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INLFUENCE OF INCREASING NITROGEN FERTILIZATION ON CONTENT OF MICROELEMENTS IN GRASSES CULTIVATED ON ORNAMENTAL LAWNS

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Abstract

The main aim of the study, conducted in 2007-2008, was to define the influence of nitrogen levels 0, 50, 100, 150, 200 mg N dm^{-3} applied to grass lawns on the content of metallic microelements: iron, manganese, zinc and copper and on their quantitative ratios in turf grass. The study was carried out on a 2-year-old lawn, composed of a mixture of lawn grasses species and varieties: perennial ryegrass (*Lolium perenne* L.) var. Grasslands Nui (45%), tall fescue (*Festuca arundinacea* Schreb) Finelawn (25%), red fescue (*Festuca rubra* Hack.) Olivia (10%), red fescue (*Festuca rubra* Hack.) Boreal (15%) and Kentucky bluegrass (*Poa pratensis* L.) Balin (5%). With the exception of copper, the nitrogen fertilization raised the content of iron, manganese and zinc in aerial plant parts. The application of nitrogen (as ammonium nitrate) increased the uptake of nutrients by aerial plant parts: Fe to 143.0%, Mn – 227.2%, Zn – 233.3% Cu – 180.7%, and modified the ratios between amounts of the microelements. In general, it has been demonstrated that nitrogen nutrition of plants grown on ornamental lawns, within ranges of N – 150 to N – 200, increased the ratios of Fe : Mn : Zn : Cu. The best ornamental quality of lawns was obtained where the aerial plant parts contained (in mg kg^{-1} d.m.): Fe 231.6-292.8, Mn 35.6-50.5, Zn 26.5-47.5 and Cu 16.9-17.6. These ranges could be recommended as preliminary guidelines for ornamental lawns. In practice, considering the positive and stimulating influence of nitrogen nutrition on crops, the chemical composition of plants and the uptake of microelements by a mixture of grasses on ornamental lawns, it is crucial to monitor actual fertilization by taking into account losses of nutrients. These losses are caused by intensive uptake of nutrients by the aerial plant parts and due to the leaching of nutrients from the rhizosphere. It is necessary to replenish lost elements using mineral fertilizers.

Key words: nitrogen, lawn, turf grass, microelement content, plant analysis.

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WPŁYW WZRASTAJĄCEGO NAWOŻENIA AZOTEM NA ZAWARTOŚĆ MIKROELEMENTÓW W RUNI TRAWNIKÓW DEKORACYJNYCH

Abstrakt

Celem badań w latach 2007-2008 było określenie wpływu wzrastających poziomów azotu: 0, 50, 100, 150, 200 mg N dm^{-3} na zawartość mikroelementów metalicznych żelaza, manganu, cynku i miedzi oraz stosunki ilościowe w runi trawników dekoracyjnych. Doświadczenie wegetacyjne wykonano na 2-letnim trawniku, na którym wysiano mieszankę traw o następującym składzie gatunkowym (w %): życica trwała (*Lolium perenne* L.) Grasslands Nui – 45%, kostrzewa trzcinowa (*Festuca arundinacea* Schreb.) Finelawn – 25%, kostrzewa czerwona (*Festuca rubra* Hack.) Olivia – 10%, kostrzewa czerwona (*Festuca rubra* Hack.) Boreal – 15%, wiechlina łąkowa (*Poa pratensis* L.) Balin – 5%. Z wyjątkiem miedzi, nawożenie azotem wpływało na wzrost zawartości żelaza, manganu i cynku w częściach nadziemnych traw. Nawożenie azotem (w formie saletry amonowej) zwiększało pobranie mikroelementów przez części nadziemne roślin: Fe o 143,0%, Mn – 227,2%, Zn – 233,3%, Cu – 180,7% oraz ich stosunki ilościowe. Wykazano, że wysokie nawożenie azotem trawników dekoracyjnych, od N-150 do N-200, zwiększało stosunek Fe : Mn : Zn : Cu. Najlepszymi walorami dekoracyjnymi charakteryzowała się murawa zawierająca w częściach nadziemnych (w mg kg^{-1} s.m.): Fe 231,6-292,8, Mn 35,6-50,5, Zn 26,5-47,5 i Cu 16,9-17,6. Zakresy te można zalecać jako tymczasowe zawartości wskaźnikowe dla trawników dekoracyjnych. Z praktycznego punktu widzenia, biorąc pod uwagę pozytywny i stymulujący wpływ nawożenia azotem na plonowanie, skład chemiczny roślin i pobieranie mikroelementów przez mieszankę traw na trawniku dywanowym, konieczne jest – w ich kontrolowanym nawożeniu – uwzględnienie strat wynikających z wynoszenia tych składników z gleby wraz z plonem części nadziemnych, a także ich wypłukiwania z rizosfery, i ewentualne ich uzupełnienie nawozami mineralnymi.

