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Some aspects of drought resistance in *Citrullus colocynthis* L. in the Egyptian deserts

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Abstract

Samples of *Citrullus colocynthis* shoots were collected from nine stands during two seasons (winter and summer 2015) in two tributaries of Wadi Qena (W. El-Atrash and W. El-Ghuza) in the Eastern Desert of Egypt. Soil of these stands was characterized by slight alkalinity and low soil moisture and organic matter percentages. Soil macronutrients were arranged as Ca>K> Na>Cl>SO_4>Mg>PO_4. However, in *C. colocynthis* tissues, these nutrients accumulated in the following order: SO_4 >K > Ca > Mg > Na> Cl > PO_4. The plant chlorophyll contents (Chl. a and b), their ratio and their stability index (CSI) increased drastically during summer. Shoot accumulated SO_4, PO_4 and all cations during summer more than winter, except Cl that was higher during winter. Soluble sugars (SS) and soluble proteins (SP) increased during summer while total free amino acids were higher during winter. Data revealed that there were close relationships between the high SO_4, K and Ca contents and the hot-dry conditions and the accumulation of SS and SP on the relatively hot-dry season However, this may be primarily related to metabolism of drought resistance in such desert plants. Correlations between plant and soil variables showed important positive relations between soil Ca, Mg and plant Mg and between soil SO_4 with Ca and Mg of plant. Spatial distribution of *C. colocynthis* was the most important factor that controls WC, Na, K, Ca, Mg, Cl, PO_4, CSI a, CSI b , Chl. a and b, Chl. a/b ratio, TAA, , SS and SP. While, the interaction between both factors, spatial and temporal, could be the promoter.

Keywords: Drought resistance, Plant-environment relations, Chlorophyll, soluble sugar and Nitrogen metabolism, *Citrullus colocynthis* L.

Introduction

In the arid and semi-arid deserts, most plants are exposed to water stress due to extreme soil water deficits. Drought resistance is a complex trait involving several interacting properties (Aziz and Khan, 2003; Martnez *et al*., 2005; Scholz *et al.*, 2012). The adaptation in desert plants is due to their ability to maintain their turgidity and water uptake. The most important mechanism to maintain the plant water potential more negative than the external medium to insure the water uptake is the ability of plants to accumulate the inorganic solutes in high quantities inside their tissues (Kan *et al.*, 2000; Gadallah *et al*., 2001; Mile *et al.*, 2002; Sheded *et al*., 2006; Sayed *et al.*, 2013).

The plants also tend to accumulate the most compatible solutes in cytoplasm to balance the osmotic pressure inside the cells, especially by increasing their content of organic solutes (Mile *et al*., 2002; Sayed *et al*., 2013).

Wadis are the most widespread ecosystems in the mountainous desert of the world (Fossati *et al.*, 1999). The wadi system is an extreme case of a temporary inundated ecosystem in which the duration of flooding is shorter than the dry period (Evenari, 1985). Various habitats can be identified in a wadi: channels,

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bars, banks, etc. (Abdel Rahman and Batanouny, 1965). A wadi system embraces all the biotypes and related biocoenoses found in arid or hyper arid zones (Fossati *et al*., 1999; Salama *et al.,* 2012).

The Egyptian Eastern Desert extends eastwards from the Nile Valley up to Red Sea. It is located on an Eocene calcareous substratum more than 1000 m thick (Said, 1990), at the junction of the Sahara and Arabian Desert. The origin of wadi courses can be understood in the context of palaeoclimatic history.

Citrullus colocynthis (Cucurbitaceae) is a climber or crawling annual herb native to dry areas of north Africa, and common throughout the Sahara including areas of Morocco, Egypt and Sudan eastward through Iran to India and other parts of tropical Asia. It is characterized by fibrous and shallow root system. It was found that the extract of *Citrullus colocynthis* used for many medical purposes (Bendjeddou *et al.*, 2003; Seger *et al.*, 2005; Nayab et al., 2006; Qazan *et al*,. 2007; Daradka *et al*., 2007; AL-Ghamdi *et al*., 2009). It could be used as a herbal medicine for treatment of diabetes, oedema, bacterial infection and cancer (Kumar *et al*., 2008; Huseini *et al*., 2009). Mosquito larvacidal material was isolated from *C. colocynthis* by Rahuman *et al.*, (2008).

Ecophysiological studies on elucidated the usefulness in plant functions and identifying traits that are adaptive in specific environmental conditions. Therefore, in this study we focus on some ecophysiological aspects of *Citrullus* plants in lower tributaries of Wadi Qena, to understand the possibility of osmotic adjustment as well as the physiological adaption traits adopted by these plants to resist drought in desert environment.

Material and methods

Study area

Nine stands were selected in the eastern tributaries of W. Qena (W. El-Ghuza and W. El-Atrash) and geo-referenced using GPS technique between latitudes of 26° 44' and 26° 57' E and altitudes of 32° 55' and 33° 06' N with height ranging from 262-382 meters above sea level. The stands were chosen according to the presence of *C. colocynthis* plants and visited twice during the cold and hot seasons of 2015.

Soil sampling and analysis

Soil samples that inhabited by *C. colocynthis* were collected from each stand in triplicates in plastic bags for the laboratory physical and chemical analyses. Soil mechanical and chemical analyses were carried out according to the methods described by Farrag (2012). The soil fractions; gravels, coarse sand, fine sand, silt and clay were expressed as percentage of the original weight according to Ryan *et al*. (1996). Water content (WC%) of the soil samples was estimated on the dry weight basis. Organic matter (OM%) content was estimated by ignition at 600 °C for 3 h. Soil-water extracts (1:5, w:v) were prepared for the determination of total soluble salts were estimated as described by Jackson (1958): TSS = 0.64 × EC mS. Cm^{-1} × dilution factor., pH values using a glass electrode pH meter. Calcium and magnesium determination were carried out by titration against 0.01 N EDTA according to Upadhyay and Sharma (2005), while sodium and potassium were determined using flame photometer technique (Williams and Twine, 1960). Available phosphorus was determined calorimetrically according to Watanabe and Olsen (1965). In the meantime, chlorides were carried out by titration against 0.01N $AgNO_3$ according to Jackson (1958). Sulphates were determined by a turbidemetric technique as $BaSO_4$ according to Bardesly and Lancaster (1965).

