Delta J. Sci. 16 (3) 1992

ECOPHYSIOLOGY OF LYGOS RAETAM IN COASTAL DUNES OF THE WESTERN DESERT OF EGYPT.

BY

Masarrat, M. Migahid

Department of Biology, Faculty of Education,

University of Alexandria, Alexandria, Egypt.

Received: 16 - 12 - 1992

ABSTRACT

Morphological and physiological studies were carried out on Lygos raetam, growing in the coastal dunes in the western Mediterranean desert of Egypt. Water relations, chlorophyll content, chlorophyll stability and accumulation of solutes (sugars, amino acids, proteins and minerals) were determined in the plant shoot system. Results obtained revealed that drought stress and harsh conditions (sea water spray and sand storm) at the coastal dunes led to early abscission of the plant leaves. In summer, the great decrease in water content and relative water content in the shoot system were due to the high transpiration rate. Chloropyll content and stability increased coinciding with the accumulation of dry matter. Osmotic potential decreased in the dry season to - 12.3 bars. This osmoregulation was mainly achieved by the decrease in ionic osmotic potential. The plant accumulated a great amount of Na, Fe+3 and organic solutes specially soluble

Delta J. Sci. 16 (3) 1992

sugars during the dry season. Because malate did not show accumulation at night, it was concluded that such species may not change its photosynthetic pathway under stress conditions.

Key words: Lygos raetam, osmoregulation, osmotic potential, amino acids carbohydrates, chlorophyll.

1. INTRODUCTION

It has been repeatedly realized that plants exhibit marked morphological responses to environmental stress such as water deficit, salt and temperature stress. Many plants respond to and survive transient or long term, seasonal, growth by developing hardiness, both changes might well be accompanied by changes at the ultra-structure of organization (Reid and Wample 1985).

Osmotic adjustment (i.e active lowering of osmotic potential in response to drought) is regarded as a mechanism that significantly contributes to increased drought resistance (Blum and Sullivan 1986). Osmotic adjustment, as defined by Turner and Jones (1980) refers to net accumulation of solutes, causing a lowering of osmotic potential in response to water deficit or salinity. Alternatively, the plant might be capable of osmoregulation by salts and organic solutes accumulation within living cells and thus avoid drought stress, but could still be adversely affected by the salt ions (Flanagan & Jefferies 1988).

The aim of this study is therefore to determine the changes in morphological and physiological characteristics that occur in *Lygos raetam* during winter and summer seasons,

due to changes in levels of drought stress.

Materials and Methods

The study area is characterized by one rainy season, with an annual 168.9 mm. The monthly mean air temperature varies between 13.2 °C in winter and 27.0 °C in summer season. The relative humidity is generally higher in summer than in winter. The plant selected for the present study *(Lygos raetam)* in one of the main perennial growth forms (deciduous shrubs) in the western Mediterranean desert of Egypt and restricted to the coastal dunes.

Transpiration was measured in the field in summer and winter seasons according to rapid weighing method of Stocker (1956). Plant samples (shoot) were collected at random, representing different individuals of species, according to chronological data, covering two seasons (summer and winter) to study the effect of drought stress on the plant. Plant materials were washed by running tap-water, followed by distilled water, then wiped thoroughly and divided into 3 lots, one was used as a fresh material to determine relative water content (RWC), water content, chlorophyll content and chlorophyll stability. The chlorophyll content and chlorophyll stability were calculated according to Metzner et al (1965) and by the modified technique proposed by El-Sharkawi and Salama (1977). The second lot was extracted with cold distilled water to determine the total soluble K, Na and Ca using the flame photometric method, while Mg was assayed using the atomic absorption method (Allen 1974). The total soluble salts were measured in the cold water extract and the values

were changed by Black et al. (1965) equation of ionic osmotic potential (IOP). The total osmotic potential (TOP) of the shoot sap was measured in the water extract by means of an advanced range according to osmometer Model 3 WII, while pH values were assayed by means of electric pH-meter.