Słowa kluczowe: azot, trawnik, darń, zawartość mikroelementów, analiza roślin.

INTRODUCTION

Grasses, forming natural green areas, have for long been fulfilling ornamental functions. With time, grass began to be introduced to gardens, generally as lawns. Together with the development of architecture, their practical meaning gradually started to increase. In recent time, grass lawns have been treated as one of the most important components of green areas.

Despite many significant functions performed by grass plants, there are no recommended values of microelements in aerial part of grasses that would facilitate a diagnosis of the actual plant nutrient status, which is essential for controlling fertilization of ornamental lawns. The experiments conducted so far on the influence of nitrogen fertilizers have focused on the abundance of soil, harvesting of plants and values of ornamental lawns (KLEIBER et al. 2009a), status of plant supply with macroelements (KLEIBER et al. 2009b) and microbiological changes that occur in soil under lawns (NIEWIADOMSKA et al. 2010).

The main aim of the present study has been to determine the influence of increasing nitrogen fertilization on the content of iron, manganese, zinc and copper, their uptake by plants and quantitative ratios in aerial plant parts. Another objective has been to propse preliminary guidelines for levels of microelements in aerial parts of grass plants, which will ensure the best ornamental efects. These data are valuable in practice for controlled nitrogen fertilization of lawns.

MATERIAL AND METHODS

Vegetation experiments were carried out in 2007-2008, at the Experimental Station of the Horticulture and Landscape Architecture Department, Poznań University of Life Sciences. The increasing levels of nitrogen fertilization were tested (in mg N dm^{-3}): 0, 50, 100, 150, 200 (marked N-0 to N-200), corresponding to the doses of nitrogen such as 0, 10, 20, 30 and 40 g N m^2 (in ammonium nitrate – 35% N), on iron, manganese, zinc and copper content, their uptake and quantitative ratios in aerial plant parts. Apart from nitrogen, the other macroelements in all treatments were applied to maintain standard levels of fertilization (in mg dm^{-3}): P 100, K 200, Mg 180 (in 2007) and Mg 300 (in 2008). A detailed description of the material and methods in this experiment is given by KLEIBER et al. (2009a).

The tests were carried out on 2-year-old lawn, where a mixture of lawn grasses was sown in the amount of 25 g m^{-2}, composed of perennial ryegrass (*Lolium perenne* L.) var. Grasslands Nui (45%), tall fescue (*Festuca arundinacea* Schreb) Finelawn (25%), red fescue (*Festuca rubra* Hack.) Olivia (10%), red fescue (*Festuca rubra* Hack.) Boreal (15%) and Kentucky bluegrass (*Poa pratensis* L.) Balin (5%).

During the vegetation period, samples of aerial plant parts were collected for chemical analyses. The samples were obtained after cutting the grass with of a lawn mower. The experiments were set up in four replications; each replication was a plot of 12 m^2. The samples were collected separately from each plots on the following days: 26.07 and 03.09.2007 or 18.06, 23.07 and 25.08.2008. The collected aerial plant parts were dried at the temperature of 45-50°C and ground. The plant samples were digested in a mixture of nitric and perchloric acids 3:1 (v/v). Afterwards, Fe, Mn, Zn, and Cu were determined with the AAS method (AAS3; Carl Zeiss Jena). The results of plant analyses were subjected to statistical analysis with Duncan's test (α=0.05).

