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Research Paper

Acclimation of Dipterygium glaucum Decne. Grown in the Western Coastal part of Saudi Arabia to different water supplies

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Abstract- *The perennial shrub species Dipterygium glaucum is a dominant species in shrubby, sandy communities in Saudi Arabia. This species suffers from the severe aridity. This work aims to investigate anatomical alterations as responses to variations in water relations-resulting from different water treatments to provide information on the capability of plants to adapt to the harsh conditions. Moreover, such study can also provide information on how to restore and maintain vegetation in the arid lands worldwide.* ***Accordingly*** *the relative growth rate (RGR), plant productivity and the internal structure of either roots ,stems and leaves by applying three irrigation treatments, 100, 200 and 400 mm year^{-1} for two successive seasons ,* from *August-November, 2005 for the first season and from May-August, 2006 for the second season. The nutritional value of the plants, including the mineral ion content in shoots and roots as well as the chemical composition of treated and wild plants was obtained. The results revealed that D.glaucum acclimінate with the arid harch habitat present in the studied location and to the water availabilities and stress.*

Keywords: Acclimation, Arid ecosystem, Anatomical alterations, Dipterygium *glaucum*, Water stress.

Introduction

Climatic change and global warming have greatly affected the ecosystem, especially in arid regions, due to the changes happened in both animal and plant life. Wild plants are a vital component in all terrestrial ecosystems. Mackey (2007) Predict an interaction between climate change and other drivers of biodiversity that will increase extinction risk from that seen in periods of rapid climate change in the past. Barange *et al.* (2010) Pointed to the loss of water, dams, chemical pollution and introduced species in rivers, lakes and ponds according to environmental disorders. Arid regions suffer from quick disturbance in the ecosystem, soil characters and even morphological variations between individuals of the same species.

Saudi Arabia is generally an arid country, it is one from the biggest countries in the world. It occupied about 4/5th of the Arabian Peninsula with great variations in climates, elevations, soil and vegetative characters. The climate is generally very dry and very hot, dust storms and sandstorms are frequent. However, due to the topographic differences and variations in soil compositions, a significant number of species and plant associations can be seen in many places. The western coastal escarpment in Saudi Arabia can be considered two mountain ranges separated by a gap in the vicinity of Mecca (Map 1). This gap is characterized by special climate which affect the type of vegetation there. Tihama lies between the Red Sea and the Escarpments. It is narrow in the northwestern side and wider in the southwestern side. This is an open plain, generally divided into shoreline, salt pans, plains and wadis. Tihama is dissected by major wadis and their tributaries. During rainy days flash floods often over flows the low banks of the wadis and spill over a wide area. The study area located in Tihama plains in the way between Jeddah and Mecca, where the species *Dipterygium glaucum* Decne is dominated in the shrubby, sandy communities. This species suffer from the rarity of water and the very high temperature which affect its phenotypic characters. In spite of that, it has multiple medicinal uses by the Bedouins in constructing houses and fences and as fuel source. *D. glaucum* is a source of volatile alkaloids, flavinoides, cumarins and cyanides [19,23] in addition to its popular utility as a trachea dilating agency in miss-breathing troubles [3]. This species is also used as soil erosion control, shelters against windblown sand, construction material for fences and simple houses, a fuel source and generating a microclimate suitable for range grass re-establishment under grazing pressure [18].

Taxonomical position and characteristic features of *D. glaucum*

D. glaucum belongs to subclass Dilleniidae [8], superorder Violanae [16], order Capparales [16], family Capparidaceae Adans. This family is one of the hot arid areas families. The plant species is up to 0.6 m tall, from a woody base, stems slender, ± sparsely branched with sessile minute glands (Photo 1 and 3). Leaf-blades oblong or elliptic, up to 15 x 3.5 mm, with sessile or subsessile glands on both surfaces, midrib raised beneath, petiole usually 1–1.5 mm long, longer in very young plants (Photo 2). Flowers tetramerous, sepals' papery, whitish yellow up to c. 1 mm long. Petals pale yellow fading whitish, often tinged violet, 3–4 mm long. Fruit length is 4.5–5 x 4–4.5 mm including the wings. Fruit surface is rugose or crested (Photo 2 and 4).

Map 1: Saudi Arabia, arrow indicates the position of the studied area

Plants characterized by possessing Ranunculaceous stomata, chlorophyllous stems, glandular and papillose leaf trichomes, strands of leaf vascular bundles arranged in straight or arched bands and clustered vessels in radial rows. An anomalous stem structure consisting of successive rings of growth, little parenchyma rays in roots (up to 1-3 cells wide) and presence of myrosin cells in leaf epidermis and cortex [25].