Plant sampling and analysis

C. colocynthis shoots were collected in triplicates, placed in plastic bags in the field, then transferred immediately to the laboratory for chemical assessments. Known-weight samples of leaves were used for photosynthetic pigments (Chlorophyll; Chl.) extraction and determination according to the method of Metzner *et al.* (1965). For calculation of chlorophyll stability index (CSI) the ratio (expressed in percentage) between the chlorophyll content in heated sample to the fresh sample for chlorophyll a or b calculated as follows:

$$(\mathrm{CSI})_{a\ \text{or}\ b} = \frac{\text{Content of chlorophyl l }_{\text{"a" or "b"}}\text{ in heated sample}}{\text{Content of chlorophyl l }_{\text{"a" or "b"}}\text{ in fresh sample}} \times 100$$

In previous investigations by Todd and Basler (1965) and Fanous (1967), they used to test the heat stability of chlorophyll using heated extracts rather than heated intact leaves. Since chlorophyll in extract represents a rather unnatural condition, El-Sharkawi and Salama (1977) modified the technique by testing chlorophyll resistance to heat in intact leaves instead of the extract.

The bulk of plant shoots dried at 70°C in known-weight paper bags till reach a constant dry weight; hence the water content could be assessed. These oven-dried samples ground into a fine powder which consequently extracted in distilled water and assayed for minerals and metabolites determinations. Soluble cations (Na, K, Ca and Mg) and soluble anions (Cl, SO_4 and PO_4) were estimated as previously mentioned in soil solution. In the meantime, soluble proteins, total free amino acids and soluble sugars were determined calorimetrically in the studied plant according to procedures described by Lowry *et al.* (1951), Lee and Takahashi (1966) and Dubois *et al.* (1956), respectively. The content of each was expressed in mg.g^{-1} d. wt.

Statistical analysis

Analysis of variance was applied using a general one-way model (ANOVA), Duncan test was used for comparison between means to evaluate the effects of changes in locations (stands) on the parameters tested. Pearson correlation coefficient (r) was calculated for assessing the type of relationship between the spatial variations in the estimated soil-plant and plant-plant relations. Statistical inferences necessary to evaluate the effects and relative role (shares) of single factors and their interactions on the parameters tested included analysis of variance (F value) and coefficient of determination (η^2). The coefficient of determination (η^2) for each parameter has been devised as a ratio between sum of squares to the total sum of squares to evaluate the relative effect of each single factor and interaction in contributing to the total response. SPSS version 20 for windows was used for all these tests.

Results

Soil analysis

Silt and sand represent the higher part among other soil compartments of soil texture (Fig. 1A). Silt represented by 22.55 % at stand 5 and reached to 87.71% at stand 9 at W. El-Atrash. Sand came after silt as the lowest value of sand was recorded as 2.89% at stand 9, and the highest was 62% at stand 1. On the other hand, gravel and clay recorded the lowest percentages. Phosphates were represented in small quantities (Fig. 1B), and ranged between 0.01 mg.g^{-1} dry soil at stand 5 at W. El-Atrash to 0.06 mg.g^{-1} dry soil at stand 3 at W. El-Atrash. Chlorides concentration ranged between 0.13 mg.g^{-1} dry soil (stand 2 of W. El-Atrash) to 0.95 mg.g^{-1} dry soil (stand 8 of W. El-Ghuza; Fig. 1B).

Sulphates were increased at stand 3 and 8 as 1.32 and 1.27 mg.g^{-1} dry soil , while the lowest value was 0.11 mg.g^{-1} dry soil recorded at stand 9 (Figure 1B).

Most of the investigated stands (2, 5, 6, 7, and 9) had remarkable scarce contents of their cations, even they totally not reached to 1.5 mg.g^{-1} dry soil (Fig. 1C). Comparing the measured soluble cations showed the notable receding of Mg within the others and the predominance of Na, K and Ca. Sodium ranged between 0.06 to 1 mg.g^{-1} dry soil at stand 2 and stand 8, respectively. Potassium contents in these soils ranged between (0.98 mg.g^{-1} dry soil at stand 8 to 0.10 mg.g^{-1} dry soil at stand 2. Calcium and magnesium showed the same behavior in most stands. The results of pH (Fig. 1D) showed that, the soil solution was slight alkaline and ranged between 7.93 at stand 8 and 9.74 at stand 2. Values of soil water content (WC%; Fig. 1D) were approximately similar and ranged between 0.01-0.21% while there were one exceptions in stand 8 (0.65%). Figure (1E) indicated that organic matter in this study area was normally distributed between 0.97-2.03% while there were two extremes in stands 2 and 4 of W. El-Atrash where it reached to 3.78 and 3.12%, respectively. Total soluble salts were significantly varied among the stands (Fig. 1E) and highly increased in stands 1 at W. El-Atrash, 3, 4 and 8 (1.74%, 2.58%, 3.43% and 6.37%, respectively). On the other hand the lowest value was at stand 9 (0.31%)

