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Performance of Lactating Dairy Cows Managed on Pasture-Based or in Freestall Barn-Feeding Systems*

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ABSTRACT

The objective was to compare productive and metabolic responses of lactating dairy cows managed on 2 pasture-based systems using a concentrate supplement (n = 16) with those of a freestall housing system (n = 24). In a 259-d experiment, 3 multiparous Holstein cows were assigned at calving to each of 4 replicates of 2 pasture systems. For system 1, winter pastures were a mixture of rye, ryegrass, and crimson and red clover; summer pastures were pearl millet. Pasture system 2 included a rye-ryegrass mixture during winter and bermudagrass during summer. Pregraze herbage mass averaged 2.3 and 3.6 Mg/ha for winter and summer pastures, respectively; however, during August through September, pearl millet pregraze mass was reduced to about 1 Mg/ha. Daily dry matter intake by cows on pasture averaged 24.7 kg/d in winter and 19.0 kg/d in summer, of which 55% was from pasture; that of cows in confined-housing averaged 23.6 kg/d. Cows in confinement produced 19% more milk (29.8 vs. 25.1 kg/d) than those on pasture systems. Differences in concentration of milk fat, protein, or urea N were not detected among treatment groups. Grazing cows lost more body weight than confined cows (113 vs. 58 kg) and had lower concentrations of plasma glucose in the early weeks postpartum. Despite greater milk yield by cows housed in freestalls, milk income minus feed costs including that of pasture was similar for the 3 management systems. Although these pasture systems might be a viable management system in the southeastern US, extensive loss of body weight immediately postpartum for pasture-based cows are a potential concern.
(**Key words:** forages, grazing, management system, milk yield)

Abbreviation key: EXPD = expected digestibility, **FO** = fecal output, **IVOMD** = in vitro organic matter digestibility, **OMI** = organic matter intake, **PUN** = plasma urea nitrogen.

INTRODUCTION

Milk yield based on intensively managed pasture is a rapidly growing production system in the United States and Ireland, and has been important in New Zealand for many years (Hanson et al., 1998b). The key concept is substituting the cow for expensive machinery in the harvest of forages. These authors proposed that lower production costs are the primary economic benefit of intensive grazing compared with traditional systems based on mechanized harvesting and forage conservation. During the 1980s, an increasing public perception of dairies having a negative effect on the environment (Russelle et al., 1997), rising costs of machinery and housing, and reduced profit margin (Parker et al., 1992) began to make pasture systems more attractive. Staples et al. (1994) listed several reasons for greater interest in grazing including 1) lower expenses for feed, equipment, and buildings potentially leading to greater income per cow, 2) reported improvements in animal health and reproduction (less culling), 3) growing pressure from regulatory agencies and environmental interests to reduce centralized accumulation of cattle wastes, and 4) improved quality of life for managers (less stress, more leisure time, etc.).

Grazing lactating dairy cows on pasture is not a new feeding method. This approach has been advocated, abandoned, and now is being advanced again as an alternative feeding system, particularly in the northeastern United States. In a historical review, Hanson et al. (1998a) detailed these changes. By the late 1940s, farmers began to significantly increase their application of manufactured inputs, particularly purchased fertilizers, herbicides, and hybrid corn (*Zea mays* L.) seed. Between the late 1940s and 1990s, farmers achieved more than a 2-fold increase in yield of row crops such as corn and soybean (*Glycine max* [L.] Merr.),

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mainly due to new cultivars and use of purchased inputs. Advances associated with feeding technology pushed management toward feeding/finishing livestock in confinement. Within this context, the pasture was viewed as a low-yield source of supplemental forage or as an exercise lot. Muller and Holden (1994) described these changes in the Pennsylvania dairy industry, where the average number of cow days on pasture decreased from 170 in the early 1950s to 64 in 1990. The grazing system that has evolved in many areas of the United States during the 1980s and 1990s maintains an emphasis on concentrate feeding and high milk yield but with most forage coming from grazed pasture. Use of pasture-based dairy systems is challenging in Florida, however, because of the widely varying nutritive value of forage throughout the year, heat stress, and the difficulty in formulating balanced rations due to problems of quantifying forage intake on pasture.

