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Effect of Seed Type, Water Regime and Partial Cutting on the Nutritive Value of *Emex spinosa* (L.) Campd. in Egypt.

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Abstract: The objective of the present study is to investigate the effect of seed type, water regime and partial cutting on the nutritive values of *Emex spinosa* leaf, stem and root at the vegetative, flowering and fruiting stages. Three experiments were carried out in the Experimental Farm of the Faculty of Science, Tanta University (Tanta, Egypt) to study the effect of 3 seed types (aerial light, aerial heavy and subterranean), 3 water regimes (wet, medium and dry) and 3 cutting percentages (25, 50, and 75 %) on the total carbohydrates, nitrogen, crude protein, phosphorus and potassium. Results indicated that plants originated from the subterranean seeds (the heaviest ones) gave the highest values of all nutrients for each organ at each stage, followed by those from the aerial heavy seeds, then the aerial light ones. On the other hand, plants growing under the wet regime gave higher values than those growing under the medium and dry ones. In the different organs of *Emex spinosa*, most of protein, nitrogen, phosphorus and potassium contents increased after being subjected to light cutting (25 %), which can be considered a simulation to the light grazing by the domestic and wild animals. Thus, this process is not only beneficial for flourishing of the fodder plants, but also leads to improve their nutritive value. In general, the comparison between the nutritive values of *Emex spinosa*, as estimated in the present study, and those of some fodder plants naturally growing in the Nile Delta and the Mediterranean coastal desert of Egypt may indicate that this plant is a promising fodder plant.

Key words: nutrients, water stress, seed size, simulated grazing, little Jack, Egypt.

INTRODUCTION

Many plants are of structural and economic importance in arid regions. They play an important role in providing a forage source for animals and fuel for local inhabitants, and have medicinal and potential industrial values (Thalen 1979). Little jack *Emex spinosa* (L.) Campd., an annual member of family Polygonaceae, is a Mediterranean weed. Its distribution in Egypt includes Nile Delta, Eastern and Western Deserts, Oases, Mediterranean Coast and Sinai. It inhabits fields, orchords, gardens, waste ground and canal banks (Boulos & El- Hadidi 1994). *Emex spinosa* is regarded as a minor weed (Holm *et al.* 1979), although it is well suited to the climate of southern Australia, and south-western Australia in particular, it is found also from Arabia to India.

Emex spinosa is edible by the local inhabitants who plucked it and eat its petiole and carrot-like tap root (Mandaville 1990). Its phytochemical screening revealed the presence of alkaloides, anthraquinones, coumarins and flavonoides (Rizk 1986). Five anthraquinone pigments were detected in this plant: chrysophenol, physcion, emodin, a mixture of three (δ- sterols, β- sitosterol, stigmasterol and campesterol) in additional to B- sitosterol and B-D- glucoside (Abdel-Fattah *et al.* 1990). It is one of the important medicinal plants used to relief dyspepsia; stimulate appetite, and a remedy for stomach disorders and to relif colic. It is believed to be purgative and diuretic (Watt & Breyer-Brandwjik 1962).

This paper is the second in a series of studies dealing with the biology of *Emex spinosa* (L.) Campd. in Egypt: the first dealt with the effect of seed type, water regime and partial cutting on its growth variables (Shaltout *et al.* 2008). The present study aims at studying the effect of seed type, water regime and partial cutting (as a simulation to the controlled grazing) on the total carbohydrates, nitrogen, protein, phosphorus and potassium contents of *Emex spinosa* (L.) Campd. organs (leaf, stem and root) at three growth stages (vegetative, flowering and fruiting).

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MATERIALS AND METHODS

Aerial and subterranean seed samples of *Emex spinosa* were collected from Al-Arish at the Mediterranean coast of Sinai. The aerial seeds were divided into two categories depending on the weight of seeds: aerial heavy seeds (≥ 0.2 mg) and aerial light seeds (< 0.2 mg). Seeds were weighed and soaked in distilled water for 48 hours, then put in Petri dishes on one layer of moistened Whatman filter paper. The germinated seeds were transplanted into pots, each of 12 cm diameter and 20 cm height.

