Pak. J. Bot., 37(4): 853-858, 2005.

SEASONAL VARIATIONS OF ASH CONTENT OF THE HALOPHYTE *ZYGOPHYLLUM QATARENSE* HADIDI FROM SALINE AND NON-SALINE HABITATS IN BAHRAIN

J. A. ABBAS

Department of Biology, College of Science, University of Bahrain,
P. O.Box 32038, Isa Town, Kingdom of Bahrain
e-mail: jameelab@sci.uob.bh

Abstract

The roots and leaves of the halophytic plant *Zygophyllum qatarense* Hadidi from saline and non-saline habitats in Bahrain island were analysed for their ash content during four seasons: winter, spring, summer and fall. Ash content of leaves was higher than that in the roots from the two habitats. Statistical analyses of the results showed significant seasonal differences in the ash content in both roots and leaves in each of the two habitats. Comparison between the ash content of leaves from the two habitats showed no significant difference between the averages for the leaves in all seasons except in the spring. Root comparisons showed significant differences between the two habitats in all seasons except in the fall. The results demonstrated that the change in soil salinity is reflected, at least in some seasons, in the ash content of *Z. qatarense*. The only significant difference in the ash content between the leaves of the two habitats was during spring. However, the only nonsignificant difference in the ash content between the roots of the two habitats was during the fall.

Introduction

Zygophyllum qatarense is one of the common plant species in the floras and checklists of eastern Arabian Peninsula (Batanouny, 1981; Western, 1989; Mandaville, 1990; Boulos & Al-Dosari, 1994; El-Oqlah & Abbas, 1994). The plant is an ascending, many-branched, highly succulent shrublet to c. 75 cm high, with glabrous to sparsely tomentose foliage (Mandaville, 1990). In Bahrain, *Z. qatarense* was reported to occur in various habitats ranging in salinities from 0.07 mS cm^{-1} to 45.5 mS cm^{-1} (El-Oqlah & Abbas, 1992; Abbas & El-Oqlah, 1996; Abbas, 1998) which reflects a facultative halophyte type (Waisel, 1972). To our knowledge only three studies have dealt with the physiological ecology of this species in Arabia (Batanouny *et al*., 1985; Laurie *et al*., 1994; Abbas, 1995). The present study investigates seasonal variations, if any, in ash content in the roots and leaves of *Z. qatarense* from saline and non-saline habitats, and if there are differences between the ash content of the plant from the two habitats.

Materials and Methods

Study area: Bahrain is an archipelago in the Arabian Gulf 25 km off the eastern Saudi Arabian coast (Fig.1). The climate of Bahrain is characterized by a dry period extending from March to November. Rainfall is rare, scattered and occurs in the period extending from December to February with a maximum monthly value of 17 mm and an annual value of 74 mm (Abbas *et al*., 1991). Bahrain Island (Fig. 1) is divided into five physiographic zones (Doornkamp *et al*., 1980) which are: (i) the Central Plateau and

Jabals; (ii) the interior basin; (iii) the multiple escarpments; (iv) the main backslope; and (v) the coastal lowlands. The study was carried out at two sites: a site representing saline habitat and a site representing a non-saline habitat (Fig. 1). The saline site is located in the Coastal Lowland zone. This zone is composed of a fringe of young, unconsolidated, and superficial deposits laid down by a combination of marine and aeolian processes. The non-saline site is located in the Interior Basin zone. This zone is in the form of asymmetrical ring of lowland surrounding the Central Plateau. Surface form is very variable and includes wind-faceted bedrock surfaces near the Central Plateau, gypcrusted erosion surfaces, marginal sedimentary basins and playa basins (Doornkamp *et al*., 1980).