Photo 1


Photo 2


Photo 3


Photo 4

In view of desert reclamation, the maintenance of the vegetation belt by this species and others is of high ecological and economic importance. Generally, water is the limiting factor that restricts vegetation-regeneration and restoration in desert areas. For the economic importance, pharmaceutical and ecological benefit of the *D.glaucum* puts emphasis on suitable water management that is suitable and necessary for its cultivation and propagation. The overall aim of this work is to facilitate construction of green belts that serve as dust shelters and other ecological uses. Accordingly, this study was carried out to investigate the morphological, anatomical or chemical responses of *Dipterygium glaucum* grown under different water supplies. This investigation aimed to elucidate the relative growth rate (RGR), plant productivity and the internal structure of either roots, stems and leaves by applying three irrigation treatments, 100, 200 and 400 mm/year for two successive seasons.

Study site (Map 1)

The study area located at Tihama region western Saudi Arabia in the way between Jeddah-Mecca road. The site was chosen carefully to be dominated with the studied species *D. glaucum*. The study site called Al-Shumaisy, 40 Km from Jeddah city. The soil there was yellow sandy dry and loose.

Material and Methods

Seeds of *Dipterygium glaucum* L. were collected from the study site during April to June 2005 for laboratory work. Dry seeds were preserved in dark containers until forthcoming use. Due to the hardness of the testa and – in turn- the difficulty of seed germination, seeds were soaked under running tap water for two continuous hours The cultivation experiment lasted nearly for four continuous months during each season . Cultivation took place in a wire greenhouse in the house garden, using clay pots (50 cm height x 30 cm diameter) filled with sandy soil collected from the species natural habitat.

After seedling establishment thinning was carried out and only 10 seedlings per pot were left. Three water supplies (100, 200 and 400 mm / year) were applied throughout the growing season that extended for four continuous months. Cultivation was undergone for two successive seasons, from August-November, 2005 for the first season and from May-August, 2006 for the second season. External growth was monitored during the different stages of growth. Relative growth rate (RGR) was calculated on basis of oven dry weights for the two successive seasons according to Hunt (1978, 1982) following the equation:

$$RGR = \ln w_2 - \ln w_1 / T_2 - T_1 \ \ g\ g^{-1}\ day^{-1}$$

Where w_2=air dry weight in the second stage at fixed time, w1=air dry weight in the first stage at the same time, T_2= time intervals of the second stage, T_1= time intervals of the first stage.

The recorded growth stages were as follows:
1- juvenile–seedling, 2- vegetative–juvenile, 3- flowering–vegetative and 4- fruiting–flowering.

Productivity tests of plants were undertaken for the two cultivation seasons. By the end of the growing season, specimens of leaves, stems and roots of either treated or wild plants were conserved in 95% ethyl alcohol , sectioned, and prepared (according to Sass,1958) for forthcoming examination and measurements using the optical light microscope micrometer .Comparison of internal structure of both treated and wild species carried out. In addition, estimation of mineral ion content as well as the biochemical (carbohydrate, proteins and fats) composition of plant shoots and roots was undertaken in order to detect the nutritional status of the species for grazing.

Results

Relative Growth Rate (RGR) of plants

Relative Growth Rate is defined as the increase in the dry weight of plant material per unit weight per unit time. Results summarized in table 1 and illustrated in Fig. 1 indicate that RGR attained a higher values of 0.499 g g^{-1} d^{-1} on using the irrigation amount of 100 mm for the flowering – vegetative stage (Stage 3) during the first growing season and 0.259 g g^{-1} d^{-1} during the second growing season on using 200 mm irrigation treatment. Stages 1 and 4 were the best in the first regime of water in the first season while stage 2 was better in the first season, first regime. Moreover, RGR values remarkably decreased during the second growing season when using the irrigation supply of 100 mm, especially during all stages of growth. By the end of the mature vegetative stage (Stage 4), in the two growing seasons and the second water regime (200mm), complete death of plants occurred and the same happened in the plants grown in the first season in the first water treatment(100mm). The zero value denoting no results.

