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Milk Production of Fall-Calving Dairy Cows During Summer Grazing of Grass or Grass-Clover Pasture[1]

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ABSTRACT

Milk production of fall-calving dairy cows during subsequent summer grazing was evaluated in two consecutive years using a total of 80 mid- to late-lactation Holsteins. Cows calved during September and October and grazed from April to August in the following year. In yr 1, 27 cows grazed a native grass pasture and 13 cows grazed a native grass-clover mixed pasture containing 26% red clover and white clover. In yr 2, 40 cows grazed native grass pasture as one group. Also, cows in yr 2 were administered bovine somatotropin, whereas in yr 1, no bST was used. Grazing cows also were fed concentrate supplements at 6.2 kg/d of dry matter (DM) in yr 1 and 7.9 kg/d of DM in yr 2 to provide 35 to 40% of total intake. Average daily milk during the grazing period decreased 3.6 kg in yr 1 and 7.7 kg in yr 2 when compared with milk yield extrapolated from the lactation curve established 10 wk before being turned out to pasture. Estimated DM intake during grazing was also less than what would have been expected had cows continued on a total mixed ration in confinement. Cows grazing the mixed pasture of grass and clover yielded 1.3 kg/d more milk than those grazing the grass pasture in yr 1. A decrease in milk resulting from the change from total mixed ration fed in confinement to grazing supplemented with concentrates was not avoided with these mid- to late-lactation cows, but the cumulative loss over the lactation was less than with early lactation cows in a companion study. Clover enhances the grazing value of pasture when grown with grasses.
(**Key words:** pasture, grass, clover, milk production)

INTRODUCTION

Rotational grazing can be an economical way of feeding dairy cows, but it has proven difficult to support or sustain maximum milk yield with high producing cows (Holden et al., 1994). Jones-Endsley et al. (1997) reported an average of 25 kg of milk from cows supplemented with 6.4 to 9.4 kg of concentrate per day during an 80-d grazing study. At the onset of the study, cows were 125 DIM and producing 36 to 46 kg of milk/d when fed a TMR. To better utilize the potential for lower cost of grazing and the animal's milking potential, a logical strategy is to have cows calve in the fall, feed a TMR in confinement over winter to capture peak milk production, and then graze the cows in summer when cows are in the latter stage of lactation. Total grass consumption is not likely to be much less with this strategy compared with grazing cows in early lactation, because concentrate can make up a smaller proportion of total DMI with late lactation cows. The typical decrease in milk production upon turning cows out to pasture has less negative effect on total lactation performance when done in late lactation as opposed to early lactation (Dhiman et al., 1996).

Most native or permanent pasture in the northeastern and north central United States consists primarily of grass species, with small amounts of legumes, primarily white clover. Legume content of these pastures can be increased at relatively low cost by overseeding with red clover. This type of permanent pasture is commonly found on rough land that cannot be readily tilled, or reseeded without risking loss of existing ground cover. These pastures require low inputs and have the potential to provide the forage portion of the diet for lactating dairy cows. The objective of this study was to determine milk production response of fall-calving cows to grazing of native pasture in late lactation during the following summer and to determine the potential of grass pasture and grass-legume mixed pasture to support milk production.

MATERIALS AND METHODS

This experiment was part of a study involving phosphorus supplementation to lactating cows (Wu and Satter, 2000), and was carried out over a 2-yr period using a protocol approved by the Animal Care Committee of

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[1]Trade names and the names of commercial companies are used in this report to provide specific information. Mention of a trade name or manufacturer does not constitute a guarantee or warranty of the product by the USDA or an endorsement over products not mentioned.

the College of Agricultural and Life Sciences, University of Wisconsin-Madison. The pasture, located at the US Dairy Forage Research Farm in Prairie du Sac, Wisconsin, was about 20 ha in size divided into 0.4- to 0.8-ha paddocks by electric fence. The pasture was fertilized with 56 kg/ha of nitrogen (urea) spread in each of two applications, one in June and August of each year. This is a rather low level of nitrogen fertilization, but no visible signs of nitrogen deficiency (pale green or yellowish leaves) were observed. Soil tests indicated that P, K, and pH were appropriate for pasture growth. In yr 1 (1997), the pasture had two distinct types of paddocks, one containing predominantly grasses and one containing mixed grasses, white clover (*Trifolium repens*), and red clover (*Trifolium pratense*). In yr 2 (1998) all paddocks were similar, containing mostly grasses. The grasses in all paddocks in both years were Kentucky bluegrass (*Poa pretensis*), quackgrass (*Elytrigia repens*), and smooth bromegrass (*Bromus inermis*).

