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Seasonal chemical composition of saltbush in semiarid grasslands of Jordan

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Abstract

Saltbush (*Atriplex halimus* L.), a native shrub which is adapted to arid rangelands, was transplanted to the semiarid grassland at Jordan University of Science and Technology Campus in 1986. Our objective was to determine the seasonal changes in the chemical composition of the annual growth of leaves and stems of saltbush (*Atriplex halimus* L.) during 1995–96 and 1996–97. A strong positive correlation was found among P, Ca, crude protein, and nitrogen free extract and a strong negative correlation was found between fiber and P, Ca, crude protein, and nitrogen free extract. Nitrogen free extract (NFE) had a strong positive linear correlation with P, Ca, and crude protein. P, Ca, Ca:P ratio, crude protein, and NFE contents were found to be higher in leaves than in stems on all the occasions.

Leaves had relatively higher concentrations of P, Ca, crude protein, and NFE during the growing season (February to April). Crude protein of leaves reached its maximum in March (22.7%). The concentrations decreased, however, to 15% during the dry period (June to October). Crude protein content of stems ranged from 11.3 to 12.2%. Fiber content of leaves was lowest during February and March (16.9 to 18%), and reached maximum values during August and October. Saltbush is a good protein source for sheep during the dry season; however, P content would not meet nutritional requirements of ewes.

Key Words: *Atriplex halimus*, crude protein, dry season, ewes, fiber, leaves, Middle East, stems

Resumen

En 1986 se transplantaron arbustos de "Saltbush" (*Atriplex halimus* L.) (una especie nativa adaptada a pastizales áridos) en un pastizal semiárido de la Universidad Científica y Tecnológica de Jordania. Nuestro objetivo fue determinar los cambios estacionales de la composición química del crecimiento anual de hojas y tallos de "Saltbush" (*Atriplex halimus* L.) durante las estaciones de crecimiento de 1995-1996 y 1996-1997. Se encontró una fuerte correlación positiva entre P, Ca, proteína cruda, y extracto libre de nitrógeno. También se encontró una fuerte correlación negativa entre la fibra y P, Ca, proteína cruda, y extracto libre de nitrógeno. El extracto libre de nitrógeno (ELN) tuvo una fuerte correlación lineal positiva con P, Ca y proteína cruda. En todos los muestreos el contenido de P, Ca, la relación P:Ca, proteína cruda, y ELN fueron mayores en hojas que en tallos.

Durante la estación de crecimiento (Febrero a Abril), las hojas tuvieron un contenido relativamente mayor de P, Ca, proteína cruda y ELN. La proteína cruda de las hojas alcanzó su máximo valor (27%) en Marzo, sin embargo, la concentración disminuyó a 15% durante el período seco (Junio a Octubre). El contenido de proteína cruda de los tallos vario de 11.3 a 12.2%. El menor contenido de fibra de las hojas ocurrió en Febrero y Marzo (16.9 a 18%) y los valores máximos se alcanzaron en Agosto y Octubre. Durante la época seca, el "Saltbush" es una buena fuente de proteína para los ovinos; sin embargo, el contenido de P podría no satisfacer los requerimientos nutricionales de las borregas.

Atriplex spp. are halophytes that have considerable forage potential in the arid and semiarid rangelands of West Asia (Le Houerou 1992, 1995). In Jordan *Atriplex* spp. are thought to be a solution to feed shortages that occur during droughts and dormant seasons. Most forages usually have high nutritive value during early growth, but their nutritive value declines rapidly with maturity. Most shrubs generally have high levels of crude protein, phosphorous and calcium throughout the year (Stidham et al. 1982).

In Israel, *Atriplex halimus* L. furnishes protein, vitamins and minerals to sheep during summer and autumn (Benjamin et al. 1959). Sheep grazed on dormant crested wheatgrass ((*Agropyron cristatum* L.) had greater weight losses than those grazing a mixture of crested wheatgrass and fourwing saltbush (*A. canescens* (Pursh) Nutt.) (Otsyina et al. 1982). Protein content of *A. canescens* leaves had decreased from 25% in April to 10% in August before it gradually increased during winter to about 20%. The feed value of leaves again decreased during June through December (Thomson et al. 1997). Chatterton et al. (1971) reported a remarkable variation in the nutritive value of different parts of the plant *A. polycarpa* (Torr.) S. Wats. over the year.

Jordan has over 2.6 million sheep and 1 million goats, and the amount of supplemented feed stuff is estimated at 444 thousand tons (FAO 1994). Sheep in autumn depend on crop stubble and native pasture. Saltbush (*A. halimus* L.) is a native shrub found in many salty and arid regions of the Middle East including Jordan. It's a promising forage source and supplemental feed during dry seasons and emergencies, but the seasonal variation of its nutritive value and chemical composition has not been investigated. Our objective was to determine the seasonal changes in chemical

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composition of the current year's growth of leaves and stems of saltbush (*Atriplex halimus* L.) on semiarid grassland in Jordan.

