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The content of mineral elements in some grasses and legumes

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Mineral element (Ca, P, K, Mg, Na, Cu, Zn, Mn, Fe, Co) content in some plants, such as alfalfa (*Medicato sativa*), white clover (*Trifolium repens*), red clover (*Trifolium pratense*), alsike clover (*Trifolium hybridum*), meadow pea (*Lathyrus pratensis*), quack-grass (*Elymus repens*), meadow fescue (*Festuca pratensis*), red fescue (*Festuca rubra*), timothy (*Phleum pratense*), perennial ryegrass (*Lolium perenne*), smooth brome (*Bromopsis inermis*), cocks-foot (*Dactylis glomerata*), and meadow grass (*Poa pratensis*) were analyzed regarding their nutritional value. Mineral element content in the plants was found to be species- and family-dependent. Leguminous (*Fabaceae*) plants accumulated more Ca than cereal (*Poaceae*) grasses. There were no peculiarities of K and P accumulation in the plant families. Potassium content exceeded the limit nutritional value in all plants, while all of them, except white clover and quack-grass, lacked P. The legumes accumulated more Mg as compared to the grasses. All the plants, except ryegrass, lacked Na. All the plants contained sufficient amounts of Fe. The legumes had sufficient levels of Mn, while grasses, except cocks-foot, lacked it. All the plants lacked Cu and Zn. Also, the grasses were lacking in Co, while in the legumes Co levels were sufficient. On average, all the plants contained an excess of Ca, K and Fe and lacked P, Na, Zn and Cu. Grasses accumulated less Ca, Mg, Cu, Zn, Mn, Fe, Co, but more Na than the legumes. Mixtures of the study legumes and grasses in forages may optimize the content of Ca and some other mineral elements, but supplements of microelements must be applied. In order to improve the nutritional value of forages, it is essential to search for the methods of soil enrichment with mineral elements and improving the quality of forages as well as the elemental balance in the agro-ecosystems.

Key words: grasses, legumes, animal niutrition, mineral elements, elemental balance

INTRODUCTION

From the ecological viewpoint, plant and animal production is evaluated by the optimal contents of macro- and microelements. Uniform feeding of animals, even with forages of the best quality, reduces their productivity and makes them weak and sensitive. Some species of fodder plants can contain an excess of some elements and lack others. Sometimes, even if total mineral element amounts correspond to the nutritional values, imbalance may occur due to their synergetic-antagonistic interactions in plants and animal organisms. Therefore, uniform feeding leads to metabolism disorders and inferior production (Marschner, 1995). This question is extremely topical in anthropogenically polluted areas and in soils poor in macro- and microelements.

Grass forages usually are lacking in Ca, P, Na, Co, Cu, J, Se and Zn. Sometimes there may be a deficiency of Mg, K, Fe and Mn, as well as an excess of F, Mo, Se (McDowell, 1996). Grass forages in Lithuania mostly lack in microelements due to their lack in the soils, while their excess is displayed only in some anthropogenically polluted areas. Soils in Lithuania mostly lack P, K, S, Mo, Co, Cu, and Zn (Antanaitis ir kt., 1996).

Accumulation of mineral elements in plants depends on soil properties, total and plant-available amounts of elements, cultivation and fertilization system, climate, as well as plant properties (Bengtsson et al., 2003; Warman, Termeer, 2005 a). Moreover, various plant species have a different ability to accumulate mineral elements, even if they are grown under the same conditions. For example, in Ukraine clover grown in the *Chernozem* soil (pH_{KCl} 5.9; Cu 4.3 mg/kg; Zn 12.4 mg/kg) accumulated Cu 1.2–2.5 mg/kg dry matter (d. m.) and Zn 17–21 mg/kg d. m., while a mixture of fescue and perennial ryegrass contained 1.7–3.4 mg/kg d. m. of Cu and 8.5–11 mg/kg d. m. of

Zn. At the same time, clover grown in *Podzoluvisol* soil (pH_{KCl} 6.2; Cu 1.4 mg/kg; Zn 7.5 mg/kg) contained 5.5–7.1 mg/kg d. m. of Cu and 9–22 mg/kg d. m. of Zn, while a mixture of fescue and perennial ryegrass contained 2.5–3.8 mg/kg d. m. of Cu and 13–24 mg/kg d. m. of Zn. Also, in the *Histosol* soil grown clover (pH_{KCl} 5; Cu 5.4 mg/kg; Zn 11 mg/kg) contained Cu 1.3–1.5 mg/kg d. m. and Zn 19–25 mg/kg d. m., while a mixture of fescue and perennial ryegrass contained Cu 2.7–4.2 mg/kg d. m. and Zn 14–24 mg/kg d. m. (Grytsyuk et al., 2006). Plants' ability to accumulate mineral elements depends on their root system, synergetic-antagonistic interactions of the elements, rainfall amount and intensity during the plant vegetation period, also on soil nitrogen content and pH (Marschner, 1995). Plants accumulate more mineral elements in light, more acidic soils. On the contrary, plants grown in heavy, more alkaline soils contain less microelements, especially Zn, Mn, and Fe. Soil organic matter mostly binds the mineral elements to the non-plant-available compounds prohibiting their transfer to the plants. On the other hand, during the mineralization process elements are released and plants can assimilate them easily. Thus, organic fertilizers become an extra source of soil mineral elements. The aerobically or anaerobically treated sewage sludge, various organic waste composts, lake sapropel can be a valuable organic fertilizers supplementing soil with macro- (N, P, K, Ca) and microelements (Fe, Cu, Zn, Mn, S, B) (Paulauskas et al., 2004; Brazauskienė et al., 2005; Warman, Termeer, 2005 a, b). However, heavy metals and toxic substances must be strictly controlled according to the state legislations when using these bio-wastes in agriculture.

