Bulgarian Journal of Agricultural Science, 23 (No 2) 2017, 204–212
Agricultural Academy

MINERAL COMPOSITION OF FORAGE CROPS IN RESPECT TO DAIRY COW NUTRITION

K. MARIJANUŠIĆ[*1]; M. MANOJLOVIĆ[1]; D. BOGDANOVIĆ[1]; R. ČABILOVSKI[1]; P. LOMBNAES[2]
[1] *University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovica 8, 21 000 Novi Sad, Serbia*
[2] *Norwegian Institute of Bioeconomy Research, Raveien 9, 1430 Ås, Norway*

Abstract

Marijanušić, K., M. Manojlović, D. Bogdanović, R. Čabilovski and P. Lombnaes, 2017. Mineral composition of forage crops in respect to dairy cow nutrition. *Bulg. J. Agric. Sci.*, 23 (2): 204–212

In order to evaluate the mineral composition of forage crops in respect to dairy cow nutrition 40 soil and corresponding plant (alfalfa, grasses and silage corn) samples were collected from 15 locations in Serbia and analyzed for the concentration of macro- (P, K, and Ca) and microelements (Mn, Cu, Zn, Fe, Co, Se, and Mo). On average, the soils were well provided with the studied elements from the aspect of plant nutrition, but the analyzed fodder crops could not secure sufficient amounts of Cu, Zn, Se, and Ca for dairy cow nutrition. Principal components analysis was applied in order to determine the connection between the concentrations of macro- and microelements in forage crops and their grouping into components responsible for most of the variability in mineral content. The mineral composition of alfalfa was defined by three components (Se, Zn, and Cu) which accounted for the largest part of the established variability. The variability of mineral composition of grasses was defined by four components (Zn, K, Se, and P) and that of silage corn by the concentrations of Fe, Mn, and K.

Key words: silage corn, alfalfa, grasses, macroelements, microelements
List of abbrevations: phosphorus (P), potassium (K), manganese (Mn), copper (Cu), zinc (Zn), calcium (Ca), iron (Fe), cobalt (Co), selenium (Se), molybden (Mo), diethylenetriaminepentaacetic acid - triethanolamine (DTPA+TEA), principal components analysis (PCA), explained variance (EV); proportion of total variance (PTV)

Introduction

Forage crops are an important part of livestock production, as they represent basic source of minerals in cattle nutrition (Suttle, 2010). The element composition of forage crops depends largely on soil type, plant species and its usage, i.e., cultural practices applied. Soil is the main source of macro- and microelements for plants, however, only a small portion of their total content is plant available. A soil is considered deficient in a particular element if it cannot provide that element in amounts sufficient for normal growth and development of plants or organisms (Hooda, 2010). Transfer of microelements from soil to plants is part of a complex chemical cycle taking place in nature. Soil-to blood transfer factor with a very high correlation was found between the contents of the metabolically important element (potassium (K), selenium (Se), zinc (Zn), iron (Fe) and manganese (Mn)) in cattle blood and the soil in Southern Serbia (Popović, 2010). The most important factors determining the availability of microelements are: pH and redox potential, soil texture, quality and quantity of organic matter, mineral composition, temperature and water regimes, as well as interactions between chemical elements (Kabata-Pendias, 2004). Soil texture and organic matter content affect the absorption of microelements, therefore, light sandy soils contain smaller available amounts of microelements than the soils with heavier texture. Finally, the relationship between microelements and other elements in the soil is important because disturbance in the relationship creates antagonism between elements.

**Corresponding author*: klaram@polj.uns.ac.rs

The macroelements phosphorus (P), K, and calcium (Ca) and the microelements copper (Cu), Zn, Fe, Mn, and molybdenum (Mo) are essential for plant growth. In addition to these elements, Se as an antioxidant is an essential element for development and continual health of animals and humans. Also, cobalt (Co) is not necessary for plant nutrition, but is required indirectly for legumes and its role in nitrogen fixation. The absence (or excess) of the above elements causes characteristic symptoms and disrupts normal functioning of living organisms. For this reason it is important that the daily diet provides sufficient amounts of macro- and microelements. When it comes to animal nutritional requirements for minerals, they are much higher compared to plant needs.

Zinc and Fe deficiency in the soil and plants is a global problem. In a study conducted in 2013 on the territory of Serbia (sample size n = 157), the Zn content in soil was lower than the specified limits in only 13% of the analyzed samples while the Fe content in almost all samples was above the specified limits (Nikolić et al., 2016). However, Manojlović and Singh (2012) cited several studies which had dealt with the concentrations of trace elements in soils and forage samples collected on the territory of Serbia and Balkan. The content of Cu, Mn, Fe and Zn in alfalfa, grasses and corn varied considerably among collection sites. In some parts of Serbia, the contents of these microelements were below the limit value required by cattle, particularly in case of Zn and Cu.

Serbia represents the region of Se deficiency, especially the area south of the Danube (Valčić, 2013). Low contents of Se were detected in some soils in Serbia as well as in plants used for the preparation of animal feed (Čuvardić, 2003; Valčić, 2013). The low levels of Se in livestock feed affect the Se supply to the animals. A study conducted in Serbia has indicated that a diet of heifers and calves with fodder deficient in Se (<0.1 mg Se kg^{-1} DM) caused a low level of Se in blood plasma (Jovanović et al., 2004). Ademi et al. (2015) found inadequate levels of Se in 45.6% of the total number of blood samples collected at 39 cattle farms located in Northern Serbia and Bosnia and Herzegovina.

