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Eco-Physiological Studies on some Lithophytes Growing in Sinai, Egypt.

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The objective of the present study is to investigate the possible mechanisms by which *Artemisia judaica* L, *Capparis cartilaginea* Decne and *Gomphocarpus sinaicus* Boiss (3 lithophytic medicinal plants) are able to tolerate xeric habitats (Sinai Peninsula). Accordingly, it has been found that the highest degree of succulence and ash content were attained by *C. cartilaginea* during winter and summer, respectively. The same plant accumulated the highest amounts of total carbohydrates, nitrogenous constituents, DNA, RNA, Na^{+}, Mg^{-}, Ca^{++} and B^{+} ions and the highest levels of phenol (during autumn) as compared to the other two plants. As to the activities of the studied enzymes, polyphenol oxidase and peroxidase attained their maximum activities during summer in *C. cartilaginea* and RN-ase reached its maximum activity in both *A. judaica* and *C. cartilaginea* during autumn, while IAA-oxidase activity reached its highest value during winter (*C. cartilaginea*), spring (*G. sinaicus*) or summer (*A. judaica*). Alkaloids tended to increase mostly during summer in *C. cartilaginea* and *G. sinaicus*. Finally, the seasonal variations in the endogenous phytohormones: auxins, giberellins, cytokinins, ABA and phenolic inhibitors in the 3 tested species were found to be highly fluctuating but their allover activities at any time always control the biosynthetic capacity of plant cells. The different results obtained were discussed.

Key words: *Artemisia judaica*, *Capparis cartilaginea*, *Gomphocarpus sinaicus*, lithophytes, Sinai Peninsula, phytohormones, alkaloides, total chlorophylls, succulence and osmotic adjustments.

This study deals with the elucidation of the adaptive responses of three lithophytes confined to rocky habitats. The Egyptian desert xerophytes always show characteristic adaptations to decreased water content (Zahran, 1989 and Dash, 1993). A drought avoider must maintain a high water potential when exposed to an external water stress (Merino *et al.*, 1976). Osmond *et al.* (1980) concluded that there are two principal ways of lowering both leaf temperature and transpiration rate. One is through the alteration of orientation of leaves and the other is by increasing the reflectance of the leaf surface (Smith, 1978). Desert perennials usually develop deep extensive roots which extend freely in every direction in order to increase the capacity of water uptake and drought resistance (Migahid, 1962; Osmond *et al.*, 1980 and Youssef, 1994).

Xerophytes depend, to a large extent, on the accumulation of organic intermediates, while electrolytes are the main osmotically active constituents of halophytes (Ahmed and Girgis, 1979). The accumulation of total chlorophyll, carotenoids and total pigments were associated with remarkably low soil moisture (Al-Tantawy, 1983 ; Hussein, 1988 ; Fahmi, 1990 and Mossallam & Abd El-Maksoud, 1996). Also, the important role played by the photosynthetic pigments in the osmotic adjustment of plants is widely reviewed (Turner and Jones, 1980 ; Osmond *et al.*, 1980 and Ziegler, *et al.*, 1981).

Succulence is considered a mechanism through which plants are adapted to adverse environmental conditions including salinity and drought (Ahmed and Girgis, 1979 and Marie, 1988). Ash content of plant material is known to be a good criterion of the total mineral content as it includes all the ions analyzed in addition to others in the form of oxides (Youssef, 1994). Accumulation of hydrophilic substances like low molecular weight proteins, some carbohydrates and polyhydric alcoholic compounds are among the mechanisms causing tolerance to drought conditions (Malik and Srivastava, 1982). They also suggested that during stress conditions, certain proteins appear in the cells that resist denaturation. Among the effects of water stress on nitrogen metabolism are the hydrolysis of proteins and accumulation of amino acids (Mossallam, 1993).

It was reported that the activity of IAA- oxidase, protease, cytochrome oxidase and peroxidase (Dwivedi *et al.*, 1979) were remarkably increased under stress conditions. Meanwhile, the activity of catalase and proline oxidase (Stewart and Boggess, 1978; and Sells & Koeppe, 1981) were found to be decrease as the water stress increased.

According to Ahmed and Girgis (1979) and Youssef (1994), succulence of *Zygophyllum coccineum* depends primarily on Ca^{++} accumulation and, to a lesser extent, on Mg^{++} and Cl^- ions, whereas *Anabsis articulata* retains high levels of Ca^{++}, Mg^{++}, K^+, P^{+++} and SO^4 through osmotic adjustment under drought stress. Furthermore, Waisel (1972) reported that Na^+ plays an important role in maintaining a favourable water balance.

Itai and Benzioni (1976) concluded that stresses lead to a decrease in cytokinin and to an increase in abscisic acid (ABA). The most common observed effect of increased concentration of ABA is stomatal closure, which enables the plant to regain full turgor (Hiron and Wright, 1973). A relationship between the water stress induced accumulation of ethylene and auxin transport was indicated by Davenport *et al.* (1977-a, b and c) and Morgan *et al.* (1977). Itai and Benzioni (1976), El-Telwany (1987), Hassanein *et al.* (1989), Mossallam (1993) and Youssef (1994) found that water stress led to a decrease in growth promotors, particularly cytokinins and increased ABA, which in turn modified the membrane function and decreased synthetic aspects of metabolism.

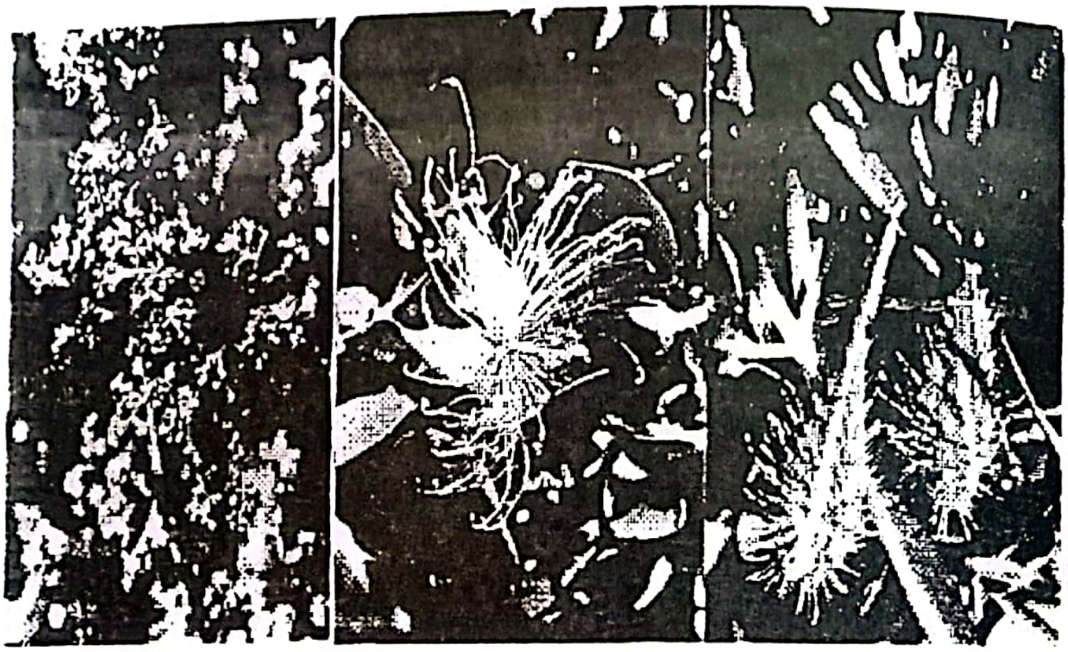
The objectives of this work is to study the eco-physiological adaptive responses of three lithophytic species; *Artemisia judaica* L., *Gomphocarpus sinaicus* Boiss and *Capparis cartiliginea* Decne (which are known as medicinal plants) to the possible changes in the physical and chemical properties of the soil in their habitats during the wet and dry seasons. The study includes: climatic and edaphic conditions; seasonal changes in plant succulence, photosynthetic pigments, carbohydrates and nitrogen contents ; seasonal fluctuations in ash content and mineral composition of each species and their relation to its adaptive responses ; the possible changes in the endogenous phytohormones including auxins, gibberellins, cytokinins and growth inhibitors in each studied species and a discussion of the results.