For both years, cows calved during September and October in the previous year. Fall-calving was achieved by synchronizing for breeding using GnRH (Cystorelin; Abbott Laboratories, North Chicago, IL) and $PGF_{2\alpha}$ (Lutalyse; Pharmacia & Upjohn Comp., Kalamazoo, MI) (Pursley et al., 1997). After calving, cows were fed a TMR containing no supplemental phosphorus or a TMR supplemented with phosphorus. Cows grazed from April to August, when pasture was available, for 11 wk in yr 1 and 18 wk in yr 2. At the beginning of grazing, the DIM averaged 220 (SD 15) in yr 1 and 203 (SD 17) in yr 2. Cows were transitioned from confinement and TMR feeding to pasture over a 1-wk period. During this time they were given access to a reduced amount of the TMR while having full access to the pasture. Body weight was measured after milking at the beginning and end of the grazing period. Cows were administered bST (Posilac; Monsanto Co., St. Louis, MO) every 2 wk in yr 2, but not in yr 1. During grazing, cows were supplemented with a concentrate mix that also contained either no supplemental phosphorus or dicalcium phosphate according to treatments (Table 1). Supplement formulations were identical for both years. The mixes were fed to treatment groups at 6.2 kg/d per cow in yr 1 and 7.9 kg/d per cow in yr 2 (DM basis) to account for approximately 35 to 40% of the total DMI. The amount of supplement fed in yr 2 was increased because bST was administered in yr 2. In each year, 40 cows (20 primiparous cows in yr 1 and 12 primiparous cows in yr 2) grazed the pasture. Of the 40 cows in yr 1, 27 (14 primiparous, 13 multiparous; 14 low phosphorus, 13 normal phosphorus) grazed grass paddocks and 13 (6 primiparous, 7 multiparous; 7 low phosphorus, 6 normal phosphorus) grazed mixed paddocks, assigned randomly within phosphorus amount and parity subclasses. In yr 2, all 40 cows (12 primiparous, 28 multiparous; 20 low phosphorus, 20 high phosphorus) grazed grass paddocks as one group. Cows were in the paddocks continuously, except for approximately 2 h each time cows were taken to the milking parlor at 0500 and 1500 h. Cows were group-fed their supplemental feed after milking according to phosphorus treatments. All ingredients of the supplements were mixed together before feeding. Intensive rotational grazing was practiced by allocating a new paddock every 24 h. The area allocated varied during the season according to pasture availability. Each paddock had water available at all times.

In yr 1, pasture forage was evaluated during each grazing cycle for botanical composition, nutrient composition, and yield with two representative plots averaging 0.4 ha each for each pasture type. For botanical evaluation, herbage from six strips in yr 1 and 10 in yr 2 (approximately 0.5×0.1 m each) in each of the sampling plots was cut before grazing at ground level and separated into plant species by hand; species profile was composed from dry weights (60°C oven-dried). For nutrient and yield evaluation, six strips in yr 1 and 10 in yr 2 (1×0.3 m each) were randomly selected in each of the sampling plots. Both before and after grazing, the herbage in the strips was measured for sward height using a rising plate meter (weighing 0.225 kg and exerting a pressure of 2.5 kg/m^2 on the canopy of 0.3×0.3 m), then clipped at ground level to obtain dry yield (60°C). A composite sample of the herbage across strips of each plot was used for chemical analysis. Using averages from the two replicate plots, a linear regression of DM yield before and after grazing as a function of herbage height was developed for each pasture type during a grazing cycle. To estimate forage yield of a paddock, sward height was measured from 45 to 93 randomly selected sites. The average height was applied to the regression to estimate forage yield (kg/ha). From the yields estimated before and after grazing, amount consumed (kg/ha) was obtained. Based on the consumed amount and the average grazing area (ha/d per cow) allocated during the grazing cycle, daily forage intake per cow was estimated. In yr 2, pasture forage was sampled only before grazing and analyzed for botanical and nutrient composition as in yr 1; no yield estimates were made.

