Can *Festulolium*, *Dactylis glomerata* and *Arrhenatherum elatius* be used for extension of the autumn grazing season in Central Europe?

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ABSTRACT

The paper compares the quality of *Festulolium*, *Dactylis glomerata* and *Arrhenatherum elatius* at the end of the growing season over three years with the contrasting weather in the Czech Republic. The effect of pre-utilisation dates in June or July on the quality of grass forage in October, November and December (harvest dates) was investigated. In the first two years, *Arrhenatherum elatius* exhibited higher yields ($P < 0.05$) than *Festulolium* and *Dactylis glomerata*. In all treatments, differences between the species and between the years were inconsistent for organic matter digestibility (OMD) and neutral detergent fibre (NDF) but *Festulolium* showed the lowest crude protein (CP) in all years and crude fibre (CF) in the first 2 years. The longer re-growth time due to earlier final cut in summer increased the yield and decreased the nutritive value in winter. Yields of DM, OMD and CP content generally declined and the CF content increased with the delay of winter harvest. Significant species harvest date interactions in some years were due to the steep increase of CF and NDF in *Festulolium*. Based on DM yields and nutritive value, all species have some merits as forage for use in possibly extended grazing season. *Festulolium* and *Dactylis glomerata* could be used to extend the grazing period in continental conditions. *Arrhenatherum elatius* had sufficient quality at both dry and warm end of the growing season due to the fact that *Arrhenatherum elatius* was a representative of drought-resistant species; however, intense grazing could suppress it.

Keywords: grasses; digestibility of organic matter; crude protein; crude fibre; neutral detergent fibre; winter grazing; weather conditions

Winter grazing can take place overseas under continental weather but can be found also in the United Kingdom or in Ireland (Taylor and Templeton 1976, Hennessy et al. 2006). Year-round grazing is also used under weather conditions of countries in Central Europe including Germany and/or the Czech Republic (Deblitz et al. 1993, Hejcman et al. 2005). Grass species used for swards at the end of the growing season should provide adequate yields and high forage quality for the nutrition of beef cattle breeds and/or cows without market production of milk during autumn and winter (Opitz von Boberfeld and Banzhaf 2006). Extension of the grazing season to winter can reduce the cost of dry feeding for dairy cows (Adams et al. 1994). Due to the fact that the pasture stand can be used also in winter, the last mowing or grazing cycle in June or July or a shift of the last summer utilization term to the first week of August is needed (Opitz von Boberfeld and Banzhaf 2006). Moreover, the last summer utilization period influences winter forage yields and quality (Gerrish et al. 1994). Towards

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the end of the growing season, grasslands become a forage source for wildlife (Kamler et al. 2007). Therefore, the species to be used should be cold resistant and able to grow at low temperatures (Wheeler 1968). *Festuca arundinacea* Schreb. belongs among species that were tested to fulfil the requirements as shown by Taylor and Templeton (1976) referring to USA continental locations and by Opitz von Boberfeld and Wolf (2002) in German continental locations. It is a tolerant, long green species with the pronounced erectophile growth (Stählin and Tirtapradja 1974); its greater use is however limited by the poor intake of the fresh forage by herbivores (Opitz von Boberfeld and Wolf 2002). Interspecific hybrids of *Festulolium* ssp. combine the persistence of *Festuca* sp. genus with the high forage quality of *Lolium* sp. genus (Casler et al. 2002). The festucoid hybrids can be better adapted for use at the end of the growing season than the loloid hybrids (Opitz von Boberfeld and Banzhaf 2006). Besides the above-mentioned species, the use of *Dactylis glomerata* L. at the end of the growing season was shown by Prigge et al. (1999). Holúbek et al. (2007) found that the quality of *Dactylis glomerata* sharply decreased if the harvest date of the first cut was exceeded. In addition, they stated that harvest date in the following cuts was prolonged thanks to the species' winter character. Moreover, *Arrhenatherum elatius* (L.) P. Beauv is a representative of drought-resistant species (Dostálek and Frantík 2008). It finds a particular use in meadow stands. If not given a chance to shed seeds, its resistance against low temperatures is limited. Due to this, intense grazing of this drought-resistant specie can be suppressed (Holúbek et al. 2007).

Data concerning the quality of forages made from grasses suitable for winter cattle grazing originate mostly from overseas or from regions more affected by the Atlantic climate. Grass species suitable for extension of the grazing period should be adapted to generally anticipated climate changes. *Festulolium*, *Dactylis glomerata* and *Arrhenatherum elatius* belong to such species and thus we were interested whether *Festulolium*, *Dactylis glomerata* and *Arrhenatherum elatius* could be used for extending the autumn grazing season in Central Europe. The aim of this study was to compare the yields and quality of *Festulolium*, *Dactylis glomerata* and *Arrhenatherum elatius* towards the end of the growing season under climatic conditions of Central Europe (Czech Republic) during three years of different weather behaviour. The obtained results were then used to assess the extension of the grazing period of the concerned grass species.

MATERIAL AND METHODS

Experimental locality and weather. The small-plot experiment was conducted in the Research Station of Fodder Crops in Vatín, Czech Republic (49°31'N, 15°58'E) and established in 2004 at the altitude of 560 m a.s.l. In 1970–2000, mean annual precipitation and mean annual temperature were 617 mm and 6.9°C, respectively. According to Walter (1957), weather conditions in the three experimental years (2004–2007) were as in Figure 1. In addition, Table 1 shows the number of days with the snow cover higher than 1 cm.