Materials and Methods

Site Description

The saltbush on which this study was conducted grows on semiarid grassland located within the campus boundary of the Jordan University of Science and Technology (JUST) 22 km east of Irbid (32° 34' N, 36° 0' E). Altitude is 520 m, and the site is characterized by flat to gently rolling topography with less than 10% slope. The soil is a weakly cracked and deep silty clay. Natural vegetation is typical of Mediterranean semiarid grassland. Our study utilized 3 hectares of *A. halimus* L. transplanted in an adaptability trial during 1986–87 and protected from grazing. Mean annual precipitation for that site is 230 mm, and annual rainfall during 1995–96 and 1996–97 occurred during October to April. Highest accumulations and the most rapid plant growth occurred during the period from January to March (Fig. 1). Plant growth usually starts during December and stops by the end of April due to dry-hot conditions.

Sampling

Four100-m transects were randomly selected. In 1995–96 and 1996–97, 16 saltbush shrubs on each transect were selected randomly, and 8 shrubs per transect were utilized for the experiment each year. Samples were collected on 28 December, January, February, March, April, June, August, and October. On each sampling date, the current year's growth of 4 randomly selected shrubs was clipped, and the leaves and stems separated and dried at 70°C for 72 hours.

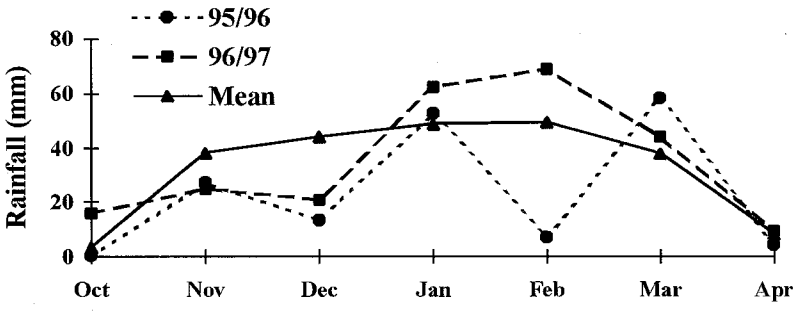

Fig. 1. Monthly rainfall (mm) for 1995–96, 1996–97 and long term means (n=11).

Chemical Analysis

One hundred-gram samples of oven-dry leaves and stems from each shrub were milled to pass a 0.4-mm screen and used for subsequent chemical analyses. Calcium was determined by atomic absorption spectrophotometer. Phosphorous was determined following Watanable and Olsen (1965) procedures. Crude protein (Nx6.25), nitrogen free extract (NFE) and fiber were determined according to AOAC (1984) procedures.

Statistical Analysis

The data were analyzed using a 2 x 8 x 2 factorial using a randomized complete block design. Factors were years (2), months (8), and plant parts (2) with 4 replications. Null hypotheses related to all 3 main effects and the pertinent interactions were tested at the $P \leq 0.01$ level of significance. Analyses of variance did not show a significant year effect (Table 1), therefore, means of the chemical composition of leaves and stems were pooled over years. Means were separated by Fisher's Least Significant Difference (LSD) at $P \leq 0.01$. Linear relationships among the chemical properties were determined by correlation techniques described by Steel and Torrie (1980).

Results

Simple linear correlation analysis (Table 2) showed strong positive relationships between P, Ca, crude protein, and nitrogen free extract, whereas fiber exhibited a strong negative correlation with P, Ca, crude protein, and nitrogen free extract. Analyses of variance did not show a significant year effect, however, there were significant differences between leaves and stems and significant seasonal effects in the composition of leaves and stems during the year at $P \leq 0.01$ (Table 1).

Leaves

Leaves of *Atriplex halimus* L. showed higher ($P \leq 0.01$) P, Ca, Ca:P ratio, crude protein, and nitrogen free extract (NFE) values than stems on any clipping date (Fig. 2). Leaves had maximum levels of P, Ca, crude protein, and NFE during the February to April growing season, and the Ca:P ratio increased gradually from 5 during February to 11.7 during October (Fig. 2C). Crude protein content ranged from 15.8 to 22.7% (Fig. 3A), with the highest values detected in February (20.8%) and March (22.7%). Crude protein decreased to about 15% during the June to October dry period. Nitrogen free extract (NFE)

Table 1. Significance levels in analyses of variance of various chemical components extracted from saltbush (Atriplex halimus L.) *in Jordan from* December 1995-October 1997.

