EVALUATION OF MACRO- AND MICROELEMENT CONTENTS IN PLANTS AND SILAGE OF *TRIFOLIUM PRATENSE* L. AND *LOLIUM MULTIFLORUM* L. DEPENDING ON THE YEAR, METHOD OF CULTIVATION AND CUT

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In a closed field experiment conducted in 1993–1995 at the Experimental Station in Prusy near Cracow N, P, K, Ca, Mg, Na, Zn, Ni, Pb and Cd contents were compared, as well as interrelations between some elements in plants and silages of red clover and Italian ryegrass cultivated pure and in mixtures. The assays were carried out on dry mineralised plant material using PHILLIPS PU 9100X Atomic absorption spectrophotometer (ASA). P was assessed colorimetrically in DU-600 Beckman apparatus, while N was determined using Kjeldahl's method. Macro- and microelement contents in plant mass and silage were differentiated by the fodder plant species. Separate cultivation (pure sowing) or red clover sowing in a mixture did not diversify the contents of most macroelements in plants. An interaction of sowing with cut markedly affected magnesium content in red clover plants, while Mg amount in ryegrass was significantly differentiated in the result of cooperation of the years of cultivation and methods of sowing. Relations between macroelements revealed changes in the years and cuts. The year of cultivation was an agent which most strongly and significantly differentiated macroelement contents in red clover and Italian ryegrass plants from researched sources of variability.

red clover and Italian ryegrass; mixture; plants; silage; contents of elements

INTRODUCTION

According to agrotechnological assumptions concerning field cultivation of grasses and legumes those two crops are best grown as simple legumes-and-grasses mixtures (Lehman, Meister, 1982; Shatilov et al., 1985; Zajac, Borowiec, 1996). As seen on an example of red clover and Italian ryegrass coexistence of legumes and grasses allows to achieve high yield of plant mass with a balanced energy-and-protein ratio and optimal contents of minerals in the plant mass. In Poland, especially in the southern part, red clover is grown on arable lands for ruminant fodder; it is sown in mixtures with grasses and the species is valued for its high abundance in protein that becomes decomposed in the rumen to a high degree. Red clover plant mass is also abundant in minerals, mainly calcium (Ledoux, Martz, 1991). Consumption and digestibility of minerals depending on the amount of consumed feed decide whether the animal requirement for has been satisfied (Anke, Grühn, 1982).

In their review work Kruczyńska and Mocek (1997) state, that many factors affect the contents of macro- and microelements in yields. The main differentiating agents are soil (its geological origin, recent pH and applied organo-mineral treatment) and the plant (species, development phase at harvest, individual cut in a year and the method of sowing – pure or mixed).

Multi-factor conditioning of plant mass abundance in biogenic elements prompts to use mineral additives for ruminant (dairy cattle) feeding, which according to INRA 88 system, as shown by Kowalski and Kański (1997) did not satisfy the cow requirement for Ca, irrespective of their yield. Individual element utilisation from feeds is affected by many factors and the most important are their mutual proportions (Günter, 1987). It is assumed that ruminants absorb between 30 and 50% Ca and 50–80% P from plant mass, whereas the conditions in the rumen decide about the metabolism of most minerals (Martens, Gäbel, 1987).

Bulk feeds and concentrates cannot fully satisfy ruminant requirement for some microelements, particularly zinc (Kirchgessner, 1986).

Apart form the absolute contents of macro- and microelements in feeds their mutual proportions both in hay and silage are also very important. Nutritional conditions strongly affect animal supply in biogenic elements and cattle, which is primarily fed with farm prepared feeds is dependent on mineral composition of those, particularly for winter feeding.

The study aimed at analysing the contents of N, P, K, Ca, Mg, Na, Zn, Ni, Pb and Cd as well as mutual relations between some elements in plants and silage of red clover and Italian ryegrass grown pure and in mixtures.