Experimental design. A split plot design was used with plots of 1.5 × 5 m. The plots were split according to species (SP) and pre-utilisation (PU, cut before utilisation in winter in the beginning of June or July) and harvest date (HD). The experiment was carried out in three independent replications. The plots were used in the same manner for a period of three years and the cumulative effects were measured. The first evaluated factor was species (SP) with the levels being *Festulolium* (*Festuca arundinacea* × *Lolium multiflorum*), cv.

Table 1. Sum of days with snow cover > 1 cm, temperatures below 5°C and below 0°C during the three years of the study

Month	2005			2006			2007		
	snow	temperatures		snow	temperatures		snow	temperatures	
	> 1 cm	< 5°C	< 0°C	> 1 cm	< 5°C	< 0°C	> 1 cm	< 5°C	< 0°C
October	0	7	0	0	2	0	1	11	0
November	12	23	13	2	15	3	21	27	18
December	25	31	19	1	25	13	21	30	20
Sum	37	61	32	3	42	16	43	68	38

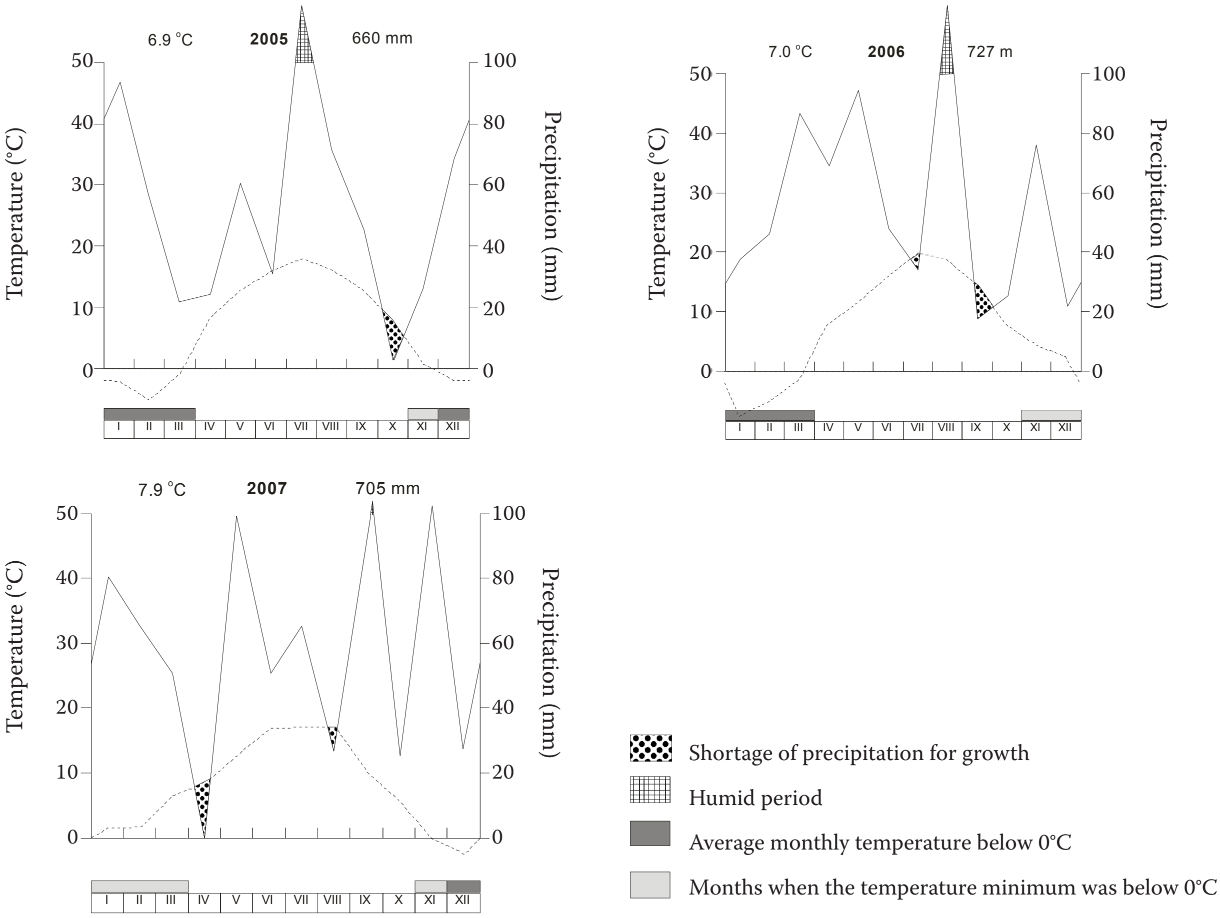

Figure 1. Temperature and precipitation at the Research Station Vatin, arranged according to Walter (1957). The growth is negative affected due to the lack of precipitation if monthly mean of temperature in °C exceeds the monthly rainfall in mm

Felina (FS), *Dactylis glomerata*, cv. Vega (DGS) and *Arrhenatherum elatius*, cv. Median (AES). The second evaluated factor was pre-utilisation (PU) with the levels being the first half of June (1PU) and the first half of June and the end of July (2PU). The third evaluated factor was harvest date (HD) with the levels being the beginning of October (OCT), the beginning of November (NOV) and the beginning of December (DEC). Soil type used in our experiments was Cambisol as a sandy-loam on the diluvium of biotic orthogenesis. Soil nutrient contents determined by Mehlich III method are given in Table 2. Experimental details are shown in

Table 2. Soil nutrients content in the observed years 2005–2007

Year	pH/KCl	P	K	Ca
		(mg/kg)		
2005	4.98	111	315	808
2006	4.88	100	200	785
2007	4.64	86	249	853

Zbíral (2002), whereas various methods for element extraction were recently compared (Kulhánek et al. 2009, Matula 2009). It follows from our results that P and K contents can be considered as high. The representative soil samples (blended sample from all replications) were collected at a depth of 20 cm.