Two experiments were carried out in the Experimental Farm of the Faculty of Science, Tanta University, Tanta, Egypt. In the first one seed type (subterranean, aerial heavy and aerial light seeds) and water regime (wet, medium and dry; where irrigation was carried out every 2, 4 and 12 days, respectively) were tested. For each treatment, 6 pots, each of three seedlings, were tested. The total number of the experimental units (i.e. pots) was 108 pots. The experimental design followed the complete random block design. The second experiment was carried out on the aerial heavy seeds subjected to a medium water regime and three cut levels simulating different grazing intensities (25, 50 and 75 %). For each cut level, 6 pots, each of three seedlings, were used. The total number of the experimental units (i.e. pots) was 18 pots. The experimental design followed the complete random design.

Samples of the leaves, stems and roots of *Emex spinosa* were used to determine the average concentration of nitrogen, crude protein, total soluble carbohydrates, potassium and phosphorus. Samples of plant materials were collected at three growth stages (vegetative, flowering and fruiting stages). The samples were cleaned, then oven-dried (60^o C) to constant weights, powdered and prepared for analysis. The total nitrogen was estimated by the micro-kjeldahel method, and the nitrogen content was multiplied by the factor of 6.25 to obtain the crude protein content. Total soluble carbohydrates were determined using anthrone reagent. Phosphorus was determined spectrophotometrically using the standard curve of potassium dihydrogen phosphate. Potassium was determined by Flame photometer adjusted at 405 nm using the standard curve of potassium sulfate. All these procedures are outlined by Allen *et al*., (1986).

The significance of variation in the chemical composition of root, stem and leaves in different stages in relation to the different treatments (seed type, water regime and partial cutting) were assessed using a factorial analysis model. The applications of these techniques were according to Stat-ITCF program (SAS 1985).

RESULTS AND DISCUSSION

The application of two-way analysis of variance (ANOVA-2) indicated that the variation in most nutritive values in the three organs (leaf, stem and root) at the three growth stages (vegetative, flowering and fruiting) of *Emex spinosa* in relation to seed type (aerial light seeds, aerial heavy seeds and subterranean seeds) and water regime (dry, medium and wet) were significant (Tables 1-5). Total carbohydrates varied between 5.1 % at the fruiting stage of the roots of individuals originated from the aerial light seeds and 30.1 % at vegetative stage of the leaves of individuals originated from the subterranean seeds (Table 1). At the flowering stage, the leaf and root had the highest value of nitrogen under the wet water regime (1.3 %); while at the flowering and fruiting stages (Table 2), the stem from the aerial light seeds had the lowest (0.3 %). Crude protein varied between 1.8 % for the stem from the aerial light seeds at the fruiting stage and 8.3 % for the root under wet water regime at the flowering stage (Table 3). At all growth stages, phosphorus of the leaf and root from the aerial light seeds attained the lowest value (0.2 %); while at the flowering stage (Table 4), the stem under the wet water regime had the highest (0.6 %). Potassium varied between 0.3 % for the leaf and stem from the aerial light seeds at the fruiting stage and 1.2 % for the stem from the subterranean seeds at the flowering stage (Table 5).

Regarding the cut treatments, which were applied only at the fruiting stage, the roots of individuals subjected to 25 % cut treatment had the highest value of nitrogen (1.7 %), protein (8.3 %), phosphorus (0.6 %) and potassium (1.1 %), while the stems of those subjected to 75 % had the lowest for all constituents, except the total carbohydrates (Table 6).

In general, the variation in relation to the seed type indicated that the three organs of the individuals originated from the subterranean seeds had the maximum values of all constituents followed by the aerial heavy seeds, then aerial light seeds (Fig. 1). Regarding the variation in water regime, total carbohydrates were the highest under the dry conditions, while the other constituents were the highest under the wet ones (Fig. 2). The variation in relation to the organs indicated that leaf had the highest value of the total carbohydrates at each stage, while the root had the lowest (vegetative > flowering > fruiting). On the other hand, the stem had the lowest values of nitrogen and protein. The three organs attained the highest values of all constituents at the flowering stage, except the total carbohydrates (Fig. 3).

