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Sward and milk production response to early turnout of dairy cows to pasture in Finland

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The timing of turnout is an important factor affecting the grazing management of dairy cows. However, its consequences are not well known in the short grazing season of northern Europe. Thus, the effect of the turnout date of dairy cows to pasture on sward regrowth, herbage mass production and milk production was studied in two experiments, 1) a grazing trial with 16 Holstein-Friesian dairy cows and 2) a plot trial where the treatments simulated the grazing trial. The treatments were early turnout (1 June) and normal turnout (6 June). Early turnout decreased the annual herbage mass (HM) production in the plot trial ($P = 0.005$), but due to a higher average organic matter (OM) digestibility ($P < 0.001$) the difference in digestible OM yield was not significant ($P = 0.14$). Similarly, early turnout decreased the mean pre-grazing HM in the grazing trial. The differences in HM quantity and quality between early and normal turnout occurred mainly in late June and early July and thereafter levelled out. Average post-grazing sward heights were lower for early turnout, indicating better HM utilization. There were no differences in yields of milk, milk fat or milk protein ($P > 0.05$). Although early turnout had no effect on milk yields it meant easier management of pastures.

Key words: dairy cows, *Festuca pratensis*, grazing, meadow fescue, milk production, *Phleum pratense*, timothy

Introduction

The timing of turnout is an important factor in the grazing management of dairy cows (Baker and Leaver 1986, Sayers and Mayne 2001). The general belief concerning the effect of the turnout date of cows is that if it is delayed, the herbage accumulates faster than the rate at which the animals can harvest it. This increases the proportion of generative tillers and dead material accumulating. Consequently, the feeding value of the grass decreases and the proportion of rejected areas increases. If the herbage mass (HM) values are high before defoliation, the leaf area index (LAI) will be high, which will lower the

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formation of new tillers which in turn will lower the regrowth ability of the sward (e.g. Baker and Leaver 1986). These aspects indicate that, in general, early turnout is advantageous in grazing management. However, too early turnout will require additional feeds to cows and it may lead to lowered dry matter (DM) production over the whole season. If tiller density increases, compensating for the lower tiller weight, the drop in grass production may not be serious (e.g. perennial ryegrass (*Lolium perenne* L.) and smooth meadow grass (*Poa prantensis* L.) pastures (Baker and Leaver 1986, Frankow-Lindberg 1989).

The growing season in the northernmost parts of Europe is short. For example, in Central Finland the growing season begins normally in early May and ends at the end of September – early October. Thus the length of the growing season is only 143–150 d. The frost-free period is even shorter, ranging from early June to end of August (Mukula and Rantanen 1987). Consequently, the duration of the grazing period is typically only 120 d (Pulli 1992). However, the rate of grass DM production at northern latitudes is relatively high due to long days and rapid reproductive development. In early summer the concentration of digestible organic matter concentration in DM (D value) of herbage decreases rapidly at high latitudes compared to areas of lower latitudes (daily decrease in D value at high latitudes 4.8–6.5 g kg^{-1} d^{-1}, Deinum et al. 1981; 3.9–5.7 g kg^{-1} d^{-1}, Rinne 2001). The physiological development of grass is also faster and the switch from vegetative to generative growth commences earlier (Virkajärvi and Järvenranta 2001). Furthermore, timothy (*Phleum pratense* L.) and meadow fescue (*Festuca pratensis* Huds.), the two most common grass species in North-East Europe, have both lower tiller production and regrowth ability than e.g. perennial ryegrass (Ryle 1964). Due to these differences, on northern timothy – meadow fescue pastures the importance and consequences of early turnout of cows may be different to those reported with perennial ryegrass in other parts of Europe.

The study was conducted to compare the effects of two different turnout times on the growth and nutritive value of the grass and on the daily milk production. The second aim was to find out the effect of the initial harvest date on the regrowth properties of timothy – meadow fescue pastures throughout the season.

Material and methods

Treatments, experimental design and procedures

The study was carried out at MTT Agrifood Research Finland, North Savo Research Station (63°10’N, 27°18’E), Maaninka, Finland, in 1997. The soil type was fine sand. The experimental fields were sown in the previous year (1996) with a mixture of timothy, cv. Tarmo (12 kg ha^{-1}) and meadow fescue, cv. Kalevi (10 kg ha^{-1}) with oats as a cover crop (90 kg ha^{-1}). The study consisted of two experiments: 1) a grazing trial with dairy cows and 2) a plot trial where treatments simulated certain paddocks of the grazing trial.

Grazing trial. Sixteen multiparous, Holstein-Friesian cows were allocated to eight blocks according to milk yield and calving date, and the treatments were randomly assigned to each cow within a block (eight cows per treatment). Four fields were divided into two areas of equal size, which were then randomised within fields to treatments. Both groups (no replicates) were strip-grazed through the four fields. The cows were mid and late lactating, on average 203 days in milk (± 64.8 SD) at the start of the experiment. The mean pre-experimental milk yield was 24.2 (± 3.60 SD) kg day^{-1} and mean live weight (LW) 615 (± 43.6 SD) kg.

The treatments in the grazing trial were early turnout (T_E) and normal turnout (T_N). The T_E date was assessed as the first possible day (HM 200 kg DM ha^{-1} >5 cm). The T_N date was adjusted according to the average turnout date in 1997 in the North Savo region (HM 900 kg DM ha^{-1} >5 cm). The T_E and T_N turnout dates were 1 June and 6 June, respectively. The experiment continued until the end of the grazing season (6 September). The experiment consisted of three periods, 1 June to 4 July (Period 1), 5 July to 31 July (Period 2) and 1 August to 6 September (Period 3). In June, treatment T_E used 0.19 ha per cow and treatment T_N 0.18 ha per cow. The rest was harvested as big bale silage which was fed as buffer feed during pasture shortage in July. The total area requirement was 0.28 ha per cow during the entire grazing season. Pastures were fertilized three times during the growing season, the total amounts of N, P and K were 196, 22 and 12 kg ha^{-1} year^{-1}, respectively. The paddocks were topped when needed (once or twice during grazing season) after grazing.

