Effect of different agronomical measures on yield and quality of autumn saved herbage during winter grazing – 1st communication: Yield and digestibility of organic matter

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ABSTRACT: The objective of this paper was to obtain information about the effect of interactions and different agronomical measures on autumn saved herbage of different sites in Central Europe (Czech Republic, Germany, Hungary, Poland). Within the different sites, the effect of the factors pre-utilisation (accumulation since June, July or August) and winter harvest date (November, December or January) on dry matter (DM) yield and digestibility of organic matter (DOM) was investigated over three consecutive years. All results were examined by analysis of variance and least-significance differences (LSD) were calculated (with $P < 0.05$). For all years, date of winter harvest was the most important source of variance. The highest yields were attained in November (varied from 2.3 to 0.8 t/ha), the lowest in January (from 1.5 to < 0.2 t/ha). The highest DOM concentration (from 70.4 to 52.4% of dry matter) was reached in November, and it decreased until January (from 59.6 to 35.2% of dry matter). Predominantly caused by the prevailing climatic conditions, the DM yields of the sites varied considerably during winter, showing a significance for the interaction winter harvest date × site as well as for the factor site. The utilisation of autumn saved herbage, pre-utilised in July, might be the best opportunity providing an adequate quantity and DOM for suckler cows until the end of the year, but the prevailing climatic conditions at different sites in Central Europe finally decide on the practicability of winter grazing.

Keywords: low-input grassland; winter grazing; suckler cow; forage quality; Central Europe

Competitive grassland systems, such as year-round outdoor stock keeping of suckler cows or beef cattle herds, became more important during the last years particularly for peripheral sites in Central Europe (Langholz, 1992; Opitz von Boberfeld, 1997; Möller et al., 2002). Thereby, the extension of the grazing period into late autumn and winter by using autumn saved herbage reduces the supply of cost intensive preserved forage such as silage or hay (Hughes, 1954; Boeker, 1957; Corbett, 1957; Deblitz et al., 1993; Freeze, 1999). Regarding the animal welfare during winter grazing, autumn saved herbage as the main pasture source has to provide the grazing livestock with an adequate supply of herbage mass and forage quality (Opitz von Boberfeld, 1997). Available knowledge about DM yield and DOM, as an important feature determining forage quality, is limited to findings from the USA (Taylor and Templeton, 1976; Balasko, 1977; Matches, 1979; Bartholomew et al., 1997), but due to the increasing importance of winter grazing systems, recent results from investigations in Central Germany were released by Opitz von Boberfeld and Wöhler (2002), Opitz von Boberfeld and Wolf (2002), Wolf (2002) and Wöhler (2003). DM yield and DOM of autumn saved herbage strongly depend on the length of the growing period before winter and the date of utilisation in winter (Gardner and Hunt, 1955; Gerrish et al., 1994), whereas the special climatic conditions during winter additionally influence the development of DM yield and DOM decisively (Baker at al., 1965; Balasko, 1977). A shorter growing period before winter utilisation improved DOM, but it led to lower DM yields at the same time (Opitz von Boberfeld and Wolf, 2002; Wolf and Opitz von Boberfeld, 2003). Wolf (2002) demonstrated a superior role of the winter-green species *Festuca arundinacea* for winter grazing in Central Germany. Furthermore, Wöhler (2003) demonstrated that autumn saved herbage based on the existing plant communities *Lolio-* or *Festuco-Cynosuretum* in peripheral sites of Central Germany produced sufficient DM yield and DOM for suckler cows or beef cattle until the end of the year. In the context of these results winter grazing could also be interesting for farmers in Poland, Hungary and in the Czech Republic (Golinski et al., 2003; Tasi et al., 2003; Skladanka, 2004), but knowledge about the effects of different agronomical measures under these climatic conditions is hardly available. Besides, some investigations revealed that under low-input conditions different sites conformed to similar DM productivity and forage quality during the growing season (Opitz von Boberfeld and Sterzenbach, 1999; Buchgraber and Pötsch, 2000) and in winter (Wöhler, 2003; Banzhaf, 2004). In this context an international project was established investigating the influence of pre-utilisation and date of winter harvest on DM yield and forage quality of autumn saved herbage at sites in the Czech Republic, Hungary and Poland compared to data from Central Germany. This paper presents the results concerning DM yield and DOM, the 2nd communication (Opitz von Boberfeld et al., 2006, in press) examines the results concerning crude protein, energy and ergosterol concentration.

