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YIELD OF COCKSFOOT (*DACTYLIS GLOMERATA* L.) AND ITS NITROGEN AND SULPHUR CONTENT AFTER FERTILIZATION WITH VARIOUS FORMS OF THESE NUTRIENTS

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Abstract

This study has analyzed the effect of fertilization with various forms of nitrogen and sulphur on cocksfoot yield and on the content of these nutrients in the plant. The study was based on a strict experiment conducted on soil material from the arable layer of brown soil of clayey silt granulometric composition. The soil used in the experiment was characterized by slight acidity and low content of assimilable forms of phosphorus, potassium, magnesium and sulphur. The results indicate that the experimental factors caused significant variation in cocksfoot yield. Significant variations in yield also occurred as a result of the interaction between these factors. The highest yields were obtained where nitrogen was applied in the liquid form (UAN-30) and sulphur was applied in the form of Na_2SO_4. Significant increases in yield after application of elemental sulphur were not observed until the second cut was harvested, which clearly indicates that this is a slow-acting fertilizer. Fertilization with various forms of nitrogen and sulphur also caused marked variation in total S content, total N content and N-NO_3 in the plants. Total sulphur content – depending on the experimental object and on the time of harvest – ranged from 1.37 to 3.15 g $S \cdot kg^{-1}$, while total nitrogen content ranged from 29.06 to 38.72 g $N \cdot kg^{-1}$. The data obtained indicate that sulphur content in plants that were not fertilized with this nutrient was much lower than is considered optimal for grasses. This explains the effect of sulphur on yield observed in the experiment. Fertilization with sulphur also had a beneficial effect on nitrogen metabolism, manifested as a more than twofold decrease in nitrate nitrogen in the plants fertilized with sulphur.

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Key words: form of sulphur, nitrogen fertilization, sulphur content, nitrogen content, cocksfoot.

PLONOWANIE ORAZ ZAWARTOŚĆ AZOTU I SIARKI W KUPKÓWCE POSPOLITEJ (*DACTYLIS GLOMERATA* L.) NAWOŻONEJ RÓŻNYMI FORMAMI TYCH SKŁADNIKÓW

Abstrakt

W pracy przeanalizowano wpływ nawożenia kupkówki pospolitej różnymi formami azotu i siarki na plonowanie i zawartość tych składników w roślinie. Badania oparto na ścisłym doświadczeniu założonym na materiale glebowym pobranym z warstwy ornej gleby brunatnej o składzie granulometrycznym utworu pyłowego ilastego. Gleba użyta w doświadczeniu charakteryzowała się lekko kwaśnym odczynem oraz niską zawartością przyswajalnych form fosforu, potasu, magnezu i siarki. Wykazano, że czynniki doświadczalne istotnie zróżnicowały plony kupkówki pospolitej. Istotne zróżnicowanie plonów roślin wystąpiło również w efekcie interakcyjnego działania tych czynników. Największe plony roślin uzyskano w serii, w której zastosowano azot w formie płynnej (RSM-30) i siarkę w formie Na_2SO_4. Istotne zwyżki plonów rośliny testowej po zastosowaniu siarki elementarnej odnotowano dopiero przy zbiorze II pokosu, co wyraźnie wskazuje, że jest to nawóz wolno działający. Nawożenie różnymi formami azotu i siarki wpłynęło również widocznie na zróżnicowanie zawartości $S_{og.}$, $N_{og.}$ i $N\text{-}NO_3$ w roślinach. Zawartość siarki ogółem – w zależności od obiektu doświadczalnego i terminu zbioru – wynosiła od 1,37 do 3,15 g $S \cdot kg^{-1}$, a azotu od 29,06 do 38,72 g $N \cdot kg^{-1}$. Stwierdzono, że zawartość siarki w roślinach nie nawożonych tym składnikiem była wyraźnie niższa od wartości przyjętych za optymalne dla traw. Wyjaśnia to plonotwórcze działanie siarki w przeprowadzonym eksperymencie. Nawożenie siarką wywarło również korzystny wpływ na metabolizm azotu. Przejawił się on ponad dwukrotnym obniżeniem zawartości azotu azotanowego w roślinach nawożonych siarką.

