, Waldren PR, Teare ID (1973). Rapid determination of free proline for water-stress studies. Plant and soil, 39(1):205-207.

Bayoumi TY, Eid MH, Metwali EM (2008). Application of physiological and biochemical indices as a screening technique for drought tolerance in wheat genotypes. African Journal of Biotechnology, 7 (14), 2341-2352.

Begum MK, Alam MR, Islam MS, Arefin MS (2012). Effect of water stress on physiological characters and juice quality of sugarcane. Sugar Tech 14(2):161 167.

Bernhart DN, Wreath AR (1955). Colorimetric determination of phosphorus by modified phosphomolybdate method. Anal. Chem. 27, 440–441.

Bezerra BKL, Lima GPP, dos Reis AR, Silva MDA, Camargo MSD (2019). Physiological and biochemical impacts of silicon against water deficit in sugarcane. Acta Physiologiae Plantarum, 41:189, 1-12.

Bradford MM (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Anal Biochem. 72 (1-2): 248–254.

CoHort Software (1998). CoStat version 6.400. 798 Lighthouse Ave. PMB 320, Monterey, CA, 93940, USA.

Couso LL, Fernández RJ (2012). Phenotypic plasticity as an index of drought tolerance in three Patagonian steppe grasses. Annals of Botany, 110(4):849-857.

Dos Santos CM, Silva MA (2015). Physiological and biochemical responses of sugarcane to oxidative stress induced by water deficit and paraquat. Acta Physiologiae Plantarum, 37, n. 8, 1- 14.

Dos Santos CM, Endres L, da Silva ACS (2019). Water Relations and Osmolite Accumulation Related to Sugarcane Yield Under Drought Stress in a Tropical Climate. Int. J. Plant Prod. 13, 227–239.

Duncan DB (1955). "Multiple range and multiple F tests". Biometrics. 11: 1–42.

Farooq M, Wahid A, Kobayashi N, Fujita D, Basra SMA (2009). Plant Drought Stress: Effects, Mechanisms and Management. In: Lichtfouse E., Navarrete M., Debaeke P., Véronique S., Alberola C. (eds) Sustainable Agriculture. Springer, Dordrecht. https://doi.org/10.1007/978-90-481-2666-8_12.

Gaber AA, Abou-Hadid AF, El-Gabry YA, Ebid MHM (2021). Morphological and Physiological Study for Sugarcane Early Selection to Drought Tolerance. Plant Archives 21(1):1935-1944.

Garcia FHS, das Chagas Mendonça AM, Rodrigues M (2020). Water deficit tolerance in sugarcane is dependent on the accumulation of sugar in the leaf. Ann. Appl. Biol., 176:65–74.

Gardner MP (1985). Mood states and consumer behavior: A critical review. Journal of Consumer research, 12(3):281-300.

Hellal F, El-Sayed S, Taha ZK, Desouky SF, Chedly Abdelly (2020). Biochemical changes of mediterranean barley as affected by drought stress. Plant Archives, 20, 3717- 3724.

Hoang DT, Hiroo T, Yoshinobu K (2019). Nitrogen use efficiency and drought tolerant ability of various sugarcane varieties under drought stress at early growth stage, Plant Production Science, 22:2, 250-261.

Horneck DA, Hanson D (1998). Determination of potassium and sodium by flame emission spectrophotometry. In: Kalra, Y.P. (Ed.), Handbook of Reference Methodsfor Plant Analysis, pp. 153–155.

Horneck DA, Miller RO (1998). Determination of total nitrogen in plant tissue. In:Kalra, Y.P. (Ed.), Handbook of Reference Methods for Plant Analysis, pp. 75–83.

Inman-Bamber NG, Bonnett GD, Smith DM, Thorburn PJ (2005). Sugarcane physiology: Integrating from cell to crop to advance sugarcane production. Field Crops Research 92: 115–117.

Kaya C, Tuna L, Higgs D (2006). Effect of Silicon on Plant Growth and Mineral Nutrition of Maize Grown Under Water-Stress Conditions, Journal of Plant Nutrition, 29:8, 1469-1480.

Khonghintaisong J, Songsri P, Toomsan B, Jongrungklang N (2018). Rooting and Physiological Trait Responses to Early Drought Stress of Sugarcane Cultivars. Sugar Tech 20(4):396–406.

Lichtenthaler HK, Buschmann C (2001). Extraction of PhtosyntheticTissues:Chlorophylls and Carotenoids. Current Protocols in Food Analytical Chemistry, 1: F4.2.1-F4.2.6.

Marcos FCC, Silveira NM, Mokochinski Jo˜aoB, Sawaya ACHF, Marchiori PER, Machado EC, Souza GM, Landell MGA, Ribeiro RV (2018). Drought tolerance of sugarcane is improved by previous exposure to water deficit. J. Plant. Physiol. 223, 9–18.

