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MORPHOLOGICAL AND PHYSIOLOGICAL STUDY FOR SUGARCANE EARLY SELECTION TO DROUGHT TOLERANCE

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ABSTRACT

In Egyptian sugarcane breeding program, a pot experiment was carried out during 2019 season at Agricultural Research Station, Giza Governorate (latitude 26° 33′ N and longitude 31° 12′ E), Egypt, to evaluate twenty sugarcane clones, compared with the cultivated variety GT.54-9, under three irrigation water levels IWL (100, 80 and 60% of IWL). The traits FW of the shoot and root, root: shoot ratio, LAI, LAR, Chl*a*, Chl*b*, Chl*a*: Chl*b* ratio, carotenoids and proline were assessed. From this study clones 17 had height shoot fresh weight under water stress condition, as same as, clones 1, 18 and 19 had great behavior under water stress. In addition to most of sugarcane tested clones were not affected by increase the degree of water stress from 100 to 80% of IWL. The LAI, Chl.a and Chl.b traits showed the high correlation with shoot fresh weight, whereas, proline had strong relationships with root fresh weight under sugarcane drought stress.

Keywords: Sugarcane, drought stress, irrigation water levels, correlation and clones selection

INTRODUCTION

Drought stress is affected by climatic, edaphic and agronomic factors. The susceptibility of plants to drought stress varies in dependence of stress degree, different accompanying stress factors, plant species, and their developmental stages (Shao *et al.,* 2008 and Demirevska *et al.,* 2009. An estimated, one-third of the world's terrestrial area suffers from water stress, which is predicted to increase owing to global warming, causing the reduction in crop production in several regions (Silva *et al.,* 2013 and Tack *et al.,* 2015). Solutes accumulation during water deficit acts to maintain the water balance in the cell, in the protection of enzymes and membranes, and they are sources of nitrogen and carbon after rehydration (Yordanov *et al.*, 2000 and Ashraf and Foolad, 2007).

Sugarcane physiological and morphological traits responsible for improved cane yield, sucrose content and resource use remained poorly understood (Inman-Bamber *et al.,* 2005). Researchers have also linked various physiological responses of plants to drought with their tolerance mechanisms, such as root: shoot dry weight ratio (Huang and Id 1998). Drought stress not only affects the physiological aspects of plants but also their internal metabolic system and gene expression. A severe water deficit situation can lead to the decrease in plant membrane stability and transport activity along the membrane (Rahdari *et al.*, 2012).

There is great variability in the degree of drought tolerance among species, and even among varieties of specie. This difference is observed through the value of the ideal water potential for plants and the development stage in which the stress occurs. Apart from the development of drought tolerant varieties the information on drought response among them is generally gained after they have been released for commercial production (Inmam-Bamber and Smith, 2005).

The current study aims gain an accurate early selection of sugarcane clones for drought tolerance to provide early information about the promising clones which could be used in breeding program. Thus, twenty clones of sugarcane were evaluated under three irrigation regimes at early growth stage and know which traits more correlated with drought tolerance.

MATERIALS AND METHODS

The present experiment was carried out during season 2019 at Giza Agricultural Research Station, Giza Governorate latitude 26° 33′ N and longitude 31° 12′ E. to test the performance of some clones obtained from sugarcane selection program of nine populations (Table 1) under different irrigation levels. Experiment comprised of 63 treatments which were the combinations of three irrigation levels and the twenty tested clones compared with the cultivated variety GT.54-9.

The experiment was carried out using a completely randomized experimental design, 21 × 3 factorial arrangement (twenty-one sugarcane genotypes × three soil irrigation regimes: control and 2 stressed levels), with five replications. The plastic pots (20 cm ×20 cm in diameter with a bottom drainage hole) were filled with about12 kg of the substrate of sand and clay at a ratio of 1:1. On March 22nd 2019, one seed cutting was planted in each pot. Irrigations and other cultural practices were done as and when required to all plant in pot for natural growth. The seedlings were considered established at 60 days after planting.

Table 1: Sugarcane hybrids names were used and number of tested clones from each hybrid.