In light of the above considerations, the aim of this study was to determine the macro- and microelements status of soil and forage crops grown in Northern and Western Serbia, and to compare the obtained values against the nutritional requirements of dairy cows. Also, the study was intended to establish the correlations between individual elements in plants as well as the variability of the mineral composition of alfalfa, grasses and silage corn.

Materials and Methods

In order to determine the mineral composition of forage crops and the effect of soil fertility on the mineral composition in plants, soil and plant samples were collected in 2013 from 15 locations in Serbia (12 locations in north part, on the territory of Vojvodina Province and three in western Serbia, Kolubara county) (Figure 1). The choice of locations was based on the presence of livestock production in a given region. Soil and plant samples were taken exclusively at dairy farms. Dairy cow needs are determined by the National Research Council (NRC) model for Holstein cows with milk production of 25 kg.

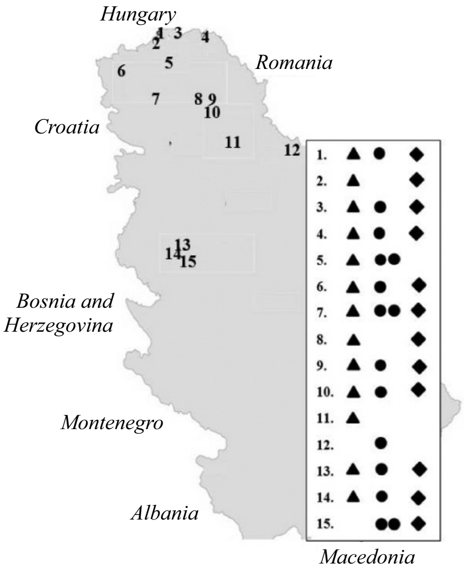


Fig. 1. Map of Serbia with the studied locations. The study included alfalfa (triangles), grasses (circles) and silage corn (squares)

A total of 40 soil samples were taken in fields under alfalfa (n = 15), grasses (n = 13) and silage corn (n = 12). The samples taken in a disturbed state, from the soil layer of 0-30 cm, were subsequently air dried, ground, and sieved through a 2-mm mesh sieve. The selected locations represented the dominant soil types in Serbia: chernozem, gleysol, solonetz, fluvisol, and planosol.

Alfalfa and grass samples were taken in early May, at the time of first mowing, while the samples of silage corn were taken at the time of silage preparation at the farms, i.e., in late August 2013. The aboveground plant mass was collected at random from the same plots from which soil samples had been previously taken. Plant mass was dried at 60°C to constant weight.

Soil reaction was determined in 1:2.5 suspension of soil:water and soil:1M KCl. The content of $CaCO_3$ was determined volumetrically (ISO 10693:2005) by Scheibler's kalcimeter (Hedas, Serbia). Humus was determined indirectly, by Tyurin'smethod (ISO 14235:2005), by multiplying the carbon content with 1.72. Available P and K were extracted with a solution of ammonium lactate (0.1 M) and acetic acid (0.4 M) (AL-method, Egner and Riehm, 1960). Phosphorus content was determined spectrophotometrically (Shimadzu UV 2600, Japan), K contents flame photometrically (Jenway 6105, USA). The available contents of Cu, Mn, Zn, Fe and Co were determined by extraction in the buffered solution of diethylenetriaminepentaacetic acid - triethanolamine (0.005 M DTPA + 0.01 M $CaCl_2$ + 0.1 M TEA) and the soil:solution ratio of 1:2 (ISO 14870:2001). The concentration of microelements was measured with atomic absorption spectrophotometer (Shimadzu 6300, Japan). The referent sample was ISE 973 (WEPAL, Netherlands). Total contents of Se and Mo were determined using ICP-MS (Agilent 8800 QQQ, USA) after microwave digestion of soil with HF and HNO_3 acid in UltraCLAVE (Milestone, Italy). We used two certified reference materials: NCS DC73324 and NCS ZC73007 (National Analysis Center for Iron and Steel, China).

Plant material destruction for determination of microelements was done with a mixture of HNO_3 and $HClO_4$ - nitric-perhloric acid wet digestion in an open vessel (Kalra, 1998). For determination of the concentrations of Se and Mo, digestion was performed with nitric acid in Milestone UltraCLAVE. The content of microelements in plants was measured in the same manner as in soil. The reference materials for Se and Mo determinations were Wheat Flour 1567a and Apple Leaves 1515, respectively (National Institute of Standards and Technology, USA), while Maize IPE 885 (WEPAL, Netheralands) was used for other microelements. High-temperature dry ashing (Kalra, 1998) was applied for the determinations of P and K. Plant samples were first ashed in an oven at 550°C and then digested in HCl (25%). Phosphorus was subsequently determined by spectrophotometry and potassium by flame photometry.

Descriptive statistics was used for the calculation of average values, standard deviation, and the range of values. The principal components analysis (PCA) was used to establish the relationship between the concentrations of macro- and microelements in plants and the variability of mineral composition in forage crops. PCA was applied to a data matrix consisting of the content of microelements in plants (columns) and the observed locations (rows). Number of components was determined on the basis of Kaiser's rule, which stipulates that only components with eigenvalues greater than 1 are taken into account. Macro (micro) elements with the loadings of ≥0.70 were included into the components. After the analysis of principal components, data were rotated using Varimax rotation method. Statistical analyses were performed using STATISTICA 12 software.