For precision farming management, it is important to take into account the vegetation season, soil fertility, the type and quantity of fodder, its protein content and energetic value, the individual animal demands, water salinity, and the chemical element form (compound) when calculating doses of mineral supplements (Corah, 1996). In building grasslands, it is important to take into account not only plants' growth interrelations, but also their ability to accumulate mineral elements. Evaluation and management of elemental balance is the innovative method in the farming practices, ensuring fodder quality as well as ecosystem stability (Janssen, 1999; Vos, Van der Putten, 2000; Goodlass et al., 2003). In order to ensure stable agro-ecosystems, it is essential to maintain their fertility within the least influence on the environment. The elemental balance in the soil–forages–animal system depends on various environmental factors, such as atmospheric precipitations, runoff water and elution in the soil, fertilization and liming, grown crops and their rotation (Bengtsson et al., 2003). Low fertility and poor forage quality may be caused by long-term elimination of some elements from the ecosystem, together with uniform agricultural production or by the accumulation of other elements in the soil due to fertilization, wastes and other environmental pollutants. Biodiversity expansion is one of the main principles of ecological farming, ensuring the natural elemental balance and stability of ecosystems. Consequently, grassland rich in various plant species is more stable and more valuable from the ecological and probably also from the animal nutrition viewpoints.

The aim of the present research was to investigate the levels of mineral elements in grasses and legumes depending on plant species as well as in their mixtures recommended in animal breeding practices.

METHODS

The stationary experiments were performed at the Experimental Station of the Lithuanian University of Agriculture on cultivated *sod gleyey* loamy soil, well structured and drained by a closed drainage system.

The soil pH (H_2O) was determined by potentiometry, mobile P amount according to Kirshanov, mobile K amount by the Egner-Rim-Doming (A–L), humus amount by the Tiurin, and mineral elements by the standard spectrometric methods. Soil quality indices are presented in Table 1.

Mixtures of plants (40% of legumes and 80% of grasses) were undersowed into the barley nurse crop in three replicates. The legumes used were alfalfa (*Medicato sativa),* white clover (*Trifolium repens*), red clover (*Trifolium pratense*), alsike clover (*Trifolium hybridum*), meadow pea (*Lathyrus pratensis*), while the grasses were quack-grass (*Elymus repens*)*,* meadow fescue (*Festuca pratensis*), red fescue (*Festuca rubra*), timothy (*Phleum pratense*), perennial ryegrass (*Lolium perenne*), smooth brome (*Bromopsis inermis*), cocks-foot (*Dactylis glomerata*), and meadow grass (*Poa pratensis*).

Plant samples of different species were taken separately at the beginning of flowering, while samples of cocks-foot were taken at the earing stage. Samples were air- dried by active ventilation and then ground finely and investigated for Ca, P, Mg, K, Na, Cu, Zn, Mn, Fe and Co content by the standard spectrometric methods. Mineralization of each sample and measurement of element amounts were performed in three replicates. The average values were evaluated by statistical methods and unreliable results were rejected. Element content was calculated in dry plant matter dried at 105 °C (d. m.). The average values of mineral element amounts in the legumes and grasses, also in their mixtures recommended for forages were calculated using statistically evaluated mathematical average values in plants of respective species.

Table 1. **General soil quality indices (mean values ± standard deviation)**

Indices	Value
pH (H_2O)	6.57 ± 0.03
$P_{mobile,}$ mg/kg	20.39 ± 1.24
K_{mobile}, mg/kg	49.79 ± 2.41
Humus, %	2.25 ± 0.35
Cu, mg/kg	9.3 ± 0.31
Zn, mg/kg	30.5 ± 2.82
Mn, mg/kg	180 ± 9.61

RESULTS

The legumes accumulated over twice as much Ca as did the grasses (Fig. 1). Ca levels were lower in cereal plants: quack-grass (7.20 ± 2.07 g/kg d. m.), meadow and red fescue (6.23 ± 1.81 and 5.86 ± 0.30 g/kg d. m.), and timothy (4.82 ± 1.30 g/kg d. m.). The poorest in Ca were perennial ryegrass, smooth brome, cocks-foot and meadow grass, containing, respectively, 4.82 ± 0.40, 4.49 ± 1.10, 3.80 ± 0.91 and 3.08 ± 0.51 g/kg d. m. (Fig. 1). Ca doses as low as these in the feed diet can result in serious animal illness.