Population	**Hybrid Name** ♀ ♂	*A count of clones*	*Clones number*
I	Co.284 X CP.57-614	1	5
II	CP.57-617 X Co.617	2	10, 15
III	CP.63-35 X CP.46-115	4	3, 14, 16, 20
IV	Co.1129 X G.73-211	2	1,8
V	H.86-37 X Co.617	2	9, 11
VI	EH.67-11 X SP.81-1763	2	12, 13
VII	Co.744 X BO.19	5	2, 6, 7, 18, 19
VIII	CP.57-614 X Co284	1	4
IX	Co.284 X CP.44-101	1	17
Total		20	

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

Data Collection

After 60 days from starting the irrigation levels treatment the plants were collected and recorded the following data:

I- **Morphological traits:**

1- Shoot fresh weight gm/plant

2- Root fresh weight gm/plant

3- Root: shoot ratio

II- **Growth indices:**

1- Leaf area Index (LAI)

Leaf area of three randomly pot selected stalks at 70 days from planting was measured. LAI was computed by using the following formula as suggested by Watson (1958).

2- Leaf area ratio (LAR) (cm^2/gm) it was calculated according to the following formula (Gardner 1985):

III- Physiological parameters

1- Chlorophyll a (Chl.*a*).

2- Chlorophyll b (Chl.*b*).

3- Chl*a*:Chl*b* ratio.

4- Carotenoids content.

Photosynthesis pigments mg g^{-1}based onfresh weight was analyzed following the methods of Shabala *et al.,* (1998) and Lichtenthaler and Buschmann (2001), respectively.

5- Free proline in leaves: it was determined according to Bates *et al.,* (1973).

Data analysis

Statistical analysis was performed using CRD with five replications and mean values were compared using LSD at 5% level of significance (Gomez and Gomez, 1984). The phenotypic correlation between studied traits were calculated as shown by Cardinal and Burton (2007).

RESULTS AND DISCUSSIONS

I-Morphological traits:

1- Shoot fresh weight g/plant:

Table 2 showed significant differencein shoot fresh weight of twenty sugarcane clones and the commercial variety (GT.54-9). In this regard, clone 17, GT.54-9 and clone 18 recorded statistically similar increases in shoot fresh weight surpassing the other genotypes. While the lowest shoot fresh weight value was observed in clone 1. These results might be due to the genetic variability

Decreasing irrigation water level caused significant reductions shoot fresh weight amounted to 21.1 and 34.8% with 80% and 60%, respectively, comparing to the normal irrigation (100%).The differences between irrigation levels results might be due to the effect of drought stress on sugarcane shoot fresh weight. The insufficient soil moisture declined cell division, elongation and thus reduce expansion of leaves in turn shoot fresh weight (Gharib and El-Henawy, 2011). These results are in harmony with the finding of Abd El-Raheem (2018).

The remarkable interaction between irrigation levels and sugarcane genotypes (Table 2), revealedboth of GT.54-9 and clone 18 (with 100% or 80%) as we las clone 17 (with 100%, 80% or 60%) were the effective combinations for producing the highest values of shoot fresh weight.

Under normal irrigation,clones 1, 3, 6, 8, 10, 12, 13 and 16 showed the lowest shoot fresh weight. Stalk and leaf growth inhibition, are the most common initial adaptation when sugarcane plants are subjected to mild to moderate dehydration (Inman-Bamber and Smith, 2005). The decrease of shoot fresh weight may be caused by decrease in pressure potential stomata conductivity and relative water content of leaf in water stress that causes lower growth of leaves because less development of cells (Esmaeilie, 2011). Accordingly, our findings proved that clone 17 could represent a promising germplasm for drought tolerant.

2- Root fresh weight g/plant:

Among the significant difference between studied genotypesin Table 2, the highest significant values were found in clones no 18 and 17 superior the commercial variety GT.54-9 by 4.4 and 3.7 g/plant, respectively. While, the lowest value obtained in clone 2 that was decreased amount5.53 g/plant than the commercial variety.

In respect to the water stress treatments, decreasing IWL from 100% to 80% led to significantly increase of root fresh weight by 39.8%, while increase water stress to 60% significantly reduced by 18.3%. In water deficient soil, roots of plant become clumped and hence the ability of water uptake is reduced making plant vulnerable to severe structural problems (Couso and Fernandez, 2012).

The interaction between the irrigation water levels and sugarcane genotypes was different significantly (Table 2). Under full irrigation water level, clones 17 and 18 were the better genotypes gave the highest root fresh weight superior than commercial variety GT.54-9 by7.5 and 6.1 g/plant, respectively. The same trend was obtained when decrease water level to 80%. The commercial variety GT.54-9 was one of the best genotype where, it had the higher value in roots fresh weight after clones no 18 and 17 under the increase water stress to 80 % of IWL. Results in Table 2 showed wide response by different genotypes for water regimes of root fresh weight, these results might be due to different resistance reaction for various genotypes. In sugarcane, the development of deep and large root as systems can be used selection criteria for water stress tolerance (Smith *et al.*, 2005). Root development is influenced by water deficit (Inman-Bamber and Smith, 2005 and Smit and Singels, 2006). Root characteristics are helpful to predict the ability of plants to adapt to drought stress (Songsri *et al.*, 2008 and Wang *et al.*, 2009). Similar results were reported by (Abd El-Raheem, 2018).