MATERIAL AND METHODS

The trials were established in low-input pasture systems as randomised block designs with

Table 1. Site specific data

Site	Elkenroth I, Germany	Elkenroth II, Germany	Brody, Poland	Gödöllö, Hungary	Vatin, Czech Republic
Region	Lahn-Dill region	Lahn-Dill region	Wielkopolska region	Central Danubia	Bohemian-Moravian uplands
Altitude (m above sea level)	420	460	92	230	553
Mean annual temperature (°C)	6.7	6.7	8.0	11.5	6.1
Mean annual rainfall	1 160	1 160	587	583	736
Soil type	Cambisol	Stagnic Luvisol	Poorly mineralised Histosol	Dystric Cambisol	Stagnic Luvisol
pH (in 0.01 M$CaCl_2$)	5.3	4.5	6.5	3.9	5.6
P (mg/kg soil)*	27.9	14.8	240.0	62.5	7.8
K (mg/kg soil)*	50.6	66.4	116.2	239.0	102.9
Dominating species	*Holcus lanatus, Poa trivialis*	*Festuca rubra*	*Poa pratensis*	*Festuca arundinacea*	*Festuca rubra Elymus repens*

*available nutrients were determined according to the calcium acetate lactate (CAL) extraction method

Table 2. Days with snow cover from November to January in three years of observations

Month	Year 1			Year 2			Year 3			Average		
Site	XI.	XII.	I.	XI.	XII.	I.	XI.	XII.	I.	XI.	XII.	I.
Elkenroth, Germany	9	15	8	0	6	12	0	13	14	3.0	10.1	10.1
Brody, Poland	0	8	6	0	13	21	0	5	11	0.0	8.7	12.7
Gödöllö, Hungary	0	1	4	5	31	0	0	5	9	1.7	12.3	4.3
Vatin, Czech Republic	0	3	22	4	30	27	3	17	15	2.3	16.7	21.3

three replications at five different sites in Central Europe. Data describing site specific conditions and the dominating species are given in Table 1. The swards in Elkenroth I (Germany) and Brody (Poland) were classified as *Lolio-Cynosuretum*, Elkenroth II (Germany) as *Festuco-Cynosuretum* community. Vatin (Czech Republic) was *Festuco-Cynosuretum* as well, but had a higher proportion of different species of other plant communities. In Gödöllö (Hungary) the trial was established on a permanent *Festuca arundinacea* sward. In general, all examined swards were dominated by grass species at a proportion >80%. Simulating the deposition of excreta by grazing ruminants, each year all plots were fertilised with 50 kg N/ha in August. Table 2 shows weather conditions during the winter grazing period with regard to days with snow cover. As the snow cover never occurred in October, only the period from November to January of each year is presented. All trials were observed over three consecutive years. Besides the influence of the factor site, the other factors were: pre-utilisation (accumulation before utilisation in winter since the beginning of June, July or August) and date of winter harvest (beginning of November, mid-December or end of January). To determine DM yield, the plots were harvested at a standardised stubble height of 5 cm. The snow cover lasting during January of the year of observations one and three and December of year two in Gödöllö as well as during January of year one and two in Vatin made it impossible to do the harvest on schedule. Consequently, cuts on these variants were postponed to February and March, respectively. For analyses, samples from each plot were dried at 60°C and ground to pass a 1mm screen. DOM was estimated using the *in vitro* fermentation technique of the Hohenheim Gas Test (Anonymus, 1997) applying formula 41f (Menke and Steingass, 1987) including the variables rumen liquid and crude protein. All results including DM yield refer to 103°C and were examined by analysis of variance with $P < 0.05$ as the level of significance. At first, the sites were analysed separately, but as the residual errors of several sites did not differ significantly, the analysis of variance was done considering all sites by involving the factor site (Heyland and Kochs, 1978; Weber, 1986). Furthermore, least-significance differences ($LSD_{site/pre\text{-}utilisation/winter\ harvest\ date}$) at $P < 0.05$ were calculated. Generally, the years were observed separately to avoid interactions of higher order which would be difficult to interpret.