Table 1: Effect of seed type and water regime on the total carbohydrates (%) at three growth stages of *Emex spinosa*. *: P ≤ 0.05, **: P ≤ 0.01 and ***: P ≤ 0.001 according to ANOVA-2. ns: not significant.

Organs	Factor		Growth stage		
			Vegetative	Flowering	Fruiting
Leaf	Seed type (s)	Aerial light	19.3	13.8	11.3
		Aerial heavy	26.1	18.8	16.1
		Subterranean	30.1	21.6	19.1
	Water regime (w)	Wet	21.2	24.8	21.2
		Medium	25.3	29.4	25.7
		Dry	29.0	-	-
	F-ratio	Fs	35.8***	40.4***	148.2***
		Fw	18.2***	650.6***	156.5***
		Fsxw	2.6*	11.3***	40.8***
Stem	Seed type (s)	Aerial light	-	8.7	7.9
		Aerial heavy	-	11.8	10.5
		Subterranean	-	14.0	13.1
	Water regime (w)	Wet	-	15.0	13.8
		Medium	-	19.0	17.7
		Dry	-	-	-
	F-ratio	Fs	-	3.4*	14.0***
		Fw	-	48.6***	175***
		Fsxw	-	ns	3.7**
Root	Seed type (s)	Aerial light	9.1	6.6	5.1
		Aerial heavy	10.7	8.5	6.5
		Subterranean	12.3	9.6	8.5
	Water regime (w)	Wet	8.9	11.3	8.4
		Medium	11.2	13.5	11.7
		Dry	12.1	-	-
	F-ratio	Fs	ns	6.0**	20.3***
		Fw	ns	137.4***	245.9***
		Fsxw	ns	ns	5.7***

Table 2: Effect of seed type and water regime on the nitrogen (%) at three growth stages of *Emax spinosa*. *: P ≤ 0.05, **: P ≤ 0.01 and ***: P ≤ 0.001, according to ANOVA-2. ns: not significant.

Organ	Factor		Growth stage		
			Vegetative	Flowering	Fruiting
Leaf	Seed type (s)	Aerial light	0.5	0.5	0.4
		Aerial heavy	0.7	0.7	0.5
		Subterranean	0.9	1.2	0.9
	Water regime (w)	Wet	0.9	1.3	1.1
		Medium	0.7	1.0	0.8
		Dry	0.6	-	-
	F-ratio	Fs	23.4***	88.7***	60.5***
		Fw	13.9***	331.5***	156.5***
		Fsxw	ns	24.9***	19.2***
Stem	Seed type (s)	Aerial light	-	0.3	0.3
		Aerial heavy	-	0.5	0.4
		Subterranean	-	0.7	0.5
	Water regime (w)	Wet	-	0.8	0.6
		Medium	-	0.7	0.5
		Dry	-	-	-
	F-ratio	Fs	-	46.2***	57.4***
		Fw	-	313.1***	528.6***
		Fsxw	-	12.0***	14.4***
Root	Seed type (s)	Aerial light	0.5	0.5	0.5
		Aerial heavy	0.7	0.7	0.6
		Subterranean	1.2	1.1	0.8
	Water regime (w)	Wet	1.1	1.3	1.0
		Medium	0.8	1.0	0.8
		Dry	0.6	-	-
	F-ratio	Fs	61.8***	23.9***	22.0***
		Fw	27.1***	134.3***	272.8***
		Fsxw	ns	6.5***	6.2***

Table 3: Effect of seed type and water regime on the protein (%) at three growth stages of *Emax spinosa*. *: P ≤ 0.05, **: P ≤ 0.01 and ***: P ≤ 0.001, according to ANOVA-2 ns: not significant.