The cows were offered good quality grass silage *ad libitum* before turnout. The amounts of silage and concentrate given were reduced gradually during the transition period (outdoors) which lasted 11 days for treatment T_E and 6 days for treatment T_N. The transition periods were included in the experiment. After the transition period the cows were supplemented with 0.75 kg of concentrate (composed of 467 g kg^{-1} wheat bran, 333 g kg^{-1} molassed beet pulp and 200 g kg^{-1} sunflower oil) and minerals (300 g d^{-1}, 75 Ca, 40 P, 56 Mg, 51 Na g kg^{-1}). After the transition period the cows were allowed to graze approximately 19 h d^{-1}. Daily pre-grazing HM was in each treatment estimated by cutting two independent sets of grass samples on the next area to be grazed. Each set consisted of 7 randomly located squares (25 x 100 cm), cut above a stubble height of 5 cm. Each set was bulked, weighed and dried at 105°C for 20 h. The mean and the standard error of the two bulked samples were calculated. A daily strip grazing system was used with a front and back fence with a herbage allowance (HA) of 23 kg DM d^{-1} cow^{-1} (>5cm) in June and 21 kg DM d^{-1} cow^{-1} in July and August for both treatments.

Sward height (SH) was measured by a 'Sward Stick' (Bircham 1981) at 50 random points per strip and classified as frequently grazed, infrequently grazed and lodged or trampled vegetation. Grass samples for chemical composition were collected for each treatment by cutting 10 to 20 sub-samples to 5 cm once a week. The samples collected from each strip were stored frozen (–23°C) and then oven-dried at 60°C for 24 h for analyses. The DM content of the grass was determined by drying the samples at 105°C for 20 h. The organic matter (OM) content was determined by ashing at 600°C for 12 h, nitrogen (Kjeldahl-N) by the AOAC (1990) method and *in vitro* OM digestibility (IVOMD) by the cellulase method (modification of Friedel and Poppe 1990). The D value of the grass (digestible organic matter in DM g kg^{-1}) was calculated based on ash and IVOMD analyses.

The cows were milked indoors at 0700 and 1600. Milk yields were recorded daily and the average of each period for each cow was used in the statistical analyses. Pooled samples from six consecutive milkings at the end of each period were analysed for fat and protein content using an infrared milk analyser (Milcoscan 605).

The plot trial was conducted simultaneously with the grazing trial using a plot size of 10 m^2 and four replicates. Four initial cutting dates (3 June ($T_{E–A}$), 6 June ($T_{N–A}$), 13 June ($T_{E–B}$) and 24 June ($T_{N–B}$)) were imposed as treatments. Treatment $T_{E–A}$ represented the second strip of the first rotation of T_E in the grazing trial and treatment $T_{E–B}$ the last strip of the first rotation of T_E. Similarly $T_{N–A}$ and $T_{N–B}$ represented the first and last strip of the first rotation of group T_N. This means that these plots were cut simultaneously whenever the animals entered these strips. Likewise, the plots were fertilized on the same days as the corresponding strips. During the first rotation, the treatment effect was solely due to initial cutting date. However, when counting the results over the whole season, the effect of the four treatments can be divided into two factors, i.e. turnout date (T_E and T_N) and date of initial cut. Thus term 'treatment effect' is used when both effects are concerned and the 'effect of initial cutting date' for the results of the first rotation. To make it easier to compare the results with the grazing trial, average values over $T_{E–A}$ and $T_{E–B}$ were calculated to represent treatment T_E. Similarly, averages over treatments $T_{N–A}$ and $T_{N–B}$ were calculated to represent treatment T_N.

Prior to harvesting the phenological development stage was assessed from bulked samples of 80 tillers (20 per replicate). The tillers were classified according to Simon and Park (1981) and then oven-dried at 105°C for 20 h and the mean stage by weight (MSW) was calculated. Herbage mass was determined by cutting the plots to a stubble height of 7 cm using a Haldrup 1500 plot harvester. The HM samples were analysed for DM content by oven-drying the samples (2 x 200 g) at 100°C for 20 h. Sub-samples (300 g) were taken to separate live and dead herbage fractions, which were oven-dried at 60°C for 40 h. The live fractions were analysed for chemical composition as in the case of the grazing trial.

The pre- and post-harvest LAI of the canopy was measured at 9 points within a plot using a LICOR-2000 canopy analyser (LI-COR Inc., Lincoln, Nebraska, USA). At each point a reading consisted of one measurement above canopy and four in-line measurements beneath the canopy with 10 cm distances and a view cap of 180°. To asses the regrowth rate, LAI was measured again 3, 6 and 10 d after defoliation.

