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THE EFFECT OF SOWING TIME/METHOD ON YIELD AND UPTAKE OF MACROELEMENTS IN AUTUMN REGROWTH OF GENOTYPES OF RED FESCUE

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Abstract

The yield of autumn regrowth of grasses and the content of macronutrients are affected by environmental and agronomic factors as well as genetic traits of species and varieties. Biomass yield and the concentration of mineral elements determine their uptake by plants. The aim of this study was to evaluate dry matter yield as well as the content and uptake of N, P, K, Ca and Mg in the autumn regrowth of three varieties of red fescue in the first two production years depending on different sowing time and methods. This study was based on a strict field experiment conducted in 2004-2007, located in the Province of Kujawy and Pomorze (*województwo kujawsko-pomorskie*) (53°09′N, 17°35′E). The first factor was the time/method of sowing (spring: pure or with spring barley, and summer: in mid- and late July and in mid-August), while the second factor was the variety (chewings, slender creeping and strong creeping fescue cultivars). An average of 3.5 t ha^{-1} and 3.9 t ha^{-1} of regrowth of dry matter was obtained in the first and second production years, respectively. A delay of the sowing date until summer caused an increase in yield during the first production year in comparison with the spring sowing. In both years, the creeping variety gave the highest yield. The yield of the chewings variety was higher than that of the slender creeping one in the second production year. The concentration of N in the strong creeping variety was lower than that of the chewings one in the first year, and also in relation to the slender creeping variety in the second production year. The chewings and slender creeping varieties were characterized by a higher concentration of P than the strong creeping cultivar. The K and N uptake in the average regrowth yield from the first and second production years was the highest (106.3 kg ha^{-1} K and 62.7 kg N);

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the P and Ca uptake was low (12.5 and 11.3 kg ha^{-1}) and that of Mg was the lowest (6.6 kg ha^{-1}). A rise in the regrowth yield caused an increase in the N, P, K, Ca and Mg uptake in summer sowing crops compared with spring ones in the first year and a high uptake of these elements by the strong creeping variety in both production years. In the first year, owing to the high N and P concentration, the uptake of these elements by the chewings and strong creeping fescue was similar. In the second year, the uptake of N, P, K, Ca by the slender creeping variety was the smallest due to a strong reduction in yield. In the first year, with no differences in the regrowth yield and K, Ca and Mg content, the uptake of these nutrients by the chewings and slender creeping varieties was similar.

Key words: macroelements, autumn regrowth, red fescue, sowing time/method, variety.

WPŁYW TERMINU/SPOSOBU SIEWU NA PLON ORAZ POBRANIE MAKROSKŁADNIKÓW W ODROŚCIE JESIENNYM GENOTYPÓW KOSTRZEWY CZERWONEJ

Abstrakt

Na wielkość plonu biomasy odrostu jesiennego traw oraz zawartość makroskładników mają wpływ czynniki siedliskowe, agrotechniczne oraz genetyczne właściwości gatunków i odmian. Plon biomasy oraz koncentracja składników mineralnych określają wielkość ich pobrania z plonem. Celem badań była ocena wielkości plonu suchej masy, zawartości i pobrania N, P, K, Ca i Mg w odroście jesiennym trzech odmian kostrzewy czerwonej w dwóch latach pełnego użytkowania, w warunkach różnych terminów i sposobów zakładania plantacji nasiennych. Podstawą badań było ścisłe doświadczenie polowe prowadzone w latach 2004-2007, w rejonie kujawsko-pomorskim (53°09′N; 17°35′E). Pierwszym czynnikiem był termin/sposób siewu (wiosenny: czysty lub z jęczmieniem jarym oraz letni: połowa i koniec lipca oraz połowa sierpnia), drugim – odmiana (kępowa, półrozłogowa oraz rozłogowa). Uzyskano 3,5 t ha^{-1} suchej masy odrostu w pierwszym roku pełnego użytkowania i 3,9 t ha^{-1} w drugim. Opóźnienie zasiewów letnich spowodowało zwiększenie plonu w pierwszym roku w stosunku do zasiewów wiosennych. W obu latach odmiana rozłogowa dała największy plon. W drugim roku plon odmiany kępowej był większy niż półrozłogowej. Koncentracja N w przypadku odmiany rozłogowej była mniejsza niż w przypadku kępowej w pierwszym roku użytkowania i najmniejsza w drugim. U odmiany kępowej i półrozłogowej stwierdzono większą koncentrację P niż u rozłogowej. Pobranie K i N z plonem odrostu, średnio z dwóch lat użytkowania, było największe (106,3 kg ha^{-1} K i 62,7 kg N), P i Ca niewielkie (12,5 i 11,3 kg ha^{-1}), a Mg najmniejsze (6,6 kg ha^{-1}). Zwiększona produkcja suchej masy spowodowała wzrost pobrania N, P, K, Ca i Mg w zasiewach letnich w porównaniu z wiosennymi w pierwszym roku, a także wysokie pobranie tych składników u odmiany rozłogowej w obu latach użytkowania. W pierwszym roku, wskutek wysokiej koncentracji N i P, pobranie tych składników u odmiany kępowej było podobne jak u rozłogowej. Z silnej redukcji plonu wynikało najmniejsze pobranie N, P, K, Ca u odmiany półrozłogowej w drugim roku użytkowania. W pierwszym roku, przy braku różnic w plonie odrostu oraz zawartości K, Ca i Mg, pobranie tych składników u odmiany kępowej i półrozłogowej było podobne.