3- Root: shoot ratio (on the basis of fresh weight):

Mean of root: shoot ratio of recorded data the significant differences between all genotypes under study varied from 2.08 to 0.69. The higher root: shoot ratio which values from 2.08 to 1.01 were found in nine genotypes, this mean that root fresh weight was heavier than shoot. The vice versa for other genotypes had the lower root: shoot ratio from 0.94 to 0.69.

In over all means of the three irrigation levels Table 2, results showed that root: shoot ratio was increase significantly by increasing water stress from 100 to 80% of IWL. In case of low available of water, plants adapt themselves to minimize the water loss through transpiration and also strive to expand roots to achieve the maximum possible absorption of water (Shahzad *et al.*, 2017). While, the increase of water stress from 80 to 60% of IWL, root: shoot ratio was significantly decreased from 1.22 to 1.06. Abdollahian-Noghabi (1999) reported that, under water deficiency stress in the early growth stages, shoot growth was more restricted than that of the roots.

The significant results were found in the interaction between the irrigation levels and sugarcane genotypes were shown in Table 2. The higher significant root: shoot ratio was recorded by clone 1 followed by no 13 under the three irrigation levels without significant difference between 60 and 80% of IWL. On the other hand, clones 20 and 17 gave the lowest root: shoot ratio recorded 0.49 and 0.63 at stress 60% of IWL, this caused by increase root fresh weight against decrease of shoot fresh weight. Hessini *et al.,* (2009) found that, root to shoot ratio on the base of fresh weight were increased by the effect of water stress indicating that shoot growth is more sensitive to this stress than root growth. Chapae *et al,* (2020) recorded that, the shoot-reduced cultivar responded to early drought in hydroponics by reducing root dry weight and the proportion of green leaves number. However, the drought resistance mechanisms that can maintain aboveground dry matter of sugarcane cultivars in this condition responded variously.

II- Growth indices:

1-Leaf area Index (LAI):

Data recorded in Table 3, showed significantly variances in LAI values for twenty sugarcane clones and cultivated one (GT.54-9). LAI values ranged from 0.84 to 2.00, the highest value was produced from clone 17 and the lowest for clone 12, whereas commercial variety had 1.38.

The levels of water stress imposed in this experiment induced a significant LAI values and these results indicated to decrease LAI values by increasing water deficientto 13% and 31.7% with 80% and 60%, respectively, comparing to the normal irrigation (100%). Water deficit reduced LAI and the effect varied depending on its timing and severity. Early water deficit reduced the rate of leaf expansion and consequently the maximum area of individual leaves; it reduced the LAI (Stone *et al.,* 2001).Low water potentials

Table 2: Effect of irrigation level on shoot and root fresh weights and root: shoot ratio of sugarcane genotypes

