

Determination of mineral concentrations in stem and seed of *Juncus acutus*

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Abstract: The objective of this study was to determine micro and macro mineral concentrations in stem and seed of *Juncus acutus* for ruminant nutrition. The samples of *Juncus acutus* stem and seed were randomly collected from Kızılırmak Delta, Samsun, Turkey. Micro and macro mineral concentrations of samples were analyzed by using an inductively coupled plasma mass spectrophotometer (ICP-MS) and ion chromatography (IC) methods, respectively. Differences between mean concentrations of B, Al, Cr, Mn, Fe, Co, Ni, Cu, Zn and Se in stem and seed of *Juncus acutus* samples were significant ($P<0.05$). The mean values of Al, Cr, Fe, Co, Ni and Se for stem of *Juncus acutus* were higher than values for seed of *Juncus acutus* but, the mean values of Mn, Cu and Zn for seed of *Juncus acutus* were higher than stem of *Juncus acutus* ($P<0.05$). The concentrations of Na, K and Ca in stem were higher than seed of *Juncus acutus*. On the other hand, the concentration of Mg for seed of *Juncus acutus* were higher than stem of *Juncus acutus* ($P<0.05$). In conclusion, the obtained results show that stem and seed of *Juncus acutus* may be a good source to meet the micro and macro mineral requirements of ruminant animals. Besides, the seeds of *Juncus acutus* may also provide micro and macro minerals to birds in wetlands.

Keywords: *Juncus acutus*, macro mineral, micro mineral, wetland

Juncus acutus'ün gövde ve tohumunda mineral konsantrasyonlarının belirlenmesi

Özet: Bu çalışmanın amacı *Juncus acutus*'ün gövde ve tohumunda bulunan makro ve mikro mineral konsantrasyonlarının ruminanat besleme için belirlenmesidir. Türkiye, Samsun ili Kızılırmak Deltası'ndan *Juncus acutus* 'ün gövde ve tohum örnekleri rastgele toplandı. Örneklerin mikro mineral analizleri indüktif olarak eşleştirilmiş plazma kütle spektrofotometresi (ICP-MS) ile, makro mineral analizleri iyon kromatografisi (IC) ile yapıldı. *Juncus acutus* 'ün gövde ve tohumu B, Al, Cr, Mn, Fe, Co, Ni, Cu, Zn ve Se mineralleri yönünden karşılaştırıldığında aralarında önemli farklılıklar tespit edilmiştir ($P<0,05$). Al, Cr, Fe, Co, Ni ve Se minerallerinin ortalama değerleri *Juncus acutus* 'ün gövdesinde tohumuna oranla daha yüksek fakat Mn, Cu ve Zn mineralleri ise tohumda gövdeye göre daha yüksek bulunmuştur ($P<0,05$). *Juncus acutus* 'ün gövdesindeki Na, K ve Ca konsantrasyonları *Juncus acutus* 'ün tohumundan daha yüksek bulunmuştur ($P<0,05$). Diğer taraftan *Juncus acutus* 'ün tohumunda Mg konsantrasyonu *Juncus acutus* 'ün gövdesinden daha yüksek bulunmuştur ($P<0,05$). Sonuç olarak, bulunan sonuçlar ruminant hayvanların mikro ve makro mineral ihtiyaçlarının karşılanmasında *Juncus acutus* 'ün gövde ve tohumunun iyi bir kaynak olabileceğini göstermektedir. Bununla birlikte *Juncus acutus* 'ün tohumları sulak alanlarda yaşayan kuşlar için de mikro ve makro mineral kaynağı olabilirler.

Anahtar sözcükler: *Juncus acutus*, makro mineral, mikro mineral, sulak alan

Introduction

Wetlands represent some of the most productive habitat on earth. They are often referred to as “nature’s kidneys” because of their ability to filter, metabolize, and sequester nutrients and minerals. Plant species play an important function in wetland geochemistry because they are the main living collectors and transporters of micro minerals through active and passive absorption (29). Salt

marsh plants generally accumulate different levels of minerals in the below and aboveground parts. The availability of minerals for plants may be affected by several factors: their loading rates, chemical characteristics, pH, soil texture, clay, and organic matter contents, etc. (26). Several other factors also affect the uptake of micro minerals and heavy metals, including differences in plant age and growth stages, seasonal

