Turkish Journal of Range and Forage Science, 2024, 5(1): 12-20
doi: 10.51801/turkjrfs.1420268

Research

Turkish Journal of Range and Forage Science
https://dergipark.org.tr/tr/pub/turkjrfs

Change in Monthly Mineral Content of Russian Thistle

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A R T I C L E I N F O

Received *15/01/2024*
Accepted *27/02/2024*

Keywords:

Salsola kali subsp. ruthenica (Iljin) Soó.
Macro mineral
Micro mineral
Period
Nitrogen
Phosphorus

A B S T R A C T

This study was conducted in 2022 to determine the changes in the mineral content of Russian thistle according to its development periods on the area of Iğdır University Şehit Bülent Yurtseven Campus. In the 7-month period from April to October, the plant's N (Nitrogen), K (Potassium), P (Phosphorus), Mg (Magnesium), Na (Sodium), Ca (Calcium), Fe (Iron), Cu (Copper), Mn (Manganese) and Zn (Zinc) contents were determined. While the nitrogen content of the plant was high in April, May and June, there were decreases in nitrogen content in the following months. While the potassium content increased in May and June compared to April, there were decreases in potassium content in July and the following months. As the development of the plant advanced, there was a decrease in the phosphorus content. While magnesium content was highest in April and September, it was low in the other months. Calcium content was highest in April and May and lowest in August. While the sodium content increased until June, there were decreases in the following months. While the iron content increased until July, there were decreases in the following months. Copper content reached its highest level in July and October. Manganese content was highest in September and lowest in July. Zinc content decreased with the advancement of plant development. According to the research results, it was determined that the nitrogen, potassium, phosphorus (except April), magnesium, sodium, iron, manganese and zinc contents of Russian Thistle are among the values that should be included in feed. On the other hand, it was determined that the calcium content was high and the copper content was low.

1. Introduction

The most important source of animal nutrition is the forage plants grown in range-meadow areas and field areas. Misuse of grazing areas failure to comply with the principles of improvement and management have caused to decrease in the productivity of these areas and not meet the feed needs of animals (Öztürk and Güvensen, 2002; Kara and Yüksel, 2014). On the other hand, soil characteristics, excessive irrigation, annual rainfall regime, excessive fertilization cause salinization of the soil, and low annual rainfall causes drought. Xerophyte and halophyte plants grow widely in these extreme grazing areas. Russian thistle, an annual plant, grows widely in both xerophyte and halophyte areas. It has been observed that this plant begins to develop from the end of April and dries by the beginning of December. It has been observed that Russian thistle can adequately meet the daily nutritional needs of small ruminants grazing during the grazing periods from spring to autumn in arid regions and is a good alternative feed source in the winter months with its protein-rich feed supplements (Temel and Keskin 2019a).

In order to the plants to grow and develop, it must acquire sufficient nutrients from the growth environment. While the amount of some nutrients

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such as nitrogen can reach 200 kg per hectare, some nutrients such as molybdenum can only remove 20 grams (Gezgin and Hamurcu, 2006). In addition to their effects on plant development, minerals affect the healthy development and the quality of products of animals that consume these plants (Gökkuş et al., 2013). Macro minerals (N, K, P, Na, Mg, Ca) and micro minerals (Mn, Fe, Cu, Zn) are very important for living organisms, plants, animals and humans. Since these minerals are not synthesized in the metabolism of animals, the needed minerals are largely provided by plants. Deficiency and excess of these minerals affect the feed use efficiency, reproduction, growth and immunity of animals (Forstner and Witmann, 1983; Spears, 1994; Kutlu et al., 2005; Gökkuş et al., 2013).

The mineral content of plants depends significantly on the plant species and variety, the amount of rainfall, the soil in which the plant is grown, the type and amount of fertilization, and the root system of the plants. It is important to know the mineral contents of plants as well as their quality characteristics (Khan et al., 2007; Abari et al., 2011; Aksoy and Dinler, 2014; Temel and Sürmen, 2018). Macro and micro mineral contents of plants growing in areas with low soil mineral content are also low, and mineral deficiency is observed in animals grazing the plants growing in these areas (Abdullah et al., 2013). Therefore, many studies have been conducted on the determination of mineral contents of plants growing in areas with extreme climate and soil conditions and important results have been recorded (Ghazanfar et al., 2011; Abdullah et al., 2013; Gökkuş et al., 2013; Keskin, 2018; Temel, 2019).