Traits	Shoot fresh weight (g/plant)				Root fresh weight (g/plant				Root:Shoot ratio			
Geno-type(G)	Irrigation level (I)											
	100%	**80%**	**60%**	**Mean**	**100%**	**80%**	**60%**	**Mean**	**100%**	**80%**	**60%**	**Mean**
1	11.5	9.3	7.6	**9.5**	20.30	23.30	14.90	**19.50**	1.77	2.51	1.96	**2.08**
2	19.7	16.4	15.8	**17.3**	11.90	13.50	10.50	**11.97**	0.60	0.82	0.66	**0.69**
3	18.6	17.3	12.7	**16.2**	11.00	16.70	14.00	**13.90**	0.59	0.97	1.10	**0.89**
4	22.7	18.2	11.8	**17.6**	14.50	17.00	14.60	**15.37**	0.64	0.93	1.24	**0.94**
5	21.0	14.5	9.8	**15.1**	14.00	17.50	13.40	**14.97**	0.67	1.21	1.37	**1.08**
6	17.5	12.9	12.3	**14.2**	12.00	14.40	10.50	**12.30**	0.69	1.12	0.85	**0.89**
7	19.6	9.1	7.0	**11.9**	13.50	15.00	11.50	**13.33**	0.69	1.65	1.64	**1.33**
8	16.1	12.7	9.3	**12.7**	10.30	14.60	12.70	**12.53**	0.64	1.15	1.37	**1.05**
9	20.6	14.3	9.6	**14.8**	13.20	15.00	13.00	**13.73**	0.64	1.05	1.35	**1.01**
10	18.8	18.6	17.3	**18.2**	13.40	16.30	11.00	**13.57**	0.71	0.88	0.64	**0.74**
11	20.0	9.8	7.6	**12.5**	13.00	17.00	10.00	**13.33**	0.65	1.73	1.32	**1.23**
12	13.6	11.2	11.0	**11.9**	13.20	16.50	10.00	**13.23**	0.97	1.47	0.91	**1.12**
13	18.8	11.1	10.7	**13.5**	18.10	21.30	14.70	**18.03**	0.96	1.92	1.37	**1.42**
14	21.7	15.4	13.3	**16.8**	12.00	19.60	10.50	**14.03**	0.55	1.27	0.79	**0.87**
15	24.3	11.0	9.7	**15.0**	15.50	20.50	10.40	**15.47**	0.64	1.86	1.07	**1.19**
16	19.3	17.8	12.1	**16.4**	11.70	15.50	11.60	**12.93**	0.61	0.87	0.96	**0.81**
17	27.4	26.5	26.3	**26.7**	25.00	22.00	16.60	**21.20**	0.91	0.83	0.63	**0.79**
18	25.0	24.9	23.7	**24.5**	23.60	23.50	18.60	**21.90**	0.94	0.94	0.78	**0.89**
19	20.0	19.8	19.0	**19.6**	13.10	14.00	13.10	**13.40**	0.66	0.71	0.69	**0.69**
20	19.6	18.2	17.2	**18.3**	17.50	18.50	8.50	**14.83**	0.89	1.02	0.49	**0.80**
GT.54-9	32.7	28.7	15.6	**25.7**	17.50	19.50	15.50	**17.50**	0.54	0.68	0.99	**0.74**
Mean	**20.4**	**16.1**	**13.3**		**12.65**	**17.68**	**14.97**		**0.76**	**1.22**	**1.06**	
LSD5%												
I				**1.7**				**1.18**				**0.16**
G				**4.6**				**3.11**				**0.42**
I*G				**8.0**				**5.39**				**0.73**

induce the limitation of green leaves for all cultivars (Chapae *et al.,* 2020).

Results obtained in Table 3 cleared that, studied genotypes significantly differed in LAI values when stressed by irrigation levels. Clone 17 was the best than other clones where it gave the highest value of LAI recorded 0.73 and 0.34 followed by clone no 18 registered 0.13 and 0.16, higher than commercial variety when irrigated by 80 % and 60 % of IWL, respectively. The increase LAI of clone no 17 and 18 caused by the increase of shoot fresh weight which may be due to its more tolerance to drought stress. Drought stress accompanied by a series of gene encoding regulatory proteins that are involved in signaling and enhancing the expression of a number of certain other genes. Wahid and Ghazanfar (2006), Patade *et al.*, (2011) and Begum *et al.,* (2015). The good adaptations of the traits supporting shoot mass maintenance under hydroponics was green leaf number proportions. The ability to perform acclimation of this trait might be useful for improving drought resistance genotypes in the future. (Chapae *et al.,* 2020).

2-Leaf area ratio (LAR cm^2 g^{-1}):

In Table 3, significantly differences in LAR (cm^2 g^{-1}) were obtain, were the highest value of LAR (32.59 and 27.30 cm^2 g^{-1}) were recorded in clones 1 and 6, while the lowest (18.59 and 18.99 cm^2 g^{-1}) was observed in commercial variety and clone no 16, respectively. These differences between genotypes may be due to genetic variability.

In respect of irrigation water levels, data in Table 3 cleared that the average LAR (cm^2 g^{-1}) tends to slightly decrease LAR from 25.29 to 22.74 cm^2 g^{-1} with increasing water stress from 100 to 80% of IWL, and then the decrease was significant at 60% as compared to 100% of IWL. The reduction of leaf area is principally explained by decreases of the new leaf production, number of leaves and leaf size. Furthermore, a decrease of leaf area could also be beneficial to plants under water stress condition because it allows a reduction of the leaf transpiration (Hiessini *et al.,* 2009).