Słowa kluczowe: forma siarki, nawożenie azotem, zawartość siarki, zawartość azotu, kupkówka pospolita.

INTRODUCTION

In recent years, there has been a deficiency of sulphur for plants in most countries of the world (KACZOR, KOZŁOWSKA 2000, SCHERER 2001). Alongside plants with high sulphur requirements, grains and grasses belonging to species with lower requirements also show increased yields in response to fertilization with sulphur (MCGRATH et al. 1996, SCHERER 2001).

The effectiveness of fertilizing crops with sulphur depends to a great extent on their nitrogen supply. It is so because proper proportions of nitrogen and sulphur determine metabolism of these nutrients and thus the quality of the yield (MESSICK, FAN 1999, KACZOR, BRODOWSKA 2005).

The aim of this study was to analyze the effect of fertilization with various forms of sulphur and nitrogen on yield and on the content of these nutrients in cocksfoot.

MATERIALS AND METHODS

The study was based on results obtained in a strict pot experiment with a completely randomized design conducted on soil material taken from the arable layer of brown soil of clayey silt granulometric composition. Before the experiment, the soil was characterized by slight acidity and low content of assimilable forms phosphorus, potassium, magnesium and sulphur. The experiment had two variables: the form of nitrogen fertilization and the form of sulphur fertilization. Two nitrogen fertilizers were used – UAN 30 (urea ammonium nitrate solution) and NH_4NO_3 (in granular form), and three forms of sulphur – $Na_2S_2O_3$, elemental S and Na_2SO_4. Both test plants were fertilized with sulphur in the amount of 0.025 g $S \cdot kg^{-1}$ soil and nitrogen in the amount of 0.14 g $N \cdot kg^{-1}$ soil according to the scheme presented in Tables 1 and 2. Sulphur in the form of $Na_2S_2O_3$ and Na_2SO_4 was applied in the liquid form, and elemental sulphur in the solid form. Before weighted portions were measured out, the granules were pulverized in an agate mortar.

Table 1

The effect of form of sulphur and nitrogen fertilization on yielding of cocksfoot (g d.m.$\cdot$pot^{-1})

Object	First cut	Second cut
RSM-30	12.35	15.82
RSM-30 + $Na_2S_2O_3$	13.50	18.50
RSM-30 + elemental S	12.83	17.92
RSM-30 + Na_2SO_4	14.20	19.49
NH_4NO_3	11.16	13.05
NH_4NO_3 + $Na_2S_2O_3$	12.11	15.24
NH_4NO_3 + elemental S	11.54	14.91
NH_4NO_3 + Na_2SO_4	13.46	16.28
LSD(p=0.01) form of sulphur (S)	1.38	1.46
Nitrogen fertilizer (N)	0.86	0.91
S × N form of sulphur x nitrogen fertilizer	1.95	2.06

In the first year of the experiment, the test plant was Ismena variety of spring wheat, and in the second year it was Bepro variety of cocksfoot, harvested twice during the vegetation period. The wheat was harvested at the full maturation stage and cocksfoot at the beginning of the heading stage. This paper comprises an analysis of the effect of the experimental factors on yield and on the total content of nitrogen, sulphur and nitrates in dry mass of cocksfoot. After cocksfoot was harvested, total nitrogen content

Table 2

The effect of form sulphur and nitrogen fertilization on the content of sulphur ($g\ S \cdot kg^{-1}$) and nitrogen ($g\ N \cdot kg^{-1}$) in cocksfoot

Object	Total S		Total N		$N\text{-}NO_3$ ($mg\ N \cdot kg^{-1}$)	
	first cut	second cut	first cut	second cut	first cut	second cut
RSM-30	1.95	1.42	30.51	34.25	3246.1	3051.4
RSM-30 + $Na_2S_2O_3$	3.12	2.54	33.22	38.42	926.3	1050.1
RSM-30 + elemental S	2.35	2.65	31.50	36.95	1428.0	1000.2
RSM-30 + Na_2SO_4	3.15	2.70	34.03	38.00	1051.3	911.0
NH_4NO_3	2.06	1.37	29.06	32.60	3851.4	3102.5
NH_4NO_3 + $Na_2S_2O_3$	2.85	2.35	32.51	38.72	925.3	1021.1
NH_4NO_3 + elemental S	2.23	2.32	31.06	36.94	1725.4	1312.0
NH_4NO_3 + Na_2SO_4	2.80	2.42	33.21	37.92	1235.1	1301.1

in average samples was determined by Kiejdahl method and total sulphur content was determined using Butters and Chenery's nephelometric method (1959). Nitrate nitrogen was determined colorimetrically using sodium salicylate (Łoginow, Witaszek 1964).

