15

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Adaptive Responses of *Aerva javanica* to Severe Aridity in the Egyptian Deserts

Fawzy Salama[(1)#], MonierAbdEl-Ghani[(2)], Noha El-Tayeh[(3)], Ahmed Amro[(1)] and Sara El-Naggar[(3)]

[(1)]Department of Botany & Microbiology, Faculty of Science, Assiut University, Assiut; [(2)]Botany Department, Faculty of Science, Cairo University, Giza, Cairo and [(3)]Botany Department, Faculty of Science, South Valley University, Qena, Egypt.

TWELVE stands of *Aerva javanica* shrubs were visited during the winter and summer seasons of 2015 in two tributaries of WadiQena (Wadi El-Atrash and Wadi El-Ghuza) in the Egyptian Eastern Desert. Soil analysis showed low contents of soil moisture (SMC) and organic matter and slight alkalinity. Chlorophyll contents (Chl. a & b) and their ratio increased significantly during summer season, while their stability index increased during winter. The contents of Ca and K were high during summer, while PO_4 and Na were higher during winter. Soluble sugars and soluble proteins increased during summer while total free amino acids were higher during winter. It can be concluded that there are close relationships between the high K, Ca and Cl contents and the hot-dry conditions prevailed in the summer season, and the accumulation of soluble sugars (SS) and soluble proteins (SP) on the relatively humid-cold season. Statistical correlations showed important positive relations between soil Na and plant water content (PWC), chlorophyll parameters, SS and SP. Fortunately, there was negative relation between soil PO_4 and the contents of Na and Cl in the shoots. Spatial variations were the most important factor that controls *A. javanica* PWC, Na, K, Ca, Cl, PO_4, Chl. a and b, SS and SP. While, Mg, chlorophyll a stability index (CSI a), CSI b and total amino acids (TFAA) were affected by the variation in both spatial and temporal gradients.

Keywords: Drought resistance, Plant-environment relations, Chlorophyll, Carbon and Nitrogen metabolism.

Introduction

Wadi Qena (220km long) is one of the most notable unique features of the Egyptian Eastern Desert. It runs from north to south (the opposite direction to the Nile Valley) and debouches at the city of Qena 600 km south-East of Cairo (Salama et al., 2012).

Aerva javanica (Amaranthaceae) is an erect perennial herb widely distributed in the various parts of the world (Srinivas & Reddy, 2012). It is native to Africa and also found in some Asian countries (Boulos, 1999). As a medicinal plant, it is known as a vital source of to combat a variety of kidney problems, against bladder and kidney stones (Mahmood et al., 2011), also for teeth cleaning, remove acne from the face, and to relief headache pains (Imran et al., 2009).

Desert plants generally follow two main strategies to cope with arid conditions. They tolerate drought through phenological and physiological traits (Evans et al., 1992). Both tolerance and avoidance mechanisms enable the plant to survive drought conditions. Moreover, the frequency and the severity of the drought periods add more burdens on plants (Alpert, 2000 and Otte, 2001). Plants under such conditions regulate their water status using several tactics viz., osmotic adjustment, stomatal aperture, turgor maintenance, root distribution and leaf canopy properties (Rhizopoulou et al., 1997). Leaves developed under drought conditions generally exhibit small cell size, thick cell walls, small vacuoles and higher concentration of osmotica (Crawford, 1989).

Under the subtropical conditions, the prevailing drought together with temperature stress greatly affect the plant functions through the reduction in stomatal conductance (Hester & Mendelssohn, 1989) which is associated with

[#]Corresponding author email: fawzysalama2020@yahoo.com Tel. 01005357087 Fax: 0020882080209
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reduction of water content and the water potentials of both plant tissues and xylem sap (Bradbury, 1990; Shelden & Sinclair, 2000 and Gulzar & Khan, 1998). It was also observed that under water stress, chlorophyll formation was markedly depressed and there is no linear relationship between the water content and chlorophyll, and an inverse relationship between growth and chlorophyll content (William & Sharon, 1981).

Solutes are known to accumulate with water stress and to contribute to osmotic adjustments of non-halophytic mesophytes and xerophytes include inorganic cations, organic acids, carbohydrates and free amino acids (Munns et al.,1983).

In Egypt, *A. javanica* shrubs are commonly found growing in extreme arid habitats, sandy areas, flat plains, degraded and disturbed areas, along road sides and hilly areas. Our field observations revealed that the plants of *A. javanica* remain metabolically active all the year. This activity might indicate that *A. javanica* plants are able to withstand water stress. The aims of this study were to: (1) Identifysome metabolic activities of *A. javanica*, and (2) Assess the role of major edaphic and climatic parameters (particularly temperature and air humidity) that are thought to affect the physiological processes of the species.

Material and Methods

Study area

Twelve stands (Fig. 1) were studied in the eastern tributaries of Wadi Qena (W. Qena). Stands 1-8 were located in W. El-Ghuza and those from 9-12 were in W. El-Atrash (between 26° 50’ and 26° 57’ E and 33° 01’ and 33° 06’ N). The elevationso f these stands ranged from 335 to 394 meters above sea level. The stands were chosen according to the presence of *A. javanica* plants and were visited twice during the winter (in January) and summer (in July) seasons of 2015.

The Eastern desert climate between Qena and Red Sea is subtropical without a rainy season. Torrents may occur between October and March coming westward from the Red Sea Mountains; the last torrent in this area was in 1996 (Kamel, 2003). Available meteorological data of means of some climatic factors in the last six years (2010-2016) showed that temperatures were ranged between 6.45°C in January and 42.26°C in August, while the RH% was ranged between 79.29 % in January and 5.32 % in May. Scanty rainfall in January, March, October and November (0.06, 0.12, 0.023 and 0.024 ml, respectively) were recorded.

