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INFLUENCE OF DIFFERENT FORMS OF NITROGEN FERTILIZATION ON THE CONTENT OF MACROLEMENTS (K, Na) IN MEADOW SWARD Part I

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Abstract

Present intensification of plant production rises a need to search for new solutions, such as novel fertilization technologies which reduce environmental pollution.

The aim of this work has been to examine principles of rational fertilization of permanent meadows, including delivery of nitrogen doses applied in various forms. The investigations were led in the region of Siedlce in 1999-2001. Basic fertilization was applied once during the growing season, in spring, and consisted of N–60 kg·ha^{-1}, P–60 kg·ha^{-1}, K–60 kg·ha^{-1} applied to soil. The fertilizers were used in two forms: multiple (Polifoska 15) [P] and a mix of fertilizers (ammonium nitrate, superphosphate, potassium salt) [M]. Nitrogen fertilization of the second and third cuts was conduced as various foliar (20%, 30%, 40% urea solution) or soil (ammonium nitrate). The doses of nitrogen in respective variants were 27.6 kg·ha^{-1} (N_1), 41.4 kg·ha^{-1} (N_2) and 55.2 kg·ha^{-1} (N_3). Every year three cuts for determination of potassium and sodium were collected.

Fertilization of the experimental objects with the multiple fertilizer resulted in increasing plants' potassium content whereas the mixture of fertilizers increased the quantity of sodium in plants. Foliar fertilization with nitrogen in the form of urea solution gave a higher increase in the plants' content of potassium and sodium than fertilization to roots with ammonium nitrate (independently on the basic fertilization).

By analysing the content of potassium in plants in dependence of the doses as well as the kind of supplementary nitrogen fertilization, it has been verified that most of this component was determined in plants treated with foliar fertilization consisting of 55.2 kg N·ha^{-1} (N_3), the lowest potassium concentration occurred in plants receiving foliar fertilization with dose 41.4 kg N·ha^{-1} (N_2).

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The analysis of the sodium content in plants in dependence of the doses and type of supplementary nitrogen fertilization showed that most potassium was in plants produced on the plots receiving foliar fertilization with a nitrogen dose of 27.6 kg·ha^{-1} (N_1), and the least potassium was determined in plants nourished with 41.4 kg N·ha^{-1} (N_2) applied to soil.

Key words: meadow sward, nitrogen dose, mineral fertilization, foliar fertilization, potassium, sodium.

WPŁYW FORMY NAWOŻENIA AZOTEM NA ZAWARTOŚĆ MAKROELEMENTÓW (K, NA) W RUNI Z ŁĄKI TRWAŁEJ

Abstrakt

Celem pracy było porównanie wpływu nawożenia azotem użytków zielonych na zawartość makroelementów w runi łąkowej. Badania prowadzono w latach 1999-2001 na łące trwałej. Każdego roku po ruszeniu wegetacji stosowano nawożenie podstawowe pogłównie, wnosząc do gleby odpowiednio: N–60 kg·ha^{-1}, P–60 kg·ha^{-1}, K–60 kg·ha^{-1}. Zastosowano dwie formy nawozów: wieloskładnikowy (Polifoska 15) [P] i mieszaninę nawozów jednoskładnikowych [M] (saletra amonowa, superfosfat pojedynczy, sól potasowa). W drugim i trzecim odroście stosowano nawożenie azotem w formie dolistnej (20%, 30%, 40% roztwór mocznika) i dokorzeniowej (saletra amonowa). Dawki azotu wynosiły: 27,6 kg·ha^{-1} (N_1), 41,4 kg·ha^{-1} (N_2), 55,2 kg·ha^{-1} (N_3). W każdym roku badań zebrano po trzy pokosy. W runi łąkowej określono zawartość potasu i sodu. Nawożenie nawozem wieloskładnikowym powodowało wzrost zawartości potasu w roślinach, a nawożenie mieszaniną nawozów jednoskładnikowych przyczyniło się do wzrostu ilości sodu. Dolistne dokarmianie roślin azotem w formie roztworu mocznika spowodowało większy wzrost zawartości potasu i sodu w porównaniu z nawożeniem dokorzeniowym saletrą amonową (niezależnie od zastosowanego rodzaju nawożenia podstawowego).

Analizując zawartość potasu w roślinach w zależności od dawek i rodzaju nawożenia uzupełniającego azotem, stwierdzono, że najwięcej tego składnika było w roślinach nawożonych dolistnie dawką 55,2 kg·ha^{-1} azotu (N_3), natomiast najmniej w przypadku zastosowania dolistnie dawki 41,4 kg·ha^{-1} (N_2).