Organ	Factor		Growth stage		
			Vegetative	Flowering	Fruiting
Leaf	Seed type (s)	Aerial light	3.4	3.1	2.7
		Aerial heavy	4.3	4.1	3.4
		Subterranean	5.9	7.2	5.4
	Water regime (w)	Wet	5.5	8.0	6.6
		Medium	4.6	6.4	4.9
		Dry	3.6	-	-
	F-ratio	Fs	22.4***	64***	59.0***
		Fw	13.3***	250.2***	357.2***
		Fsxw	ns	16.4***	19.1***
Stem	Seed type (s)	Aerial light	-	2.1	1.8
		Aerial heavy	-	3.0	2.4
		Subterranean	-	4.1	3.0
	Water regime (w)	Wet	-	4.9	3.8
		Medium	-	4.3	3.3
		Dry	-	-	-
	F-ratio	Fs	-	45.4***	32.0***
		Fw	-	320.9***	357.5***
		Fsxw	-	11.7***	8.3***
Root	Seed type (s)	Aerial light	3.2	3.3	3.1
		Aerial heavy	4.4	4.4	3.7
		Subterranean	7.7	6.9	5.0
	Water regime (w)	Wet	6.7	8.3	6.5
		Medium	4.9	6.3	5.2
		Dry	3.7	-	-
	F-ratio	Fs	67***	29.4***	21.9***
		Fw	27***	156.9***	272.8***
		Fsxw	3.5*	9.2***	6.2***

Table 4: Effect of seed type and water regime on the phosphorus (%) at three growth stages of *Emax spinosa*. *: P ≤ 0.05, **: P ≤ 0.01 and ***: P ≤ 0.001, according to ANOVA-2. ns: not significant.

Organ	Factor		Growth stage		
			Vegetative	Flowering	Fruiting
Leaf	Seed type (s)	Aerial light	0.2	0.2	0.2
		Aerial heavy	0.3	0.3	0.3
		Subterranean	0.3	0.4	0.4
	Water regime (w)	Wet	0.3	0.5	0.4
		Medium	0.3	0.4	0.4
		Dry	0.3	-	-
	F-ratio	Fs	67.8***	107.4***	189.7***
		Fw	231.1***	675.4***	977.6***
		Fsxw	ns	29.3***	50.8***
Stem	Seed type (s)	Aerial l light	-	0.3	0.3
		Aerial heavy	-	0.3	0.3
		Subterranean	-	0.5	0.4
	Water regime (w)	Wet	-	0.6	0.5
		Medium	-	0.5	0.4
		Dry	-	-	-
	F-ratio	Fs	-	153.4***	26.5***
		Fw	-	1896.9***	554.8***
		Fsxw	-	41.3***	8.8***
Root	Seed type (s)	Aerial light	0.2	0.2	0.2
		Aerial heavy	0.3	0.3	0.3
		Subterranean	0.4	0.4	0.3
	Water regime (w)	Wet	0.4	0.5	0.4
		Medium	0.3	0.4	0.4
		Dry	0.2	-	-
	F-ratio	Fs	77.3***	19.8***	34.6**
		Fw	82.9***	286.1***	351.5***
		Fsxw	2.7*	5.3***	8.7***

Table 5: Effect of seed type and water regime on the potassium (%) at three growth stages of *Emax spinosa*. *: P ≤ 0.05, **: P ≤ 0.01 and ***: P ≤ 0.001, according to ANOVA-2. ns: not significant.

Organ	Factor		Growth stage		
			Vegetative	Flowering	Fruiting
Leaf	Seed type (s)	Aerial light	0.4	0.4	0.4
		Aerial heavy	0.5	0.5	0.4
		Subterranean	0.5	0.7	0.5
	Water regime (w)	Wet	0.6	0.9	0.7
		Medium	0.5	0.7	0.5
		Dry	0.4	-	-
	F-ratio	Fs	13.2***	11.9***	27.5***
		Fw	27.0***	86.1***	743.8***
		Fsxw	ns	3.0*	8.1***
Stem	Seed type (s)	Aerial light	-	0.4	0.3
		Aerial heavy	-	0.5	0.4
		Subterranean	-	1.2	0.8
	Water regime (w)	Wet	-	1.1	0.8
		Medium	-	0.9	0.6
		Dry	-	-	-
	F-ratio	Fs	-	80.8***	114.3***
		Fw	-	150.8***	300.8***
		Fsxw	-	22.6***	31.9***
Root	Seed type (s)	Aerial light	0.6	0.5	0.4
		Aerial heavy	0.7	0.6	0.5
		Subterranean	0.7	0.8	0.6
	Water regime (w)	Wet	0.7	1.0	0.8
		Medium	0.6	0.8	0.7
		Dry	0.6	-	-
	F-ratio	Fs	13.5***	28.4***	115.3***
		Fw	14.8***	448.7***	1510.4***
		Fsxw	ns	12.5***	31.8***