Results

Table 1 shows the average, minimum and maximum values of the basic properties of soil under alfalfa, grasses and silage corn. The studied soils are in a class of poorly to medium humous, poorly to highly calcareous soils. The established contents of available P and K varied broadly from low to very high, particularly in the case of P. In most of the analyzed locations, the soil reaction ranged from neutral to strongly alkaline. Several locations in Western Serbia, in which pseudogley and planosol were dominant soil types, were exceptions in which low carbonate contents and acid soil reaction were found.

Table 1

Average, standard deviation and range (in parentheses) of the values of basic soil properties under forage crops

	Alfalfa	Grasses	Silage corn
pH inH_2O	7.79 ± 0,93	7.66± 1.22	7.65± 1.18
	(5.52 - 8.37)	(5.30 - 9.40)	(5.67 - 8.67)
pH inKCl	6.91± 1.10	6.69± 1.30	6.86± 1.40
	(4.25 -7.67)	(3.88-7.83)	(4.41-8.01)
$CaCO_3$	7.93± 5.34	9.69± 8.74	8.46± 5.90
	(2.08-18.99)	(2.49-26.79)	(2.53 -18.54)
Humus (%)	2.32 ± 0.74	2.62± 0.74	2.71 ± 0.54
	(1.00 - 3.22)	(1.78 - 4.62)	(1.45 - 3.38)
P_2O_5 mg 100 g^{-1}	17.75±12,23	23.44± 19.66	22.28± 16.08
	(0.21-41.36)	(0.85-57.13)	(2.64 -52.73)
K_2O mg 100 g^{-1}	16.65± 5.70	20.87± 12.38	23.69± 8.09
	(7.29-26.58)	(6.50-46.07)	(12.03 -37.90)

In almost all of the examined locations the contents of available Mn, Cu, Zn, Fe and Co (DTPA extracted) met the requirements of the cultivated plants, i.e. they were above the deficiency level for agricultural production (Table 2). The soil Se was generally lower than the suggested level of 0.6 mg Se kg^{-1}.

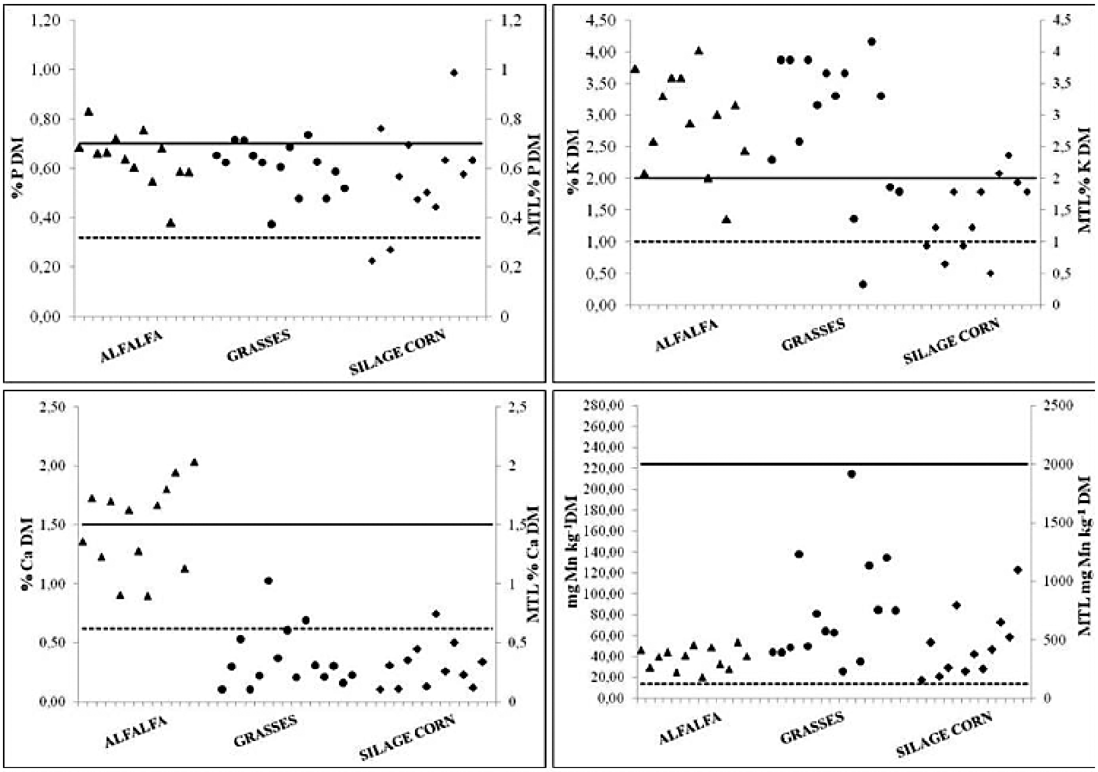
The contents of macro- and microelements in the samples of alfalfa, grasses, and silage corn collected at the locations selected for this study was shown in Figure 2, 3 and 4a. In all the analyzed forage samples, P content (Figure 2) is above the lower critical limits, but in about 17% of the samples exceeds the maximum tolerable levels. The K content is above the maximum tolerable levels in almost all of the analyzed samples of alfalfa and grasses and in two samples of silage corn. In grass and silage corn samples the Ca content is below nutritional requirements

Table 2

Mean values and standard deviations for the contents of total and available microelements in the soil under forage crops, mg kg[-1]