Medeiros DB, da Silva EC, Nogueira RJMC, Teixeira MM, Buckeridge MS (2013). Physiological limitations in two sugarcane varieties under water suppression and after recovering. Theoretical and Experimental Plant Physiology, 25(3): 213-222.

Ramadoss BR, Subramanian U, Alagarsamy M, Gangola MP (2021). Non-Enzymatic Antioxidants' Significant Role in Abiotic Stress Tolerance in Crop Plants. Hamed Abdel Latef, A.A. (2021). Organic Solutes, Oxidative Stress, and Antioxidant Enzymes Under Abiotic Stressors (1st ed.). CRC Press. https://doi.org/10.1201/9781003022879.

Sadasivam S, Manickam A (2010). Biochemical methods, third ed. New Age International Publishers. pp. 1–19.

Shabala SN, Shabala SI, Martynenko AI, Babourina O, Newman IA (1998). Salinity effect on bioelectric activity, growth, Na+ accumulation and chlorophyll fluorescence of maize leaves: a comparative survey and prospects for screening. Functional Plant Biology, 25(5): 609-616.

Silva EC, Nogueira RJMC, Silva MA, Albuquerque MB (2011). Drought stress and plant nutrition. Plant stress 1: 32- 41.

Silva M, de A, Jifon JL, Silva JAGD, Sharma V (2007). Use of physiological parameters as fast tools to screen for drought tolerance in sugarcane. Braz. J. Plant Physiol. 19:193–201.

Silva TRD, Cazetta JO, Carlin SD, Telles BR (2017). Drought-induced alterations in the uptake of nitrogen, phosphorus and potassium, and the relation with drought tolerance in sugar cane. Ciência e Agrotecnologia 41(2):117-127

Stefánsson A, Gunnarsson I, Giroud N (2007). New methods for the direct determination of dissolved inorganic, organic and total carbon in natural waters by Reagent- FreeTM Ion Chromatography and inductively coupled plasma atomic emission spectrometry. Anal. Chim. Acta 582, 69–74.

Sultan MARF, Hui L, Yang LJ, Xian ZH (2012). Assessment of drought tolerance of some *Triticum* L. species through physiological indices. Czech J. Genet. Plant Breed., 48: 178-184.

Swamy PM (2008). Laboratory manual on biotechnology. Rastogi Publications, India, pp. 80–82.

Taha AM, Zohry A (2018). Adaptation of sugarcane national production in Egypt to climate change. Egypt. J. of Appl. Sci., 33 (5) 203-218.

Watson DJ (1958). The dependence of net assimilation rate on leaf-area index. Annals of Botany. 22(1):37-54.

Zhao D, Barry Glaz, Comstock JC (2013). Sugarcane Leaf Photosynthesis and Growth Characters during Development of Water-Deficit Stress. crop science, vol. 53, 1066- 1075.

الملخص العربي

تقييم بعض التراكيب الوراثية لقصب السكر تحت ظروف الجفاف

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تم إجراء تجربة أصيص خلال موسمي ٢٠١٩ و ٢٠٢٠ في محطة البحوث الزراعية بمحافظة الجيزة (خط عرض ٢٦ درجة و ٣٣ درجة شمالاً وخط طول ٣١ درجة و ١٢ درجة شرقاً) ضمن برنامج تربية قصب السكر المصري، لتقييم سلالتين من قصب السكر، بالمقارنة مع الصنف المنزرع جيزة تايوان ٥٤–٩ (هجن نوعية من جنس القصب)، تحت ثلاثة مستويات لمياه الري ١٠٠و ٨٠ و ٦٠٪ . تم إستخدام التصميم تام العشوائية. تم تقدير صفات مثل الوزن الغض للمجموع الخضري والجذر، نسبة المجموع الخضري إلى الجذر، دليل مساحة الأوراق (LAI)، نسبة مساحة الأوراق (LAR)، وكذلك تم تقدير بعض المكونات الكيميائية الحيوية مثل الكلوروفيل، والكاروتينات، والبرولين، والسكريات الذائبة الكلية، والأمينات الكلية كما تم تقدير الأحماض والبروتينات الكلية القابلة للذوبان والعناصر الكبرى مثل النيتروجين والفوسفور والبوتاسيوم والماغنسيوم والكالسيوم.

أشارت نتائج هذه الدراسة إلى أن السلالة رقم ٢ اعطت أفضل القيم لمعظم الصفات المورفولوجية والكيميائية الحيوية تحت ظروف الجفاف والذي يعني تحملها للجفاف. على العكس من ذلك ، أظهرت السلالة رقم ١ أقل القيم تحملا للجفاف. بالإضافة إلى ذلك لم تتأثر السلالات تحت الدراسة من قصب السكر بزيادة درجة الإجهاد المائي من ١٠٠ إلى ٨٠٪.

الكلمات المفتاحية: الجفاف، النمو، منظمات الإسموزية، قصب السكر، التحمل، نقص المياه.