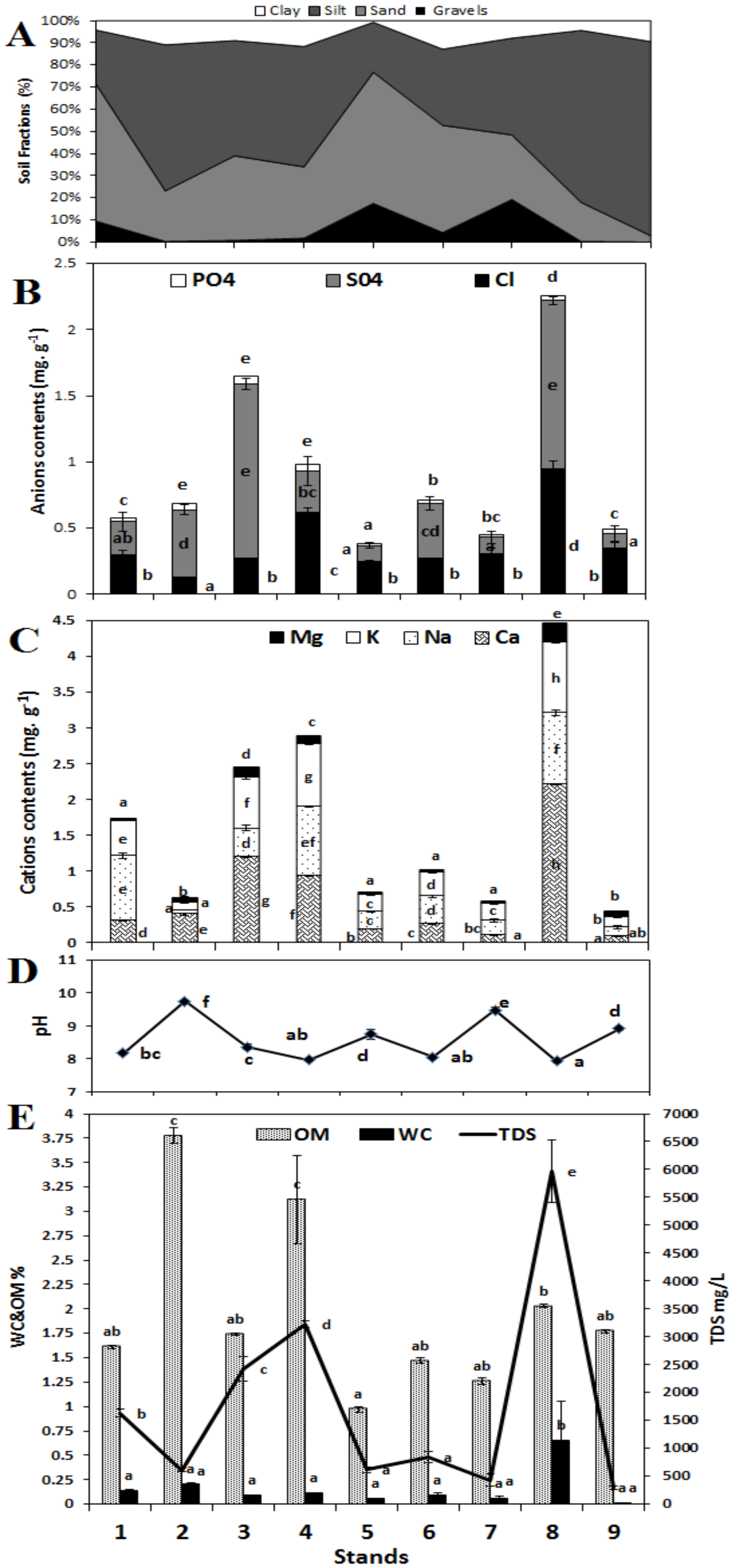

Figure 1: Soil characters; A: soil fractions (%), B: Soluble anions (mg.g^{-1} d.wt.), C: Soluble cations (mg.g^{-1} d.wt.), D: soil reactions (pH) and E: water content (WC%),organic matter (OM%) and TDS (mg.L^{-1}) in soils sampled from *C. colocynthis* stands at lower tributaries of W. Qena. Values are means ± standered error (error bars), values with different letters are significantly different ($p < 0.05$) according to Duncan test

Plant analysis

Photosynthetic pigments

The contents of chlorophyll (Chl. a, Chl. b); Chl. (a and b) and Chl. a/Chl. b ratio in *Citrullus colocynthis* plants (Fig. 2A) indicated that total pigment increased during summer than winter in most stands. The highest content of total pigments of the collected plants found in stand 4 (1.41 $mg.g^{-1}$ lf. f.wt.) in winter, while in summer found in stand 8 (1.49 $mg.g^{-1}$ lf. f.wt.). Chlorophyll a contents and Chlorophyll b contents during summer were higher than winter in all stands, except stands 3 and 4 showed the reverse. The highest Chl. a and Chl. b contents recorded during summer were 1.06 and 0 .47 $mg.g^{-1}$ lf. f.wt. in stands 8 and 6, respectively at W. El-Ghuza. Chlorophyll a content recorded the lowest value in stand 2 and stand 9 (0.32 $mg.g^{-1}$ lf. f.wt.) at W. El-Atrash during winter, while chlorophyll b recorded the lowest value at stand 9 (0.12 $mg.g^{-1}$ lf. f.wt.), also during winter. Chl. a /Chl. b ratio showed a significant increase during summer than winter in most stands. It ranged between 1.42 and 2.98 at stands 6 and 7, respectively at W. El-Ghuza during winter, while during summer ranged between 2.20 to 2.78 at stands 2 and 3 respectively of W. El-Atrash. Chlorophyll stability index of chlorophyll a% (CSI a %) and chlorophyll stability index of chlorophyll b% (CSI b %) were higher in summer than winter in most stands (Fig. 2B). In winter, CSI a and CSI b showed significant increase at stand 9, as 83.47% and 87.63% respectively, also the minimum value of them were 48.95% of CSI a and 48.67% of CSI b at stand 3 for each. On the other hand, during summer the maximum value of CSI a was 84.33% at stand 8, and the minimum value was recorded in stand 4 (63.83 %), while CSI b was significant increase in at stand 2 (87.89%), the minimum value was recorded in stand 3 (68.01%).

Table (1) revealed the relative contribution (η^2) of single factor (St) had the highest effects in case of Chl. a, chl. b, Chl. (a + b), Chl. a/b ratio, CSI a and CSI b while the (Se x St) interaction had the minor role.