The third lot was dried at 60 ℃ in an oven with circulating air, then finally ground. The dry powdered plant samples were extracted with distilled water to determine soluble sugars, proline, amino acids and proteins by methods proposed by Dubis (1956), Bates et al (1973), Ya and Tunekazu (1966) and Bradford (1976) respectively. Polysaccharides were determined in the residue of plant sample after extraction (Naguib 1963).

Seeds of these plants were collected from the field for germination under greenhouse conditions. Before germination, seeds were pretreated in various ways but germination took place only after breaking of the seed coats before sowing in pots. Seeds were grown under greenhouse conditions for 6 months in ED 73 EINHEITS ERDE soil using normal irrigation until they had developed to mature plants. Malate determination was used as an indicator for CAM. Malate was determined in the plants under normal and stress conditions by the UV enzymatic method (Hohorst 1970). This method was applied for unstressed and shock stress plants.

Statistical analysis: Standard deviations were calculated for the data and were represented on the graphs (Snedecor and Cochran 1973).

Delta J. Sci. 16 (3) 1992

RESULTS

Lygos raetam plants growing in the field are characterized by being leafless desert shrubs, or even small trees, with long virgate whiplike branches, and inflated, 1-seeded, and nearly indehiscent legume. The germination of seeds under greenhouse conditions leads to the formation of leaves which fall under stress condition to avoid the stress. Transpiration increases three times in the dry season than in wet season and this leads to a decrease in RWC and water content in the plant with 26% and 51% with respect to wet period (Fig. 1). There are also slight increases in the dry matter content with drought stress. The seasonal variations in chlorophyll contents and chlorophyll stability are represented in figure (2). Chlorophyll a and carotenoid increased slightly with drought stress, but chlorophyll b decreased, and this led to an increase in the chlorophyll a/b ratio during drought. The level of chlorophyll stability in the plant appeared to increase in the dry season up to three times than in winter.

Total osmotic potential (TOP) and ionic osmotic potential (IOP) increased in the dry period by 15% and 28%, but the non-ionic osmotic potential (NIOP) dropped by 38% relative to the value in the wet season (Fig. 3). The data in figure (4) illustrate the changes in the Na, K, Ca, Mg and Fe^{+3} under drought stress. Sodium and iron highly increased greatly during the drought period, by 87% and 50% as compared to wet season. Potassium ion was constant in the two seasons leading to the increase in Na/K ratio in drought period than in wet period, but Ca and Mg were reduced with 49% and 18% respectively in drought season.

Soluble sugars showed greater increase throughout the dry season and the increase was up to three times that of the wet season, but polysaccharides increased slightly (Fig. 5). The other organic soluble solutes (proline, amino acids and proteins) increased slightly (6%, 25% and 25% respectively) throughout the dry period (Fig. 5).

Dark accumulation of malic acid, which is considered as an indicator for CAM, did not occur in this plant. On the other hand, malic acid showed slightly dark accumulation under shock stress, only from 6.94 to 7.09 mg/g plant water content.

DISCUSSION

Lygos raetam was recorded in the coastal dunes by Ayyad (1978) as an evergreen succulent perennial shrubs. In the present study *L. raetam* was observed to produce intire leaves which were not succulent when grown under the greenhouse conditions. So we could conclude that *L. raetam* is a perennial deciduous shrub. Leaves could not be observed on the plant at the field and its branches persist green through wet and dry periods. Leaves may be formed and fall at early stages which is a morphological responses of *L. raetam* to drought stress. Kozlowski (1976) reported that abscission is a response of leaves to severe drought. Also some tropical forest species avoid drought by dropping leaves during the dry season (Wright and Cornejo 1990 a, b). During the dry season the low water content and RWC in *L. raetam* was found to be due to the increase in the rate of transpiration. Kappen et al (1972) showed also that *Artemisia herba alba* in the Negev desert has a very low water content during the dry season. Thomas (1991)

reported that RWC declined significantly only after more than 6 weeks drought, but water content declined gradually during the first 6 weeks of drought. The increase in the transpiration rate and dry matter content indicates that these species can maximize annual carbon gain, during the period when water is severely limiting. This may indicated that *L. raetam* have a high efficiency in surviving with the low value of water content.