Element	Requirements of cultivated plants	Alfalfa	Grasses	Silage corn
Mn available	1*	22.93± 30.55 (4.82-107.65)	29.56± 33.50 (1.66-95.84)	38.11±15.33 (25.79-70.18)
Cu available	0.2*	6.16± 2.38 (3.41-12.09)	7.96± 3.09 (4.42-15.90)	4.53±2.79 (1.86-9.36)
Zn available	0.8*	1.61± 0.90 (0.02-3.79)	2.09± 0.85 (0.93-4.43)	2.84±1.35 (1.26-5.68)
Fe available	4.5*	45.79±12.96 (23.76-70.73)	52.51±18.93 (20.02-79.54)	64.99±20.85 (29.68-97.67)
Co available	0.25**	0.41±0.14 (0.21-0.73)	0.45± 0.13 (0.29-0.72)	0.66±0.26 (0.42-1.28)
Se total	0.6***	0.31±0.07 (0.16-0.41)	0.33± 0.11 (0.14-0.57)	0.26±0.06 (0.18-0.37)
Mo total		0.50±0.14 (0.24-0.73)	0.51± 0.14 (0.16-0.68)	0.46±0.12 (0.33-0.71)

*Lindsay and Norwell, 1978; **Stewart, 1952; *** Gupta and Gupta, 2002



The measured contents of macro- and microelements in alfalfa (triangles), grasses (circles) and silage corn (squares) – left axis. The horizontal lines indicate the recommended levels required by dairy cows - left axis, dashed lines **(NRC, 2001)** and the maximum tolerable levels (MTL) in the feed - right axis, full line **(Suttle, 2010)**

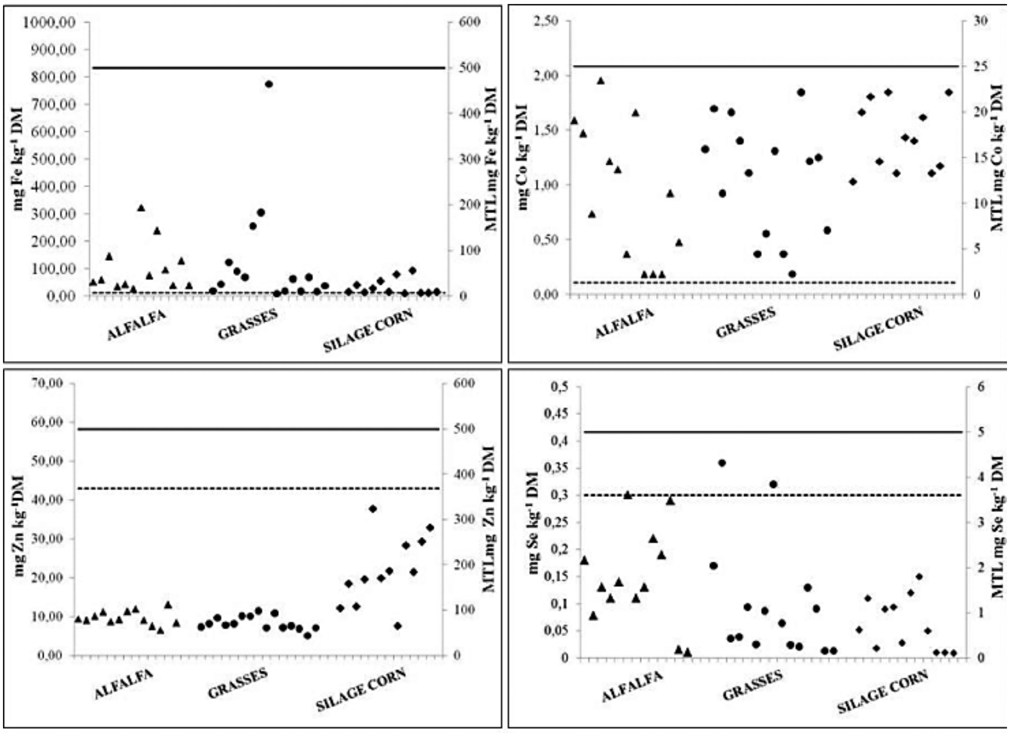
Fig. 2. Contents of P, K, Ca and Mn in plants

of dairy cattle. In the collected samples of forage, the contents of Mn (Figure 2), Fe and Co (Figure 3) is at the appropriate level of nutritional needs of dairy cows and does not exceed the maximum allowed concentration, while the contents of Cu and Zn are not satisfactory. The content of Cu (Figure 4a) in over 80% of the samples of alfalfa and grass and in all samples of corn silage is below the critical level of 11mg kg DM^{-1} required by dairy cows. The Zn content (Figure 3) in all analyzed forage crops is below the critical limit of 43 mg kg^{-1} DM. Comparing the requirements of dairy cows (NRC, 2001) given in the Figure 3 with the element contents of the collected samples of alfalfa, grass and silage corn, we found that the average Se content in all analyzed samples was below the required value.

In 10% of the samples (Figure 4b), Cu and Mo ratio is below the marginal band while in almost 60% of the analyzed samples the ratio is below the recommended level of 6. Also, in a great number of samples the ratio is above the upper limit of 10.