Most research done with pasture-based systems has been short-term in nature. Longer, full-lactation comparisons of pasture and confinement systems are needed. Systems should be explored where cows freshen in fall and early winter and are assigned to high quality cool-season pasture for the first 4 mo or more of their lactation, thus matching periods of peak milk yield with cooler temperatures and higher quality forage. This experiment was conducted to compare pasture-based and confinement systems for Holstein cows milking from January to October.

MATERIALS AND METHODS

The experiment was performed at the University of Florida Dairy Research Unit (DRU) in Hague, which is located about 20 km north of Gainesville (latitude 30°N and longitude 82.5°W). Soils were fine sands of moderate fertility with an average pH of 5.7, and Mehlich I extractable P of 116 g/kg, K of 40 g/kg, Mg of 46 g/kg, and Ca of 400 g/kg.

The 3 treatments were 2 pasture systems and a traditional free-stall housing management system. Pasture system 1 was designed to use the highest quality annual forages for grazing that are available in the region. Pasture system 2 was intended to reflect less intensive management, utilizing a perennial grass for warm-season grazing and annual grasses for the cool season. Concurrently, Holstein cows were managed in sand-bedded free-stall housing at the university farm as system 3.

System 1 was based on a mixture of 'Grazemaster' rye (*Secale cereale* L.), 'Surrey' annual ryegrass (*Lolium multiflorum* Lam.), 'Flame' crimson clover (*Trifolium incarnatum* L.), and 'Cherokee' red clover (*Trifolium pratense* L.) grazed during the winter-spring season and 'Tifleaf 2' pearl millet (*Pennisetum glaucum* [L.] R.Br.) grazed during the summer-fall season. System 2 used rye-ryegrass mixtures (no clover) during winter-spring and 'Tifton 85' bermudagrass (*Cynodon* spp.) during summer-fall. The cool-season annual forages were planted on 23 October, by sod seeding one replicate over bermudagrass, and 3 replicates over 'Florigraze' rhizoma peanut (*Arachis glabrata* Benth.) pastures without use of herbicide. The seeding rates for system 1 were 68 kg/ha for rye, 11.4 kg/ha for ryegrass, 10 kg/ha for crimson clover, and 6 kg/ha for red clover. The clovers were inoculated with *Rhizobium trifollii*. The seeding rates for system 2 were 91 kg/ha for rye and 17 kg/ha for ryegrass. Irrigation was used as needed to ensure good stand establishment.

For the warm weather period of system 1, pearl millet was seeded on 20 May at 25 kg/ha. Before planting, the area was sprayed using 5.0 L/ha of Roundup (Monsanto Co., St. Louis, MO; Glyphosate, N-phosphonomethyl glycine in the form of its isopropylamine salt, 1%) to kill common bermudagrass (*Cynodon dactylon* [L.] Pers.). Selection of Tifleaf 2 was based upon 2 yr of experiments that compared a group of pearl millet and sorghum-sudangrass cultivars under frequent defoliation (Fontaneli et al., 2001). Irrigation was used as needed and grazing was begun on 16 June when pearl millet reached a height of 40 cm. For system 2, well-established stands of the summer perennial Tifton 85 bermudagrass were available for grazing when growth began in late spring. Cows transitioned from winter to summer pastures in early June and grazed summer pastures until early October.

Pasture fertilization was guided by soil tests, previous experience at this location, and need for forage. The total amount applied in each system was 280-17-99 kg/ha of N-P-K, respectively, on system 1 (rye-ryegrass-clovers/pearl millet), and 360-17-99 on system 2 (rye-ryegrass/bermudagrass). An additional application of 40 kg of N/ha was made to system 2 pastures in late spring (no clover in this system) and late summer (bermudagrass production continued longer than pearl millet). Although system 1 included clover, previous experience has shown that early-season growth of rye-ryegrass-clover mixtures is slow when no N fertilizer is applied, thus a total of 120 kg of N/ha was used from 2 wk after fall planting until clovers became productive in midspring.