RESULTS AND DISCUSSION

Nutrient status of plants

Significant influence of the application of nitrogen fertilizers on the content of iron in aerial parts of plants has been demonstrated (Table 1). The significantly highest content of this nutrient (287.5-300.5 mg Fe kg^{-1} d.m.) was found in plants that were supplied with the lower and average quantities of nitrogen (N-0 to N-100). A significant decrease in the iron content was noticed when plants were fed higher nitrogen doses (N-150 to N-200); then it ranged from 231.6 to 234.0 mg Fe kg^{-1} d.m. A higher content of iron was shown by WIATER et al. (2005), who tested a mixture of grasses nourished with sewage fertilizer; there, aerial parts of plants contained 357 to 801 mg Fe kg^{-1} d.m. In our experiment, the year of the tests modified the iron content of the plants.

Table 1

The influence of nitrogen nutrition on the content of iron, manganese, zinc and copper in aerial plant parts (mg kg^{-1} d.m.)

N level (A)	Fe			Mn			Zn			Cu		
	year											
	2007	2008	mean	2007	2008	mean	2007	2008	mean	2007	2008	mean
N-0	341.1	233.9	287.5*a*	40.8	24.9	32.9*b*	56.5	29.7	43.1*a*	18.2	18.3	18.2*a*
N-50	371.2	229.8	300.5*a*	55.7	25.2	40.4*ab*	36.3	17.5	26.9*b*	16.7	17.5	17.1*a*
N-100	368.2	217.5	292.8*a*	76.3	24.7	50.5*a*	33.2	19.8	26.5*b*	16.9	18.4	17.6*a*
N-150	307.8	160.3	234.0*b*	59.5	22.0	40.7*ab*	40.5	22.6	31.5*b*	16.6	17.5	17.0*a*
N-200	291.5	171.7	231.6*b*	48.2	23.0	35.6*b*	64.5	30.6	47.5*a*	14.5	19.3	16.9*a*
Mean	341.1*a*	233.9*b*	287.5	40.8*a*	24.9*b*	32.9	56.5*a*	29.7*b*	43.1	18.2*a*	18.3*a*	18.2

* Values designated with the same letters in columns do not significantly differ at p=0.05.

The tested nitrogen plant nutrition had a significant influence on the content of manganese in aerial plant parts. The lowest content of manganese was found under the extreme levels of nitrogen in the soil N-0 and N-200, where it reached 32.9 and 35.6 mg Mn kg^{-1} d.m., respectively. The highest content of this element (50.5 mg Mn kg^{-1} d.m.) appeared in response to N-150 fertilization. By analogy to iron, the content of manganese was significantly different between the two years of the study. Demonstrably lower content of manganese (79-119 mg Mn kg^{-1} d.m.) was determined by WIATER et al. (2005). BARYŁA et al. (2009) turn our attention to the important influence of grass species on nutrient accumulation. CZARNECKI, HARKOT (2000) express an opinion that red fescue (*Festuca rubra* Hack.) accumulates higher amounts of manganese than other grass species.

Analogously to iron and manganese, differences in the influence of nitrogen fertilizers on the content of zinc in plants were shown. The significantly highest content of this nutrient appeared in the control combination (N-0) and the treatments that had received the highest quantities of nitrogen (N-150): 43.1 and 47.5 mg Zn kg^{-1} d.m. of aerial plant parts, respectively. The content of zinc in the other treatments was as follows: from 26.5 to 31.5 mg Zn kg^{-1} d.m. The year of the experiment significantly influenced the content of zinc in aerial plant parts. Similarly to iron and manganese, in the experiment conducted earlier by WIATER et al. (2005), a higher content of zinc was discovered, ranging from 49.1 to 103.4 mg Zn kg^{-1} d.m. of aerial plant parts. In turn, BARYŁA et al. (2009), who compared the chemical composition of different grass species, demonstrated higher accumulation of zinc in aerial parts of *Phalaris arundinacea*.