Plants growing in the grazing areas do not always have the same amount of mineral content throughout their growth period. Plants with high mineral content at the beginning of growth experience a decrease in their mineral content as their development period progresses (Underwood and Suttle, 1999). It has been stated that the mineral content of plants obtained from degraded grazing lands with low fertility soils is insufficient than the levels needed by ruminants (Abdullah et al., 2013). Species that can grow naturally in the area in regions with arid and semi-arid climates are important feed sources for ruminants (Temel and Tan, 2011; Temel and Keskin, 2022; Keskin, 2018; Dökülgen and Temel, 2015).

This study was carried out to determine the mineral contents in different development periods of the Russian thistle plant, which grows in arid meadow areas. Additionally, it is unclear whether Russian thistle, which grown in arid meadows, will meet the mineral needs of animals and whether it is an important feed source in animal nutrition will be revealed.

2. Materials and Methods

This study was carried out to determine the changes in the 7 (seven) month mineral content of Russian thistle (*Salsola kali* subsp. *ruthenica* (Iljin) Soó.) (Temel et al., 2017) growing in the arid meadows area (Figure 1).

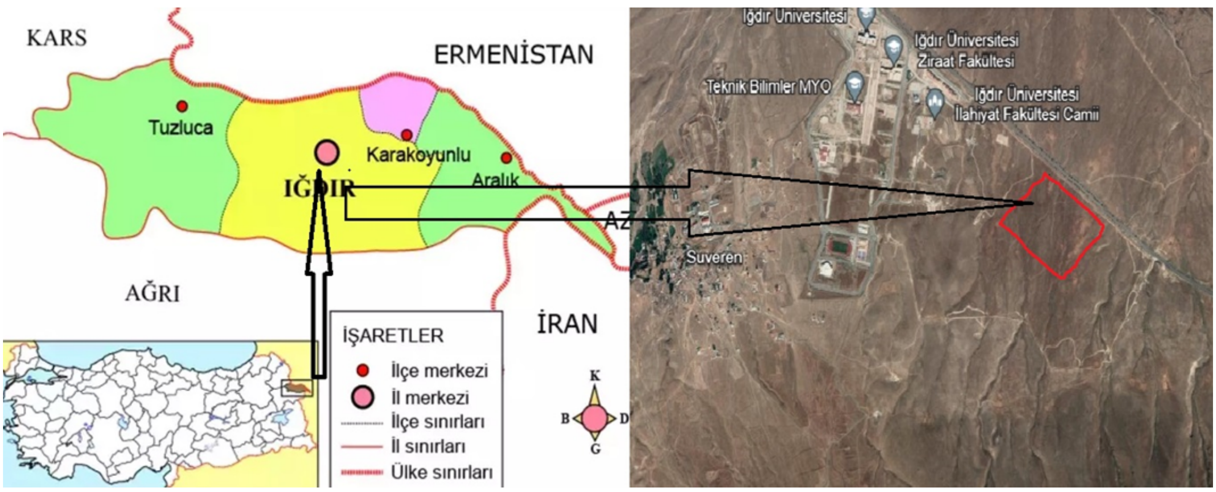

Figure 1. Experimental area (39° 48'' 12' N, 44° 05'' 32' E

Plant material was taken in the arid meadow with water table in the last week of each month between April and October in 2022. According to the long-term average of the region (1978-2017), the annual rainfall was 266.4 mm, the average temperature was 12.4 ºC and the relative humidity was 54.6%. In 2022, when the samples were taken, the annual rainfall was determined as 171.6 mm, the average temperature was 15.2 ºC, and the relative humidity was 51.5%. (Table 1) (Anonymous, 2022). These climate values show that the region has an arid climate.