Both pasture systems were replicated 4 times in a randomized block design. Pasture size for each experimental unit was 1.2 ha, with 0.8 ha of this area being grazed during winter-spring and 0.4 ha being grazed during summer-fall. A total of 40 multiparous Holstein cows calving in January and February were assigned randomly at calving to the 3 treatments during about

Table 1. Ingredient composition of experimental diets and supplements fed to cows managed in freestalls or on pasture.

Ingredient	TMR fed in barn	TMR fed on pasture	Supplement fed in winter	Supplement fed in summer
Corn silage	29.3	...	...	...
Alfalfa hay	16.0	...	...	...
Hominy	20.0	13.7	29.6	26.6
Citrus pulp	9.3	19.7	15.0	15.0
Distillers grains	3.2	8.7	6.0	6.0
Soybean meal	11.7	10.8	...	3.0
Fish meal	...	...	2.5	2.5
Whole cottonseed	5.7	14.8	19.2	19.2
Cottonseed hulls	...	18.7	...	...
Soybean hulls	...	10.9	22.5	22.5
Sodium bicarbonate	...	1.1	1.6	1.6
Trace mineralized salt[1]	...	0.2	0.2	0.2
Mineral-vitamin mix[2]	4.3	1.3	3.1	3.1
MgO	...	0.1	0.3	0.3

[1]Trace mineralized salt contained a minimum concentration of 40% Na, 55% Cl, 0.25% Mn, 0.2% Fe, 0.033% Cu, 0.007% I, 0.005% Zn, and 0.0025% Co (DM basis). Product was purchased from Flint River Mills, Inc., Bainbridge, GA.

[2]Mineral and vitamin mix contained 26.4% CP, 10.5% Ca, 2.5% P, 7% K, 2.5% Mg, 8.5% Na, 0.5% S, 5.4% Cl, 1400 ppm Mn, 1500 ppm Zn, 430 ppm Cu, 25 ppm Co, 15 ppm I, 8.2 ppm Se, 147,740 IU/kg of vitamin A, 42,990 IU/kg of vitamin D, and 728 IU/kg of vitamin E (DM basis).

(**PUN**) [a modification of Marsh et al. (1965) as described in Bran and Luebbe Industrial Method # 339-01].

Voluntary forage intake by cows on pasture was measured once during winter (average of 81 DIM) and once during summer (average of 178 DIM) using a pulse dose technique (Pond et al., 1987, 1989a,b) with chromium-mordanted fiber as an inert marker to determine fecal output (**FO**). Forage of quality similar to that consumed was collected across all pastures within a treatment and composited. Forages were dried at 65°C and ground to pass a 2-mm screen using a Wiley mill. Fiber from the forage was mordanted using the methodology of Udén et al. (1980). The ground forage (~700 g) was

Table 2. Average chemical composition of TMR fed to cows managed in freestalls and concentrate supplement and TMR fed to cows managed on pasture.

Measure	TMR fed in barn	SE	Concentrate fed on pasture[1]	SE	TMR fed on pasture[2]	SE
NDF, % of DM	44.9	3.71	36.4	1.81	45.6	0.42
ADF, % of DM	30.0	3.26	24.7	2.04	36.4	1.27
Ether extract, % of DM	5.8	0.44	7.3	0.35	6.35	0.07
NE_L, Mcal/kg of DM[3]	1.63	0.03	1.86	0.05	1.7	0.00
CP, % of DM	18.1	0.85	17.5	0.67	17.5	0.99
RUP, % of DM	6.3	0.30	6.1	0.23	6.15	0.35
RDP, % of DM	11.8	0.56	11.4	0.43	11.35	0.64
Soluble CP, % of DM	5.7	0.30	6.1	0.23	6.15	0.35
Ca, % of DM	1.03	0.12	1.13	0.13	0.77	0.11
P, % of DM	0.47	0.05	0.64	0.06	0.44	0.00
K, % of DM	1.54	0.12	1.25	0.08	1.24	0.05
Mg, % of DM	0.32	0.02	0.52	0.05	0.34	0.01
Na, % of DM	0.39	0.05	0.86	0.07	0.58	0.12
S, % of DM	0.18	0.05	0.18	0.01	...	...
Cl, % of DM	0.54	0.12	0.42	0.06	0.34	0.00
Mn, mg/kg of DM	70	12.8	59	10.4	40	3.53
Fe, mg/kg of DM	344	100	403	62	290	17.8
Cu, mg/kg of DM	25	7.2	20	6.2	14	7.8
Zn, mg/kg of DM	80	14.4	110	12.4	112	13.4

[1]Average of samples collected from January to September.