Pure stands of each species were sown with 20 kg/ha seeds. Percentages of germinable seeds of *Festulolium*, *Dactylis glomerata* and *Arrhenatherum elatius* were 96%, 97% and 89%, respectively. The plots were treated with two weed clearance cuts upon the year of establishment including start fertilization before sowing. The experimental plots were fertilized with 50 kg/ha N (ammonium nitrite with limestone, 27% N), 30 kg/ha P (Hyperkorn, 26% P_2O_5 (11.3% P) + 3% MgO (1.8% Mg)) and 60 kg/ha K (60er Kali, 60% K_2O (49.8% K) in KCl) at the beginning of April in each experimental year. Dates of cuts are presented in Table 3. The plots were not cut in the period from December to June. The plots were harvested by the self-propelled mowing machine with an engagement of 1.25 m.

Table 3. Cutting dates in the observed years 2005–2007

Year	Pre-utilisation		Harvest date		
	June	July	October	November	December
2005	6.6.	27.7.	12.10.	4.11.	5.12.
2006	14.6.	25.7.	6.10.	1.11.	5.12.
2007	11.6.	25.7.	3.10.	1.11.	6.12.

The harvested area was 6.25 m^2. Stubble height was 7 cm. All harvested biomass was weighed.

Biomass chemical properties. Subsequently, the harvested biomass was prepared prior to the analysis of the following parameters. Dry matter weight was detected after drying of the biomass at 103°C. Moreover, the forage samples dried at 60°C and homogenized to a particle size of < 1 mm were analyzed for organic matter digestibility (OMD), crude protein content (CP), crude fiber content (CF) and neutral detergent fiber (NDF). The content of nutrients was determined according to the norm of the Czech Standards Institute (Anonymous 1997).

As to individual parameters of interest, OMD was detected in vitro by the pepsin-cellulase method. The samples were incubated anaerobically in the pepsin solution at 39°C for 24 h. Then, the sample was placed in the cellulase solution and incubated at the same temperature for 24 h. The CP content was determined with using Kjeltec 2300 (Foss, Denmark) and the CF content was determined by using the Fibre analyzer (ANKOM, USA). To determine CF, the samples were washed in petrolether, leached in 2000 ml of 0.255N H_2SO_4 at 100°C for 45 min and, after rinsing, the sample was leached in 2000 ml of 0.313N NaOH at 100°C for 45 min. In the end, the samples were immersed in acetone for 2–3 min. To detect the NDF content, the samples were kept in the analyzer with neutral detergent agent (solution of chelatone III, sodium tetraborate

Table 4. Sources of variations for DM, OMD, CP, CF and NDF in 2005–2007

Factor	*df*	DM		OMD		CP		CF		NDF	
		mean square	*F*-value	mean square	*F*-value	mean square	*F*-value	mean square	*F*-value	mean square	*F*-value
Species (SP)	2	3.5299	7.8801**	0.00134	2.2	4445	72.27**	6001	33.27**	6010	10.13**
Pre-utilisation (PU)	1	90.6266	202.3146**	0.05646	93.1**	32887	534.67**	91756	508.63**	311657	525.14**
Harvest date (HD)	2	11.2272	25.0636**	0.12803	211.2**	3659	59.49**	3738	20.72**	46133	77.73**
Year (Y)	2	28.0127	62.5354**	0.05515	91.0**	316	5.14**	6603	36.60**	3283	5.53**
SP × PU	2	0.8829	1.9710	0.00316	5.2**	673	10.94**	2872	15.92**	4501	7.58**
SP × HD	4	0.8180	1.8261	0.00459	7.6**	286	4.65**	1054	5.84**	509	0.86
PU × HD	2	4.5519	10.1616**	0.00651	10.7**	2183	35.49**	24	0.13	1009	1.70
SP × Y	4	1.0693	2.3872	0.00310	5.1**	480	7.80**	3372	18.69**	13216	22.27**
PU × Y	2	3.3761	7.5367**	0.01184	19.5**	423	6.88**	566	3.14*	2802	4.72*
HD × Y	4	0.3692	0.8242	0.01314	21.7**	188	3.06*	1660	9.20**	1433	2.41
SP × PU × HD	4	0.1533	0.3421	0.00037	0.6	149	2.43	117	0.65	351	0.59
SP × PU × Y	4	0.1380	0.3081	0.00152	2.5*	88	1.42	145	0.80	775	1.31
SP × HD × Y	8	0.2511	0.5606	0.00284	4.7**	40	0.64	295	1.64	711	1.20
PU × HD × Y	4	0.3248	0.7251	0.00030	0.5	149	2.42	1396	7.74**	4557	7.68**
SP × PU × HD × Y	8	0.0552	0.1232	0.00222	3.7**	19	0.30	258	1.43	668	1.13
Error	108	0.4479		0.00061		62		180		593	

*significant at 0.05 level of probability; **significant at 0.01 level of probability decahydrate, sodium hydrogen orthophosphate, sodium laurylsulphate and ethylenglycol modified to pH 6.9–7.1), sodium sulphite and stable alpha amylase for 75 min.

Statistical analyses. Results are expressed as a mean ± standard error (s.e.). The obtained results were further analyzed using the multi-factor analysis of variance (Snedecor and Cochran 1971) with a subsequent verification based on the Tukey Test. The data were processed using the STATISTICA. CZ Version 8.0 (Czech Republic).