RESULTS

Dry matter yield

In all years the interaction winter harvest date × site was the most important interaction (Table 3); depending on the year, the DM yields of the different sites did not change uniformly during winter (Figure 1). In the first year the DM yields in Gödöllö and Vatin hardly changed with advancing winter, but at the other sites DM yields decreased significantly from November to January. While the interaction during the second winter was simply caused by different extents of decrease at the sites, different development of DM yields in Brody and Gödöllö in contrast to the other sites led to the significance of the interaction during the last year. The increase in DM production from December to January at the site Gödöllö can apparently be attributed to the delayed harvest date because of the lasting snow cover during that winter and therefore it is of no significance. In contrast to the results of the other sites, the factor pre-utilisation had no relevant effect on the DM yield in Gödöllö at several winter harvest dates, so that the interaction pre-utilisation × site occurred in the last two years. In all years, winter harvest date was the main source of variance for DM yields during winter (Table 3); the postponing of winter harvest caused lower DM yields. In some cases 90% of DM yield was lost between November

Table 3. Sources of variation for DM-yield and digestibility of organic matter during the three years of observations

Source of variance	Degrees of freedom	DM-yield Year 1 Mean square	DM-yield Year 1 *F*-test	DM-yield Year 2 Mean square	DM-yield Year 2 *F*-test	DM-yield Year 3 Mean square	DM-yield Year 3 *F*-test	Digestibility of organic matter Year 1 Mean square	Digestibility of organic matter Year 1 *F*-test	Digestibility of organic matter Year 2 Mean square	Digestibility of organic matter Year 2 *F*-test	Digestibility of organic matter Year 3 Mean square	Digestibility of organic matter Year 3 *F*-test
Block (over all sites)	10	40.31	**	23.38	**	15.80	**	16.58	*	8.10		12.17	**
Pre-utilisation (**P**)	2	460.51	**	980.96	**	1 029.71	**	139.16	**	357.32	**	512.65	**
Winter harvest (**W**)	2	836.59	**	1 676.21	**	950.38	**	2 046.42	**	937.38	**	828.18	**
Site (**S**)	4	367.01	**	503.97	**	236.94	**	1 043.19	**	1 112.65	**	179.97	**
P × W	4	11.97		22.93	*	26.43	**	7.87		8.11		13.92	*
P × S	8	13.15	*	28.58	**	92.98	**	16.54	*	17.69	**	25.64	**
W × S	8	86.65	**	140.11	**	299.44	**	87.65	**	125.39	**	65.88	**
P × W × S	16	7.12		17.67	**	30.23	**	16.68	**	23.18	**	8.87	*
Error	80	5.91		7.49		5.84		7.25		5.62		4.54	
Total	134												

*significant at 0.05 level of probability, **significant at 0.01 level of probability

and January. Depending on year and site, the impact of the factor pre-utilisation varied, but in the majority of cases the herbage saved since June reached the highest DM yields. The influence of the factor site was verified each year, but dependent on the year the ranking order of the sites regarding the DM productivity varied and could not be identified clearly. Furthermore, yields were frequently comparatively low (below 1 t/ha) in January so that differences between sites were predominantly relevant at the beginning of winter only.

Digestibility of organic matter

In most cases DOM decreased from November to January, but to a different extent depending on the site; therefore the interaction winter harvest date × site occurred in all years (Table 3 and Figure 2). While most variants, which were pre-utilised in August, frequently reached the highest DOM concentrations, this factor induced no significant effect at the site Vatin, so that the interaction pre-utilisation × site occurred in the last two years. In all years, winter harvest date was the main source of variance; the highest concentrations were determined in November, the lowest in January. Depending on the year, the impact of the factors site and pre-utilisation varied, but a significant effect was detected for all years. During the first two years of observations the factor site influenced DOM markedly because the herbage mass harvested in Vatin frequently contained the lowest concentrations. In contrast to all the other examined sites, these growths showed DOM concentrations clearly below 50% in December and January. Actually, the delayed harvest at this site caused by the lasting snow cover during these winters limited a comparison with the other results. The factor pre-utilisation was of greater importance in the last year; the growths saved since August mostly reached higher DOM concentrations than those pre-utilised in June or July.

