Influence of growth stage of permanent grassland on DM yield, nutritive value, feed intake and milk yield of dairy cows during the whole period of vegetation

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Abstract

The impact of vegetative stage of permanent grassland on DM yield, cell wall content, sheep *in vivo* digestibility, *in situ* ruminal degradability as well as feed intake and yield of dairy cows was investigated for three consecutive years covering all three growths of the total vegetation period. Both the influence of growth number as well as the week of vegetation were statistically significant in all essential criteria. Regarding the parameters DM yield, cell wall content, feed intake and milk yield a significant interaction between growth number and week of vegetation was found, but this was not the case with digestibility and ruminal degradability. Hence there was a very close correlation between cell wall content and digestibility in the primary growth, but the relationship became weaker in the first regrowth and especially in the third growth. On average of the three growths, the DM yield increased from 1,808 to 4,812 kg ha^{-1} during 7 weeks of vegetation, the NDF content rose from 542 to 608 g $kg\ DM^{-1}$ and the digestibility of OM decreased from 77.3 to 63.8%. The forage intake was reduced from 12.9 to 11.3 kg DM and theoretical milk production from forage decreased from 13.4 to 6.7 kg.

Keywords: Meadow forage, vegetative stage, digestibility, feed intake, milk yield

Introduction

In meadow forage the vegetative stage of the various species is of outstanding influence on the nutritive value. The vegetative stage determines the proportion and the composition of the cell wall substances. Whereas the rumen microbes can degrade the fibre carbohydrates (cellulose, hemicellulose) to a certain degree depending on lignification, lignin itself is indigestible and the most significant factor limiting the availability of plant cell wall material to animal herbivores (Van Soest, 1994). The digestibility is reduced by both the cross-linking of the core lignin with hemicellulose and by penetrating the cellulose fibrils.

Materials and methods

In the present paper the impact of vegetative stage of permanent grassland on DM yield, nutrient and cell wall content, *in vivo* digestibility (using sheep), *in situ* ruminal degradability (nylon bag technique; Orskov and McDonald model, 1979) as well as feed intake and yield of dairy cows was investigated for three consecutive years covering all three growths of the total period of vegetation. The botanical composition of the grassland was 51% grasses, 21% legumes and 28% herbs. The experimental period of each growth lasted for 7 weeks. The forage was cut daily and directly fed to wethers and dairy cows in order to measure digestibility (continuous method), feed intake and milk yield potential of the forage. The chemical analyses were carried out according to conventional methods (VDLUFA, 1976; Goering and Van Soest, 1970; Mertens, 2000). The statistical model considered the fixed effects of year, growth number, week of vegetation and their interactions (Proc GLM of SAS, 2010).

Table 1: Experimental results (DM yield, nutrient and carbohydrate content, digestibility *in vivo*, degradability *in situ*, feed intake and milk yield)