Materials and Methods

The present study was carried out during 1998. Sampling covered the four seasons, winter, spring, summer and autumn. The plant materials of *Artemisia judaica* and *Capparis cartilaginea* were sampled from upstream parts of Wadi Sudr whereas samples of

Gomphocarpus sinaicus were obtained from Wadi El-Sheikh at Sant Katherin. See Plate (I, a,b,and c).

Plate (I): Close up view of the three studied lithophytic plants.



a) *Artemisia judaica* b) *Capparis cartilaginea* c) *Gomphocarpus sinaicus*

Soil characteristics:

Owing to the rocky nature of the concerned habitats, profiles were sampled at depths from 0–20 cm from the soils supporting the studied plants. The granulometric analysis (by the sieve method), soil saturation percentage and field capacity, electrical conductivity (E.C.), pH, total soluble salts (T.S.S. as %), total organic carbon (%), total humus (%), total nitrogen (%), chlorides (%), sulphates (%) and total carbonates (%) were determined in the supporting soil as described by Wilde *et al.* (1979), (Table 1) . Sodium, K , Ca , Mg and P were also determined after Wilde *et al,* (1979).

Plant characteristics:

The methods adopted for plant sampling and analysis can be summarized as follows: photosynthetic pigments (Metzner *et al.*, 1965), extraction and estimation of carbohydrate fractions (Younis *et al.*,1969 and A.O.A.C.,1975), extraction and estimation of nitrogenous constituents(Hassanein,1977),proline determination

(Bates *et al.*,1972), preparation of amino acids for injection in GLC (Lamin & Gehrke, 1966).

Quantitative estimation of ribonucleic acid, RNA and deoxyribonucleic acid, DNA (Burton, 1956); extraction and assay of peroxidase, polyphenol oxidase and catalase activities were accomplished following the method of Kar and Mishra (1976), while IAA-oxidase activity was assayed according to Darbyshire (1971). Total phenols were estimated by the method of Malik and Singh (1980). Alkaloids and total ash contents were obtained according to the method described in A.O.A.C. (1975).

Mineral contents were determined according to the following methods: chlorides (Jackson and Thomas, 1960); extraction by wet ashing method (Chapman and Pratt, 1961); determination of sodium and potassium using flame photometry (B-700 E) as adopted by Irri (1976); magnesium was determined by atomic absorption spectrophotometery (FMD_3); phosphorus , iron and boron were measured as described by Irri (1976).

Extraction and bioassay of auxins and their inhibitors (Foda and Radwan, 1962); bioassay of gibberellins and gibberellin-like substances (Bentley-Mowat, 1966) and bioassay of cytokinin substances (Esashi and Leopold, 1969).

Compounds on chromatograms were visualized by subjecting them to various colour reactions using ferric–perchloric reagent testing for indole compounds (Powell, 1959), $KMnO_4$ testing for reducing substances, ethanolic ferric chloride testing for hydroxyl groups, diazotized p-nitro-aniline testing for unsaturated lactones (Swain, 1953) and concentrated H_2SO_4 testing for ABA (Narasimhareddy and Swamy, 1979). In addition, gibberellins were tested using 20% antimony trichloride (Kegawa *et al.*, 1963) and purine compounds having cytokinin activity using purine/silver chromate complex (Reguera and Asimov, 1950).

Characterization of the studied areas and species:

Sinai region may be divided into three subregions: southern, central and northern. Because of its high altitude, the southern section receive sample rainfall which has produced wadis. Climatically, the

Sinai Peninsula can be divided into two zones (Ayyad and Ghabbour, 1986): an arid zone which includes the northern subregions, with hot summer and mild, rainy winter and a hyperarid subregion with cool winter and hot summer.

The flora of Sinai combines the elements of the three phytogeographical regions of the world (El-Hadidi, 1969). These regions are Saharo-Scindiani (African-Indian), Irano-Turanian (West and Central Asiatic) and the Mediterranean (Good, 1974).

The most crowded populations of *Gomphocarpus sinaicus* were recorded on the rocky upstream parts of Wadi El-Sheikh (Sant Katherine), while *Capparis cartilaginea* was sampled from the upstream parts of Wadi-Sudr (south west Sinai), where its dense populations grow in the form of hanging gardens.

Samples of *Artemisia judaica* were collected from the rocky extensions of the midstream Wadi bed of the same wadis.

Physical and chemical characteristics of soil profiles associated with the studied plants:

The study areas of the present work (Table 1) enclude Wadi Sudr and Wadi El-Sheikh. The W. El-Sheikh habitat is its upstream part near Sant Katherin Monastery. Wadi Sudr is one of the most outstanding drainage lines dissecting the western horn of El-Tih plateau. Its habitat was the upstream part the main trunk of the wadi extends in the NE – SW direction for a distance of about 55 Km to terminate at Ras Sudr (Girgis and Ahmed, 1985).

The climate of the studied areas:

Climatic data are represented graphically in Fig.(1)

Results and Discussion

The present study, evaluated some adaptive responses of three perennial lithophytic species growing under different habitat conditions in the Sinai Peninsula. The changes in succulence and different metabolites of the three species during the four seasons of the year and the changes in amino acid composition of the same plants during winter and summer are presented in Table (2). In addition, the changes in auxins and their inhibitors, gibberellins and their inhibitors, and cytokinins and their inhibitors are illustrated graphically in Fig (2). The chemical colour reactions testing for the presence of auxins, gibberellins, cytokinins and inhibitors in the fractionated extract are recorded in Table (3). All analyses were carried out in triplicate samples and the mean value is recorded.

Fig. (1a) : Climatic Monthly Changes of Ras Sudr area.