DISCUSSION

Irrespective of the site and pre-utilisation DM yields of autumn saved herbage were mainly affected by the date of utilisation in winter (Figu-

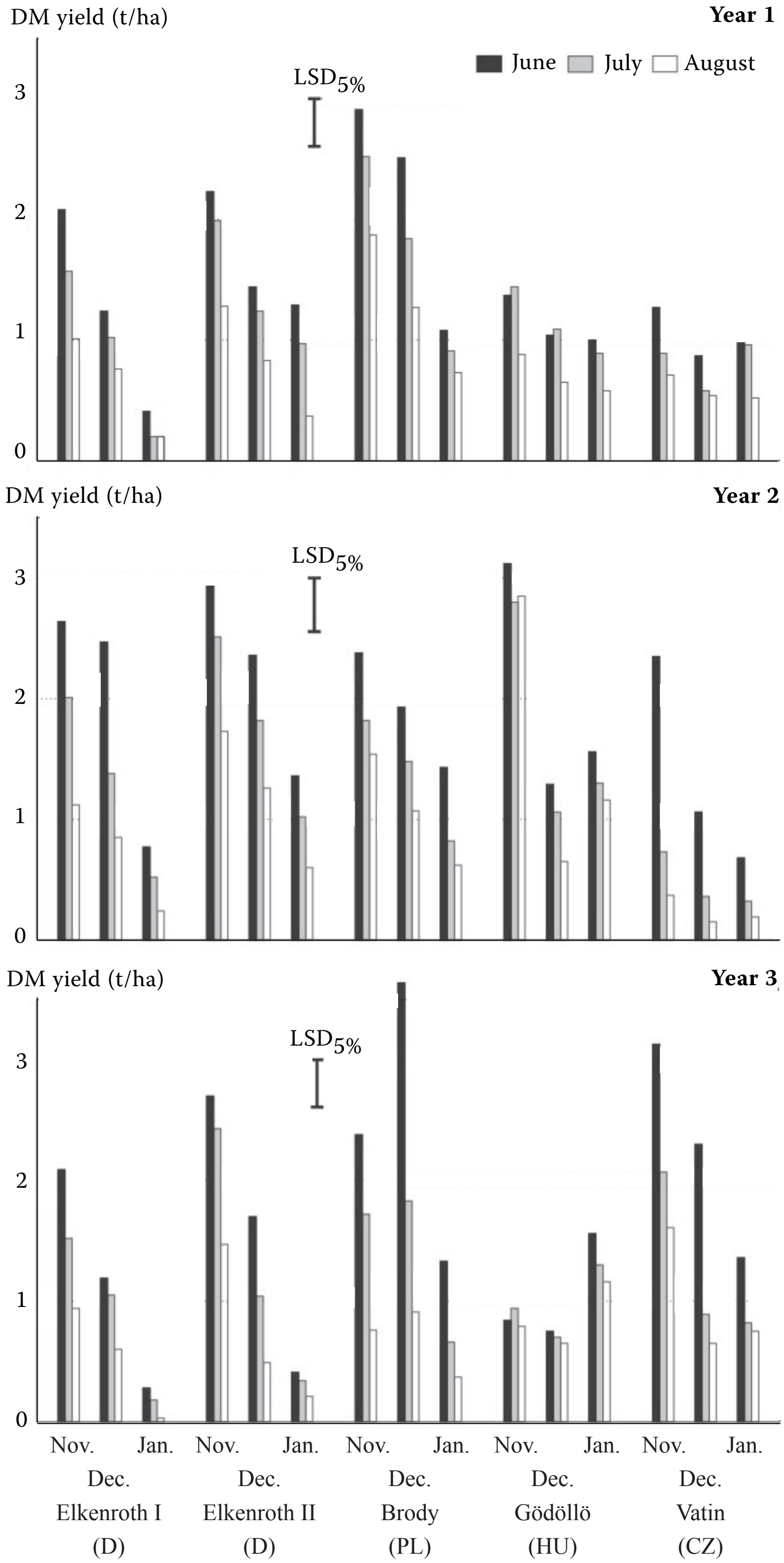

Figure 1. DM yield depending on pre-utilisation, winter harvest date and site

re 1). In accordance with observations from the northern part of the USA (Archer and Decker, 1977; Balasko, 1977; Fribourg and Bell, 1984) and recent results from Central Germany (Wolf, 2002; Wöhler, 2003) DM yields declined with advancing winter. The growths were affected by decomposition processes connected with senescence (Marschner, 1995) and unfavourable weather conditions during winter.