Productivity tests of plants: Data present in Table 2 and illustrated in Fig.2, revealed a general decrease in the produced number of flower buds, flowers and fruits but the decrease was more pronounced for plants of the second season than those of the first (Figure 2) . It is to be noted that *D. glaucum* plants irrigated with 100 mm- during the second growing season- could not sustain this severe water stress and died by the end of June (end of spring and beginning of summer). Highest produced number of flowers (6.5/individual) was attained on using 400 mm water supply during the first growing season whereas the value of 23 represented the highest produced number of flower buds in the same season when the irrigation water was 200 mm (Table 2). Meantime, the number of fruits/individual decreased to 6.5 in plants supplied with 100 mm during the first cultivation season. The highest average dry weight of fruits (one-seeded winged nutlets) represented a ratio of 11.97% of the total dry weight of the individual plant when irrigated with 100 mm during the first season. On the contrary, the least ratio of 1.72 was experienced using 400 mm irrigation water, in the first season.

Table 1: Relative growth rate (g g^{-1} d^{-1}) of *D.glaucum* plants under different water treatments. N.B.: S1 = first season S2= second season, T1, T2 and T3= three water treatments

Treatment (mm/year)		RGR values (g g^{-1} d^{-1})			
		Juv.–seedl. Stage 1	Veg.–juv. Stage 2	Flow.–veg. Stage 3	Fruit.–flow. Stage 4
S1	T1(100)	0.116	0.000	0.499	0.075
	T2(200)	0.041	0.132	0.215	0.000
	T3(400)	0.057	0.119	0.009	0.026
S2	T1(100)	0.038	0.061	0.00	0.00
	T2(200)	0.074	0.083	0.259	0.000
	T3(400)	0.031	0.145	0.095	0.019

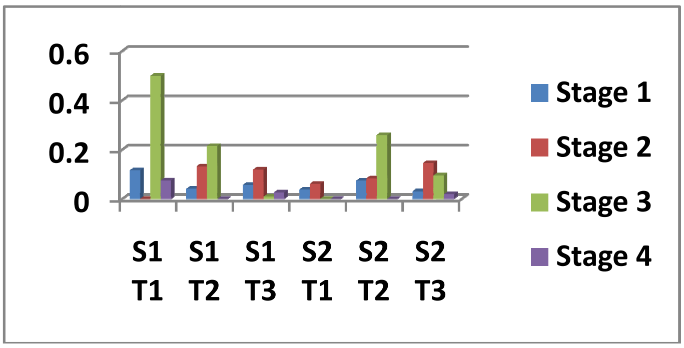

Figure 1: RGR of *R.glaucum* in the two studied seasons throughout the four growing stages

Table 2: Productivity test of *R.glaucum* in the two studied seasons throughout the three growing stages treated with the different amount of water

Water treatment (mm/year)		Number (per individual) of ……			Average dry wt. of fruits (g) /individ.	Average dry wt.(g) / individ.
		flower buds	flowers	fruits		
T1 (100)	S1	3.7±0.88	4.7±1.33	6.5±1.78	0.014	0.117±0.09
	S2	-	-	-	-	-
T2 (200)	S1	23±8.39	6.3±2.73	3.7±0.88	0.009	0.155±0.23
	S2	5.0±0.00	2.0±0.00	3.0±0.29	0.003	0.074±0.02
T3 (400)	S1	16±5.20	6.5±2.60	3.5±0.34	0.0063	0.366±0.62
	S2	6±0.58	3.2±0.33	6.3±0.34	0.004	0.108±0.01

N.B.: S1 = first season S2= second season, T1, T2 andT3= three water regimes, Av. D.W.F.= average dry weight of flowers, Av.D.W. In.=average dry weight of individuals. The numbers of flower buds, flowers and fruits have been corrected to the nearest number without decimals.

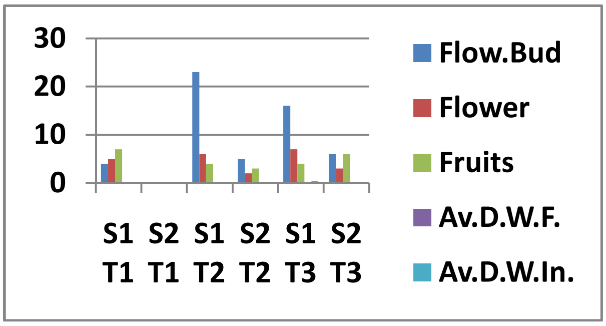

Figure 2: Productivity test of *R.glaucum* in the two studied seasons throughout the three growing stages treated with the different amount of water