Table 6: Effect of three cut levels on the chemical composition of *Emex spinosa* at the fruiting stage of *Emax spinosa*.*: P ≤ 0.05, **: P ≤ 0.01 and ***: P ≤ 0.001, according to ANOVA-1.

Organ	Cut level	Total carbohy	Nitrogen	Protein	Phosphorus	Potassium
			(%)			
Leaf	Uncut	11.2	0.6	3.6	0.3	0.4
	25	18.7	0.9	5.8	0.4	0.7
	50 (%)	26.6	0.6	3.7	0.3	0.5
	75	32.1	0.6	3.0	0.2	0.3
	Mean	22.2 ± 9.1	0.7 ± 0.2	4.0 ± 1.2	1.0 ±1.4	0.5 ± 0.2
	F-ratio	31.9***	3.4*	6.1***	11.5***	31.4***
Stem	Uncut	7.6	0.3	2.8	0.3	0.3
	25	9.1	0.7	4.6	0.5	1.1
	50 (%)	15.8	0.5	3.0	0.4	0.5
	75	21.8	0.3	2.0	0.3	0.3
	Mean	13.6 ± 6.5	0.5 ± 0.2	3.3 ± 0.9	0.4 ± 0.14	0.6 ± 0.4
	F-ratio	8.8***	24.5***	24.5***	11.1***	11.3***
Root	Uncut	5.1	0.6	3.7	0.3	0.4
	25	8.2	1.7	8.3	0.6	1.1
	50 (%)	11.1	0.8	5.0	0.3	0.5
	75	26.7	0.6	3.6	0.3	0.3
	Mean	12.8 ± 9.6	0.9 ± 0.5	5.2 ± 2.2	0.3 ± 0.1	06 ± 0.4
	F-ratio	16.6***	20.2***	4.5***	12.0***	6.6**

Table 7: Comparison between the range of the nutritive values of *Emex spinosa* and those of some fodder plants as reported in the previous studies.

Variable (%)	Present study (*Emex spinosa*)			Shaltout & El-Beheiry (1997)		El-Kady (1987) (36 species)
	Vegetative	Flowering	Fruiting	Vegetative	Flowering	
P	0.53	0.36	0.34	0.13	0.10	0.01 - 0.40
K	0.25	0.73	0.55	2.60	2.20	0.55 - 3.98
N	0.77	0.82	0.64	2.90	1.40	0.50 - 2.40
Protein	4.90	5.10	4.10	18.10	8.70	2.60 -10.10
Carbohy.	17.90	15.50	13.10	20.60	6.60	2.71 - 5.19