In the area where the research was conducted, a 30 cm deep soil sample was taken and analyzed. Soil analyzes were carried out in the laboratories of Iğdır University Faculty of Agriculture. Analysis results are given in Table 2 (FAO, 1990; Lindsay and Norvell, 1969; Follet, 1969; Ülgen and Yurtsever, 1974; Richards, 1954). This study was designed according to the completely randomized trial design with 3 replications. The time of collection of plant samples was determined as a factor.

Table 1. Some climatic features of the research area

Months	Temperature °C		Precipitation mm		Air humidity %	
	2022 year	LTA*	2022 year	LTA	2022 year	LTA
January	-2.0	-3.1	6.8	13.1	66.2	66.5
February	4.4	0.3	5.6	15.5	54.2	59.8
March	5.1	6.9	24.8	22.0	54.9	49.9
April	15.7	13.4	25.8	37.9	43.8	49.9
May	17.0	17.6	54.8	48.9	53.8	51.1
June	24.6	22.3	26.0	33.2	47.2	45.7
July	27.7	26.2	0.2	14.7	37.6	43.3
August	27.9	25.6	0.4	9.8	39.3	44.5
September	23.1	20.7	5.5	10.3	42.5	48.9
October	15.4	13.3	12.0	28.1	60.5	62.3
November	8.1	5.9	9.7	19.8	65.4	65.7
December	3.0	-0.4	5.8	13.0	83.2	68.4
Average/Total	14.7	12.4	177.4	266.4	54.0	54.6

*LTA (Long-term Average): Average of values between 1978 and 2017.

Table 2. Some climatic features of the research area

Soil properties	Value	Classification	Soil properties	Value	Classification
Organic matter	% 0.6	very low	K	0.40 me/100g	sufficient
pH	7.5	neutral	Mg	3.83 me/100g	sufficient
EC	0.8 dS/m	non-saline	Na	2.48 me/100g	
Lime	%7.60	medium	P	7.30 ppm	low
Clay	%27.20		Zn	0.98 ppm	sufficient
Silt	%36.60	clay loam	Cu	0.27 ppm	sufficient
Sand	%36.20		Fe	2.84 ppm	low
N	%0.07	low	Mn	0.62 ppm	very low
Ca me/100g	13.60	sufficient			

Plant samples were taken in an area of 1 decare. At the end of the month in which the plant samples were to be taken, 5 plants in an area of 1 decare were cut with grape shears 5 cm above the soil surface, and 1 replication was obtained. 15 plants were harvested for 3 replicates in each month of the experiment. After drying in the shade for a while, the plant samples were dried in an oven set at 70 ºC for 48 hours and then the plant samples were ground. Macro (N, K, P, Na, Mg, Ca) and micro (Mn, Fe, Cu, Zn) mineral changes were determined in the ground plant samples over a 7-month period. After weighing 0.1 g of the ground plant samples, it was placed in microwave containers. Hydrogen peroxide and nitric acid (2/3 ratio) were added into the microwave combustion containers and the lids of the container were closed after waiting for 2 minutes. The combustion process was carried out in a speedwave MWS-2 microwave incineration device. In the 1st stage of the combustion process, the combustion process was completed at 145 °C for 5 minutes at 75% microwave power, in the 2nd stage at 180 °C for 10 minutes at 90% microwave power, and in the 3rd stage at 100 °C for 10 minutes at 40% microwave power (Mertens 2005a). K, P, Na, Mg, Ca, Mn, Fe, Cu, Zn contents of plant samples were determined on the PerkinElmer Optima 2100 DV ICP/OES device (Mertens 2005b). Nitrogen contents of plant samples were determined by the micro kjeldahl method (AOAC 2005).

Data were analyzed for variance according to the completely randomized trial design using the SPSS 17.0 statistical package program, and the averages of the significant data were grouped according to the Duncan multiple comparison test (SPSS, 2008).

3. Results and Discussion

In the study, the differences in the N, K, P, Mg, Ca, Na, Fe, Cu, Mn and Zn contents of Russian thistle according to months were found to be significant ($p < 0.01$) (Tables 3 and 4).