It appears that this desert species adapts to drought conditions through the increase in chlorophyll content and chlorophyll stability which leads to the increase in the dry matter content with drought stress.

Like other desert species (Migahid 1989), *L. raetam* acclimates to drought through adjustment in osmotic potential. Osmotic potential is considered an ambiguous ecological indicators (Tyree and Jarvis 1982). Plants that are drought or salt-stressed often accumulate high levels of certain ions and organic compounds, thus lowering their osmotic potential. In *L. raetam* drought can stimulate a remarkably accumulation of soluble Na and Fe^{+3}. It was indicated that K and Na act as osmoregulatory solutes (Morgan 1984, Storey & WynJones 1979). The accumulation of Na in response to drought stress was also reported by many workers (e. g. Flanagan and Jefferies 1988 and Bowman 1988). In the present study soluble carbohydrates accumulation was more on the expense of polysaccharides. In this regard Thomas (1991) found that water soluble carbohydrates increased during drought in water stressed cotton plants. Amino acids, proline and proteins increased slightly with drought which may indicate some involvement in

osmoregulation. Many workers as Boyer & Meyer (1979) and Bowman (1988) reported that the solutes which accumulated during osmotic adjustment in both fully expanded and growing tissues were amino acids and in particular proline.

However, there is an increasing evidence that accumulation of malic acid in CAM is of significance as an adaptational mechanism facilitating photosynthesis in arid environments (e. g. Kluge 1976). Malic acid was not found to be accumulated in the leaves of *L. raetam* during dark period under drought stress which may indicate that this species is not a CAM plant.

ACKNOWLEDGMENT

The author is grateful to prof. Dr. M. S. Taha, Prof. of plant physiology and head of Biology Department, Faculty of Education Alexandria University, for his valuable advising and revising this work.

REFERENCES

Allen, S., Grimshay, H. M., Parkinson, J. A. and Quarmby, C. (1974). Chemical analysis of ecological materials. Blakwell Scientific Publications Osney, Oxford, London, 557 PP.

Ayyad, M. A. (1978). A preliminary assessment of the effect of protection on the vegetation of the Mediterranean desert ecosystem. Taeckholmia 9:85-101.

Bates, L. S., Waldern, R. P. and Teare, I. D. (1973). Rapid determination of free proline for water-stress studies. Plant and Soil 39:203-207.

Black, C. A., Evans, D. D. and Ensminger, L. E. (1965). Methods of Soil Analysis. Agronomy, 9 Amer. Soc. Argon., Inc. Publisher, Madison, Wisconsin, U S A.

Blum, A. and Sullivan, C. Y. (1986). The comparative drought resistance of landraces of sorghum and millet from dry and humid regions. Annals of Botany 57: 835-846.

Bowman, W. D. (1988). Ionic and water relations responses of two populations of a non-halophyte to salinity. Journal of Exp. Bot. 39: 97-105.

Boyer, J. S. and Meyer, R. F. (1979). Osmoregulation in plants during drought. In: Genetic engineering of osmoregulation, (D. W. Rains, R. C. Valentine, A. Hollaender, eds), New York: Plenum. pp 189-202.

Bradford, M. M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle protein-dye binding. Anal. Biochem. 12: 248-254.

Dubois, M., Gillies, K. A., Hamitton, J. K., Rebers, P. A. and Smith, F. (1956). Colorimetric method for determination of sugars and related substances. Anal. Chem. 28: 350-356.

El-Sharkawi, H. M. and Slama, F. M. (1977). Effect of drought and salinity on growth contributing parameters in wheat and barley. Plant and Soil, 46: 423-437.

Flanagan, L. B. and Jefferis, R. L. (1988). Stomatal limitation of photosynthesis and reduced growth of the halophyte *plantago maritima* L., at high salinity. Plant Cell and Environment, 11: 239-245.