For both years, high moisture corn, roasted soybeans, and corn silage used in the supplements were sampled weekly. The samples were dried at 60°C for 48 h. Supplement formulations (as fed) were adjusted weekly for changes in DM content of the ingredients. Dried samples of feed ingredients and pasture were ground through a Wiley mill using a 1-mm screen (Arthur H.

Table 1. Ingredient and chemical composition of the supplements fed (DM basis).

Item	Low phosphorous	High phosphorous
Ingredient		
Corn silage, %	11.0	11.0
High moisture corn, %	74.7	74.1
Soybean, roasted, %	10.6	10.6
Calcium carbonate, %	2.8	1.7
Dicalcium phosphate, %	. . .	1.7
Salt, %	0.6	0.6
Trace mineral and vitamin premix[1], %	0.3	0.3
Chemical analysis		
CP, %	11.1	11.1
ADF, %	8.7	8.7
NDF, %	18.9	18.9
Ca, %[2]	1.10	1.10
P, %	0.33	0.65
NE_L, Mcal/kg[2]	1.83	1.83

[1]Each kilogram contained 0.32 g of Se, 0.43 g of Co, 1.03 g of I, 13.35 g of Cu, 23.99 g of Fe, 51.00 g of Mn, 62.01 g of Zn, 7,000,000 IU of vitamin A, 2,222,000 IU of vitamin D, and 17,630 IU of vitamin E.

[2]Calculated using tabular values from NRC (1989).

Thomas, Philadelphia, PA). Ground samples were analyzed for DM (105°C), CP (LECO FP-2000 Nitrogen Analyzer, Leco Instruments, Inc., St. Joseph, MI), NDF (heat stable α-amylase and Na_2SO_3 were used) and ADF (Robertson and Van Soest, 1981). The ANKOM^{200} Fiber Analyzer incubator (ANKOM Technology, Fairport, NY) was used for NDF and ADF analyses. Chemical analyses were expressed on a DM (105°C) basis. Nutrient content of the supplement mixes was computed from analysis of the ingredients or using the NRC (1989) ingredient values for Ca and NE_L.

Milk yield was recorded at each milking, and milk samples were collected biweekly from two consecutive milkings. The samples were analyzed at the AgSource Milk Analysis Laboratory (Menomonie, WI) for fat, protein, lactose, total solids, and SCC using an infrared spectrophotometer with a B filter (Fossmatic 605; Foss Technology, Eden Prairie, MN); SNF was calculated as total solids minus fat.

Data pertinent to dietary phosphorus supplementation during grazing were discussed in a separate paper (Wu and Satter, 2000) that addresses phosphorus effects during the entire lactation. The present paper deals only with data on grazing. Animal performance data during grazing in yr 1 were statistically analyzed to determine the effect of paddock type using the general linear models procedure of SAS (1985) according to the following model:

$$Y = \mu + L + P + LP + E$$

where Y= observation, μ = overall mean, L = lactation number (primiparous or multiparous), P = pasture type (grass or mixed), LP = interaction between L and P, and E = error term.

For milk, FCM, milk fat, and milk protein yields, a covariate term using data collected during the last 2 wk prior to grazing was added to the model. Results are presented as means and SE for each pasture type. Statistics related to parity are excluded in the discussion because of lack of interactions.

RESULTS AND DISCUSSION

In both years, grass species dominated the pasture, although some clover was usually present (Table 2). The mixed pasture in yr 1 contained approximately 23 to 28% clover, averaging 26% throughout the season. Approximately two thirds of the clover was red clover and one third was white clover. The grass species in

Table 2. Botanical composition of grass pasture and mixed grass-clover pasture.