Soil sampling and analysis

Three soil samples were collected from the soil supporting *A. javanica* at the root zone level (about 50cm depth) and placed in plastic bags for the physical and chemical analyses. The soil texture was determined using the sieve method; the amount of each fraction (sand, silt and clay) was expressed as percentage of the original weight used (Ryan et al., 1996). Soil moisture content (SMC) of the soil samples was estimated as percentage of oven-dry weight. The percentage of organic matter (OM) was estimated by ignition at 600°C for 3 h. Soil-water extracts (1:5 weight to volume) were prepared for the determination of total soluble salts (TSS), pH and chemical components. Calcium and magnesium determination were carried out by titration against 0.01 N EDTA according to Upadhyay & Sharma (2005), while sodium and potassium were determined using the flame photometer (Williams & Twine, 1960). Available phosphorus (PO_4) was determined colorimetrically according to Watanabe & Olsen (1965). In the meantime, the content of chloride in the dry soil was determined by titration against 0.01 N $AgNO_3$ according to Johnson & Ultrich (1959). Sulphates were determined by the turbidmetric technique as $BaSO_4$ according to Bardesly & Lancaster (1965).

Plant sampling and analysis

Fresh known-weight samples of *A. javanica* leaves (triplicates × 2 seasons) from the median internodes were used for extracting photosynthetic pigments (Chlorophyll a and b) according to Metzner et al. (1965). Chlorophyll stability index (CSI%) determined according to El-Sharkawi & Salama (1977) as ratio of chlorophyll content in heated sample to the fresh sample for chlorophyll a or b and calculated as follows :

$$(CSI)_{a"orb"} = \frac{\text{Content of chlorophyll } _{a"orb"} \text{ in heated sample}}{\text{Content of chlorophyll } _{a"orb"} \text{ in fresh sample}} \times 100$$

Reasonable number of shoot branches (about 20 branches) × triplicates (once for each season), dried at 70°C in known-weight paper bags until reaching a constant dry weight then water content calculated according to Stocker (1929) as [(fresh weight-dry weight)/fresh weight]×100. These oven-dried samples were ground into fine powder, extracted in distilled water for 2 h at 90°C, and assayed for

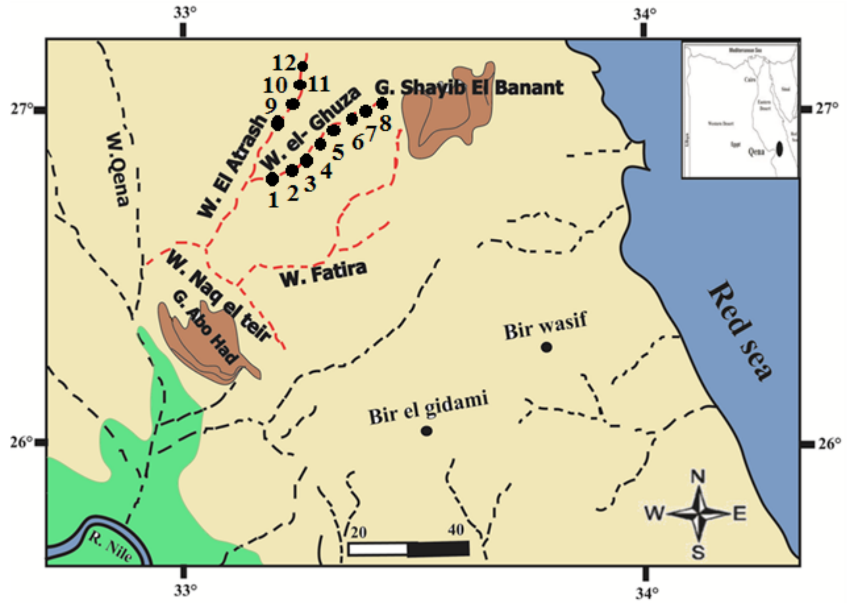

Fig. 1. Location map with the visited 12 stands.

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 colourimetrically according to the procedures described by Lowry et al. (1951), Lee & Takahashi (1966) and Dubois et al. (1956). The content of each determination 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 each single factor, and their interactions on the parameters tested included analysis of variance (F value) and measure of determination (Eta-squared). Eta-squared (η^2)measures of determinations either measure the sizes of associations or the sizes of differences (η^2) for each parameter has been devised as a ratio between Σ of squares to the total Σ of squares in order to evaluate the relative effect of each single factor and interaction,which contributes to the total response. SPSS version 20 was used for all these tests.

Results

Soil analysis

The soil mechanical analysis (Fig. 2A) revealed the predominance of sand and silt among the other soil-particle components. Sand percentages varied between stands and ranged from 0.9% in stand 12 to 54.7% in stand 6, while silt ranged between 26.14% in stand 7 to 77.50% in stand 12. On the other hand, gravel and clay yielded the lowest percentages, yet clay did not exceed 21.61% (stand 12). Also, there were no fractions of gravelin stand 12, whileits highest contents(19.2%) were recorded in stand 3.

Most of the investigated stands (2, 3, 4, 7, 8, 9 and 10) had remarkable low contents of cations (0.8 $mg.g^{-1}$ dry soil; Fig. 2B). The comparison of the measured soluble cations showed a notable receding of Mg within the others and the predominance of Na and K. The contents of sodium were significantly high in stands 1 and 5 at W. El-Ghuza and 11 and 12 at W. El-Atrash, while the highest value was recorded in stand 11 (0.42 $mg.g^{-1}$ dry soil). However, the lowest Na content was recorded in stand 2 of W. El-Ghuza. The contents of potassium were significantly high in stands 1, 4, 5, 6 of W. El-Ghuza and 11 and 12 of W. El-Atrash. Calcium and magnesium showed the same behavior of potassium in most stands.The highest values of both Ca and Mg were in stands 5, 6 and 11.