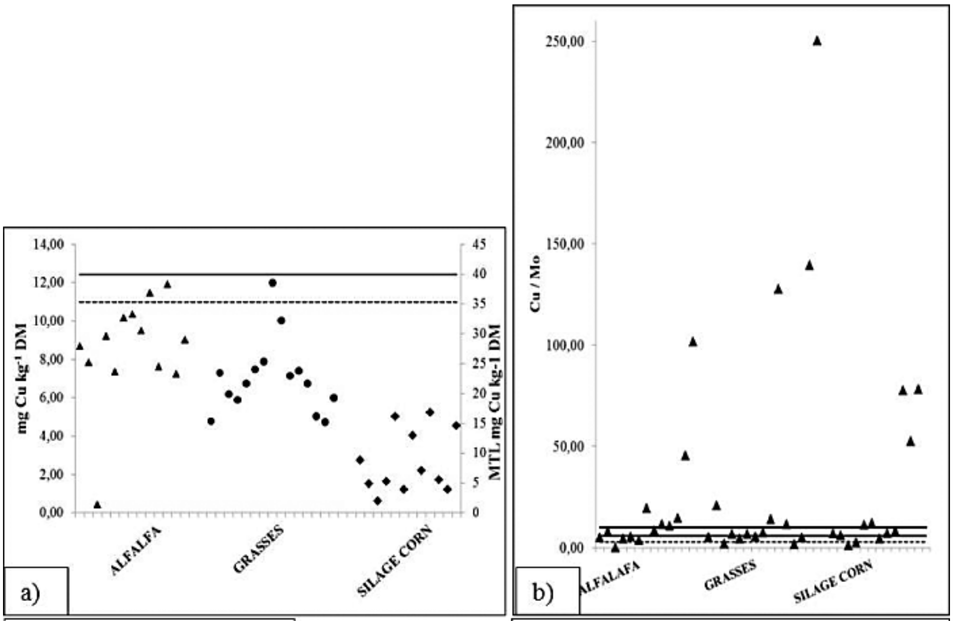
The load graphs (Figure 5a,b,c) indicate that there were correlations between the observed elements in the analyzed plant materials. Close correlations were observed between Mn and Fe, as well as among Co, P, and K, in the alfalfa samples (Figure 5a). Figure 5b shows that there were correlations among the contents of Ca, Zn, Fe and Cu as well as between Mo and K in the grass samples. Figure 5c shows that there were correlations between Fe, Cu and Ca and between Mn and P and P and K in the silage corn samples.

PCA was applied in order to group the correlated macro- and microelements from forage crops into components that represented most of the variability in mineral composition. To facilitate the interpretation of the variability of mineral composition, the element with the highest loading was selected as a representative for each component. Table 3 shows the most important components retained after PCA application and data rotation. In this study, the three principal components explained 71.78% of the total variability of mineral content in alfalfa. On account of the highest loading, K was the representative element for the first component, Fe for the second, and Se for the third. The variability of the mineral composition of grasses was explained by 4 components (80.96% of the total variability). Zn was selected as the representative element for the first component, K for the second component. As for the components 3 and 4 they had high loadings for a single component, Se and P, respectively, which were automatically the representative elements. Three components explained the variability in the element content in silage corn. Two elements, Ca and Fe, were equally correlated with the first component and so both of them were considered as representative. Mn was representative for the second component, K for the third.



Explanation below Figure 2.

Fig. 3. Contents of Fe, Co, Zn and Se in plants



Explanation below Figure 2

The horizontal lines indicate the recommended ratio (full line) and the marginal ratio (dashed line) **(Govasmark, 2005).**

Fig. 4. a) Content of Cu and b) Cu/Mo ratio in plants

Discussion

With the exception of selenium, the soils of Serbia are well-supplied with the examined elements; however, in terms of livestock feeding, the forage crops grown on these soils do not provide sufficient amounts of Cu, Zn, Se and Ca.

On average, the content of P and K in forage crops observed on most of the site is at satisfactory level for dairy cows, however, the K content in alfalfa and grasses is above the maximum tolerable level. The determined content of K in these plants is in the range of values specified by other author (Barker and Pilbeam, 2007). Despite its high content in plants, K toxicity is very rare in cattle. Dairy cattle have a high level of tolerance to excessive content of K in feed due to the body's ability to readily excrete potassium as well as regulate absorption (NRC, 2005).

In general, monocotyledonous plants contain much less of calcium than the dicotyledonous plant (Barker and Pilbeam, 2007). Accordingly, the analyzed samples of alfalfa contain significantly higher content of Ca compared to grass and silage corn. Although the concentration in grass and maize is below the nutritional requirements of cattle, it corresponds or is even higher than the Ca concentration in forage crops specified by other author (Bergmann, 1992).

Soil reaction has a decisive impact on the dynamics of trace elements in the soil, because acidic environments tend to release increased amounts of trace elements into the soil solution. The exceptions are Se and Mo, which are more accessible in alkaline soils. Organic matter content in the soil affects positively the content of Cu and Mn in plants, while it affects negatively the content of Fe (Govasmark, 2005).

Marginal bands for assessing the risk of Fe deprivation in cattle are 40-60 mg Fe kg^{-1} DM (Suttle, 2010), while according to NRC standards of 12 mg Fe kg^{-1} DM meets the nutritional needs of cattle. On average, the content of Fe in forage crops in Serbia is above the specified limits (Manojlovic and Singh, 2012) except in the case of alfalfa, with a slightly lower range of values determined. In our study, the concentration of Fe in forage crops is above the limit of 12 mg kg^{-1}DM, however, on most sites concentration is only slightly more than the set limit, especially in the case of maize. Despite the relatively good supply of Fe in animal feed, the lack of Fe was identified in cows in Serbia (Popović, 2010).