Internal structure of plants

Stem anatomy

Data presented in Table (3) and illustrated in Figure 3, indicates that the thickness of the epidermal layer ranged from 33 µ for 400 mm water treatment to 39 µ (evenly for T_1 andT_2 water treatments. Epidermis of wild plants was exceedingly thicker (52 µ). Stem diameters showed gradual decreased values of (1.5, 1.3 and1.2 mm) for treatments T_1, T_2 andT_3 successively while it gave 1.6 mm for wild plants. Though stem diameter of wild plants realized the highest value, the thickness of cortex (195 µ) of T_3 treatment overcome that of wild plants (130 µ). The least value of (104 µ) was attained by T_1 plants while an equal value of (130 µ) was obtained by T_2 watered plants when compared with the wild plants .The thickness of vascular tissues achieved its highest value 325 µ) for wild plants whereas it exhibited the values of (260 , 221 and 156 µ) successively for T_1 , T_2 and T_3) water treatments. The highest value of parenchyma thickness (780 µ) was given by 100 mm watered plants, while the values ranged between (586 and 260 µ) for T_1 and T_3 consequently. An intermediate value of (650 µ) was recorded for the wild plants.

Leaf anatomy

Data concerning the leaf anatomy of *D. glaucum* plants present in table 3 and clarified in Figure 4 revealed that the stomatal density (number / mm-^{2}) varied from the upper surface (adaxial) to the lower one (abaxial). Stomatal density was significantly higher for the adaxial surface than for the abaxial one. Values of (7.7, 9.2 and 5.5 stomata / mm^{-2}) were realized for the adaxial surface when the plants were irrigated with (100, 200 and 400 mm) successively. On the other hand, stomatal density gave the values of (5.6, 6.3 and 3.9) for the plants supplied with 100, 200 and 400 mm) water treatment. Wild plants attained the values of (6.1 and 3.0 stomata / mm^{-2}) for either the adaxial and abaxial surfaces consequently. The highest value of midrib thickness (523 µ) was attained in T_1 irrigated plants. Lowered values of (481, 312 and 468 µ) were recorded for (T_2 T_4 and wild) plants successively. Thickness of mesophyll was exceedingly higher for wild plants (364 µ) than for the watered plants that exhibited the values of (208, 260 and 195 µ) successively for ($T_{1,}$ T_2 and T_3) irrigated plants. The dimensions of vascular bundles achieved its highest values of (260 x 117 µ) for T_2 water supplied plants. This was followed by the values of (321 x 91 and 260 x 91µ) for treatments T_3 and T_1 respectively. The least value of (182 x 91µ) was attained by the wild plants. There was a concordance of these results and those concerned with the number of xylem arches / leaf. The later criterion recorded its highest value of (13) for the (T_2) irrigated plants (Fig.4).

Root anatomy

From Table 3 and Figure 5 it's obvious that the roots of wild plants achieved the highest values of both root diameter (3.8 mm), cork thickness (195 µ**)** and vascular cylinder diameter (2.5mm). On the other hand, root diameter of water treated plants showed lower values started from (0.98 mm) in (T_1) to (0.87 mm) in (T_2) plants and (0.79 mm) in (T_3) plants. Thickness of cork layer gave the lowered value of (52 µ) in both T_1 and T_3 plants, whereas a value of (39 µ) was measured for (T_2) watered plants. It is to be noted that the vascular cylinder of *D. glaucum* roots realized an excessive high growth – represented in its increased thickness–that recorded a value of 65.8% of the root diameter for wild plants. This ratio approximately was 50% for the water treated plants. The values of (46.9, 44.8 and 48.1%) were attained for (T_1, T_2 and T_3) irrigated plants successively.

Mineral ion composition of plants

A common trend observed in the (Tables 4 and 5) and showed in Figure 6 and 7. Generally, the content of both k, Ca and Mg were higher in plant shoots than in roots. This observation was obvious throughout the two successive growing seasons. On the other hand, Na and Fe contents were higher in roots than in shoots especially, during the first growing season. Also, there was a conspicuous significant increase in most of the recorded values for (K, Na, Fe and Mg) in treated plants than in wild plants in both roots and shoots and during the two cultivation seasons. A diverted trend was monitored for Ca where the wild plants revealed higher significant values than the irrigated ones. This was clear for both plant roots and shoots and during the two successive growing seasons. Least mineral values were generally recorded for Fe either in shoots or in roots throughout the two growing seasons of *D.glaucum* plants (Figure 6 and 7).