The soils seemed to be very poor in PO_4 (0.01-0.04 mg.g^{-1} dry soil), but showed notably highcontents of Cl and SO_4 (Fig. 2C). The contents of chloride were not significantly different among the different stands. An exception was observed in stand 11 of W. El-Atrash, where the chloride content was 0.61 mg.g^{-1} dry soil. There were wide variations between the different stands regarding their contents of sulphate, which showed the highest values in stands 1 and 9 (ranged between 0.42 and 0.77 mg.g^{-1} dry soil, respectively).

The results of pH (Fig. 2D) showed that, the soil solution was alkaline and ranged between 8.02 and 9.48. The soil of W. El-Ghuza (stands 3, 5, 7 and 8) showed the highest significant alkalinity (pH = 9.12-9.48).

Soil water content (SMC) of soil samples in the stands inhabited by *A. javanica* plants (Fig. 2E) showed that SMC of the soil samples were approximately similar and ranged between 0.06-0.14%, while there were two extremes in stands 7 at W. El-Ghuza (0.4%) and in stand 12 (0.26%; the maximum) at W. El-Atrash. Organic matter (Fig. 2E) was normally distributed between 0.85-1.47%, while there were two extremes in stands 11 and 12 where it reached to 2.32 and 2.6%, respectively at W. El-Atrash.

Total soluble salts were significantly varied among the stands (Fig. 2E). They were significantly high in stands 1, 5, 6, and 11 (2.7%, 4.5%, 4% and 6%, respectively). This trend was reversed in stands 7, 8, 9, and 10 (0.8-1.2%).

Plant analysis

The size measurement of determination (η^2) of single season (Se) and stand (St) as well as their interaction (Se × St) significantly affected PWC in *A. javanica* shoots (Table 1). The role of location differences (St) was the most important on PWC,while Se × St interaction showed the least effect on PWC.

Photosynthetic pigments

During summer, the contents of chlorophyll a and b were higher than in winter in plants inhabiting all the study area. An exception was observed in plants of the stands 3 and 5 in W. El-Ghuza which showed the reverse trend in case of Chl. b. The highest contents of Chl. a and Chl.b (1.10 and 0 .89 mg.g^{-1} lf. f.wt, respectively) were recorded in plants of the stand 6 of W. El-Ghuza (Fig. 3A). Chlorophyll a and chlorophyll b contents attained their lowest values in the leaves of *A. javanica* in stands 2 and 3, respectively. Consequently, the summation of the two green pigments (Chl. a and b) showed the same behavior with maximum content in plant leaves of stand 6 (1.98 mg.g^{-1} lf. f. wt.).

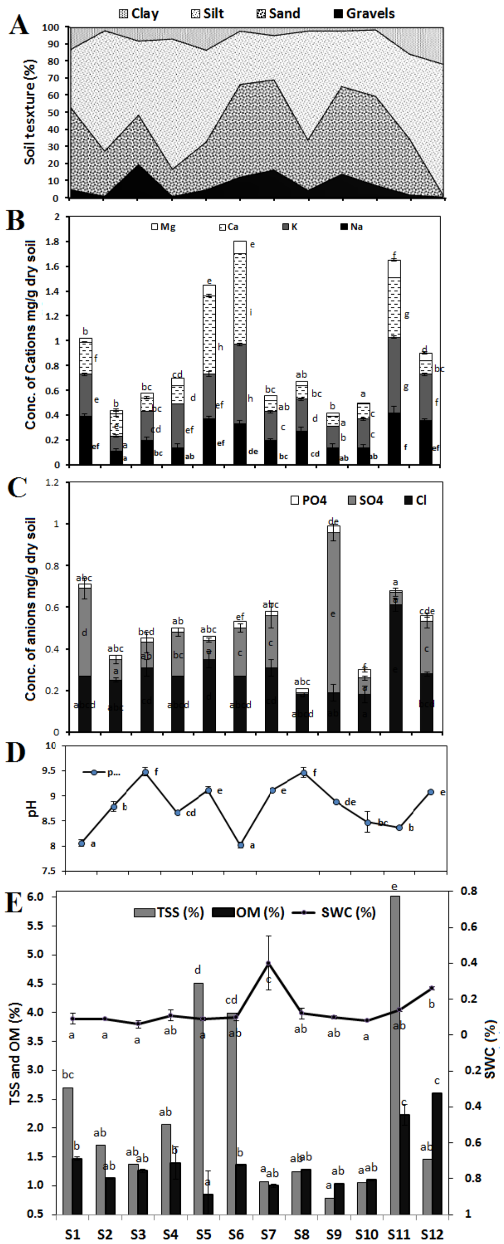

Fig. 2. Soil characters; A: Soil fractions (%), B: Soluble cations (mg.g^{-1}d.wt.), C: Soluble anions (mg.g^{-1}d.wt.), D: Soil reactions (pH) and E: Water content (SWC%), organic matter (OM%) and TSS (mg.L^{-1}) in soils sampled from *A. javanica* stands at lower tributaries of W. Qena. Values are means ± SE. values with different letters are significantly different ($p < 0.05$) according to Duncan test.