variations, tidal inundations, and salinity (6, 27). Some of micro minerals are essential and these elements (Cu, Zn, Fe, Mn and Mo) play biochemical and physiological functions in plants and animals. On the other hand, heavy metals are highly toxic elements such as Hg, Pb, As and Ba. Metals in halophytes are mainly accumulated in the roots, with small quantities translocated to the stems and leaves (30). According to Hosseini Alhashemi et al. (15) reported that uptake trend of micro minerals in plant decreases as root>stem>leaf. The extent and pattern of mineral deficiencies/excess in plants vary in different agro-climatic conditions as available mineral content in green vegetation depends on physical and chemical properties of soil, soil erosion, cropping pattern, fertilizer/chemical application, species and genetic variation in plants, stage of maturation, presence of other minerals etc. (19).

Juncus acutus (*Juncaceae*) is a long-lived and common plant of wetlands. There are around 300 species of *Juncus acutus* and they present worldwide. There are about 2549.2 ha of natural grassland in the Kizilirmak Delta. *Juncus acutus* presents mainly in Yorukler, Doganca and Sarikoy districts of Bafra, Samsun, Turkey, the production capacity of *Juncus acutus* is 8.650 tons (10). *Juncus acutus* are consumed by water buffaloes and cattle in Kizilirmak Delta. Phenolic compounds and antioxidant activity of stem and seed of *Juncus acutus* plant were determined by Erdem et al. (12). Effects of different *Juncus acutus* maize silage ratios on digestibility and rumen cellulolytic bacteria were reported by Cetinkaya and Erdem (7). Organic matter digestibility and metabolisable energy values of *Juncus acutus* and the effects of *Juncus acutus* on cellulolytic bacteria in rumen were studied (11).

However, no information is available regarding to the concentrations of micro and macro minerals in stem and seed of *Juncus acutus* for animal nutrition. The objective of this study was to determine macro minerals Na, K, Ca, Mg and NH₄; micro minerals B, Al, Cr, Mn, Fe, Co, Ni, Cu, Zn and Se values in the stem and seed of *Juncus acutus* for mineral nutrition of animals.

Material and Methods

Feed material: Seed of *Juncus acutus* samples was collected randomly by hand, and stem samples were collected from 20 plants in August 2017 from Kizilirmak Delta, Samsun, Turkey. The GPS coordinates of sampling locations were shown below.

- 36 19' 53 81" E, 41 16' 30 29" N
- 36 6' 51 52" E, 41 36' 24 24" N
- 36 5' 33 18" E, 41 38' 16 85" N

The month August was chosen for sample collection because of seeds availability. The stems were chopped

into small pieces with garden scissors. Samples were weighed and dried in an oven at 65 °C for 48 h. After drying, all stems and seeds were ground in a mill to pass through a 1 mm screen, and kept in plastic boxes until mineral analysis. Duplicate samples were prepared for each analysis.

Mineral analysis: The micro mineral concentrations B, Al, Cr, Mn, Fe, Co, Ni, Cu, Zn and Se were determined by ICP-MS (ICP-MS, Agilent-7700 Model) and macro mineral concentrations (Na, K, Ca, Mg and NH₄) were determined through an IC (IC, Dionex ICS 3000 Model) at the Department of Molecular Microbiology, Public Health Laboratory, Ministry of Health, 55060 Samsun, Turkey.

0.5 g in 1 mm dimension stem and seed of *Juncus acutus* samples were put into vessels and a mixture composed of 10 ml of concentrated HNO₃, 3 mL of concentrated HCl and 2 mL H₂O₂ was added to each vessel. They were placed in Microwave Oven (Model CEM Mars) and were digested at two steps, first 15 min at 180 °C then after secondly 30 min at 200 °C (22). The resulting liquid samples were diluted with deionized water to bring the volume up to 50 ml for micro minerals analysis by ICP-MS and macro mineral analysis by IC.

The concentrations of B, Al, Cr, Mn, Fe, Co, Ni, Cu, Zn and Se in *Juncus acutus* stem and seed samples were measured by ICP-MS method (2). The levels of Na⁺, K⁺, Ca⁺², Mg⁺² and NH₄⁺ in all samples were measured by IC method (18).