Contrary to the other microelements, no significant influence of nitrogen nutrition on the content of copper in aerial parts of plants was shown. The content of copper was from 16.9 mg Cu kg^{-1} d.m. in combinations the plants fed with higher rates of nitrogen (N-200) to 18.2 mg Cu kg^{-1} d.m. in the control combination (N-0). There were no significant differences between the two years of the experiment in the content of copper in aerial parts of plants. The content of copper was higher than the data reported by WIATER et al. (2005).

Some earlier experiments, e.g. conducted by VUCKOVIC et al. (2005), did show significant influence of nitrogen fertilization levels, within ranges of 0 to 160 kg ha^{-1}, on the condition of feeding grasses with zinc and copper. The content of zinc, as shown bythe above auhtors, was higher than in our experiment, i.e. from 68 to 75 mg Zn kg^{-1} d.m. The same is true about copper, ranging from 24 to 31 mg Cu kg^{-1} d.m. It was also shown, as in our study, that the year of the experiment had some influence on the plants' nutrient status with zinc. These authors claim that an increase of nitrogen doses caused an increase of the content of copper accompanied by a decrease in the content of zinc. The content of zinc and manganese determined in our tests was higher than the results reported by COURTNEY, TIMPSON (2004), who stated that the biomass of *Lolium perenne*, in dependence on the physiochemical characteristics of the soil, contained on average from 12.1 mg to 36.3 mg Mn kg^{-1} d.m. The same authors reported that the content of zinc ranged from 15.9 mg to 33.4 mg Zn kg^{-1}. SAWICKA (1996) pointed out that higher doses of nitrogen fertilizers cause some decrease in the content of zinc and copper in plants. The influence of nitrogen nutrition on the status of plant supply with microelements and their translocation within plants has been also noticed by HU-LIN et al. (2007).

Nutrient uptake by aerial parts of plant

Some positive influence of nitrogen nutrition on the uptake of microelements by aerial parts of grass plants was noticed (Table 2). Among all treat-

Table 2

The influence of nitrogen nutrition on yield of dry matter (g m^{-2}) and uptake microelements by aerial parts of grasses (mg m^{-2}) – average from two years

Nutrient (mg m^{-2})	N level					
	N-0	N-50	N-100	N-150	N-200	mean
Dry matter	313.8*c*	452.8*b*	590.8*b*	763.8*ab*	946.6*a*	613.6
Fe	90.2*c*	136.1*b*	173.0*ab*	178.7*ab*	219.2*a*	159.4
Mn	10.3*c*	18.3*b*	29.8*a*	31.1*a*	33.7*a*	24.6
Zn	13.5*b*	12.2*b*	15.7*b*	24.1*b*	45.0*a*	22.1
Cu	5.7*c*	7.7*b*	10.4*b*	13.0*a*	16.0*a*	10.6

* Values designated with the same letters in rows do not significantly differ at p=0.05.

ments, the lowest uptake of microelements appeared in plants cultivated in the control combination. As the nutrition of plants with nitrogen rose, so did the uptake of microelements. Under the highest nitrogen nutrition (N-200), relative to the control combination (N-0), the uptake of microelements rose as follows: Fe-143.0%, Mn-227.2 %, Zn- 233.3% and Cu-180.7%. For zinc, the lowest uptake of this microelement was in the treatment fertilized with the nitrogen level N-50. The average uptake of microelements by aerial parts of plants under the tested nitrogen levels was (in mg m^{-2}): Fe 159.4, (90.2-219.2), Mn 24.6 (10.3-13.7), Zn 22.1 (12.2-45.0) and Cu 10.6 (5.7--16.0). WIATER et al. (2005) reported that the uptake of microelements, depending on the year of the experiment, was the following (in mg m^2): Fe (33.7-147.0), Mn (10.1-21.7), Zn (9.25-16.5) and Cu (0.0012-1.38).