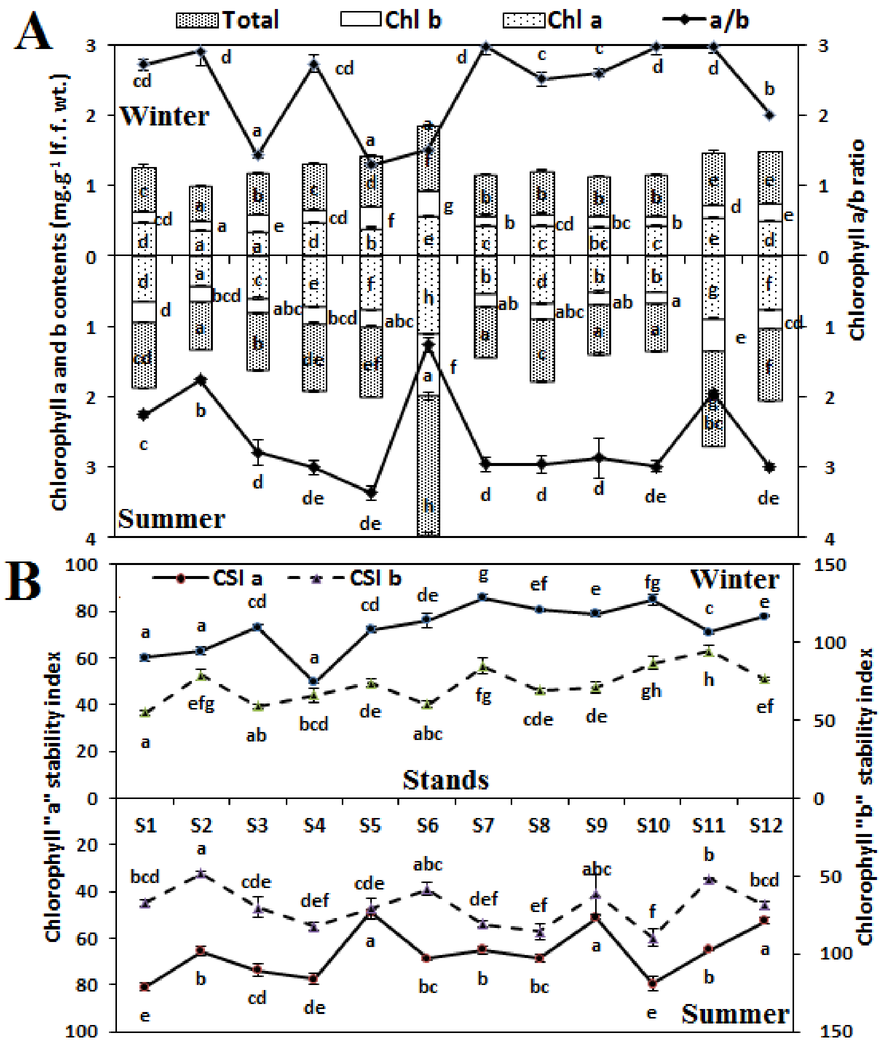

Fig. 3. (A) Chlorophyll a (Chl. a), chlorophyll b (Chl. b) contents (mg.g^{-1} leaf f.wt.), total Chl. (a+b) and Chl. a/b ratio and (B) Chlorophyll a and b stability index for both seasons at different stands inhabited by *A. javanicain* W. Qena. Values are means ± SE. Values with different letters are significantly different ($p < 0.05$) according to Duncan test.

Plant water content

During winter months, the plant water contents (PWC) of the shoots of *A. javanica* was higher than that during summer (Fig. 4A). During winter, PWC was significantly high in stands of W. El-Ghuza over the other wadi. Meanwhile during summer; the maximum PWC was 59.22% in stand 6 and the minimum was 30.05 % in stand 2.

The ratio of Chl. a/b revealed a significant increase during summer than winter, except in stands 1, 2, 6, 7 and 11. It ranged between 1.26 and 3.36 in stands 6 and 5, respectively at W. El-Ghuza.

The chlorophyll stability index of chlorophyll a (CSI a%) and the chlorophyll stability index of chlorophyll b (CSI b%) were higher in winter than summer in most stands (Fig. 3B). The CSI was significantly high during winter in plant leaves of stands 4-10 (85.81% in stand 10). Also, CSI b was highin plant leaves of stands 10 and 11 (86.90 and 94.59%, respectively) of W. El-Atrash.During summer, the maximum value of CSI a was 80.82% in plants of stand 1, where the minimum value was 48.75% in plants of stand 5. Also, CSI b showed significant high percentagesin plants of stand 10 (89.54%).

Table 1 revealed the high effect of stands (St) differences on Chl. a, Chl. b and Chl. (a + b) while the interaction between the two factors, stands (St) and seasons (Se) was the predominant key factor that control the differences in Chl. a/b ratio, CSI for Chl. a and b.