There were no peculiarities of K and P accumulation between the plant families studied (Figs. 1 and 2). In all the plants, K level exceeded the limit value (Fig. 1). Only alsike and red clovers, also meadow pea contained less K, respectively 15.2 ± 3.4, 13.0 ± 3.4, and 14.6 ± 2.7 g/kg d. m. Similar K levels were found also in some cereal plants such as meadow and red fescue (14.5 ± 2.0 and 14.4 ± 1.9 g/kg d. m.) as well as smooth brome (14.3 ± 1.7 g/kg d. m.). No significant diference was observed in K content in alfalfa (19.3 ± 3.7 g/kg d. m.), timothy and perennial ryegrass (17.7 ± 2.1 and 17.8 ± 2.8 g/kg d. m.). A little more K was accumulated by white clover (20.2 ± 2.3 g/kg d. m.), cocks-foot and meadow grass (18.9 ± 2.1 and 18.3 ± 1.1 g/kg d. m.). The highest K level (28.3 ± 3.7 g/kg d. m.) was determined in quack-grass (Fig. 1). This level of K may be toxic for grass-feeding animals.

The P levels optimal for animal nutrition were accumulated only in white clover (3.60 ± 0.93 g/kg d. m.) and quack-grass (3.31 ± 0.07 g/kg d. m.). The rest of the study plants lacked in P, but P content was statistically significantly less only in alfalfa, red and alsike clover, meadow pea and smooth brome, respectively 2.08 ± 0.13; 2.2 ± 0.78; 2.1 ± 1.21; 2.4 ± 0.1 and 1.7 ± 0.39 g/kg d. m. (Fig. 2).

The legumes accumulated more Mg (2.16 ± 0.51 to 3.00 ± 0.51 g/kg d. m.) compared to the grasses (Fig. 2). Otherwise, Mg amounts in the grasses (1.02 ± 0.81 to 1.76 ± 0.27 g/kg d. m.) were closer to the optimum animal nutritional value.

Only perennial ryegrass contained the optimum Na level (0.91 ± 0.42 g/kg d. m.) while the other plants lacked

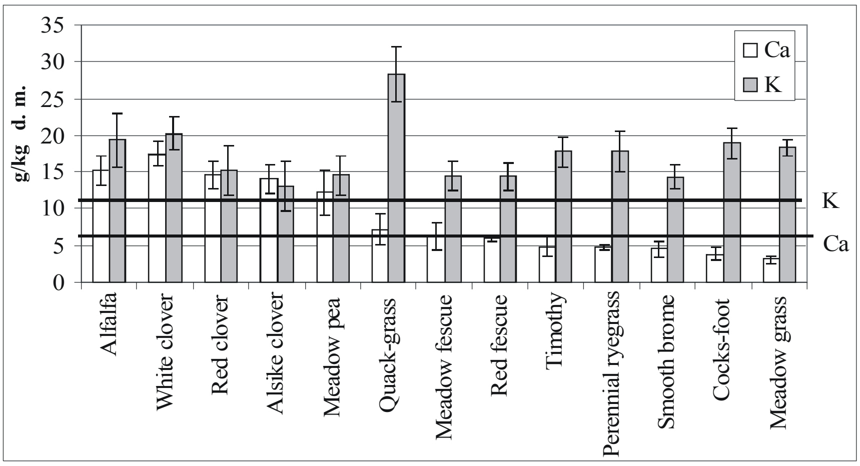

Fig. 1. Average values and standard deviations (in the bars) of Ca and K content (g/kg d. m.). Bold lines indicate optimal nutritional values in forages. Toxic doses are: Ca > 20 g/kg d. m., K > 30 g/kg d. m. (NRC, 2000)

