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REACTION OF *Dactylis glomerata* L., *Festuca pratensis* Huds. AND *Lolium perenne* L. TO MICROBIOLOGICAL FERTILIZER AND MINERAL FERTILIZATION

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Abstract. Studies with cultivation of *Dactylis glomerata* (cultivar Borna), *Festuca pratensis* (cultivar Ureus) and *Lolium perenne* (cultivar Inka), were carried out in the polyurethane pots, in 4 replications, on the experimental area of Department of Grassland and Green Area Creation. Eight seeds of one of the tested species were sown into each of the pots. After germination of grains, when the seedlings reached the 2-3 leaf stage, negative selection was carried out by removing 4 weakest plants. Then, four experimental factors in the form of the following fertilizer combinations were introduced: control – without fertilization, NPK – mineral fertilization, UG – microbiological fertilizer, UG + NPK – combined rates as for combinations NPK and UG. The experiment was carried out in 2008-2010. Detailed study included the following characteristics: aboveground biomass yield (g DM·pot^{-1}) and leaf greenness index (SPAD). All tested grass species reacted to fertilization applied in the experiment. However, significantly highest yield occurred on the objects with mineral fertilization combined with a microbiological fertilizer (on average 96.97 g DM·pot^{-1}). The largest amount of chlorophyll pigment occurred in plants cultivated on soil with a microbiological fertilizer and with a microbiological fertilizer together with mineral fertilization. The study showed usefulness of a microbiological fertilizer in the cultivation of *Dactylis glomerata, Festuca pratensis* and *Lolium perenne*. However, its highest effectiveness was observed in combination with mineral fertilization.

Key words: aboveground biomass yield, cocksfoot, meadow fescue, microbiological fertilizer, perennial ryegrass, SPAD

INTRODUCTION

In literature, there is emphasis on the role of microorganisms in increasing fertility of arable land, and thus the yield of crop plants [Golinowska and Pytlarz-Kozicka 2008, Sulewska *et al*. 2009, Wojtala-Łozowska and Parylak 2010]. These organisms take part not only in the breakdown of organic matter, in releasing biogenic components required

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by plants for normal development, but they are also responsible for creating correlation systems between abiotic part of soil and higher organisms.

In soils deficient in organic substances there occur oligotrophic microorganisms which grow very slowly, and require minimum amounts of carbon compounds for survival [Badura 2005]. Soil fertility may be improved with the use of fertilizer UGmax, which composts and humifies post-harvest residue, manure, organic fertilizers and along with soil minerals forms humus [Sulewska *et al*. 2009]. It also supports the development of the root system of plants, increasing their resistance and health. Preparation, based mainly on microorganisms [Trawczyński 2006], caused the yield increase in mixtures of *Festulolium braunii* with alfalfa and red clover [Sosnowski and Jankowski 2010] and maize cultivated for grain and silage [Sulewska *et al*. 2009].

The aim of the research was determination of the effect of microbiological fertilizer UGmax, which was applied after mineral fertilization, on the yield and leaf greenness index of *Dactylis glomerata* L., *Festuca pratensis* Huds. and *Lolium perenne* L.

MATERIAL AND METHODS

Research on the cultivation of cocksfoot (cultivar Borna), meadow fescue (cultivar Ureus) and perennial ryegrass (cultivar Inka) were carried out in pots in 4 replications, in the Department of Grassland and Green Area Creation of Siedlce University of Natural Sciences and Humanities (52°17’ N; 22°28’ E). Pots of the diameter 36 cm and height 40 cm were dug into a depth of 30 cm and were filled with soil material belonging to the type of soils changed by intensive cultivation, hortisole, formed from loamy sand (Table 1).

