

# **CONTENT OF MACROELEMENTS IN PLANTS GROWING ON FALLOW FIELDS**

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## Abstract

A large area trial involving four methods of soil fallowing (goat's rue, traditional fallow, goat's rue + brome grass, brome grass) was established in the spring 1996. This paper contains the results of our investigations concerning the content of macroelements in plants in the years 2000–2004. The weakest accumulation of nitrogen, potassium and magnesium by mono- and dicotyledonous plants occurred in the traditional fallow field; slightly richer concentration of the macroelements was determined in plants growing on the object sown with brome grass. Goat's rue, both in a monoculture and mixed with brome grass, stimulated plants to accumulate more nitrogen, phosphorus, potassium and magnesium. Using goat's rue to raise the content of macroelements in plants can prevent transfer of those elements to lower soil layers.

**Key words:** traditional fallowing, goat's rue, brome grass, macroelements.

## **ZAWARTOŚĆ MAKROELEMENTÓW W ROŚLINNOŚCI Z PÓL ODŁOGOWANYCH**

### Abstrakt

Doświadczenie łanowe obejmujące cztery sposoby odłogowania gleby (rutwica wschodnia, odłóg klasyczny, rutwica wschodnia + stokłosa bezostna i stokłosa bezostna) założono wiosną 1996 roku. W pracy ujęto wyniki dotyczące zawartości makroelementów w roślinach w latach 2000–2004. Najslabsze możliwości akumulacji azotu, potasu i magnezu w roślinności jedno- i dwuliściennej wystąpiły na odłogu klasycznym, tylko nieco „bogatszą” koncentracją charakteryzowały się rośliny z obiektu obsianego stokłosą bezostną. Rutwica wschodnia rosnąca w monokulturze lub w mieszance ze stokłosą bezostną sprzyjała większemu nagromadzeniu w roślinach towarzyszących azotu, fosforu, potasu i magnezu. Rutwica wschodnią poprzez zwiększanie zawartości makroelementów w roślinach może zapobiegać ich przemieszczaniu do niższych warstw gleby.

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Słowa kluczowe: odłóg klasyczny, rutwica wschodnia, stokłosa bezostna, zawartość makroelementów w roślinach.

## INTRODUCTION

Soil fallowing should be performed in such a way as to be able to restore the productive function of the soil. Soils which are to be set at rest should be the weakest ones and while resting they should be maintained under plant cover. It is therefore necessary to test suitability of both native and foreign species of grass for this purpose. Such studies in Poland are not common. There are more reports on chemical modifications in uncultivated soils but papers on chemism of plants growing on idle lands are rare (ROLA 1995, DZIENIA et al. 1997, KOŚCIK, KALITA 2000, ŁĘTOWSKA, STRĄCZYŃSKA 2001). Preventing unfavourable changes from occurring in fallow soils is essential and growing grasses or mixtures of grasses and papilionaceous plants seems to be a good solution (MARKS et al. 1999). Fallow fields sown with grass are better at protecting soils from loss of available macroelements. Besides, the elements taken up by plants can return to the soil via mineralization of organic matter left on fields (WOJNOWSKA et al. 2003). The relevant references, however, lack detailed reports on the fertilization value of plants used to protect fallow fields. One of the factors in favour of growing specific species of plants on uncultivated arable land is the concentration of macroelements in the biomass thus produced (MALICKI, PODSTAWKA-CHMIELEWSKA 1998).

The objective of this paper has been to trace the concentration of macroelements in the biomass of plants covering fallow land on soil excluded from agricultural use.

## MATERIAL AND METHODS

A large area trials was established in the spring 1996 on soil which was classified as good wheat complex class III a in the Polish soil classification system. The trial was set up in the village Knopin (the commune of Dobre Miasto, the Province of Warmia and Mazury) on a privately-owned farm. This paper presents results obtained in the years 2000-2004. The field set aside for the experiment was used to create four types of fallow land:

- 1) goat's rue (*Galega orientalis* Lam.),
- 2) traditional fallow field,
- 3) goat's rue (*Galega orientalis* Lam.) with brome grass (*Bromus inermis*),
- 4) brome grass (*Bromus inermis*).