Tiller density was determined three times during the season (June, July and August) counting generative and vegetative tillers from four 10 cm x 10 cm samples per plot. A tiller was classified as generative when the first node was discernible. The number of tillers included timothy, meadow fescue and *Agropyron repens,* but the number of *Poa* sp. was counted separately. The concentration of water-soluble carbohydrates (WSC; g kg^{-1} DM) was determined from separate grass samples which were taken from each treatment on the initial cutting day, each time at 0830–0900. The samples consisted of three 10 cm x 10 cm sub-samples per plot from replicates 1–3. The tillers were excavated and put immediately into an icebox. In the laboratory the samples were cut to a stubble height of 4 cm and roots to a length of 1 cm. Attached leaves were included in the samples. The samples were freeze-dried. After water extraction, carbohydrates were analyzed by HPLC (Ag2+ column, RI detector, + 30°C, flow rate 0.6 ml min^{-1}). The water-soluble carbohydrate pool (g WSC m^{-2}) was calculated based on stubble DM (g m^{-2}) and WSC content in DM.

Soil moisture was measured at three points of the experimental area. At each point, one gypsum block (Model 5201, Soilmoisture Equipment Corporation, Santa Barbara, Ca., USA) was located at a depth of 20 cm and another at 40 cm. The gypsum blocks were read twice a week. Weather data were recorded at a meteorological station near the experimental fields.

Statistical analyses

In the grazing trial, both herbage data and animal data were divided into three periods according to sward properties and changes in grazing management. For sward data means and standard errors were calculated. The animal production data were analysed using the analysis of variance and milk yields prior to the experiment as covariates. The mean values of cows over periods were used as observations. The analysis was carried out according to the following model:

$$y_{ijk} = \mu + \text{Comilk}_i + \text{Cow}_i + \text{Period}_j + \text{Treatment}_k + \text{Period} \times \text{Treatment} + E_{ijk}$$

where μ is the overall mean, Comilk is the milk yield of an individual cow prior to the experiment, Cow is the random effect of the cow, Tr and Period are the fixed effects of the turnout date and the period, respectively, and Period x Tr is the interaction of the period and the treatment. E_{ijk} is an error term.

In the plot trial the sward variables in the first cut, regrowth after first cut and annual HM production were analysed using the analysis of variance in a randomised complete block design. When appropriate, the differences between treatment means were tested using Tukey's procedure. The effect of turnout day (T_E and T_N) was analysed by contrast statement (T_{E-A} and T_{E-B} vs. T_{N-A} and T_{N-B}). The tiller population density was analysed in a randomised complete block design

Table 1. Monthly mean temperature, precipitation and evaporation during the growing season 1997 and corresponding long-term averages.

	Year	May	Jun	Jul	Aug	Sep	Sum
Temperature (°C)	1997	6.0	15.6	18.7	16.4	9.8	
	1961–1990	8.5	14.2	16.2	13.9	8.7	
Precipitation (mm d^{-1})	1997	21	62	51	44	71	249
	1961–1990	43	57	67	85	61	313
Pan evaporation (mm d^{-1})	1997	80	137	143	118	42	520
	1961–1997	99	130	122	80	34	465

with three observation occasions as a repeated factor. Square root transformation was used for the number of generative tillers. Since the results of the analysis of variance were equal with or without transformation, the original values are presented for the convenience of readers. All analyses were performed using the SAS MIXED Procedure (Littel et al. 1996).

Results

Weather and soil moisture

The growing season was warm from June onwards (Table 1). Precipitation during the growing season was about 80% and pan evaporation was 112% of the long-term average. The precipitation was low especially in May and August. However, due to high evaporation the soil moisture deficit (pan evaporation – precipitation) was highest in July, 92 mm. In the plot trial, the gypsum blocks at a depth of 40 cm showed that the amount of water available to plants was generally over 80% of the soil water holding capacity until mid-July and thereafter remained at the level of 50–60%. At a depth of 20 cm the soil moisture was more variable, depending on the rainfall. It was generally 50–90% until mid-July and 30–55% from mid-July onwards.

Herbage mass and milk production in the grazing trial

In the grazing trial the greatest differences occurred in period 1 (Table 2). Mean pre-grazing SH, HM and bulk density all increased with turnout T_N compared to turnout T_E. The maximum sward height was 42 cm for T_E and 64 cm for T_N, respectively (Fig. 1). These high SH values corresponded to HM values of 3320 and 4750 kg DM ha^{-1} (not shown in Table 2). This was reflected in the post-grazing SH of frequently grazed areas, which was high for both groups whenever the pre-grazing SH was higher than 40 cm. The post-grazing SH for group T_N was generally higher than for group T_E in late June – early July. Later in the season the differences levelled out or remained small.

There were no differences between the treatments in the feeding value of the grass except during a period of about three weeks in late June to early July when the herbage IVOMD of group T_N was 26–100 g kg^{-1} lower than for group T_E. There were some periods (8.5 feeding days for group T_E and 11 feeding days for group T_N) of pasture shortage for both groups during which big bale silage (D value 700 g kg^{-1}) was used as buffer feed. Group T_E was given 1130 MJ ME per cow of buffer feeding whereas group T_N was given 1750 MJ ME per cow during the experiment.

There were no differences between the treatments ($P > 0.05$) in milk yield either in period 1

Table 2. Sward variables and milk production as influenced by turnout date in the grazing trial. (SEM in parentheses).