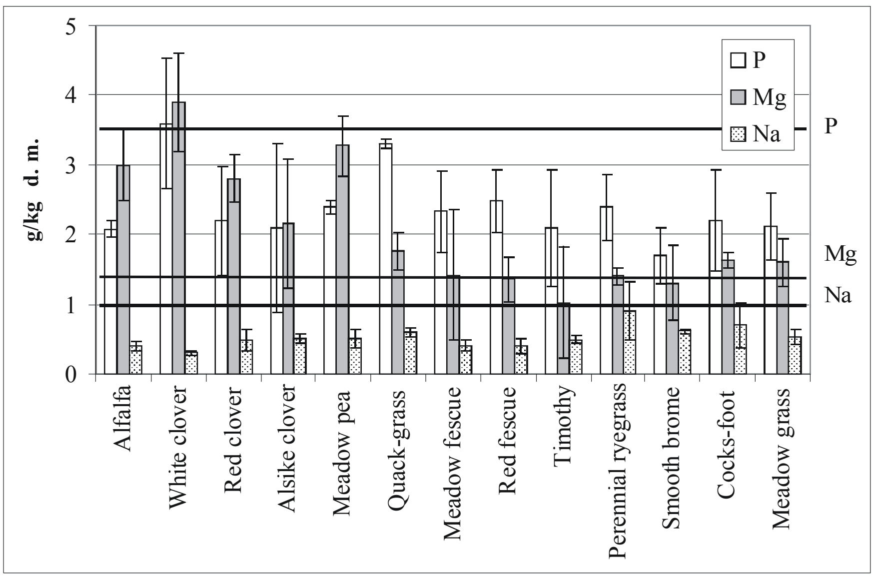

Fig. 2. Average values and standard deviations (in the bars) of P, Mg, and Na content (g/kg d. m.). Bold lines indicate optimal nutritional values in the forages. Toxic doses are: P > 10 g/kg d. m., Mg > 4 g/kg d. m., Na – no value (NRC, 2000)

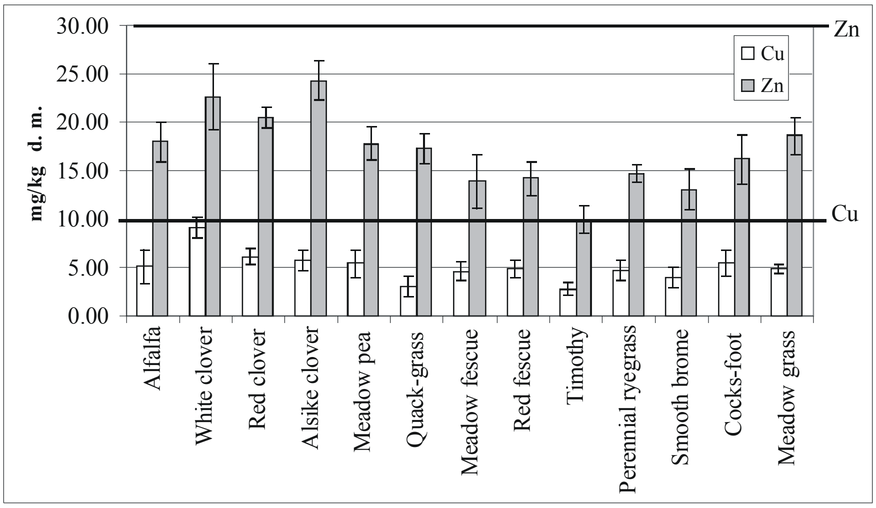

Fig. 3. Average values and standard deviations (in the bars) of Cu and Zn content (mg/kg d. m.). Bold lines indicate optimal nutritional values in forages. Toxic doses are: Cu > 100, Zn > 500 mg/kg d. m. (NRC, 2001)

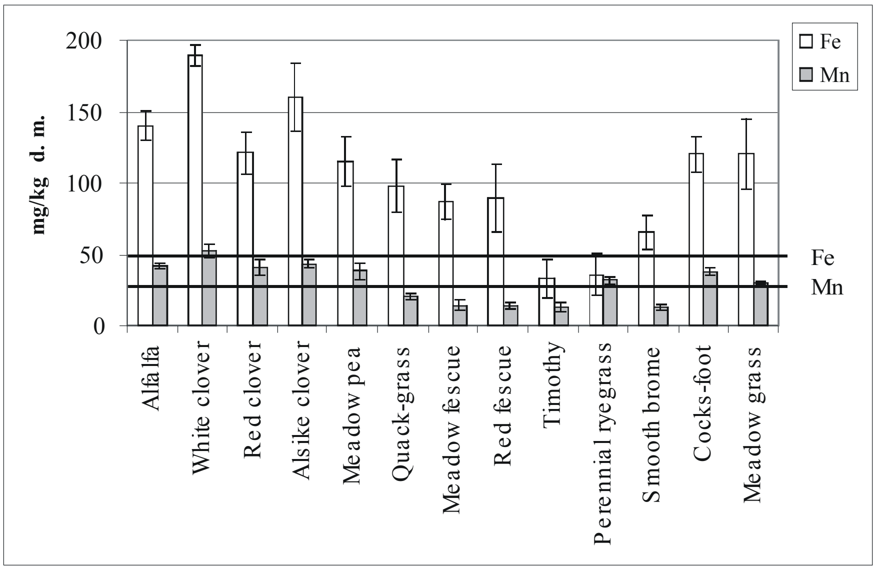

Fig. 4. Average values and standard deviations (in the bars) of Fe and Mn content (mg/kg d. m.). Bold lines indicate optimal nutritional values in forages. Toxic Fe and Mn doses are above 1000 mg/kg d. m. (NRC, 2000)