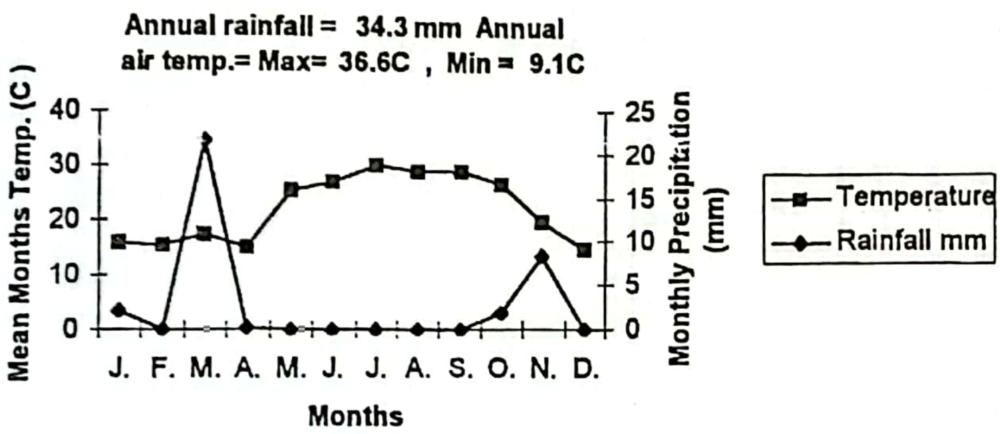


Fig. (1.b) : Climatic Monthly Changes of Sharm El-Sheikh Area.

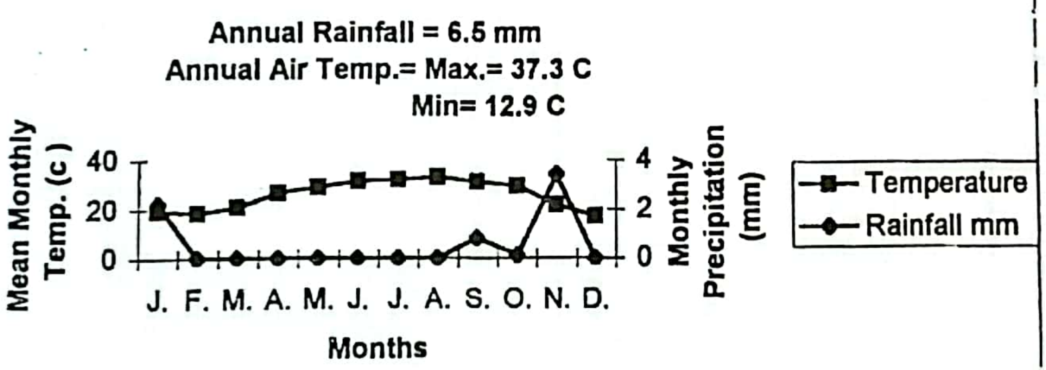


Fig. (1c) : Climatic Monthly Changes of Sant-Katherine Area.

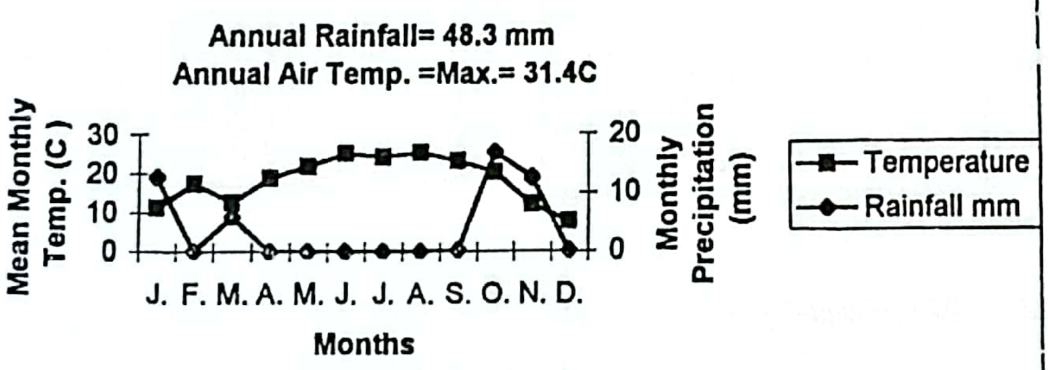


Table (1) :Physical and chemical analysis of the different soil profiles associated with the three studied xerophytic plants.

A : Physical Analysis

Plant/locality	Depth of soil (cm)	Granulometric analysis						Texture class	Field capacity		Saturation percentage		EC mmhos/cm		Total soluble salts %	
		Gravel	Coarse sand	Medium sand	Fine sand	Silt	Clay		Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
		2.1 mm	1-0.5 mm	0.5-0.125 mm	0.25-0.125 mm	0.125 - 0.06 mm	<0.06 3 mm									
Jasonia montana (Upstream part of wadi Sudr)	0-30	21.6	29.4	17.7	17.9	13.6	29	Coarse sand	21	19.1	25	23	1.4	0.6	0.001	0.0003
Juniperus phoenicea (Gebel EL-Maghara locality)	0.30	24.5	29.6	18.6	12.7	11.8	2.8	Coarse sand	17.5	28	19.5	29.5	0.64	7.9	0.0004	0.01
Solenostemma argel (Wadi Wassit locality)	0-30	25.5	35.4	28.4	8.2	1.8	0.7	Coarse sand	16	24	17	21	0.9	0.34	0.002	0.001

B: Chemical Analysis :

Plant/locality	Depth of soil (cm)	pH		Total carbonic%		Organic carbon %		Humus g%		Chlorides g%		Sulphates g%		Sodium g%		Potassium g%		Calcium g%		Magnesium g%		Phosphorus g%		Nitrogen g%	
		Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Jasonia montana (Upstream part of wadi Sudr)	0.30	7.73	[illegible]	[illegible]	[illegible]	[illegible]	0.05	0.16	[illegible]	0.02	[illegible]	0.004	0004	0002	[illegible]	[illegible]	[illegible]	0.02	0001	0.01	[illegible]	[illegible]	[illegible]	.A04	0.04
Juniperus phoenicea (Gebel EL-Maghara locality)	0.30	7.33	7.1	41.8	33.3	0.24	0.26	0.41	1.43	0.02	0.1	.A 001	0002	.002	0.06	0003	[illegible]	0.01	[illegible]	[illegible]	0.04	[illegible]	[illegible]	0.1	0.04
Solenostemma argel (Wadi Wassit locality)	0.30	7.76	7.70	2.41	3.0	0.24	[illegible]	0.04	.002	0.01	0.01	.003	.003	[illegible]	.004	0004	[illegible]	.001	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.2	0.04

Table (2): Seasonal variation in succulence and metabolism of *Artemisia judaica*, *Capparis cartilaginea* and *Gomphocarpus sinaicus* plants.