Statistical analysis: The micro minerals concentrations (B, Al, Cr, Mn, Fe, Co, Ni, Cu, Zn and Se) and macro mineral concentrations (Na, K, Ca, Mg and NH₄) were performed by one-way analysis of variance (ANOVA) test (24). Means differences were considered significant at P<0.05.

Results

The estimated micro minerals B, Al, Cr, Mn, Fe, Co, Ni, Cu, Zn and Se concentrations in stem and seed of *Juncus acutus* are shown in Table 1. Differences between mean values of stem and seed samples were significant (P<0.05). The mean values of Al, Cr, Fe, Co, Ni and Se for stem of *Juncus acutus* were higher than the estimated values for seed of *Juncus acutus*, but the mean values of Mn, Cu and Zn for seed of *Juncus acutus* were higher than the estimated values for stem of *Juncus acutus*.

The estimated macro mineral Na, K, Ca, Mg and NH₄ concentrations of stem and seed of *Juncus acutus* are shown in Table 2. The concentrations of Na, K and Ca for stem of *Juncus acutus* were higher as compared to those in the seed of *Juncus acutus*. On the other hand, the levels of Mg and NH₄ for seed of *Juncus acutus* were higher than the reported levels for stem of *Juncus acutus*.

Table 1. Micro mineral concentrations of stem and seed of *Juncus acutus* (mean \pm SE, n=20)

<i>Juncus acutus</i>		
Micro mineral (mg/kg)	Stem ($\bar{x} \pm Sx$)	Seed ($\bar{x} \pm Sx$)
B	17.77 \pm 1.25	28.25 \pm 1.74
Al	129.9 \pm 7.6	43.25 \pm 2.01
Cr	7.82 \pm 1.11	0.300 \pm 0.010
Mn	17.23 \pm 1.21	43.75 \pm 2.23
Fe	153.0 \pm 5.4	50.51 \pm 1.96
Co	0.12 \pm 0.02	0.030 \pm 0.001
Ni	13.84 \pm 1.14	ND
Cu	3.70 \pm 0.98	5.95 \pm 0.94
Zn	4.32 \pm 0.87	11.24 \pm 1.03
Se	0.11 \pm 0.02	0.070 \pm 0.010

ND: Not detectable. SE: Standart error of the mean. Differences between mean values of stem and seed samples in the same row were significant ($P < 0.05$).

Table 2. Macro mineral concentrations of stem and seed of *Juncus acutus* (mean \pm SE, n=20)

<i>Juncus acutus</i>		
Macro mineral (g/kg)	Stem ($\bar{x} \pm Sx$)	Seed ($\bar{x} \pm Sx$)
Na	0.900 \pm 0.020	0.140 \pm 0.010
NH ₄	0.020 \pm 0.006	0.037 \pm 0.005
K	11.04 \pm 1.00	8.50 \pm 0.09
Mg	0.160 \pm 0.030	0.310 \pm 0.020
Ca	0.380 \pm 0.020	0.260 \pm 0.020

SE: Standart error of the mean. Differences between mean values of stem and seed samples in the same row were significant ($P < 0.05$).

Discussion and Conclusion

The Fe (153.0 mg/kg), Cr (7.82 mg/kg) and Ni (13.84 mg/kg) levels for stem of *Juncus acutus* were higher than those of levels for stem of *Juncus acutus* grown in Rio Naracauli (112.0 mg/kg, 4.80 mg/kg, 2.90 mg/kg), respectively. The Zn (4.32 mg/kg) levels for stem of *Juncus acutus* was lower than that of *Juncus acutus* grown in Rio Naracauli (290 mg/kg) but Co (0.120 mg/kg; 0.120 mg/kg) and Cu (3.70mg/kg; 3.90 mg/kg) levels were similar to each other (20). The Fe (153.0 mg/kg) and Cu (3.70 mg/kg) levels for stem of *Juncus acutus* were similar to those of *Festuca ovina* (148.0 mg/kg and *Bromus variegatus* (4.06 mg/kg), respectively. Mn (17.23 mg/kg) levels for stem of *Juncus acutus* was similar to that of *Trifolium montanum* (18.18 mg/kg). B (17.77 mg/kg) levels for stem of *Juncus acutus* was similar to that of *Vicia cracca* (17.02 mg/kg). On the other hand, The Cu (5.95 mg/kg), Mn (43.75 mg/kg) and B (28.25 mg/kg) levels for seed of *Juncus acutus* were similar to those of *Lotus corniculatus* and *Trifolium montanum* (5.530 mg/kg; 5.640 mg/kg), *Bromus variegatus* (43.53 mg/kg) and *Medicago sativa* (27.09 mg/kg), respectively (14).