	Grass pasture			Mixed pasture		
Month/day	Grass[1]	Clover[2]	Other[3]	Grass[4]	Clover[2]	Other[3]
	(DM %)					
Year 1						
5/13–31	88.5	6.5	5.0	57.0	22.6	20.5
6/1–26	78.8	17.1	4.1	64.4	28.2	7.4
6/27–7/17	92.6	3.8	3.6	66.8	27.2	5.9
7/18–8/11	99.2	0.1	0.6	64.2	25.8	10.1
Year 2						
5/12–5/22	83.2	12.0	4.8			
7/6–7/17	72.2	9.5	18.3			
8/14–8/24	56.8	17.3	25.9			

[1]Kentucky bluegrass : quackgrass plus smooth bromegrass = 65:35 in yr 1 and 52:48 in yr 2.

[2]Red clover : white clover = 2:1 in yr 1 and 4:1 in yr 2.

[3]Primarily dead matter and some dicot species.

[4]25% as Kentucky bluegrass and 75% as quackgrass and smooth bromegrass.

Table 3. Chemical composition of forage from grass pasture or mixed grass-clover pasture measured before and after grazing.

Month/day	Grass pasture Pregrazing	Grass pasture Postgrazing	Mixed pasture Pregrazing	Mixed pasture Postgrazing
	(% of DM)			
Year 1				
CP				
5/13–31	17.2	14.9	20.4	16.8
6/1–26	14.6	11.9	18.1	14.6
6/27–7/17	14.3	12.6	18.8	15.8
7/18–8/11	17.4	15.4	18.9	17.4
ADF				
5/13–31	27.3	29.5	30.5	31.7
6/1–26	32.6	36.6	31.6	35.8
6/27–7/17	32.9	35.5	37.0	40.5
7/18–8/11	35.0	36.6	39.0	40.3
NDF				
5/13–31	46.9	48.6	43.5	43.5
6/1–26	55.2	59.3	46.2	51.4
6/27–7/17	57.0	59.4	50.0	53.8
7/18–8/11	57.3	59.3	49.7	52.7
Year 2				
CP				
5/12–5/22	17.2			
7/6≠7/17	17.7			
8/14–8/24	19.6			
ADF				
5/12–5/22	28.3			
7/6–7/17	31.0			
8/14–8/24	27.5			
NDF				
5/12–5/22	46.7			
7/6–7/17	48.1			
8/14–8/24	44.8			

both types of pasture were Kentucky bluegrass, quackgrass, and smooth bromegrass, although proportions of species varied between the pasture types. Kentucky bluegrass represented 52 to 65% of the grass pasture, with quackgrass and smooth bromegrass contributing most of the remainder. The grasses in the mixed pasture were 75% quackgrass and bromegrass combined, and 25% Kentucky bluegrass.

In yr 1, CP content of the forage was higher during the early and late grazing season than during the middle of the season for the grass pasture, but remained relatively constant for the mixed pasture (Table 3). The ADF and NDF content of both types of pasture was lower during the early grazing season than during the late grazing season, reflective of seasonal temperature changes and consistent with measurements on the same pasture in three previous years (Kanneganti et al., 1998). The CP and ADF content of pregrazed forage was higher during most of the season for the mixed pasture than for the grass pasture. Pregrazed forage from the mixed pasture had consistently lower NDF content. The opposite trends between the pasture types in their NDF and ADF content indicate that forage from the mixed pasture contained less hemicellulose than forage from the grass pasture. The forage present after grazing was lower in CP, but higher in NDF and ADF than forage present before grazing, reflecting selective grazing. Thus the forage actually consumed was of higher quality than the average of what was present before grazing. In yr 2, nutrient content of the pasture was relatively constant throughout the season.

The amounts of forage present pre- and post-grazing in yr 1 were comparable between the two types of pasture, but the consumed amounts and percentages were higher for the mixed pasture than for the grass pasture most of the time (Table 4), especially during July to August when hot temperatures and lack of moisture caused slow growth and more herbage senescence. The mixed pasture was better able to provide consumable forage than the grass pasture under the adverse conditions of late summer. Clover has horizontally expanding stolen internodes, and the leaves are supported by petioles, which are structurally weaker than stems of grass. These characteristics result in the dead leaves tending to fall out of the grazed horizon of the sward. Clovers therefore present a higher proportion of green leaves and petioles for grazing (Clark et al., 1997). Overall, up to 45% of the forage was consumed early in the season, but the proportion consumed declined as the season progressed. Grazers often tend to use sward height to judge pasture available when allocating grazing areas. This can be misleading, because a consistent relationship between sward height (Table 5) and forage selected for consumption (Table 4) cannot be assumed. Plant senescence plays an important role in determining forage availability.