Water content and ionic composition of the plant cells

The water contents (WC %) of *Citrullus colocynthis* shoots increased during winter than that of summer in most stands (Fig. 3A). During winter water content ranged between 58.39 % at stand 1 of W. El-Atrash to 70.90 % at stand 4 in the same wadi. Meanwhile the mean maximum water content in summer season was 68.96 % at stand 8 in W. El-Ghuza and the mean minimum was 49.72 % at stand 1 of W. El-Atrash. Statistical analysis (Table 1) indicated that the single factors Se and St as well as their interaction (Se × St) showed significant effect on the percentages of water contents in *Citrullus colocynthis* shoots. The effect of the single factor (St) was the highest on WC and Se × St interaction had minor effect.

Concentrations of cations and anions except chloride in *Citrullus colocynthis* plants were higher during summer season than winter season in most stands (Figs. 3A, 3B). The figure exhibited that the predominance of K, Ca and SO_4 as the major accumulated nutrients in shoot of the investigated plants and the lowest was for Na and PO_4. The cations contents in the shoots of *Citrullus colocynthis* differed between stands, it showed general high levels mostly at stands 3, 4 and 8. The highest value of Na appeared at stand 4 (4.09 mg. g^{-1} d.wt) during winter, for K was 10.02 mg. g^{-1} d.wt recorded at stands 4 and 8 during summer. Ca and Mg were significant increased at stand 3 during summer as (Ca; 8.50 mg. g^{-1} d.wt. and Mg; 4.25 mg. g^{-1} d.wt.). The lowest concentrations of Na and Ca recorded at the same stand during winter (stand 9), while the minimum value of K and Mg recorded also during winter at stands 5 and 7 respectively. Cl and PO_4 were significantly increased during winter at the same stand (stand 8) of W. El-Ghuza (5.44 and 3.30 mg. g^{-1} d.wt., respectively), while highest concentration of SO_4 was 17.67 mg. g^{-1} d.wt at stand 9.

The minimum values of Cl, SO_4 and PO_4 were 1.30, 6.73 and 0.3 mg. g^{-1} d.wt at stands 1, 5 and (3 and 6 for PO_4), respectively. Statistical analysis for data of anions and cations concentration of the plant shoots (Table 1) revealed that, the effects of single factors and their interaction on Cl, SO_4 , PO_4 , Na, K, Ca and Mg contents in *Citrullus colocynthis* were statistically significant. The effect of St x Se the most important factor in the case of SO_4 (η^2

= 0.729) and the effect of single factors was subsidiary, but the relative contribution (η^2) of single factor (St) had a very high value in case of Na (η^2 = 0.574),K (η^2 = 0.656), Ca (η^2 = 0.617), Mg (η^2 = 0.686), Cl (η^2 = 0.791) and PO_4 (η^2 = 0.507), while interaction (Se x St) was the minor factor.

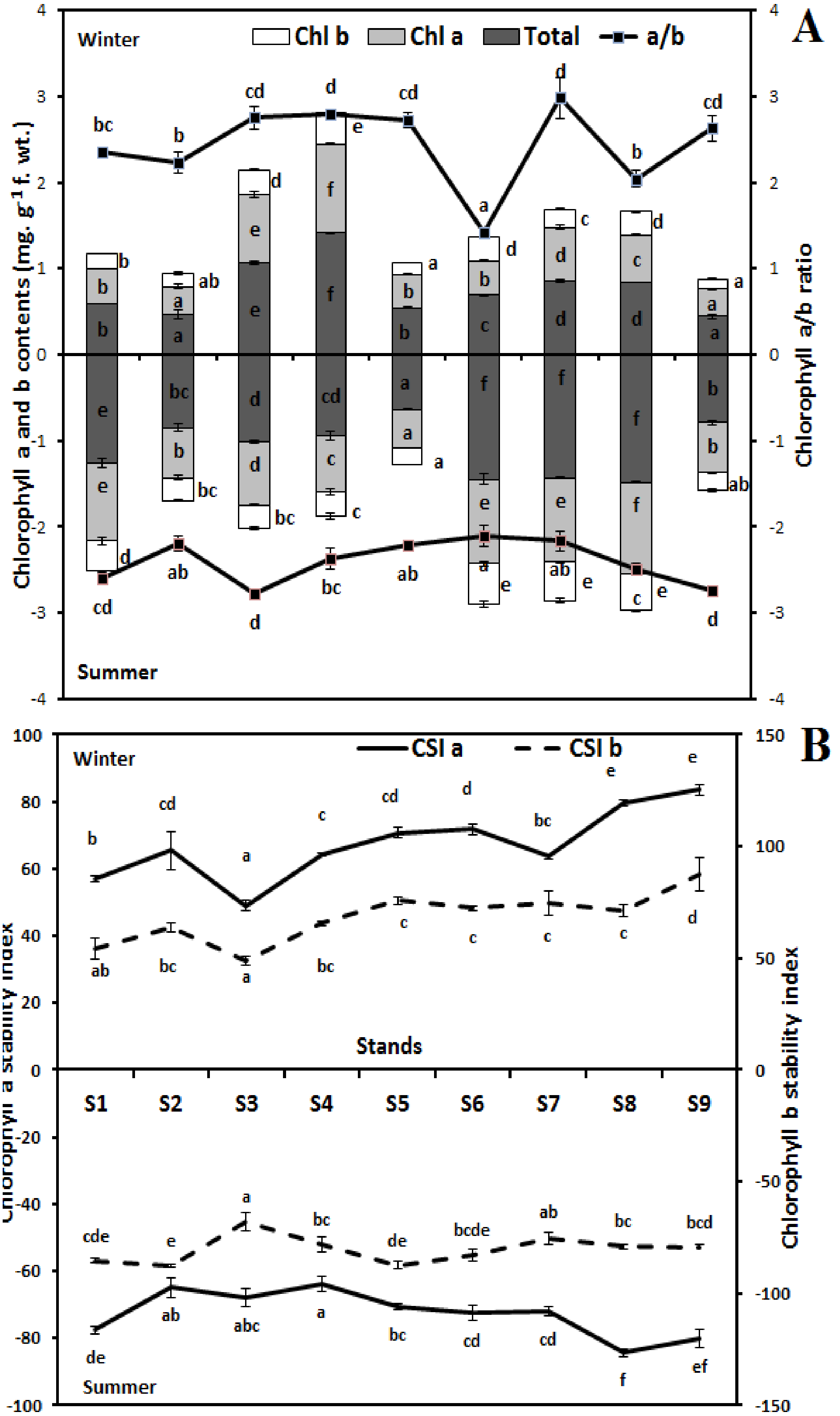

Figure 2: (A) chlorophyll a (Chl. a), chlorophyll b (Chl. b) contents (mg.g^{-1} leaf f.wt.), total Chl. (a+b) and Chl. a/b ratio and (B) Chlorophyll a and b stability index for both seasons at different stands inhabited by *C. colocynthis* in W. Qena. Values are means ± SE. Values with different letters are significantly different ($p < 0.05$) according to Duncan test.