In the case of zinc and copper, similar factors affect their concentration in the plants. Zn shortage in plants may be caused by various factors such as low content of total Zn

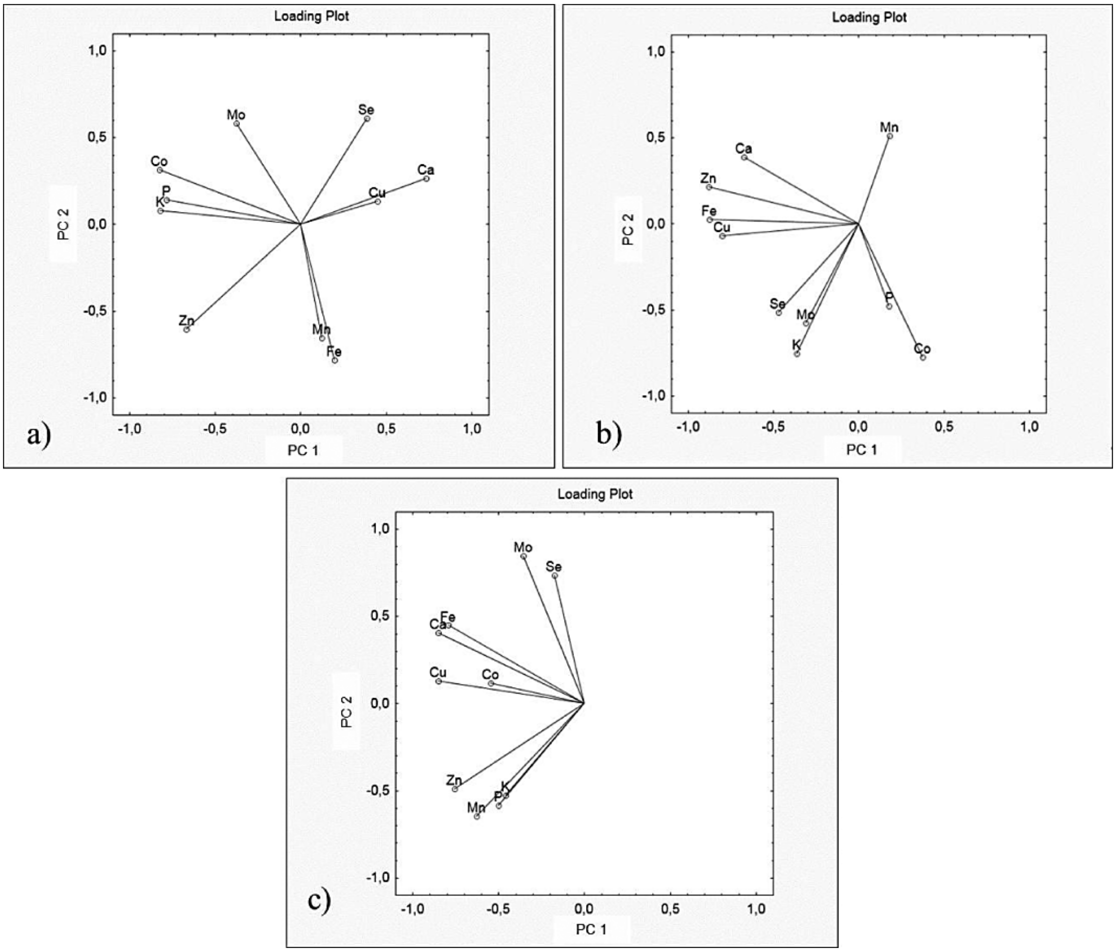


Fig. 5. Loadings prior to data rotation - mineral composition of (a) alfalfa; (b) grasses; (c) silage corn

Table 3
Results of the principal component analysis of microelements in alfalfa samples: varimax rotated principal component loadings

	Alfalfa			Grasses				Silage corn		
	PC 1	PC 2	PC 3	PC 1	PC 2	PC 3	PC 4	PC 1	PC 2	PC 3
P	-0.699	0.394	-0.290	-0.151	0.139	-0.078	**-0.891**	-0.003	0.405	**0.705**
K	**-0.861**	0.017	0.112	0.078	**0.866**	0.355	0.041	0.106	0.099	**0.953**
Mn	0.017	**-0.816**	-0.005	0.047	-0.017	-0.561	0.628	-0.105	**0.899**	0.338
Cu	0.370	-0.129	0.393	0.659	-0.030	0.540	-0.197	0.626	0.607	0.092
Zn	**-0.700**	-0.525	-0.309	**0.907**	0.144	0.103	0.180	0.139	**0.781**	0.446
Ca	**0.751**	0.207	0.168	**0.846**	0.010	-0.193	0.102	**0.909**	0.259	0.204
Fe	0.124	**-0.834**	-0.190	**0.747**	0.021	0.493	0.016	**0.908**	0.182	0.181
Co	**-0.815**	0.343	0.070	-0.580	**0.700**	0.073	-0.078	0.276	**0.767**	-0.419
Se	0.243	0.085	**0.905**	0.069	0.274	**0.852**	0.066	0.632	-0.190	-0.373
Mo	-0.494	0.181	**0.728**	0.262	**0.803**	-0.103	-0.262	**0.871**	-0.220	-0.258
*EV	4.112	2.430	2.134	2.882	1.941	1.718	1.310	3.703	3.052	2.437
**PTV %	34.02	20.11	17.65	29.72	20.02	17.71	13.51	33.18	27.34	21.83

Numbers in bold - elements with the loadings of ≥0.70
*Explained variance (EV); **Proportion of total variance (PTV)

in the soil (10-30 mg Zn kg^{-1}), limy soils with the pH value >7.4, low content of organic matter, plant species, high content of available phosphorus, etc. (Alloway, 2008). Corn in general, and especially high-yielding corn hybrids, accumulate Zn in very small amounts (Gupta et al., 2008). The content of zinc in all three observed type of forage crops is below the set limit for cattle nutrition. In our study, the zinc content in the soil under alfalfa, pasture and silage maize does not exceed 3.79, 4.43 and 5.68, respectively.