Results obtained in Table 3 showed that, genotypes were differed significantly when stressed by different irrigation

Table 3: Effect of irrigation level on leaf area index (LAI) and leaf area ratio (LAR) of sugarcane genotypes

Traits	LAI				LAR (cm^2/g)			
Genotypes(G)	Irrigation level (I)							
	100%	**80%**	**60%**	**Mean**	**100%**	**80%**	**60%**	**Mean**
1	1.06	0.97	0.87	**0.97**	36.00	32.69	29.08	**32.59**
2	1.32	1.22	1.22	**1.25**	24.24	23.36	21.06	**22.89**
3	1.32	1.20	0.65	**1.06**	22.31	21.70	16.16	**20.06**
4	1.56	1.56	1.39	**1.50**	27.56	26.89	17.10	**23.85**
5	1.70	1.34	0.75	**1.26**	28.93	25.49	23.89	**26.10**
6	1.45	1.38	0.87	**1.23**	33.70	27.36	22.24	**27.77**
7	1.32	0.87	0.61	**0.93**	30.07	25.97	21.17	**25.74**
8	1.22	1.01	0.78	**1.00**	26.48	25.01	23.79	**25.09**
9	1.16	1.13	0.58	**0.96**	24.87	19.00	17.71	**20.53**
10	1.67	1.45	1.15	**1.42**	27.89	24.43	20.91	**24.41**
11	1.45	1.32	0.58	**1.12**	26.34	24.00	22.80	**24.38**
12	0.93	0.85	0.75	**0.84**	23.89	21.46	21.28	**22.21**
13	1.15	0.73	0.73	**0.87**	21.31	20.54	19.24	**20.36**
14	1.26	0.91	0.87	**1.01**	20.57	18.46	18.21	**19.08**
15	1.45	0.73	0.65	**0.94**	21.15	20.73	18.70	**20.19**
16	1.16	1.16	0.68	**1.00**	18.90	20.49	17.59	**18.99**
17	2.30	2.09	1.60	**2.00**	26.41	24.78	19.07	**23.42**
18	1.60	1.49	1.42	**1.50**	20.06	18.80	18.86	**19.24**
19	1.36	1.36	1.10	**1.27**	21.28	21.49	18.24	**20.34**
20	1.26	1.26	1.06	**1.19**	21.71	20.16	19.44	**20.44**
GT.54-9	1.42	1.36	1.26	**1.38**	27.28	14.83	13.67	**18.59**
Mean	**1.39**	**1.21**	**0.95**		**25.29**	**22.74**	**20.01**	
LSD5%								
I				**0.10**				**3.11**
G				**0.27**				**6.77**
I*G				**0.47**				**9.73**

levels, where, the highest values in LAR were recorded by clone no 1,5.6 and 7 under 100% of IWL. The same clones showed more LAR with least reduction as compared to other genotypes in 80 % of IWL, as same as, in 60% of IWL recorded highest values by clones 1 and 5. While, the lowest LAR values were found in clones no 3 and 4 at 60% of LAR. These results may be due to drought tolerance by those clones.

III-Physiological parameters

1- Chlorophylls *a* and *b* (Chl. *a* and Chl. *b*):

Table 4 cleared that the twenty sugarcane clones and commercial variety according to chl.*a* and chl.*b* significantly differenced. The highest value of chl.a and chl.b were produced from commercial variety recorded (0.16 and 0.13mg g^{-1})**,**respectively,followed by clone no 17 with values (0.14 and 0.09 mg g^{-1})**.** These results referred to the superior of commercial variety than all clones might be due to genetic variability.

Means of overall chl.a and chl.b of three irrigation levels were significant (Table 4). Decreasing irrigation water level from 100 to 80 % significantly decrease chl.a and chl.b from 0.12 to 0.09 mg g^{-1} and from 0.08 to 0.04 mg g^{-1} respectively then more reductionwas obtainedfor chl.a and chl.b, under 60% of IWL. Previous studies also highlighted tolerant genotypes maintained better amount of these pigments under drought (Seher *et al*., 2015).

Significantly was obtained in the interaction between the irrigation levels and sugarcane genotypes (Table, 4). Thecommercial variety GT.54-9 was the best genotype than other one where it had significantly the highest pigments value of chl.a recording 0.20, 0.18 and 0.011 mg g^{-1} by 100%, 80% and 60% of IWR respectively and 0.21, 0.09 and 0.08 mg g^{-1} for chl.b. Chlorophyll contents executed more reduction in all wheat genotypes with the increment in levels of water stress because thylakoid membranes disintegrate upon dehydration of cells (Zeng *et al*., 2016). Photosynthetic pigments, chl.a, chl.b and carotenoids executed more reduction at higher water deficit conditions (Summiya Faisal *et al.,* 2017).