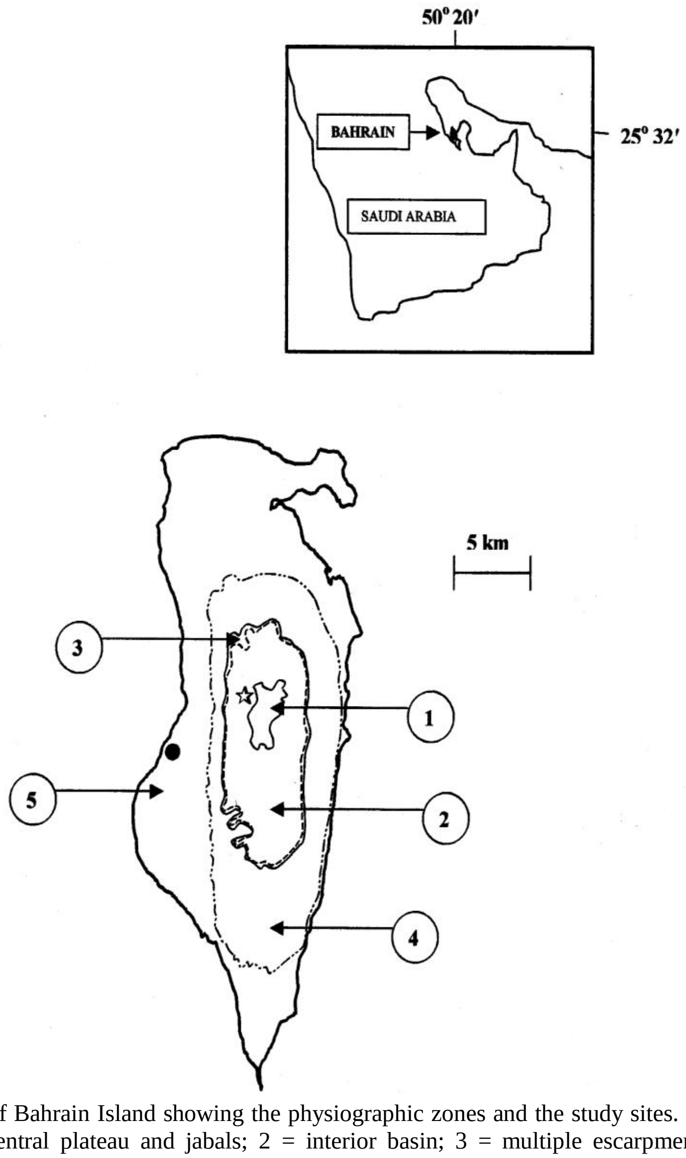

Fig. 1. Map of Bahrain Island showing the physiographic zones and the study sites. Physiographic zones: 1 = central plateau and jabals; 2 = interior basin; 3 = multiple escarpments; 4 = main backslope; 5 = coastal lowlands. Study sites: (●) = saline; (☆) = non-saline.

Table 1. pH, and electrical conductivity (mS cm^{-1}) from saline and non-saline habitats during January, March, June and September.

Soil factor/Month	Saline Saline		Non-saline	
	PH	EC	PH	EC
January	7.83 ± 1.5	4.95 ± 1.1	8.63 ± 0.12	0.6 ± 0.45
March	7.86 ± 0.35	0.52 ± 0.2	7.83 ± 0. 06	0.05 ± 0.03
June	7.66 ± 0.21	11.06 ± 3.42	8.03 ± 0. 06	0.04 ± 0.0
September	6.75 ± 0.17	21.53 ± 9.55	6.92 ± 0. 12	0.83 ± 0.3

Nine plants were collected from each site. Also, rhizosphere soil samples were collected from the top 30 cm of each of the plants. This sampling was carried out in four seasons: winter (January), spring (March), summer (June), and fall (September). After collection, the samples were taken to the laboratory for analysis.

Plant analyses: Plants were cleaned gently with distilled water to remove any sand, salts or debris and dried at room temperature. Succulent leaves were detached carefully from the stem and branches. The leaves were then dried in an oven at 80°C, ground to fine powder and used for analyses. Ash content was determined by ashing roots and leaves to a powder in a furnace at 500 °C until the weight was constant.

Soil analyses: The soil samples were extracted on a shaker for 30 minutes with distilled water (1:5, w:v). The extract, after settlement, was used for the measurement of pH and electrical conductivity (mS cm^{-1}) using a Genway water analyser.