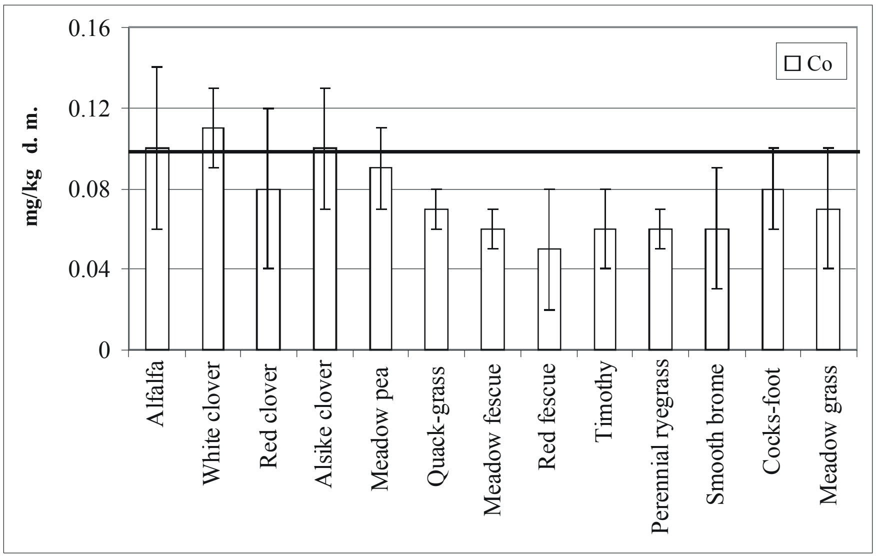

Fig. 5. Average values and standard deviations (in the bars) of Co content (mg/kg d. m.). The bold line indicates optimal nutritional value in forages. Toxic dose: Co > 10 mg/kg d. m. (NRC, 2001)

it (Fig. 2). Also, an insignificant difference ($p < 0.05$) was found among perennial ryegrass and smooth brome (0.61 ± 0.03 g/kg d. m.), cocks-foot (0.70 ± 0.32 g/kg d. m.), meadow grass (0.53 ± 0.11 g/kg d. m.), timothy (0.49 ± 0.06 g/kg d. m.), quack-grass (0.60 ± 0.07 g/kg d. m.), meadow pea (0.50 ± 0.13 g/kg d. m.), red and alsike clover (0.49 ± 0.15 and 0.51 ± 0.07 g/kg d. m.). Least Na levels were accumulated by meadow and red fescue (0.40 ± 0.08 and 0.39 ± 0.11 g/kg d. m.), alfalfa (0.40 ± 0.07 g/kg d. m.) and white clover (0.30 ± 0.04 g/kg d. m.).

Although the legumes accumulated more Cu and Zn compared to the grasses, all of them were lacking in it (Fig. 3). More Cu accumulated white clover (9.03 ± 1.05 mg/kg d. m.), followed by alfalfa, red and alsike clover, and meadow pea (respectively, 5.10 ± 1.79; 6.10 ± 0.86; 5.80 ± 1.03 and 5.40 ± 1.41 mg/kg d. m.). Significantly ($p < 0.05$) lower Cu levels were found only in quack-grass and timothy (respectively 2.98 ± 1.05 and 2.80 ± 0.72 mg/kg d. m.) (Fig. 3). More Zn was found in alsike, white and red clover (24.30 ± 2.04 to 20.50 ± 1.07 mg/kg d. m.), followed by alfalfa, meadow pea and meadow grass (respectively 18.00 ± 2.07; 17.80 ± 1.75, and 18.60 ± 1.90 mg/kg d. m.) (Fig. 3). Similar Zn levels were found in quack-grass (17.30 ± 1.48 mg/kg d. m.), meadow and red fescue (13.90 ± 2.83 and 14.20 ± 1.74 mg/kg d. m.), perennial ryegrass (14.70 ± 0.93 mg/kg d. m.) and smooth brome (13 ± 2.11 mg/kg d. m.). The least Zn (9.92 ± 1.38 mg/kg d. m.) was accumulated by timothy (Fig. 3).

All the plants contained sufficient Fe levels, though in timothy and perennial ryegrass Fe content was marginal (respectively 33.0 ± 13.4 and 36.0 ± 13.4 mg/kg d. m.) (Fig. 4). Less Fe was also accumulated by smooth brome, meadow and red fescue (respectively 65.6 ± 11.7, 87.0 ± 12.3 and 89.4 ± 23.7 mg/kg d. m.). The legumes had sufficient Mn levels (38.3 ± 5.7 to 52.3 mg/kg d. m.). Also in cocks-foot Mn content was optimal (38.1 ± 2.9 mg/kg d. m.). The rest of the grasses lacked Mn (Fig. 4).

The legumes contained sufficient Co levels (0.08 ± 0.04 to 0.11 ± 0.02 mg/kg d. m.). Also, cocks-foot and meadow grass had more Co, respectively 0.08 ± 0.02 and 0.07 ± 0.03 mg/kg d. m. (Fig. 5). The other grasses lacked Co (0.05 ± 0.03 to 0.07 ± 0.01 mg/kg d. m.).