2- Chlorophyll a:b ratio:

Table 4, Effect of irrigation level on chlorophyll (Chl.) *a* and *b* contents and Chl. *a*: Chl. *b* ratio of sugarcane genotypes

Traits	**Chl. *a* mg g^{-1}dry matter**				**Chl. *b* mg g^{-1}dry matter**				**Chl *a*:*b* ratio**			
Genotypes(G)	**Irrigation level (I)**											
	100%	**80%**	**60%**	**Mean**	**100%**	**80%**	**60%**	**Mean**	**100%**	**80%**	**60%**	**Mean**
1	0.12	0.11	0.07	**0.10**	0.07	0.03	0.03	**0.04**	1.7	3.7	2.3	**2.6**
2	0.11	0.11	0.02	**0.08**	0.05	0.03	0.02	**0.03**	2.2	3.7	1.0	**2.3**
3	0.14	0.14	0.03	**0.10**	0.05	0.03	0.01	**0.03**	2.8	4.7	3.0	**3.5**
4	0.14	0.12	0.01	**0.09**	0.04	0.01	0.01	**0.02**	3.5	12.0	1.0	**5.5**
5	0.13	0.10	0.04	**0.09**	0.04	0.02	0.01	**0.02**	3.3	5.0	4.0	**4.1**
6	0.11	0.07	0.03	**0.07**	0.02	0.02	0.01	**0.02**	5.5	3.5	3.0	**4.0**
7	0.05	0.04	0.02	**0.04**	0.04	0.01	0.01	**0.02**	1.3	4.0	2.0	**2.4**
8	0.09	0.02	0.01	**0.04**	0.02	0.01	0.01	**0.01**	4.5	2.0	1.0	**2.5**
9	0.12	0.06	0.03	**0.07**	0.02	0.02	0.01	**0.02**	6.0	3.0	3.0	**4.0**
10	0.11	0.11	0.08	**0.10**	0.05	0.02	0.01	**0.03**	2.2	5.5	8.0	**5.2**
11	0.14	0.09	0.05	**0.09**	0.10	0.04	0.01	**0.05**	1.4	2.3	5.0	**2.9**
12	0.09	0.04	0.03	**0.05**	0.04	0.03	0.02	**0.03**	2.3	1.3	1.5	**1.7**
13	0.08	0.07	0.04	**0.06**	0.08	0.01	0.01	**0.03**	1.0	7.0	4.0	**4.0**
14	0.09	0.04	0.04	**0.06**	0.07	0.01	0.01	**0.03**	1.3	4.0	4.0	**3.1**
15	0.07	0.06	0.04	**0.06**	0.06	0.02	0.01	**0.03**	1.2	3.0	4.0	**2.7**
16	0.10	0.09	0.03	**0.07**	0.06	0.04	0.04	**0.05**	1.7	2.3	8.0	**1.6**
17	0.16	0.15	0.10	**0.14**	0.13	0.08	0.05	**0.09**	1.2	1.9	2.0	**1.7**
18	0.12	0.07	0.05	**0.08**	0.09	0.02	0.02	**0.04**	1.3	3.5	2.5	**2.4**
19	0.18	0.04	0.02	**0.08**	0.19	0.04	0.02	**0.08**	0.9	1.0	1.0	**1.0**
20	0.15	0.11	0.06	**0.11**	0.15	0.05	0.04	**0.08**	1.0	2.2	1.5	**1.6**
GT.54-9	0.20	0.18	0.11	**0.16**	0.21	0.09	0.08	**0.13**	0.9	2.0	1.4	**1.4**
Mean	**0.12**	**0.09**	**0.04**		**0.08**	**0.03**	**0.02**		**2.2**	**3.7**	**2.7**	
LSD5%												
I				**0.01**				**0.01**				**1.1**
G				**0.04**				**0.04**				**NS**
I*G				**0.07**				**0.07**				**5.1**

Results in Table 4 recorded that, the differences between the twenty sugarcane clones and commercial variety (GT.54-9) in chl.a: b ratio was insignificant.

As respect of water stress Table 4 found that chl.a:b ratio was significantly increased by increasing water deficit from 100 to 80 % of IWL. While increase the stress from 80 to 60 % of IWL led to insignificant decrease chl.a:b ratio. This means that the synthesis of chlorophyll a is higher than that of chlorophyll b under water stress.

