Analysis of dry matter yield structure of forage grasses

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ABSTRACT

An average dry matter yield structure (three cuts per growing season) in relation to agronomically valuable characteristics of six forage grass species and a year of herbage utilization was studied over the period of 1989–2002 in Lithuania. The most productive species of the first cut of two years of herbage utilization were *Phleum pratense* ($P < 0.01$) and *Festulolium* hybrids ($P < 0.05$) (average dry matter yield were 7.42 and 6.66 t/ha, respectively), moderately productive – *Festuca pratensis*, *Dactylis glomerata* and *Lolium perenne* (5.58, 5.42 and 5.20 t/ha), significantly lower ($P < 0.01$) yielding was *Poa pratensis* (4.19 t/ha). During two years of herbage utilization *Dactylis glomerata* produced significantly ($P < 0.01$) higher dry matter yield of aftermath – 7.30 t/ha. Other grass species were ranked in the following order: *Festulolium* hybrids 5.85 t/ha, *Festuca pratensis* 4.94 t/ha, *Poa pratensis* 4.57 t/ha, *Lolium perenne* 4.48 t/ha, and *Phleum pratense* 3.92 t/ha. *Dactylis glomerata* and *Poa pratensis* distinguished by the highest aftermath percent in the structure of the annual dry matter yield (57.7 and 52.2%). *Phleum pratense* formed an especially poor aftermath – only 34.6%. An average annual dry matter yield data analysis of two years of herbage utilization over the period of 1989–2002 showed that *Dactylis glomerata* and *Festulolium* hybrids were most productive ($P < 0.01$) species.

Keywords: forage grasses; dry matter yield; first cut; aftermath; regrowth

The major forage grasses currently cultivated in Lithuania are common timothy (*Phleum pratense* L.), meadow fescue (*Festuca pratensis* Huds.), perennial ryegrass (*Lolium perenne* L.), cocksfoot (*Dactylis glomerata* L.), *Festulolium* hybrids and Kentucky blue grass (*Poa pratensis* L.). The productivity of these species is not stable. A very important property of forage grasses is their ability to give stable and high dry matter yields under different environmental conditions. The level of the productivity and stability mostly depends on the genetic potential of the forage grass species (Černiauskas 1992, Chapman 1996, Moser et al. 1996).

Literature sources provide various data of the dry matter yield of major perennial grasses (Černiauskas 1992, Daugeliene 1996). The shortcoming of these data is that the trials are not comparative, since they were conducted not in the same experimental year, not covering many years and did not describe grass species, as only a few or most often even one variety were investigated.

The connection between dry matter yield of first cut of forage grasses and the climatic factors over the period 1989–1998 was investigated and the species were compared (Lemežienė et al. 2000).

The objective of the current study was to analyse the average annual dry matter yield structure (the first cut and aftermath) and stability of each of the 6 major grasses in relation to agronomically valuable characteristics of the species and year of herbage utilization. It was important to determine which place according to dry matter yield takes among grasses the new fodder grass species, *Festulolium* hybrids, whose cultivation has been recently started in Lithuania. *Festulolium* hybrids have a great recombination potential, which is being successfully used in plant breeding, while combining high forage quality and resistance to climate stress (Thomas and Humphreys 1991, Nekrošas et al. 1995, Humphreys et al. 1998, Sliesaravičius and Sliesaravičiene 1998, Casler et al. 2002).

MATERIAL AND METHODS

The perennial grasses were tested in the Central Lowland of Lithuania, where the annual amount of precipitations are 520–700 mm, a mean air temperature 6.3°C (Bukantis et al. 2001). The warm period of the year lasts six months. Variety testing experiments of perennial grasses were established on carbonate gleyic, moderately heavy drained brown soil. The plough layer 25–30 cm, whose pH 7.2–7.5, humus 1.9–2.2%, total nitrogen 0.14–0.16%, mobile phosphorus 201–270, potassium 101–175 mg/kg of soil.

Competitive variety trials of *Lolium perenne*, *Festuca pratensis*, *Phleum pratense*, *Dactylis glomerata*, *Festulolium* hybrids and *Poa pratensis* were assessed over the period 1989–2002 (13 variety testing trials, which were established annually).