[2]Average of samples collected during winter and summer seasons.

[3]Calculated using NE_L (Mcal/kg of DM) = 0.0245 × %TDN − 0.12 (NRC, 1989).

computed from estimates of FO (called observed FO) obtained from the marker appearance curve, and total diet digestibility [called expected digestibility (**EXPD**)] to balance for the estimated proportion of forage and concentrate supplement OM consumed and their respective digestibilities. Estimated forage OMI is the difference between total OMI and known supplement OMI. The equation to calculate EXPD is:

$$\text{EXPD} = (\text{forage OMI} \times \text{forage OMD} + \text{supplement OMI} \times \text{supplement OMD})/\text{total OMI}.$$

This EXPD was further adjusted to help account for associative effects (Moore et al., 1992; Dixon and Stockdale, 1999) that may result from mixed forage-concentrate diets. This new calculation of total diet digestibility, called adjusted digestibility, was obtained using an equation developed from a wide range of published data of mixed diet digestibilities showing deviation from the expected (based on calculations from the weighted intake and digestibilities of the forage and concentrate supplement components) when mixed diets are fed (Moore et al., 1999). The equation is:

$$\text{Adjusted Digestibility} = 59.71 - 0.8948 \times \text{EXPD} + 0.01399 \times \text{EXPD}^2$$

Using this adjusted digestibility value (ADJ), a prediction of FO was computed:

$$\text{Predicted FO} = \text{Total OMI} \times (1 - \text{ADJ})$$

Given that supplement OMI is fixed, the iterative SAS program then adjusted estimates of forage intake until the difference between observed FO and predicted FO is less than 0.01 kg of OM/d. Forage OMI estimates were converted to DMI estimates by dividing the OMI by OM concentration of the forage.

Feed Costs and Milk Income

Feed costs and income from milk were calculated for the 2 forage systems and the confined housing system. Calculation of feed costs included establishment (soil preparation and seed) and maintenance (fertilization, herbicide, and insecticide use) of pastures, costs of feedstuffs, costs of TMR for barn cows, concentrate supplement for grazing cows, cottonseed hull-based supplement for grazing cows, total ration costs for 3 systems, costs of herbage and amount and extent of use of concentrate supplements fed per cow.

Statistical Analysis

The experimental design was a randomized complete block with 4 replications. Data were analyzed using SAS procedures for repeated measures (Littell et al., 1996, 1998; SAS Institute, 1989).

The standard model for repeated measures experiment of animal and plant response variables was

$$yij = \mu + \alpha i + \beta j + (\alpha\beta)ij + eij$$

where yij = the response at time j on treatment i, μ = the overall mean, α_i = fixed effect of treatment i, βj = fixed effect of time j, $(\alpha\beta)$ij = fixed interaction effect of treatment i with time j, and eij = random error at time j on treatment i.

Contrasts of barn vs. pasture system 1 and barn vs. pasture system 2 were made. Interactions between treatment and sampling period (time) were determined using contrast statements in PROC MIXED. Differences were considered significant at $P < 0.05$. Pasture systems were tested at each evaluation date for plant response variables (herbage mass, IVOMD, CP, NDF, and intake) and all systems were tested every week for animal response variables (milk yield, milk composition, BW, and plasma NEFA, glucose, and urea N concentrations). Economic variables were analyzed using ANOVA models for a completely randomized design in PROC MIXED (SAS Institute, 1989). An *F*-protected least significant difference test was used to compare all treatment effects.