In yr 1, milk yield decreased 2.2 kg/d the first week cows were put on pasture and remained lower throughout the 11-wk grazing period compared with the projected lactation curves if cows had remained on a TMR throughout lactation (Figure 1). The difference between projected and actual lactation averaged 3.6 kg/d. The comparable decrease in milk for yr 2 was even larger (4.2 kg/d the 1st wk cows were put on pasture, and averaging 7.7 kg/d less than the projected lactation; Figure 2). This may reflect the higher milk production associated with the use of bST when cows were placed on pasture, as well as the absence of legume species in the pasture. Similar or larger decreases in milk yield during grazing compared with the week before grazing for early to midlactation cows were reported by Hoffman et al. (1993a) (DIM 82; averaged 7 kg/d less during the 12-wk grazing period; primarily orchardgrass with some bromegrass), Holden et al. (1994) (DIM 133; averaged 8 kg/d less during the 10-wk grazing period; orchardgrass, Kentucky bluegrass, and smooth bromegrass), Jones-Endsley et al. (1997) (DIM 125; averaged 17 kg/d less during the 80-d grazing period; equal pro-

Table 4. Amount of forage present pre- and post-grazing with grass pasture or mixed grass-clover pasture (yr 1).

	Grass pasture				Mixed pasture			
			Grazed				Grazed	
Month/day	Pregrazing (kg/ha)	Postgrazing (kg/ha)	(kg/ha)	(%)	Pregrazing (kg/ha)	Postgrazing (kg/ha)	(kg/ha)	(%)
5/13–31	3774	2278	1497	39.7	4497	2600	1897	42.2
6/1–26	3350	2081	1269	37.9	3137	2117	1020	32.5
6/27–7/17	3004	1990	1013	33.7	2747	1683	1064	38.7
7/18–8/11	2699	2416	283	10.5	2389	1703	686	28.7

portions of alfalfa and orchardgrass), and Kolver and Muller (1998) (DIM 59; averaged 11 kg/d less during 2-wk transition to grazing, but this was grazing without supplementation; primarily ryegrass with some other grasses and 19% white clover). Pasture quality in these studies was generally high. One would expect, at minimum, a temporary decrease in milk production in switching from a TMR in confinement feeding to a grazing situation simply because of the change. Cows in our experiment had all grazed as young stock, so that might have eased the transition from confinement to grazing. It appears that grazing pasture of the types cited cannot sustain milk yield at the same level that a high quality TMR fed in confinement can, whether cows are in early or late lactation. It should be pointed out that the potential effect of summer heat stress is not considered in the foregoing comparisons. Cows fed TMR in confinement would likely have some accelerated decrease in milk due to heat stress during the hot summer months, as was most probably true for cows in the grazing studies. Thus, the comparisons above are perhaps somewhat exaggerated.

Milk yield for the complete lactation (308 d) in our study was 8990 kg (SEM 220) for yr 1 and 10,055 kg (SEM 255) for yr 2. While cows in yr 2 received bST, these yields are higher than those averaging 7300 kg/308 d for spring-calved cows pastured in early lactation under similar conditions (Dhiman et al., 1996). If seasonal calving is to be combined with grazing, it appears that fall-calving has some production advantages. Some cows lost BW during grazing (Table 6), even though they were gaining BW prior to grazing. Some cows also appeared to lose body condition. Milk fat and protein concentrations were normal and did not appear to change during grazing.

The supplements were formulated to complement the anticipated CP content of pasture forage. The CP content of pasture forage was lowest from June to July in yr 1, especially for the grass pasture (Table 3). Calculated from forage yields and the CP content of the grass pasture from June 27 to July 17 before and after grazing (Table 3), when CP was lowest, the CP content of consumed forage was estimated to be 17.6%. Using this CP content for the forage and the CP content of the supplement mixes (11.1%, Table 1), and assuming that the mixes (6.2 kg/d) provided 35% of the total feed intake and forage provided the remaining 65%, the CP content of the total diet would be 15.3%. This compares with 15% recommended by NRC (1989) for cows at this production level.