Table 1: Statistical analysis of *C. colocynthis* water content, chlorophyll, inorganic components and organic components, showing analysis of variance (F-value) and determination coefficient (η^2).

Parameters	S.O.V	F	η^2
WC	Se	18.742**	0.088
	St	15.459**	0.582
	Se × St	8.768**	0.330
Chl. A	Se	568.607**	0.219
	St	140.87**	0.433
	Se × St	113.208**	0.348
Chl. B	Se	214.042**	0.245
	St	57.069**	0.520
	Se × St	25.696**	0.234
Chl. a+b	Se	510.351**	0.235
	St	122.53**	0.451
	Se × St	85.536**	0.315
Chl. a/b	Se	0.395	0.002
	St	17.451**	0.619
	Se × St	10.673**	0.379
CSI a	Se	29.296**	0.094
	St	26.94**	0.690
	Se × St	8.454**	0.216
CSI b	Se	66.186**	0.319
	St	10.764**	0.415
	Se × St	6.878**	0.265
SS	Se	16.861**	0.209
	St	4.862**	0.482
	Se × St	3.119**	0.309
SP	Se	19.121**	0.058
	St	25.666**	0.620
	Se × St	13.308**	0.322
TFAA	Se	62.645**	0.078
	St	62.773**	0.629
	Se × St	29.213**	0.293
Na^+	Se	3.604	0.004
	St	65.469**	0.574
	Se × St	48.097**	0.422
K^+	Se	265.926**	0.182
	St	119.613**	0.656
	Se × St	29.432**	0.161
Ca^{2+}	Se	315.375**	0.236
	St	103.073**	0.617
	Se × St	24.469**	0.147
Mg^{2+}	Se	73.809**	0.101
	St	62.781**	0.686
	Se × St	19.483**	0.213
Cl^-	Se	48.091**	0.018
	St	257.886**	0.791
	Se × St	62.102**	0.190
SO_4^{2-}	Se	9.247**	0.019
	St	15.556**	0.252
	Se × St	44.973**	0.729
PO_4^{3-}	Se	24.5**	0.029
	St	53.431**	0.507
	Se × St	48.875**	0.464