Source of variation	df		P	Ca	Ca:P	CP	NFE	Fiber
replicate	(r-1)	3	ns	ns	ns	ns	ns	ns
year	(y-1)	1	ns	ns	ns	ns	ns	ns
plant part	(s-1)	1	**	**	**	**	**	**
year X plant part	(y-1)(s-1)	1	ns	ns	ns	ns	ns	ns
month	(m-1)	7	**	**	**	**	**	**
year X month	(y-1)(m-1)	7	ns	ns	ns	ns	ns	ns
plant part X month	(s-1)(m-1)	7	**	**	**	**	**	**
year X plant part X month	(y-1)(s-1)(m-1)	7	ns	ns	ns	ns	ns	ns
Error	(r-1)(ysm-1)	93						

** Significant at P<0.01
ns Not significant

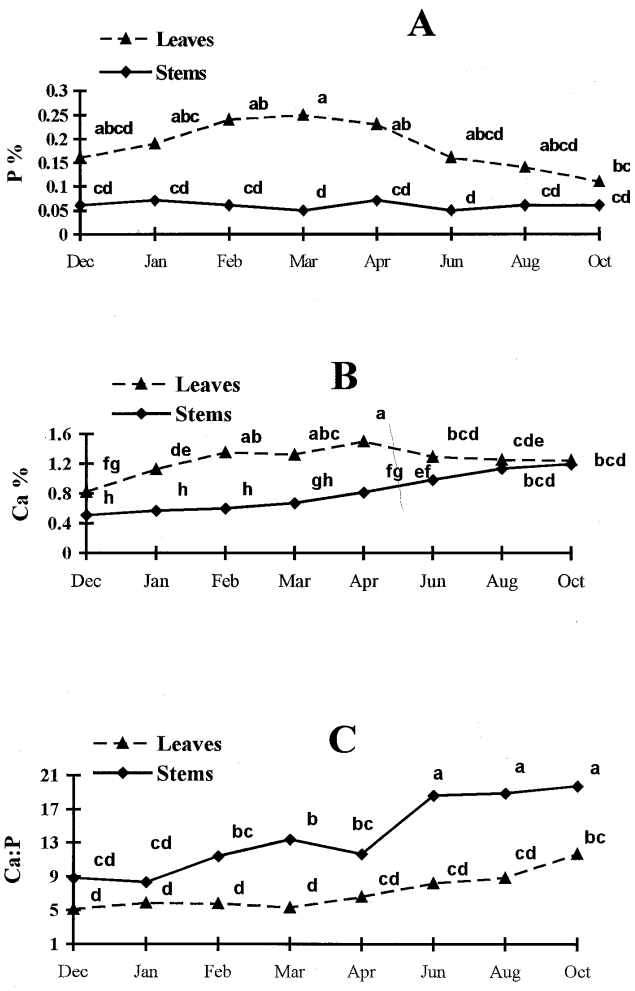

Fig. 2. Seasonal phosphorous (A), calcium (B) and Ca:P ratio (C) contents of saltbush (*A. halimus* L.) leaves and stems during 1995–96 and 1996–97 at Jordan University of Science and Technology Campus. Means within a component having a common letter do not differ significantly (P> 0.01).