Measurements	Plants / Season	*Artemisia judaica* Autumn	*Artemisia judaica* Winter	*Artemisia judaica* Spring	*Artemisia judaica* Summer	*Capparis cartilaginea* Autumn	*Capparis cartilaginea* Winter	*Capparis cartilaginea* Spring	*Capparis cartilaginea* Summer	*Gomphocarpus sinaicus* Autumn	*Gomphocarpus sinaicus* Winter	*Gomphocarpus sinaicus* Spring	*Gomphocarpus sinaicus* Summer
	Succulence	1.60	1.68	3.3	1.83	3.2	3.8	3.0	2.6	1.3	2.4	2.9	3.3
Pigments (mg/g F. wit)	Chlorophyll a	5.3	5.88	7.2	6.4	0.12	2.2	0.9	3.7	3.6	7.4	5.4	8.6
	Chlorophyll b	1.4	4.08	2.7	4.9	0.89	0.1	1.1	2.9	1.4	5.8	2.8	4.5
	(a+b)	6.70	9.96	9.9	11.22	1.01	2.3	2.02	6.64	4.9	13.3	8.2	13.1
	Carotenoids	0.93	1.68	2.4	0.06	0.95	0.52	3.2	0.42	0.17	3.6	1.9	0.8
	Total pigments	7.6	11.6	12.4	11.28	1.96	2.80	5.2	7.1	5.1	16.9	10.2	13.9
Carbohydrates (mg/100g D. wit)	Reducing sugars	1120	1365	2482	1982	2016	1729	1689	1988	2464	2912	1281	2485
	sucrose	2530	2129.4	2683	2324	2721	1638	3042	2504	1108	245.7	1083	1789
	Polysaccharides	5712	8960	11760	8330	6664	11200	11760	16184	4284	11200	9072	8568
	Total carbohydrates	9325	12454	16928	12612	11401	14567	16491	20670	7856	14357	11436	12842
Nitrogen (mg/100g D. wit)	Soluble-N	640	880	800	800	1060	1000	1200	1880	750	1600	1120	1560
	Protein-N	1360	1680	1400	1400	500	1180	1400	920	1150	700	580	520
	Total-N	2000	2560	2200	2200	2100	2180	2600	2800	1900	2300	1700	2080
Nucleic acid (mg/100g D. wit)	DNA	24.4	35.8	29.6	22.8	19.2	21.6	25.6	20.8	31.2	20	28	28
	RNA	66	312	240	96	270.0	360.0	384.0	336.0	288	102	240	108
Enzyme Activity/g fresh wt/hour	RN-ase	3.38	2.13	1.87	2.55	2.4	1.25	1.25	1.5	2.2	3.1	1.9	3
	Polyphenoloxidase	12.0	11.25	13.5	6.0	16	15	20.3	22.8	11.3	15.8	18.8	9.6
	Peroxidase	21	25.5	18.8	14.4	30	37.5	28.5	42	26	30	24	22
	IAA-oxidase	63	47.3	110	128	120	131.1	52.2	127.6	141	89	158	84
	Catalase	337.5	412.5	450	300	300	262.5	412.5	348	263	300	450	240
Total alkaloid	g/kg						0.03		0.04		0.04		0.05
Total phenols	mg/100g	74	118.4	29.8	133.2	133.2	100.2	88.8	90.0	207	266	148	296
Ion contents (mg/100g D. wit)	Ash	22.8	22.0	23.0	27.3	24.2	18.4	22.7	30.0	23	23	24	28
	Na^{+}	80	90	100	60	1340	1320	500	940	106	180	125	110
	K^{+}	142	42	125	168	96	52	145	196	100	51	103	148
	Mg^{++}	194.14	279.7	1337	575.9	1102	740.5	1275.4	2287.5	609	318	658	789
	Ca^{++}	3467	3800	7166.6	7200	5200	5332	8166	4800	4801	4798	6683	4800
	P^{+++}	875	937.5	1562.5	1125	1125	1063	1250	1750	900	963	1563	1200
	B^{++}	21	14	38.5	24.5	28	17.5	39.3	29.7	29.7	10.5	32.8	26.2
	Fe^{+++}	25.8	37.63	69.99	12.90	10.75	19.35	16.13	6.46	17.2	37	35	17
	Cl^{-}	681.6	479	959	799	859.1	653.2	1065	653.9	816	852	816.5	994
Amino acids (mg/100g D. wit)	Aspartic acid	-	100	-	920	-	640	-	710	-	990	-	690
	Threonine	-	50	-	330	-	140	-	110	-	240	-	220
	Serine	-	40	-	280	-	150	-	130	-	260	-	220
	Glutamic acid	-	110	-	770	-	460	-	360	-	750	-	970
	Proline	-	314	-	294	-	250	-	270	-	252	-	370
	Glycine	-	50	-	350	-	240	-	220	-	330	-	280
	Alanine	-	50	-	330	-	186	-	130	-	270	-	250
	Cystein	-	-	-	060	-	050	-	050	-	060	-	060
	Valine	-	70	-	360	-	170	-	120	-	270	-	290
	Isoleucine	-	50	-	270	-	110	-	130	-	240	-	220
	Leucine	-	80	-	530	-	230	-	180	-	510	-	400
	Tyrosine	-	20	-	150	-	080	-	070	-	180	-	120
	Phenylalanine	-	40	-	340	-	150	-	120	-	300	-	260
	Histidine	-	20	-	120	-	700	-	070	-	110	-	110
	Lysine	-	50	-	390	-	180	-	170	-	300	-	240
	Arginine	-	90	-	290	-	130	-	120	-	590	-	180