**Significant at 0.01 confidence level.

*Significant at 0.05 confidence level

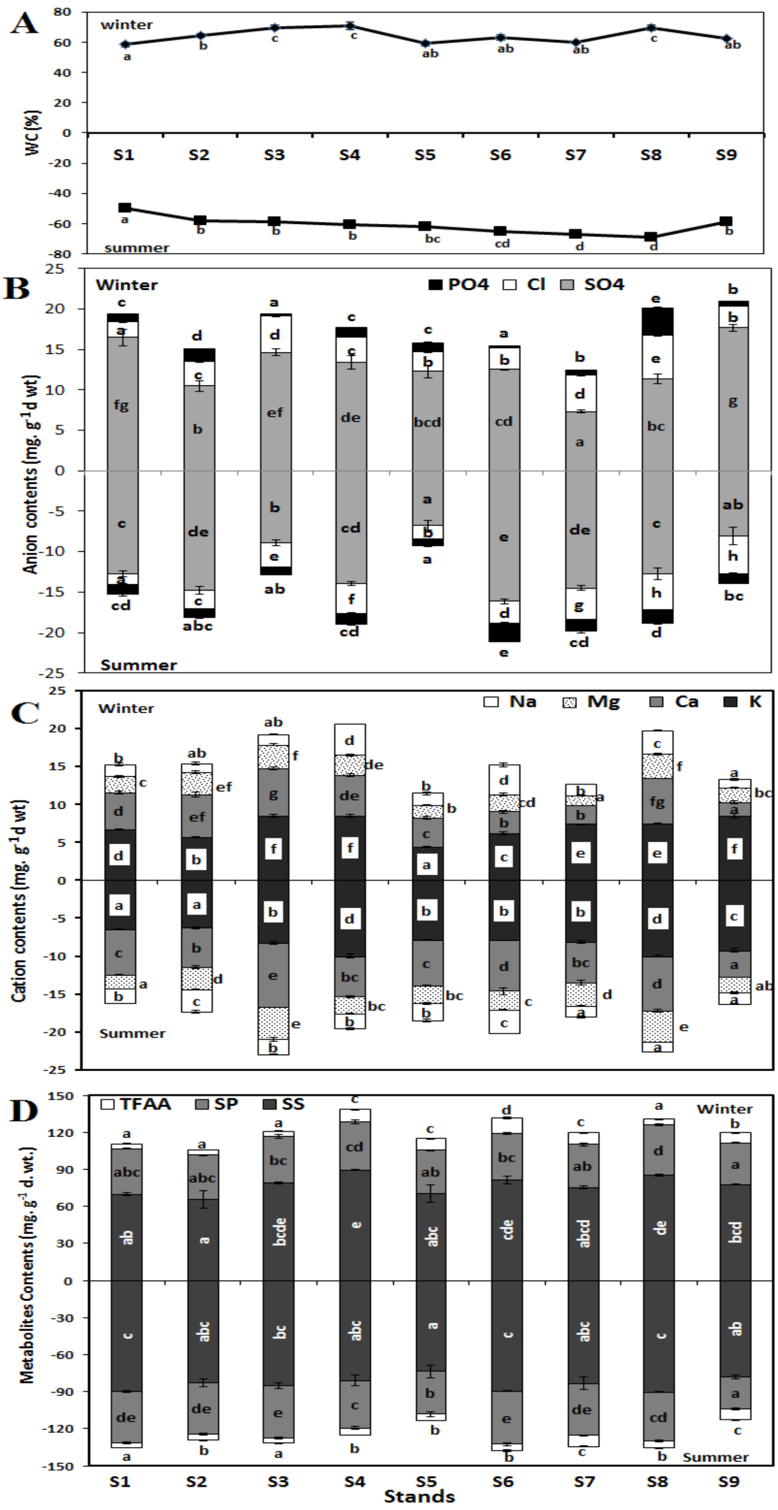

Figure 3: (A) Water content (%), soluble cell inclusions (B) anions, (C) cations and (D) metabolites of *C. colocynthis* shoots collected from east tributaries of W. Qena during both seasons. Values are means ± SE. Values with different letters are significantly different ($p < 0.05$) according to Duncan test.

Metabolic components

The contents of some soluble metabolic fractions (soluble sugars (SS), soluble proteins (SP) and total free amino acids (TFAA) in the studied plants were illustrated in Fig. (3D). In comparison with the different estimated metabolites, concentrations of soluble sugars were generally the highest value of the investigated plants while total free amino acids contents were the lowest fraction. Generally, all of the determined major metabolites were significantly increased or decreased depending upon the distribution during winter and summer. In The contents of SS and SP in plant extracts during summer season were higher than that during winter in most stands (Fig. 3D). The highest soluble sugars and soluble proteins contents were 90.57 and 43.01 $mg.g^{-1}$ d. wt. at stands 8 and 6 respectively of W. El-Ghuza during summer, while the lowest (65.40 $mg.g^{-1}$ d. wt, 25.68 $mg.g^{-1}$ d. wt., respectively) was at stands 2 and 9 at wadi El-Atrash. Generally, the total free amino acids increased during winter than those of summer in most stands (Fig. 3D), except in stands 2, 8, and 9. Total free amino acids ranged between 3.69 $mg.g^{-1}$ d. wt.(the lowest value) in summer and 12.29 $mg.g^{-1}$ d. wt. (the highest value) in winter at stands 1 and 6 respectively. The season variations, locations and their interaction had highly significant effects on SS, SP and TFAA in *Citrullus colocynthis* plants (Table 1). The role of single factor (St) was the most important and the role of (Se x St) was the least one.

Correlations between plants and soil contents

Notably there were correlations (positive or negative) among of estimated parameters between soils during winter (Table 2A) more than summer (Table 2B). The soil organic matter and clay seem to be non-effective in cytoplasmic contents of *C. colocynthis* in summer and winter. During winter, high correlation between soil and plant exist (Table 2A). High significant positive correlation between Ca and Mg of soil with (Cl, PO_4, Mg, WC and SP of shoots), also Ca had positive correlation with plants Ca), SO_4 of soil with (Cl, Mg, WC and SP of plants). PO_4 of soil with (Ca, Mg, and WC of shoots). TSS with (PO_4, Mg, WC and SP of plant), Na of soil with (SP of shoots), K of soil with (WC, SP, SS, Chl. a , Chl. b and Chl.(a+b) of plant). Cl of soil with (PO_4, SP and SS of plant).WC of soil with (shoot PO_4 and SP). Also there were negative correlation between soil and plant, gravel with (Mg and WC of shoots), pH with (Na, SP and SS of shoots). The plant behavior during summer was estimated in (Table 2B). The most important soil variables for the plant cell inclusions were SO_4 which showed significant positive correlation with shoots (Ca and Mg), Cl showed significant positive correlation with shoots K and Mg and Ca of soil had positive significant with plant Mg, and silt had positive significant on plant Cl. Sand showed negative correlation with plant Cl.

Discussion

The data obtained showed that soil water content of lower tributaries of wadi Qena was very low, and it suffers from severe aridity. Rains fall was rarely, while the presence of ground water near the surface may raise the chance for serving perennials. The soil content of organic matter was low, this may be because high temperature and the very scattered vegetation.

The estimated pH values in the soil extract of different studied stands tended to be slight alkaline. This slight alkalinity may be due to the slight increase in TSS values in most stands. These results were agreed with many authors which described the general characteristics of soils of arid regions and the relationships between soil with climate and vegetation; Zahran and Willis (1992) and El-Khatib (1993). Such studies indicated that the soils of arid lands had a low level of organic matter, alkaline in reaction (pH) at the surface and had low biological activity.

Total soluble salts were relatively high. These may be due to the severe aridity and low moisture content in the desert. Total soluble salts in the soil were affected by the evaporation and precipitation rate. The evaporation process in semi-arid areas causes the ionic enrichment of ground water, leading to increase in salinity. High rates of evaporation lead to salt accumulation in the unsaturated zone, which can be dissolved by infiltrating water (Tizro and Voudouris, 2007). Consequently, TSS of the soil extract of the studied area was also relatively high. This reflects the richness of these habitats with soluble salts.

The soil in the studied stands of *Citrullus colocynthis* plants was varied. Silt and sand represent the highest part among other soil compartments. Silt will increase the water catching capacity of the soil and consequently increases the vegetation density. On the other hand sand structure of the soil affect the soil water content and decreased the mean number of species per stand.

Table 2. Correlation coefficient values (r) between the internal mineral elements in *C. colocynthis* and their contents in the soil samples in the studied stands in both seasons.

