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MACROELEMENT CONTENT IN PASTURE SWARD UNDERSOWN WITH PERENNIAL RYEGRASS IRRADIATED WITH DIODE AND LASER. PART 1

ZAWARTOŚĆ MAKROELEMENTÓW W RUNI PASTWISKOWEJ PODSIEWANEJ ŻYCICĄ TRWAŁĄ NAŚWIETLANĄ DIODĄ I LASEREM. CZĘŚĆ I

Summary: Studies were conducted in 2003–2005 in the area of two agricultural farms: in Skrzeszowice near Krakow (220 m a.s.l.) and in Trzebunia near Pcim (450 m a.s.l.).The experiments were set up on permanent grasslands managed by undersowing with perennial ryegrass. The experiment was used for hay production and grazed five times by dairy cattle during the vegetation period. It comprised the following variants: control, $P_{20}K_{66}$, $N_{120}P_{20}K_{66}$ with and without irradiation of diode and laser. The experiment aimed to determine the effect of diode and laser irradiation of perennial ryegrass sowing material on the content of nutrients in the sward of lowland and mountain pasture under the influence of variable nitrogen fertilization.

Meadow sward of all experimental variants situated in the lowland (I) generally contained higher concentrations of nitrogen, calcium and magnesium than the sward of the pasture situated in the mountains (II). A reverse content was observed for phosphorus and sodium in the sward of most treatments but only in the plants undersown with the irradiated material. The lowest amounts of the analyzed constituents were determined in the control sward and the highest in plants from $N_{120}P_{20}K_{66}$ treatments.

Keywords: macrolements, pasture sward, undersown plants, perennial ryegrass, irradiation, diode, laser

One of the methods of improving the sowing material is its irradiation with various kinds of light which supply energy for modification of physiological and biochemical processes causing among others an increase in yields [1, 2]. Recently growing attention has been paid to physical factors which might be used for sowing material treatment [3]. Due to the specific character of this objective, laser light is useful for it [4]. Hitherto results of pre-sowing seed stimulation with light primarily applied to annual plants which were irradiated by a divergent laser bunch [5, 6] and the cotyledons, mainly alfalfa and

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hybrid alfalfa [7]. However, there is no adequate information about laser light and diode irradiated grass plants, especially utilized for hay production, frequently grazed and producing relatively large yields of dry matter and nutrients. The content of basic nutrients, whose concentrations in the obtained large dry matter yield decreases, is also significant. In such a situation a deficit in relation to animal nutritional needs appears. It is common knowledge that phosphorus and magnesium deficiency along with excessive amounts of potassium in relation to animal nutritional needs are often encountered in grass plants [8].

The presented investigations were conducted to determine the effect of stimulation by diode and laser light of perennial ryegrass seeds used for pasture undersowing on the content of nutrients during three years of lowland and mountain sward utilization.

Materials and methods

The analyses were conducted in 2003–2005 in the area of two agricultural farms. The first one (I) was located in Skrzeszowice near Krakow (220 m a.s.l.) and the second (II) in Trzebunia in the Pcim community in the Średni Beskid Mts. (450 m a.sl.).

The experiments were set up on permanent grasslands, which were managed by a semi-radical method (of undersowing), *ie* the old turf was destroyed in 50–60 % by cultivator prior to new seed sowing and then perennial ryegrass seeds, Solen c.v. were sown at the dose of 15 kg · ha^{-1}. Before sowing the sowing material was irradiated by red laser light of wavelength $\lambda = 532$ nm and power of 5 mW and with green light (diode) with wavelength $\lambda = 660$ nm and power of 21.9 nW for 30 seconds. Irradiation of husked kernels was conducted at the Chair of Environmental Biotechnology and Ecology at the Faculty of Mining Surveying and Environmental Engineering, University of Science and Technology AGH in Krakow.

The experiments were conducted in randomized block design in four replications and each plot surface was 12 m^2.

The experimental plots in the first holding were located on degraded chernozem developed from loess. The soil revealed the following chemical properties: pH_{KCl} – 5.03 and available content of P – 20.3; K – 94.5 and Mg – 68.1 mg · 100 g^{-1} of soil. Moreover were assessed N-organic 2.9 g and total carbon 15.8 · kg^{-1} of soil. In the second farm the experimental plots were located on acid brown soil with the following chemical properties: pH_{KCl} – 4.74 and available content of P – 11.6; K – 83.2 and Mg – 41.4 · 100 g^{-1} of soil. Determined were also N-organic – 2.1 and total carbon – 14.4 g · kg^{-1} of soil. The following methods were used for chemical assessments of soil: the potentiometric method to asses pH in 1 mol · dm^{-3}, the Tiurin method modified by Oleksynowa for the total carbon and the Kjeldahl method using the Kjeltec apparatus for the total nitrogen determination, the Egner-Riehm colorimetric method for available phosphorus and the Egner-Riehm method using flame photometry for available potassium assessment and finally for available magnesium determining atomic absorption spectrometry AAS after extraction with 0.0125 mol $CaCl_2$ · dm^{-3}.