Nutrient ratios in aerial plant parts

The influence of nitrogen nutrition on changes in ratios between microelements in aerial parts of plants grown on an ornamental lawn has been demonstrated (Table 3). Noted was also Diminishing ratios between Fe : : Mn = 1.00: 0.17 under the nitrogen levels in soil from N-100 to N-150 were also observed. When the nitrogen nutrition of plants was low (N-0 and N-50), the ratio of iron to manganese rose to Fe : Mn = 1.00: (0.11-0.13).

The ratio Fe : Zn in aerial parts of grasses also rose under the influence of the nitrogen levels from N–50 to N–150 [Fe : Zn = 1.0 : (0.09-0.13)] in comparison to the control combination N-0. The highest Fe : Zn ratio = 1.00 : 0.20 was noted in plants that had received the highest dose of nitrogen (N-200).

Together with intensive increase in plant nitrogen nutrition, the ratio between Fe : Cu kept decreasing (from 1.00 : 0.06 to 1.00 : 0.07). The average ratios between microelements (Fe : Mn : Zn : Cu) for all tested levels of nitrogen soil fertilization were 1.00 : 0.15 : 0.13 : 0.06.

Table 3

The influence of nitrogen nutrition on ratios between nutrients in aerial parts of grasses (average from the years 2007-2008)

Nutrient	N level					
	N-0	N-50	N-100	N-150	N-200	mean
Microelements						
Fe	1.00	1.00	1.00	1.00	1.00	1.00
Mn	0.11	0.13	0.17	0.17	0.15	0.15
Zn	0.15	0.09	0.09	0.13	0.20	0.13
Cu	0.06	0.06	0.06	0.07	0.07	0.06
Macroelements (Kleiber et al. 2009b)						
N	1.00	1.00	1.00	1.00	1.00	1.00
P	0.25	0.26	0.25	0.23	0.18	0.23
K	1.26	1.32	1.28	1.20	1.06	1.22
Ca	0.39	0.48	0.52	0.35	0.23	0.39
Mg	0.21	0.24	0.23	0.20	0.16	0.21
S	0.19	0.19	0.19	0.16	0.16	0.18

In general, the results of the tests show that nitrogen nutrition of plants growing on ornamental lawns with nitrogen, within ranges of N-150 to N-200, increased the ratios of Fe : Mn : Zn : Cu. In contrast to these microelements, same as in the experiment carried out by Kleiber et al. (2009b), high nitrogen fertilization decreased the ratio of nitrogen to the remaining macroelements in aerial plant parts.

SUMMARY

In practice, considering the positive and stimulating influence of nitrogen nutrition on crops (Kleiber et al. 2009a), the chemical composition of plants and the uptake of microelements by a mixture of grasses on ornamental lawns, it is crucial to monitor their fertilization, taking into account losses of nutrients. These losses are caused by intensive uptake of nutrients by the aerial plant parts and due to the leaching of nutrients from the rhizosphere. It is necessary to replenish lost elements using mineral fertilizers.

CONCLUSIONS

1. The study has confirmed significant influence of nitrogen nutrition on plants growing on ornamental lawns, and in particular, on the content of iron, manganese and zinc in their aerial parts. Soil nitrogen fertilization did not have any significant influence on the content of copper.

2. Positive influence of nitrogen nutrition of grasses on the uptake of metallic microelements by aerial plant parts was shown. The lowest uptake of iron, manganese, zinc and copper was noted in grasses in the control combination (N-0). Increasing nitrogen nutrition of plants caused some increase in the uptake of these microelements.

3. Under the highest level of nitrogen fertilization (N-200), in relation to the control object (N-0), the uptake of microelements by aerial parts of plants rose as follows: Fe – 143.0%, Mn – 227.2%, Zn – 233.3% and Cu – 180.7%.

4. Increasing nitrogen nutrition of grasses modifies ratios of quantities of microelements in aerial parts of plants.

5. The lawns with the best ornamental attributes are those that are characterized with the following content of elements (in mg kg^{-1}): Fe – 231.6÷292.8, Mn – 35.6÷50.5, Zn – 26.5÷47.5 and Cu – 16.9 ÷ 17.6.

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