The duration of one trial was two years of herbage use (excluding the sowing year). Altogether 779 varieties and breeding lines of Lithuanian origin

Table 1. Mean squares relevant to the study of species, year of utilization and their interaction

Source	*df*	Dry matter yield (t/ha)		
		first cut	aftermath	annual
Years (Y)	1	183.14**	80.21**	512.83**
Species (S)	5	30.77**	37.92**	53.94**
Y × S interactions	5	7.12	3.17	16.41
Error	137	3.24	4.381	7.411

*, **significant at the 0.05 and 0.01 probability levels, respectively

including those 127 of *Lolium perenne*, 134 of *Festuca pratensis*, 214 of *Phleum pratense*, 104 of *Dactylis glomerata*, 100 of *Poa pratensis*, 100 *Festulolium* hybrids (*F.* pratensis × *L. perenne*, *F. pratensis* × *L. multiflorum)*) were tested during these years.

Grasses were sown with four replications. The record area of a plot was 9.5–10.5 m^2. In the autumn of each year of use phosphorus and potassium fertilizers ($P_{60}K_{90}$) were applied. Nitrogenous fertilizers (N_{150}) were applied each year of herbage utilization in several applications: in spring N_{60}, and N_{45} after the first and second cut.

The grasses were sown in the first half of June without a cover crop. In the year of utilization the grass was cut 3 times with a Hege 212 field mower and herbage samples of 0.5 kg were taken for dry matter content determination. The first cut was taken at heading of different species; the second and third cuts were taken after regrowth of aftermath. In the variety trials, besides dry matter yield, were also determined plant damage after winter, regrowth in spring and after cuts, beginning of heading, as well as the state of the trials in the sowing year – field germinating ability, winter damage, etc. A 1–9 score system was used for evaluation, where 1–3 means a very low and low value of the character, 5 – moderate, 7–9 – a high or very high value of the character (Tyler et al. 1987).

Each year's experimental data were processed by the method of one-or two-factorial dispersion analysis. In order to reveal differences among the grass species and between the years of utilization, the averaged data were processed by the method of two-factorial analysis according to the scheme: species × year of herbage use (Clewer and Scarisbrick 2001).

RESULTS AND DISCUSSION

Data of the variance analysis showed that the first cut, aftermath and annual dry matter yield values

Table 2. Agronomically valuable characteristics and an average dry matter yield of the first cut over the period of 1989–2002

Characteristic	*Phleum pratense*	*Festulolium*	*Dactylis glomerata*	*Festuca pratensis*	*Lolium perenne*	*Poa pratensis*
First year of herbage utilization						
Field germination (points)	6.5^{--}	8.5^{++}	7.5	8.0^{++}	8.5^{++}	4.7^{--}
Winter damage (points)	1.0^{++}	1.9^{-}	1.7	1.0^{++}	2.7^{--}	1.0^{++}
Earliness	very late	late	early	intermediate	late–very late	very early
Height in heading (mm)	784^{++}	792^{++}	760^{+}	704	513^{--}	449^{--}
Dry matter yield (t/ha)	8.20^{++}	8.22^{++}	5.80^{-}	6.89	6.99	4.85^{--}
Second year of herbage utilization						
Winter damage (points)	1.0^{++}	2.8^{--}	2.4	1.2^{++}	4.4^{--}	1.0^{++}
Height in heading (mm)	693^{++}	659^{++}	700^{++}	546	400^{--}	368^{--}
Dry matter yield (t/ha)	6.65^{++}	5.09	5.05	4.26	3.42^{--}	3.53^{-}

$^{+}$, $^{++}$ indicate the highest and $^{-}$, $^{--}$ the lowest differences from the average data significance at $P < 0.05$ and 0.01 probability levels, respectively

reliably ($P < 0.01$) depended on species (S) and year of utilization (Y) (Table 1). The data of analysis of variance represented in the Table 1 specify absence of significant interaction between the years of utilization and the species of grasses (S × Y) i.e. the null hypothesis in this case is not rejected ($P < 0.05$**)**. Absence of the significant interaction (S × Y) shows an inadequate response of fodder grass species to changes in growing conditions in different years. The results will be further given a more detailed analysis by relating dry matter yield of different species with the factors affecting it (morphologic and agronomic traits of species, year of herbage utilization).

Dry matter yield of the first cut

The average dry matter yield of the first cut in the first year of use was most markedly dependent on the rhythm of grass species development – the later the grass species – the higher yielding it was (Table 2). An exception was very late species of *Lolium perenne* which, being later than *Festulolium* hybrids, produced a lower dry matter yield. This can be explained by the fact that the dry matter yield of the first cut of *Lolium perenne* was affected by a rather poor overwintering even in the first winter. The overwintering of *Festulolium* hybrids was better (Table 2). Furthermore, plant height also influences dry matter yield of these species. *Lolium perenne* is attributed to short grasses, while the *Festulolium* hybrids are attributed to tall grasses (Table 2).