	Period 1		Period 2		Period 3		SEM	P value		
	T_E	T_N	T_E	T_N	T_E	T_N		Period	Turnout	Period × Turnout
Pre-grazing										
Sward height (cm)	28.7	43.0	28.5	31.8	24.6	29.8				
	(1.6)	(2.5)	(1.2)	(1.0)	(1.1)	(1.3)				
HM (kg ha^{-1})	1680	3100	1760	1990	1420	1880				
	(145)	(238)	(96)	(65)	(84)	(105)				
Bulk density (kg DM m^{-3})	0.68	0.84	0.76	0.77	0.72	0.76				
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)				
In DM										
IVOMD (g kg^{-1}OM)	806	779	788	788	786	780				
	(17)	(32)	(14)	(6)	(10)	(12)				
D value (g kg^{-1}DM)	731	710	709	706	707	708				
	(14)	(26)	(9)	(4)	(10)	(10)				
CP (g kg^{-1}DM)	237	214	207	228	223	212				
	(22)	(32)	(24)	(8)	(15)	(7)				
Post-grazing										
Sward height (cm)	10.5	13.5	8.8	9.2	9.2	10.1				
	(0.6)	(1.0)	(0.4)	(0.3)	(0.4)	(0.4)				
Milk production										
Milk yield (kg d^{-1})	22.7	22.0	19.9	18.5	n.a.	n.a.	1.10	<0.001	0.46	0.58
ECM yield (kg d^{-1})	22.5	22.2	19.5	18.5	n.a.	n.a.	0.92	<0.001	0.58	0.54
Fat (g kg^{-1})	39.5	41.7	38.4	40.9	n.a.	n.a.	1.35	<0.07	0.23	0.69
Protein (g kg^{-1})	34.0	34.0	35.1	34.7	n.a.	n.a.	0.98	<0.001	0.89	0.51

T_E = early turnout, T_N = normal turnout.
HM = herbage mass; CP = crude protein; IVOMD = in vitro organic matter digestibility; ECM = energy-corrected milk yield (Tuori et al. 1996).
SEM = standard error of the mean; n.a. = not available.

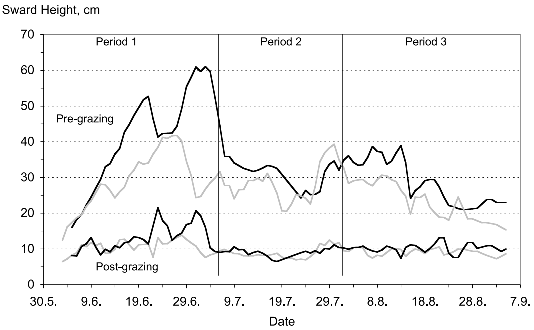

Fig. 1. Pre- and post-grazing sward height as influenced by turnout date in the production trial presented as 3-day moving averages. Grey line = early, black line = normal turnout date.

or in period 2. Since the milk composition was not changed, there were no differences in the energy corrected milk (ECM) production either. Milk yields in period 3 are not reported, since some cows had a steep decrease in milk production due to the end stage of their lactation period.

Effect of initial cut in the plot trial

The timing of the initial cut had a marked effect both on the sward properties and on the regrowth after the initial cut (Table 3). The pre-harvest HM, LAI and MSW were increased by delaying

Table 3. Pre- and post-grazing sward parameters and subsequent increase in leaf area 3 and 10 d after the cut as influenced by initial harvest date (T_{E-A}, T_{N-A}, T_{E-B} and T_{N-B}).

	Treatment1)				SEM	P value	Turnout2)		P value
	T_{E-A}	T_{N-A}	T_{E-B}	T_{N-B}			T_E	T_N	T_E vs. T_N
Date of initial cut	3 Jun	6 Jun	13 Jun	24 Jun					
Pre-grazing									
Herbage mass (kg ha^{-1})	430^{c}	730^{c}	2610^{b}	4570^{a}	91	<0.001	1520	2653	<0.001
LAI	1.7^{c}	2.1^{c}	5.1^{b}	7.0^{a}	0.19	<0.001	3.4	4.5	<0.001
MSW	23.3	23.2	32.8	41.1	–	–	28.0	32.1	–
In DM (g kg^{-1})									
IVOMD	864^{a}	857^{a}	803^{b}	740^{c}	2.4	<0.001	834	798	<0.001
D value	772^{a}	771^{a}	723^{b}	678^{c}	2.8	<0.001	748	725	<0.001
CP	341^{a}	302^{b}	246^{c}	162^{d}	4.3	<0.001	293	232	<0.001
Post-grazing									
LAI	0.6	0.6	0.5	0.6	0.05	0.111	0.6	0.6	0.34
WSC (g kg^{-1})	47.6^{b}	57.0^{b}	55.8^{b}	119.8^{a}	7.6	0.002	51.7	88.4	0.003
WSC pool (g m^{-2})	4.2^{a}	4.5^{a}	4.5^{a}	12.1^{a}	1.94	0.044	4.4	8.3	0.059
Vegetative tillers (m^{-2})	4760^{a}	4370^{a}	1930^{ab}	620^{b}	841	0.021	3340	2490	0.29
Regrowth									
LAI 3 d	1.1^{b}	1.6^{a}	0.7^{c}	0.7^{c}	0.06	<0.001	0.9	1.1	0.003
LAI 10 d	4.0^{a}	4.1^{a}	1.4^{b}	1.8^{b}	0.14	<0.001	2.7	2.9	0.13

1) T_{E-A} represents the first strip and T_{E-B} the last strip of early turnout (T_E). Treatments T_{N-A} and T_{N-B} represent normal turnout (T_N), respectively.

2) The influence of turnout date, early vs. normal, was calculated as contrasts (T_{E-A} and T_{E-B} vs. T_{N-A} and T_{N-B}).

LAI = leaf area index; MSW = mean stage by weight; IVOMD = in vitro organic matter digestibility; D value = digestible organic matter in dry matter; CP = crude protein; WSC = water-soluble carbohydrates.