Słowa kluczowe: makroskładniki, odrost jesienny, kostrzewa czerwona, termin/sposób siewu, odmiana.

INTRODUCTION

Seed plantations of grasses can be a valuable source of bulky feeds in the form of autumn regrowth (ROGALSKI, ŁYDUCH 1981). Additional sources of cheap fodder must be found if an area of permanent grassland is insufficient to sustain a given cattle stock (WILCZEWSKI et al. 2008). The size of the autumn regrowth yield of grasses and its phytochemical composition are affected by the species and even cultivars of plants (KOZŁOWSKI, GOLIŃSKI 1997, ROGALSKI, ŁYDUCH 1981, GOLINSKI et al. 2004). Yield and the content of mineral elements in grass green forage are also determined by fertilization, particularly with nitrogen (KOZŁOWSKI, GOLIŃSKI 1997, GOLIŃSKI 2003, KOLCZAREK et al. 2008, KACZOR, BRODOWSKA 2009, SKINDER et al. 2011), and by row spacing as well as the sowing time and method (SZCZEPANEK, SKINDER 2006). The content of mineral elements in the biomass determines its usefulness in animal feeding (ROGALSKI, ŁYDUCH 1983, RADKOWSKI et al. 2005). Together with the yield, it also determines the uptake of minerals, the fact which should be taken into consideration when making a fertilization balance.

The aim of this study was to assess the size of dry weight yield as well as the content and uptake of N, P, K, Ca and Mg in the autumn regrowth of three different genotypes of red fescue in the first and second year of production under conditions of different season and methods of establishing seed plantations.

MATERIAL AND METHODS

The study was based on a strict field experiment, located in the region of Kujawy and Pomorze (53°09’ N; 17°35’ E), on lessive soil developed from heavy loamy silty sands deposited on loose sands. The soil had a very high content of phosphorus (104 mg P kg^{-1}) and potassium (212 mg K kg^{-1}). Its reaction was neutral (pH in KCl 6.75).

The experiment was conducted in two series, each including one establishment year (2004 in series I and 2005 in series II) and two successive years of production (2005 and 2006 in series I, 2006 and 2007 in series II). The quantity and chemical composition of autumn regrowth of red fescue harvested in each production year on the last ten days of September (three months after seed harvesting). A split plot design with four replications was used. The area of a plot was 15 m^2. The first factor was the time/method of sowing and the second one was the cultivar. Fescue was sown in spring (the middle of April) in a pure stand or as a crop undersown into spring barley. The grass was also sown in summer: in the middle and end of July and in the middle of September. Spring barley was sown prior to sowing red fescue, at a row spacing of 12 cm, depth of 3 cm and amount of seeds equal 125 kg ha^{-1}. Red fescue was sown at a row spacing of 24 cm, depth of 1 cm an amount of 8 kg ha^{-1}. Three lawn cultivars of red fescue (*Festuca rubra* L.) were investigated: chewings (ssp. *commutata* Gaud.) cv. Mirena, slender creeping (ssp. *trichophylla* Gaud.) cv. Womira and strong creeping (ssp. *rubra* = *genuina* Hack.) cv. Nista.