The CP of pasture forage is highly degradable (60 to 80%) (Berzaghi et al., 1996; Holden et al., 1994), and therefore feeding a supplement with high RUP would seem beneficial (Polan et al., 2000). However, Jones-

Table 5. Sward height[1] of grass pasture or mixed grass-clover pasture measured before and after grazing in yr 1.

	Grass pasture		Mixed pasture	
Month/day	Pregrazing	Postgrazing	Pregrazing	Postgrazing
	(cm)			
5/13–31	16.3 (4.5)[2]	12.4 (4.0)	22.9 (6.2)	11.8 (4.8)
6/1–26	25.7 (11.5)	10.0 (4.8)	27.0 (11.1)	10.1 (4.6)
6/27–7/17	19.0 (5.5)	12.0 (4.7)	19.5 (5.0)	10.8 (4.7)
7/18–8/11	17.4 (6.5)	12.3 (5.5)	15.0 (5.9)	9.7 (5.4)

[1]Compressed forage height determined with a rising plate meter.
[2]Mean (SE).

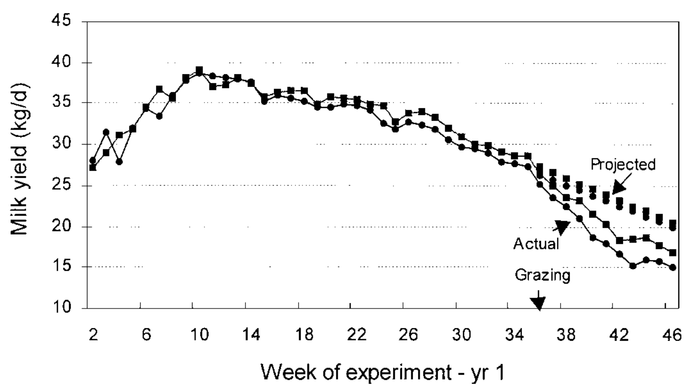

Figure 1. Milk yield of cows grazing grass pasture (●) or grass-clover mixed pasture (■) during wk 36 to 46 of experiment. Cows were fed TMR before wk 36. Milk yield dropped during the 1st wk of grazing and remained lower than projected from the lactation curves that would be developed if cows remained on TMR—yr 1.

Table 6. Means for BW and milk components of cows grazing grass pasture or mixed grass-clover pasture for 11 wk in yr 1 and grass pasture for 18 wk in yr 2.

	Yr 1					Yr 2	
	Grass pasture (n = 27)[1]		Mixed pasture (n = 13)[1]			Grass pasture (n = 40)[1]	
Item	Mean	SE	Mean	SE	P	Mean	SD
Initial BW, kg	633	10	596	14	0.04	643	88
BW change, g/d	–436	82	–335	119	0.49	–159	257
Milk, kg/d[1]	19.1	0.3	20.4	0.5	0.03	21.4	5.1
3.5% FCM, kg/d[1]	20.0	0.3	21.8	0.5	0.01	23.1	3.5
Milk							
Fat							
%	3.85	0.10	3.71	0.15	0.44	3.78	0.49
kg/d[1]	0.724	0.014	0.793	0.021	0.01	0.848	0.141
Protein							
%	3.23	0.04	3.15	0.06	0.33	3.31	0.22
kg/d[1]	0.615	0.009	0.657	0.014	0.02	0.745	0.112
Lactose, %	4.63	0.04	4.67	0.05	0.60	4.62	0.27
SNF, %	8.60	0.07	8.60	0.09	0.99	8.69	0.37
SCC, 10^3/ml	501	92	318	133	0.27	360	272

[1]n = Number of cows.

[2]Adjusted by covariance using milk yield values from the last 2 wk prior to the grazing period.