Table 1. Chemical and granulometric composition of soil as a subsoil in the experiment
Tabela 1. Skład chemiczny i granulometryczny materiału glebowego stanowiącego podłoże pod doświadczenie

pH	Content of assimilable components, mg·100g^{-1} of soil Zawartość składników przyswajalnych, mg·100g^{-1} gleby			Content – Zawartość %		Content, mg·kg^{-1} DM Zawartość, mg·kg^{-1} s.m.		
in – w KCl	P	K	Mg	N-total N-ogólny	humus próchnica	$N\text{-}NO_3$		$N\text{-}NH_4$
6.99	39.2	15.8	8.4	0.18	3.78	10.10		7.47
Percentage of earth fractions (diameter in mm) – Procentowy udział frakcji ziemistych (średnica w mm)								
1-0.1	0.1-0.05	0.05-0.02	0.02-0.06	0.06-0.002	<0.002	sum of fractions suma frakcji 0.1-0.02	sum of fractions suma frakcji <0.02	granulometric group grupa granulo-metryczna
76	9	5	4	4	2	14	10	psg

On the basis of chemical analysis carried out at the Regional Chemical Station in Wesoła, it was found that the soil in pots was characterized by a neutral reaction, medium-high humus level, very high phosphorus content, high magnesium content and average content of assimilable forms of potassium, total nitrogen, nitrate nitrogen and ammonium nitrogen compared with the standards given by Kowaliński and Gonet [1999] and Grzebisz [2009].

On 8 April 2007, 8 seeds of one of the studied species were sown into each pot. After grain germination, when the seedlings reached the stage of 2-3 leaves, negative selection was conducted of removing 4 weakest plants, and some experimental factors were introduced in the form of the following fertilizer combinations:

- control – without fertilization,
- NPK – mineral fertilization at annual rates of 0.6 g N·pot^{-1}, 0.11 g P·pot^{-1} and 0.77 g K·pot^{-1},
- UG – microbiological fertilizer in the form of 0.25% solution and a rate of 3.7 cm^3·pot^{-1},
- UG + NPK – combined rates as in combination NPK and UG.

Nitrogen fertilization (in the form of 34% ammonium saltpeter) and potassium fertilization (in the form of 60% potassium salt) in combinations NPK and UG + NPK were applied in three divided rates, however phosphorus fertilization (in the form of 46% triple superphosphate) – in a single rate sown in early spring. On the other hand, solution of fertilizer UGmax (trade name) was used in a single application at the stage of shooting. Composition of the fertilizer is given in Table 2.

Table 2. Composition of the microbiological fertilizer used in the experiment
Tabela 2. Skład użyźniacza glebowego użytego w doświadczeniu

Content of macro- and microelements, mg·dm^{-3} Zawartość makro- i mikroelementów, mg·dm^{-3}						Microorganisms – Mikroorganizmy
N	P_2O_5	P_2O_5	Mg	Na	Mn	
1200	500	3500	100	200	0.3	Lactic acid bacteria, photosynthetic bacteria, *Azotobacter*, *Pseudomonas*, yeast, Actinobacteria bakterie kwasu mlekowego, bakterie fotosyntetyczne, *Azotobacter*, *Pseudomonas*, drożdże, promieniowce

The period of three-harvest utilization was in the years 2008-2010. At that time the following features were subjected to evaluation:

- yield of the aboveground biomass (g DM·pot^{-1}),
- leaf greenness index (SPAD).

Measurement of leaf greenness index was carried out on every plant in each pot, on 10 randomly chosen laminae (in 10 replications) at the stage of ear development in grass. Chlorophyll meter SPAD-502 Spektrum Technologies was used for this purpose. Obtained results were subjected to statistical evaluation (Statistica 6.0 – 2001), using analysis of variance for multifactorial experiments. Variation in the means was verified with Tukey test with the significance level $P \leq 0.05$.