SEM = standard error of the mean. Within each row, means denoted by a common superscript are not significantly different at $P > 0.05$ (Tukey-Kramer).

the cut and simultaneously the IVOMD, D value and crude protein (CP) content of the grass were decreased. The HM increase was greatest between treatments T_{N-A} and T_{E-B}, 268 kg DM ha^{-1} d^{-1}($P = 0.025$). The delay of the cut and the consequent increase in pre-harvest HM and LAI had no effect on post-harvest LAI. The WSC content and WSC pool were similar for the first three cutting dates (treatments T_{E-A}, T_{N-A} and T_{E-B}) but increased for the last cutting date (treatment T_{N-B}). The number of vegetative tillers decreased by delaying the initial cut.

Regrowth rate after the first cut was measured as an increment of LAI during the first 10 days after the cut (Fig. 2). During this period the soil moisture was very constant at a depth of 40 cm but more variable at a depth of 20 cm. Regrowth was rapid and almost linear for treatments T_{E-A} and T_{N-A} (first two cutting dates). On the contrary, regrowth was slower for treatments T_{E-B} and T_{N-B} (last two cutting dates) with a clear lag period, during which the increment in LAI values after defoliation was slow or absent. The LAI values after a regrowth of 10 d correlated positively only with the number of vegetative tillers (correlation coefficient 0.77, $P = 0.003$).

Tiller population density in the plot trial

There was great variation in tiller population density between vegetative and generative tillers during the season. The treatment (initial cutting date and rotation length) had a clear effect

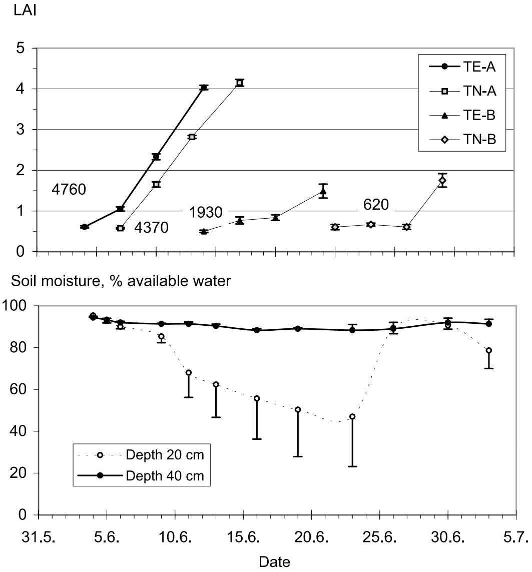

Fig. 2. Sward regrowth of leaf area and amount of water available to plants expressed as percentage of soil water holding capacity as influenced by the time of the first harvest day. Vertical bars represent ± SE (n = 4 for LAI; n = 3 for gypsum blocks). The numbers indicate the tiller population density of vegetative tillers m^{-2} at each harvest date.

on the number of vegetative and generative tillers as a whole, but the effect was dependent on the observation period (treatment x period interaction $P < 0.001$). Therefore the analyses were also performed by period (Table 4).

The population density of vegetative tillers was on average (over the treatments) the same every period ($P = 0.22$), but the treatment had a marked effect on the population density. The most distinct differences between the initial cutting dates were found in period 1, since the population density of vegetative tillers was directly affected by the harvest date. Thus, on 3 June and 6 June all the tillers were vegetative, but thereafter the tillers switched to the generative phase. Thus, the proportion of vegetative tillers was only 0.50 by 13 June and 0.18 by 24 June (treatments T_{E-B} and T_{N-B}, respectively). Therefore the population density of vegetative tillers decreased and on 24 June the population density of vegetative tillers was only 7% of the peak value observed on 6 June. Later in the season the differences between the treatments were smaller, but

Table 4. Population density (tillers m^{-2}) of vegetative and generative tillers during the grazing season (tillers per m^{2}) as influenced by initial harvest date and turnout date.

	Treatment[1]				SEM	P value	Turnout[2]		P value
	T_{E-A}	T_{N-A}	T_{E-B}	T_{N-B}			T_E	T_N	T_E vs. T_N
Vegetative									
Period 1	4740^{a}	5280^{a}	1850^{b}	390^{b}	369	<0.001	3290	2830	0.25
Period 2	2690	3360	2720	3070	514	0.73	2700	3210	0.31
Period 3	3280^{ab}	3180^{ab}	4140^{a}	2740^{b}	282	0.038	3710	2960	0.026
Mean	3570^{a}	3940^{a}	2900^{ab}	2070^{b}	305	0.009	3234	3000	0.46
Generative									
Period 1	0^{b}	0^{b}	2040^{a}	1960^{a}	253	<0.001	1020	980	0.85
Period 2	920	1840	1510	1140	226	0.052	1220	1490	0.23
Period 3	40	150	120	180	35	0.09	80	160	0.038
Mean	320^{b}	660^{b}	1220^{a}	1090^{a}	121	<0.001	770	880	0.22
Total									
Period 1	4740^{a}	5280^{a}	3890^{ab}	2360^{b}	520	0.016	4310	3820	0.36
Period 2	3610	5190	4230	4210	692	0.42	3920	4700	0.25
Period 3	3320	3320	4260	2920	297	0.058	3790	3120	0.052
Mean	3890	4600	4120	3160	414	0.15	4010	4130	0.76

[1] T_{E-A} represents the first strip and T_{E-B} the last strip of early turnout (T_E). Treatments T_{N-A} and T_{N-B} represent normal turnout (T_N), respectively.

[2] The influence of turnout date, early vs. normal, was calculated as contrasts (T_{E-A} and T_{E-B} vs. T_{N-A} and T_{N-B}).
SEM = standard error of the mean. Within each row, means denoted by a common superscript are not significantly different at $P > 0.05$ (Tukey-Kramer).

Table 5. Sward rotation, pre-grazing sward state, annual herbage yield and chemical composition of herbage (weighted means) as influenced by turnout date and initial harvest date.