The rates of fertilizing nutrients were N 40, P 26 and K 66 kg ha^{-1}. They were applied in the establishment year in August, after harvesting barley from mixed sowing plots, and on fescue green forage plots from the spring pure sowing as well as presowing on summer sown fescue plots. Identical rates of these elements were applied immediately after harvesting fescue seeds (the beginning of July) in the years of production. Before the plants began to grow, at the end of March and at the beginning of April in the first and second year of production, the rate of mineral nitrogen reached 60 kg ha^{-1}.

At harvest, the fresh weight yield of the autumn regrowth from each plot was weighed and 1 kg samples were collected for determination of dry weight content and performance of chemical analyses. Dry weight was determined with the drying method at 105°C. Chemical analyses of plant material involved determination of the content of total N (with Kjeldahl method), P (vanadium-molybdenum method), K and Ca (flame photometry method) and Mg (colorimetrically with titan yellow). The uptake of macroelements was calculated as a product of their content and the size of dry weight yield. The results were subjected to an analysis of variance for multi-factorial experiments and a synthesis of the data was made according to the model of combined inaccuracies for the first and second year of production. Significance of differences between means was verified with Tukey's test. With no directional interactions, the results are presented as means for the tested factors and years.

RESULTS AND DISCUSSION

Red fescue can be established as a catch crop in a cover crop or in pure sowing from spring till late summer. The sowing time/method determines the amount of green biomass produced in the first half of the next growing season (the first production year) (Boelt 1997a, b, Fairey, Lefkovich 2001). In the present study, it was proven that the sowing time/method had a significant effect on the amount of vegetative biomass produced (autumn regrowth) in the second half of the growing season (Table 1). In the first production year, the dry matter yield of regrowth was significantly higher from swards sown in summer than in spring. Red fescue sown in spring produced 22% more of threshed straw biomass in the first half of growth than if sown in

Table 1

The dry matter yield of autumn regrowth of red fescue depending on time/method of sowing in the first and second production year (t ha^{-1})

Production year	Time/method of sowing					LSD (p=0.05)
	spring		summer			
	pure	with barley	middle of July	end of July	middle of August	
First, mean 2005-2006	2.695	3.107	3.800	4.140	3.999	0.642
Second, mean 2006-2007	3.743	3.771	4.093	3.954	3.902	n.s.

July and August (data not presented). This could have been caused by drier soil and lower quantities of available nutrients in soil later on in the plant growing season, particularly in the early regrowth of the sward. Hence, a decrease in the production of autumn regrowth biomass from spring sowing of grass. The availability of nutrients and water is a major determinant of grass yield (GOLIŃSKI 2003, KACZOR, BRODOWSKA 2009, SKINDER et al. 2011).

No effect of the time/method of sowing on the content of macroelements in the autumn regrowth of red fescue was found, either in the first or in the second production year (Table 2). According to MCCARTNEY et al. (2004), the chemical composition of red fescue green forage is dependent on the duration of its regrowing period. New sward (at 3-4 cuts in the growing

Table 2

Content of macroelements in autumn regrowth of red fescue depending on time/method of sowing in the first and second production year (%)

Production year	Element	Time/method of sowing					LSD (p=0.05)
		spring		summer			
		pure	with barley	middle of July	end of July	middle of August	
First, mean 2005-2006	N	1.753	1.793	1.837	1.825	1.898	n.s.
	P	0.303	0.308	0.296	0.291	0.290	n.s.
	K	2.423	2.603	2.622	2.617	2.773	n.s.
	Ca	0.313	0.323	0.321	0.341	0.332	n.s.
	Mg	0.182	0.191	0.190	0.191	0.189	n.s.
Second, mean 2006-2007	N	1.605	1.721	1.517	1.575	1.634	n.s.
	P	0.330	0.350	0.332	0.376	0.348	n.s.
	K	2.739	2.883	2.750	2.844	2.955	n.s.
	Ca	0.274	0.314	0.281	0.294	0.289	n.s.
	Mg	0.175	0.175	0.162	0.176	0.175	n.s.

season) contained more N than older one (cut twice in the season). In the present study, the duration of sward regrowing in all the variants of fescue sowing times/methods was identical, hence a similar chemical composition of the regrowth. The K content in the autumn fescue regrowth determined in the present study can be claimed to almost reach the highest amount in this grass species, as implied by the literature data (Goliński et al. 2004, Radkowski et al. 2005, Skinder, Szczepanek 2011). The high content of this element in soil and regular application of mineral fertilizers favoured high accumulation of K in the regrowth. The optimal concentrations of nutrients for dairy cows are claimed to be 0.4-0.5% P, 0.6-0.9% Ca, 0.2-0.3% Mg (Krzywiecki 1985), hence the concentrations of these elements, particularly Ca, in the regrowth of the tested cultivars seem deficient. Similar conclusions are presented also in other studies concerning the fodder value of the autumn regrowth of grasses (Rogalski, Łyduch 1981, Kozłowski, Goliński 1997, Goliński et al. 2004, Skinder et al. 2011).