Hohorst, H. J. (1970). L-malate bestimming mit malate

dehydrogenase and NAD. In: Methadon der enzymatischen analyses, Vol. II, (H. U. Bergmeyer, ed), Vorlage Chemie, Weinheim, pp 1544-1548.

Kappen, L., Lange, O. L., Schulze, E. D., Evenari, M. and Buschbom, U. (1972). Extreme water stress and photosynthetic activity of the desert plant *Artemisia herba alba* Ass. Oecologia, 10: 177-182.

Kluge, M. (1976). Crassulacean acid metabolism (CAM): CO_2 and water economy. In: Water and Plant Life. Problems and modern approaches Ecol. Stud. 19, (L. O. Lange, L. Kappen, E. D. Schulze, eds.), Springer-Vorlage Berlin Heidelberg New York Tokyo, pp 313-323.

Kozlowski, T. T. (1976). Water supply and leaf shedding. In: Water Deficits and Plant Growth, (T. T, Kozlowski, ed), Academic press, New York, pp 191-231.

Metzner, H., Rauh, H. J. and Senger, H. (1965). Untersuchungen zu Synchronisierbarkeit einzelner Pigmentmangelmutanten von Chlorella. Planta, 65: 186-194.

Migahid, M. M. (1989). A study of drought resistance of plant lifeforms in the Mediterranean desert of Egypt. Ph. D. thesis Fac. Sci., Alexandria Univ. Egypt.

Morgan, J. M. (1984). Osmoregulation and water stress in higher plants. Annual Rev. of Plant Physiol., 35: 299-319.

Naguib, M. I. (1963). Colorimetric estimation of plant polysaccharides. Zucker, 16: 15-18.

Reid D. M. & Wample R. L. 1985. Water relation and plant

hormone. 2. Insufficient water, In: Encyclopedia of Plant Physiology. Vol. 11 (R. P. PHARIS and D. M. REID, eds), Springer-Vorlage Berlin Heidelberg New York Tokyo, pp 514.

Snedecor, G. W. and Cochran, W. G. (1973). Statistical Methods, 6 th Edition, The Iowa State Univ. Press, Ames, Iowa.

Stocker, O. (1956). Messmethoden der transpiration. In: Encyclopedia of Plant Physiology. Vol 3, (W. Ruhland, ed), Springer-Vorlage Berlin Heidelberg New York Tokyo, pp 436.

Storey, R. and Wyn Jones, R. G. (1979). Responses of *Atriplex spongiosa* and *Suaeda monoica* to salinity. Plant Physiol., 63: 156-162.

Thomas, H. (1991). Accumulation and consumption of solutes in swards of *Lolium perenne* during drought and after rewatering, New Phytologist, 118: 35-48.

Turner, N. C. and Jones, M. M. (1980). Turgor maintenance by osmotic adjustment: a review and evolution. In: Adaptation of plant to water and high temperature stress, (N. C. Turner and P. J. Kramer, eds), wiley, New York, pp 87-105.

Tyree, M. T. and Jarvis, P. G. (1982). Water in tissues and cells. In: Encyclopedia of plant physiology. New seires Vol. 12, (B. O. L. Lange, P. S. Nobel, C. B. Osmond, and H. Ziegler, eds) Springer-Vorlage, Berlin, pp 436.

Wright, S. J. and Cornejo, F. H. (1990a). Seasonal drought and leaf fall in a tropical forest. Ecology 71:

1165-1175.

Wright, S. J. and Cornejo, F. H. (1990b). Seasonal drought and the timing of flowering and leaf fall in a Neottropcal forest. In: Reproductive biology of tropical forest plants. Man and the biosphere series, (K. Bawa and M. Hodley, eds), UNESCO, Paris and parthenon publishing, Carnfarth, U. K. pp 49-61.