MATERIALS AND METHODS

In a closed field experiment conducted in 1993–1995 at the Experimental Station in Prusy near Cracow productivity and chemical composition of red clover variety cv. Nike and Italian ryegrass cv. Kroto were compared. 18 kg of clover and 24 kg of ryegrass were sown per hectare. The crops were sown pure and in two variety mixture with equal component share. They were sown in the first decade of April under spring barley cultivated as cover crop and harvested at the full grain maturity. Over the following years the plot areas were between 10.8 and 30.0 m^2 in four replications.

Three cuts were harvested each year, their dates were determined by the starting phase of clover flowering and the calendar dates were as follows: 2 June, 15 July and 8 September 1993; 31 May, 13 July and 22 September 1994; 2 June, 13 July and 31 August 1995. Precipitation amount over growing season and the cuts has been shown in Table I.

One-two kilogram samples for botanical and weight analysis were collected immediately after the harvest, which cut into chaff and dried were used for determining the chemical composition.

The crops were cultivated in degenerated black earth classified as very good wheat complex with pH_{KCl} 5.7–6.4 and total nitrogen content 0.1–0.16%. The contents of other available forms according to Egner-Riehm were as follows: 11.2–14.1 mg phosphorus, 1 mg P_2O_5 and 13.7–19.6 mg K_2O per 100 g soil. Pre-sowing treatment under barley in the year of the sowing was as follows: 30 kg N/ha, 60 kg P_2O_5/ha, 80 kg K_2O/ha. Microelement contents have been presented in Table II.

Assessments were made in dry mineralised plant material. 5 g of ground plant material were sampled and incinerated at 500 °C. After removing from the incinerator and cooling, the ash moistened with redistilled water was treated with 5 cm^3 of HNO_3 diluted in 1 : 2 ratio, evaporated till dry and once more incinerated. The material removed from the incinerator was treated with 5 cm^3 of 20% HCl and evaporated, then treated with 5 cm^3 HNO_3 1 : 2 and once more evaporated on the sand bath. The reminder was treated with 5 cm^3 of KNO_3 1 : 2 and 5 drops of hydrogen peroxide solution and boiled under the watch glass. The next step was to filter the evaporating dish contents through a medium filter into a 50 cm^3 measuring flask. In such prepared solution the contents of K, Ca, Mg, Na, Zn, Ni, Pb and Cd were assayed in PHILLIPS PU 9100X Atomic absorption spectrophotometer (ASA). P was assessed colorimetrically in DU-600 Beckman apparatus, while N was determined using Kjedahl's method. Statistical calculations of the obtained results were carried out by the analysis of variance using mixed model where the years were a random factor.

I. Total rainfall (mm) during the growth period

Year	During winter	During the growth period of cuts			Total rainfall during growing season
		I	II	III	
1993	202.0	89.3	72.6	43.7	205.6
1994	182.3	183.0	50.1	114.1	347.2
1995	184.8	177.0	132.7	75.6	385.3
1981–1990	171.0	107.0	117.0	120.0	344.0

II. Microelement contents in soil

Year	Symbol	Depth (cm)	Microelements (mg.100 g^{-1})			
			zinc	nickel	lead	cadmium
1993	Ap	0–27	76.8	15.9	28.7	0.55
	A	27–44	45.8	18.7	19.9	0.05
	AEet	44–62	50.8	24.0	21.6	0.03
	A/C	62–94	44.6	22.6	20.7	0.06
	C	94–150	36.6	16.5	18.8	0.07
1994	Ap	0–23	80.3	14.7	28.7	0.51
	AEetBt	23–40	37.3	16.2	17.7	0.09
	A/Bt	40–102	46.9	22.3	21.8	0.01
	Cg	102–150	39.9	19.5	19.7	0.01
1995	Ap	0–30	64.9	13.8	26.8	0.49
	A 1	30–77	37.8	14.5	21.9	0.09
	A 2	77–140	39.2	16.5	19.8	0.07
	ABtC	140–165	42.1	21.5	21.1	0.01

RESULTS

Macro- and microelements contents in red clover mass were significantly diversified in the individual years of cultivation (Table III). In relation to all the analysed elements red clover was stabile feed as to the nitrogen content, however the revealed differences in this element amount in the individual the years were significant. Years of cultivation particularly strongly differentiated Ca, P, Zn and Ni contents.