DISCUSSION

On average, all the plants contained excess Ca, K and Fe and lacked P, Na, Zn, and Cu (Table 2). The average Ca, Mg, Cu, and Zn amounts in the legumes were similar to those reported in references, whereas K, Mn, and Fe levels appeared to be lower (Nutritional Value..., 2006). Grasses accumulated less Ca, Mg, Cu, Zn, Mn, Fe, Co, but more Na.

Mixtures of various grass forages are supposed to improve the balance of mineral elements. Here we discuss some commonly mixtures of plants in forages recommended in Lithuanian feeding practices (Table 2).

Alfalfa is a plant species rich in Ca, Mg, Fe and Mn. However, if grazing entirely in alfalfa crops, symptoms of overgrazing appear on the third week because of saponins and big amounts of nitrates. Also, feeding in alfalfa crops results in Ca overdose. Ca content should not exceed 8–10 g/kg d. m. even in a fatty feed diet, and the toxic Ca dose is over 20 g/kg d. m. (NRC, 2001). The optimal Ca content ensures proper assimilation of fats, fibres, reduces formation of "greenhouse gas" methane in animal organisms (Machmüller, Kreuzer, 2005). Ca excess in feed diet inhibits assimilation of Mg and microelements, especially Zn, increasing their demand (NRC, 2001). On the other hand, Ca deficiency may result in hyperphosphataemia and other disorders of Ca, P, and Mg metabolism. In order to optimize Ca and Mg amounts, it is recommended to combine alfalfa with perennial ryegrass or cocks-foot, timothy, meadow and red fescue and meadow grass low in Ca (Table 2).

White clover may be combined with meadow and red fescue to reach an optimal elemental balance, but a mixture of all the grasses results in more optimal Ca, Na, Mn and Fe levels (Table 2).

Alsike clover is suitable for supplementing grass forage diets with mineral elements and optimizing K levels. It is useful to combine alsike clover with timothy, meadow grass, meadow and red fescue and smooth brome, but the diet should be supplemented with P, Na and microelements excepting Fe (Table 2).

It is recommended to use red clover forage in combination with meadow and red fescue and timothy, but red clover in a mixture with all the cereal grasses studied results in more appropriate Ca, K and Fe levels (Table 2).

The recommended mixtures of meadow pea with meadow and red fescue or perennial ryegrass are similar in mineral element content. However, both diets require supplementing with P, Na, Cu, Zn, Mn and Co (Table 2).

Meadow and red fescue are proper to be sown in crops of legumes rich in mineral elements and tending to rarefy, such as clover and alfalfa. Fescues in timothy crops must be undersown sparser as they overrun other species in meadows of perennials, however, keeping their ratio at 1:0.8 results in a deficiency of P, Na, and microelements excepting Fe, and in overdosage of K (Table 2). Timothy is good to combine with all legumes.

Quack-grass is established as an undesirable weed in agriculture, but it can be a valuable grass in animal breeding, supplementing leguminous forages with P and Na while optimizing Ca, Mg and Fe amounts. Also, it enriches crops of grasses with Ca, P, Mg, Zn and Co (Table 2). However, the main disadvantage of quack-grass is the trend to accumulate K. The optimal K amount in forage diet for dairy cows is 6–10 g/kg, for sheep 5–7 g/kg (NRC 1994, 2001). Potassium has an antagonistic effect on Mg while synergetic on Na assimilation. Too big K doses cause animal tetany, also more nitrates in plants. In order to reduce K accumulation and to increase P content in grass forage crops more abundant fertilization with N_{168} and P_{128} is recommended.

All the study plants lacked microelements, except Fe. Cu deficiency becomes obvious when its amount in

Table 2. **Average content of mineral elements and standard deviations (SD) in the selected plant families as well as in their recommended mixtures**