Analiza zawartości sodu w roślinach w zależności od dawek i rodzaju nawożenia uzupełniającego azotem wykazała, że najwięcej tego składnika było w roślinach z poletek nawożonych dolistnie dawką azotu 27,6 kg·ha^{-1} (N_1), natomiast najmniej w przypadku dawki 41,4 kg·ha^{-1} (N_2) zastosowanej dokorzeniowo.

Słowa kluczowe: ruń łąkowa, dawka azotu, forma azotu, dokarmianie dolistne, nawożenie mineralne, potas, sód.

INTRODUCTION

According to many authors (Doboszyński 1994, Winnicka, Bobrecka-Jamro 1996, Wasilewski, Sutkowska 2001), mineral fertilization is one of the basic treatments influencing the botanical composition of meadow sward. Mineral fertilization influences the height and quality of crops. In order to obtain high yields of crops, it is necessary to apply a suitable mineral fertilization

regime (CZUBA 1996, WASILEWSKI 1999, JODEŁKA et. al. 2000). However, for mineral fertilization to be an economically profitable practice, one must establish optimum doses of fertilizers to be applied on grasslands.

Fertilization of grasses most often consists of traditional fertilizers applied in the solid form as top-dressing. However, in a period of drought such fertilizers stay on the surface of soil for a long time and their effect becomes delayed. In contrast, during excessive precipitations the fertilizers can be washed out to deeper layers of soil, where they are inaccessible to shallow roots of grasses. Present intensification of plant production rise a need to search for various solutions, such as new fertilization technologies which reduce environmental pollution. Such technologies allow combination of fertilizing components and improved utilization of nitrogen by plants. It has been empirically confirmed that foliar fertilization of meadow sward is beneficial (JANKOWSKI et. al. 1999, JODEŁKA et. al. 1999, 2000, JODEŁKA, JANKOWSKI 2001), which has encouraged us to study the reaction of fodder grasses to this fertilization method in terms of their content of mineral compounds. Thus, the aim of this work has been to examine the influence of nitrogen fertilization applied in different forms on the content of potassium and sodium in meadow sward.

MATERIAL AND METHODS

A three-year experiment was established in spring 1999 on permanent meadow in the region of Siedlce.

The trial plots were set out on gley proper soil created from light loamy sand on medium silt clay. The soil was slightly alkaline in reaction, both in KCl solution and in H_2O (pH in 1 n KCl 7.15); it had a high content of total nitrogen (0.45%), manganese (450 mg·kg^{-1}) and iron (1700 mg·kg^{-1}), an average content of magnesium (0.31 mg·kg^{-1}) and a very low content of phosphorus (0.15 mg·kg^{-1}) and potassium (0.25 mg·kg^{-1}).

The meteorological measurements (temperature and precipitations) used for this report were obtained from the meteorological station in Siedlce. The meteorological conditions in the particular years of the investigations were different (Table 1). The average air temperature in the growing period (April – September) in the successive years was higher than the long-term average (4.1, 3.9 and 3.8°C, respectively). Also the total precipitation in the growing seasons analyzed exceeded the long-term average (about 87.3 mm in 1999, about 74.5 mm in 2000 and about 46 mm in 2001).

Two forms of fertilizer were used for basic fertilization: multiple (Polifoska 15) [P] and a mixture of single-element fertilizers (ammonium nitrate, superphosphate, potassium salt) [M]. Both introduced to the soil 60 kg N·ha^{-1}, 60 kg P·ha^{-1} and 60 kg K·ha^{-1}. Additionally, the second and third cut were

Table 1

Meteorological conditions 1999-2001, data provided by the meteorological station in Siedlce

Year	Mean monthly air temperatures (°C)						Mean in growing season (Apr-Sept)
	Apr	May	June	July	Aug	Sept	
1999	9.9	12.9	20.5	21.8	18.7	16.1	16.7
2000	12.9	16.4	19.5	19.0	19.1	11.8	16.3
2001	8.7	15.5	17.1	23.8	20.6	12.1	14.7
Long-term mean (1987-1999)	7.8	12.5	17.2	19.2	18.5	13.1	14.7
Year	monthly precipitations (mm)						Sum in growing season (Apr-Sept)
	Apr	May	June	July	Aug	Sept	
1999	87.5	26.4	121.7	21.9	77.4	27.8	362.5
2000	47.5	24.6	17.0	155.9	43.6	61.1	349.7
2001	69.8	28.0	36.0	55.4	24.0	108.0	321.2
Long-term mean (1987-1999)	38.6	44.1	52.4	49.8	43.0	47.3	275.2

fertilized with nitrogen applied as foliar treatments (20%, 30%, 40% urea solution) or in the solid form (ammonium nitrate) to soil. Both fertilization treatments introduced identical amounts of nitrogen: N_1– 27.6 kg·ha^{-1}, N_2– 41.4 kg·ha^{-1} and N_3– 55.2 kg·ha^{-1}.