Table 3. Macro mineral contents of Russian thistle according to different development periods

Months	N(%)	K(%)	P(%)	Mg(%)	Ca(%)	Na(%)
April	1.23 ab	1.22 b	1.08 a	0.52 a	2.88 a	0.12 c
May	1.27 ab	1.55 a	0.66 b	0.44 b	2.89 a	0.18 b
June	1.33 a	1.49 a	0.57 c	0.41 b	2.34 bc	0.25 a
July	1.14 bc	0.89 c	0.35 d	0.43 b	2.45 bc	0.16 bc
August	1.06 cd	0.73 c	0.24 e	0.45 b	2.16 c	0.16 b
September	0.96 d	0.73 c	0.26 e	0.56 a	2.38 bc	0.15 bc
October	0.93 d	0.69 c	0.29 de	0.39 b	2.57 ab	0.14 bc
F value and significance	7.86**	25.50**	156.16**	9.64**	6.38**	15.35**

**The statistical difference between months is significant at the 1% level; The difference between identical letters in columns is not significant.

3.1. Macro minerals

Nitrogen: The nitrogen content of Russian thistle varied between 0.93-1.33%. The protein equivalents of these nitrogen contents are between 5.81-8.31%. The nitrogen content of the plant was higher in the first months of plant development (April, May, June) than in other months. A continuous decrease in nitrogen content was observed in July and the following months. Studies conducted on herbaceous species have reported that the nitrogen content, which is high in spring, decreases in summer and autumn (Gökkuş et al., 2013).

Potassium: The potassium content of the plant varied between 0.69-1.55%. While the potassium content was 1.22% in April, this rate reached 1.55% and 1.49% in May and June. After June, there was a continuous decrease in the potassium content of the plant, and the lowest value was in October with 0.69%. In a study on herbaceous plants, potassium content was high in the first months when the plant started to develop, while there were decreases in potassium content towards summer and autumn (Gökkuş et al., 2013). It has been determined that the potassium content decreases as the plants mature advanced (Spears, 1994). According to NRC (2005), it is stated that 0.65% potassium in the feed of ruminants is sufficient. Potassium plays a role in the regulation of osmotic pressure, stimulation of nerves and muscles, and carbohydrate metabolism in animals. It has been reported that lack of potassium in feeds will cause a decrease in the growth and in the productivity of animals (NRC, 2005; McDonald et al., 2011; Kutlu et al., 2005). In the current study, the potassium value of Russian thistle reached up to 1.55%. However, according to NRC (2005) and ANAC, (2018), it has been reported that the potassium content must be at 2% in order to have a toxic effect in animals. Therefore, the potassium content of Russian thistle is not at a level that could cause toxic effects.

Phosphorus: Phosphorus contents of plant samples varied between 0.29% and 1.08% depending on the months. While the highest phosphorus content was obtained in the first month (April) when the plant started to development, there were decreases in phosphorus content depending on the advanced of development. The lowest phosphorus contents were obtained in August, September and October. The amount of phosphorus contained in the plant also varies depending on growth and sampling times (Ghazanfar et al, 2011). On the other hand, the phosphorus content of the plant decreases as maturation advanced (Aygün et al., 2018; Keskin, 2018; Keskin and Temel, 2019). It has been reported that if phosphorus is not sufficient in feed, it will cause weakening of bone formation in animals, decreased appetite, milk yield and fertility rates (NRC, 2005; Kutlu et al., 2005; McDonald et al., 2011). According to NRC (2005), it has been reported that feeds for ruminants should contain 0.4-0.7% phosphorus. According to ANAC (2018), it is recommended that the phosphorus content in small ruminant feeds should not exceed 1%. According to NRC (2005), the maximum tolerable level of phosphorus has been reported as 0.7% in cattle and 0.6% in sheep. It was determined that the phosphorus content of Russian thistle exceeded the phosphorus amount determined by ANAC (2018) and NRC (2005) only in April. Animal grazing should be avoided in April in areas where Russian thistle is common.