The trial did not involve any agronomic treatments. Samples of plants for chemical analyses were taken from the plant covered objects and the whole biomass was left on the field. Plant samples were collected once every year at the same plant growth and development stage, i.e. in the early flowering stage of goat's rue when the plants had obtained the maximum weight (4 x 1 m<sup>2</sup> from each object). The plant material was separated into mono- and dicotyledonous plants. Concentration of macroelements in the plant material (following wet mineralization in H<sub>2</sub>SO<sub>4</sub>) was determined with the following methods – nitrogen by Kjeldahl method, phosphorus by the vanadium-molybdenum method, potassium and calcium by the ESA and magnesium by the ASA.

## RESULTS AND DISCUSSION

Goat's rue grown in a mixture or as a monoculture accumulated comparable amounts of nitrogen (Tab. 1). In the research carried out by SIENKIEWICZ et al. (2005), the N content in green mass of goat's rue was on a somewhat higher level (from 33.87 to 41.23 g·kg<sup>-1</sup> d.m.). Among the dicotyledonous plants, the lowest nitrogen concentration was found in the plants growing on a traditional fallow field. The same tendency was determined for monocotyledonous plants, for example brome grass grown in a monoculture contained nearly 40% more nitrogen than monocotyledonous plants from the traditional fallow land. On the other hand, brome grass grown

Table 1  
Tabela 1

Content of N in plants (g·kg<sup>-1</sup> of d.m.)  
Zawartość N w roślinach (g·kg<sup>-1</sup> s.m.)

Type of plants Rodzaj roślinności	Objects – Objekty				Mean Średnio
	goat's rue rutwica wschodnia	goat's rue + brome grass rutwica wschodnia + stokłosa	brome grass stokłosa bezostna	traditional fallow odłóg klasyczny	
Dicotyledons Rośliny dwuliścienne	33.86	33.59	21.18	16.36	26.25
Monocotyledons Rośliny jednoliścienne	25.36	20.71	19.29	14.92	20.07
Mean	29.61	27.15	20.23	15.64	

LSD<sub>0.05</sub> for type of plant NIR<sub>0.05</sub> – dla rodzaju roślinności – 0.84

LSD<sub>0.05</sub> for treatments NIR<sub>0.05</sub> – dla obiektów – 1.19

LSD<sub>0.05</sub> for interaction NIR<sub>0.05</sub> – dla współdziałania – 1.68

in a mixture with goat's rue accumulated significantly more nitrogen compared to the same plant species grown in a monoculture. This proves that the plant grew under different conditions. The admixture of goat's rue and its decomposing organic matter created an additional source of nitrogen; this contributed to the accumulation of nitrogen in brome grass on a level similar to its content cited by NOWAK, DRASZAWKA-BOLZAN (2003) for darnel fertilized with multi-component fertilizers.

The highest concentration of phosphorus ( $4.17 \text{ g}\cdot\text{kg}^{-1}\text{d.m.}$ ) was found in goat's rue from the object covered exclusively with this plant (Tab. 2). IGNACZAK (1995) reported slightly lower concentrations of P (between 3.10

Table 2  
Tabela 2

Content of P in plants ( $\text{g}\cdot\text{kg}^{-1}$  of d.m.)  
Zawartość P w roślinach ( $\text{g}\cdot\text{kg}^{-1}$  s.m.)

Type of plants Rodzaj roślinności	Objects – Objekty				Mean Średnio
	goat's rue rutwica wschodnia	goat's rue + brome grass rutwica wschodnia + stokłosa	brome grass stokłosa bezostna	traditional fallow odłóg klasyczny	
Dicotyledons Rośliny dwuliścienne	4.17	3.99	2.67	3.10	3.48
Monocotyledons Rośliny jednoliścienne	3.98	3.01	2.45	2.52	2.99
Mean	4.08	3.50	2.56	2.81	

LSD<sub>0.05</sub> for type of plant NIR<sub>0.05</sub> – dla rodzaju roślinności – 0.18

LSD<sub>0.05</sub> for treatments NIR<sub>0.05</sub> – dla obiektów – 0.26

LSD<sub>0.05</sub> for interaction NIR<sub>0.05</sub> – dla współdziałania – 0.37

and  $3.40 \text{ g}\cdot\text{kg}^{-1}$  d.m.). Significantly less P was determined in goat's rue grown with brome grass. This may have been caused by the grass competing with other plants. The lowest quantities of phosphorus in dicotyledonous plants occurred in the brome grass object ( $2.67 \text{ g}\cdot\text{kg}^{-1}$  d.m.). Analogously to nitrogen, the highest concentration of phosphorus in monocotyledonous plants was found in the field sown with goat's rue. This leads to a conclusion that the presence of this papilionaceous plant stimulated the uptake of phosphorus by brome grass up to the level observed in many fertilized grass species (KOCHANOWSKA, NOWAK 1992).