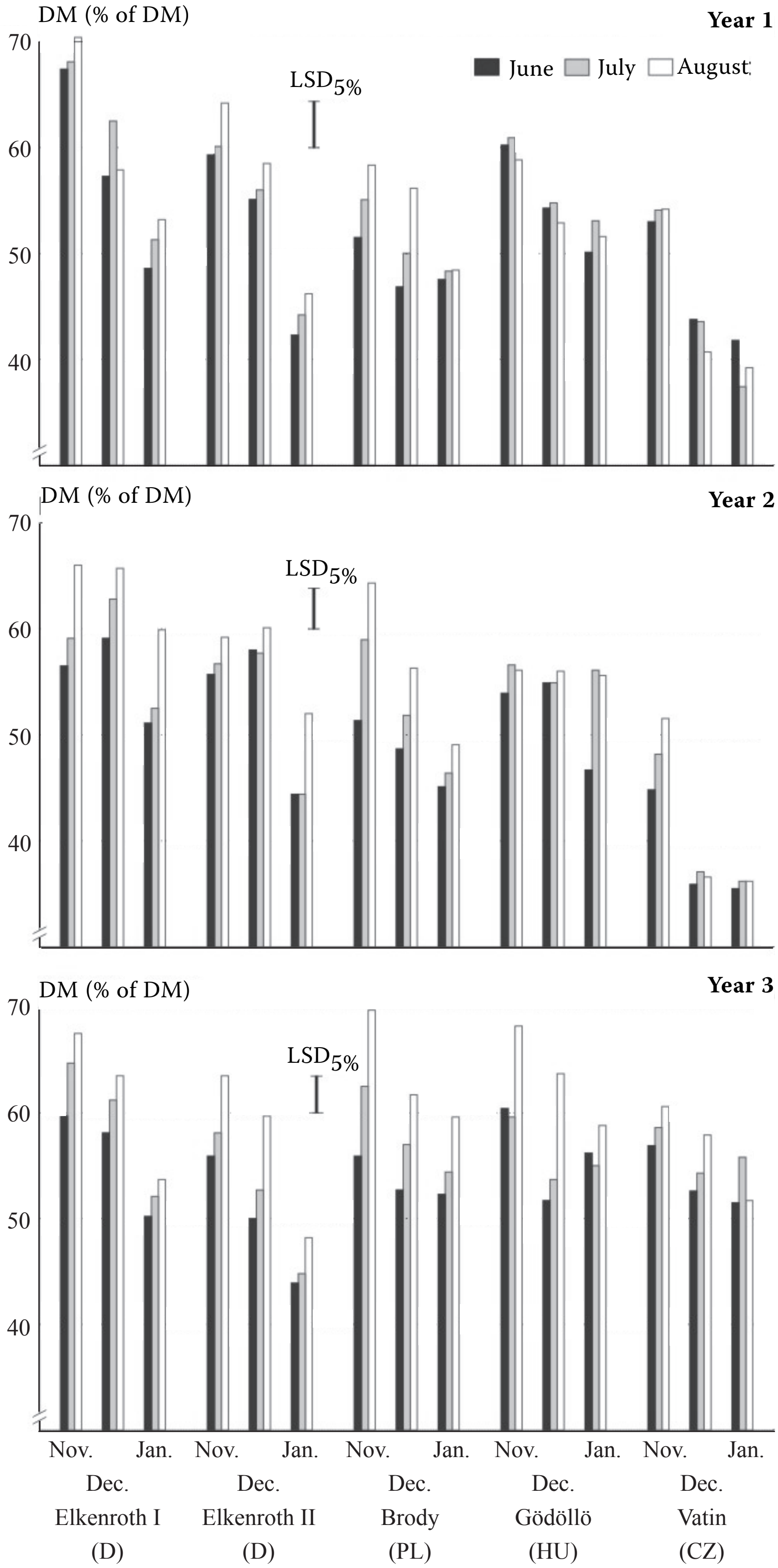

Figure 2. Digestibility of organic matter depending on pre-utilisation, winter harvest date and site