Endsley et al. (1997) reported that varying CP or RUP of supplements did not affect milk yield. Furthermore, high RUP did not prevent milk yield decreases during grazing, although the intestinal supply of protein was increased by the RUP supplementation in that study. Efficiencies of rumen microbial protein production were high during grazing. They concluded that metabolizable energy intake, rather than protein, was the limiting factor for milk production and maintaining body condition.

Forage intake was estimated (Table 7) by each of two approaches. In the first approach, forage intake was calculated from the difference in the amount of forage present immediately pre- and post-grazing (Table 4). In the second approach, forage intake was calculated as the amount needed to balance the difference between the NE_L from the supplement and the NE_L needed for maintenance, BW change, and FCM yield. Both approaches are subject to large error due to variation in forage yield measurements, or variation in BW measurements and unknown supplement intake by individual animals under the group-feeding situation. Nevertheless, compared with the average feed intake (20.7 kg/d) during the last 2 wk before grazing, most of the estimates, taking the average supplement intake (6.2 kg/d) into account, suggest that feed intake decreased

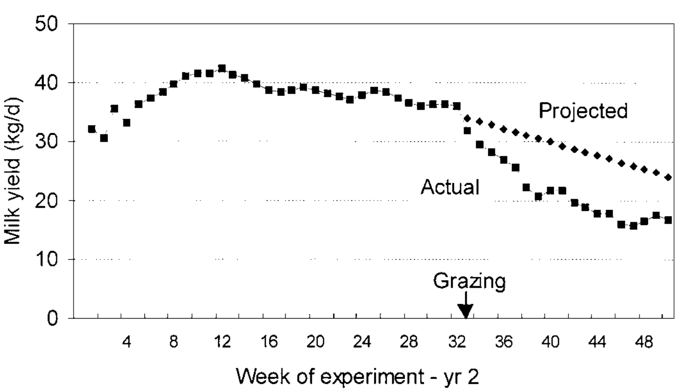

Figure 2. Milk yield of cows grazing grass pasture during wk 33 to 50 of experiment. Cows were fed TMR before wk 33. Milk yield dropped during the first week of grazing and remained lower than projected from the lactation curve that would be developed if cows remained on TMR—yr 2.

Table 7. Forage intake estimated from grazed pasture[1] or from animal performance[2] (yr 1).

	Grass pasture		Grass-clover mixed pasture	
Month/day	Grazed pasture	Animal performance	Grazed pasture	Animal performance
	(kg/d)			
5/13–31	12.5	10.2	14.3	10.5
6/1–26	9.9	8.2	9.8	9.0
6/27–7/17	14.1	6.3	8.9	8.1
7/18–8/11	4.6	4.4	10.6	6.1

[1]Estimated from amounts grazed (kg/ha; Table 4) and stocking rates (ha/d per cow).

[2]Estimated as the amount needed to balance the difference in NE_L required for maintenance plus FCM yields, with BW change taken into account, and NE_L provided by the supplements (Table 1). The NE_L requirement for maintenance included a 20% increase to account for grazing activity. The forage NE_L values used in converting daily NE_L needed from pasture to amounts of forage consumed were 1.54, 1.47, 1.39, and 1.32 Mcal/kg for the respective grazing periods.

during grazing. The estimates also suggest that the mixed pasture provided more consumable forage than grass pasture during much of the time (Table 7).

The reason for low feed intake is most likely related to limits in bite mass as a function of sward characteristics. Pasture intake is the product of bite mass, bite rate, and grazing time (Forbes, 1988). The height and density of the grazed herbage will influence bite mass. Forbes and Coleman (1987) found that bite size for cattle reached a maximum when forage mass was about 5000 kg/ha. As shown in Table 4, herbage mass ranged between 2400 and 4500 kg/ha in our study. Cattle will attempt to compensate for reductions in bite size by increasing either rate of biting or grazing time, but frequently the degree of the compensation is inadequate. Selective grazing, while tending to increase digestibility of consumed forage, can be a major cause for declines in bite size (Forbes, 1988). All of the lactation studies cited earlier that reported marked reductions in milk yield when cows were switched from confinement feeding to grazing used pasture with two or more permanent forage species. Mixed species pasture will promote selective grazing and may contribute to smaller bite size and reduced efficiency of grazing. Chilibroste et al. (2000) concluded that DMI or grazing time by cows grazing ryegrass was not related to rumen fill, ruminal VFA, or ammonia concentrations.