RESULTS

We attempted to describe the results according to the parameter of interest. The results of multifactor analyses are presented in Table 4. The table includes the sources of variations for DM, OMD, CP, CF and NDF in 2005–2007. In 2005 and 2006, *Arrhenatherum elatius* produced significantly ($P < 0.05$ in 2005 and $P < 0.01$ in 2006) more DM than the other 2 species, independently of management (Tables 5 and 6). The highest determined value was 2.45 t/ha. In 2007, DM yields of the concerned grass species (SP) were similar (Table 7). However, they were lower in comparison with the previous years. The pre-utilisation (PU) had a highly significant ($P < 0.01$) influence on DM yields, whereas 1PU stands showed a higher DM production compared to 2PU stands. In addition, an early start of re-growth in summer or a delay in winter harvest had the expected effect of increasing DM yield for all species (no significant interactions). The influence of the harvest date (HD) was also considered due to the highly significant effects ($P < 0.01$) on DM yields in 2005 and 2007. The reduction of yields from October to December in 2006 was not significant thanks to average temperatures (Figure 1). The yields were significantly lower in 2007 compared to 2005 and 2006 (Table 8).

OMD was another parameter of interest. Over the treatments, *Dactylis glomerata* had the significantly lowest OMD in 2006 and lower OMD than *Arrhenatherum elatius* in 2007. The decline in OMD with the earlier start of re-growth was significant for *Festulolium* in 2005 and for all species in 2006 and 2007. A highly significant ($P < 0.01$) SP × PU interaction was observed in 2005 (Figure 2). The decline in OMD was caused by delayed winter harvest, being significant in all years. In 2006, OMD showed a particular decrease from October

Table 5. Effect of species (SP), pre-utilisation (PU) and harvest date (HD) on dry matter yields (t/ha), DOM, and contents of CP, CF and NDF (g/kg DM) in 2005

Factor	DM	OMD	CP	CF	NDF
Species (SP)					
FS	1.75^{a}	0.728^{ab}	75.4^{a}	253.6^{a}	561.0^{a}
DGS	1.69^{a}	0.704^{a}	91.7^{b}	275.2^{b}	565.9^{a}
AES	2.34^{b}	0.736^{b}	79.2^{a}	301.4^{c}	612.0^{b}
Significance	0.03986	0.0100	0.0000	0.0000	0.0002
s.e.	0.1895	0.0171	2.2501	4.5509	8.5121
Pre-utilisation (PU)					
1PU	2.74^{a}	0.715^{a}	71.1^{a}	303.9^{a}	629.0^{a}
2PU	1.11^{b}	0.730^{a}	93.1^{b}	249.5^{b}	530.3^{b}
Significance	0.0000	0.0703	0.0000	0.0000	0.0000
s.e.	0.1547	0.0140	1.8373	3.7158	6.9501
Harvest date (HD)					
OCT	2.39^{a}	0.773^{a}	91.1^{a}	277.6^{a}	565.8^{a}
NOV	2.07^{a}	0.758^{a}	79.9^{b}	278.8^{a}	567.8^{a}
DEC	1.32^{b}	0.636^{b}	75.2^{b}	273.7^{a}	605.3^{b}
Significance	0.0009	0.0000	0.0000	0.7135	0.0031
s.e.	0.1895	0.0092	2.2502	4.5509	8.5121
SP × PU × HD	0.8627	0.0325	0.3648	0.4533	0.5408

Mean values in the same column with different superscripts ($^{a, b, c}$) are significant at a level of $P < 0.05$. FS – *Festulolium*; DGS – *Dactylis glomerata*; AES – *Arrhenatherum elatius*; OCT – Beginning of October; NOV – Beginning of November; DEC – Beginning of December

Table 6. Effect of species (SP), pre-utilisation (PU) and harvest date (HD) on dry matter yields (t/ha), OMD, contents of CP, CF and NDF (g/kg DM) in 2006

Factor	DM	OMD	CP	CF	NDF
Species (SP)					
FS	1.66[a]	0.710[a]	75.1[a]	283.1[a]	605.1[a]
DGS	1.78[a]	0.730[a]	90.5[b]	303.3[b]	577.5[b]
AES	2.45[b]	0.718[a]	94.9[b]	302.5[b]	597.1[a]
Significance	0.0066	0.0999	0.0000	0.0000	0.0000
s.e.	0.1771	0.0066	2.2502	2.0881	3.3009
Pre-utilisation (PU)					
1PU	2.92[a]	0.684[a]	71.1[a]	319.7[a]	639.6[a]
2PU	1.01[b]	0.755[b]	102.5[b]	272.9[b]	546.6[b]
Significance	0.0000	0.0000	0.0000	0.0000	0.0000
s.e.	0.1446	0.0054	1.8373	1.7050	2.6952
Harvest date (HD)					
OCT	2.19[a]	0.768[a]	98.2[a]	283.2[a]	562.3[a]
NOV	2.09[a]	0.714[b]	82.0[b]	291.7[b]	582.1[b]
DEC	1.62[a]	0.676[c]	80.3[b]	314.0[c]	634.8[c]
Significance	0.0663	0.0000	0.0000	0.0000	0.0000
s.e.	0.1771	0.0066	2.2502	2.0881	3.3009
SP × PU × HD	0.9969	0.0683	0.6248	0.8048	0.0440

Mean values in the same column with different superscripts ([a, b, c]) are significant at a level of $P < 0.05$. FS – *Festulolium*; DGS – *Dactylis glomerata*; AES – *Arrhenatherum elatius*; OCT – Beginning of October; NOV – Beginning of November; DEC – Beginning of December

to November in *Arrhenatherum elatius* and a contrasting increase from November to December in *Dactylis glomerata*. The harvest date (HD) had a statistically highly significant influence ($P < 0.01$) on the OMD value. The OMD values were significantly higher in 2007 compared to 2005 and 2006.