		Cl	SO4	PO4	Na	K	Ca	Mg	WC	SP	TFAA	SS	Chl.a	Chl.b	Chl. a+b	Chl. a/b	CSI a	CSI b
A- Plant characters in winter																		
Soil Characters	**Gravels**	-.142-	-.443-	-.242-	-.227-	-.482-	-.421-	**-.821-****	**-.712-***	-.476-	0.359	-.370-	-.115-	-.311-	-.156-	0.374	-.155-	0.165
	Sand	-.457-	0.033	-.299-	0.101	-.549-	0.119	-.216-	-.425-	0.031	0.138	-.278-	-.020-	0.044	0.008	-.113-	-.525-	-.467-
	Silt	0.444	0.123	0.405	-.070-	0.555	0.058	0.418	0.532	0.121	-.294-	0.305	0.012	-.008-	-.007-	0.018	0.511	0.346
	Clay	-.028-	-.010-	-.385-	0.34	0.431	-.101-	0.244	0.401	0.07	0.312	0.323	0.248	0.426	0.299	-.263-	-.060-	-.015-
	OM	0.014	-.074-	0.294	0.139	0.146	0.507	0.605	0.51	0.3	-.314-	0.018	0.207	0.208	0.206	-.066-	-.055-	-.222-
	WC	0.613	-.243-	**.940****	0.307	0.017	0.547	0.597	0.449	**.749***	-.494-	0.272	0.02	0.225	0.072	-.380-	0.294	-.091-
	pH	-.038-	-.433-	-.184-	**-.695-***	-.287-	-.289-	-.365-	-.426-	**-.730-***	-.063-	**-.692-***	-.398-	-.635-	-.476-	0.342	0.001	0.251
	TSS	0.63	-.018-	**.759***	0.514	0.363	0.659	**.667***	**.725***	**.907****	-.393-	0.635	0.482	0.602	0.524	-.152-	0.075	-.271-
	Na	0.171	0.204	0.481	0.613	0.316	0.498	0.391	0.427	**.816****	-.220-	0.568	0.503	0.597	0.547	-.133-	-.093-	-.370-
	K	0.528	0.088	0.483	0.597	0.493	0.653	0.609	**.765***	**.893****	-.258-	**.745***	**.714***	**.790***	**.753***	-.030-	-.165-	-.427-
	Ca	**.739***	-.067-	**.735***	0.389	0.353	**.718***	**.761***	**.787***	**.858****	-.474-	0.566	0.441	0.563	0.479	-.149-	0.029	-.312-
	Mg	**.777***	-.030-	**.757***	0.272	0.444	0.579	**.706***	**.776***	**.723***	-.478-	0.557	0.349	0.426	0.37	-.083-	0.214	-.110-
	Cl	0.576	-.043-	**.758***	0.573	0.414	0.311	0.379	0.598	**.751***	-.132-	**.738***	0.42	0.507	0.455	-.088-	0.395	0.123
	SO_4	**.715***	-.024-	0.438	0.135	0.3	**.731***	**.823****	**.714***	**.678***	-.567-	0.334	0.296	0.458	0.336	-.223-	-.224-	-.516-
	PO_4	0.37	0.169	0.162	0.031	0.558	**.752***	**.827****	**.791***	0.464	-.582-	0.247	0.516	0.462	0.502	0.114	-.419-	-.606-
B- Plant characters in summer																		
Soil Characters	**Gravels**	-.349-	-.101-	-.150-	-.123-	-.288-	-.084-	-.240-	0.126	0.123	0.213	-.307-	0.024	0.15	0.065	-.468-	-.047-	0.173
	Sand	**-.849-****	-.007-	-.023-	0.387	-.498-	0.422	-.280-	-.328-	0.466	-.656-	0.093	0.027	0.083	0.046	-.264-	-.237-	0.296
	Silt	**.788***	-.059-	-.007-	-.368-	0.508	-.306-	0.327	0.226	-.467-	0.461	-.011-	-.046-	-.153-	-.081-	0.402	0.295	-.267-
	Clay	0.311	0.558	0.438	0.446	0.083	-.152-	-.041-	0.065	0.161	0.158	0.193	0.081	0.177	0.113	-.111-	-.435-	-.252-
	OM	0.061	0.418	-.084-	0.297	-.038-	-.209-	0.024	-.184-	0.121	-.157-	0.038	-.240-	-.206-	-.232-	-.065-	-.462-	0.161
	WC	0.271	0.23	0.246	-.280-	0.306	0.361	0.554	0.388	0.219	-.196-	0.529	0.481	0.386	0.457	0.042	0.485	0.028
	pH	-.048-	-.003-	-.377-	0.116	-.483-	-.483-	-.031-	-.019-	-.104-	0.457	-.447-	-.364-	-.224-	-.323-	-.302-	-.284-	0.191
	TSS	0.358	0.107	0.161	-.416-	0.594	0.501	0.545	0.302	0.202	-.285-	0.48	0.436	0.269	0.388	0.284	0.328	-.308-
	Na	0.045	0.222	0.251	-.330-	0.405	0.336	0.038	-.063-	0.244	-.403-	0.523	0.458	0.294	0.411	0.242	0.262	-.101-
	K	0.28	0.095	0.134	-.368-	0.609	0.578	0.456	0.181	0.281	-.366-	0.452	0.405	0.23	0.354	0.343	0.131	-.471-
	Ca	0.38	0.039	0.078	-.360-	0.545	0.594	**.727***	0.348	0.228	-.297-	0.449	0.379	0.214	0.33	0.319	0.272	-.399-
	Mg	0.574	-.047-	0.039	-.480-	0.634	0.404	**.719***	0.395	0.01	-.068-	0.342	0.309	0.132	0.256	0.397	0.379	-.421-
	Cl	0.591	0.096	0.274	-.580-	**.792***	0.173	0.339	0.462	-.074-	0.084	0.325	0.432	0.3	0.395	0.193	0.485	-.243-
	SO4	0.214	-.018-	0.013	-.120-	0.245	**.791***	**.882****	0.222	0.381	-.435-	0.506	0.342	0.18	0.294	0.397	0.137	-.521-
	PO4	0.182	0.107	-.244-	-.010-	0.14	0.31	0.478	-.237-	0.236	-.337-	0.239	-.055-	-.205-	-.104-	0.481	-.336-	-.464-

The estimated ions in the soil were dominated by Ca^{+2}, Cl^- , K^+, Na^+ and SO_4^2 while PO_4^- and Mg^{+2} were less. The high temperature of the desert increase the rate of evaporation which concentrated the soil solution. The present data were agreed with the results obtained by Badri *et al.* (1996).