Analysis of the data showed that the year of herbage utilization had a very great effect on the dry matter yield of the first cut. On average, during the whole experimental period in the first year of herbage use six of the species studied gave a higher ($P < 0.01$) dry matter yield of the first cut (Table 2, Figure 1). This is quite logical, as forage grasses early in the first year utilization are at the initial stage of their growing and development and have not yet been or have only slightly been exposed to negative effects (not efficient utilization of grasses, diseases invasion and unfavorable growing or wintering conditions). For instance, *Poa pratensis* usually suffers no damage in winter, but its bushing was poor because of the lack of precipitation and the insufficient number of cuttings (three cuts) which should be higher for this species (Bryan at al. 2000). *Festulolium* hybrids, and especially *Lolium perenne* often are insufficient resistant to wintering conditions (Table 2).

During the period 1990–2002, under the effect of these factors in the second year of herbage utilization, the dry matter yield of first cut of *Lolium perenne* declined on average by 51.1%, *Festuca pratensis* 38.2%, *Festulolium* hybrids 38.1%, *Poa pratensis* 27.2%, *Phleum pratense* 18.9%, *Dactylis glomerata* 12.9%. Unfavorable overwintering conditions resulted in the greatest reduction in the dry matter yield of *Lolium perenne*, the reduction being somewhat less in the dry matter yield of *Festulolium* hybrids.

A relatively good dry matter yield of *Dactylis glomerata* of the first cut in the second year of herbage utilization can be explained by a good regrowth of this species after cuts, even during the droughty period in the first year, which resulted in satisfactory overwintering of unweakened plants and a better resistance to unfavorable growing conditions.

According to the dry matter yield of the first cut in the second year of herbage utilization the species were ranked in the following order: *Phleum pratense* > *Festulolium* hybrids > *Dactylis glomerata*

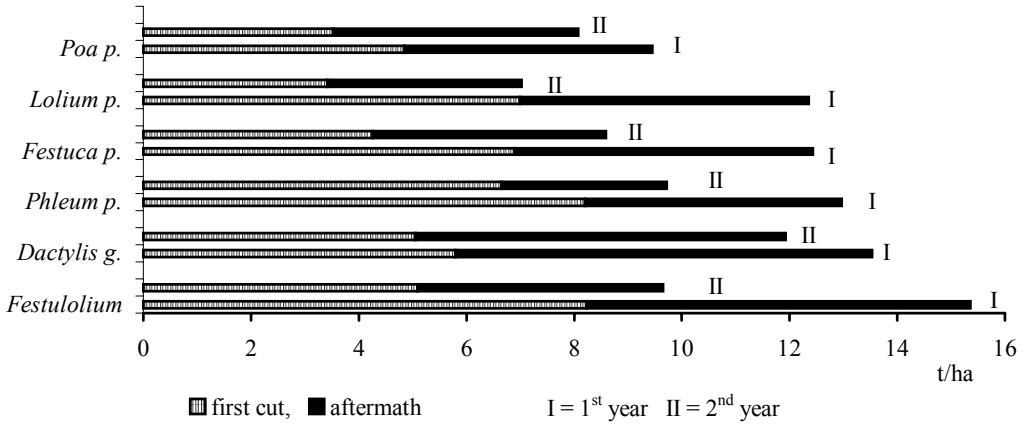

Figure 1. An average annual dry matter yield

Table 3. Plant height before cuts and average dry matter yield of aftermath over the period of 1989–2002

Characteristic	*Phleum pratense*	*Festulolium*	*Dactylis glomerata*	*Festuca pratensis*	*Lolium perenne*	*Poa pratensis*
First year of herbage utilization						
Plant height before 2nd cut (mm)	420^{--}	754^{++}	689^{++}	359^{--}	499	449^{-}
Dry matter yield of 2nd cut (t/ha)	2.98^{--}	4.37^{+}	4.36^{+}	3.10	2.98^{--}	3.04^{-}
Plant height before 3rd cut (mm)	290^{-}	415	581^{++}	310	306^{-}	328
Dry matter yield of 3rd cut (t/ha)	1.79^{-}	2.77	3.37^{++}	2.44	2.38	1.56^{--}
Second year of herbage utilization						
Plant height before 2nd cut (mm)	353^{--}	659^{++}	604^{++}	302^{--}	397	288^{--}
Dry matter yield of 2nd cut (t/ha)	1.83^{--}	2.71	3.98^{++}	2.36	1.99^{--}	3.07
Plant height before 3rd cut (mm)	306	354	555^{++}	271^{-}	299	248^{--}
Dry matter yield of 3rd cut (t/ha)	1.24^{-}	1.85	2.90^{++}	1.97	1.61	1.47

$^{+}$, $^{++}$ indicate the highest and $^{-}$, $^{--}$ the lowest differences from the average data significance at $P < 0.05$ and 0.01 probability levels, respectively

> *Festuca pratensis* > *Poa pratensis* > *Lolium perenne* (Table 2, Figure 1). This order of the grass species was predetermined by the fact that in the second year of herbage utilization the dry matter yield of *Dactylis glomerata* declined least (only by 12.9%) whereas that of *Lolium perenne* declined most significantly (by 51.1%).