Three cuts were harvested in the vegetation period. The chemical analysis of the plant material was performed by absorption atomic spectrophotometry (ACE) for the following macronutrients: K and Na.

Mathematical models proposed for this type of experiments by Trętowski and Wójcik (1991) were applied. Significance of differences between means of the experimental factors was determined with Tukey's test at the level of significance $P<0.05$.

RESULTS AND DISCUSSION

The results confirmed that spring application of two fertilization (Table 2) significantly differentiated the content of potassium in plants. Significantly more potassium was found in meadow sward from plots fertilized with the multiple fertilizer. However, these contents were lower than an optimum potassium concentration suggested by other authors, for example 17 g·kg^{-1} K of d.m (Falkowski et. al. 1990), about 20 g·kg^{-1} d.m. (Nowak 1992), and from 10 to 30 g·kg^{-1} d.m. (Preś 1984).

The content of potassium determined in our study was also variable depending on the type of basic fertilization, supplementary nitrogen fertilization method and doses of nitrogen (Table 2). The highest content of potassium, between 16.2 and 16.0 $g \cdot kg^{-1}$ of d.m., appeared in plants which had received foliar fertilization with urea solution in the fertilizer variants N_1 and N_3 with the multiple fertilizer for basic fertiliztaion. This potassium level was significantly higher in comparison with the variants of identical additional fertilization and basic fertilization consisting of a mixture of single-component fertilizers.

The present experiment has demonstrated (Figure 1) that most potassium was in plants from the first re-growth. Other authors, e.g. BARRYŁA (1992) and JODEŁKA (1998), also reported higher potassium content in the first regrowth on meadows. Our comparison of the results produced by additional

Table 2

Content of K and Na in plants ($g \cdot kg^{-1}$ d.m.) depending on fertilization technique (soil and foliar) and nitrogen dose (mean for the years of the experiment

Basic fertilization	Nitrogen dose	Potassium		$\bar{x}$	Sodium		$\bar{x}$
		additional fertilization			additional fertilization		
		foliar	soil		foliar	soil	
Polifoska [P]	N_1	16.2	13.9	15.1	2.4	2.1	2.3
	N_2	13.8	15.1	14.5	2.5	2.5	2.5
	N_3	16.0	15.3	15.7	2.1	2.2	2.2
	$\bar{x}$	15.3	14.8	15.1	2.3	2.3	2.3
Mix of fertilizers [M]	N_1	14.5	14.6	14.6	2.7	2.0	2.4
	N_2	13.9	14.8	14.4	2.5	2.3	2.4
	N_3	15.4	14.5	15.0	2.6	2.2	2.4
	$\bar{x}$	14.6	14.6	14.6	2.6	2.2	2.4
Mean [PM]	N_1	15.4	14.3	14.9	2.6	2.1	2.4
	N_2	13.9	15.0	14.5	2.5	2.4	2.5
	N_3	15.7	14.9	15.4	2.4	2.2	2.3
	$\bar{x}$	15.0	14.7	14.9	2.5	2.3	2.4
n.s. – non-significant		$LSD_{0.05}$ additional fertilization (A) – n.i. nitrogen dose (B) – 0.4 basic fertilization (C) – 0.4 interaction: A x B – 1.0 A x C – 0.5 B x C – 0.5 A x B x C – 0.6			$LSD_{0.05}$ additional fertilization (A) – 0.22 nitrogen dose (B) – n.s. basic fertilization (C) – n.s. interaction: A x B – 0.30 A x C – 0.27 B x C – 0.25 A x B x C – 0.36		