RESULTS AND DISCUSSION

Botanical Composition

During winter, the average contribution of ryegrass was 47% in pastures with clovers (system 1) and 59% in pastures without legumes (system 2). The ryegrass contribution increased and rye decreased as the season progressed. Crimson and red clovers made their greatest contribution late in the cool season, being 20 to 25% of total DM in April/May (>500 kg of DM/ha).

Herbage Mass

Pregraze and postgraze herbage mass in winter/spring averaged 2350 ± 330 and 910 ± 190 kg of DM/ha, respectively. Pregraze and postgraze herbage mass in summer averaged 3580 ± 830 and 2400 ± 630 kg DM/ha. Herbage mass did not differ between pasture systems during winter and through 23 July in summer (Figure 1). This situation changed during late summer when growth rate of pearl millet decreased. From 12 August throughout September, herbage mass of Tifton 85 bermudagrass (system 2) was greater than that of pearl millet.

Table 4. Dry matter intake by lactating dairy cows managed on 2 pasture systems.

Measure of DM intake	Treatment			
	Pasture system 1[2]	Pasture system 2[3]	SE	*P*
Cr pulse dose method				
Winter forage, kg/d	13.3	13.5	2.8	0.87
Summer forage, kg/d	10.9	10.3	2.8	0.59
Winter forage plus supplement, kg/d	24.7	24.8	2.9	0.95
Summer forage plus supplement, kg/d	19.1	18.9	3.1	0.86
Sward difference method				
Winter forage intake, kg/d	13.1	14.7	2.0	0.31
Summer forage intake, kg/d	7.5	8.0	2.1	0.77

[1]Rye-ryegrass-clovers in winter and pearl millet in summer.

[2]Rye-ryegrass in winter and bermudagrass in summer.

cows consuming an all-pasture diet produced 33% less milk than cows fed a TMR (29.6 vs. 44.1 kg/d), and had a milk protein concentration that was 0.19 percentage units lower. Fike et al. (1997) reported large decreases (10 to 15 kg/d) in milk yield for cows moved from a confined housing system to bermudagrass or rhizoma peanut (*Arachis glabrata* Benth.) pastures in Florida in midsummer. Based upon DMI (Table 4) and energy density and digestibility of the dietary components (Tables 2 and 3), intake of energy may not have differed between housed and pastured cows. However, 48-h IVOMD values for grazed forages do not account for the fast rate of passage of digesta from the rumen during grazing and therefore may overestimate the digestible energy derived from the pasture forage. In addition, energy expenditures must have been greater for pastured cows due to their grazing activity and their round trips from pastures to the milking parlor twice daily,

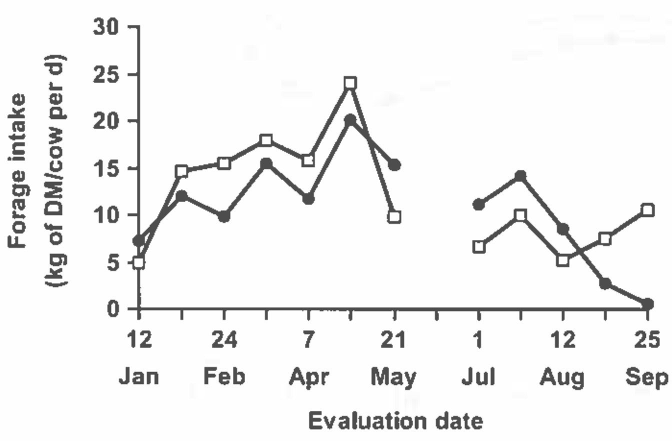

Figure 2. Intake of pasture forage (measured by the sward difference method) by lactating dairy cows (kg/d) managed on 2 pasture systems [rye-ryegrass-clovers in winter and pearl millet in summer (●) or rye-ryegrass in winter and bermudagrass in summer (□)] over the first 37 wk of lactation. Test of □ vs. ● was significant ($P < 0.05$) on February 24, March 17, July 1, July 22, and September 25.

thus leaving less dietary energy for productive purposes. In addition, pastured cows did not have the benefit of fans and sprinklers, as did the cows housed in cooled free stalls.