Plant family	Macroelements, g/kg					Microelements, mg/kg				
	Ca	P	K	Na	Mg	Cu	Zn	Mn	Fe	Co
Leguminous (Fabaceae) / 5 species* (ratio 1:1:1:1:1)										
Mean	**14.70**	**2.48**	**16.5**	**0.44**	**3.03**	**6.29**	**20.64**	**43.4**	**145.0**	**0.10**
SD	1.93	0.64	3.1	0.09	0.64	1.58	2.84	5.3	30.3	0.01
Cereal (Poaceae) / 8 species**										
Mean (ratio 1:1:1:1:1:1:1:1)	**5.04**	**2.33**	**18.0**	**0.58**	**1.44**	**4.26**	**14.73**	**21.8**	**81.1**	**0.06**
SD	1.34	0.46	4.6	0.17	0.23	0.94	2.70	10.1	33.8	0.01
Average amounts Leguminous 5 species* + cereal 8 species**										
Mean	**8.75**	**2.39**	**17.4**	**0.53**	**2.05**	**5.27**	**17.68**	**32.6**	**113.1**	**0.08**
SD	5.12	0.34	4.0	0.10	1.13	1.43	4.18	15.2	45.2	0.02
Recommended mixtures of leguminous and cereal plants in forages										
Alfalfa + perennial ryegrass (ratio 1:2)	6.21	1.72	13.7	0.56	1.45	3.63	11.85	26.6	53.0	0.06
Alfalfa + cocks-foot (ratio 1:2)	5.70	1.62	14.3	0.45	1.57	4.00	12.60	29.6	95.0	0.07
Alfalfa + timothy + meadow and red fescues + meadow grass (ratio 1:1:1:1:1)	7.04	2.22	16.8	0.44	1.68	4.43	14.92	22.7	93.9	0.07
White clover + meadow and red fescues (ratio 0.5:1:1)	6.95	2.20	13.0	0.31	1.58	4.66	13.13	17.9	90.3	0.06
White clover + mixture of the cereal grasses (ratio 1:2)	6.17	1.71	12.8	0.41	1.42	3.66	12.49	21.2	70.8	0.05
Alsike clover + timothy + fescues + smooth brome + meadow grass (ratio 1:1:1:1:1)	6.41	2.14	15.4	0.49	1.48	4.46	15.65	21.2	92.5	0.07
Red clover + meadow and red fescues + timothy (ratio 1:1:1:1)	7.88	2.28	15.4	0.44	1.65	4.59	14.63	20.5	82.6	0.06
Red clover + mixture of the cereal grasses (ratio 1:2)	6.17	1.71	12.8	0.41	1.42	3.66	12.49	21.2	70.8	0.05
Meadow pea + meadow and red fescues (ratio 0.5:1:1)	6.06	1.22	12.1	0.35	1.47	4.05	12.33	15.6	78.0	0.05
Meadow pea + ryegrass (ratio 1:2)	5.46	0.98	12.6	0.58	1.52	3.70	11.80	25.6	46.8	0.05
Meadow and red fescues + timothy (ratio 1:0.8)	5.64	2.30	15.5	0.43	1.27	4.08	12.67	13.6	69.8	0.06

Table 2 (continued)

Plant family	Macroelements, g/kg					Microelements, mg/kg				
	Ca	P	K	Na	Mg	Cu	Zn	Mn	Fe	Co
Quack-grass + mixture of the leguminous grasses (ratio 1:1)	10.37	2.92	22.81	0.52	2.36	4.78	18.50	30.06	117.7	0.08
Quack-grass + mixture of the cereal grasses (ratio1:1)	6.12	2.82	23.16	0.59	1.60	3.62	16.01	21.07	89.56	0.07
Nutritional values (NRC, 2000, 2001)	5.4–6.7	3.2–4.4	10.0–10.7	0.6–1.0	1.0–2.0	10	30	40	50	0.1

* Leguminous species: alfalfa (*Medicato sativa*), white clover (*Trifolium repens*), red clover (*Trifolium pratense*), alsike clover (*Trifolium hybridum*), meadow pea (*Lathyrus pratensis*).

** Cereal species: quack-grass (*Elymus repens*), meadow fescue (*Festuca pratensis*), red fescue (*Festuca rubra*), timothy (*Phleum pratense*), perennial ryegrass (*Lolium perenne*), smooth brome *(Bromopsis inermis*), cocks-foot (*Dactylis glomerata*), and meadow grass (*Poa pratensis*).

forage diet is 3–5 mg/kg d. m. It results in Ca, P, and Fe imbalance, also in toxic Mo effect. The average Zn level (17.68 ± 4.18 mg/kg d. m.) in the study plants comprised only a half of the average Zn level (29 mg/kg d. m.) reported in pastures (Nutritional Value..., 2006). Zn deficiency results in shedding hair, increased animal nervosity, overall organism exhaustion, osseous diseases. Furthermore, it lowers sexual activity, causes infertility and dyspepsia, and anemia may be the outcome of disordered Fe absorption. The reason for the low Cu and Zn accumulation in grass forages could be their low plant-availability related to the soil pH, meteorological conditions and fertilization. It is known that surplus of nitrogen fertilizers may have an antagonistic influence on Cu accumulation in plants.

Forages often lack microelements, hence mineral supplements are usually recommended in forage diets (Helal et al., 1999). However, while choosing them it is important to evaluate the assimilation efficiency of their compounds and to avoid overdosage. For example, piglet organisms can assimilate only 20% of ZnO. When increasing ZnO dose up to 120 mg/kg, assimilation of Zn increases from 8–14 to 37–43 mg per day, however, higher ZnO doses are not efficient (Poulsen, Larsen, 1995). In addition, Zn and Cu overdoses result in the ecological problems, as animal manure becomes a source of Cu and Zn pollution harmful for plants, animals and soil microorganisms. It is proposed that reducing Cu and Zn amounts in the pig feed diet respectively from 100 to 20 mg/kg and from 250 to 100 mg/kg, accumulation of these elements in the upper soil layer may be reduced by 35%. That is why it is essential to search for more efficient ways of supplementing the forages with mineral elements and ensuring their optimal doses (Jondreville et al., 2003). On the other hand, animal manure can be a valuable source of microelements if soil is lacking them.