Magnesium: Mg contents of plant samples varied between 0.39% and 0.56%. The Mg content of Russian thistle reached its highest values in April and September. The Mg content in other months was low and there were no significant differences between the Mg contents in these months. In a study conducted on herbaceous plants, magnesium content was high in the first months when the plant started to develop, while there were decreases in magnesium content towards summer and autumn (Gökkuç et al., 2013). Magnesium plays important roles in carbohydrate and fat metabolism, activation of some enzymes (phosphate transferase) and respiratory events. Magnesium deficiency in feed causes weakening of the nail and skeletal systems, developmental delay in nerves and muscles, and a decrease in fat and carbohydrate metabolism (NRC, 2005; McDonald et al., 2011; Kutlu et al., 2005). It is recommended that feeds contain 0.07-0.10% magnesium in the nutrition of ruminants (NRC, 2005). It has also been reported that more than 0.6% magnesium must be present in sheep feed to have a toxic effect (NRC, 2005). In the current study, it was determined that the magnesium content in Russian thistle did not reach toxic levels.

Calcium: During the 7-month development period of Russian thistle, Ca amounts varied between 2.16% and 2.59%. The Ca content of the plant changed significantly depending on months. The first months of plant development (April and May) and the last month when plant development ceased (October) had higher Ca content compared to other months. In a study conducted on herbaceous plants, they determined that Ca accumulated the most among macro minerals in the plant (Gökkuş et al., 2013). Calcium constitutes approximately 99% of the teeth and bone structures of animals. In calcium deficiency, bone formation is weakened and bone fractures occur (NRC, 2005; McDonald et al., 2011; Kutlu et al., 2005). It has been reported that the calcium content that should be included in the feed of ruminants should be 1.2% according to ANAC (2018) and 1.5% according to NRC (2005). In the current study, it was determined that Russian thistle contains calcium above the determined maximum in all development periods. In areas where Russian thistle is common, animal grazing should be avoided during all the season due to calcium toxicity.

Sodium: The Na content of Russian thistle varied between 0.12% and 0.25%. The Na content of the plant (0.25%) was highest in June. In the other months, the amount of Na contained in the plant was low and there was no significant difference between them. Sodium plays important roles in regulating the body's osmotic pressure, stimulating nerves, and absorbing amino acids and sugars in animals. In sodium deficiency, growth retardation, decrease in energy and protein use, and decrease in osmotic pressure are observed in animals (NRC, 2005; McDonald et al., 2011; Kutlu et al., 2005). It has been reported that Na content in the range of 0.1-0.4% would be appropriate in animal feed (NRC, 2005). Although Na deficiency is most frequently observed in feed (McDowell and Arthington, 2005), in the current study it was observed that the Na content of Russian thistle was within recommended levels in all months of development.

3.2. Micro minerals

Iron: The iron content of the plant varied between 142.1 ppm and 273.4 ppm according to months. While the iron content of the plant increased until July, a continuous decrease in iron content was observed in the following months compared to July. In a study conducted on shrub plants, the iron content of the plant increased until August and started to decrease in the following months (Temel and Keskin, 2019b). It is located in the structure of hemoglobin, which plays an important role in carrying oxygen to tissues. Iron deficiency causes oxygen deficiency in animal tissues, anemia, developmental delay and loss of appetite in animals (NRC, 2005; McDonald et al., 2011; Kutlu et al., 2005). According to NRC (2005), it has been reported that the amount of iron required in feed should be between 50-100 ppm. In the current study, it was determined that Russian thistle contains more iron than the amount recommended by NRC (2005) in all development stages. On the other hand, it has been reported that toxic effects may occur in animals when the iron level contained in feed is 500 ppm (NRC, 2005) and 1000 ppm (McDowell and Arthington, 2005). The amount of iron contained in Russian thistle is at a level that does not cause toxic effects on animals.

Copper: The copper content of plant samples varied between 1.63 pm and 2.90 ppm. The copper content in the plant reached its highest levels in July and October. The lowest copper contents were detected in May, June, August and September. It has been recommended that ruminants should contain 4-20 ppm Cu in the feed (NRC, 2005). Copper plays an important role in bone formation, hemoglobin formation, activation of some enzymes (lysyl oxidase, cytochromoxidase, triosinase), development and appetite of animals (NRC, 2005; McDonald et al., 2011; Kutlu et al., 2005). In the current study, the amount of Cu contained in Russian thistle was determined below these recommended values. Due to the low copper content of Russian thistle, additional copper minerals must be given to animals when grazing in areas where the plant is common.