The next parameter to explore was CP. In 2005, 2006 and 2007 *Festulolium* had the lowest CP (75.4, 75.1 and 71.1, respectively) while the highest CP values were recorded in *Dactylis glomerata* in 2005 and 2007 and in *Arrhenatherum elatius* in 2006. The CP content was higher in the 2PU stands compared to the 1PU stands. Moreover, pre-utilisation (PU) had a highly significant influence ($P < 0.01$) on the CP content. The decline in CP content with the earlier start of re-growth in summer was significantly steeper for *Arrhenatherum elatius* in comparison with other species. In 2006, while the decline in the CP content due to the delay in winter harvest was greater for *Festulolium* from October to November, it was reversed for *Arrhenatherum elatius* from November to December. The harvest date (HD) had a highly significant influence ($P < 0.01$) on CP. In 2006, the SP × HD interaction was significant ($P < 0.05$) (Figure 3). A significant difference in CP contents was determined between 2005 and 2006.

Over all treatments in 2005 and 2006, *Festulolium* had the significantly lowest CF. In 2005, CF in *Dactylis glomerata* was significantly lower than in *Arrhenatherum elatius* (301.4 g/kg). The 1PU stands had a higher CF content (from 303.9 to 319.7 g/kg DM) compared to 2PU stands (from 249.5 to 274.6 g/kg DM). The decline in the CF content with the delay in commencing re-growth in the autumn was greatest in *Arrhenatherum elatius*, significantly in 2006 and 2007. Also in these two years, the CF content of *Festulolium*, which was particularly low at the October harvest, increased significantly more rapidly than the content in the other species with the delayed winter harvest. In 2006 and 2007, a highly significant ($P < 0.01$) interaction between SP × HD was observed. The CF content was the lowest in 2005.

NDF was the final parameter of interest. In 2005 and 2006, *Festulolium* had a higher NDF than *Dactylis glomerata* but *Arrhenatherum elatius* had NDF significantly lowest in 2006 and highest in 2007. The 1PU stands showed a higher NDF content compared to 2PU stands. As for the CF content, *Arrhenatherum elatius* had a sharper fall of NDF with the delayed start to re-growth in summer than the other species in 2006 and 2007. *Festulolium* had a steeper rise in

Table 7. Effect of species (SP), pre-utilisation (PU) and harvest date (HD) on dry matter yields (t/ha), OMD, contents of CP, CF and NDF (g/kg DM) in 2007

Factor	DM	OMD	CP	CF	NDF
Species (SP)					
FS	0.78[a]	0.780[a]	71.1[a]	297.9[a]	610.5[a]
DGS	0.62[a]	0.769[b]	90.0[b]	294.9[a]	573.5[b]
AES	0.69[a]	0.780[a]	89.8[b]	293.4[a]	554.8[c]
Significance	0.4175	0.0030	0.0000	0.3648	0.0000
s.e.	0.0859	0.0025	1.6806	2.2349	3.9446
Pre-utilisation (PU)					
1PU	1.17[a]	0.763[a]	67.6[a]	316.1[a]	615.3[a]
2PU	0.23[b]	0.789[b]	99.6[b]	274.6[b]	543.9[b]
Significance	0.0000	0.0000	0.0000	0.0000	0.0000
s.e.	0.0702	0.0020	1.3722	1.8248	3.2207
Harvest date (HD)					
OCT	1.17[a]	0.804[a]	90.0[a]	283.3[a]	553.5[a]
NOV	0.78[b]	0.779[b]	86.0[a]	296.5[b]	574.9[b]
DEC	0.15[c]	0.745[c]	74.9[b]	306.4[c]	610.3[c]
Significance	0.0000	0.0000	0.0000	0.0000	0.0000
s.e.	0.0859	0.0025	1.6806	2.2349	3.9446
SP × PU × HD	0.9016	0.1622	0.3629	0.0398	0.7769

Mean values in the same column with different superscripts ([a, b, c]) are significant at a level of $P < 0.05$. FS – *Festulolium*; DGS – *Dactylis glomerata*; AES – *Arrhenatherum elatius*; OCT – Beginning of October; NOV – Beginning of November; DEC – Beginning of December

NDF in response to the delayed winter harvest in 2006. Pre-utilisation (PU) had a highly significant influence ($P < 0.01$) on the NDF content. The SP × PU interaction was significant ($P < 0.05$) in 2006 and highly significant ($P < 0.01$) in 2007. The harvest date (HD) had a highly significant influence ($P < 0.01$) on the NDF content, too. The NDF content was highest in 2006.