The method of sowing, red clover cultivation pure or in mixture with Italian ryegrass did not cause significant diversification in macroelement contents. Such arrangement of the factors shows that clover plants growing in congeneric stand or in mixture with grass do not change chemical composition. However, microelement content in red clover plant mass from pure stand was markedly higher in comparison with the mixture with Italian ryegrass. On this basis it may be assumed that in red clover plants growing in mixtures the process of microelement uptake was disturbed.

Variability of elements contents in cuts occurred variously. Nitrogen content in red clover plant mass increased from cut to cut, which is a fact known for many years, however, the revealed differences were not significant.

The other macroelements except Ca and Na revealed more differentiated contents. It should be emphasised that the plants from the second cut had

III. Macro- and microelement contents in green fodder of red clover (mg.kg^{-1})

Factor	Macroelements (% d.m.)						Microelements (mg.kg^{-1})			
	N	P	K	Ca	Mg	Na	Zn	Ni	Pb	Cd
Year of cultivation (A)										
1993	2.61a	0.19a	0.95b	0.74a	0.22a	0.01a	38.0a	4.84a	4.10b	0.41ab
1994	2.96b	0.25b	0.81a	1.1b	0.36c	0.02b	64.6c	4.80a	3.36a	0.38a
1995	2.76a	0.32c	1.20c	0.96b	0.30b	0.02ab	56.3b	8.37b	3.60a	0.44b
	**	**	**	**	**	**	**	**	**	**
Method of sowing (B)										
Pure sowing	2.87	0.27	0.99	0.96	0.30	0.02	55.3b	6.45b	3.83b	0.45a
Mixture	2.69	0.25	0.98	0.90	0.28	0.02	50.6a	5.55a	3.54a	0.38b
	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	**	**	**	*
Cut (C)										
I	2.67	0.29	1.33b	0.91	0.28	0.02ab	57.7b	5.09a	3.43a	0.32
II	2.75	0.22	0.89ab	0.80	0.26	0.02a	46.8a	6.11ab	3.31a	0.43
III	2.91	0.26	0.74a	1.07	0.33	0.02b	57.5b	6.8b2	4.32b	0.49
	n.s.	n.s.	*	n.s.	n.s.	*	*	*	*	n.s.
Interaction										
B x C					*					

Signifficance level: * $P < 0.05$; ** $P < 0.01$

lower amounts of P, K, Ca, Mg and Na as compared to the other cuts in the same year. It should be stressed that vegetation of plants from the second cut fell over water shortage in soil, so this factor might affected negatively the above mentioned elements possible uptake by clover. Also zinc and lead revealed lower contents in the second cut, which made them similar to the elements discussed above.

As compared to red clover Italian ryegrass had lower contents of N, Ca, Mg, Zn, Ni, Pb and Cd (Table IV). The years of cultivation were an agent significantly diversifying element contents in Italian ryegrass. Both compared fodder plants had a changeable mineral composition over the years. In 1994 both red clover and Italian ryegrass contained more nitrogen, magnesium, and zinc as compared with the other years. The method of ryegrass sowing changed its mineral composition to a small degree. Italian ryegrass growing together with red clover had slightly increased contents of nitrogen, phosphorus, lead and cadmium. This method of sowing markedly increased the contents of sodium and zinc. The effect of cut on the contents of selected elements was significant in a majority of cases. Strong influence of a cut was