Statistical analyses: The averages of ash content for roots and leaves for the four sampling months of each habitat were compared statistically using the Kruskal-Wallis test. T-test was used for the comparison between average of ash content from the saline and non-saline habitats for the four seasons (Fowler & Cohen, 1992).

Results

Results of the soil analyses showed differences in the salinity level between the saline and non-saline habitats (Table 1). The range of electrical conductivity (mean ± S.D.) for the saline soil was between 0.52 ± 0.2 mS cm^{-1} in March and 21.3 ± 9.55 mS cm^{-1} in September, and the range for the non-saline soil was between 0.04 ± 0 mS cm^{-1} in June and 0.83 ± 0.3 mS cm^{-1} in September. However, the pH range in the two habitats was very close: the range in the saline habitat was from 6.75 ± 0.17 to 7.86 ± 0.35 and the range in the non-saline was from 6.92 ± 0.12 to 8.63 ± 0.12.

Seasonal variations in the mean of ash content in the roots and leaves of *Z. qatarense* during the sampling months are shown in Fig. 2 and Fig. 3, respectively. Root ash content ranged from 6.7% (September) to 9.2% (June) in the saline habitat, and 4% (March) to 7.6% (June) in the non-saline habitat (Fig. 2). Leaf ash content ranged from 23.2% (September) to 28.2% (March) in the saline habitat, and 21.2% (September) to 30.5% (March) in the non-saline habitat (Fig. 3).

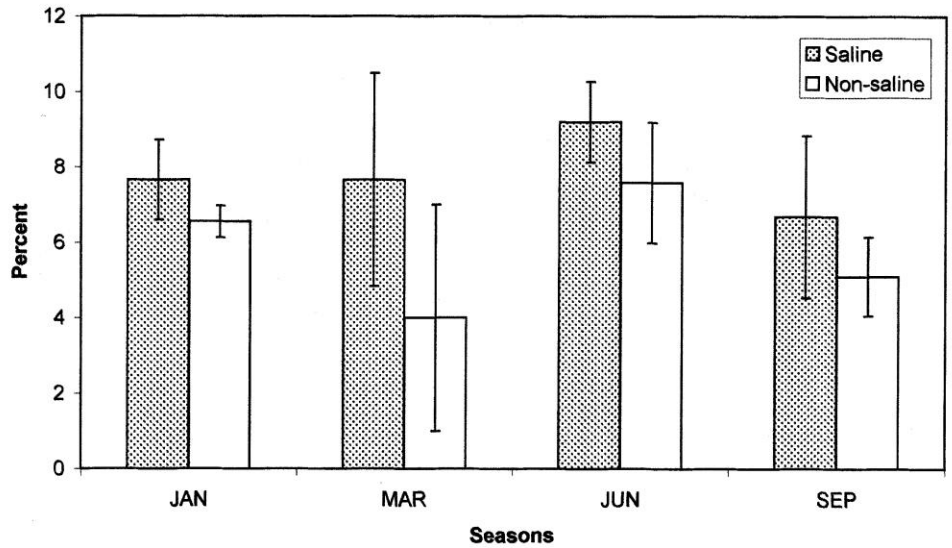

Fig.2. Seasonal variation in the ash content (average +/- SD) of the roots of *Zygophyllum qatarense* from saline and non-saline habitat.