Meteorological data from the years of research was obtained from the Hydrological and Meteorological Station in Siedlce. In order to determine the time and space variation of meteorological components and their effect on the process of plant growing, Sielianinow's index was calculated [Bac *et al*. 1993], whose values for particular months and years of research are presented in Table 3. The most beneficial distribution and amount of rainfall with optimum air temperatures occurring in the growing period of the plants, was characteristic of 2009, in which there occurred no dry months. Months with strong and weak drought were observed in other years of the experiment.

Table 3. Value of Sielianinow's hydrothermal index in individual months of the growing period and years of study
Tabela 3. Wartość współczynnika hydrotermiczny Sielianinowa w poszczególnych miesiącach okresu wegetacyjnego i latach użytkowania

Year Rok	Month – Miesiąc						
	April Kwiecień	May Maj	June czerwiec	July lipiec	August sierpień	September wrzesień	October październik
2008	0.82	1.34	1.08	1.23	0.54	0.69	1.72
2009	1.03	2.24	1.03	1.26	1.36	1.01	1.73
2010	0.40	2.21	1.19	1.18	1.79	2.81	0.53

K < 0.5 – high drought – silna posucha, 0.51-0.69 – drought – posucha, 0.70-0.99 – weak drought – słaba posucha, K >1 – no drought – brak posuchy

RESULTS AND DISCUSSION

All studied species reacted on average with an app. 25% yield increase both to mineral fertilization and to the microbiological fertilizer (Table 4). Conducted statistical analysis proved, however, that independently of the species and the year of research, the significantly highest yield of dry matter was observed in pots with mineral fertilization and additionally supplied with a microbiological fertilizer (on average 96.97 g DM·pot^{-1}). Positive effects of the combination of a fertilizer with mineral fertilization are also confirmed by the research of Sosnowski and Jankowski [2010] in cultivation of *Festulolium braunii* with red clover and alfalfa. According to the authors, addition of biopreparation caused on average 24% yield increase in all analyzed mixtures compared with the control (crops with only mineral fertilization), while reducing their weed infestation.

Yields obtained from pots supplied only with a fertilizer or with mineral fertilization did not differ significantly between each other. The highest yield (on average app. 90 g DM·pot^{-1}) in the whole period of the experiment was characteristic of meadow fescue and cocksfoot. Because of the most beneficial weather conditions connected with the lack of droughts in the second year of experiment (Table 2), all analyzed species created the highest amount of biomass in that period.

In literature there can be found research in which fertilizer UGmax was the one most frequently used for soil supplementation under cereal cultivation [Sulewska *et al*. 2009, Wojtala-Łozowska and Parylak 2010] and root crops [Golinowska and Pytlarz-Kozicka 2008]. However, there is lack of studies concerning application of this preparation in cultivation of one-species forage grasses.

The research of Sulewska *et al*. [2009] proved that application of fertilizer UGmax in the cultivation of maize, with a large amount of post-harvest residues left on the field, resulted in a significant yield increase (on average by 9.4% compared with the control). Moreover, application of microbiological preparation in winter crops favourably affects the increase in biometrical parameters, especially in wheat at the stage of tillering [Klama *et al*. 2010]. In the research it was proved that the applied microbiological fertilizer did not improve plants' resistance to stem-base diseases [Wojtala-Łozowska and Parylak 2010].

Table 4. Yield of the aboveground mass of grasses depending on the used fertilization and study years (total from mowings), g DM·pot^{-1}
Tabela 4. Plon masy nadziemnej traw w zależności od nawożenia-użyźniania gleby i roku badań (suma z pokosów), g s.m.·$wazon^{-1}$