Ya, P. L. and Tunekazu, T. (1966). An improved colourmeteric determination of amino acids with the use of ninhydrin. Anal. Biochem. 14: 71-7.

Delta J. Sci. 16 (3) 1992

Legends

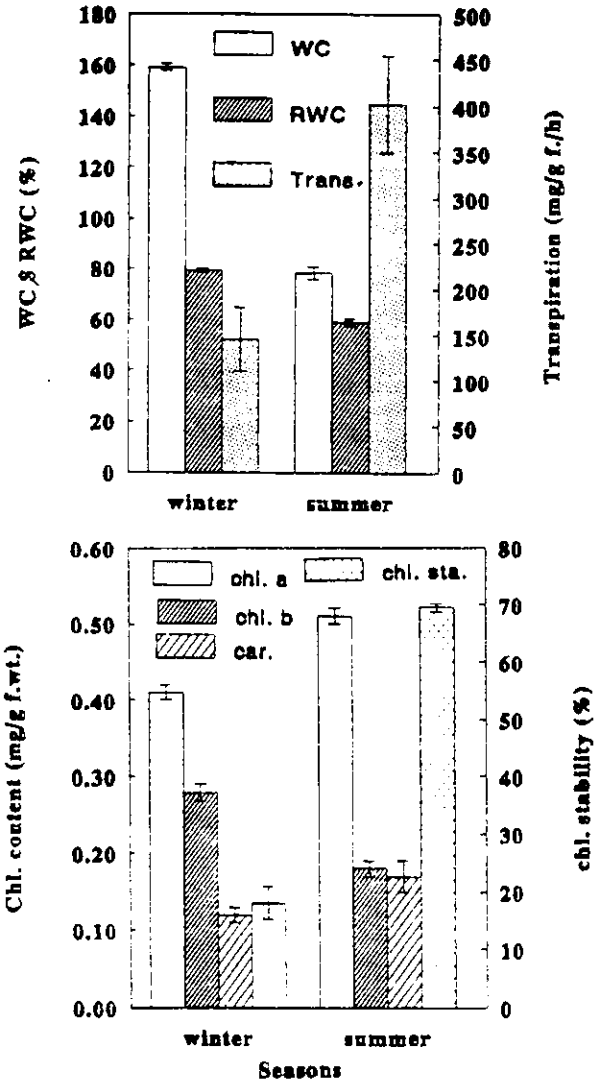
Fig. 1: Variations in the transpiration rate (mg/g F. Wt/h), relative water content (%) and water content (%) in *Lygos raetam* in winter and summer seasons.