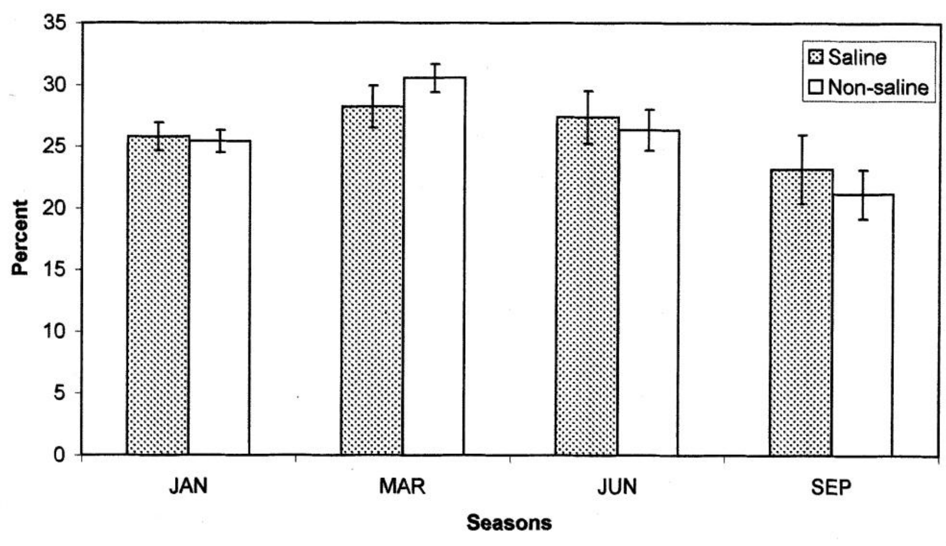

Fig.3. Seasonal variation in the ash content (average +/- SD) of the leaves of *Zygophyllum qatarense* from saline and non-saline habitat.

The K values of the Kruskal-Wallis Test was 7.6 and 13.59 for the roots and leaves from the saline habitat, respectively; and 12.91 and 29.48 for the roots and leaves from the non-saline habitat, respectively. The level of significance at 0.05 is 7.81 and at 0.01 is 11.34. The t-test analysis was used to compare between the ash content of leaves from the two habitats for each season. The results of this test show that there was no significant difference between the averages for the leaves in all seasons except March, with the average ash content reaching 28.22% in the saline and 30.55% in the non-saline habitat. The t-value for this month was 5.72, which was significant at the 0.01 level. However, statistical analysis of roots has shown significant differences between the ash content averages from the two habitats at the 0.05 level in January, March, and June with t-values of 2.96, 2.56 and 2.9, respectively. There was no significant difference in September.

Discussion

Le Houerou (1993) reported that all halophytes have 15-50% salts in the leaf dry matter. In a study on *Atriplex griffithii*, Khan *et al*., (2000) reported induced accumulation of large quantities of ions, with the ash content reaching 39% of the dry weight in leaves with increased treatment of NaCl. A number of studies (Ungar, 1991) have shown that variation in soil salinity content during the year may be reflected in changes in root or shoot ion content at different times during the phenological development of plants. Gul *et al*., (2001) reported that seasonal changes in dry weight are directly related to soil salinity stress and that Na^+ and Cl^- ions were accumulated in plant tissues in much greater amounts than other ions. Proline content of *Z. qatarense* plant increases with drought (Batanouny, 1985). Also, it responds to water stress by developing into unifoliate xeromorphic leaves, and as the dry season progress, the plant tends to reduce its transpiring surface area by means of substantial leaf loss (Sayed, 1996). Abbas (1995) reported that the chloride ions concentration in *Z. qatarense* was lowest in March (spring) and highest in November (fall) in both the saline and the non-saline habitats. However, the accumulation ratio of cholride in the plant was highest in December and January. Ash concentration from the present study agree with the above mentioned studies. Average ash content of the four seasons in leaves was 26.1% in the saline habitat and 25.86% in the non-saline habitat, and it was about three folds higher than content in roots.

The statistical comparison of the seasonal values for ash from both habitats (Table 2) shows significant differences among the leaves values at the 0.01 significant level. The highest statistical K-value (29.48) was in the leaves from the non-saline habitat. The maximum average ash content of leaves from this habitat was 30.55% (spring) and the minimum average was 21.17% (fall). Seasonal differences in root values, however, are statistically significant only in the non-saline habitat. The maximum average in this case was 7.58% (summer) and the minimum average was 4% (spring). In a previous study (Abbas, 1998), the vegetation of the saline habitat was shown to be composed mainly from few halophytic species with a relatively low diversity index (0.27) according to Simpson's Diversity Index. It was dominated by *Z. qatarense* with a relative cover reaching 94% and a relative density of 85%. The diversity index of the non-saline habitat was higher (0.56). However, the relative cover of *Z. qatarense* in this habitat was 65% with a very low relative density of ca. 1%. The results of the above-mentioned study and the present study indicate that the difference in salinity between the two habitats was reflected in their community structure and plant abundance.