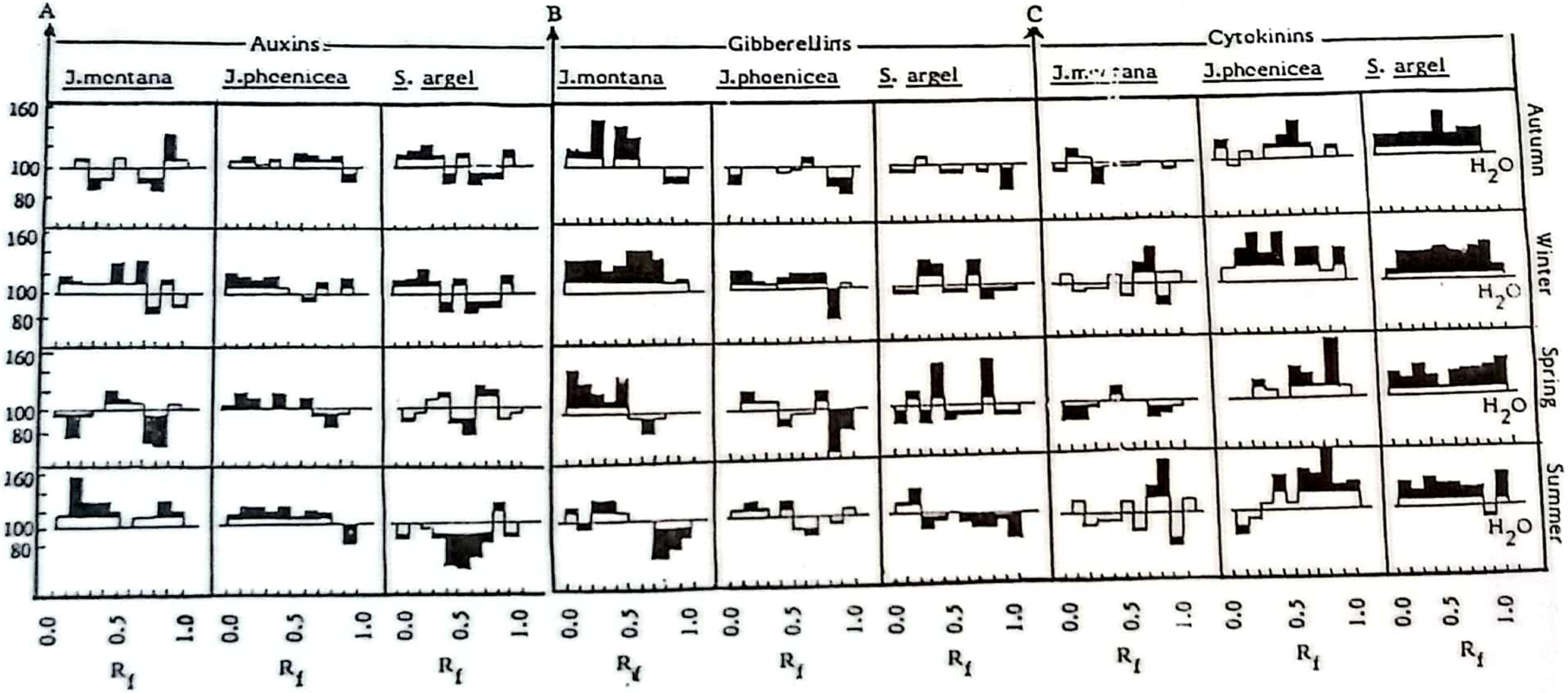


Fig. (1) : Seasonal variations in auxins, gibberellins, cytokinins and their inhibitor contents of *Jasonia montana*, *Juniperus phoenicea* and *Solenostemma argel*.

N.B. Y axis of A represents: Mean length of coleoptile sections as % of control.
Y axis of B represents: Mean length of first leaf sections of sorghum as % of control.
Y axis of C represents: Mean area of cotyledonary leaf sections as % of control.

***1- Artemisia judaica*:**

During autumn, the lowest contents of Ca^{2+}, P^{3+} and Mg^{2+} were associated with the lowest values of photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids), total carbohydrates, soluble-N, protein-N, total-N and nucleic acid (RNA and DNA) contents (Table 2). The lowest value of RNA was accompanied by the highest activity of RN-ase enzyme. The present work clearly shows that the level of growth promoters including auxins, gibberellins, cytokinins and growth inhibitors varied greatly, during the different seasons.

During winter, the soluble-N, protein-N, total-N, RNA and DNA contents increased to their maximum values. Concomitantly, RN-ase activity recorded relative low values (Table 2). Also, 16 amino acids were detected in the leaves of *A. judaica* (Table 2) . The content of each shows a remarkably high value as compared with that during summer especially aspartic and glutamic acids which reached the highest values of all amino acids.

In addition, the lowest ash content (22.0 mg/100 g) was estimated where the EC and the total soluble salts of the associated soil extract attained low values of 1.33 mmhos/cm and 0.004 g %, respectively. This was accompanied with the lowest Mg^{2+} and markedly low values of Ca^{2+}, P^{3+}, Cl^{-}, K^{+} and SO_4^{2-} (Table 1).

In spring, the mineral composition was characterized by the accumulation of Na^{+}, Fe^{3+}, P^{3+}, B^{+} and Mg^{+} as well as Cl^{-} (Table 2). Moreover, attainment of the highest succulence was associated with the highest contents of pigments and reducing sugars, sucrose, polysaccharides and consequently the total carbohydrates. Marie (1988) concluded that the accumulation of electrolytes and non-electrolytes or higher concentrations of chlorophyll and carotenoides together with the development of succulence, seem to be essential responses in the adjustment of saxicolous species (Al-Tantawy, 1983; and Youssef, 1994).

Regarding enzyme activity during spring, Table (2) indicated that catalase and polyphenol oxidase attained the highest activities, RN-ase activity was reduced and associated with the highest value of RNA. Similarly, the highest value of polyphenol oxidase was accompanied by the lowest value of total phenol. In this regard, Dwivedi *et al.* (1979) reported that activities of many enzymes were shown to be affected by water stress in different plants. Lukicheva (1968) reported that drought increased catalase activity.

During summer, *A. judaica* tended to accumulate maximum level of K^+ and Ca^{2+}, (Table 2). The role of potassium as an osmoregulatory cation has been widely reviewed (Walter and Standelsmann, 1974). Wyn Jones and Pollard (1983) found that K^+ ions, fulfill a number of interrelated and integrated roles in the activation of enzymes involved in turgor, volume, osmotic regulation, in membrane linked energy conservation and in cytoplasmic pH regulation. Ash contents reached the maximum value during summer season, and proline content attained its highest level, while other amino acids greatly decreased and cysteine was hardly detected. These results agree with those obtained by Ahmed and Girgis (1979), Marie (1988), Hussein (1988) and Fahmi (1990). Furthermore, Daniel *et al.* (1991) found that the amount of proline under drought stress was 3 to 4 fold higher than in unstressed conditions. Proline was proposed to act as an osmoticum.

It has been also found that the summer season was characterized by the presence of the highest values of total phenols and IAA-oxidase activity and the lower amounts of DNA, RNA and activities of polyphenol oxidase, peroxidase and catalase enzymes.

Under drought conditions (summer), the highest ash content (Table 2) was accompanied by high values of EC and total soluble salts of the saturated soil extract. In addition, plants retained the highest contents of Na^+, Ca^{2+}, Mg^{2+}, available phosphorus and Cl^-. The role of mineral ions in osmotic adjustment, creating a favourable osmotic gradient has been early reviewed (Abd El-Rahman *et al.*, 1975 ; El-Monayeri *et al.*, 1982 ; Al-Tantawy, 1983; Hussein, 1988 and Fahmi, 1990).

Concerning the seasonal changes in endogenous phytohormones, the highest auxin activity was recorded in the shoot extract of *J.montana* during winter while the lowest one was observed during summer. The extract of *A.judaica* during winter contained at least 4 fractions having auxin activities. All fractions, except the first one, contain auxin of indole nature according to their chemical reactions (Table 3).

The fractions having R_f values of 0.4–0.6 coincided with the R_f value of the authentic indole-acetic acid (IAA). The same extract contained one inhibiting fractions (R_f: 0.9–1.0) that appeared to be an unsaturated lactone compound having at least one hydroxyl group, since it gave positive chemical colour reactions.

During summer, the auxin contents sharply decreased to their minimum levels as the extract contained two fractions of significantly active indole auxins (R_f: 0.2–0.5 and 0.5–0.7) and three fractions containing auxin inhibitors (R_f: 0.0–0.2, 0.7–0.8 and 0.8–1.0). The first inhibitor appeared to be a phenolic compound according to its chemical colour reaction (Fig. 2 and Table 3) while the second inhibitor seemed to be abscisic acid (ABA). The third growth inhibitor appeared to be an unsaturated lactone compound having at least one hydroxyl group.

Concerning the seasonal variation in gibberellin contents of *A. judaica* (Fig. 2 and Table 3) it has been found that the biological activities of gibberellins were relatively low during the different seasons. Moreover the gibberellin inhibitors were shown to be much higher in autumn and winter than in spring and summer. Therefore, the highest level of biologically active gibberellin was found in the extract during summer.