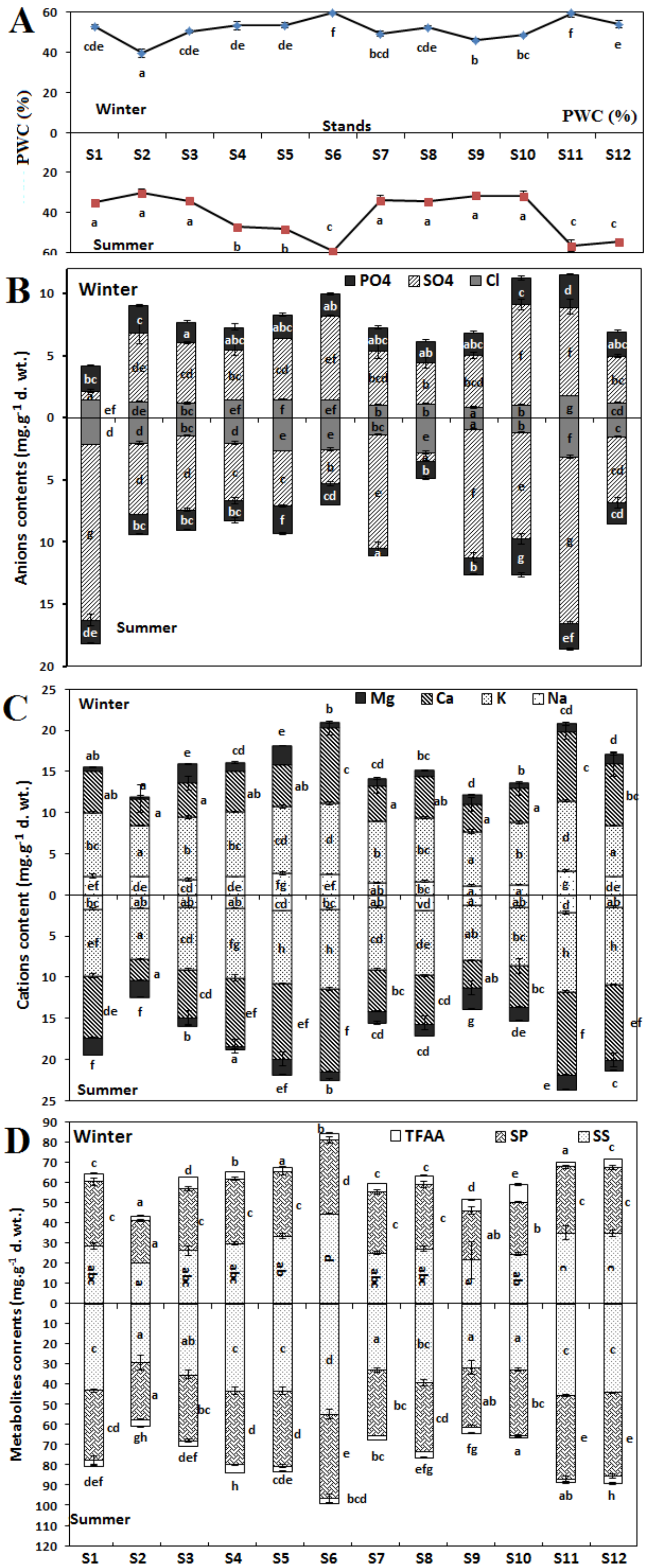

Fig. 4. (A) Plant water content (PWC%), soluble cell inclusions (B) anions, (C) cations and (D) metabolites of *A. javanica* shoots collected from east tributaries of W. Qena during both seasons. Values are means ± SE. Values with different letters are significantly different ($p < 0.05$) according to Duncan test.

TABLE 1. Statistical analysis of plant water content, inorganic components (anions and cations), chlorophyll and organic components of *A. javanica.*, showing analysis of variance (F-value) and determination coefficient (η^2). Se = season, St = stand.

	S.O.V	F	η^2
	Se	262.871**	0.269
WC	St	54.133**	0.61
	Se × St	10.736**	0.121
	Se	3066.946**	0.423
Chl. a	St	284.743**	0.432
	Se × St	95.545**	0.145
	Se	249.403**	0.091
Chl. b	St	162.558**	0.653
	Se × St	63.848**	0.256
	Se	2716.13**	0.271
Chl. a+b	St	508.603**	0.559
	Se × St	154.959**	0.17
	Se	22.195**	0.029
Chl. a/b	St	32.02**	0.459
	Se × St	35.734**	0.512
	Se	85.413**	0.087
CSI a	St	27.576**	0.311
	Se × St	53.443**	0.602
	Se	3.302	0.018
CSI b	St	7.892**	0.473
	Se × St	8.508**	0.509
	Se	95.064**	0.361
SS	St	15.009**	0.627
	Se × St	0.299	0.012
	Se	117.751**	0.262
SP	St	28.036**	0.686
	Se × St	2.153*	0.053
	Se	308.946**	0.215
TFAA	St	37.948**	0.291
	Se × St	64.559**	0.494
	Se	88.171**	0.202
Na^+	St	24.112**	0.607
	Se × St	7.628**	0.192
	Se	84.926**	0.094
K^+	St	57.722**	0.703
	Se × St	16.702**	0.203
	Se	23.211**	0.1
Ca^{2+}	St	17.163**	0.817
	Se × St	1.737	0.083
	Se	165.375**	0.157
Mg^{2+}	St	33.739**	0.353
	Se × St	46.92**	0.49
	Se	696.591**	0.321
Cl^-	St	100.963**	0.511
	Se × St	33.239**	0.168
	Se	218.658**	0.123
SO_4^{2-}	St	65.969**	0.407
	Se × St	76.161**	0.47
	Se	33.816**	0.083
PO_4^{3-}	St	23.393**	0.635
	Se × St	10.39**	0.282

**Significant at 0.01 confidence level.

*Significant at 0.05 confidenc elevel.

Ionic composition of the plant cells

Generally, the determined nutrients (cations and anions) were significantly increased or decreased depending upon the distribution during winter and summer. Figure 3B and 3C illustrated the predominance of K, Ca and SO_4 as the major accumulated nutrients in shoot of the investigated plants. The lowest contents of elements were Mg and PO_4. In the shoots the trend was K > Ca > SO_4> Na = Cl > PO_4> Mg.

During summer, the contents of chlorides, sulphates, potassium, calcium and magnesium in *A. javanica* shoots were higher than in winter in most plants growing stands (Fig. 4B and 4C). On the contrary, in winter season, the contents of both sodium and phosphates were higher than those in summer.

During hot-dry season, Cl and Na were significantly highin stand 11 of W. El-Atrash, while the significant high value of SO_4 was recorded in plants of stands 1 and 11. Also, the maximum value of PO_4 was recordedin plants of stand 10. Potassium was statistically the highest in stands 5, 6, 10 and 11 whereas the highest contents of Ca were recorded in plants of stands 6 and 11. The content of Mg was the highest in plants of stand 9, while the lowest values of Na and Cl were recorded in stand 9. Meanwhile, K, Mg and Ca were significantly low in plants of stand 2, and the minimum values of SO_4 and PO_4 were in stands 8 and 7, respectively.

The effects of single factors and their interaction on Cl, SO_4, PO_4, Na, K, Ca and Mg contents in *A. Javanica* shrub were statistically significant (Table 1). The role of St × Se was the most important factor in the case of Mg and SO_4 while the difference in locations (St) was the highest for Cl, PO_4, Na, K and Ca.

Metabolic components

The contents of soluble sugars (SS), soluble proteins (SP) and total free amino acids (TFAA) were illustrated in Fig. 3D. In comparison with the different estimated metabolites, contents of soluble sugars were generally the highest values, while total free amino acids contents were the lowest cell metabolic component.