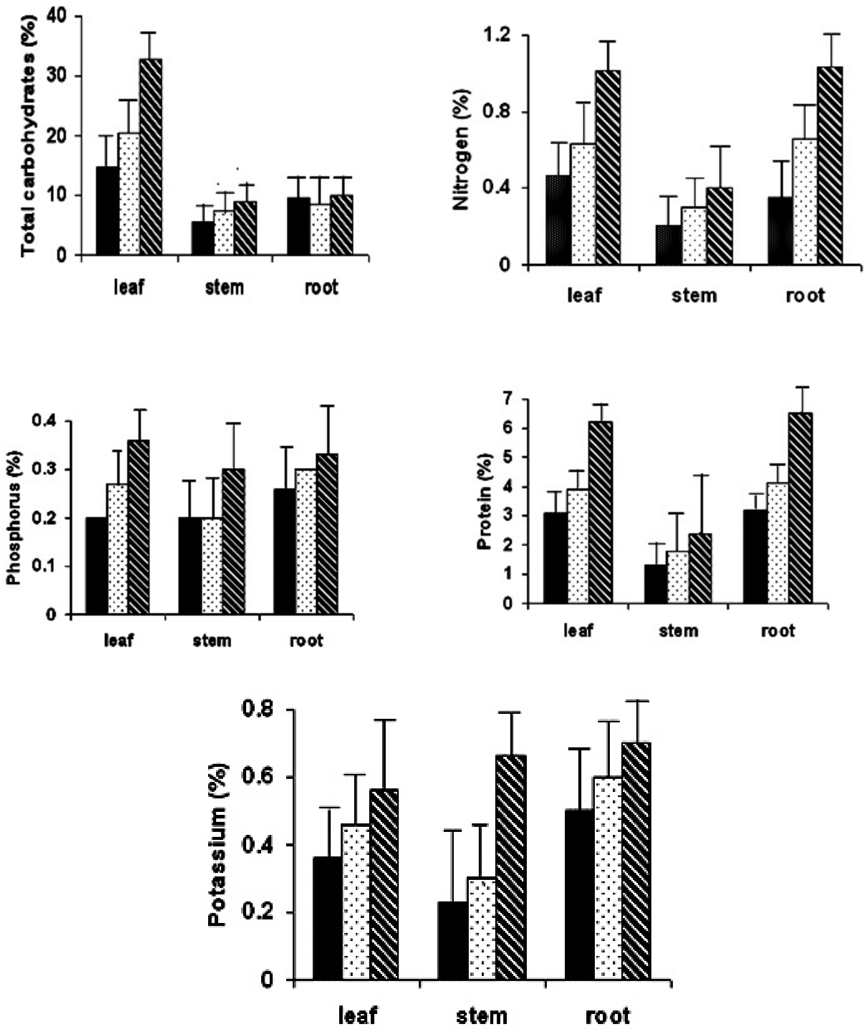

Fig.1: Effect of seed type on the chemical composition of *Emex spinosa* organs: ■ aerial light seeds, ⬚ aerial heavy seeds and ▧ subterranean seeds. Vertical bars indicated the standard deviations of the means.

Discussion:

Empirical studies have shown that seed size can affect seedling survival, growth and establishment (Houssard & Escarré 1991). Harper *et al.* (1970) reported that seed size is an important life-history trait for life prospects of seedlings that stabilizing selection canalizes it to be quite constant within species. This view was later questioned when field studies showed that there is a considerable variation in seed size at the within-individual, within-population and within-species levels (Vaughton & Ramsey 1998). The study of Shaltout *et al.* (2008) indicated that the seed size of *Emex spinosa* affects various growth measures, where the plants originated from the subterranean seeds (the heaviest one) having the highest average of leaf number, leaf length and leaf width compared with the aerial heavy and light ones. The present study indicated that not only the growth variables of *Emex spinosa* were affected by the seed size, but also its nutritive value, where the leaf stem and root of individuals originated from the subterranean seeds achieved the maximum values of the estimated nutrients (carbohydrates, protein, nitrogen, potassium and phosphorus) followed by the aerial heavy seeds, then the aerial light seeds.

Water regime is a most important environmental factor that regulates plant growth and development. Plants respond and adapt to water regime by altering their cellular metabolism and invoking various defense mechanisms. Survival under water stress depends on the plant's ability to perceive the stimulus, generate and transmit the signals, and initiate various physiological and chemical changes (Bohnert & Jensen 1996 and