As regards the seasonal variation in cytokinin contents (Fig. 2 and Table 3), those contents were shown to be much higher during autumn, reached maximum level during winter and decreased sharply during spring and summer. Moreover, a very biologically active cytokinin inhibitor appeared at R_f: 0.3–0.5 during summer.

Therefore, one of the most adaptive response of *A. judaica* in the winter season is to increase the levels of auxins and cytokinins and to decrease the levels of growth inhibitors. This accompanied with the increases in the values of DNA, RNA, free amino acids, total-N and total carbohydrates cause an increase in the biosynthetic capacity of the cells which increase the osmotic uptake of water to maintain swelling force against the softening cell walls (Muller and Leopold, 1966). On the other hand, decreases of auxins and cytokinins, concomitantly with the increases of ABA (Itai and Benzioni, 1976 ; El-Telwany, 1987; and Hassanein *et al.*, 1989) and accumulation of total phenols, during the dry season of *A. judaica* are considered to be other adaptive responses for drought during the summer season.

2- Capparis cartilaginea:

Table (2) indicated that during autumn *C. cartilaginea* attained the lowest values of some metabolites (*e.g.* DNA, RNA, protein-N, total-N, pigments, polysaccharides and total carbohydrates) while reducing sugars and total phenols attained the highest values. Furthermore RN-ase enzyme reached the highest value (2.4).

Hassanein and El-Telwany (1989-b) reported that the most effective physiological characteristics and safeguard against drought injury in radish plants is the presence of high levels of reducing sugars, which lead to a drop in the osmotic potential of roots that enable the plants to absorb their requirements of water from soils suffereing from water deficiency. Similar results were also obtained by Abdel Aal and Nasser (1993).

Also, Na^{+} reached the highest content in the plant material whereas during autumn the mineral ions attained relatively high values suggesting that sodium plays an important role in maintaining a favourable water balance (Waisel, 1972).

In this season (autumn), cytokinin and GA_3 contents reached relatively high levels. In contrast auxins attained the lowest value which was associated by a relatively high value of IAA-oxidase (Letham *et al.*, 1989).

During winter, *C. cartilaginea* showed relatively high activity compared with autumn, where succulence reached its maximum value (3.8). Meanwhile, total pigments, total sugars, protein-N, total-N, DNA and RNA obtained relatively high values. At this time, catalase and polyphenol oxidase activities reached the lowest values (see Table 2) and IAA-oxidase reached the highest value (131.1). These results are in accordance with those obtained by Mall *et al.*(1981).

Furthermore, K^{+}, Mg^{2+}, P^{3+}, B^{+} and Cl^{-} attained the lowest values during the winter season (winter), while Fe^{3+} attained the highest value (19.35 mg/100g). It is well known that a large proportion of iron is associated with porphyrin enzymes such as cytochromes, peroxidase and catalase (Epstein, 1972).

The amino acid composition showed some variation during winter. While aspartic acid, proline, cysteine and isoleucine attained low values, the rest of the amino acids had higher values, as compared with those detected in summer, in particular histidine which reached the highest value among all amino acids (700 mg/100g). Jones *et al.* (1980) and Wyn-Jones (1981) reported that amino acids are involved in osmotic adjustment of the cytoplasm. The amount and source of nitrogen available for the synthesis of amino acids directly affects the synthesis of phytohormones (cytokinin and IAA) which are all derived from amino acids (Hale and Orcutt, 1987). In this regard, indole auxins (R_f: 0.2–0.4 , 0.4–0.6 , 0.6–0.8 and 0.9–1.0) and a cytokinin of purine nature (R_f: 0.3–0.5) had relatively high activity in the extracts of *C.cartilaginea* during winter (Fig. 2 and Table 3). Alkaloids attained value of 0.03 g/kg tissue during this season.

Data presented in Table (1) concerning the soil analysis indicated that humus content and total N attained the highest values (0.62 and 0.1 g % respectively). Moreover, Ca^{2+} and SO_4^{2-} reached the highest values and Mg^{2+} attained the lowest value (0.01g %).

In spring, *C. cartilaginea* attained the highest values of sucrose, DNA, RNA and also the highest values of Ca^{2+}, Cl^- and B^{2+} (8166.6 , 1065 and 39.3 mg/100g). The role of Ca^{2+} in membrane-phytohormone interaction is important to the physiology of the plant. Cramer *et al.* (1985) reported that Ca^{2+} also protects against membrane damage induced by Na^+ accumulation which may act through displacing Ca^{2+} in the plasma membrane.

In the present study while IAA oxidase, peroxidase and RN-ase attained the lowest values, catalase enzyme reached the highest value (412.5). Growth promoters, auxins, cytokinins and GA_3 reached their highest activities during spring and the amount of rainfall was also the highest during this season.

In the following dry season (summer), total pigments, polysaccharides and total carbohydrates attained the highest values. Similarly soluble-N and protein-N reached the highest values. In addition, aspartic acid, isoleucine and proline reached maximum values during this season. Furthermore, the total alkaloids detected during the summer season reached a value of 0.04 g/kg. In this regard, one can suggest that, the increase in soluble-N, particularly the amino acids in *C. cartilaginea* during the dry season (summer), creates a higher osmotic gradient between plants and soil, a phenomenon which stimulates the upward translocation of water. Ahmed and Girgis (1979), concluded that xerophytes depend, to a large extent, on the accumulation of organic intermediate in building up their osmotic pressure. Similarly, Stewart and Lee (1974), Flowers *et al.* (1977), Osmond *et. al.* (1980), Larcher *et al.* (1982), Rhodes *et al.* (1986) and Mossallam (1993) reported that proline plays an important role in osmotic adjustment of plants under various stress conditions.

Consistent with osmotic adjustment, *C. cartilaginea* accumulated the maximum values of ash content, K^+, P^{3+} and Mg^{2+}. Hussein (1988) concluded that there is a relation between ash content and the accumulation of certain electrolytes which varied according to the species.

During this season (summer) *C. cartilaginea* contained the highest levels of auxins, accompanied by relatively high contents of gibberellins and cytokinins. Muller and Leopold (1966) and Mossallam (1993) reported that auxins, gibberellins and cytokinins act as mobilizing agents directing the movement of numerous substances to areas of the plant containing relative high levels of growth substances.

Under xeric habitats *C. cartilaginea* soil conditions attained the maximum value of EC (19 mmhos/cm), associated with the highest values of total soluble salt, Cl^- and Mg^{2+}. Meanwhile total nitrogen, humus and organic carbon were low in the soil profile supporting *C. cartilaginea*.

3- Gomphocarpus sinaicus:

Data in Table (2) indicate that accumulation of the highest values of DNA, RNA and protein-N were attained during autumn, while photosynthetic pigments, polysaccharides, total carbohydrates and soluble-N decreased to their lowest values. In addition, ash content, Cl^- , Na^+ and P^{3+} reached the lowest values during this season with the minimum value of succulence.