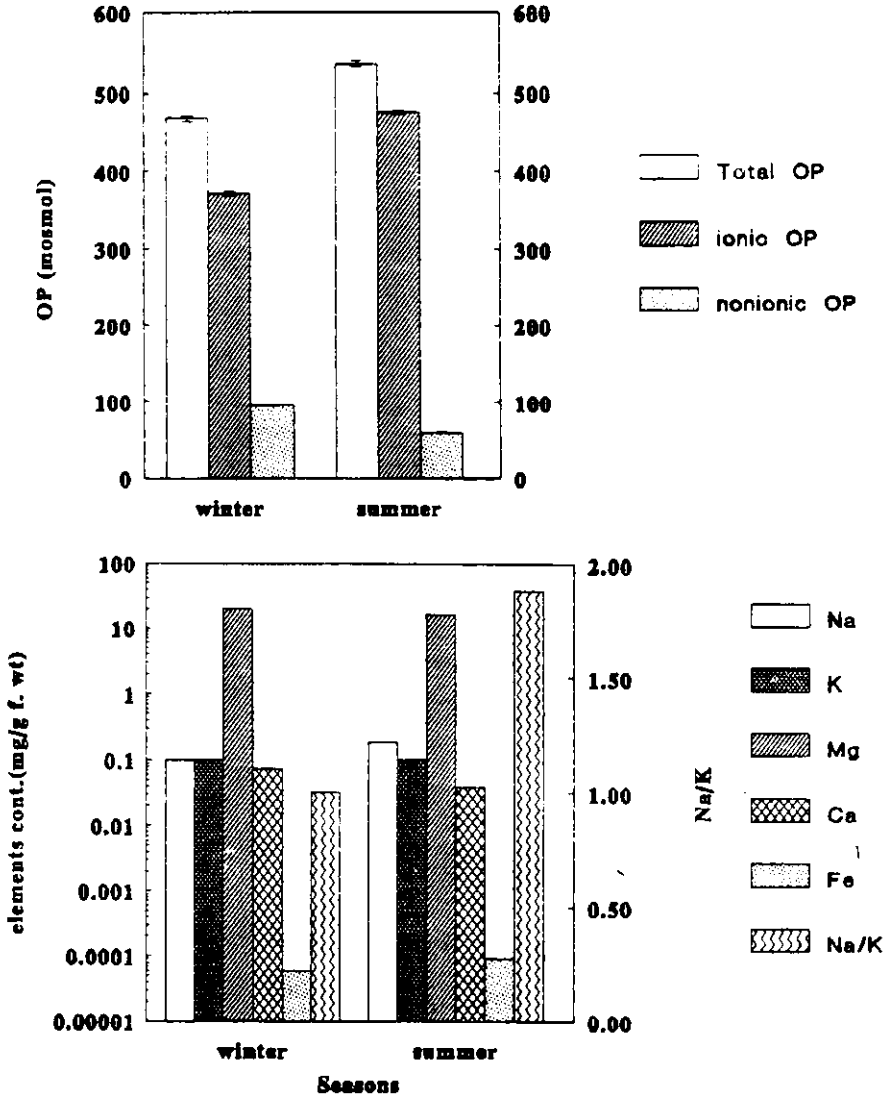
Fig. 2: Variations in chlorophyll content (mg/g F. Wt) and chlorophyll stability (%) in *Lygos raetam* in winter and summer seasons.

Fig. 3: Variations in osmotic potentials (mosmol) in *Lygos raetam* in winter and summer seasons.

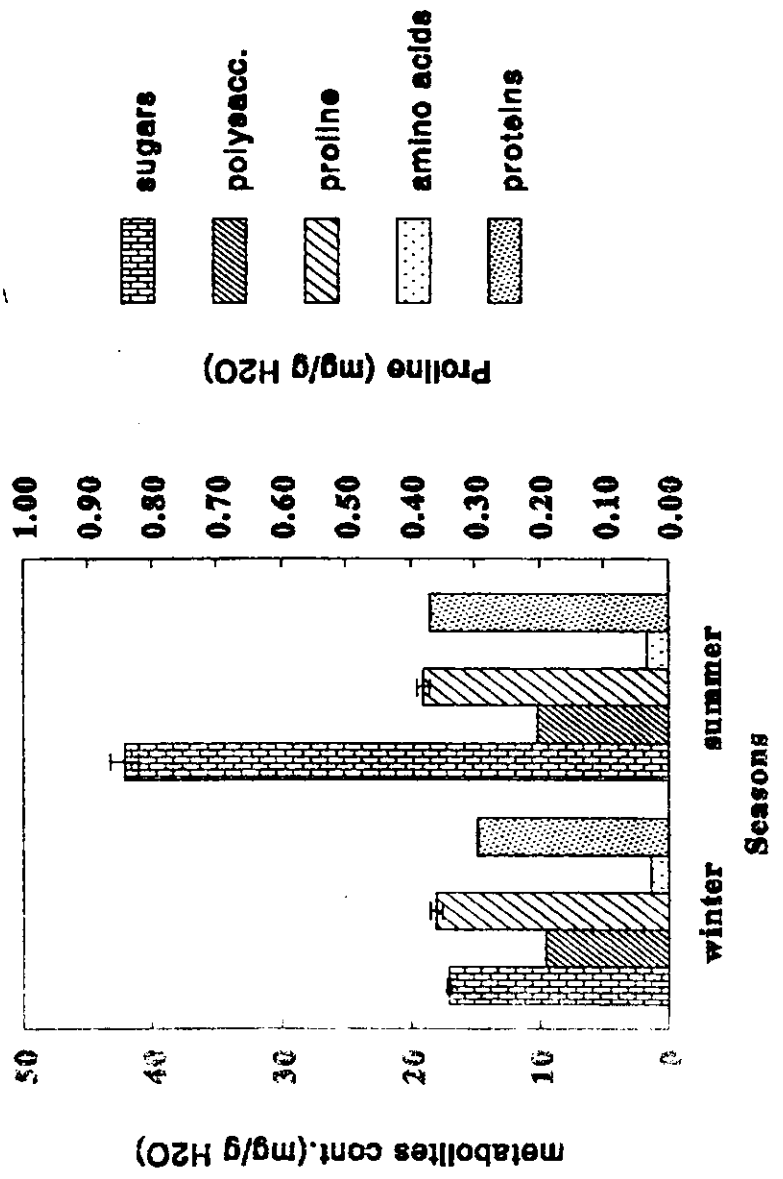
Fig. 4: Variations in the content of Na, K, Ca, Mg, and Fe (mg/g F. Wt) in addition to Na/K ratio in *Lygos raetam* in winter and summer seasons.