The Mn (43.75 mg/kg) and Zn (11.24 mg/kg) levels for seed of *Juncus acutus* were similar to those of *Vicia sativa* (49.00 mg/kg, 13.00 mg/kg), respectively and It was also found similar to Zn (11.00 mg/kg) levels of *Lupinus albus* (8). The Al (129.0 mg/kg), Ni (13.84 mg/kg) and Zn (4.32mg/kg) levels for stem of *Juncus acutus* were lower than those of *Typha domingensis* (358.0 mg/kg; 48.40 mg/kg;126.0 mg/kg), but higher than those of *Arundo donax* (15.50 mg/kg; 0.97 mg/kg; 1.93 mg/kg), respectively (4). The Cu levels of *Juncus acutus* (3.70 mg/kg) and *Myriophyllum verticillatum* (3.23 mg/kg) were similar to each other. Beside the Fe (11528.0 mg/kg;153.0 mg/kg), Zn (35.46 mg/kg; 4.32 mg/kg) and Mn (9113.0 mg/kg; 17.23 mg/kg) levels of *Myriophyllum verticillatum* were higher than those of *Juncus acutus*, respectively (9). Singh et al. (25) reported that the levels of Cr, Cu and Fe for stem of *Panicum antidolale* were found ND; ND and 0.87 mg/kg, respectively. Moreover, these results lower than those for stem of *Juncus acutus*. The Co levels for stem of *Juncus acutus* (7.82 mg/kg) was higher than that of *Myriophyllum spicatum* (5.34 mg/kg) (31). The B (11.00 mg/kg; 17.77 mg/kg) and Se (<0.05

mg/kg; 0.110 mg/kg) levels for stem of *Phragmites australis* were lower than those of *Juncus acutus*, respectively. However, the Co levels was similar to each other (0.120 mg/kg) (3). The Cu (6.41 mg/kg; 4.67 mg/kg; 3.70 mg/kg) and Zn (9.480 mg/kg; 13.57 mg/kg; 4.320 mg/kg) levels of *Alisma gramineum* and *Sparganium emersus* were higher than those of *Juncus acutus*, respectively (16). The Mn (17.23 mg/kg) and Cu (3.700 mg/kg) levels of *Juncus acutus* were lower than those of *Juncus maritimus* (48.60 mg/kg and 8.02 mg/kg), *Juncus effusus* (140.0 mg/kg and 7.430 mg/kg) and *Juncus articulatus* (218.0 mg/kg and 14.80 mg/kg), respectively (28). In the other research, Cr (0.42 mg/kg; 7.82) and Ni (0.43 mg/kg; 13.84 mg/kg) levels of stem of *Juncus maritimus* were lower than those of stem of *Juncus acutus* in our study, respectively (1). The Al (17.23 mg/kg; 558.1 mg/kg), Co (0.12 mg/kg; 0.60 mg/kg) and Fe (153.0 mg/kg; 500.5 mg/kg) levels of *Juncus acutus* were lower than those of *Sueda maritima* (21). Regarding the element mobility from roots to stems, translocation factors were more variable among plants rather than among elements, and showed their highest mean values in the congener species *Juncus maritimus* and *Juncus acutus*, which, however have different life forms (5).

The obtained Na and K levels were in line with the published range for wheat straw and triticale straw (13). Mineral concentrations in forage vary widely among species, and are influenced by many soil and other factors including growth stage, plant part, climate and fertilizer application (23, 17).

In conclusion, the estimated macro and micro mineral concentrations of both stem and seed samples of *Juncus acutus* showed that micro and macro minerals might be a good source for meeting mineral requirements of ruminant animals. Even, seeds of plant may provide necessary levels of macro and micro minerals to birds during summer and fall seasons in Kızılırmak delta.

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Ethical Statement

This study does not present any ethical concerns.

Conflict of interest

The authors declare that they have no conflict of interest.

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