The increase in DNA and RNA concomitantly with the increase in protein-N and decrease in RN-ase activity can be attributed to the presence of relatively high levels of auxins and gibberellins (Fig. 2). This feature of *G. sinaicus* during autumn was induced by large amounts of rainfall (16.9 mm in 6 days, see Fig. 1).

In winter, values of photosynthetic pigments, reducing sugars, polysaccharides, total carbohydrates, soluble-N and total-N sharply increased (Table 2). Similarly, amino acids accumulated to high levels, in spite of levels of glutamic acid, proline and valine being low (750, 252 and 270 mg/100 g, respectively) as compared with those recorded in summer. Total phenols reached 266 mg/100g (a relatively high value). In contrast, sucrose, DNA, RNA and protein-N showed low values associated with the highest activity of RN-ase and peroxidase enzymes. Moreover, the alkaloid content of *G. sinaicus* reached a value of 0.04 g/kg of plant tissue.

However, the presence of low content of sucrose concomitantly with the highest content of reducing sugars and total carbohydrates could be attributed to increas activity of invertase. This hydrolytic activity could be induced by the presence of high content of gibberellins in *G. sinaicus* during winter. Therefore, the accumulation of the hydrolytic organic products in addition to the total phenolic compounds (involved in osmoregulation) could be ascribed to the increased ability of *G.sinaicus* plants to cope with drought stress or it could be due to the adaptabiliy of the plant to water deficiency (Wyn Jones and Gorham, 1983 ; Hassanein and El-Telwany, 1989 a and b and Abdel Kader, 1995).

During spring, the auxin contents decreased to relatively low levels (Fig. 2) concomitantly with the appearance of two growth inhibitors (R_f: 0.0–0.1 and R_f : 0.7-0.8). All active auxins are of indole nature according to their chemical colour reactions, while the first inhibitor might be an unsaturated lactone compound having at least one hydroxyl group (Table 3). The second inhibitor appeared to be ABA. Moreover, gibberellin contents were still very high, while cytokinin contents were relatively low.

The total phenol content reached a minimum value of 148 mg /100 g associated with the maximum value of polyphenol-oxidase. Meanwhile, catalase and IAA-oxidase recorded the highest activities (Table 2). Most phenolic compounds appeared to be auxin-oxidase cofactors. Monophenols, diphenols and polyphenols are interconvertible in the cell according to the environmental conditions (Krishnamorthy, 1981).

During spring, the mineral contents including Ca^{2+}, P^{3+}, B^{+} reached the highest value while K^{+} attained a relative high value (Table 2).

The following dry summer, was associated with the highest levels of sucrose, glutamic acid, valine, proline and total phenol contents. Total alkaloids reached a value of 0.05 g/kg of tissue in this season. This was associated with relative high levels of auxins and cytokinins and an appreciable level of gibberellins. In accordance with these results, Turner *et al.* (1978) and Abdel Kader (1995) detected a decrease in the polysaccharide content accompanied by an increase in hexoses and sucrose in response to water stress. They attributed their results to an increase in amylolytic activities under stress conditions. Furthermore, Stewart *et al.* (1966) suggested that proline may act as a storage compound for energy. Kramer (1983) pointed out that proline accumulated in response to water stress because water stress stimulates its synthesis from glutamate by loss of feed back inhibition, decreases the rate of proline oxidation and decreases its incorporation. Ash, Cl^{-}, K^{+} and Mg^{2+} contents accumulated to their highest values concomitantly with the highest succulence during the summer season.

Table (4) Chemical tests of indole compounds , gibberellin compounds, purine substances having cytokinin activity and certain growth inhibitors in the shoot extracts of *Jasonia montana*, *Juniperus phoenicea* and *Solenostemma argel* plants during the four season of the year

Plant / Season / Reagent	*Jasonia montana*				*Juniperus phoenicea*				*Solenostemma argel*			
	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
Ferric chloride perchloric acid	Rf 0.0-0.2 0.2-0.4 0.6-0.8 0.8-1.0	Rf 0.0-0.2 0.4-0.6 0.8-.04	Rf 0.4-0.6 0.9-1.0	Rf 0.1-0.2 0.2-0.4 0.4-0.5 -.8-1.0	Rf 0.0-0.2 0.2-0.4 0.4-0.6 0.6-0.8 0.8-0.9	Rf 0.0-0.2 0.2-0.4 0.4-0.6 0.7-0.8 0.9-1.0	Rf 0.0-0.2 0.2-0.4 0.4-0.5 0.6-0.7	Rf 0.0-0.2 0.2-0.4 0.4-0.6 0.6-0.8	Rf 0.0-0.2 0.2-0.4 0.5-0.6 0.6-0.8 0.8-1.0	Rf 0.0-0.2 0.2-0.4 0.5-0.7 0.9-1.0	Rf 0.0-0.2 0.2-0.4 0.6-0.8	Rf 0.7-0.9
Ethanolic ferric chloride	Rf 0.4-0.6 0.6-0.85	Rf 0.6-0.8 0.8-1.0	Rf 0.0-0.2 0.2-0.4 0.6-0.8 0.8-0.9	Rf -ve	Rf 0.8-1.0	Rf 0.8-1.0	Rf 0.6-08 0.8-1.0	Rf 0.8-1.0	Rf 0.4-0.5 0.6-0.8	Rf 0.0-0.2 0.6-0.9	Rf 0.0-0.2 0.4-0.6 0.8-1.0	Rf 0.4-0.5 0.6-0.8
$KMNO_4$ Solution	Rf 0.0-0.2 0.2-0.4 0.4-0.6 0.6-0.8 colour reduced	Rf 0.0-0.2 0.2-0.4 0.4-0.6 0.6-1.0 colour reduced	Rf 0.4-0.6 0.6-0.8 0.8-1.0 colour reduced	Rf 0.0-0.2 0.2-0.4 0.4-0.6 0.6-1.0 colour reduced	Rf 0.6-0.8 0.8-1.0	Rf 0.5-0.7 0.7-0.9	Rf 0.6-0.8 0.8-1.0	Rf 0.8-1.0	Rf 0.2-0.4 0.4-0.5 0.6-0.8 colour reduced	Rf 0.8-1.0 colour reduced	Rf 0.1-0.3 0.3-0.5 0.5-0.7 0.7-1.0 colour reduced	Rf 0.0-0.2 0.4-0.6 0.6-0.8 colour reduced
Diazotized-p-nitro aniline	Rf 0.0-0.2 0.2-0.4 0.4-0.6	Rf 0.0-0.2 0.2-0.4 0.6-0.8 0.8-1.0	Rf 0.0-0.2 0.2-0.4 0.4-0.5	Rf 0..0-0.1 0.2-0.4 0.4-0.6 0.6-0.8	Rf 0.8-1.0	Rf -ve	Rf 0.8-1.0	Rf 0.8-1.0	Rf 0.4-0.6 0.6-0.8 0.8-1.0	Rf 0.4-0.5 0.6-0.8	Rf 0.0-0.2 0.4-0.6 0.8-1.0	Rf 0.0-0.2 0.2-0.4 0.4-0.6 0.8-0.9
Concentrated H_2SO_4	Rf 0.2-0.4 0.6-0.8	Rf 0.9-1.0	Rf 0.0-0.2 0.8-0.9	Rf -ve	Rf -ve	Rf 0.6-0.7	Rf 0.7-0.8	Rf -ve	Rf 0.6-0.8	Rf 0.6-0.9	Rf -ve	Rf 0.6-0.8
Antimony Tri-chloride in chloroform (20%)	Rf 0.6-0.8	Rf 0.7-0.8	Rf 0.7-0.8	Rf -ve	Rf 0.6-0.8	Rf 0.0-0.2 0.4-0.6 0.6-0.8 0.9-1.0	Rf 0.0-0.2 0.2-0.4 0.4-0.6 0.7-0.8	Rf 0.0-0.2 0.2-0.3 0.4-0.5 0.9-1.0	Rf 0.2-0.4	Rf 0.2-0.4 0.6-0.7	Rf 0.1-0.2 0.3-0.4 0.7-0.8	Rf 0.0-0.2
Silver nitrate/ Potassium dichromate	Rf 0.1-0.3	Rf 0.0-0.1 0.4-0.5 0.6-0.8 0.9-1.0	Rf 0.4-0.6	Rf 0.0-0.1 0.4-0.5 0.6-0.8 0.9-1.0	Rf 0.0-0.1 0.4-0.6 0.6-0.8 0.9-1.0	Rf 0.0-0.1 0.2-0.55 0.6-0.8 0.9-1.0	Rf 0.2-0.4 0.5-0.7 0.7-1.0	Rf 0.2-0.4 0.4-0.6 0.6-0.8 0.8-1.0	Rf 0.0-0.2 0.2-0.4 0.4-0.6 0.8-1.0	Rf 0.0-0.2 0.2-0.4 0.4-0.6 0.8-1.0	Rf 0.0-0.2 0.2-0.4 0.4-0.6 0.8-1.0	Rf 0.0-0.2 0.2-0.4 0.4-0.6 0.8-1.0