The interaction between three irrigation water levels and sugarcane genotypes including commercial variety were significant (Table 4). Under full water, the higher values of chl.a:chl.b amounted 6.0 and 5.5 were recorded by clones no 9 and 6, respectively, whereas, commercial variety recorded 0.9 only. At 80% of IWL, clone 4 gave the highest value 12.0 as compared to other genotypes. It is important to mentioned that, clones 10 and 16 achieved the maximum chl.a:b ratio 8.0 at 60% of IWL. The increases of chl.a:b ratio might be attributed to decrease chl.b content by decrease of water quantity in irrigation. The rate of decline in drought-sensitive cultivar is much faster than in more drought-resistant cultivar (Shaddad and El-Tayeb, 1990). Similar results showed by Kraus *et al.,* 1995, drought stress caused significant declines in chlorophyll content. Higher chlorophyll content has also been associated with the stress tolerance of plants.

3- Carotenoids content

Table 5 cleared that, there was no any significant between all studied clones and commercial variety for carotenoids content mg g^{-1}.

Means of overall carotenoids content of three irrigation levels Table 5, data showed that decreasing irrigation water level from 100 to 60 % of IWL significantly decrease carotenoids content from 2.86 to 1.91mg g^{-1} then more decrease to 1.29 mg g^{-1} at water deficient to 60 % of IWL.

Interaction between the irrigation water levels and sugarcane genotypes (Table, 5) were significant, under full

Table 5: Effect of irrigation level on carotenoids and proline contents of sugarcane genotypes

Traits	Carotenoids mg g^{-1}drymatter				Proline mg g^{-1}			
Genotypes (G)	Three irrigation level (I)							
	100%	80%	60%	Mean	100%	80%	60%	Mean
1	3.36	2.44	1.37	**2.39**	0.17	0.26	0.34	**0.26**
2	3.01	2.44	1.27	**2.24**	0.13	0.19	0.24	**0.19**
3	2.51	2.66	1.18	**2.12**	0.13	0.17	0.22	**0.17**
4	3.66	1.52	0.26	**1.81**	0.19	0.24	0.32	**0.25**
5	2.51	2.49	1.50	**2.17**	0.11	0.15	0.19	**0.15**
6	1.79	1.41	1.30	**1.50**	0.10	0.15	0.18	**0.14**
7	2.49	1.75	1.24	**1.83**	0.08	0.18	0.27	**0.18**
8	1.63	1.58	0.95	**1.39**	0.14	0.23	0.30	**0.22**
9	2.02	1.85	1.64	**1.84**	0.16	0.18	0.21	**0.18**
10	2.30	1.87	1.60	**1.92**	0.09	0.17	0.30	**0.19**
11	1.82	1.47	1.03	**1.44**	0.18	0.29	0.39	**0.29**
12	3.51	1.80	1.22	**2.18**	0.24	0.30	0.38	**0.31**
13	3.68	1.95	1.59	**2.41**	0.17	0.19	0.21	**0.19**
14	2.54	1.98	1.48	**2.00**	0.27	0.27	0.27	**0.27**
15	3.27	0.96	0.06	**1.43**	0.28	0.32	0.35	**0.32**
16	3.44	2.35	1.07	**2.29**	0.26	0.32	0.39	**0.32**
17	4.16	2.95	2.32	**3.14**	0.33	0.34	0.40	**0.36**
18	5.36	1.42	1.23	**2.67**	0.31	0.34	0.42	**0.36**
19	2.30	2.05	1.75	**2.03**	0.26	0.33	0.39	**0.33**
20	2.21	1.43	1.41	**1.68**	0.23	0.33	0.38	**0.31**
GT.54-9	2.52	1.81	1.63	**1.99**	0.24	0.26	0.28	**0.26**
Mean	**2.86**	**1.91**	**1.29**		**0.19**	**0.25**	**0.30**	
LSD5%								
I				**0.40**				**0.02**
G				**NS**				**0.05**
I*G				**1.85**				**0.09**

irrigation level 100 of IWL, the highest significant value of carotenoids was recorded by clone no 18 followed by clone no 17. While under stress at 80 and 60 % of IWL, clone 17 was the best gave the highest level of carotenoids as compared to other clones or commercial variety.

4- Proline content:

Data recorded in Table, 5 showed significantly differences of proline content mg g^{-1} to the twenty clones and commercial variety of sugarcane. The clones no 17 or 18 proline value were equal and it's more than commercial variety value by 0.1 mg g^{-1}, with significant difference. The data cleared that, these differences were due to genetic variability. Wallace *et al.,* (1983) suggested that inter-species differences in osmotic potential might reflect different drought tolerances.