IV. Macro- and microelement contents in green fodder of Italian ryegrass (mg.kg^{-1})

Factor	Macroelements (% d.m.)						Microelements (mg.kg^{-1})			
	N	P	K	Ca	Mg	Na	Zn	Ni	Pb	Cd
Year of cultivation (A)										
1993	1.75a	0.22a	0.95b	0.31a	0.13a	0.02ab	26.11a	2.86a	3.00b	0.18a
1994	1.89b	0.31b	0.81a	0.43b	0.24b	0.04b	53.12c	2.56a	2.68a	0.25b
1995	1.82ab	0.30b	1.20c	0.51c	0.16a	0.02a	38.43b	6.34b	2.69a	0.40c
	**	**	**	**	**	**	**	**	**	**
Method of sowing (B)										
Pure sowing	1.80	0.27	0.99	0.43	0.17	0.02a	35.66a	4.18	2.62	0.27
Mixture	1.84	0.29	0.98	0.40	0.18	0.03b	42.78b	3.60	2.97	0.29
	n.s.	n.s.	n.s.	n.s.	n.s.	*	**	n.s.	n.s.	n.s.
Cut (C)										
I	1.56a	0.28	1.33b	0.38a	0.17	0.03ab	45.10b	3.77	2.69	0.22
II	1.51a	0.26	0.89a	0.32a	0.18	0.03b	32.74a	3.82	2.82	0.26
III	2.38b	0.31	0.74a	0.55b	0.17	0.02a	39.83b	4.24	2.93	0.34
	*	n.s.	*	*	n.s.	**	**	n.s.	n.s.	n.s.
Interaction										
A x B					*	*				

pronounced for the content of nitrogen due to the third cut when Italian ryegrass plants revealed high content of nitrogen, slightly lower than in red clover. Magnesium in Italian ryegrass showed hardly any differentiation depending on the cut. Cadmium content in both crops increased from cut to cut, which points to an effect of dilution as the yield of the first and also the highest cut had the highest Cd content. The third cut, the lowest as to the amount, revealed the highest content of this element in ryegrass.

Most elements in red clover and Italian ryegrass did not reveal changes in their contents resulting from interactions between the investigated factors.

While evaluating fodder utility of multi-cut crops the interrelations between elements are also considered (Table V). Years and cuts were agents diversifying the interrelations between elements. The method of sowing did not influence significantly the relations between elements either in the clover or ryegrass mass. From the nutritional point of view Ca : P ration in red clover exceeding 1.5 : 1 should be considered too broad. Calcium ration to phosphorus in Italian ryegrass was on the optimal level.

K : Na ratio developed identically in both plants. The mutual set-up of potassium and sodium shows that both plants seem to be sodium deficient,

V. Development of element ratio in red clover and Italian ryegrass mass depending on the year, method of sowing and cut

Factors	K : Ca + Mg		K : Mg		Ca : P		K : Na	
Year of cultivation (A)								
	1	2	1	2	1	2	1	2
1993	1.02b	2.27b	4.36b	7.98b	4.05b	1.44b	74.60c	51.19b
1994	0.57a	1.74a	2.39a	4.82a	4.51b	1.49b	47.31b	31.14a
1995	0.98b	2.21b	4.09b	7.98b	3.07a	1.37a	55.54a	50.21b
	**	**	**	**	**	**	**	**
Method of sowing (B)								
Pure sowing	0.85	2.01	3.60	6.92	3.77	1.63b	53.25a	48.66b
Mixture	0.87	2.14	3.62	6.93	3.97	1.24a	65.05b	39.69a
	n.s.	n.s.	n.s.	n.s.	n.s.	*	**	**
Cut (C)								
I	1.14b	2.51b	4.80b	8.14b	3.34a	1.52	71.82b	44.76ab
II	0.89a	2.10ab	3.65ab	6.12a	3.97a	1.22	61.21a	34.16a
III	0.54b	1.61a	2.40a	6.51ab	4.32b	1.57	44.42a	53.62b
	**	*	**	*	*	n.s.	*	*
Interaction								
B x C								*

1 – red clover, 2 - Italian ryegrass

which may contribute to a decreased milk yield and mineral deficiency, which may be limited by using salt-lick (U n d e r w o o d , 1971).