Generally, all of the determined metabolites were significantly differed depending upon the distribution of *A. javanica* plants in the stands investigated during winter and summer. Notably, plant shoots of stands 5 and 6 (W. El-Ghuza), 11 and 12 (W. El-Atrash) had significant high means for most of the measured metabolites.

Soluble sugars (SS) and soluble proteins (SP) contents in plant extracts during summer season were higher than that during winter (Fig. 4D). The highest SS and SP contents were 54.77 and 41.93 $mg.g^{-1}$ d. wt, respectively in the shoots of plants growing in stand 6 of W. El-Ghuza, while the lowest contents (20.25 $mg.g^{-1}$ d. wt, 21.06 $mg.g^{-1}$ d. wt., respectively) were in plants growing in stand 2 and of the same wadi.

Total free amino acids were higher during winter than in summer (Fig. 4D), except in stands 2, 4, and 5. Total free amino acids ranged between 1.11 $mg.g^{-1}$ d. wt. in summer and 8.82 $mg.g^{-1}$ d. wt. the shoots of plants growing in stand 10 in winter.

The majority of variations due to seasons, locations and their interaction had highly significant effects on SS, SP and TFAA in *A. javanica* shoots (Table 1). On the contrary, the sizes of the effects of the interactions of Se × St were very small in the case of the SS and SP (Table 1). The role of single factor (St) was dominant in case of SS (η^2 = 0.627) and SP (η^2 = 0.686) in corporation to the interaction of Se × St in this case, for TFAA, the reverse holds true.

Correlations between plant and soil contents

Interpretation of all possible correlations between the estimated parameters analyzed in the shoot tissues of *Aerva javanica* and the characters of its supporting soil in the 12 stands during winter and summer were shown in Table 2. Notably, almost the same trend was observed in both seasons. Some concentrations of mineral ions and metabolites in the plant tissues were significantly (positively or negatively) correlated, with the soil gradients. Generally, *A. javanica* shoots responded to most of the soil chemical properties. The soil organic matter content was the most important factor which possibly affected the contents of calcium and chlorophyll a in *A. javanica* leaves. The cations of Na, K, and Ca, and the anion Cl in the soil appeared to affect the majority of the plant traits analyzed (Table 2). Moreover, during winter season, the sulphate content of the soil appeared to exert no effect on the plant traits analyzed, whereas the effects due to PO_4 were only significant in

TABLE 2. Correlation coefficient values (r) between the internal mineral elements in *Aerva javanica* and their contents in the soil samples in the studied stands in both winter (A) and summer (B) seasons.

		Cl	SO_4	PO_4	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 (During winter)																
Soil characters	Gravels	-.523	0.084	-.548	-.492	0.105	-.232	0.346	-.096	0.001	0.4	-.144	-.332	0.144	-.088	-.291	0.486	-.261
	Sand	-.280	0.195	-.032	-.369	0.336	-.133	-.283	-.050	-.112	0.336	-.103	0.024	-.077	-.013	0.206	0.381	-.029
	Silt	0.255	-.110	0.1	0.305	-.343	0.042	-.002	-.087	-.060	-.325	-.003	-.025	-.077	-.081	0.001	-.459	0.087
	Clay	0.526	-.275	0.349	**.582***	-.011	0.451	0.382	0.46	0.447	-.353	0.411	0.337	0.264	0.342	-.234	-.185	0.091
	OM	0.423	-.031	0.435	0.45	-.108	**.671***	-.102	0.488	0.385	-.186	0.452	**.626***	0.119	0.418	0.045	-.087	0.202
	WC	-.180	-.136	-.027	-.172	-.177	0.098	-.057	0.038	0.163	-.108	0.009	0.173	-.147	-.004	0.254	0.399	0.398
	pH	-.451	-.186	-.451	-.368	-.361	-.443	0.554	-.333	-.166	0.089	-.404	**-.655***	-.125	-.451	-.247	0.317	0.049
	TSS	**.893****	0.285	0.537	**.870****	**.679***	**.667***	0.161	**.673***	0.519	**-.632***	**.681***	0.566	0.499	**.649***	-.230	-.255	0.163
	Na	**.653***	-.184	0.314	**.703***	**0.462**	**.721****	0.188	**.762****	**.727****	-.447	**.716****	**.587***	0.524	**.678***	-.341	0.006	-.054
	K	**.738****	0.272	0.293	**.729****	**.705***	**.945****	0.005	**.920****	**.798****	-.406	**.931****	**.880****	**.654***	**.922****	-.282	-.102	-.001
	Ca	**.682***	0.327	0.194	**.735****	**.675***	**.652***	0.151	**.615***	0.538	-.538	**.781****	0.497	**.767****	**.783****	-.497	-.104	-.075
	Mg	**.796****	0.344	0.4	**.812****	**.586***	**.786****	0.245	**.746****	**.611***	**-.649***	**.768****	**.656***	**.580***	**.744****	-.297	-.150	0.222
	Cl	**.771****	0.267	**.641***	**.710****	0.447	0.512	0.267	0.517	0.372	-.549	0.404	0.417	0.174	0.347	0.00	-.163	0.424
	SO_4	-.459	-.397	-.251	-.380	-.350	-.217	-.090	-.197	-.203	0.153	-.20	0.005	-.125	-.086	0.101	-.007	-.298
	PO_4	**-.594***	0.268	-.263	-.566	-.304	-.079	-.191	-.189	-.231	**.731****	-.033	-.024	0.107	0.048	-.085	0.448	-.047
		B. Plant Characters (During summer)																
Soil characters	Gravels	-.493	0.049	-.366	-.465	-.267	-.308	-.019	-.320	-.310	-.311	-.245	-.136	0.029	-.051	0.051	0.038	0.119
	Sand	-.181	0.38	-.003	-.141	-.268	-.279	0.377	-.321	-.286	**-.675***	-.122	-.074	0.242	0.094	-.287	0.257	0.032
	Silt	0.256	-.467	0.065	0.184	0.114	0.133	-.321	0.211	0.152	**.663***	0.049	-.011	-.223	-.128	0.185	-.137	-.001
	Clay	0.243	0.274	0.193	0.312	**.628***	**.646***	-.052	0.55	**.614***	0.197	0.417	0.351	-.028	0.165	0.168	-.312	-.194
	OM	0.223	0.175	0.119	0.232	**.610***	0.548	-.201	**.606***	**.658***	0.228	0.451	0.434	0.234	0.346	-.181	-.102	-.273
	WC	-.212	0.093	**-.597***	-.166	0.124	0.02	-.101	0.083	0.124	-.009	-.082	-.050	-.138	-.100	0.217	-.261	0.194
	pH	-.220	-.457	-.400	-.158	-.302	-.338	-.086	-.339	-.326	0.294	-.467	-.402	**-.608***	-.532	**.662***	-.378	0.339
	TSS	**.795****	0.193	0.365	**.805****	**.717****	**.737****	-.001	**.722****	**.679***	-.338	**.683***	**.721****	**.591***	**.683***	-.428	-.135	-.483
	Na	**.646***	0.185	0.224	**.678***	**.811****	**.798****	0.047	**.664***	**.775****	-.193	**.741****	**.704***	0.444	**.594***	-.189	-.208	-.254
	K	**.652***	0.036	0.241	**.602***	**.921****	**.895****	-.335	**.906****	**.917****	-.270	**.922****	**.956****	**.827****	**.927****	-.482	0.004	-.289
	Ca	**.680***	-.097	0.326	**.609***	**.663***	**.677***	-.043	**.698***	**.628***	-.351	**.742****	**.785****	**.768****	**.809****	-.485	-.191	-.420
	Mg	**.690***	0.049	0.137	**.672***	**.819****	**.789****	-.197	**.873****	**.792****	-.181	**.724****	**.813****	**.634***	**.753****	-.368	-.303	-.475
	Cl	0.543	0.418	0.119	**.638***	0.569	0.555	-.031	0.564	0.533	-.283	0.368	0.447	0.273	0.375	-.256	-.146	-.461
	SO_4	-.541	0.42	-.294	**-.596***	-.240	-.252	0.425	-.196	-.260	0.295	-.139	-.180	-.073	-.122	0.028	-.257	-.192
	PO_4	**-.609***	-.178	0.33	**-.624***	-.211	-.212	0.039	-.142	-.124	-.124	-.126	-.128	0.01	-.059	0.142	0.013	0.333