Fig. 5: Variations in the content of soluble sugars (mg/g H_2O), polysaccharides (mg/g D. Wt) and nitrogenous compounds (mg/g H_2O) in *Lygos raetam* in winter and summer seasons.


WC
RWC
Trans.
WC & RWC (%)
Transpiration (mg/g f./h)
winter
summer
chl. a
chl. b
car.
chl. sta.
Chl. content (mg/g f.wt.)
chl. stability (%)
Seasons


600
500
400
300
200
100
0
OP (mosmol)
winter
summer
Total OP
ionic OP
nonionic OP
100
10
1
0.1
0.01
0.001
0.0001
0.00001
elements cont.(mg/g f. wt)
2.00
1.50
1.00
0.50
0.00
Na/K
Seasons
Na
K
Mg
Ca
Fe
Na/K

Delta J.Sci. 16(3) 1992



Delta J. Sci. 16 (3) 1992

دراسات بيئية فسيولوجيه على نبات الرتم على الكثبان الرمليه بصحراء الساحل الغربى لمصر

مسرات محمد عبد العزيز مجاهد

قسم البيولوجى - كلية التربيه - جامعة الإسكندرية - مصر

أجريت دراسات للشكل الظاهرى والفسيولوجيا لنبات الرتم النامى على الكثبان الرمليه للساحل الغربى لمصر • وقد أجريت دراسات للعلاقات المائيه والمحتوى الصبغى وثبات صبغات الكلوروفيل تراكم الذائبات مثل السكريات والأحماض الأمينيه والبروتينات والعناصر المعدنيه فى النظام الخضرى للنبات •

وقد أظهرت النتائج أن ظروف الجفاف والأبخره الملحيه والعواصف الرمليه على الكثبان الرمليه تؤدى إلى السقوط المبكر لأوراق النبات فى فصل الصيف كانت الزياده فى عملية النتح تعتبر السبب فى النقص الشديد فى المحتوى المائى النسبى للنبات وكانت الزياده فى الماده الجافه متزامنه مع الزياده فى المحتوى الكلوروفيلى وثبات الكلوروفيل وقد نقص الجهد الإسموزى للنبات فى موسم الجفاف إلى -٣ و ١٢ وكان هذا التعديل الإسموزى ناتج عن النقص فى الجهد الإسموزى الأيونى •

تراكمت كميات كبيرة من عنصر الصوديوم والحديد وكذلك الذائبات العضويه خاصه السكريات الذائبه أثناء موسم الجفاف ولأنه لم يبدو تراكم للمالات فى الليل فقد أمكن إستنتاج أن هذا النبات لايفير من طريقة بناؤه الضوئى تحت ظروف الإجهاد •