The NDF content of forage apparently consumed was high (ranged from 43.5 to 57.3% for yr 1, Table 3), especially during the last three grazing periods. Estimated NDF content of the total diets averaged 36.5 and 34.0% for cows grazing the grass pasture and mixed pasture in yr 1, compared with a minimal value of 28% recommended by NRC (1989).

Despite the high dietary NDF, physical fill of the rumen may not have been a limiting factor for maximum feed intake because the passage of herbage through the rumen might have been rapid. Berzaghi et al. (1996) determined that ruminal retention time was 5.5 h for liquid and 13.7 h for particulate matter in grazing cows. Typical rumen retention time in lactating cows when fed conserved feeds was 12 h for liquid and 24 h for particulate matter (Hartnell and Satter, 1979). Short retention time in the rumen may minimize the effect of rumen fill on intake, but could result in reduced digestibility of fiber in the rumen, and consequently reductions in absorbable energy intake.

High sugar content and fermentability of herbage material has been suggested as a factor causing low fiber digestibility (Berzaghi et al., 1996; Meijs, 1986). Accordingly, feeding a supplement high in fiber relative to a grain supplement should increase fiber digestibility by improving fermentation conditions in the rumen. However, feeding 6.4 kg/d of a corn-based supplement (95% corn and 5% minerals plus vitamins) did not affect ruminal OM digestibility of the total diet (Berzaghi et al., 1996), and feeding 2.3 kg/d of corn silage (accounting for 20 to 25% of forage intake) in addition to a grain mix did not increase milk yield of grazing cows (Holden et al., 1995).

Mean milk yield was 1.3 kg/d higher ($P = 0.03$) for cows grazing the mixed pasture than for cows grazing the grass pasture in yr 1 (Table 6). Higher milk yield resulted in higher ($P < 0.02$) milk fat and protein yields. Milk yield was sustained better with the mixed pasture than with the grass pasture (Figure 1). Greater consumption potential (Table 7) and lower NDF content (Table 3) appeared to be factors contributing to the superior performance of cows grazing the mixed pasture compared to the grass pasture. Additionally, Hoffman et al. (1993b) determined that degradation rates of NDF were higher, resulting in shorter times for digestion to occur for legumes than for grasses at similar maturity. More rapid degradation of legume NDF was related to lower content of hemicellulose, a potentially degradable but slowly degradable fiber component that is usually higher in grass than legumes. These observations are consistent with those of Aitchison et al. (1986), Moseley and Jones (1984), and Steg et al. (1994). Thus, with short retention time in the rumen, legume herbage should be more extensively digested than grass herbage.

Over the 2-yr period, 46% of the cows became pregnant by 100 DIM, and 64% of cows were pregnant with two or fewer inseminations. These correspond to similar values of 49 and 56% obtained with seasonal calving in the spring with cows receiving two-thirds or one-third of their DMI from grazing (Dhiman et al., 1996). Too few cows were involved in these studies to draw conclusions on seasonal effect of breeding efficiency, but it is well established that it is more difficult to obtain satisfactory reproductive efficiencies where inseminations occur in hot summer months compared with other times of the year.

CONCLUSIONS

Milk yield of mid- to late-lactation cows declined abruptly upon changing from confinement feeding to grazing native pasture, but the cumulative loss of milk production for the entire lactation was less than with early lactation cows reported in an earlier study. Estimates of DMI during grazing indicated that feed consumption declined when cows were changed from a TMR fed in confinement to grazing with supplements. If seasonal calving combined with grazing is a consideration, then placing fall-calved cows on pasture in the following spring toward the end of the lactation will result in less cumulative lactation loss than placing spring-calved cow on pasture early in lactation. Cows grazing mixed pasture containing 26% red clover and white clover yielded more milk than those grazing grass pasture. The superior value of the grass-clover mixed pasture appeared to be due to higher consumption potential and lower NDF content. Overseeding with red clover is a cost-effective way to upgrade the quality of permanent native pasture where seeding of improved grass species is not practical.

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