DISCUSSION

Based on the obtained results, the quality of forage made from the grass species of interest was affected by pre-utilisation (PU) and harvest date (HD) at the end of the growing season. A general statement can be made that swards with the preparatory cut in June (1PU) had biomass production higher than swards with the last preparatory cut in July (2PU) at the end of the growing season. The shorter time of grassland sparing reflected in a higher forage quality at the end of the growing season except for OMD in 2005, which relates to a considerable effect of climate. These general conclusions are also reported by other authors conducting similar experiments on different sites and grassland types (Opitz von Boberfeld and Wolf 2002, Wolf and Opitz von Boberfeld 2003, Hennessy et al. 2006, Opitz von Boberfeld et al. 2006). In spite of the fact that *Festulolium* had the lowest content of crude proteins (CP), it had also the lowest content of crude fibre (CF), mainly in October. Therefore, *Dactylis glomerata* and *Arrhenatherum elatius* had a higher CP content compared to *Festulolium*. Due to the low N fertilizer levels, the species that were developed for relatively intensive management conditions such as *Festulolium* had an extremely low CP content. This can be an effect of senescence and retranslocation of N into storage organs (Hejcman et al. 2010). Archer and Decker (1977) determined that the CP content in *Festuca arundinacea* was lower compared to *Dactylis glomerata* in the autumn. However, they considered the difference insignificant. On the other hand, our results presented in this study show a significant difference not only between *Festulolium* and *Dactylis glomerata* but also between *Festulolium* and *Arrhenatherum elatius*. A CP content of about 100 g/kg DM is necessary to meet the demand of pregnant suckling cows

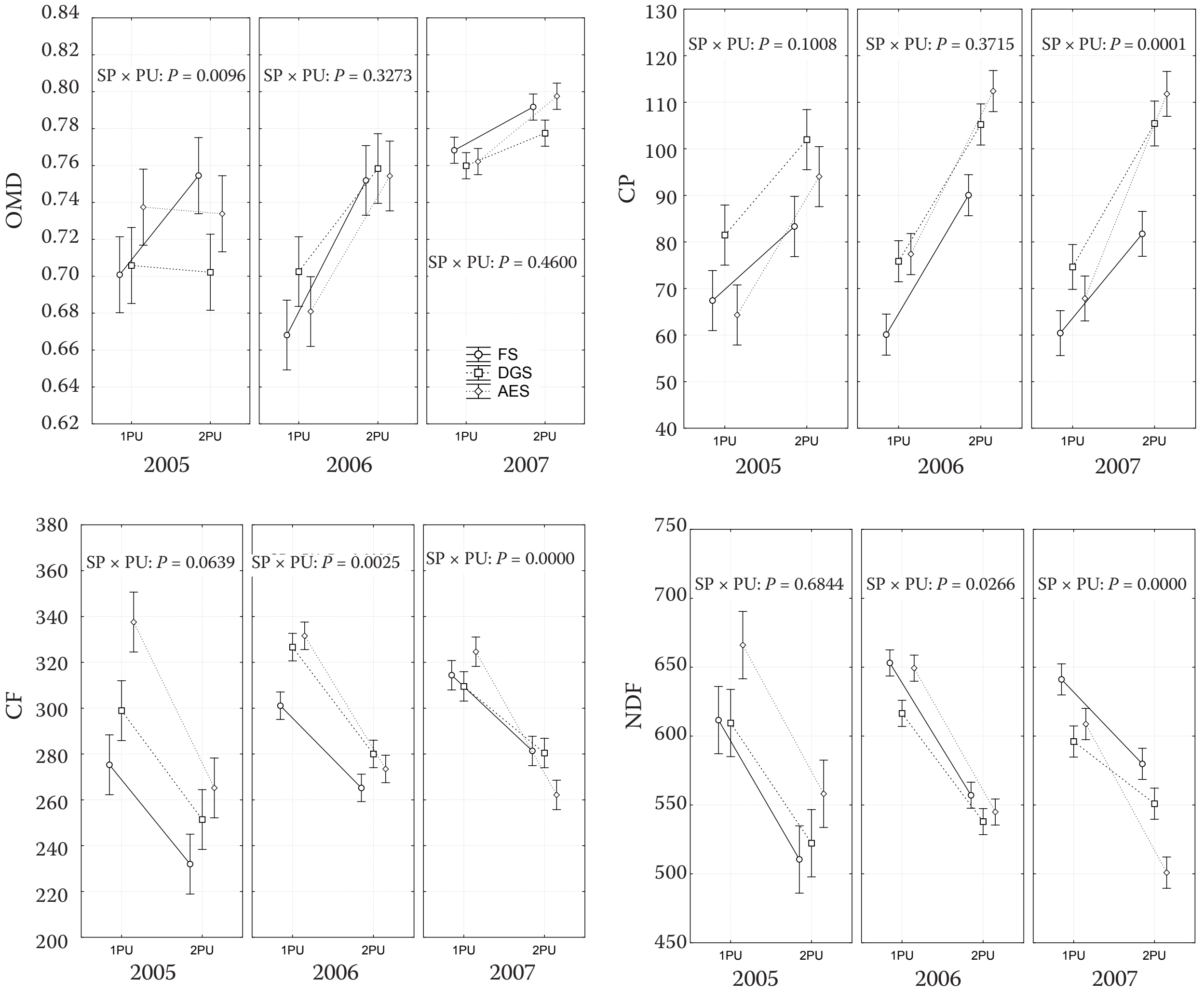

Figure 2. Interactions between species (SP) and pre-utilisation (PU) for OMD, content of CP, CF and NDF (g/kg DM) in 2005–2007. FS – *Festulolium*; DGS – *Dactylis glomerata*; AES – *Arrhenatherum elatius*

(Opitz von Boberfeld and Banzhaf 2006). *Dactylis glomerata* had a lower OMD than *Festulolium* and *Arrhenatherum elatius*. Prigge et al. (1999) observed digestibility in *Dactylis glomerata* lower than in *Festuca arundinacea* in winter. The higher silicon (Si) content in the forage of *Dactylis glomerata* reduced OMD. The insoluble form of Si creates a barrier to digestive enzymes (Kalač and Míka 1997). The lower OMD in the forage of *Dactylis glomerata*, particularly in the 2PU stands, can be explained also by the increasing Si content in older plants besides other factors.