The plants tend to readjust their internal osmotic pressure to overcome the external stresses as salinity or water deficiency to absorb water, and necessary ions from these water-nutrients poor soil from two eastern tributaries of W. Qena, Upper Egypt, in line with Salama et al. (2012) study on the main trunk of W. Qena.

To overcome the soil water deficiency, the plants cells tend to readjust their osmotic potential to prevent water losses, that can be achieved by two adaptive strategies, the first one by accumulation of inorganic ions from the external, while the second one by synthesis of compatible solutes as soluble proteins, amino acids and soluble sugars acting as osmolytes (Serrano *et al.,* 1999; Du Jinyou *et al.,* 2004; Sunkar, 2010; Sayed *et al.,* 2013 and Salama *et al.,* 2015).

The effect of high temperature in summer and salinity lead to decrease the water content in the studied plants in summer than winter. The transpiration rate increases in summer to avoid the hazard resulted from the high temperatures. Under the effect of high temperatures, plant transpiration continued through cuticle when stomata be closed (Schreiber, 2001). According to Erdei *et al*. (1990) under salinity and drought stress, the plants tend to reduce their internal water potential.

Abd El-Maksoud, (1987) and Morsy *et al*. (2008) reported that desert plants attained higher concentrations of chlorophyll and carotenoids due to their adaptive mechanisms under dry conditions. In this study, the photosynthetic pigments and chlorophyll stability index were greatly increased in the dry-hot summer. Chlorophyll a/b ratio in *C. colocynthis*, always above one at all studied stands. The Chl. a/b ratio ranged between 1.42 and 2.98 According to Quarmby and Allen (1989), the two main essential (Chl. a) and accessory (Chl. b) pigments are normally present in the ratio of about 3:1. The decreased ratio of Chl. a/b in the leaves may be due to an increase in Chl.b relative to Chl. a, or due to degradation of Chl. a.

According to Ito et al. (1996), Chl. b is converted to Chl. a in higher plants as part of a Chl. a, b inter-conversion cycle which permits plants to adapt to changing light condition.

Generally, the chlorophyll stability index of both chlorophyll a and chlorophyll b was significantly higher in summer than that estimated in winter. Chlorophyll b was more stable than Chl a, these results not agreed with Radwan (2007). The chlorophyll stability index didn't decrease beyond 48.7%, this index reflects how plant pigments can tolerate the severe high temperatures. So, it can be considered as a good indicator for desert plants. The high CSI help the plants to withstand stress through better availability of chlorophyll. This leads to increased photosynthetic rate (Madhan Mohan et al., 2000) and more dry matter production (Sivakumar *et al*., 2017).

Under drought and salinity conditions the plants tend to adjust their osmo-regulation to overcome the external conditions. As mentioned above, there are two ways to face the environmental stress. The first is quickly and depends on the on inorganic solutes (Wyn Jones and Pritchard, 1989; Lew, 1996).

Data revealed that SO_4 were higher than the other estimated minerals at all collected stands K^+ accumulated in the shoots of the studied plants by large amount (Badri and Hamed, 2000) may be to avoid Na^+ toxicity, this result agreed with Sayed et al. (2013). Also Ca largely accumulated in *C. colosynthis,* both Ca^{2+} and K^+ have also a large responsibility in this physiological reaction (Mäser *et al.,* 2002). Calcium accumulated are higher than magnesium in all plants. Salama et al., (2012) reported that *Ochradenus baccatus* accumulated considerable amounts of Ca^{2+} and Mg^{2+} under drought stress. Plants accumulate Na^+ in the vacuole or exclude it to avoid the sodium toxicity. According to Wyn Jones (1981), Na^+ and Cl^- are mostly accumulated in the vacuole which leads to increase in vacuole osmotic pressure. On the contrary PO_4 contents were lower than other ions. This is may be due to the rapid incorporation of phosphates in the plant metabolism, or poverty of the soil with phosphates.

The variations in mineral accumulation at different stands indicated the ability of the studied plant to regulate the uptake and accumulation of the elements from the external source according to their adjustment requirements. This means that ions are important in the generation of osmotic potential in the studied xerophytes plants. The second trend depends on the accumulation of organic compatible solutes as soluble sugars, soluble proteins, and amino acids. This process needs long time to synthesize the different organic solutes (Wyn Jones and Pritchard, 1989).

In summer the plants increase their biological activity. So, they accumulate the necessary amounts of organic solutes (SS > SP > TFAA) to maintain the cell turgidity. Thus the studied species are frequently adapted against drought conditions prevailing in their habitats during summer season, by accumulation of considerable amounts of soluble sugars, soluble proteins than in winter when the prevailing ecological conditions may be fairly more favorable for such plants. These results were consistent with what was found by Salama *et al.* (2012) on *Ochradenus baccatus* in Wadi Qena. On the other hand, in winter the biological activity will start again and the accumulated organic solutes will be used (Salama *et al.,* 2015).

The higher accumulation of SS, corresponding higher chlorophyll content, which means the increase in soluble sugars was the results of higher photosynthetic activities. The higher soluble sugars concentration may be an adaptive response which involves adjustment of osmotic potential that facilitates the maintenance of favorable water balance. Soluble proteins contents in the studied plant were higher than the total free amino acids. This may be due to enhancement of incorporation of amino acids into proteins (Huffaker and Peterson, 1974). Protein accumulation may be associated with improved drought tolerance as osmotic adjustment of *C. colocynthis*.

Some inorganic solutes contents inside plants were correlated significantly with their contents in the soil solution. In summer, only Mg correlated positively. In winter, the dependence of plant upon inorganic solutes was increased include Ca and Mg, These correlations reflect the effect of prevailing environmental condition on the own strategy of each species to overcome the external stress.

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