Table 3: Anatomical characteristics of stem, leaf and root of *D.glaucum* plants using different water treatments

Plant organ	character	Water treatment (mm/year)			wild
		T_1(100)	T_2(200)	T_3(400)	
Stem	Thickness of epidermis (µ)	39	39	33	52
	Stem diameter (mm)	1.5	1.3	1.1	1.6
	Thickness of cortex (µ)	104	130	195	130
	Thickness of V.B. (µ)	260	221	156	325
	Thickness of pith (µ)	780	586	260	650
Leaf	Upper stomatal density (no./mm^2)	7.7	9.2	5.5	6.1
	Lower stomatal density (no./mm^2)	5.6	6.3	3.9	3
	Thickness of midrib (µ)	523	481	312	468
	Thickness of mesophyll (µ)	208	260	195	364
	Dimensions of V.B.(µ)	260x91	260x117	321x91	182x91
	No. of xylem arches	11	13	11	8
root	Root diameter (mm)	0.98	0.87	0.79	3.8
	Thickness of cortex (µ)	52	39	52	195
	Vascular cylinder diameter (mm)	0.46	0.39	0.38	2.5

N.B. epi.th.= epidermis thickness, stem d.= stem diameter multiply by 100, Cortex th.=cortex thickness, V.B. th.= vascular bundle thickness, Pith th.= pith thickness

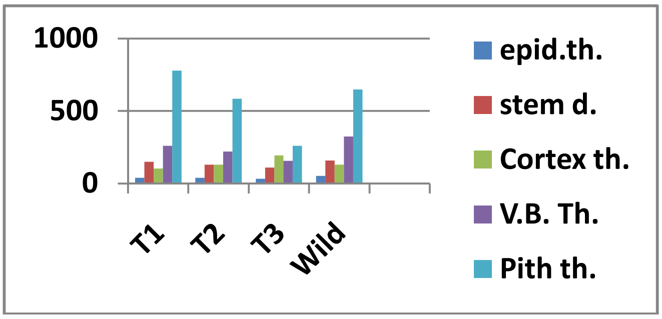

Figure 3: Anatomical characteristics of stem of *D.glaucum* plants using different water streatments.
N.B. Up.St.D.= upper stomatal density multiply by 100, L.St.D.= Lower stomatal density multiply by 100, Mid.th.= midrib thickness, V.B.L.= vascular bundle length, V.B.W.= vascular bundle width, No.X.A.= number of xylem arches multiply by 10.

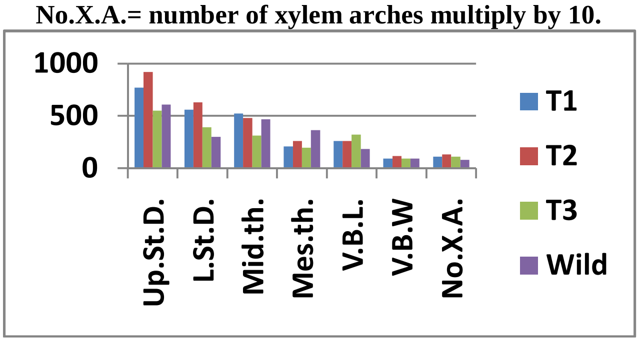

Figure 4: Anatomical characteristics of leaf of *D.glaucum* plants using different water treatments.
N.B. Root D. = root diameter multiply by 100, Cortex th.=cortex thickness, V.C. D.= vascular cylinder diameter multiply by 100

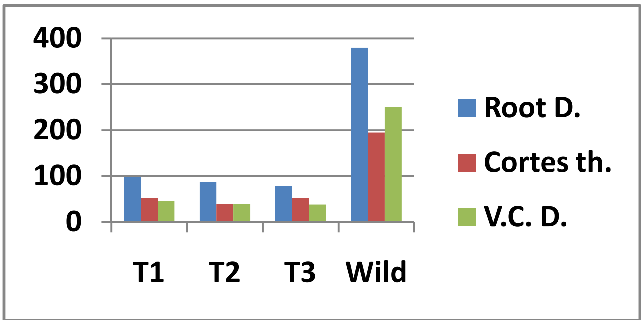

Figure 5: Anatomical characteristics of root of *D.glaucum* plants using different water treatments.