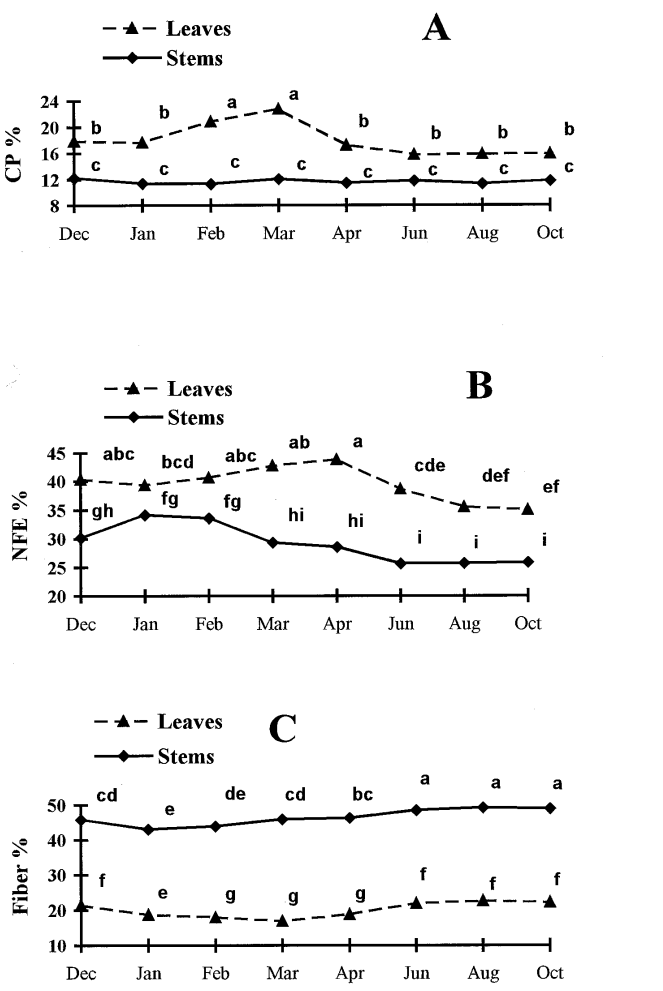

Fig. 3. Seasonal crude protein (A), nitrogen free extract (B) and crude fiber (C) contents of saltbush (*A. halimus* L.) leaves and stems during 1995–96 and 1996–97 at Jordan University of Science and Technology Campus. Means within a component having a common letter do not differ significantly (P> 0.01)..

increased gradually from 40% at the December sampling date, to 44% during April. Thereafter NFE gradually decreased to 35% in October (Fig. 3B). Fiber content increased from a low in February (16.9%) to a high of 22.6% in October (Fig. 3C).

Stems

Except for P and crude protein, where no seasonal changes occurred, the nutrient content of stems increased gradually from December to October (Fig. 2A and 3A). Crude protein content ranged from 11.3 to 12.2%. Ca content was 0.5% during December, and it increased gradually to 1.22% in October (Fig. 2B). During October, Ca concentrations of leaves and stems were equal. The Ca:P ratio increased gradually from 8.8 in December to 19.8 in October (Fig. 2C). Nitrogen free extract (NFE) was highest during January (34.1%) but started decreasing after February to a low of 25.8% in October (Fig. 3B). The crude fiber content of stems increased gradually from December (43%) to October (49%) (Fig. 3C).

Discussion

Jordanian rangeland has a unimodal precipitation pattern, with a short rainy period followed by an extended dry season furnishing limited opportunities for herbaceous forage production. Plant dormancy stimulates a decline in both quantity and quality of forage. Annual grasses may lose 75% of their protein content and up to 52% of their phosphorous during the dry season (Louis et al. 1983). Wheat and barley residue grazing starts immediatly after harvest in June and lasts until September. This provides the basic diet for sheep throughout the summer into autumn; when supplementary feeding begins (ACSAD 1983). The forage value of the crop residues deteriorates after a month of grazing, and the animals begin loosing weight. Supplementation with cotton seed meal or cereal grain at a rate of 100 g/day^{-1} could stop weight losses (Turminini 1991).

Sheep usually need supplementation for 6 months in a normal year and 9 months during drought years (Nesheiwat and Muhammed 1987). The CP content of saltbush (*Atriplex halimus* L.) is high, and would be a good protein source for livestock during dry summer and autumn periods. Protein is one of the most limiting nutrients for range livestock production and its supplementation is cost effective, because it improves forage intake and

Table 2. Correlation coefficients among some chemical components of *A. halimus* L. sampled in Jordan from December 1995–October 1997.

	Ca	Ca:P	CP	NFE	Fiber
P	0.66 **	-0.72 **	0.92 **	0.93 **	-0.87 **
Ca		0.04	0.89 **	0.50 **	-0.53 **
Ca:P			-0.68 **	-0.77 **	0.79 **
CP				0.90 **	-0.88 **
NFE					-0.85 **

** Significant at P<0.01

digestibility (Holechek and Herbel 1986). On Utah rangelands, Gade and Provenza (1986) compared the diet quality of sheep using crested wheatgrass and a wheatgrass-shrub mixture during winter. They found that sheep grazed on wheatgrass-shrub mixtures had higher forage intake, higher crude protein intake, and lower fiber levels in their diets than sheep grazing a pure stand of wheatgrass. In our study, saltbush (*A. halimus* L.) crude protein and Ca contents were sufficient to meet ewes maintenance and lactation requirements during any time of the year. Phosphorus was deficient for ewes, suggesting supplements would be necessary to adjust the high Ca:P ratio in their diet. Ewes require 7 to 9% crude protein for maintenance and 10 to 12% for lactation. They also need 0.15% to 0.20% P for maintenance and 0.25 to 0.30% for lactation (Holechek et al. 1994). The introduction of saltbush (*A. halimus* L.) into semiarid grassland of Jordan would elevate the nutritive plain of livestock and possibly minimize the need for grain supplements during summer and autumn.

Conclusion

Semiarid grasslands usually supply livestock with high food quality during spring but forage quality declines rapidly as grass mature. Saltbush showed relatively high levels of protein and nitrogen free extract throughout the year. Saltbush is drought resistant and can be grazed during droughty years. Introducing saltbush into Jordan's grassland may improve the quality of the livestock diets and minimize grain supplementation during summer and autumn. Phosphorous supplementation, however, would be necessary to adjust the Ca:P ratio.

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