The clearly more narrowed K : Mg ratio in red clover green forage as compared to Italian ryegrass results primarily from a higher magnesium content in legume green forage. More widened K: Mg ratio which occurred in Italian ryegrass shows that magnesium utilisation from this feed will be poorer due to potassium excess, as reported by M a r t e n s and G ä b e l (1987). Also the summary ratio of bivalent cations (Ca + Mg) to potassium is more narrowed in red clover green mass, especially harvested as the second and third cuts. K o r m a n (1997) states that with very low rainfall (45 mm) during the second cut re-growing a decrease in phosphorus and potassium occurred in the green fodder with a simultaneous increase in sodium, calcium and magnesium contents, which in result declined K : Ca + Mg ratio.

The kind of green fodder from the first cut affected the silage contents of nitrogen, calcium, magnesium, zinc, nickel and cadmium (Table VI). Green fodder made of red clover, more than the ryegrass abundant in minerals, was

VI. Macro- and microelement contents in silages prepared of the plants from the first cut

Silage	Macroelements (g.100 g^{-1} d.m.)						Microelements (g.kg^{-1} d.m.)					
	N	P	K	Ca	Mg	Na	Zn	Ni	Pb	Mn	Cu	Cd
Red clover	2.35d	0.26a	0.95a	0.91c	0.28b	0.02a	38.2b	6.00b	3.88a	76.1a	6.03a	0.43c
Italian ryegrass	1.54a	0.27a	0.95a	0.43a	0.18a	0.02a	29.1a	3.80a	3.19a	81.6a	5.92a	0.30a
Clover and ryegrass in natural mixture	1.78c	0.27a	0.95a	0.67b	0.21a	0.02a	33.8ab	4.14a	3.77a	79.9a	5.86a	0.33b
Clover and ryegrass in artificial mixture	1.70b	0.27a	0.94a	0.65b	0.19a	0.02a	33.6ab	4.02a	3.25a	63.9a	5.75a	0.31a

the causative agent of these changes. The fact influenced higher contents of elements in the silage from the natural mixture of red clover with Italian ryegrass as compared to an artificial mixture composed of half shares of both plants.

DISCUSSION

In the conducted experiment, growing of red clover and Italian ryegrass as fodder plants in pure or two-species mixture of legume and grass did not influence the diversification of selected macro- and microelements in the mass. The causative agents for the changes in the element contents in plants were the years and subsequent cuts over the growing season. Red clover is well known for its high water requirements. B a i e r et al. (1987) emphasise that under Czech conditions the plant yields better in the regions with higher rainfall rate. However it must be cultivated in good soil. In the Swiss studies (L e h m a n, M e i s t e r, 1987) perennial and Italian ryegrasses grown respectively with white and red clovers not only increased grass yield but also raised its protein content (nitrogen) while the macroelements contents hardly changed. S h a t i l o v et al. (1985) stress the influence of mineral plant nutrition on the process of photosynthesis during which red clover plants use 3% of photosynthetic active radiation (PAR). However, the estimation concerned only the quantitative evaluation of the phenomenon and did not investigate the clover or grass chemical composition. Z a j a c et al. (1997) revealed that red clover took up in its yearly yield over twice more Cd, Ni and Li as compared to ryegrass.

G a m b u s (1994) determined Cd, Cu, Ni, Pb and Zn contents in clover as an effect of soil cation exchange capacity (CEC), although with a considerable supply of these elements by air their contents in plants may be considerably exceeded. As shown by C o u z y et al. (1993) heavy metals are agents modifying microelement absorption due to an interference in the their metabolism.

Minerals in fodder plants have been recently treated the same as protein and energy because they play an important role in animal growth (K r u c z y ń s k a, M o c e k, 1997). I w a ń s k a et al. (1992) revealed that low concentration of minerals in feeds of food rations is reflected in their low contents in blood and beestings, which proves that animal nutrition requires, balanced amounts of fed elements. Some recent investigations (K o r m a n et al., 1997) have shown that an increase in zinc level food rations for dried up cows improved digestion of extracted non-nitrogen compounds and nitrogen retention. It also caused increased protein content and higher levels of Ca, P and Zn in the beestings, thus the recommendation for 70 ppm level of zinc in the diet.