No differences among treatments were detected in concentration of milk fat (3.69, 3.60, and 3.70%), milk protein (2.90, 2.96, and 2.95%), or milk urea N (16.5, 17.1, and 15.6 mg/100 mL) for cows managed in freestalls, pasture system 1, or pasture system 2, respectively. However, mean SCC was greater in milk from cows managed in free-stalls compared with those on pastures (654,000 vs. 223,000 and 364,000).

Grazing cows lost approximately 113 kg in the first 8 wk postpartum compared with 58 kg for confined cows (Figure 4). This greater loss of BW was accompanied by lower milk yield compared with barn-confined cows. These dual responses must have been driven by a greater negative energy status of grazing animals possibly due to lowered energy intake and greater energy expenditures as described earlier. With the growth of new forage in the summer (approximately wk 11 to 21 postpartum), cows on pastures gained BW so that BW of cows in barns or on pastures did not differ during this period. Toward the end of the summer growing season, pearl millet stands became somewhat depleted and cows lost BW and therefore were lighter than cows in free-stalls (Figure 4). Cows grazing bermudagrass did not differ in BW from cows managed in free-stalls.

Plasma Metabolites

Plasma NEFA concentrations gradually decreased from calving until wk 15 postpartum, at which time concentrations remained unchanged. Plasma NEFA concentrations were greater during the first 4 wk postpartum for cows grazing pasture system 1 compared with those in free-stalls (Figure 5). This may have been because the 2 groups of cows did not differ in milk yield but BW loss was greater for this group of grazing cows.

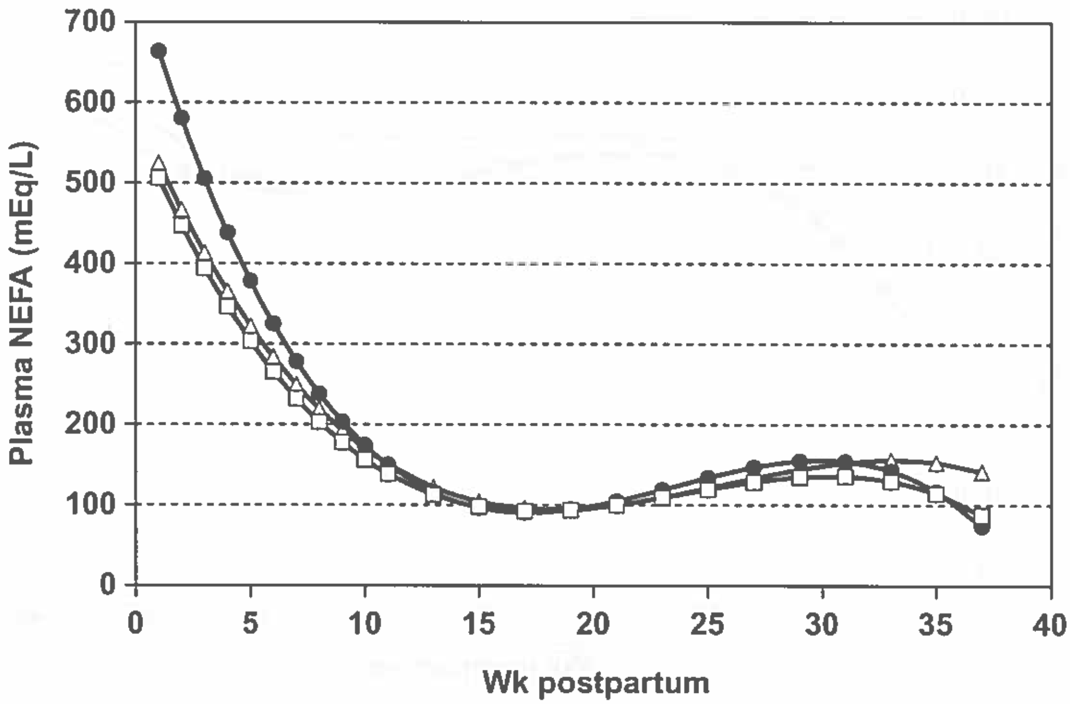

Figure 5. Concentration of NEFA in plasma of lactating dairy cows managed on 2 pasture systems [rye-ryegrass-clovers in winter and pearl millet in summer (●) or rye-ryegrass in winter and bermudagrass in summer (□)] and in free-stall housing (△) over the first 37 wk of lactation. Test of △ vs. ● was significant ($P < 0.05$) at wk 1 through 4. Test of △ vs. □ was not significant ($P \geq 0.05$) at any week. The pooled SE was 19.5 mEq/L.