The great importance of winter weather conditions for yield and herbage quality was also described by Baker et al. (1965), Balasko (1977), Prigge et al. (1999), Wolf and Opitz von Boberfeld (2003), Wöhler (2003). Regarding the present results, the prevailing climatic conditions of the regions in Germany, Poland, Hungary and Czech Republic influenced DM decisively and were responsible for different dry matter productivity of the sites. The sites in Elkenroth and Brody were affected by rather a humid atmosphere with comparatively milder winter weather. In spite of the different altitudes of these sites, they showed similar dry matter productivity. The highest DM yields were attained in winters with favourable growing conditions until December (year two in Elkenroth, year one in Brody). Due to rather continental climate snow cover at the sites Gödöllö and Vatin can be expected already at the end of the year. Especially during the second winter the lasting snow layer in December inhibited the harvest (Table 2). Winter grazing was not possible at that time, which emphasises the decisive role of considering the site dependent prevailing weather conditions. Furthermore, the climatic conditions led to different changes in the DM yield level during winter, demonstrated by the significance of the interaction winter harvest date × site, but these differences were dependent on the year and occurred inconsistently. Generally, the conformable development of DM yields during winter caused by similar altitude or plant community could not be ascertained, obviously due to the low-input production system and greater importance of weather conditions (Opitz von Boberfeld and Wöhler, 2002; Wöhler, 2003). In agreement with Archer and Decker (1977), Balasko (1977) and Wöhler (2003) the tendency that a long growing period before winter resulted in the highest DM yields could be observed. The growths pre-utilised in August frequently produced DM yields below 1 t/ha for grazing ruminants already in November. The effect of pre-utilisation was predominantly observable at the beginning of winter, but it became significantly smaller as the winter advanced so that in January the effect of lower DM yields due to a later date of pre-utilisation was negligible.

The decline of DOM with later harvest date in winter (Figure 2) was also examined under the conditions of Central Germany by Opitz von Boberfeld and Wolf (2002). Obviously, the changes in DOM concentration in the herbage mass were caused by the increasing content of structural material with advancing maturity (Opitz von Boberfeld, 1994). Based on that process, the frequently higher DOM concentrations of the growths pre-utilised in August compared to those saved since June or July could also be explained by the comparably physiologically younger status of these variants. Furthermore, as stated by Wolf (2002) and Wöhler (2003) for Central Germany, the weather conditions during winter (mild or severe) were decisive for the extent of the decline. Different climatic conditions at the sites might have been the reason for the site dependent extents of decline. Especially during the severe second winter at the site in Vatin, the snow cover from December to the end of January led to a distinctive decrease in DOM concentration. Furthermore, only at this site did the factor pre-utilisation have no relevant effect. For a sufficient supply of grazing ruminants the autumn saved herbage should have at least 50% DOM of dry matter (Collins and Balasko, 1981). While the growths of most sites reached that value until the end of the year, the herbage harvested in Vatin contained insufficient DOM concentrations already in December. Even under consideration of the ability to select for herbage with higher nutritive value (Opitz von Boberfeld, 1994) and the individual differences between the particular grazing animals (Menke, 1987), the lasting snow layer as well as the inadequate DOM concentration would shorten the winter grazing period.

For all years and irrespective of the factors pre-utilisation and site, the date of winter harvest was the dominating effect for the development of DM yield as well as the DOM concentration during winter. In conclusion, the autumn saved herbage, pre-utilised in July, could provide an adequate quantity and DOM for suckler cows or beef cattle herds, but the prevailing climatic conditions, especially early snow cover, associated with a distinctive decrease in quality, enable the extension of the grazing period until the end of the year site dependently. This yearly varying fact as well as other examined quality aspects, presented in the second part of this paper (Opitz von Boberfeld et al., 2006, in press), have to be taken into consideration for the final estimation. So far, the use of preserved forage such as silage or hay has to be taken into account in regions with early and snow rich winters. In the case of stronger influences on the differentiation of vegetation cover (Hopkins and Hrabě, 2001; Klimeš et al., 2001) it seems to be suitable to apply the following treatment of pastures (especially the harvest of ungrazed patches).

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