**Significant at 0.01 confidence level.
*Significant at 0.05 confidence level.

two cases, i.e., in the case of Cl and the TFAA. During the summer season, the PO_4 of the soil significantly affected the Cl content in the plant tissues (the same as in the winter season), as well as sodium. On the other hand, the total free amino acids showed negative significant correlations with soil Mg and TSS. Soil Na, K and Cl showed significant positive correlations with most of the anions and cations analyzed in the plants, except Mg.

Discussion

The present investigation aimed to recognize the effects of variation in locations and seasons on physico-chemical properties of *Aerva javanica* under natural desert conditions. In addition to assess their capacity to absorb water, and mineral nutrients from the poor soil of W. Qena in the Eastern Desert of Egypt. The present investigation revealed that the physico-chemical properties of the soil sampled from the 12 stands in the study area; the soil is silty, alkaline and had low moisture content. This soil alkalinity triggers the availability of the soil minerals to the plants (Abiven et al., 2009). The soil of this study areawas relatively rich in K, Na, Ca, Mg and Cl (W. El-Ghuza> W. El-Atrash), while the reverse hold true with SO_4 and PO_4.

Abd El-Maksoud (1987) and Morsy et al. (2008) reported that desert plants attained high contents of chlorophyll and carotenoids under dry conditions. This agrees with the present study where there was an increase in the contents of the photosynthetic pigments during summer.

The mechanisms that may protect drought tolerant plants from light energy damage as they wilt are rolling, curling, or folding of leaves, xanthophyll metabolism, anthocyanin synthesis and reversible loss of chlorophyll (Alpert, 2000). According to Quarmby & Allen (1989), the two main photosynthetic pigments (Chl. a and b) were normally present in the ratio of about 3:1, while Chl a/b ratio in this study ranged between 1.3 and 3.4. The decreased ratio of the leaves Chl. a/b in stands 1 and 2 during summer and 5 and 6 during winter may be due to an increase in Chl b relative to Chl a, or due to degradation of Chl a. Previous studies demonstrated that in higher plants Chl b is converted to Chl a as part of Chl a and b inter-conversion cycle which permits plants to adapt to changing light conditions (Ito et al., 1996).

This situation was reversed for the chlorophyll stability index (CSI). The chlorophyll “a” and “b” stability index was lower in summer than winter. The present data indicated that chlorophyll b showed more stability than chlorophyll a in summer in response to both higher temperature during summer and the low soil moisture contents. These observations are in agreement with what was found by Radwan (2007). Chlorophyll stability is a function of temperature, and it is found to correlate with drought tolerance. Chlorophyll stability index is a measure of integrity of membrane or heat stability of the pigments under stress conditions (Kaloyereas, 1958). The CSI is a single parameter used to measure frost (or) drought resistance of a plant. Sairam et al. (1996) reported that both drought stress and temperature stress decreased membrane stability, chlorophyll content and chlorophyll stability index. The high chlorophyll stability indices help the plants to withstand stress through better availability of chlorophyll. This leads to increased photosynthetic rate (Mohan et al., 2000) and more dry matter production (Sivakumar et al., 2017). Generally, chlorophyll a and b stability index in this study was higher in winter than that estimated in summer. The present data indicated also that chlorophyll a showed more stability than chlorophyll b in both seasons in response to both higher temperature levels and soil moisture depletion.