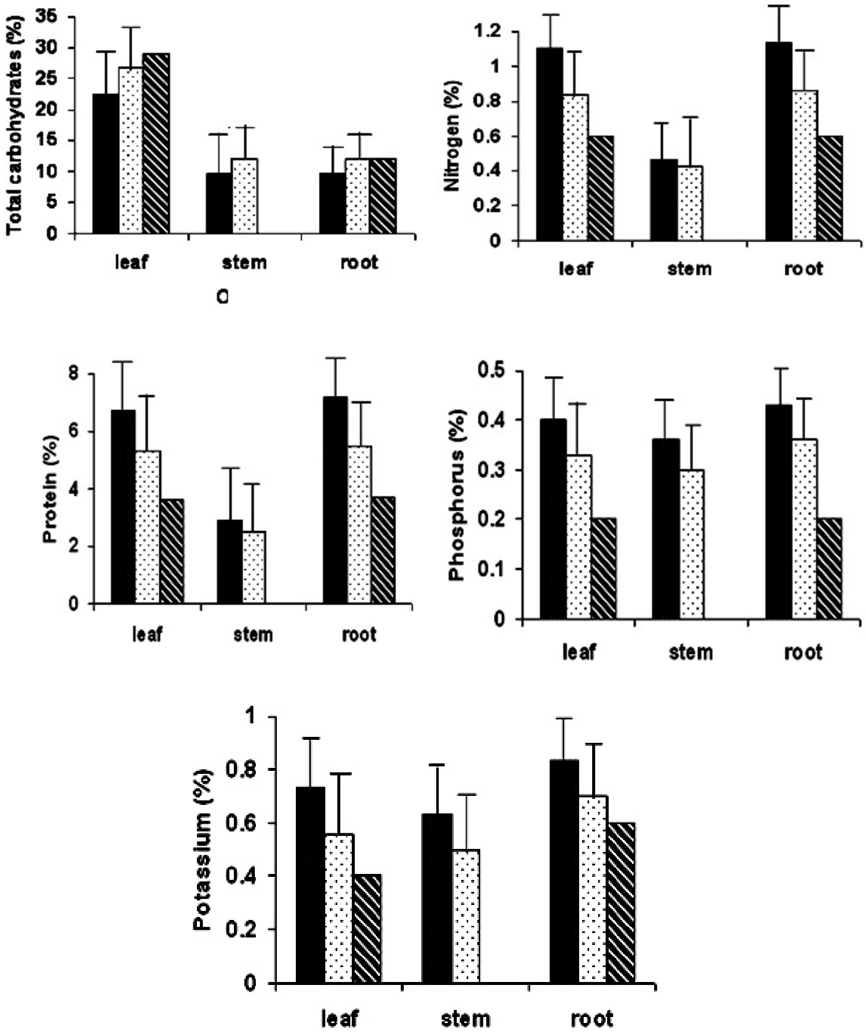

Fig.2: Effect of water regime on the chemical composition of Emex *spinosa* organs: ■ wet, ▨ medium and ▧ dry. Vertical bars indicated the standard deviations of the means.

Shinozaki & Yamaguchi-Shinozaki 1997). In the present study, increasing water content from dry to wet had resulted in increasing N, protein, P and K contents in the leaves, stems and roots of *Emex spinosa* at the three growth stages (vegetative, flowering and fruiting).

The present results do not suggest mechanisms underlying the response of plants to drought, identifying cause and effect is not simple. N accumulation is mainly a function of biomass accumulation because drought results in massive depression of shoot growth. A small successive decrease in N concentration would result in a large decrease in N accumulation. Therfore, it is important to monitor N concentration as an indicator of the impact of drought, but this subject has rarely been reported. The efficacy of mineral N in supporting plant growth and N accumulation of drought stressed plants has been confirmed by some studies (e.g. Minguez & Sau 1989 and Purcell & King 1996), but not by others (e.g. Plies-Balzer *et al.* 1995).

In general, plant responses to water deficits are various, including effects on ion uptake and partitioning, changes in hormonal balance and modification of membranes and proteins (Bohnert *et al.* 1995). Emphasis in recent years has shifted to analyze the drought responses at the level of gene expression and signal transduction (Zhang *et al.* 1999, Rathinasabapathi 2000, Tripathy *et al.* 2000 and Xiong Zhu 2001).