	Treatment 1)				SEM	P value	Turnout 2)		P value
	$T_{E–A}$	$T_{N–A}$	$T_{E–B}$	$T_{N–B}$			T_E	T_N	T_E vs. T_N
Date of initial cut	3 Jun	6 Jun	13 Jun	24 Jun	–	–	–	–	–
Number of cuts	5	4	5	3	–	–	5	3.5	–
Rest period (d)	19	27	20	30	–	–	19.5	28.5	–
MSW	27.7	33.7	25.6	33.8	–	–	26.6	33.8	–
Pre-grazing LAI	4.6^{b}	5.1^{ab}	4.6^{b}	5.8^{a}	0.20	0.004	4.6	5.5	0.002
Post-grazing LAI	0.7	0.7	0.6	0.7	0.02	0.013	0.7	0.7	0.084
Yields (kg ha^{-1})									
DM	7660^{b}	8150^{b}	8180^{b}	8940^{a}	183	0.004	7920	8540	0.005
DOM	5550^{b}	5660^{b}	5910^{ab}	6170^{a}	113	0.017	5730	5910	0.14
In DM (g kg^{-1})									
Live matter	962^{ab}	946^{b}	971^{a}	968^{a}	4.6	0.017	967	957	0.06
OM	910^{a}	908^{a}	899^{b}	910^{a}	1.7	0.002	904	909	0.01
IVOMD (g kg^{-1}OM)	797^{a}	765^{b}	804^{a}	758^{b}	2.9	<0.001	800	762	<0.001
D value	725^{a}	695^{b}	723^{a}	690^{b}	3.0	<0.001	724	692	<0.001
CP	196^{b}	182^{c}	218^{a}	166^{d}	2.8	<0.001	207	174	<0.001

1) $T_{E–A}$ represents the first strip and $T_{E–B}$ the last strip of early turnout (T_E).Treatments $T_{N–A}$ and $T_{N–B}$ represent normal turnout (T_N), respectively.

2) The influence of turnout date, early vs. normal, was calculated as contrasts ($T_{E–A}$ and $T_{E–B}$ vs. $T_{N–A}$ and $T_{N–B}$).

MSW = mean stage by weight; DOM = digestible organic matter; OM = organic matter; IVOMD = in vitro organic matter digestibility; D value = digestible organic matter in dry matter; CP = crude protein.

SEM = standard error of the mean; Within each row, means denoted by a common superscript are not significantly different at $P > 0.05$ (Tukey-Kramer).

treatment $T_{N–B}$ had the lowest tiller population density also in period 3. The turnout date, T_E vs. T_N, had in general a much smaller effect. Turnout T_E had on average a higher vegetative tiller density than turnout T_N in period 3.

The population density of generative tillers changed in an opposite manner, the last two cutting dates having the highest average densities of generative tillers. Their contribution was low in period 3. The initial cutting date affected the population density of all tillers only in period 1, when treatment $T_{N–B}$ had the lowest tiller population density.

Annual herbage yields in the plot trial

Because of the synchronization between the plot trial and the grazing trial, turnout T_N in the grazing trial led to a slower rotation for treatments $T_{N–A}$ and $T_{N–B}$ in the plot trial (Table 5). The number of cuts was smaller and the rest interval was 46% longer for turnout T_N than for turnout T_E. This also led to a more advanced vegetation stage and higher pre-grazing LAI for turnout T_N.

There was a clear trend that the later the initial cut, the higher the overall HM and digestible organic matter (DOM) yield (Table 5). Excluding the yield of the first cut the difference between treatments in yield distribution was fairly insignificant although the mean growth rates for the treatments in period 3 were different, i.e. 46, 56, 66 and 60 kg ha^{-1} d^{-1} DM for treatments $T_{E–A}$, $T_{N–A}$, $T_{E–B}$ and $T_{N–B}$, respectively ($P < 0.001$, SEM 2.4 kg ha^{-1} d^{-1}). The observed mean growth rates in period 3 did not correlate with the tiller population density ($P = 0.75$). The turnout date, T_E vs. T_N, had in general a smaller effect. Since the IVOMD values were higher for turnout T_E (treatments $T_{E–A}$ and $T_{E–B}$) there was no significant effect of turnout in the DOM yield. The turnout date had only a slight effect on the herbage production pattern, since the proportion of total herbage produced in June was 48% for turnout T_E and 53% for turnout T_N.

Discussion

The idea of this study was to link an animal production trial to a more detailed plot trial. Although milk production data are presented only for the first two periods, they cover the most important part of the grazing season.

The effect of turnout date of cows to grass will depend on the weather at the beginning of the growing season. It has been shown that the key factor for HM production as well as for the digestibility of HM in early summer under nordic conditions is the cumulative temperature sum (Rinne 2001). Therefore, it is obvious that the advantages of early turnout should be greater in years when the temperature develops rapidly. On the contrary, occasional cool and wet periods diminish the advantages. In 1997 the development of the temperature sum was slow at first, but after turnout T_E the development of the temperature sum was slightly faster than the long-term average. This may have increased the differences between the two turnout dates compared to more average years. Due to the drought after mid-July the cows required 1130 and 1750 MJ metabolizable energy (ME) buffer feeding per cow during the grazing season in treatments T_E and T_N, respectively.