The amount of rainfall over the growing season affects the mineral contents, as with deficient precipitation during the cut growth, legumes (lucerne) and grasses had less phosphorus and potassium but more Na, Ca and Mg. In many regions of Poland a deficiency of Ca, Zn, Cu and P is found in basic feeds which causes their lower contents in milk. To counteract it is postulated to use mineral additives adjusted to a typical composition of feeds used in a given region (B a n a s z k i e w i c z, O l k o w s k i, 1997). Nowadays it is assumed that mineral additives included in the prepared food rations may supplement a deficiency of biogenic elements in feeds (green feed and silage) (K o w a l s k i, K a ń s k i, 1997).

CONCLUSIONS

1. Fodder plant species was a factor diversifying macro- and microelements contents in plant mass and silages.
2. Individual cultivation (pure sowing) or red clover sowing in a mixture did not differentiate the contents of most macroelements in plants.
3. Magnesium content in red clover was significantly affected an interaction between sowing and cut, whereas Mg content in ryegrass was markedly diversified as a result of cooperation between the years of cultivation and the methods of sowing.
4. Relations occurring between macroelements revealed changes in years and cuts. The year of cultivation was an agent which significantly and most strongly differentiated macroelement contents in red clover and Italian ryegrass plants.

5. Considering the strong impact of the analysed factors on the contents of macro- and microelements in plants the following order may be established among them: > plant species > the year of cultivation > cut during growing season > the method of sowing.

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ZAJAC, T. – BOROWIEC, F. – KOŁODZIEJCZYK, M. (Poľnohospodárska univerzita Krakov, katedra rastlinnej výroby, katedra výživy zvierat, Krakov, Poľsko):

Hodnotenie obsahu makro- a mikroelementov v rastlinách a siláži ďateliny lúčnej (*Trifolium pratense*) a mätonohu mnohokvetého (*Lolium multiflorum* L.) v závislosti od roka, metódy pestovania a kosby.

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Ako vidno na príklade ďateliny lúčnej a mätonohu mnohokvetého, koexistencia strukovín s trávami umožňuje dosiahnuť vysoký výnos rastlinnej hmoty s vyrovnaným pomerom energie a proteínov a optimálnym obsahom minerálnych látok v rastlinnej hmote.

Práca sa zamerala na analýzu obsahu N, P, K, Ca, Mg, Na, Zn, Ni, Pb a Cd, ako aj na vzájomné vzťahy medzi niektorými prvkami v rastlinách a siláži ďateliny lúčnej a mätonohu mnohokvetého pestovaného samostatne alebo s miešankami. Uzavretý poľný pokus sa realizoval v rokoch 1993–1995 na Experimentálnej stanici v Prosoch neďaleko Krakova. Každý rok sa urobili 3 kosby, ich termíny sa stanovili na začiatku fázy kvitnutia ďateliny. Boli to tieto kalendárne termíny: 2. júna, 15. júla a 8. septembra 1993; 31. mája, 13. júla a 22. septembra 1994; 2. júna, 13. júla a 31. augusta 1995. Množstvo zrážok počas vegetačného obdobia a kosby je uvedené v tab. I.

Pokusy sa robili na suchom mineralizovanom rastlinnom materiále pomocou atómového absorpčného spektrofotometra (ASA) PHILIPS PU 9100X. Fosfor sa hodnotil kolorimetricky v Beckmanovom prístroji DU-600, zatiaľ čo dusík sa stanovil pomocou Kjeldahlovej metódy. Štatistické výpočty získaných výsledkov sa robili analýzou rozptylu pomocou zmiešaného modelu, kde roky boli náhodným faktorom.

Obsah makro- a mikroelementov v hmote ďateliny lúčnej boli značne diverzifikované v jednotlivých rokoch pestovania (tab. III). Vo vzťahu ku všetkým analyzovaným prvkom ďatelina lúčna bola stabilným krmivom, pokiaľ ide o obsah dusíka, avšak zistené rozdiely v množstve tohto prvku v jednotlivých rokoch boli významné. Roky pestovania zvlášť silne diferencovali obsah Ca, P, Zn a Ni.