In addition to soil pH> 7 (Barker and Pilbeam, 2007), Cu deficiency in plants can be caused by other factors such as the antagonism between the elements, fertilization with N and P (Hooda, 2010), a low content of organic matter in the soil (Govasmark, 2005). According to scientific papers, the optimal concentration of copper in alfalfa, grass and silage maize are 6-15 mg kg^{-1} (Bergmann, 1992), 7-8 mg kg^{-1} DM (Fisher, 2008) and 7-15 mg kg-1 DM (Bergmann, 1992). In our study, the content of plant available Cu in the soil is above the threshold for agricultural production, however, the content in forage on most sites does not meet the nutritional requirements of cows.

According to the NRC standards, 0.3 mg Se kg^{-1} of dry matter is the Se concentration in animal feed which meets animal needs. However, literature sources provide different minimum values below which animals start to exhibit symptoms of selenium deficiency. Gupta et al. (2008) placed the threshold value at 0.1 mg Se kg^{-1} DM while Suttle (2010) reported even lower value, 0.05 mg Se kg^{-1} DM. In our study, the content of Se in soil at all sites is below the specified limit. It is considered that the forage crops grown on the soils which contain less than 0.6 mg Se kg^{-1} cannot meet the Se requirements of domestic animals. Also, the results correspond to previous research in Serbia, where it was determined that the Se content in the Vojvodina soils ranges from 0.024 to 0:45 mgkg-1 (Manojlovic and Singh, 2012).

The interaction between the elements is very important, because it can be one of the factors to the lack of elements in both plants and animals. Calcium, P and Mg are the main antagonists in the absorption of some microelements. Antagonism is also very common between Mn and Cu, Fe and Cu, Zn and Mn. Our results are contradictory to previous studies. In our examination, high Fe concentrations were associated with high Cu concentrations in the grass and silage corn samples. The close relationships between some elements, such as Mn and Fe, Cu and Fe, may be explained by soil pH, because the availability of these elements increases in the more acidic environment. Also, when a high P concentration is established in alfalfa or silage corn samples, it is reasonable to expect to find a high K concentration too. The correlation between these two elements can be explained by the fertilization practice in Serbia, ie. the application of high doses of phosphorus and potassium fertilizers by farmers.

From the aspect of animal nutrition Cu and Mo ratio is very important. High Mo concentration in feed crops may cause Cu deficiency despite the fact that copper concentration is at a satisfactory level for livestock (Gupta et al., 2008). An unfavorable ratio on some localities is caused by a combination of generally low copper content and normal to high Mo content in alfalfa, grasses and corn silage (1.17 ± 0.78, 1.11 ± 1-01 and 0:35 ± 0.28 respectively).

In their review paper, Soetan et al. (2010) cited several studies which claim that location i.e. soil has the greatest impact on the the concentration of elements in different plant species. The variability of the content of individual elements in plants is largely determined by soil parameters. The concentration of elements depends also on the phase of plant development. The concentrations of P and Ca in alfalfa leaf, stem, and the whole plant increase in the course of plant growth and development, while the concentrations of N, K, Mg, Fe, Cu, Zn and Mn are closely linked with growth stage (Marković et al., 2009).

Grasslands in Serbia have been formed under different climatic conditions and on different soil types, which results in a complex floristic structure and great differences in plant productivity and the quality of forage produced by them (Stošić and Lazarević, 2007). In the Province of Vojvodina, which is predominantly a lowland region, natural grasslands have been left mainly on lands unfavorable for crop production (saline soils, smonitza soils, etc.). Still, in terms of forage quality, the Vojvodina grasslands are much better than the grasslands in the mountainous-hilly region of Western Serbia.

Silage corn is definitely the most important silage plant, both in the world and in Serbia. Although the quality of silage corn has been treated in a number of studies, limited data are available on its mineral composition and especially on the factors which determine the availability of elements essential for corn growth under the agroecological conditions of Serbia. The form of nitrogen applied through fertilizer affects the content of microelements in silage corn. Plants which receive nitrogen in the ammonium form contain increased amounts of P, Zn, Mn and Cu (Sabir et al., 2013).

Conclusion

High variability in mineral composition of soils and plants for animal feed were found on investigated dairy farms in Serbia, especially in the case of K, Fe and Se, therefore, in addition to soil farmers are advised to have their fodder material analyzed and obtain information about quantities and elements that should be added in order to prepare adequate rations for their livestock. However, it is also possible to increase the concentration of deficient elements by applying appropriate agricultural practices as biofortification.

Acknowledgements

The study was partly supported by the Ministry of Education, Science and Technological Development of Serbia (Project TR 31027) and the Norwegian HERD Project "Grassland Management for High Forage Yield and Quality in the Western Balkans (Project 332160UR)".

References

Ademi, A., E. Govasmark, A. Bernhoft, H. Bytyqi, M. Djikic, M. Manojlović, Z. Lončarić, M. Drinić, A. Filipović and B. R. Singh, 2015. Status of selenium in sheep and dairy cow blood in Western Balkan countries. *Acta Agriculturae Scandinavica, Section A - Animal Science*, 65: 1-8.

Alloway, B. J., 2008. Zinc in Soils ans Plant Nutrition. *Ed.IZA & IFA,* Paris (FR), 44 pp.