It appears that the main seasonal significant variation in the ash content of leaves and roots was found in the non-saline habitat. The salinity of this habitat was generally low in all seasons and its variation was minimal.

References

Abbas, J.A. 1995. Monthly variation of chloride accumulation by *Zygophyllum qatarense* from saline and non saline habitats of Bahrain. In: *Biology of Salt Tolerant Plants.* (Eds.): M.A. Khan, I.A. & Ungar. M.A. Khan, I.A. Ungar. Book Crafters, Michigan, USA, pp. 183-189.

Abbas, J.A. 1998. Distribution and structure of *Zygophyllym qatarense* communities in Bahrain Island. *Arab Gulf Journal of Scientific Research*, 16: 555-568.

Abbas, J.A. and A.A. El-Oqlah. 1996. Distribution of plant species along a transect across Bahrain Island. *Journal of Arid Environments*, 34: 37-46.

Abbas, J.A., M.A. Saleh and S.A. Mohammed. 1991. Plant communities of a protected area in the desert of Bahrain Island. *Journal of Arid Environments*, 20: 31-42.

Batanouny, K.H. 1981. *Ecology and Flora of Qatar*. Oxford: Alden Press.

Batanouny, K.H., A.H. Hassan and K.M. Zayed. 1985. Proline accumulation in plants of different ecological groups as a response to water deficit. *Qatar University Science Bulletin*, 5: 131-143.

Boulos, L. and M. Al-Dosari. 1994. Checklist of the flora of Kuwait. *The Journal of the University of Kuwait*, 21: 203-218.

Doornkamp, J.C., D. Brunsden and D.K.C. Jones. 1980. *Geology, Geomorphology and Pedology of Bahrain*. Geo Abstracts, Norwich, U.K.

El-Oqlah, A.A. and J.A. Abbas. 1992. Preliminary studies on the natural flora and vegetation of Bahrain. *Dirasat*, 19: 123-137.

El-Oqlah, A.A. and J.A. Abbas. 1994. A checklist of vascular plants of Bahrain. *Dirasat,* 21: 95-118.

Fowler, J. and L. Cohen. 1992. *Practical Statistics for Field Biology*. John Wiley & Sons. Chichester, New York, Brisbane, Toronto, Singapore.

Gul, B., D.J. Weber and M.A. Khan. 2001. Growth, ionic and osmotic relations of an *Allenrolfea occidentalis* population in an inland salt playa of the Great Basin Desert. *Journal of Arid Environments*, 48: 445-460.

Khan, M.A., I.A. Ungar and A.M. Showalter. 2000. Effects of salinity on growth, water relations and ion accumulation of the subtropical perennial halophyte, *Atriplex griffithii* var. *stocksii*. *Annals of Botany*, 85: 225-232.

Laurie, S., M. Bradbury and G.R. Stewart. 1994. Relationship between leaf temperature, compatible solutes and antitranspirant treatment in some desert plants. *Plant Science*, 100: 147-156.

Le Houerou, H. N. 1993. Forage halophytes in the Mediterranean basin. In: *Advanced Course on Halophyte Utilization in Agriculture*. (Eds.): R. Choukr-Alla & A. Hamdy. Hassan II University, Agadir, Morocco. pp. 405-436.

Mandaville, J.P. 1990. *Flora of Eastern Saudi Arabia*. Keagan Paul International, London.

Sayed, O.H. 1996. Adaptational responses of *Zygophyllum qatarense* Hadidi to stress conditions in desert environment. *Journal of Arid Environments*, 42: 445-452.

Ungar, I.A. 1991. *Ecophysiology of vascular halophytes*. CRC Press, Boca Raton.

Waisel, Y. 1972. *Biology of halophytes*. Academic Press, New York, London.

Western, A.R. 1989. *The flora of the United Arab Emirates*. An introduction. United Arab Emirates University, UAE.

(Received for publication 18 September 2004)