RESULTS AND DISCUSSION

The yields of the first cut of cocksfoot ranged from 11.16 to 14.20 g dry mass$\cdot$pot^{-1}, depending on the experimental object, and the yields of the second cut ranged from 13.05 to 18.50 g dry mass$\cdot$pot^{-1} (Table 1). The form of sulphur and of nitrogen fertilization caused significant variation in the yields of both cuts. The interaction between the factors was also found to be significant. In general, it can be concluded that higher yields of cocksfoot were obtained in the series where liquid UAN 30 was applied. This held for both analyzed cuts and all the forms of sulphur used in the experiment. With respect to spring wheat, ammonium nitrate in the solid form was found to be a more beneficial source of nitrogen (Kaczor, Brodowska 2005).

Cocksfoot showed increased yield in response to sulphur fertilization. The most beneficial source of this element in both series was found to be sodium sulphate. Where elemental sulphur was used, significant increases in yield did not occur until the second cut. The results clearly demonstrate that sulphur applied in this form is a slow-acting fertilizer (Zhao et al. 1996). They also indicate that even plants with low sulphur requirements, including meadow grasses (Scherer 2001), respond positively to fertilization with this nutrient.

Total sulphur content in the cocksfoot from the first cut ranged from 1.95 to 3.15 g $S \cdot kg^{-1}$, and in the plants from the second cut from 1.37 to 2.70 g $S \cdot kg^{-1}$ (Table 2). A study by RYCHLICKA (1989) demonstrated that the optimal sulphur content in grasses is from 2.0 to 4.0 g $S \cdot kg^{-1}$ dry mass, while less than 1.0 g $S \cdot kg^{-1}$ dry mass indicates a marked deficiency of this nutrient. The data in Table 2 indicate that cocksfoot which was not fertilized with sulphur, especially when harvested in the second cut, was characterized by deficiency of this element. This explains the increase in yield after application of sulphur fertilizers.

Total nitrogen content in the plants ranged from 29.06 to 38.72 g $N \cdot kg^{-1}$ depending on the object and the time of harvest (Table 2). The values were at the level most often observed in meadow grasses (WIŚNIOWSKA-KIELIAN, LIPIŃSKI 2007). The experimental factors, particularly sulphur fertilization, caused marked differences in nitrate content in the plants (Table 2). The highest content of this form of nitrogen was found in cocksfoot that was not fertilized with sulphur, where the nitrate content ranged from 3051.4 to 3851.4 mg $N \cdot kg^{-1}$, while in the series fertilized with sulphur it ranged from 911.0 to 1725.4 mg $N \cdot kg^{-1}$. These values confirm that fertilizing plants with sulphur has a beneficial effect on nitrogen metabolism (MESSICK, FAN 1999), which was manifested in this study as lower nitrate content in cocksfoot. It should be added that the nitrate content in dry mass of cocksfoot in all of the experimental objects was within the range of values considered low and optimal with respect to evaluation of grassland swards for use as fodder (WIŚNIOWSKA-KIELIAN, LIPIŃSKI 2007).

CONCLUSIONS

1. The highest yields of cocksfoot were obtained in the series fertilized with nitrogen in the form of UAN 30 and sulphur in the form of sodium sulphate.

2. A significant increase in cocksfoot yield as a result of elemental sulphur application was not observed until the second cut.

3. Fertilization of cocksfoot with sulphur increased the content of this nutrient in the plants to a level considered optimal.

4. Fertilization with sulphur had a beneficial effect on nitrogen metabolism in the plants, causing a more than twofold decrease in nitrate content in cocksfoot.

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