Species Gatunek	Fertilization Nawożenie	Year of study – Rok badań			Mean Średnia
		2008	2009	2010	
Dactylis glomerata	control – kontrola	70.28	77.80	72.09	73.39
	NPK	80.03	103.73	97.56	93.77
	UG	79.43	98.80	101.07	93.10
	UG + NPK	95.00	105.38	99.92	100.10
Festuca pratensis	control – kontrola	69.96	72.45	69.55	70.65
	NPK	93.86	97.65	94.23	95.21
	UG	93.10	97.65	91.71	94.15
	UG + NPK	100.10	105.05	96.64	100.59
Lolium perenne	control – kontrola	60.72	63.45	61.52	61.89
	NPK	81.84	85.93	82.92	83.56
	UG	81.04	85.46	80.52	82.34
	UG + NPK	88.08	92.93	89.67	90.22
Mean for species – Średnia dla gatunku					
Dactylis glomerata		81.18	96.42	92.66	90.08
Festuca pratensis		89.25	93.20	88.03	90.16
Lolium perenne		77.92	81.94	78.65	79.50
Mean for fertilization – Średnia dla nawożenia					
Control – Kontrola		66.98	71.23	67.76	68.65
NPK		85.24	95.77	91.57	90.86
UG		84.52	93.97	91.10	89.86
UG + NPK		94.39	101.12	95.41	96.97
Mean – Średnia		82.78	90.52	86.46	86.58

$LSD_{0.05}$ – $NIR_{0,05}$ for – dla:

study year – roku badań (A)	3.62
fertilization – nawożenia/użyźniania (B)	6.09
species – gatunku (C)	10.56
interaction – współdziałania:	
A x B	9.18
A x C	6.05
B x C	6.45
A x B x C	7.37

control – no fertilization – kontrola – bez nawożenia, NPK – fertilization – nawożenie, UG – microbiological fertilizer – użyźniacz glebowy, UG + NPK – in combined rates as for the combination NPK and UG – w łączonych dawkach jak dla kombinacji NPK i UG

A positive effect of fertilization on the concentration of chlorophyll pigments in leaves of crop plants was observed in many Polish and foreign papers [Wood *et al*. 1992, Uzik and Zafajova 2000, Fotyma 2002, Machul 2003, Zielewicz 2005, Olszewska 2008]. Thus, it can be assumed that SPAD value is a reliable feature which aids with evaluation of effectiveness of the applied nitrogen fertilization.

Measurements of greenness index of the leaf lamina proved that a significantly higher amount of chlorophyll pigments in leaves was characteristic of crop plants cultivated in fertilized pots (Table 5). Mean values of SPAD for leaves of plants from these pots were by app. 7% higher than in plants from control pots. Moreover, it should be emphasized that application of a fertilizer alone or a fertilizer combined with mineral fertilization did not significantly vary SPAD values between these combinations. It should be emphasized that the studied species were not characterized by high diversity of the index value. Independently of the fertilization index and the year of research, significantly higher values of this parameter occurred when measuring the leaf laminae in common ryegrass (40.21), while the lowest in cocksfoot (35.59).

Table 5. Leaf greenness index (SPAD) in grasses depending on the used fertilization and study years (mean for mowings)
Tabela 5. Indeks zieloności liścia (SPAD) traw w zależności do nawożenia-użyźniania gleby i roku badań (średnia dla pokosów)

Species Gatunek	Fertilization Nawożenie	Study years – Rok badań			Mean Średnia
		2008	2009	2010	
Dactylis glomerata	control – kontrola	33.30	35.05	34.17	34.17
	NPK	33.84	35.59	35.03	34.82
	UG	35.64	37.39	36.12	36.38
	UG + NPK	35.44	37.19	38.37	37.00
Festuca pratensis	control – kontrola	34.50	36.25	35.32	35.35
	NPK	38.70	40.45	39.06	39.40
	UG	37.82	39.47	41.67	39.65
	UG + NPK	38.20	40.56	40.52	39.76
Lolium perenne	control – kontrola	37.56	38.31	37.01	37.62
	NPK	39.89	40.99	40.20	40.36
	UG	41.78	42.00	41.05	41.61
	UG + NPK	40.78	42.04	41.03	41.28
Mean for species – Średnia dla gatunku					
Dactylis glomerata		34.55	36.30	35.92	35.59
Festuca pratensis		37.30	39.18	39.14	38.54
Lolium perenne		40.00	40.83	39.82	40.21
Mean for fertilization – Średnia dla nawożenia					
Control – Kontrola		35.12	36.70	35.50	35.77
NPK		37.47	39.01	38.09	38.19
UG		38.41	39.62	39.61	39.21
UG + NPK		38.14	39.93	39.97	39.34
Mean – Średnia		37.28	38.81	38.29	38.12
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla:					
study year – roku badań (A)		0.97			
fertilization – nawożenia/użyźniania (B)		0.99			
species – gatunku (C)		1.56			
interaction – współdziałania:					
A x B		2.18			
A x C		3.05			
B x C		2.75			
A x B x C		3.37			