The legumes contained slightly bigger amounts of Co than the grasses, but not big enough. Some years ago lower Co nutritional values used to be recommended in a number of countries. However, on establishing the importance of this element its optimal nutritional value has been increasing: INRA 1988 – 0.1 mg/kg, ARC 1989 – 0.11, NRC 2001 – 0.11, GfE 2001 – 0.2 mg/kg (Stemme et al., 2005; NRC, 2001). Cobalt deficiency results in the development of acobaltosis which causes disorders of digestion and metabolism (Schwarz et al., 2000). Therefore, forage diets must be supplemented with Co mineral salts as well as microelement fertilizers must be applied on grasslands.

CONCLUSIONS

1. In the same growing conditions grown leguminous plants (*Fabaceae*) accumulated more Ca, Mg, Cu, Zn, Mn, Fe and Co while less Na as compared with cereal plants (*Poaceae*).

2. There were no differences in K and P accumulation between the families of legumes and grasses.

3. To avoid the elemental imbalance, various grass forage mixtures are purposive in animal breeding practices.

4. Mixtures of the study legumes and grasses in forages may optimize Ca, also in some cases K, Mg, Na, Mn and F nutriotion, but microelement supplementation is needed in most cases.

5. The mixtures of plants commonly recommended in Lithuania may partially improve the balance of mineral elements in forages, but it is essential to search for methods to improve forage quality as well as the elemental balance in the agro-ecosystems. Generally, a more assorted composition of grass forages ensures a more optimal elemental balance.

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MINERALINIŲ ELEMENTŲ KONCENTRACIJOS KAI KURIUOSE VARPINIUOSE IR ANKŠTINIUOSE AUGALUOSE

S a n t r a u k a

Tirtos Ca, P, K, Mg, Na, Cu, Zn, Mn, Fe ir Co koncentracijos vienodomis sąlygomis užaugintose pašarinėse žolėse: mėlynžiedėje liucernoje (*Medicato sativa*), baltuosiuose dobiluose (*Trifolium repens*), raudonuosiuose dobiluose (*Trifolium pratense*), rausvuosiuose dobiluose (*Trifolium hybridum*), pelėžirnyje (*Lathyrus pratensis*), varputyje (*Elymus repens*), paprastajame eraičine (*Festuca pratensis*), raudonajame eraičine (*Festuca rubra*), pašariniuose motiejukuose (*Phleum pratense*), daugiametėje svidrėje (*Lolium perenne),* beginklėje dirsuolėje

(*Bromopsis inermis*), paprastojoje šunažolėje (*Dactylis glomerata*) ir pievinėje miglėje (*Poa pratensis*). Elementų koncentracijos įvertintos, lyginant su gyvulių mitybai optimaliomis jų koncentracijomis pašaruose (NRC, 2000; 2001). Tyrimo rezultatai parodė, kad elementų koncentracijos augaluose priklauso nuo augalo botaninės rūšies, o kai kuriais atvejais ir nuo botaninės šeimos. Ankštinės žolės (*Fabaceae*) kaupė daugiau Ca negu varpinės žolės (*Poaceae*). K ir P kaupimo dėsningumų tirtose augalų šeimose nenustatyta. K koncentracijos visuose augaluose viršijo otimalią. P trūkumas nustatytas visuose augaluose, išskyrus baltuosius dobilus ir varputį. Mg varpinės žolės sukaupė mažiau nei ankštinės, tačiau pakankamai. Na trūkumas nustatytas visose žolėse, išskyrus daugiametę svidrę. Fe visose žolėse buvo pakankamai. Mn ankštiniuose augaluose buvo pakankamai, o varpiniuose, išskyrus paprastąją šunažolę, – per mažai. Visuose augaluose trūko Cu ir Zn. Co varpiniuose augaluose buvo per mažai, o ankštiniuose – pakankamai. Apibendrinus, visose tirtose žolėse buvo per daug Ca, K ir Fe, o P, Na, Zn ir Cu – per mažai. Varpinės žolės, palyginti su ankštinėmis, kaupė mažiau Ca, Mg, Cu, Zn, Mn, Fe, Co ir daugiau Na. Sudarant atitinkamus ankštinių ir varpinių žolių mišinius galima optimizuoti Ca ir kai kuriais atvejais K, Mg, Na, Mn, Fe dozes, tačiau pašarus dažniausiai reikia papildyti mikroelementais. Siekiant pagerinti pašarų mitybinę vertę, būtina ieškoti dirvožemio praturtinimo mikroelementais, pašarų kokybės gerinimo bei elementų pusiausvyros agroekosistemose užtikrinimo būdų.

Raktažodžiai: žolės, ankštiniai augalai, gyvulių pašarai, mikroelementai, elementų pusiausvyra