Growth	**1st growth**							**2nd growth**							**3rd growth**						
Experimental week	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Yield (kg DM ha^{-1})	1692	2579	3439	4302	4842	5361	5782	1764	2586	3201	3860	4179	4686	4916	1968	2502	3068	3302	3625	3629	3739
Content of nutrients, cell walls and non-fibre-carbohydrates																					
Crude protein (g kg DM^{-1})	202	181	160	146	127	117	129	216	197	178	161	155	139	148	206	202	190	186	179	166	160
Crude fibre (g kg DM^{-1})	222	250	283	314	315	333	326	252	269	282	295	300	308	323	272	266	273	273	274	272	268
NDF (g kg DM^{-1})	521	562	572	620	615	633	623	537	545	555	596	603	619	620	568	561	575	592	564	572	558
ADF (g kg DM^{-1})	272	304	332	373	371	396	401	307	319	333	362	368	369	369	312	311	309	352	323	336	322
ADL (g kg DM^{-1})	29	30	33	40	44	47	50	42	44	48	48	53	52	52	36	32	37	44	40	43	42
NFC (g kg DM^{-1})	147	134	146	118	146	138	138	91	113	128	117	116	126	102	89	111	107	95	130	123	144
Digestibility, energy content and protein value																					
Organic matter (%)	78.2	78.1	72.6	70.4	68.5	64.9	60.8	75.8	74.8	72.3	70.8	68.4	67.3	62.9	78.0	75.9	74.6	73.4	70.7	68.3	67.7
NDF (%)	81.1	80.6	73.0	70.9	66.4	63.2	56.5	78.7	76.1	73.5	71.8	68.9	68.3	63.7	82.5	79.5	77.6	77.7	72.1	70.3	67.8
ADF (%)	76.8	77.2	71.2	69.6	65.1	62.9	56.9	74.0	72.3	69.8	69.0	65.7	63.8	59.1	77.7	75.2	71.9	73.9	67.8	66.3	63.1
Energy (MJ NEL kg DM^{-1})	6.44	6.44	5.89	5.66	5.48	5.12	4.78	6.05	5.95	5.71	5.65	5.39	5.33	4.84	6.31	6.17	6.00	5.90	5.65	5.34	5.30
Protein value (uCP, g kg DM^{-1})	146	143	133	128	122	115	111	143	139	133	130	125	122	116	146	143	139	137	132	125	123
Ruminal N-balance, g kg DM^{-1})	9.0	6.0	4.3	3.0	0.9	0.4	2.8	11.7	9.3	7.2	5.0	4.9	2.7	5.2	9.6	9.4	8.2	7.8	7.5	6.6	5.9
Degradability																					
a (% of DM)	31.5	31.2	28.3	28.4	26.2	27.5	25.3	27.6	26.8	26.9	26.0	26.6	25.7	21.7	26.3	24.6	24.6	27.0	24.6	27.1	27.2
b (% of DM)	54.5	53.8	53.5	51.7	52.7	47.3	47.0	52.8	53.2	51.8	52.8	51.8	48.0	50.5	53.6	56.4	55.9	54.9	54.8	52.1	47.9
c (% h^{-1})	8.61	5.78	6.20	5.37	4.62	4.22	4.25	7.33	7.07	5.63	4.82	5.39	3.89	4.72	6.68	5.30	4.45	4.24	4.87	4.82	5.92
Potential deg. (a + b, %)	86.0	84.9	81.8	80.1	78.9	74.9	72.3	80.4	80.0	78.6	78.8	78.4	73.7	72.2	79.9	81.0	80.5	81.9	79.4	79.2	75.0
Effective deg. k_p=0.02 (%)	74.2	70.6	67.7	65.2	61.6	59.2	57.1	67.6	67.2	64.0	62.7	63.3	56.7	56.1	66.1	63.8	61.9	62.6	62.2	62.7	60.8
Effective deg. k_p=0.05 (%)	63.4	59.4	56.5	54.0	49.4	48.6	46.7	56.5	56.3	52.7	51.0	51.9	45.7	44.6	54.8	50.8	48.7	49.7	49.5	50.6	49.4
Effective deg. k_p=0.08 (%)	56.5	53.1	50.2	47.8	43.1	43.3	41.5	49.9	49.7	46.4	44.8	45.7	40.3	38.6	48.3	43.7	42.0	43.2	42.8	44.2	43.2
Feed intake and milk yield																					
Forage (kg DM d^{-1})	13.34	12.70	12.86	12.06	12.32	11.52	10.66	12.44	12.87	12.53	12.48	12.48	11.61	11.20	12.80	12.95	13.03	12.78	13.01	12.48	12.02
Concentrate (kg DM d^{-1})	5.45	5.61	5.39	5.37	5.66	5.63	5.40	6.03	5.68	5.83	5.74	5.76	5.84	5.57	6.34	6.09	5.93	5.30	5.86	5.98	5.69
NDF intake (g kg LW^{-1})	13.2	13.2	13.2	13.2	13.5	12.9	11.8	12.8	13.1	13.0	13.5	13.7	12.8	12.5	14.0	13.8	14.0	13.8	13.5	13.2	12.3
Energy (MJ NEL d^{-1})	129.1	125.9	120.3	113.1	115.2	107.3	98.5	123.0	122.0	118.8	117.1	114.8	110.3	101.6	129.9	127.5	125.2	117.9	121.3	116.4	111.0
Milk yield (kg d^{-1})	25.6	25.0	23.8	22.4	21.3	19.5	18.1	24.4	24.6	23.6	22.1	21.3	20.2	19.3	25.0	24.6	24.8	23.1	22.5	21.3	20.3
ECM yield (kg d^{-1})	25.9	25.0	24.1	22.9	21.4	19.7	18.1	23.9	25.0	23.6	21.9	20.9	20.2	19.1	25.6	25.4	25.5	23.9	23.5	22.5	21.2
Milk fat content (%)	4.21	4.10	4.23	4.31	4.20	4.21	4.14	3.97	4.19	4.14	4.08	4.07	4.13	4.10	4.27	4.35	4.31	4.31	4.41	4.45	4.39
Milk protein content (%)	3.28	3.31	3.31	3.25	3.23	3.28	3.29	3.28	3.33	3.27	3.24	3.25	3.28	3.28	3.38	3.38	3.35	3.44	3.45	3.52	3.57
Milk prod. pot. Forage (kg d^{-1})	15.1	13.6	12.3	10.1	10.0	7.7	5.4	11.8	12.3	10.9	10.6	9.8	8.1	6.1	13.4	13.2	12.8	12.1	11.7	9.8	8.7
Milk prod. pot. Total (kg d^{-1})	28.8	27.8	25.9	23.6	24.3	21.8	19.0	26.9	26.6	25.5	25.0	24.3	22.8	20.1	29.3	28.4	27.7	25.5	26.4	24.8	23.0