Table 4: Mineral ion composition (m.eq./L) in roots and shoots of *Dipterygium* plants by the end of the first growing season

Plant organ	Water treatment (mm /year)	Cation content (m.eq./L)				
		K^+	Ca^{++}	Na^+	Fe^{++}	Mg^{++}
Root	T_1(100)	24.1±0.00	15.1±0.00	15.7±0.00	2.43±0.00	4.3±0.00
	T_2(200)	33.2±0.00	8.5±0.00	15.5±0,00	1.94±0.00	4,0±0.00
	T_3(400)	28.6±0.00	7.9±0.00	17.1±0.00	2.87±0.00	3.9±0.00
	Wild	18.6±1.33	43.97±1.41	2.97±0.45	1.37±0.25	3.77±0.23
	F-value	19.23	5.11.6	297.6	10.04	1.57
	Sig.	**	**	**	**	n.s.
Shoot	T_1(100)	67±0.11	49.1±3.98	7.35±0.49	1.46±0.06	5.55±0.04
	T_2(200)	43.7±0.64	41.55±2.5	7.6±0.46	1.64±0.13	5.85±0.14
	T_3(400)	63.85±0.72	40.55±0.21	7.55±0.61	0.93±0.06	5.7±0.00
	Wild	14.3±0.64	50.7±1.48	4.5±1.28	3.13±0.31	5.15±0.23
	F-value	288.8	4.05	2.42	27.93	1.11
	Sig.	**	*	n.s.	**	n.s.

Table 5: Mineral ion composition (m.eq./L) in roots and shoots of *Dipterygium* plants by the end of the second growing season

Plant organ	Water treatment (mm /year)	Cation content (m.eq./L)				
		K^+	Ca^{++}	Na^+	Fe^{++}	Mg^{++}
Root	T_1(100)	48.7±0.00	11.8±0.00	3.3±0.00	2.28±0.00	4.8±0.00
	T_2(200)	60.7±0.00	13.8±0.00	7.5±0,00	1.45±0.00	7.1±0.00
	T_3(400)	36.4±0.00	10.8±0.00	4.2±0.00	1.08±0.00	4.5±0.00
	Wild	18.6±1.33	43.97±1.41	2.97±0.45	1.37±0.25	3.77±0.23
	F-value	250.6	476.2	55.05	7.84	53.65
	Sig.	**	**	**	**	**
Shoot	T_1(100)	61.8±0.23	41.5±2.71	4.85±0.03	1.83±0.09	10.1±0.52
	T_2(200)	67.5±6.29	37.4±2.39	4.6±1.04	1.55±0.04	9.55±1.29
	T_3(400)	59.8±1.50	39.1±0.84	2.75±0.03	1.29±0.02	8.9±0.75
	Wild	14.3±0.64	50.7±1.48	4.5±1.28	3.13±0.31	5.15±0.23
	F-value	57	8.834	1.39	23.88	7.189
	Sig.	**	**	n.s.	**	*

N.B. T1R= first regime roots, T2R=second regime , roots, T3R=third regime roots W.R.= wild plants root, T1Sh.= first regime shoots, T2Sh.= second regime shoots, T3Sh.=third regime shoots, W.Sh.=wild plants shoots

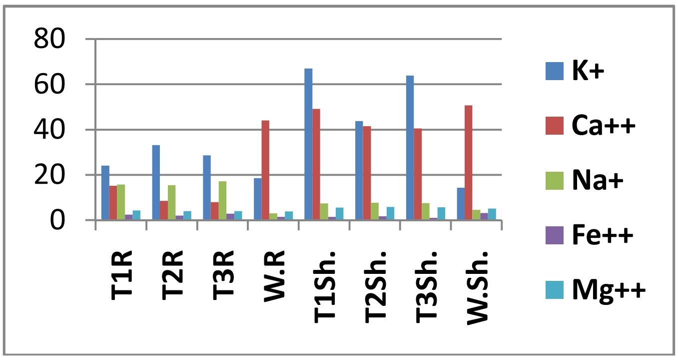

Figure 6: Mineral ion composition (m.eq./L) in roots and shoots of *D.glaucum* plants by the end of the first growing season .

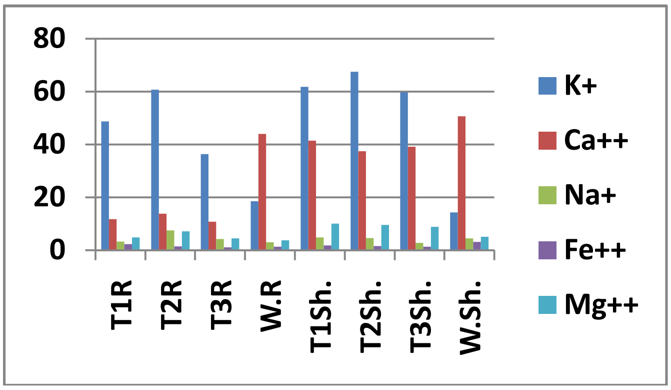

Figure 7: Mineral ion composition (m.eq./L) in roots and shoots of *D.glaucum* plants by the end of the second growing season .