The experiment comprised the following variants:

– Control – plots without mineral fertilization but grazed;

– $P_{20}K_{66}$, $N_{120}P_{20}K_{66}$ – plots receiving mineral fertilization and grazed;
– Control – plots without mineral fertilization but grazed, diode irradiated sowing material (green light 3 x 30 s);
– $P_{20}K_{66}$, $N_{120}P_{20}K_{66}$ – plots fertilized with mineral materials and grazed, diode irradiated sowing material (green light 3 x 30 s);
– Control – plots without mineral fertilization but grazed, laser irradiated sowing material (red light 3 x 30 s);
– $P_{20}K_{66}$, $N_{120}P_{20}K_{66}$ – plots receiving mineral fertilization and grazed, laser irradiated sowing material (red light 3 x 30 s).

Phosphorus in the amount of 20 kg P · ha^{-1} as triple superphosphate (40 % P_2O_5) was applied once in spring. Potassium was applied in the amount of 66 kg K · ha^{-1} as high percent potassium salt (60 % K_2O) was applied twice in equal doses under the first and third regrowth. Nitrogen fertilization was applied in doses of 80 and 120 kg N · ha^{-1}, in five equal parts under each regrowth as ammonium nitrate (34 % N).

The experiment was used for hay production and grazed by dairy cattle five times during the vegetation period, at the sward pasture maturity, *ie* at grass height about 20 cm.

Chemical analysis of the material was conducted for average samples using atomic absorption spectrometry AAS after dry mineralization in a muffle furnace at 450 °C [9].

The mean annual precipitation total for the period of experiment 2003–2005 in the Ist region fluctuated from 452 to 791 mm, while in the IInd region from 1247 to 1382. Precipitation total during the vegetation period (April–September) ranged between 287–573 mm (Ist region) and 659–920 (IInd region). The mean annual temperature reached values of 6.6–8.5 °C (Ist region) and 5.2–6.7 °C (IInd region) whereas during the vegetation period: 12.7–13.8 °C (I) and 12.1–13.2 °C (II).

The value of standard deviation (Sd) and the variability coefficient (V) were computed for element concentrations in the pasture sward.

The paper gives results for the period of three years of use.

Results and discussion

Mean weighed content of macroelements in the pasture sward of the experiment located in the lowland area fluctuated from 19.3 to 23.4 g N; 2.19–2.38 g P; 20.6–28.3 g K; 3.27–4.06 g Ca; 2.16–2.51 g Mg; 1.19–1.28 g Na · kg^{-1} d.m., while in the sward of the experiment localised in the mountains it ranged as follows: 19.3–20.7 g N; 2.24–2.46 g P; 22.4–28.9 g K; 3.29–3.75 g Ca; 2.13–2.39 g Mg and 1.19–1.27 g Na · kg^{-1} d.m. (Table 1). From among the studied elements the highest content diversification was computed for potassium in the sward of experiment I (V = 11.6 %) and the lowest for nitrogen and sodium in the sward of experiment II (V = 2.1 %). Generally, the lowest quantities of the analyzed components were found in control swards. The highest macroelement concentrations were detected in the sward of most $N_{120}P_{20}K_{66}$ treatments. Usually higher quantities of nitrogen, calcium and magnesium were registered in the sward yield of the lowland experiment than in the sward of the experiment localised in the mountains (II). A reverse dependency was observed in the sward of most treatments for phosphorus

Table 1

Macroelement content in pasture sward [g · kg^{-1} d.m.]

		N		P		K		Ca		Mg		Na	
		I	II	I	II	I	II	I	II	I	II	I	II
Control		20.5	20.2	2.19	2.4	20.6	22.4	3.84	3.75	2.30	2.13	1.19	1.19
$P_{20}K_{66}$		21.5	19.9	2.31	2.26	25.2	23.1	3.80	3.64	2.39	2.29	1.22	1.25
$N_{120}P_{20}K_{66}$		23.4	20.7	2.37	2.25	26.9	23.0	4.06	3.65	2.40	2.25	1.23	1.22
Diode	Control	20.5	20.0	2.26	2.34	21.0	26.0	3.69	3.45	2.25	2.25	1.20	1.27
	$P_{20}K_{66}$	21.4	19.8	2.36	2.42	25.6	25.6	3.58	3.49	2.34	2.30	1.21	1.26
	$N_{120}P_{20}K_{66}$	22.5	20.2	2.38	2.46	28.3	28.9	3.93	3.62	2.51	2.39	1.28	1.24
Laser	Control	19.3	19.5	2.29	2.36	22.0	23.2	3.27	3.29	2.16	2.19	1.20	1.21
	$P_{20}K_{66}$	19.4	19.3	2.33	2.35	24.2	25.1	3.35	3.41	2.19	2.18	1.20	1.21
	$N_{120}P_{20}K_{66}$	20.1	20.0	2.37	2.39	27.6	25.3	3.37	3.38	2.32	2.27	1.28	1.23
Sd		1.38	0.41	0.06	0.08	2.86	2.05	0.28	0.15	0.11	0.08	0.03	0.03
V (%)		6.6	2.1	2.7	3.3	11.6	8.3	7.6	4.3	4.7	3.4	2.8	2.1