Results and discussion

Both the influence of growth number as well as the week of vegetation was statistically significant in all essential criteria. The results regarding the interaction growth number × week of vegetation are presented in table 1. Concerning the parameters of dry matter (DM) yield, cell wall content (NDF, ADF, ADL), feed intake and milk yield a significant interaction between growth number and week of vegetation was found, but this was not the case with digestibility and ruminal degradability.

On average of weeks of vegetation, the DM yield decreased with number of growth (4000, 3599, 3119 kg DM ha^{-1} in growth 1, 2 and 3). As a mean of all growths, the DM yield increased from 1808 to 4812 kg ha^{-1} during 7 weeks of vegetation, but increase of yield was much higher in growth 1 than in growth 2 and especially in growth 3. The daily growth decreased from 138 to 43 kg DM ha^{-1} in growth 1, from 123 to 38 kg DM ha^{-1} in growth 2 and from 97 to 0 kg DM ha^{-1} in growth 3. Similar growth characteristics and levels of DM yield on comparable sites have been reported by Caputa (1966) and Gruber et al. (2000). The growth characteristics for ryegrass (*Lolium perenne*) were modelled by Taube (1990). Obviously the yield and the growth characteristics in (permanent) grassland are a reflection of the climatic (and further) growing conditions, especially light intensity and temperature.

On average, the NDF content increased from 542 to 608 g kg DM^{-1} and the digestibility of OM decreased from 77.3 to 63.8%. But cell wall content and digestibility as well as degradability developed in a quite different manner in the various growths. The cell wall content (crude fibre, NDF, ADF) increased very intensively during the 7 weeks of vegetation in the primary growth and the first regrowth (ca. 530 to 620 g NDF kg DM^{-1}), but was nearly the same in all 7 weeks of growth 3 (on average 570 g NDF kg DM^{-1}). Regarding ADL, growth 2 showed a significant higher content than the two other growths (39, 48, 39 g ADL kg DM^{-1}) and its relativ proportion to NDF was constantly high (8%) during the whole 2^{nd} growth. This higher ADL level in growth 2 is caused by the higher temperatures during the summer season (Van Soest et al., 1978). The increase of cell wall content during vegetation is well documented in various feed tables (e.g. INRA, 1989 and 2007; DLG, 1997; NRC, 2001). On the other hand, digestibility and degradability decreased in all 3 growths in a similar manner, on average from 77.3 to 63.8% during 7 weeks. This means that there was a very close correlation between cell wall content and digestibility in the primary growth, but the relationship became weaker in the first regrowth and especially in the third growth. Similar to digestibility, the forage intake was reduced from 12.9 to 11.3 kg DM and theoretical milk production from forage (according to NEL supply) decreased from 13.4 to 6.7 kg.

The impact of vegetative stage of meadow forage on digestibility and nutritive value in the broader sense is well documented in literature and was intensively studied all over the world in the past decades (Van Soest, 1967 and 1994; Burns, 2008). The decrease of digestibility during vegetation is on the one hand caused by dramatic morphological changes, i.e. stem to leaf-ratio, and on the other hand by the extensive lignification of the plant cell walls (Jung and Fahey, 1995). This lignification constrains the physical access of hydrolytic enzymes to cell wall polysaccharides due to steric hindrance and – as its consequence – the cell wall degradation (Jung and Deetz, 1993). A more detailed description of the experimental procedures and results as well as the list of references can be found in Gruber et al. (2010).

References

Gruber L., Schauer A., Häusler J., Adelwöhrer A., Südekum K.-H., Wielscher F., Urdl M. and Kirchhof S. (2010) Einfluss des Wachstumsstadiums von Dauerwiesenfutter auf Ertrag, Futterwert, Futteraufnahme und Leistung bei Milchkühen im Laufe einer ganzen Vegetationsperiode. 122. VDLUFA-Kongress Kiel, 21.-24. September 2010, Kongress-Band, 633-671.