According to 13-years average value of the first cut the most productive species of two years of herbage utilization were *Phleum pratense* ($P < 0.01$) and *Festulolium* hybrids ($P < 0.05$) (an average dry matter yield were 7.42 and 6.66 t/ha, respectively), moderately productive – *Festuca pratensis*, *Dactylis glomerata* and *Lolium perenne* (5.58, 5.42 and 5.20 t/ha), significantly lower ($P < 0.01$) yielding was *Poa pratensis* (4.19 t/ha).

Dry matter yield of aftermath

Average data of the second and third cut of the first year of use show that a higher dry matter yield of aftermath of all grass species is obtained in the second and not in the third cut: 3.47 and 2.38 t/ha, respectively (Table 3, Figure 1).

A reduction in the dry matter yield at the end of plant vegetative growth period when the third cut is forming can result from the fact that plants vigor, which promotes regrowth, declines, besides, plants often suffer from drought at the end of summer. The same trend is seen also in the second year of herbage use – the dry matter yield was lower in the third than in the second cut (2.66 and 1.84 t/ha, respectively) (Table 3, Figure 1). This phenomenon can be explained by the fact that each renewal of plants leads to inevitable senescence, which in turn results in reduction of their viability (Ong 1978, Richards 1993, Nelson 1996, Rawnsley et al. 2002).

Analysis of data showed that dry matter yield of aftermath was markedly influenced by the year of herbage utilization. The higher ($P < 0.01$) dry matter yield was obtained in the first year of herbage utilization. An average aftermath dry matter yield in all the grass species studied in the first and second year of herbage utilization was 5.86 and 4.50 t/ha, respectively. The yield of *Dactylis glomerata* aftermath accounts for as much as 57.7% of the annual dry matter yield (Figure 1). A good dry matter yield of *Dactylis glomerata* aftermath in the first and second years of herbage utilization can be explained by an excellent regrowth of this grass species after cuts and a good drought resistance. Drought resistance is a peculiar trait of *Dactylis glomerata* as compared to the other grasses in our trials. *Dactylis glomerata* aftermath dry matter yield in the especially droughty summer of 2002 was the highest (3.49 t/ha). The other species were less productive, their dry matter yield ranking from 2.20 (*Festulolium* hybrids) to 1.32 t/ha (*Phleum pratense*). The yield stability of *Dactylis glomerata* grown at limited water supply conditions was mentioned in the literature (Santen and Sleper 1996, Waldron et al. 2002).

Poa pratensis also has a good regrowth capacity. The aftermath dry matter yield of this species during the two years of herbage utilization accounted for 52.2% of the annual yield.

Festulolium hybrids, as compared with *Festuca pratensis* and *Lolium perenne* gave a similar dry matter yield (in percentage) of aftermath (46.8, 47.0 and 46.3%).

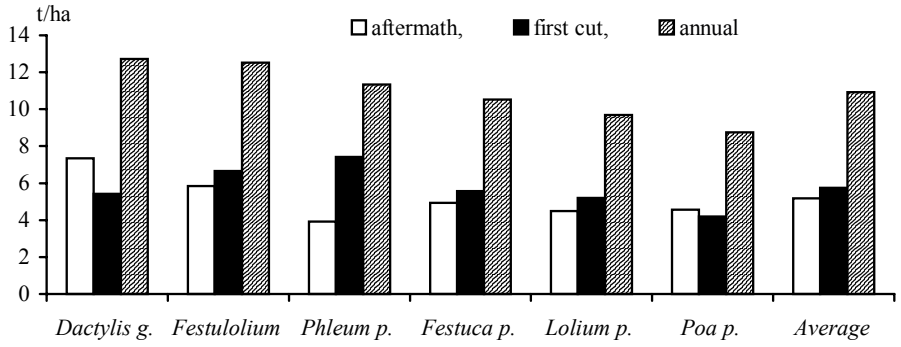

Figure 2. An average dry matter yield during two years of herbage utilization

Phleum pratense showed an especially poor regrowth capacity. *Phleum pratense*, being one of the most productive grass species according to 13-year annual dry matter yield (11.34 t/ha, 3rd place, Figure 2) and the most productive ($P < 0.01$) species according to the yield of the first cut (Figure 3), took the last place according to aftermath dry matter yield (3.92 t/ha) (Table 3). The dry matter yield of its aftermath accounted for only 34.6% of the annual yield. The low dry matter yield of the aftermath was determined by a poor regrowth of the species after cuts.