I – experiment located in lowland in Skrzeszowice; II – experiment situated in the mountains in Trzebunia

and sodium, but in the plants undersown with irradiated material. On the other hand the lowest content of nitrogen and calcium was assessed in the sward undersown with perennial ryegrass of both experiments and magnesium in the sward of the lowland experiment, where sowing material was laser irradiated. In the opinion of Sebanek et al. [10] and Szyrmer and Klimont [11], who researched the problem of treating sowing material with laser beams, the greatest changes occur in irradiated seeds and asa result in a later period of development lead to faster plant growth and larger crop yields. Therefore, nutrient cumulation in obtained larger dry matter yield should be lower. The conducted research revealed that in the sward of perennial ryegrass undersown with particularly diode irradiated sowing material, quantities of some macroelements: phosphorus, potassium, magnesium or sodium were larger or comparable to the sward undersown with seeds without irradiation.

According to nutrition standards NRC and DLG [12] the contents of macroelements such as nitrogen, potassium, magnesium and sodium were regarded as optimal for animal nutritional needs both in the experiment located in the lowland and in the mountains. The described mountain experiment was located on the formerly potassium deficient soil, therefore it was the most possible reason why no decline in magnesium availability to plants was registered because of antagonistic activity of potassium ions in soil, despite fertilization with this component. According to Choromańska [13] potassium limits magnesium uptake by plants. Among the analyzed constituents only potassium content in the sward was too high. Grasses have a tendency to absorb the excessive amounts of this component [14, 15]. The conducted research did not confirm the antagonistic effect of potassium on sodium uptake by plants [15], despite high concentrations of this element in the sward of all variants. A bigger content of sodium, according to Nowak [16], favourably affects forage value. Also phosphorus and calcium deficien-

cy in relation to animal nutritional needs was registered in the sward of all treatments of both experiments. A lower calcium concentration in the sward of both experiments should be explained by the fact that pasture plants are utilized at their earlier stages of development and this macroelement concentration increases at a later stage of maturation [8].

Conclusions

1. The pasture sward of all variants of the experiment localized in the lowland (I) generally contained larger amounts of nitrogen, calcium and magnesium than the sward of the experiment situated in the mountains (II).

2. On most treatments the mountain sward undersown with irradiated perennial ryegrass sowing material was more abundant in phosphorus and sodium in comparison with the lowland sward.

3. The lowest quantities of the analyzed components were found mostly in the control sward and the highest in plants on $N_{120}P_{20}K_{66}$ plots.

4. Considering the nutrition requirements, the analyzed sward, irrespective of the experiment location and variant used, was characterized by the optimal content of nitrogen, potassium, magnesium and sodium.

5. Phosphorus and calcium deficiency in view of animal nutrition needs was registered in plants of all treatments in both experiments.

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ZAWARTOŚĆ MAKROELEMENTÓW W RUNI PASTWISKOWEJ PODSIEWANEJ ŻYCICĄ TRWAŁĄ NAŚWIETLANĄ DIODĄ I LASEREM. CZĘŚĆ I

S t r e s z c z e n i e

Badania przeprowadzono w latach 2003–2005 na terenie dwóch gospodarstw indywidualnych w Skrzeszowicach koło Krakowa (220 m n.p.m.) oraz w Trzebuni koło Pcimia (450 m n.p.m.). Doświadczenia założono na trwałych użytkach zielonych zagospodarowanych metodą podsiewu życicą trwałą. Doświadczenie użytkowano pastwiskowo, stosując w sezonie wegetacyjnym 5-krotny wypas bydłem mlecznym. W doświadczeniu zastosowano następujące warianty: kontrolę, $P_{20}K_{66}$, $N_{120}P_{20}K_{66}$ bez naświetlania i z naświetlaniem diodą oraz laserem. Celem pracy było określenie wpływu naświetlania materiału siewnego życicy trwałej diodą i laserem na zawartość podstawowych składników pokarmowych w runi pastwiska niżowego i górskiego pod wpływem zmiennego nawożenia azotem.

Runi pastwiskowa wszystkich wariantów doświadczenia usytuowanego na niżu (I) zawierała na ogół większą ilość azotu, wapnia i magnezu niż w runi doświadczenia usytuowanego w górach (II). Zależność odwrotną zaobserwowano w przypadku fosforu i sodu w runi większości obiektów, ale tylko w roślinności podsiewanej materiałem naświetlanym. Najmniejsze ilości analizowanych składników oznaczono w runi kontrolnej, a największe w roślinności obiektów $N_{120}P_{20}K_{66}$.

Słowa kluczowe: makroelementy, ruń pastwiskowa, podsiew, życica trwała, naświetlanie, dioda, laser