explanations under Table 4 – objaśnienia pod tabelą 4

Chlorophyll level also changed within years of research and was the highest in 2009 and 2010. Values of greenness index in that period were conditioned by the weather process. Proper distribution of rainfall and high air temperature (lack of droughts in months from May to September) were favourable for the accumulation of pigment in leaves. A similar effect of weather conditions on the increase in the SPAD value was also confirmed by Michałek and Sawicka [2005], as well as Olszewska [2008].

CONCLUSIONS

1. During the whole period of research, the highest yields of cocksfoot, meadow fescue and perennial ryegrass were obtained after application of mineral fertilization combined with microbiological fertilization. Separate application of mineral fertilization and a microbiological fertilizer did not vary the yield level.
2. The most stable and highest yields were obtained from meadow fescue and cocksfoot, and significantly lower from perennial ryegrass.
3. The highest SPAD values were characteristic of crop plants cultivated on ground with a microbiological fertilizer and on the ground where the fertilizer was combined with mineral fertilization. From the studied grass species, the highest greenness index of the leaf was characteristic of perennial ryegrass (SPAD on average app. 40).

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REAKCJA *Dactylis glomerata* L., *Festuca pratensis* HUDS. I *Lolium perenne* L. NA MIKROBIOLOGICZNY UŻYŹNIACZ GLEBOWY I NAWOŻENIE MINERALNE

Streszczenie. Badania z uprawą *Dactylis glomerata* L. (odmiana Borna), *Festuca pratensis* Huds. (odmiana Ureus) i *Lolium perenne* L. (odmiana Inka) przeprowadzono w wazonach, w 4 powtórzeniach, w Katedrze Łąkarstwa i Kształtowania Terenów Zieleni. Do każdego z wazonu wysiano 8 nasion jednego z badanych gatunków. Po skiełkowaniu ziarniaków, gdy siewki osiągnęły fazę 2-3 liści, dokonano selekcji negatywnej, usuwając po 4 najsłabsze rośliny i wprowadzono czynniki doświadczalne w postaci następujących kombinacji nawozowych: kontrola – bez nawożenia, NPK – nawożenie mineralne, UG – użyźniacz glebowy, UG + NPK – łączone dawki jak dla kombinacji NPK i UG. Doświadczenie prowadzono w latach 2008-2010. Oceniano następujące cechy: plon biomasy nadziemnej (g s.m.$\cdot$wazon^{-1}) i indeks zieloności liścia (SPAD). Wszystkie badane gatunki traw reagowały na zastosowane w eksperymencie nawożenie. Jednak istotnie najwyższe plony uzyskano na poletkach zasilanych mineralnie w połączeniu z użyźniaczem glebowym (średnio 96,97 g s.m.$\cdot$wazon^{-1}). Największa ilość barwnika chlorofilowego wystąpiła w roślinach zasilanych użyźniaczem glebowym i połączeniem użyźniacza z nawożeniem mineralnym.

Słowa kluczowe: kostrzewa łąkowa, kupkówka pospolita, plon biomasy nadziemnej, SPAD, użyźniacz glebowy, życica trwała

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