Table 6: Protein, carbohydrate and lipids contents in *D.glaucum* plants according to different water treatments.

Growing season	Water treatment(mm/year)	Protein content (mg/g fr.wt.)	Carbohydrate content (mg/g fr.wt.)	Lipid (%)
S1	T1(100)	1.71±0.47	23.89±5.99	0.93±0.02
	T2(200)	0.07±0.00	57.23±9.59	0.95±0.01
	T3(400)	2.64±0.52	235.5±28.05	1.07±0.14
	Wild	2.59±0.12	11.28±2.20	0.62±0.04
	F-value	11.08	280.3	7.24
	Sig.	**	**	*
S2	T1(100)	3.46±0.65	54.09±7.94	1.19±0.05
	T2(200)	3.67±1.14	237.0±3.82	1.45±0.16
	T3(400)	4.19±0.97	59.43±4.36	3.18±0.05
	Wild	2.59±0.12	11.28±2.20	0.62±0.04
	F-value	0.68	81.98	78.25
	Sig.	n.s.	**	**

N.B. T1S1=Treatment 1 first season, T1S2=Treatment 1 second season, T2S1= Treatment 2 first season, T2S2= Treatment 2 second season, T3S1= Treatment 3 first season, T3S2= Treatment 3 second season, WS1= Wild plant first season, WS2= Wild plants second season. Protein and lipid contents multiply by 10.

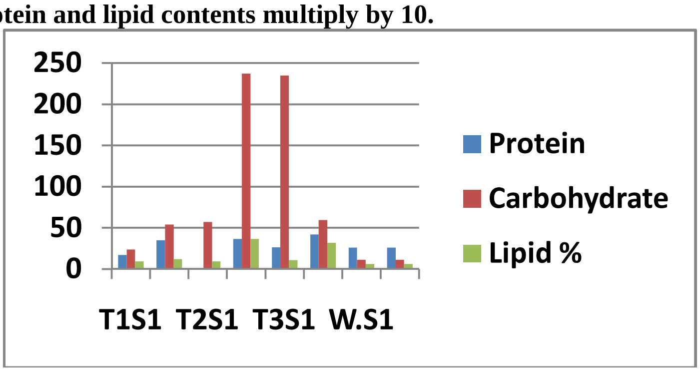

Figure 8: Protein, carbohydrate and lipids contents in *D.glaucum* plants according to different water treatments.

Protein, carbohydrate and lipids of plants

Data concerned with the total proteins, carbohydrates (soluble and insoluble) and lipids of either treated or wild plants summarized in Table 6. The result indicates the high plant contents in carbohydrates than in proteins or lipids (Figure 8). Values of (235.5 and 237 mg g-^{1} fresh weight) were recorded either for T_3 or T_2 irrigated plants during the two successive seasons respectively. Higher protein contents (2.64 and 4.19 mg g-^{1} fresh weight) were recorded during the two growing seasons at succession for the T_3 watered plants. The same trait w mg g-as achieved for lipids when the highest values of (1.07 and 3.18 mg g-^{1}) were recorded for T_3 well - watered plants during the two growing seasons. Generally, carbohydrate content extremely increased in irrigated plants than in drought – stressed wild ones during either season. A similar trend was followed for lipid content while the protein trait was contradictory.

Discussion

Dipterygium glaucum is always growing in the sandy plain habitats and is one of the sand dunes – forming species- that grows in the inland areas far from the red sea coast (Al-Nafie, 2004). It is well-known that the soil forming the mounds or dunes is usually more penetrable and looser than that in between (Batanouny, 1993).

The principle of propagation and recultivation of the rangeland plants in the arid regions was assessed and approved by many authors [7.20,27]. The main goal of these researches–including the present one – is the retrieval of the natural ecosystems and preventing further desertification and deterioration especially, when concerned with the economically and pharmaceutically important species such as *D. glaucum*.

Our data revealed that the highest relative growth rate (RGR) of plants was attained during the first season and on using 100 mm irrigation water and at the flowering - vegetative stage, what ensures the stability of climatic conditions during the spring (Aug. - Nov.) more than during the summer (May – Aug.). Death of *Dipterygium* plants by the end of the vegetative stage of the second growing season on using 100 mm irrigation water denotes the unfavorability climatic and soil conditions during this period. This might be interpreted by the decrease of absorption rate of plant roots (by the end of spring) due to the relative cooling of soil while increasing the evapo-transpiration rate as a result of higher air temperature. This would disturb the absorption – transpiration balance state.