Osmoregulation is the easier way to overcome the external biotic and/or abiotic stresses where it depends on the accumulation of inorganic solutes. The absorption, excluding or extraction of the osmo-regulator inorganic ions such as potassium, sodium, calcium, magnesium and chlorides is very helpful for readjusting the osmotic gradient in stressed plants (Kamel, 2008; Sunkar, 2010; Sayed et al., 2013 and Salama et al., 2015). The second way depends on the accumulation of organic compatible solutes as soluble proteins, soluble sugars, and free amino acids. While, this process needs long time to synthesize the different organic solutes (Wyn Jones & Pritchard, 1989). The data of the present study revealed that the above mentioned mechanisms might occur in *Aerva javanica*.

Aerva javanica accumulated high anions contents especially during summer. This ensures a high osmotic pressure to increase the specific heat of cell sap to overcome desert high temperatures. *A. javanica* accumulated more SO_4 in summer than in winter. Plants tend to accumulate more sulfates in dry seasons or habitats to maintain their succulence and they needed for biosynthesis of amino acids that contain a thiol (–SH) group (Salama et al., 2015). Phosphates appeared in low amounts in *A. javanica* may be due to the rapid incorporation of phosphates into plant metabolism, or poverty of phosphates in the soil.

Also, the plants in summer increase their biological activity. So, they accumulate the necessary amounts of organic solutes (SS > SP > TFAA) to maintain the cell turgidity in the live branches. On the other hand, in winter the biological activity will start again and the accumulated organic solutes will be used (Salama et al., 2015). 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 and amino acids than in winter when the prevailing ecological conditions may be fairly more favorable for such plants. These results agreed with what was found by Salama et al. (2012) on *Ochradenus baccatus* in Wadi Qena.

Some of the xerophytic species may adjust osmotically to stress by the contribution of nitrogen metabolites (Rayan & Farghali, 2007). Soluble protein content in the studied plants increased significantly during the dry season. The increase in protein content increases the surface exposed to binding water, as bound water is correlated to drought resistance (Jinyou et al., 2004).

The performance of all possible correlations indicated the importance of organic matter in improving the plant calcium and chlorophyll functioning in the plant cell. The soil cations and anions may stimulate the absorbance of these ions in the plant body and then synthesis of metabolic constituents as carbohydrates, which certainly exert roles in the cell osmoregulation under drought conditions. Such metabolites might serve as energetic materials for plants to persist (i.e., respiratory material) or as raw material for metabolic processes that enable plants to maintain a fair rate of growth during the dry season (El-Sharkawi, 1977). On the other hand, the increase in soil sulfates and phosphates might prevent chlorides absorption, thus they contribute with the plant escaping from salt stress. Also, the internal plant water and cations contents seem to improve the biologically active components (SS, SP and chlorophyll). In this respect, it is worth mentioning the importance of potassium as the key factor for proteins and enzymes biosynthesis (Malvi, 2011). All these relations were revealed in this study from the correlations between the plant and its environment.

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الاستجابات التأقلمية لنباتات ايرفا جافانيكا للجفاف الشديد في الصحاري المصرية

فوزي سلامة[1]، منير عبد الغني[2]، نهي التاية[3]، أحمد عمرو[1] و سارة النجار[3]
[1]قسم النبات والميكروبيولوجي - كلية العلوم - جامعة أسيوط - أسيوط ، [2]قسم النبات والميكروبيولوجي - كلية العلوم - جامعة القاهرة - الجيزه - القاهره و [3]قسم النبات والميكروبيولوجي - كلية العلوم . قنا - جامعة جنوب الوادي - قنا - مصر.

خلال موسمين (الشتاء والصيف، عام 2015) تمت دراسة اثني عشر شجيرة من نبات أرفا جافانيكا النامية في 12 موئلا في رافدين من وادي قنا (وادي الأطرش و وادي الغزاه) في صحراء مصر الشرقية. وأظهرت نتائج تحليل التربة في الموائل المدروسة انخفاض رطوبة التربة ونسبة المواد العضوية، والقلوية ضعيفة. محتويات الكلوروفيل (أ و ب) ونسبة كلوروفيل أ/ب ازدادت في النبات بشكل ملحوظ خلال الصيف كما ارتفعت نسبة ثبات كلوروفيل أو ب للحرارة خلال فصل الشتاء. تراكمت كميات كبيرة من الكالسيوم و البوتاسيوم خلال فصل الصيف، في حين الفوسفات و الصوديوم كانت أعلى خلال فصل الشتاء. وزادت كميات السكريات الذائبة والبروتينات الذائبة خلال الصيف بينما كانت الأحماض الأمينية الكليه الحرة أعلى خلال فصل الشتاء. ويمكن استنتاج أن هناك علاقات وثيقة بين محتويات البوتاسيوم و الكالسيوم و الكلور العالية والظروف الحاره الجافة وتراكم السكريات الذائبة و البروتينات الذائبة نسبيا في موسم الرطوبة البارد. ومع ذلك، قد يكون هذا وثيق الصلة بعملية التمثيل الغذائي لمقاومة الجفاف في هذه النباتات الصحراوية. أظهرت الأرتباطات الإحصائية علاقة ايجابية هامة بين الصوديوم في التربة والمحتوي المائي و الكلوروفيل و السكريات الذائبة و البروتينات الذائبة في النبات كما كانت هناك علاقة سلبية بين الفوسفات في التربة و كلا من الصوديوم و الكلور في النبات. وكان التوزيع المكاني لهذه الشجيرة العامل الأكثر أهمية التي تتحكم في المحتوى المائي ، الصوديوم، البوتاسيوم، الكالسيوم، الكلور، الفوسفات، كلوروفيل أ و كلوروفيل ب و السكريات الذائبة والبروتينات الذائبة. في حين، التفاعل بين كل من العوامل المكانية والزمانية كان الأكثـــر تأثيرا بالنسبة للمغنيسيوم وثبات كل من كلوروفيل أ وب والأحماض الأمينية الكلية الذائبة.