During two years of herbage use *Dactylis glomerata* produced significantly ($P < 0.01$) higher dry matter yield of aftermath – 7.30 t/ha. Other grass species were ranked in the following order: *Festulolium* hybrids 5.85 t/ha, *Festuca pratensis* 4.94 t/ha, *Poa pratensis* 4.57 t/ha, *Lolium perenne* 4.48 t/ha and *Phleum pratense* 3.92 t/ha.

Average dry matter yield during two years of herbage utilization

According to 13-year average dry matter yield values of the first cut, the most productive were *Phleum pratense* ($P < 0.01$) and *Festulolium* hybrids ($P < 0.05$). Their average dry matter yield of the first cut in two years of utilization were 7.42 and 6.66 t/ha, respectively. Significantly ($P < 0.01$) lower yielding was *Poa pratensis* (4.19 t/ha) and moderately productive species were *Festuca pratensis*, *Dactylis glomerata* and *Lolium perenne* (5.58, 5.42 and 5.20 t/ha).

Investigations of the dry matter yield of the second and third cuts of perennial grasses showed that during the two years of herbage utilization *Dactylis glomerata* produced the significantly ($P < 0.01$) highest dry matter yield of aftermath (7.30 t/ha) and showed the best regrowth after cuts. According to the productivity of aftermath, the other grass species were ranked in the following order: *Festulolium* hybrids 5.85 t/ha, *Festuca pratensis* 4.94 t/ha, *Poa pratensis* 4.57 t/ha, *Lolium perenne* 4.48 t/ha and *Phleum pratense* 3.92 t/ha. The dry matter yield of *Phleum pratense* aftermath accounted for only 34.6% of the annual yield.

According to the average 13-year dry matter yield (firs cut + aftermath) during two years of herbage utilization, the species were ranked in the following order: *Dactylis glomerata* 12.73 t/ha, *Festulolium* hybrids 12.50 t/ha, *Phleum pratense* 11.34 t/ha, *Festuca pratensis* 10.51 t/ha, *Lolium perenne* 9.68 t/ha, *Poa pratensis* 8.76 t/ha.

Dactylis glomerata and *Festulolium* hybrids were the most productive ($P < 0.01$), *Poa pratensis* ($P < 0.01$) and *Lolium perenne* ($P < 0.05$) – the lowest yielding species in Lithuania.

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ABSTRAKT

Analýza struktury výnosu pícních trav

V Litvě byla v letech 1989–2002 studována průměrná struktura výnosu (tři seče za vegetaci) ve vztahu k pícninářským charakteristikám šesti druhů pícních trav a k užitkovému roku porostů. Největší výnosy první seče ve dvou užitkových letech poskytovaly *Phleum pratense* ($P < 0,01$) a mezirodové hybridy *Festulolium* ($P < 0,05$) – průměrný výnos sušiny 7,42 a 6,66 t/ha, průměrně výnosné byly *Festuca pratensis*, *Dactylis glomerata* a *Lolium perenne* (5,58; 5,42 a 5,20 t/ha), průkazně nižší výnosy ($P < 0,01$) byly u *Poa pratensis* (4,19 t/ha). *Dactylis glomerata* produkovala v průběhu dvou užitkových let průkazně vyšší výnosy ($P < 0,01$) druhých a třetích sečí – 7,30 t/ha. Výnosy druhých a třetích sečí byly v následujícím pořadí: mezirodové hybridy *Festulolium* 5,85 t/ha, *Festuca pratensis* 4,94 t/ha, *Poa pratensis* 4,57 t/ha, *Lolium perenne* 4,48 t/ha a *Phleum pratense* 3,92 t/ha. *Dactylis glomerata* a *Poa pratensis* se vyznačovaly nejvyšším podílem druhých a třetích sečí v celkovém výnosu za rok (57,7 a 52,2 %). Podíl druhých a třetích sečí v celkovém výnosu u *Phleum pratense* byl pouze 34,6 %. Nejvyšší průměrné roční výnosy sušiny při pěstování na dva užitkové roky v letech 1989–2002 poskytovala *Dactylis glomerata* a mezirodové hybridy *Festulolium* ($P < 0,01$).

Klíčová slova: pícní trávy; výnos sušiny; první seč; druhá a třetí seč; obrůstání

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