The allocation of resources between the vegetative and reproductive organs relies on several factors such as: the plant environment, its habits, its mode of life history and other factors including the effect of neighbors [1]. Data revealed a general decrease in values of produced numbers of flower buds, flowers and fruits especially, during the second growing season for the above–mentioned reasons. A maximum average weight ratio was assessed for the T_1 (100 mm) irrigated plants during the first growing season. This might be attributed to the acceleration of growth and seed raining of xerophytes to overcome the onset of the severe and drastic conditions.

The present study aimed to assess the anatomical plant responses resulted from the difference in water availabilities. Wild *D. glaucum* were distinguishing by their possession of photosynthesizing chlorenchymatous tissues just beneath the stem epidermis that compensate the extremely diminished leaf area and its falling down during the dry season. This tendency agrees with Guralnick *et al.* (2001) [10] when he found the exhibition of CAM cycling pathway that withstands both the water stress and the high light environment. Other discriminative features are the presence of less dense multicellular glandular hairs on the leaf epidermis and the low leveled stomata. Stem xylem tissue takes a special clustered form. Last distinctive features are the possession of root anomalous secondary growth - that comes in concordance with [21] who monitored the presence of wood false growth rings with bands of poorly lignified tracheids in stressed *Pinus* plants–and its circumference with a thick cork layer for protection.

As a result of submitting different plant species to water stress, many authors recorded some anatomical features that imparting drought resistance such as decreasing the stomatal density [21]. Reduction of vascular (especially xylem) cross – sectional area leading to reduction in stem diameter as well as reduction in vessel element number were recorded Taia and Mousa (2011) [26] in *Calligonum comosum* plants subjected to water stress treatments. All these above – mentioned trials are considered as opponents to the obtained data in the present investigation. The most sound data concerning the stem anatomy were the increased thicknesses of epidermis, cortex, vascular tissue (especially xylem) and in stem and pith diameter that were monitored for the water – limited (T_1) *Dipterygium* plants. These agree with (Sharma and Sharma, 2008) [24]. Leaf anatomy of the water – stressed *D. glaucum* plants showed some variabilities, including increased stomatal density especially on the upper (adaxial) surface, thickness of mesophyll and vascular tissue. These observations were coping with (Manoj–Kulkarni and Uday–Deshpande 2007) [15]. Closed stomata and small intercellular spaces were recorded by Romanoand Martins–Loucao (2003) [21]. Roots of water – limited *Dipterygium* plants were distinguished by attaining increased root diameter, vascular cylinder diameter and external cork layer thickness. Liu–FeiHu *et al.* (2005)[13] recorded some root morphological and anatomical characters due to higher levels of photosynthesis for *Beohmeria nivea* drought – tolerant plants. It is to be noted that the general increase of lignifications in the plant organs and the increase in thickening of the secondary walls are means for mechanical support that makes the plant to withstand the drought–hit during the dry season.

In order to estimate the nutritional value of *Dipterygium* plants–as an edible species by the range animals–we ought to study both the mineral ion composition and the organic chemical content of proteins, carbohydrates and lipids. Data revealed that in either growing seasons, plant shoots were more richer in mineral contents of K^{+}, Ca^{+2} and Mg^{+2}. On the contrary, Na^{+} and Fe^{+3} contents were much higher in roots than in shoots especially, during the first growing season. Generally, mineral ion content was higher in water–treated than in wild and low–watered plants except for Ca^{+2} and sometimes Fe^{+3}, either in shoots or in roots. Also, *Dipterygium* plants were rich in proteins, carbohydrates and lipids and their values were significantly higher in treated than in wild plants. Their maximum profusion were assessed by the well–watered (400 mm) plants. Similar and gradual depletion in soluble carbohydrate concentration per dry mass of water - stressed was recorded by Mendes *et al.* (2001) [17]. Meantime, increased total soluble proteins and increased level of lipid peroxidation was gained for the water – stressed olive cultivars by Bacelar *et al.* (2006) [4].

In conclusion *D. glaucum* were morphologically, anatomically and chemically acclimated to water availabilities and stress. To propagate this species we have to choose the medium water treatment (T_2) and the spring season to avoid the water stress and obtain best quality of plants.

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