Soil analysis during this period showed that total carbonate and sodium contents reached high levels, whereas EC, total soluble salts, humus, organic carbon and other estimated mineral ions attained low values. The above results suggest that the adaptability of *G. sinaicus* to drought stress during summer is through increasing auxins, gibberellins and cytokinins concomitantly with increases in ash, Cl^-, K^+, Mg^{2+}, sucrose, certain amino acids, total phenols and total alkaloid levels. All these metabolites participate in decreasing the osmotic potential of plant cells, on one hand and inducing functional changes in different facets of the metabolism, on the other hand .

Finally, one can conclude that although the studied plants belong to one ecological group; lithophytes, there were wide differences in metabolic activities indicating the wide range of adjustment mechanisms experienced by such a group of plants under comparable habitat conditions. Such mechanisms were regulated by seasonal variation in endogenous phytohormones, auxins, gibberellins, cytokinins, ABA and phenolic inhibitors.

Auxins, gibberellins and cytokinins were shown in the present work to induce biosynthetic capacity of the cells (*e.g.* photosynthetic pigments, total carbohydrates, total-N, amino acids and total phenols) and/or to induce the transport of nutrients and electrolytes and to accumulate them in the plant tissues. This in turn can reduce the osmotic potential of the cells and consequently increase water uptake to maintain the water status of plants. However, the reduction of auxins, gibberellins and cytokinins, and the increase of ABA and phenolic inhibitors, maintained the water status by closing the stomata and/or by minimizing the transpiring surface.

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دراسات بيئيه فسيولوجيه على بعض نباتات البيئات الصخريه الناميه فى سيناء - مصر .

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يهدف هذا البحث محاولة اكتشاف الميكانيكيات التى يمكن عن طريقها تأقلم بعض النباتات الجفافيه ومقاومة الظروف الجفافيه للبيئة المحيطة بها خلال جميع فصول السنة وذلك بدراسة ثلاث أنواع من النباتات الطبية الجفافيه وهى :

الشيح *Artemisia judaica*
والليصوف *Capparis cartiaginea*
(اللصف) والغيل *Gomphacarpus sinaicus*

والتى تنمو فى المنحدرات الجبلية لوادى سدر (الشيح والليصوف) وفى البيئات الصخرية بوادى الشيخ بسانت كاترين (الغيل) فى شبه جزيرة سيناء.

أظهرت النتائج أن أعلى درجات العصارية وأعلى كمية للرماد النباتى امكن الحصول عليها فى نبات الليصوف خلال فصلى الشتاء والربيع على التوالى، كما وجد أن نفس النبات يتراكم به أعلى كميات من الكربوهيدرات الكلية ، المركبات النيتروجينية، الأحماض النووية (DNA, RNA) وبعض العناصر مثل الصوديوم والماغنسيوم والكالسيوم والبورون وأيضاً أعلى مستوى للمواد الفينولية خلال فصل الخريف وذلك بالمقارنة بالنوعين الآخرين من النباتات .

بالنسبة للنشاط الانزيمى فلقد تبين ان انزيمى البولى فينول اوكسيديز والبروكسيديز قد سجلا أعلى نشاط لهما خلال فصل الجفاف (الصيف) فى نبات الليصوف ، وأنزيم الريبونيوكليز (RN-ase) سجل أعلى نشاط له فى كل من نبات الشيح والليصوف فى اثناء فصل الخريف ، أما انزيم اوكسيديز اندول حمض الخليك (IAA-oxidase) فلقد وصل الى أعلى نشاط له فى فصل الشتاء (فى نبات الليصوف) ، فى فصل الربيع (فى نبات الغيل) أو فى فصل الجفاف (فى نبات الشيح) .

عند الكشف عن القلويدات الكلية فلقد أعطت نتائج ايجابية فى فصل الصيف فقط فى كل من نبات الليصوف والغيل.

كما أوضحت النتائج ان هناك تباينا واسعا فى محتوى الهرمونات النباتية الحافزة للنمو فى النباتات التى اجريت عليها هذه الدراسة وأيضا فى محتوى المواد المثبطة للنمو خلال فصول السنة المختلفة . ولقد تبين أن هناك علاقة قوية بين ارتفاع محتوى هذه النباتات من الهرمونات النباتية الحافزة للنمو (اوكسينات ، جبريلينات وسيتوكينينات) من جهة وارتفاع معدلات التفاعلات الايضية النباتية من جهة أخرى مما يؤدى الى ارتفاع محتوى خلايا النباتات بالمواد الغذائية والعناصر المعدنية كما أن هذه الهرمونات تحفز توجيه وانتقال هذه المواد الغذائية المصنعة الى الخلايا مما يؤدى لإنخفاض الجهد الازموزى بها والذى يعمل بدوره على امتصاص الماء بوفرة مما يزيد من الاتزان المائى وفى النهاية يستطيع النبات بهذه الكيفية ان يقاوم موسم الجفاف ، وعلى نحو آخر تعمل الزيادة فى محتوى حمض الابسيسك ABA والمثبطات الفينولية على المحافظة على الاتزان المائى وذلك باختزال مساحة الاوراق وموضعها على النبات .