The uptake of macroelements by the red fescue regrowth in the first and second year of production was similar (Table 3). The grass took up most K and N: on average, 106.3 kg K and 62.7 kg N ha^{-1} in the two-year utilization period. The P and Ca uptake was considerably lower and similar for both macroelements (12.5 and 11.3 kg ha^{-1}). The smallest uptake was found in the case of Mg (6.6 kg ha^{-1}).

Table 3

Uptake of macroelements with autumn re growth of red fescue depending on time/method of sowing in the first and second production year (kg ha^{-1})

Production year	Element	Time/method of sowing					LSD (p=0.05)
		spring		summer			
		pure	with barley	middle of July	end of July	middle of August	
First, mean 2005-2006	N	44.93	52.23	67.24	75.44	74.70	11.58
	P	8.860	10.31	12.34	13.11	12.54	2.031
	K	71.47	88.55	108.83	119.28	121.57	18.37
	Ca	8.346	9.846	11.72	13.71	12.98	2.097
	Mg	4.891	5.731	7.166	7.609	7.400	1.207
Second, mean 2006-2007	N	59.78	64.94	62.07	61.87	63.58	n.s.
	P	12.32	13.10	13.59	14.96	13.53	1.884
	K	103.1	108.0	113.7	113.0	115.5	n.s.
	Ca	10.27	11.91	11.57	11.56	11.25	1.603
	Mg	6.542	6.595	6.627	6.894	6.801	n.s.

A significant effect of the time/method of sowing on the uptake of N, P, K, Ca and Mg by the autumn regrowth occurred. In the first year of production, the uptake of macronutrients was larger in summer sowings than in spring ones (the said difference in the uptake of Ca by the grass undersown into barley was not significant). Having confirmed no differences in concentrations of these elements between the compared times/methods of sowing (Table 2), it was concluded that the uptake corresponded most closely to the volume of dry weight yield (Table 1). In the second year of production, a smaller uptake of P and Ca in the spring pure sowing was observed. Regarding P, the difference was significant only in comparison with the sowing at the end of July. With respect of Ca, it was significant in relation to all the other times/methods of sowing. The limited uptake of those elements grasses from the spring pure sowing resulted from both a reduction in yield and a lower content of these elements in biomass (Tables 1 and 2).

Red fescue cultivars (*Festuca rubra* L.*)* from three subspecies (ssp. *commutata* – chewings , *trichophylla* – slender creeping and *rubra* – strong creeping) show different physiologicaland morphological traits as well as different commercial value (Deleuran, Boelt 1997, Huylenbroeck, Bockstaele 1999, Martiniello, D'Andrea 2006, Szczepanek, Olszewski 2009, Chastain et al. 2011). In the present study, differences in dry matter yields of autumn regrowths of red fescue cultivars/subspecies were found both in the first and second production year (Table 4). The strong creeping cultivar Nista was characterized by the highest yield in both years. In the first production year, the yields of the chewings cultivar Mirena and slender creeping Womira were similar, while in the second the chewings cultivar gave better yields. Similarly, Goliński et al. (2004) showed that strong creeping cultivars of red fescue yielded better than chewings and slender creeping ones.

Table 4

The dry matter yield of autumn regrowth of red fescue depending on variety in the first and second production year (t ha^{-1})

Production year	Variety			LSD (p=0.05)
	chewings cv. Mirena	slender creeping cv. Womira	strong creeping cv. Nista	
First, mean 2005-2006	3.400	3.376	3.869	0.164
Second, mean 2006-2007	3.832	3.421	4.425	0.156

Significant variability of the chemical composition of the studied genotypes was observed (Table 5). The strong creeper Nista usually contained less N and P than the chewings and slender creeping varieties. Similarly, Goliński et al. (2004) proved a significant difference between cultivars in the content of nitrogen (total protein) and phosphorus in the red fescue regrowth.