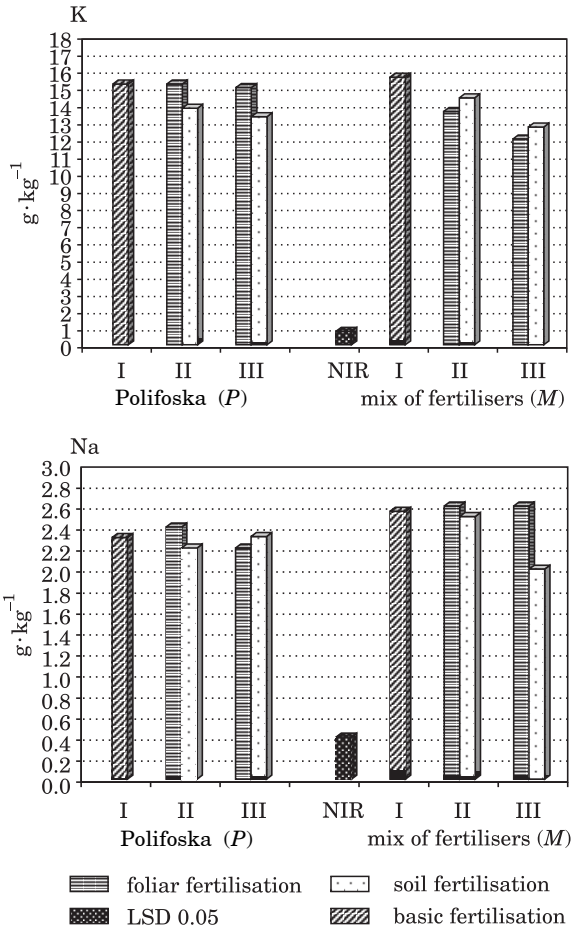

Fig. 1. Content of K and Na in plants ($g \cdot kg^{-1}$) depending on basic fertilization type, additional fertilization to soil or foliar and nitrogen dose and cuts (means for the years of the experiment)

fertilization showed that, against the background of the multiple fertilizer basic nutrition, a significantly higher content of potassium in the second regrowth occurred in the sward which had received foliar fertilization. However, when a mixture of single-component fertilizers had been used, the results were contrary – most potassium was found in the sward fertilized to the soil. When analyzing the content of potassium in plants in dependence of the nitrogen doses and method of supplementary nitrogen fertilization (Table 2), it was found out that most potassium was in plants from the plots receiving 55 $kg \cdot ha^{-1}$ of nitrogen in foliar fertilization (N_3). The smallest potassium concentration occurred in plants which had received 41.4 kg $N \cdot ha^{-1}$ applied as foliar fertilization (N_2).

Sodium is another important component animal nutrition, which is often deficient in grasses according to nutritional needs of animals. FALKOWSKI et. al. (1990) claim that animal fodder should contain 1.5 – 2.5 $g \cdot kg^{-1}$ Na in d.m. However, NOWAK (1981) suggests that sodium in fodder above 1.8 $g \cdot kg^{-1}$ d.m. fully satisfies the alimentary needs of animals.

In our investigations (Table 2), a slightly higher content of sodium in plants (average 2.4 $g \cdot kg^{-1}$ d.m.) occurred in plots fertilized with a mixture of single-component fertilizers in the comparison with plots fertilized with the multiple fertilizer (2.3 $g \cdot kg^{-1}$ d.m.).

The content of sodium was also differentiated by the nitrogen doses as well as the form of nitrogen fertilization and the type of basic fertilization (Table 2). The highest content of sodium (2.7 $g \cdot kg^{-1}$ d.m.) was determined in sward harvested from plots receiving foliar fertilization with the lowest nitrogen dose 27.6 $kg \cdot ha^{-1}$ (variant N_1) against the background of a mixture of single-component fertilizers. It was significantly higher than its concentration in the fodder fertilized with the same dose of nitrogen but applied to the soil (2.0 $g \cdot kg^{-1}$ d.m.).

The statistical analysis of the interaction between the type of basic fertilization and the way supplementary nitrogen fertilization was applied on the successive cuts (Figure 1) showed that significantly more sodium was present only in the fodder from second and third re-growths which had received foliar fertilization in the comparison with nitrogen fertilization applied to the soil.

The analysis of sodium in plants in dependence of the doses and methods of supplementary nitrogen fertilization (Table 2) showed that most sodium was in plants taken from plots where 27.6 kg $N \cdot ha^{-1}$ was introduced in foliar applications (N_1), whereas the lowest sodium concentration occurred in plants which had received 41.4 kg $N \cdot ha^{-1}$ applied to the soil (N_2). In this experiment, no statistically significant differences were revealed in sodium content in plants depending on the nitrogen doses irrespective of the basic and supplementary fertilization regimes.

CONCLUSIONS

1. The form of fertilizers significantly differentiated the content of mineral components in meadow sward. Fertilization with a multiple fertilizer resulted in an increase in the potassium content, whereas application of a mixture of single- component fertilizers increased the quantity of sodium.

2. More potassium was contained in meadow sward fertilized with a multiple fertilizer and additionally top-dressing fertilized as well as in grasses fertilized with a mixture of single-component fertilizers but receiving additional nitrogen fertilization to the soil.

3. The highest sodium content was determined in meadow sward additionally fertilized with nitrogen in the form of foliar application; the lowest sodium concentration was found in plants receiving the lowest nitrogen dose under a fertilization regime consisting of a mixture of single-component fertilizers.

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