Manganese: During the 7-month development period of the plant, the manganese content was found between 25.3 ppm and 72.1 ppm. While the highest manganese content was found in September, the lowest manganese content was detected in July. While manganese was high in the months when the plant first started to develop, manganese content decreased in the following months (Gökkuş et al., 2013). Manganese is effective in the formation of many enzymes (arginase, superoxide dismutase, pyruvate carboxylase), fatty acid synthesis, amino acid metabolism, cholesterol metabolism, and the growth and fertility of animals (NRC, 2005; McDonald et al., 2011; Kutlu et al., 2005). According to NRC (2001), it is recommended that the manganese content of feeds for ruminant nutrition should be up to 40 ppm. While the manganese content of Russian thistle exceeded the recommended values in August and September, it was determined that the manganese contents in the other months were among the recommended values. However, according to NRC (2005), it is stated that manganese must be 2000 ppm in order to have a toxic effect on animals. The amount of manganese contained in Russian thistle is at a level that does not cause toxicity in animals.

Zinc: In the research, the zinc content of plant samples varied between 22.9 ppm and 61.4 ppm. As the development period progressed, the zinc content of the plant also decreased. While zinc was high in the months when the plant first started to develop, there were decreases in zinc content in the following months (Gökkuş et al., 2013). Zinc plays a role in the activation of some enzymes (carbonic anhydrase), protein synthesis, carbohydrate metabolism, nucleic acid formation, feather and bone formation in animals (NRC, 2005; McDonald et al., 2011; Kutlu et al., 2005). It is recommended that the amount of zinc in the feed of ruminants should be between 7-100 ppm (NRC, 1985). The zinc content of Russian thistle in all development periods was within the values recommended by NRC (1985). On the other hand, it has been reported that toxic effects may occur in animals when the zinc level contained in feed is 500 ppm (NRC, 2005). It has been reported that the zinc content in plants decreases as maturation progresses (Hambidge et al., 1986).

Table 4. Micro mineral contents of Russian thistle according to different development periods

Months	Fe (ppm)	Cu (ppm)	Mn (ppm)	Zn (ppm)
April	142.1 e	2.23 b	33.1 c	61.4 a
May	166.5 de	1.77 c	38.9 c	43.6 b
June	188.3 cd	1.80 c	32.9 c	48.8 b
July	273.4 a	2.90 a	25.3 d	30.6 c
August	266.3 a	1.87 c	47.9 b	25.6 cd
September	243.3 ab	1.63 c	72.1 a	22.9 d
October	216.1 bc	2.90 a	36.4 c	24.1 cd

F value and significance	14.48**	25.14**	46.92**	44.34**

**The statistical difference between months is significant at the 1% level; The difference between identical letters in columns is not significant.

4. Conclusion

Changes of macro (N, K, P, Mg, Ca, Na) and micro (Fe, Cu, Mn, Zn) mineral contents during the 7-month development period of Russian thistle were examined. While the highest nitrogen content was in April, May and June, there were decreases in nitrogen content in the following months. While the potassium content was high in April, May and June, there was a decrease in the potassium content in the following months. A decrease in phosphorus content was recorded due to progress in plant development. While magnesium content was highest in April and September, it was low in other months. Calcium content was highest in April and May and lowest in August. While sodium content increased until June, there were decreases in the following months. While there was an increase in iron content until July, there were decreases in iron content in the following months. Copper content reached its highest values in July and October. The manganese contained in the plant reached its highest value in September. There has been a decrease in zinc content due to progress in plant development.

According to the results of the research, it was determined that the nitrogen, potassium, phosphorus (except April), magnesium, sodium, iron, manganese and zinc contents of Russian thistle are among the values that should be included in feed, its calcium content is high and its copper content is low. Since the sodium content of the plant is high throughout the season, grazing of animals should be avoided in areas where this plant is dense.

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