Table 5

Content of macroelements in autumn regrowth of red fescue depending on variety in the first and second production year (%)

Production year	Element	Variety			LSD (p=0.05)
		chewings cv. Mirena	slender creeping cv. Womira	strong creeping cv. Nista	
First, mean 2005-2006	N	1.926	1.812	1.7269	0.155
	P	0.314	0.303	0.276	0.016
	K	2.611	2.578	2.634	n.s.
	Ca	0.321	0.319	0.337	n.s.
	Mg	0.182	0.185	0.199	n.s.
Second, mean 2006-2007	N	1.645	1.645	1.540	0.101
	P	0.361	0.352	0.328	0.018
	K	2.862	2.749	2.892	n.s.
	Ca	0.286	0.291	0.294	n.s.
	Mg	0.161	0.187	0.169	n.s.

The authors reported that the protein content in strong creeping cultivars was usually smaller than in chewings and slender creeping ones. KOZŁOWSKI and GOLIŃSKI (1997) reported that ecotypes of red fescue rich in protein can accumulate twice as much of this element as compared ones with little protein.

The uptake of nutrients by the autumn regrowth was different between the cultivars, both in the first and second year of production (Table 6). In the first year, the chewings cv. Mirena and the strong creeping cv. Nista took up more N than the slender creeping cv. Womira. In the chewings cultivar, an increased uptake of N resulted from a high concentration of this element in the biomass, and in the strong creeping cultivar the same effect was achieved owing to a high dry weight yield of the regrowth (Tables 4 and 5). Also in the case of P, its increased concentration in the cultivar Mirena resulted from a higher uptake of this element than by the cultivar Womira.

The rate of K, Ca and Mg uptake, in the absence of differences in the concentration of these elements in the biomass, was most strongly determined by the volume of yield, and was higher in the strong creeping cultivar Nista than in the other cultivars.

In the second year of production, the uptake of N, P K and Ca was the highest in the strong creeping cultivar, significantly smaller in the chewings one, and the smallest in the slender creeping one. An increase in the dry weight yield of the autumn regrowth of the strong creeping cultivar Nista

Table 6

Uptake of macroelements with autumn regrowth of red fescue depending on variety in the first and second production year (kg ha^{-1})

Production year	Element	Variety			LSD (p=0.05)
		chewings cv. Mirena	slender creeping cv. Womira	strong creeping cv. Nista	
First, mean 2005-2006	N	63.31	60.21	65.21	2.194
	P	11.61	11.12	11.57	0.462
	K	98.03	96.45	111.34	4.561
	Ca	10.65	10.65	12.66	0.418
	Mg	6.116	6.174	7.388	0.253
Second, mean 2006-2007	N	63.01	56.26	68.08	2.533
	P	13.88	12.07	14.56	0.550
	K	109.9	94.0	128.0	4.481
	Ca	10.98	9.955	13.00	0.457
	Mg	6.175	6.413	7.487	0.281

(by 15.5% and 29.3% versus the cultivars Mirena and Womira) (Table 4) indicates its crucial effect on the values of uptake in the second year. Concerning Mg, its uptake was also the largest in the strong creeping cultivar, but an increased concentration in the slender creeping cultivar resulted in an increase in the uptake of this element to the level found in the chewings cultivar.

CONCLUSIONS

1. In the first production year of red fescue, a significant increase in the autumn regrowth yield from summer sowings (from the middle and end of July and from the middle of August) in comparison with spring sowings (pure and with barley) was noticed (by 1.08 t ha^{-1} dry weight), This in turn resulted in an increase in the N, P, K, Ca and Mg uptake by 23.9; 3.1; 36.6; 3.7; 2.1 kg ha^{-1}, respectively.

2. The N and P content in the autumn regrowth of the strong creeping cultivar was less than that of the chewings and slender creeping ones, but the uptake of these elements along with the highest dry weight yield was as high as in the chewings cultivar in the first year of production and higher than both compared cultivars in the second production season.

3. The K, Ca and Mg uptake by the autumn regrowth biomass of red fescue, in the absence of differences between the cultivars in the concentration of these nutrients, was determined mainly by the amount of dry weight yield; it was the largest in the creepings cultivar, both in the first and second production years.

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