The detected forage quality should be more exactly discussed in relation to weather conditions in the years of interest. Taylor and Templeton (1976), Archer and Decker (1977) or Baron et al. (2004) claim that the quality of green and dead material remains relatively constant in winter. Thus, the differences in forage quality result from the proportion of live and dead material in the forage. In October 2005, our grassland had insufficient moisture for a proper growth (Figure 1). Moreover, from the end of November it was under continuous snow cover. Forage quality was higher in *Festulolium* except for the CP content. The higher quality of *Festulolium* was apparent mainly in the 2PU stands. High OMD values were determined also in *Arrhenatherum elatius*. The year 2006 had a very warm end of the growing season (Table 1). The stand was under snow cover only for 3 days. DM yields were similar to previous years but this might have resulted from insufficient precipitation in September, which was crucial for DM yields at the end of the growing season. The decreased yields towards the end of the growing season can be explained by the senescence and decay of plant shoots (Wolf and Opitz von Boberfeld 2003). The warm autumn of that year might have slowed down the senescence.

Table 8. Effect of species (SP), pre-utilisation (PU), harvest date (HD) and year (Y) on dry matter yields (t/ha), OMD, contents of CP, CF and NDF (g/kg DM) in 2005–2007

Factor	DM	OMD	CP	CF	NDF
Species (SP)					
FS	1.40[a]	0.739	73.84[a]	278.20[a]	592.19[a]
DGS	1.37[a]	0.734	90.76[b]	291.15[b]	572.18[b]
AES	1.82[b]	0.744	87.96[b]	299.08[c]	587.98[a]
Pre-utilisation (PU)					
1PU	2.28[a]	0.721[a]	69.94[a]	313.28[a]	627.98[a]
2PU	0.78[b]	0.758[b]	98.43[b]	265.68[b]	540.26[b]
Harvest date (HD)					
OCT	1.92[a]	0.781[a]	93.08[a]	281.40[a]	560.55
NOV	1.64[a]	0.750[b]	82.66[b]	289.00[b]	574.97
DEC	1.03[b]	0.686[c]	76.83[c]	298.02[c]	616.82
Year (Y)					
2005	1.93[a]	0.722[a]	82.09[a]	276.72[a]	579.64[a]
2006	1.96[a]	0.719[a]	86.83[b]	296.32[b]	593.12[b]
2007	0.70[b]	0.776[b]	83.64[ab]	295.39[b]	579.59[a]

Mean values in the same column with different superscripts ([a, b,c]) are significant at a level of $P < 0.05$. FS – *Festulolium*; DGS – *Dactylis glomerata*; AES – *Arrhenatherum elatius*; OCT – Beginning of October; NOV – Beginning of November; DEC – Beginning of December

Festulolium showed apparently decreasing forage quality at the end of the growing season, increasing CF and NDF contents and decreasing OMD and CP content. Although the average quality of *Arrhenatherum elatius* did not differ much from that of *Dactylis glomerata*, *Arrhenatherum elatius* exhibited in December a higher CP content and a lower CF content. In December, *Dactylis glomerata* exhibited higher OMD and CF. OMD values observed in December 2005 and 2006 were comparable with the values reported by Wolf and Opitz von Boberfeld (2003) in Hessen (Germany). The year 2007 featured higher precipitation amounts at the end of the growing season. Similar to previous year, the yields decreased due to senescence. Thanks to snow cover and temperatures below zero, the stands rather dried out and the upright growth of studied species was curbed by the decay. Although the stand was not under continuous snow cover from November to the end of December, a snow layer (> 1 cm) covered it in these months for 43 days (Table 1). OMD was the highest of all three years of survey. The OMD values recorded in grasslands in the Czech Republic were comparable with OMD values reported by Hennessy et al. (2006) in Ireland. The OMD values of Hennessy et al. (2006) were determined by the in vitro method with using the rumen fluid, while we used the pepsin-cellulase method. Compared to the previous years, *Festulolium* had the highest NDF content while the NDF content in *Arrhenatherum elatius* was the lowest. In this context, it is interesting to see that *Dactylis glomerata* showed a similar NDF content in each year of the study. Forage quality of *Arrhenatherum elatius* surmounted in the third year and in the 2PU stands not only that of *Festulolium* but also *Dactylis glomerata*. Questionable is, however, a possible incidence of blights, which is higher in the fine-leaved *Arrhenatherum elatius* than in *Festulolium* (Skládanka et al. 2008). Weather and namely the year of the experiment are likely to influence yields and forage quality more than the cumulative effect. The contents of basic soil nutrients were similar during the experiment (Table 3). Despite an obvious decrease in pH and P content, deficiency of certain microelements during the experiment cannot be excluded.