Regrowth after initial harvest in the plot trial

The differences in the pre-grazing sward properties in the initial harvest and the regrowth rates were clear. However, in addition to treatment effect, the authors want to point out that weather conditions during the regrowth periods of different initial cutting dates must be taken into account. The most important external factors are temperature and soil moisture. The mean temperatures over the four 10-d regrowth periods were in the range of 17.3–19.4°C for treatments $T_{E–A}$, $T_{N–A}$ and $T_{N–B}$ but 13.6 for treatment $T_{E–B}$, which may have caused a slight decrease in the growth rate of treatment $T_{E–B}$. The soil moisture was high and very consistent at a depth of 40 cm and variable but adequate at 20 cm in the plot trial. Therefore it is unlikely that plant growth would have been adversely affected due to water stress during the measured regrowth period (McAneney and Judd 1983).

The regrowth (expressed as increase in LAI) correlated strongly ($r = 0.77$) with the population density of vegetative tillers, which is logical and in accordance with earlier studies on vegetation in the generative phase (Davies 1988, Bonesmo 1999). Post-harvest LAI, however, exhibited practically no variation and thus had no effect on the regrowth. The highest WSC content was found on the last cutting date when the regrowth rate was lowest.

Davies (1988) suggested that there is a certain critical level of storage carbohydrates, above which more carbohydrates are not advantageous for regrowth. For perennial ryegrass this level is about 100 g kg^{-1} DM WSC. In our experiment the regrowth was at a maximum (treatment $T_{N–A}$) despite the WSC concentration of 57 g kg^{-1} DM. The reason for this may be that the effect of carbohydrates is obscured by the proportion of vegetative tillers. First, the direct effect of vegetative tillers (Davies 1988, Bonesmo 1999) and, second, the carbohydrate reserves are less efficiently used if the growth commences from other than active meristems (Richards and Caldwell 1985). It must be noted that other substances than carbohydrates, such as vegetative storage proteins, may also play an important role in regrowth (Richards and Caldwell 1985, Ourry et al. 1996).

In this experiment, the timothy and meadow fescue tillers had had enough time after winter to recover their reserves of carbohydrates (and other substances), since regrowth was rapid after the first two initial cutting dates. Thus, early turnout does not impair the regrowth potential *per se*. On the contrary, regrowth after a late first cut is impaired due to the low population density of vegetative tillers.

Effect of turnout on annual herbage production in the plot trial

Early turnout did not impair the regrowth *per se*, but it lowered the annual herbage DM yields. With 670 kg DM ha^{-1} lower average HM in turnout T_E but nearly the same HA and pasture area as in turnout T_N, the area was used faster in turnout T_E than in T_N in the grazing trial. This led to 9 days shorter regrowth intervals and an increase in the number of cuts in the plot trial (from 3.5 to 5). High cutting frequency has been demonstrated to lower the DM or digestible OM (DOM) yields (Mislevy et al. 1977, Frankow-Lindberg 1989). Thus, turnout T_E restricted the HM production by 1280 kg DM (14.3%) calculated over the whole season. The difference in HM production is largely explained by the stem formation process, which is advantageous for HM production but at later stage disadvantageous for the nutritive value of the grass (Mislev et al. 1977, Mason and Lachance 1983, Carton et al. 1989). This process was better utilized by turnout T_N, especially in treatment $T_{N–B}$. Although the regrowth of treatment $T_{N–B}$ was slow, the first yield was very high due to stem formation and thus a high annual HM production was achieved. It is important to note that the lower HM production with turnout T_E was counterbalanced by a higher nutritive value of the grass and thus the DOM yield, a more important sward production parameter than HM, was similar for both turnout dates.

After the initial cut, turnout T_E led to a larger proportion of vegetative tillers, which correlated positively with the subsequent regrowth. For the rest of the season there seemed not to be fundamental changes in the tiller density although turnout T_E had a higher density of vegetative tillers in period 3, too. However, tiller density seemed to be of minor importance for HM production in late season, since the HM production in period 3 was low for all initial cutting dates compared to spring. Furthermore, the differences in growth rates were merely due to differences in rotation length rather than due to differences in the population density of vegetative tillers. This weak relationship between the tiller population density and HM production in late season diminishes the importance of tiller density for yield formation in the nordic climate. According to Heide et al. (1985), this shift to larger but fewer tillers is a general adaptation of grasses to the cool, long days of the high-latitude summer. Clearly the tiller density was much lower than reported for perennial ryegrass swards in more temperate climate, 9000–19000 m^{-2} (e.g. Baker and Leaver 1986, Roche et al. 1996), which is also in agreement with the above-mentioned adaptation theory of Heide et al. (1985).

Effect of turnout date on herbage and milk production in the grazing trial

In this trial the pasture area was nearly the same for both treatments, both in June and July-September. In order to prevent the sward reaching a mature growth stage, the rotation of treatment T_N should have been of shorter duration and thus the silage area would have been larger. This could have prevented the sward from reaching the decreased feeding value. However, if the first rotation had been ceased earlier for treatment T_N, this would have lead to an even greater pasture shortage in July, since it was not possible to graze the silage aftermath before 26 July. As seen especially in the plot trial, a late turnout decreased the regrowth rate after the defoliation of the generative sward, which also increased the need for buffer feeding. In this respect treatment T_E was easier to manage and did not impair the milk yields. Thus, with only a few days' delay in turnout date, in this experiment only five days, the pasture growth type and, hence, its management can change dramatically, while animal production remains the same. In order to achieve an easy-to-manage but efficient pasture rotation, farmers should pay attention to early turnout.