In a reciprocal fashion to NEFA, concentrations of plasma glucose gradually increased in the first 10 wk postpartum (Figure 6). This pattern followed increases in forage intake (Figure 2). Cows managed in free-stalls had greater concentrations in the first 5 wk and 2 wk postpartum compared with cows grazing pastures with and without clover, respectively. In addition, grazing cows had lower concentrations of plasma glucose during a 12-wk summer period that coincided with BW loss compared with barn-housed cows (Figure 4).

Concentrations of PUN increased with week postpartum, probably reflecting DMI patterns (Figure 7). Because the CP concentration of the pasture forages and supplements were greater than that of the TMR fed in the barn (Table 3), concentrations of PUN in pastured cows rose faster in the first 10 wk postpartum. However, PUN values from grazing cows decreased during the summer season because summer forages were lower in CP concentration than winter forages (Table 3) and because DMI was lower in summer than winter (Table 4). Grazing cows had lower PUN values than barn-fed cows probably because of lower DMI. The PUN values were ≥12 mg/100 mL for almost the entire trial, indicating that dietary CP intake was seldom, if ever, limiting milk yield.

Feed Costs and Milk Income

Although the costs of producing milk involve a number of variables, feed cost is the largest component. This section assesses the feed cost relative to milk income of the 2 pasture systems compared with the conventional housing system. The fixed and variable costs of building and maintaining a free-stall barn and purchasing and maintaining a mixer wagon were not part of this analysis.

Pasture cost was calculated to be $298.95/ha for rye-ryegrass-clovers, $289.21/ha for rye-ryegrass, $332.80/ha for pearl millet, and $288.91/ha for bermudagrass. The cost ($9.74/ha) for the winter component of system 1 was 3% higher due to the cost of clover seed that was not totally compensated for by additional N fertilization on system 2 (rye-ryegrass-without clovers). Summer pastures of system 1 (pearl millet) had a 15% greater ($43.89/ha) cost than those of system 2 (bermudagrass). Pasture costs were $0.35 and $0.30/d per cow for pasture systems 1 and 2, respectively (Table 5).

The cost of the TMR was $0.093/kg as fed, which calculated to $4.20/d per cow. Average supplement costs for grazing cows were $0.151 and $0.153/kg (as fed), or $1.94 and $1.83/d per cow for systems 1 and 2, respec-

Table 5. Feed cost and milk income of 2 pasture systems and a confined housing system.

System	Milk income	Supplement or TMR cost	Pasture cost	Milk income minus feed cost[1]
	($/cow per d)			
Pasture 1[2]	7.85[b]	1.94[b]	0.35[a]	5.56[a]
Pasture 2[3]	7.99[b]	1.83[c]	0.30[b]	5.84[a]
Barn	9.52[a]	4.20[a]	...	5.32[a]
SE	0.37	0.05	0.02	0.36

[a,b,c]Means in the same column with different superscripts tended to be different ($P < 0.10$).

[1]Milk income − supplement or TMR cost − pasture cost.

[2]System 1 = rye-ryegrass-clovers in winter and pearl millet in summer.

[3]System 2 = rye-ryegrass in winter and bermudagrass in summer.

tively (Table 5). The greater cost incurred for feeding cows on system 1 was basically due to the cottonseed hull-based supplement fed during the last month of the trial due to a shortage of pearl millet forage.