Publikované údaje zdôrazňujú, že rastlinná hmota ďateliny lúčnej je bohatá na minerálne látky, najmä na vápnik (Ledoux, Martz, 1991). Oddelené pestovanie (čistý výsev) alebo výsev ďateliny lúčnej v miešanke nediferencovali obsah väčšiny mikroelementov v rastlinách. Na rozdiel od makroelementov obsah mikroelementov v rastlinnej hmote ďateliny lúčnej od čistého výsevu bol značne vyšší než v miešan-

kách s mätonohom mnohokvetým. Na základe toho možno usudzovať, že absorpcia mikroelementov bola narušená u rastlín ďateliny lúčnej pestovanej v miešanke. Ostatné makroelementy, okrem Ca a N, mali značne diverzifikovaný obsah. Treba zdôrazniť, že rastliny z druhej kosby obsahovali menej P, K, Ca, Mg a Na v porovnaní s ostatnými kosbami v roku. Taktiež treba zdôrazniť, že vegetácia rastlín z druhej kosby sa znehodnotila kvôli nedostatku vody v pôde, čo mohlo mať negatívny vplyv na odčerpanie uvedených prvkov ďatelinou. Mätonoh mnohokvetý mal nižší obsah N, Ca, Mg, Zn, Ni, Pb a Zn v porovnaní s ďatelinou lúčnou. Roky pestovania dokázali, že obsah prvkov je silným činiteľom v mätonohu mnohokvetom (tab. IV). Obidve porovnávané kŕmne plodiny mali premenlivý obsah minerálnych látok v jednotlivých rokoch. V roku 1994 ďatelina a mätonoh mnohokvetý obsahovali viac dusíka, horčíka a zinku v porovnaní s ostatnými rokmi. Metóda výsevu mätonohu zmenila minerálne zloženie len veľmi málo. Rastliny mätonohu mnohokvetého pestované s ďatelinou lúčnou zvýšili obsah dusíka, fosforu, olova a kadmia. Táto metóda výsevu však značne zvýšila obsah sodíka a zinku. Vplyv kosby na obsah vybraných prvkov bol výrazný pre väčšinu prípadov. Silný vplyv kosby bol pozoruhodný vďaka tretej kosbe, kedy rastliny mätonohu mnohokvetého mali vysoký obsah dusíka, len o niečo nižší ako pri ďateline lúčnej. Horčík u mätonohu mnohokvetého mal len malý vplyv na akúkoľvek diferenciáciu v závislosti od sejby. Obsah kadmia v rastlinách u obidvoch druhoch sa zvyšoval od kosby ku kosbe, čo naznačuje vplyv rozptylu, keďže výnos z prvej a súčasne najvyššej kosby obsahoval najviac kadmia. Tretia kosba, najmenšia čo do množstva, mala najnižší obsah tohto prvku v rastlinách mätonohu mnohokvetého. Vzťahy medzi makroelementami ukázali zmeny za roky a kosby. Rok pestovania bol faktor, ktorý najsilnejšie a najvýraznejšie diverzifikoval zmeny makroelementov v rastlinách (tab. V). Vzhľadom na silný vplyv analyzovaných faktorov na obsah makro- a mikroelementov v rastlinách sa môže určiť medzi nimi nasledujúce poradie: > rastlinné druhy > rok pestovania > kosba počas vegetačného obdobia > metóda výsevu. Minerálne látky v krmovinách sa donedávna ošetrovali rovnako ako proteíny a energia, pretože hrajú dôležitú úlohu v raste zvierat (Kruczyńska, Mocek, 1997). Myslelo sa, že nedostatok biogénnych prvkov v krmivách (zelený krm a siláž) sa môže upraviť pomocou minerálnych prísad podľa vypočítaných kŕmnych dávok (Kowalski, Kański, 1997).

ďatelina lúčna; mätonoh mnohokvetý; miešanka; rastliny; siláž; obsah elementov

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