As regards dicotyledons, significantly highest amounts of potassium were determined in the object sown with brome grass (Tab. 3). The content of K in green mass of goat's rue from a monoculture did not exceed the figures cited by NÓMMSALU (1994), which ranged from 36 to 42 kg

Table 3  
Tabela 3Content of K in plants ( $g \cdot kg^{-1}$  of d.m.)  
Zawartość K w roślinach ( $g \cdot kg^{-1}$  s.m.)

Type of plants Rodzaj roślinności	Objects – Objekty				Mean Średnio
	goat's rue rutwica wschodnia	goat's rue + brome grass rutwica wschodnia + stokłosa	brome grass stokłosa bezostna	traditional fallow odłóg klasyczny	
Dicotyledons Rośliny dwuliścienne	32.29	34.86	37.98	34.52	34.91
Monocotyledons Rośliny jednoliścienne	30.08	29.91	23.55	26.60	28.04
Mean	31.19	32.38	30.77	31.56	

LSD<sub>0.05</sub> for type of plant NIR<sub>0.05</sub> – dla rodzaju roślinności – 1.68LSD<sub>0.05</sub> for treatments NIR<sub>0.05</sub> – dla obiektów – n.s. - n.i.LSD<sub>0.05</sub> for interaction NIR<sub>0.05</sub> – dla współdziałania – 3.37

$K \cdot kg^{-1}$  d.m., but were evidently higher than those reported by SYMANOWICZ and KALEMBASA (2005). Among monocotyledons, the concentration of potassium was more varied between particular groups of plants. Goat's rue growing with brome grass contributed to a 27% increase in the concentration of potassium in the grass. The study carried out by JELINKOWSKA (1994) revealed a similar response of brome grass to being sown with papilionaceous plants.

The concentration of magnesium in dicotyledons was clearly higher than that in monocotyledons (Tab. 4). Among the dicotyledonous species of plants, goat's rue, both in a monoculture and grown together with brome grass, was characterised by significantly higher accumulation of magnesium compared to the other dicotyledonous plants growing on the object sown with brome grass or on the traditional fallow field. The results we obtained were nearly two-fold higher than the amount of magnesium determined by IGNACZAK (1995) in goat's rue on fallow land. In the monocotyledons from the object sown with goat's rue, the concentration of magnesium was over two-fold higher than in the biomass collected from the traditional fallow object. Brome grass sown together with goat's rue accumulated on average 15% more magnesium than brome grass collected from the monoculture.

In general, dicotyledons contain more calcium than monocotyledons, the fact that our own research confirmed (Tab. 5). The highest level of calcium was observed in dicotyledonous plants growing on the object covered with brome grass. Nearly 1/3 less calcium was determined in dico-

Table 4  
Tabela 4Content of Mg in plants ( $\text{g} \cdot \text{kg}^{-1}$  of d.m.)  
Zawartość Mg w roślinach ( $\text{g} \cdot \text{kg}^{-1}$  s.m.)

Type of plants Rodzaj roślinności	Objects – Objekty				Mean Średnio
	goat's rue rutwica wschodnia	goat's rue + brome grass rutwica wschodnia + stokłosa	brome grass stokłosa bezostna	traditional fallow odłóg klasyczny	
Dicotyledons Rośliny dwuliścienne	2.03	2.05	1.78	1.92	1.94
Monocotyledons Rośliny jednoliścienne	1.17	0.75	0.65	0.54	0.78
Mean	1.60	1.40	1.21	1.23	

LSD<sub>0.05</sub> for type of plant NIR<sub>0.05</sub> – dla rodzaju roślinności – 0.06LSD<sub>0.05</sub> for treatments NIR<sub>0.05</sub> – dla obiektów – 0.08LSD<sub>0.05</sub> for interaction NIR<sub>0.05</sub> – dla współdziałania – 0.12Table 5  
Tabela 5Content of Ca in plants ( $\text{g} \cdot \text{kg}^{-1}$  of d.m.)  
Zawartość Ca w roślinach ( $\text{g} \cdot \text{kg}^{-1}$  s.m.)