Milk price was set at $31.95/kg. Greater milk income but greater feed costs of cows in free-stalls compared with those of grazing cows ($P < 0.05$) resulted in milk income minus feed cost values being not statistically different between the systems, ranging between $5.32 and $5.84/d per cow (Table 5). If costs of labor, feeding and harvesting equipment, and housing facilities were included in the analysis, profitability among the dairy management systems would likely differ. In another study, a pasture-based system was economically competitive because costs were reduced, even though milk yield of cows was lower when cows were pastured compared with being confined and fed in a barn (White et al., 2002). Cows on pasture had less clinical mastitis and lower BW and BCS than confined cows; but Holsteins generally had lower BCS, reduced reproductive rates, more mastitis, and higher culling rates than Jerseys in both the pasture and confinement systems (Washburn et al., 2002). Individual dairy producers will need to assess their own situations when making decisions regarding management systems to adopt.

CONCLUSIONS

Cows managed in free-stall housing and fed a TMR produced 19% more milk than cows grazing 2 different pasture systems and supplemented with concentrates during the first 37 wk postpartum. Concentrations of milk fat, milk protein, and milk urea N were not different. During the first few weeks postpartum, cows on pasture lost twice the BW and had lower concentrations of plasma glucose compared with cows in barns. Greater loss of BW was accompanied by increased concentrations of plasma NEFA in cows grazing rye-ryegrass-clover pastures compared with cows fed TMR during the first 4 wk postpartum. Although the planting of clovers along with rye and ryegrass in winter had some benefit in early lactation, benefit to cow performance over the 37 wk postpartum appeared negligible. Although containing more NDF and less CP, well-managed Tifton 85 bermudagrass proved to be of equal or superior value to pearl millet as a summer forage for lactating dairy cows. This was likely due to the shorter season of production and the greater cost of growing millet vs. bermudagrass, and to the relatively high amount of concentrate fed to grazing animals, which likely reduced the impact of grazing higher nutritive forage such as pearl millet. The feed cost of grazing cows was about one-half that of barn-confined cows but milk income was 20% less, resulting in similar milk income minus feed cost values.

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REFERENCES

Association of Official Analytical Chemists. 1990. Official Methods of Analysis. 15th ed. AOAC, Arlington, VA.

Dixon, R. M., and C. R. Stockdale. 1999. Associative effects between forages and grains: Consequences for feed utilization. Aust. J. Agric. Res. 50:757–773.

Fike, J. H., C. R. Staples, B. Macoon, and L. E. Sollenberger. 2003. Influence of forage species, supplementation rate, and stocking rate on performance of lactating Holstein cows managed on rotationally stocked pastures. J. Dairy Sci. 86:1268–1281.

Fike, J. H., C. R. Staples, L. E. Sollenberger, and D. A. Graetz. 1997. Intensive rotational grazing systems for dairying in a subtropical environment: animal, plant, and soil responses. Section 29:93–94 in Proc. 18th Int. Grassl. Congr., Winnipeg, Saskatchewan, Canada.

Fontaneli, R. S., L. E. Sollenberger, and C. R. Staples. 2001. Yield, yield distribution, and nutritive value of intensively managed pearl millet and sorghum-sudangrass. Agron. J. 93:1257–1262.

Gallaher, R. N., C. O. Weldon, and J. G. Futral. 1975. An aluminum block digestor for plant and soil analysis. Soil Sci. Soc. Amer. Proc. 39:803–806.

Golding, E. J., M. F. Carter, and J. E. Moore. 1985. Modification of the neutral detergent fiber procedure for hay. J. Dairy Sci. 68:2732–2736.

Gouchman, N., and J. M. Schmitz. 1972. Application of a new peroxide indicator reaction to the specific automated determination of glucose with glucose oxidase. Clin. Chem. 18:943–950.

Hambleton, L. G. 1977. Semiautomated method for simultaneous determination of phosphorus, calcium and crude protein in animal feeds. J. AOAC 60:845–852.

Hanson, G. D., L. C. Cunningham, S. A. Ford, L. D. Muller, and R. L. Parsons. 1998a. Increasing intensity of pasture use with dairy cattle: An economic analysis. J. Prod. Agric. 11:175–179.