Dry matter yields and forage quality of *Festulolium*, *Dactylis glomerata* and *Arrhenatherum elatius* were affected by pre-utilisation (PU) and by harvest date (HD). The decrease in standing biomass can be related to senescence. In addition, at low temperatures in November and December, much of the change in DM yields is likely to be due to death and decomposition. From October to December, leaf extension rate decreased and leaf senescence rate increased (Skládanka 2008). Although the CF content was low in *Festulolium*, the condition was

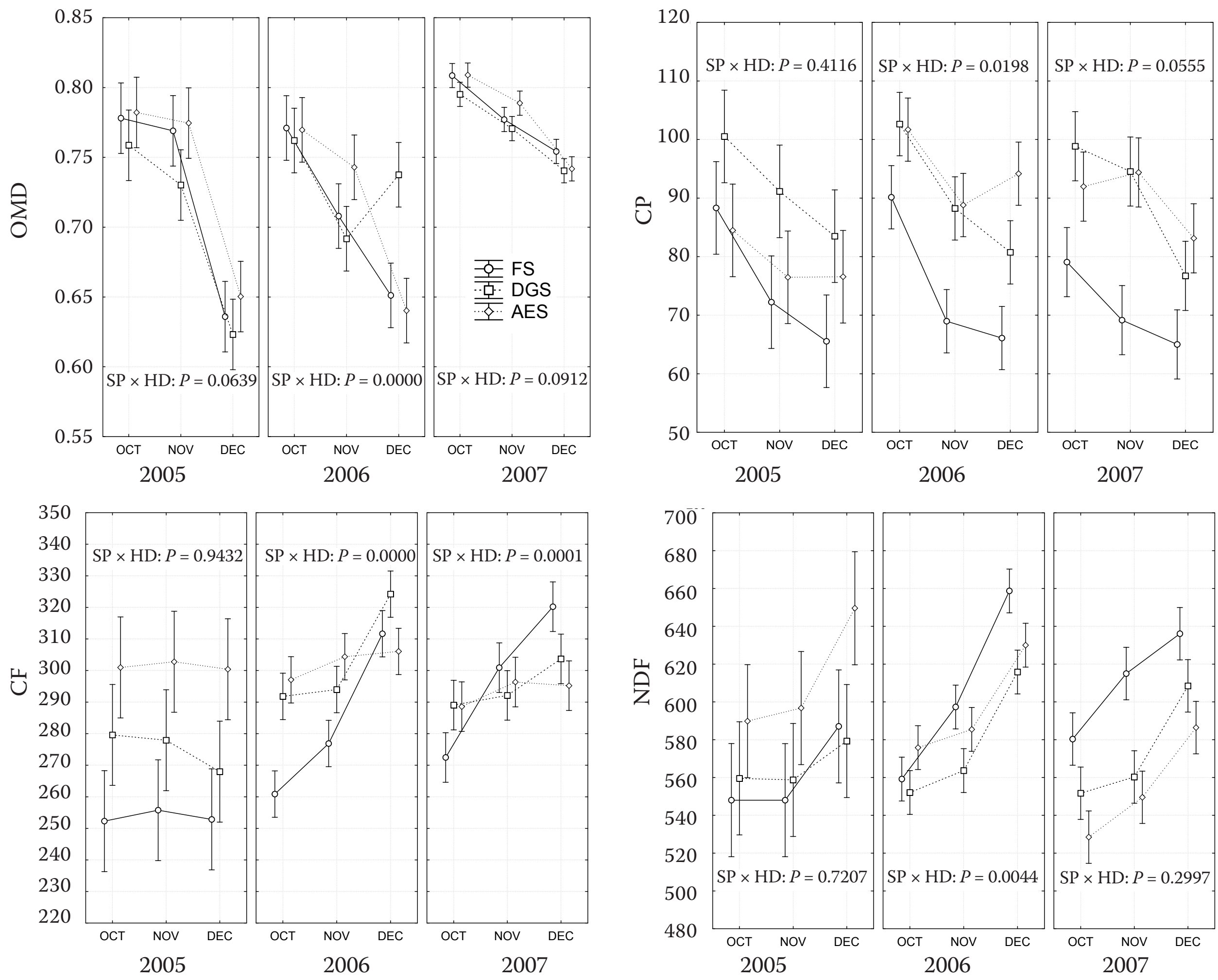

Figure 3. Interactions between species (SP) and harvest date (HD) for OMD, content of CP, CF and NDF (g/kg DM) in 2005–2007. FS – *Festulolium*; DGS – *Dactylis glomerata*; AES – *Arrhenatherum elatius*; OCT – Beginning of October; NOV – Beginning of November; DEC – Beginning of December

observed mainly in October. In December, the CF content became equable in the surveyed grass species or was even higher in *Festulolium*. The CP content was higher in *Arrhenatherum elatius* and *Dactylis glomerata*. OMD was higher in *Festulolium* and *Arrhenatherum elatius*. Based on the content of nutrients in question, none of the species can be unambiguously eliminated from being used for a possible extension of the grazing period. Higher quality of satisfactory yields was achieved in the 2PU stands. A short sparing of grasslands prior to their planned main use resulted in a similar forage quality of all concerned grass species and in a similar quality during the autumn. Therefore, it can be concluded that *Festulolium* and *Dactylis glomerata* can be used for extension of the grazing period also under continental weather. *Arrhenatherum elatius* retained sufficient quality not only during the drier and warmer end of the growing season but revealed itself as a high-quality species also in the 2PU stands at higher total precipitation amounts and higher number of days with the snow cover. In temperate environments where some growth occurs even in winter if the herbage mass is not too high at the outset, the herbage mass can accumulate until December. This is determined by the balance between leaf production and decomposition (Skládanka 2008). Questionable remains the persistence of *Arrhenatherum elatius*, which would have to be fostered by the alternate (cutting and grazing) use of the grassland. Effect of blights and the related occurrence of mycotoxins should be also considered. Climatic conditions of Central Europe fluctuate much more than the Atlantic climate. This reflects also in annual fluctuations of the quality of *Festulolium*, *Dactylis glomerata* and *Arrhenatherum elatius* forages. It follows from the research results that under climatic conditions of the Czech Republic the grazing period can be extended to the beginning of December.

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