As respect of water stress Table 5, found that proline mg g^{-1} was significantly increased by increasing water deficit from 100 to 80 % of IWL. Also, the same trend was obtained when increase the stress from 80 to 60 % of IWL. This means that water stress caused positive effect on proline content mg g^{-1}. The accumulation of compatible solutes such as proline help in protecting the plants from detrimental effects of drought stress (Ashraf and Foolad, 2007). Gzik (1996) reported that osmotic and drought-induced stress resulted in a rapid increase in leaf proline content. He concluded that the accumulation of high levels of proline under stressed conditions indicates the involvement of proline in osmo-regulation.

The interaction between irrigation water levels and sugarcane genotypes in Table, 5 cleared that, some genotypes differed significantly with commercial variety (GT.54-9) in proline content and most none.The higher proline content were obtained by clone no 18 followed by no 17 were higher than commercial variety by 0.14 and 0.12 mgg^{-1} respectively, under used higher stress 60% of IWL. The primary response of drought stressed sugarcane plantlets was osmotic adjustment through proline accumulation, which is well established in many plant species (Errabi *et al.*, 2007). The proline accumulation in drought-stressed plants may play a role as osmolyte

Table 6: Phenotypic correlations coefficient between studied traits under three levels of IWL

Traits	IWL	Shoot FW	Root FW	LAI	Chl. *a*	Chl. *b*	Carotenes	Proline
	100 %							
Shoot FW	80 %	1						
	60 %							
	100 %	0.39						
Root FW	80 %	0.23	1					
	60 %	0.41						
	100 %	0.60**	0.47*					
LAI	80 %	0.72**	0.06	1				
	60 %	0.82**	0.50*					
	100 %	0.38	0.26	0.24				
Chl. *a*	80 %	0.56**	0.34	0.40	1			
	60 %	0.41	0.38	0.42				
	100 %	0.53*	0.43	0.12	0.70**			
Chl. *b*	80 %	0.62**	0.28	0.27	0.68**	1		
	60 %	0.39	0.35	0.47*	0.71**			
	100 %	0.22	0.49*	0.19	-0.27	-0.01		
Carotenes	80 %	0.24	0.04	0.31	0.12	-0.11	1	
	60 %	0.49*	0.26	0.28	0.30	0.19		
	100 %	0.38	0.39	0.02	0.24	0.51*	0.50*	
Proline	80 %	0.32	0.39	0.12	-0.02	0.46*	-0.17	1
	60 %	0.37	-0.02	0.32	0.23	0.32	-0.09	

**. Correlation is significant at the 0.01 level (1-tailed).
*. Correlation is significant at the 0.05 level (1-tailed).

to maintain the organelles, resulting in the greenish leaf when exposed to water deficit condition (Sankar *et al.*, 2007 and Safarnejad, 2008)

IV- Phenotypic correlation

The phenotypic correlation among some studied traits was shown in Table 6. From those results, found that, LAI, Ch.a, Ch.b and carotenes significantly positive correlation with shoot fresh weight of sugarcane and the relation was increased by increase the drought stress from 100 to 60% IWL, except, correlation between shoot fresh weight and Chl.a,b was increased by increasing drought stress till 80% IWL, but decreased again where drought stress increase to 80% IWL.

From correlation results reported that, Chl.a and Chl.b more positive relation between them and not affected by drought stress. On the contrary, correlation between carotenes and proline contents was significantly positive when 100% IWL, while the relation were negatively when stressed 80 to 60% IWL.As same as, correlation between root fresh weight and proline content was positive in 100 till to 80% IWL, while in 60% IWL was negative.

The LAI, Chl.a and Chl.b traits showed the high correlation with shoot fresh weight under drought stress, whereas, proline had strong relationships with root fresh weight under drought stress (Table 6). Soomro *et al.*, 2006, concluded that, correlations among phenotypic traits may reflect biological processes that are of considerable evolutionary interest and can be the result of genetic, functional and physiological or developmental nature. The Chla, Chlb and Carot. parameters showed the positive correlation, whereas proline demonstrated negative relationships. (Cha-Um and Kirdmanee, 2008).

CONCLUSION

From this study clones 17 had height shoot fresh weight under water stress condition, as same as, clones 1, 18 and 19 had great behavior under water stress that might be due to those genotypes water stress tolerant and recommended to grown under drought stress. In addition to most of sugarcane tested clones not affected by increase the water stress from 100 to 80% of irrigation level. The LAI, Chl.a and Chl.b traits showed the high correlation with shoot fresh weight, whereas, proline had strong relationships with root fresh weight under sugarcane drought stress.

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