Type of plants Rodzaj roślinności	Objects – Objekty				Mean Średnio
	goat's rue rutwica wschodnia	goat's rue + brome grass rutwica wschodnia + stokłosa	brome grass stokłosa bezostna	traditional fallow odłóg klasyczny	
Dicotyledons Rośliny dwuliścienne	11.79	12.67	21.54	14.45	15.11
Monocotyledons Rośliny jednoliścienne	3.59	3.61	2.54	3.73	3.37
Mean	7.69	8.14	12.04	9.09	

LSD<sub>0.05</sub> for type of plant NIR<sub>0.05</sub> – dla rodzaju roślinności – 0.38LSD<sub>0.05</sub> for treatments NIR<sub>0.05</sub> – dla obiektów – 0.54LSD<sub>0.05</sub> for interaction NIR<sub>0.05</sub> – dla współdziałania – 0.76

tyledonous plants sampled from the traditional fallow object. High concentration of this macroelement in dicotyledonous weeds has also been reported by STUPNICKA-RODZYNKIEWICZ et al. (1996).

Significantly less calcium than in dicotyledons growing on traditional fallow land was observed in goat's rue. Goat's rue separated from the mixture with brome grass accumulated nearly 8% more calcium than the

same plant species growing separately from brome grass (with only a small number of accompanying weeds). Goat's rue had even a stronger effect on the content of calcium in brome grass.

Much more sodium was found in dicotyledons (Tab. 6). The highest significant amount of sodium was determined in the dicotyledonous lants growing on the object covered with brome grass. Slightly lower quantities of this macroelement were determined in plants from the traditional fallow object. Goat's rue from the mixture with brome grass contained on average 26% more sodium compared to the plants from the field sown with goat's rue alone. Similar results were reported by BOBRECKA-JAMRO and SZPUNAR-KROK (1999), who tested a mixture of goat's rue and timothy grass. Among the monocotyledonous species, significantly higher N accumulation was noticed in the plants from the object sown with goat's rue and the plants from the traditional fallow.

Table 6  
Tabela 6

Content of Na in plants ( $\text{g} \cdot \text{kg}^{-1}$  of d.m.)  
Zawartość Na w roślinach ( $\text{g} \cdot \text{kg}^{-1}$  s.m.)

Type of plants Rodzaj roślinności	Objects – Objekty				Mean Średnio
	goat's rue rutwica wschodnia	goat's rue + brome grass rutwica wschodnia + stokłosa	brome grass stokłosa bezostna	traditional fallow odłóg klasyczny	
Dicotyledons Rośliny dwuliścienne	0.24	0.29	0.45	0.38	0.34
Monocotyledons Rośliny jednoliścienne	0.21	0.18	0.17	0.21	0.19
Mean	0.22	0.24	0.31	0.29	

LSD<sub>0.05</sub> for type of plant NIR<sub>0.05</sub> – dla rodzaju roślinności i – 0.02

LSD<sub>0.05</sub> for treatments NIR<sub>0.05</sub> – dla obiektów – 0.03

LSD<sub>0.05</sub> for interaction NIR<sub>0.05</sub> – dla współdziałania – 0.04

## CONCLUSIONS

1. The weakest capacity to accumulate nitrogen, potassium and magnesium was demonstrated by mono- and dicotyledonous plants from the traditional fallow object, whereas the plants growing on the brome grass object showed the lowest accumulation of phosphorus and magnesium.

2. Goat's rue growing in a monoculture or in combination with brome grass favoured more intense accumulation of nitrogen, phosphorus, potassium and magnesium in the accompanying plants.

3. Owing to the elevated concentration of basic macroelements in plants from the objects sown with goat's rue, smaller amounts of those macroelements were involved in the circulation of nutrients, which meant that their transfer to lower soil layers was partially prevented.

4. Goat's rue can be recommended for sowing on soils temporarily excluded from agricultural production.

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