Barker, A. and D. Pilbeam, 2007. Handbook of plant nutrition. *CRC press,* Boca Raton, USA, pp.
104, 133, 294.

Bergmann, W., 1992. Nutritional Disorders of Plants Development. Visual and Analytical Diagnosis. *Gustav Fischer Vela,* Jena, Stuttgart.

Čuvardić, M., 2003. Selenium in soil. *Matica Srpska Journal of Natural Sciences, Novi Sad*, **104**: 23-27.

Egner, H., H. Riehm and W. R. Domingo, 1960. Investigations of the chemical soil analysis as a basis for the evaluation of nutrient status in soil. II. Chemical extraction methods for phosphorus and potassium determination. *K. Lantbruks. Hogsk. Ann*., **26**: 195-215 .

Fisher, G.E., 2008. Micronutrients and animal nutrition and the link between the application of micronutrients to crops and animal health. *Turkish Journal of Agriculture and Forestry*, **32**: 221-233.

Govasmark, E., A. Steen, A. K. Bakken, T. Strøm and S. Hansen, 2005. Factors affecting the concentration of Zn, Fe and Mn in herbage from organic farms and in relation to dietary requirements of ruminants. *Acta Agriculturae Scandinavica, Section B - Soil & Plant Science,* 55: 131-142.

Gupta, C. U. and C. S. Gupta, 2002. Quality of animal and human life as affected by selenium management of soils and crops. *Communications in Soil Science and Plant Analysis,* **33**: 2537-2555.

Gupta, U. C., W. U. Kening and S. Liang, 2008. Micronutrients in soils, crops, and livestock. *Frontiers of Earth Science*, 15: 110-125.

Hooda, P. S., 2010. Trace elements in soils. *John Wiley & Sons, Ltd.* Chichester, UK, pp. 175-187.

ISO International Organization for Standardization, 2001. ISO14870:2001, Soil quality - Extraction of trace elements by buffered DTPA solution.

ISO International Organization for Standardization, 2005. ISO 10693:2005, Soil quality Determination of carbonate content Volumetric method.

ISO International Organization for Standardization, 2005. ISO 14235:2005, Soil quality Determination of organic carbon by sulfochromic oxidation.

Jovanović, I., O. Pešut, **D. Gvozdić and V. Stojić,** 2004. Selenium and iodine status relationship in calves and heifers from selenium and iodine deficient areas in Serbia. *Acta Veterinaria Belgrade*, **54**: 3-11.

Kabata-Pendias, A., 2004. Soil-plant transfer of trace elements-an environmental issue. *Geoderma*, **122**: 143-149.

Kalra, Y., 1997. Handbook of Reference Methods for Plant Analysis. *CRC Press,* Boca Raton, USA, pp. 53-57.

Lindsay, W. L. and Norvell, W. A., 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. *Soil Science Society of America Journal*, **42**: 421-428.

Manojlovic, M. and B. R. Singh, 2012. Trace elements in soils and food chains of the Balkan region. *Acta Agriculturae Scandinavica, Section B - Soil & Plant Science,*. **62**: 673-695.

Marković, J., R. Štrbanović, M. Cvetković, B. Anđelković and B. Živković, 2009. Effects of growth stage on the mineral concentrations in alfalfa (*Medicago sativa* L.) leaf, stem and the whole plant. *Biotechnology in Animal Husbandry*, **25**: 1225-1231.

Nikolić, M., N. Nikolić, L. Kostić, J. Pavlović, P. Bosnić, N. Stević and N. Hristov, 2016. The assessment of soil availability and wheat grain status of zinc and iron in Serbia: Implications for human nutrition. *Science of the Tota. Environment*, **553**: 141-148.

NRC, National Research Council, 2001. Nutrient Requirements of Dairy Cows. *The National Academies Press.* Washington, USA.

NRC, National Research Council, 2005. Mineral Tolerance of Animals. *The National Academies Press.* Washington, USA.

Popović, D., T. Bozić, J. Stevanović, M. Frontsyeva, D. Todorović, J. Ajtić and V. S. Jokić, 2010. Concentration of trace elements in blood and feed of homebred animals in Souther Serbia. *Environmental Science and Pollution Research*, **21:** 401-403.

Sabir, M., M. M. Hanafi, M. T. Malik, T. Aziz, M. Zia-ur-Rehman, H. R. Ahmad, K. R. Hakeem and M. Shahid, 2013. Differential effect of nitrogen forms on physiological parameters and micronutrient concentration in maize (*Zea mays* L.). *Australian Journal of Crop Science*, **7:** 1836-1842.

Soetan, K. O., C. O. Olaiya and O. E. Oyewole, 2010. The importance of mineral elements for humans, domestic animals and plants: A review. *African Journal of Food Science*, **4**: 200-222.

Stewart, A. B., 1952. Cobalt deficiency in pastures in Great Britain. In: Proc. 6th International Grass Congress, London, UK, pp. 718-719.

Stošić, M. and D. Lazarević, 2007. Results of grassland research in Serbia. *A Periodical of Scientific Research on Field & Vegetable Crops*, 44: 333-346 (Sr).

Suttle, N. F., 2010. Mineral Nutrition of Livestock. *CABI Publishing,* Wallingford, UK, 13: 347-383.

Valčić, O., I. Jovanović, S. Milanović and D. Gvozdić, 2013. Selenium status of feedstuffs and grazing ewes in Serbia. *Acta Veterinaria Belgrade*, **63**: 665-675.

Received November, 22, 2016; accepted for printing March, 10, 2017