In the present study, most of the nutrient contents in the different organs of *Emex spinosa* (protein. nitrogen, phosphorus and potassium) increased after subjecting to light cutting (25 %). Considering that the partial cutting simulates different grazing intensities of the fodder plants by the domestic and wild animals (Taylor 1972 and Relva & Sancholuz 2000), thus light grazing is not only beneficial for the flourishing of the

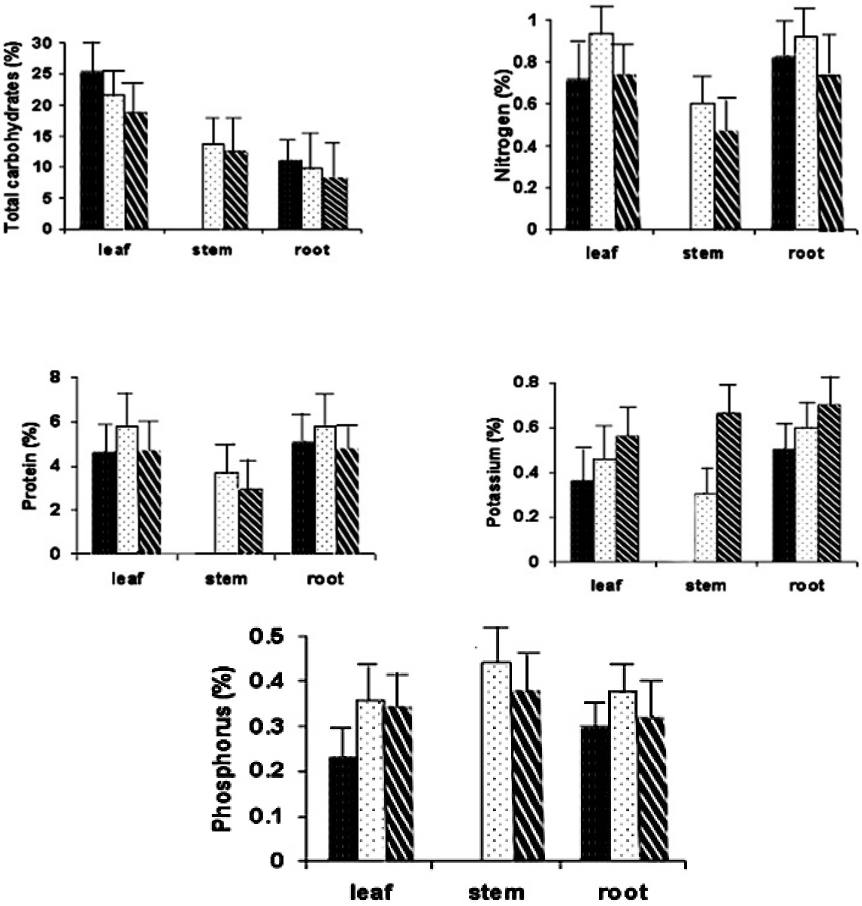

Fig. 3: Chemical composition of Emex *spinosa* organs at three growth stages: veg ■ etative stage, ⊡ flowering stage and ▧ fruiting stage. Vertical bars indicated thestandard deviations of the means.

fodder plants, but also leads to improve their nutritive value. Either full protection of vegetation against grazing or overgrazing often leads to the deterioration of the range plants (Shaltout & El-Ghareeb 1985). Thus it is suggested that partial protection and controlled grazing could be of better consequences to the range plants than full protection. Light nibbling and removal of standing-dead parts by domestic animals may promote vigor and growth of defoliated plants. Also the availability of nutrients (especially nitrogen) may be enhanced by the passage of herbage through their guts and out as feces (El-Kady 1980).

The comparison between the nutritive values of *Emex spinosa*, as estimated in the present study, and those of some fodder plants in the Egyptian Western Mediterranean rangeland (El-Kady 1987) and *Bassia indica*, a promising fodder plant in Egyptian Nile Delta (Shaltout & El-Beheiry 1997), indicated that *Emex spinosa* could be also considered a promising fodder plant (Table 7) as well as edible by the local inhabitants who plucked it and eat its petiole and carrot-like tap root (Mandaville 1990).

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