There were no differences in the milk production of cows in period 1 or period 2 despite the differences between treatments T_E and T_N in SH, HM production and digestibility of HM in period 1. There are two main reasons for this. First, the sward differences counterbalanced each other. The higher digestibility of turnout T_E compared to turnout T_N at the end of period 1 was counterbalanced by its low HM per hectare (kg DM ha^{-1}), that most probably decreased HM intake of the cows (*e.g.* Peyraud et al. 1996). On the other hand, turnout T_N had more suitable amount of HM per hectare, but the digestibility of HM was lower. However, without herbage intake measurements it is difficult to discus any further the effect of these factors. Second, the most profound differences lasted only 2–3 weeks, and may not have been sufficient to be realised in milk production using cows in the mid and late stage of lactation.

Although the turnout date did not affect the milk production, the lower quality and high pre-grazing SH in T_N led to high post-grazing SH in late June – early July and, consequently, low utilization and greater need for topping. Based on results and earlier studies (Virkajärvi et al. 2002), it seems typical of pastures at high latitudes to reach SH values up to 40 cm without a marked drop in digestibility. On the contrary, values higher than 40 cm (especially for turnout T_N) were associated with lower OMD (below 750 g kg^{-1}) and lower utilization based on higher post-grazing SH. Increased stem rigidity is most probably another reason for low utilization of swards higher than 40 cm. That is indicated by the high MSW (Table 3) and it causes marked losses due to trampling of the canopy. However, the stem formation itself is beneficial for annual DOM production (Mislevy et al. 1977, Mason and Lachance 1983, Carton et al. 1989) and in nordic conditions it should be utilized in milk production until the digestibility or stem rigidity limits its utilization.

In our study, the difference in turnout date was only five days, which was too short to show any effect of grazing plus indoor feeding compared to indoor feeding alone. It could be argued that the time difference between the treatments in our experiment was small, however, a short transition period is typical in Finland. A turnout earlier than turnout T_E with HM less than 200 kg ha^{-1} (> 5cm) would have been unrealistic. On the other hand, turnout T_N represented the average turnout date among farmers that year. Due to the rapid growth rate of pastures observed, it is obvious that a later turnout than T_N would have led to even greater difficulties in sward utilization and management, but this was beyond our study. Therefore the difference in turnout date between the treatments remained small which is realistic in Finnish conditions. Examples of longer transition periods are given by Roche et al. (1996) and Sayers and Mayne (2001), who both found a positive response in milk production for early turnout during the transition period (+1.4 kg and +3.1 kg day^{-1}, respectively). In the experiment of Roche et al. (1996) the duration was 21 d and in Sayers and Mayne (2001) 40 d, respectively.

Conclusions

A difference of only a few days in the turnout date had a marked effect on pasture HM production and grazing management. The differences in subsequent HM quantity and quality caused by turnout date occurred mainly in late June and early July. Early turnout led to better herbage regrowth after the initial cut due to a higher number of vegetative tillers. However, later in the season the difference in the number of vegetative tillers was smaller and it had no effect on the sward growth rate. Early turnout decreased the annual HM production since it led to shorter rest periods. Due to the higher digestibility of HM, the difference in DOM yields was smaller than that in HM yields. Therefore, the higher HM production with late turnout was not realised as an increase in milk production. Early turnout led to better sward utilization and decreased the need for buffer feeding, thus making pasture management easier. The effects of turnout date will be dependent on the weather conditions, especially the temperature sum in spring.

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SELOSTUS

Laiduntamisen aloitusajankohdan vaikutus laitumen tuottoon

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Oikea laiduntamisen aloitusajankohta on tärkeä laitumien hoidon ja hyväksikäytön kannalta. Sen merkitys on todennäköisesti sitä suurempi mitä lyhyempi kasvukausi on. Koska asiasta ei ole suomalaisia tutkimustuloksia, tutkittiin laitumelle laskun ajankohdan vaikutusta laitumen kasvuun ja hyväksikäyttöön sekä lehmien tuottoon kahdessa kokeessa: laidunkokeessa ja tähän yhdistetyssä simuloidussa kenttäkokeessa. Kokeessa verrattiin aikaista aloitusta (1. kesäkuuta) ja normaalia aloitusta (6. kesäkuuta). Kokeet suoritettiin timotei-nurminata -laitumella, ja laidunkokeessa käytettiin 16 Holstein – Friisiläistä lypsylehmää. Tarjolla oleva laitumen määrä oli 21–23 kg kuiva-ainetta lehmää kohti vuorokaudessa, ja laitumen typpilannoitus 196 kg ha^{-1} vuodessa.

Aikainen aloitus alensi laitumen kuiva-ainetuotantoa simuloidussa kenttäkokeessa. Toisaalta aikainen aloitus johti korkeampaan sulavuuteen, minkä vuoksi aloitusajankohta ei vaikuttanut sulavan orgaanisen aineen satoon. Myös laidunkokeessa aikainen laitumelle lasku alensi laitumen määrää (kg ha^{-1}) myöhäisempään aloitukseen verrattuna. Erot laitumen määrässä, nurmen korkeudessa ja laitumen sulavuudessa olivat suurimmillaan kesäkuun lopussa ja heinäkuun alussa. Aikaisen aloituksen ryhmän laitumen loppukorkeus oli kokeen aikana alhaisempi, mikä osoittaa parempaa laitumen hyväksikäyttöä. Aloitusajankohta ei kuitenkaan vaikuttanut maidon tuotantoon (aikainen 21,0 vs. myöhäinen 20,3 kg vrk^{-1}) eikä maidon rasva- (aikainen 39,0 vs. myöhäinen 41,3 g kg^{-1}) ja valkuaispitoisuuteen (aikainen 34,5 vs. myöhäinen 34,3 g kg^{-1}). Vaikka laiduntamisen aloituksen ajankohta ei vaikuttanutkaan maidon tuotantoon, se vaikutti laitumen kasvuun, hyväksikäyttöön ja laiduntamisen järjestelyihin.