Performance of Dairy Cows in Midlactation Fed High Quality Grass Pasture and Concentrate at Three Percents of Energy Requirements

HOMERO G. SALINAS, W. C. STRINGER, E. M. KESLER, and G. L. HARGROVE
Department of Dairy and Animal Science
The Pennsylvania State University
University Park 16802

ABSTRACT
Thirty multiparous cows rotationally grazed high quality grass pastures (predominantly Dactylis glomerata and Poa pratensis) for 140 days. Stage of lactation was 54 to 192 days at beginning of trial. Cows were offered concentrates to supply 33, 66, or 100% of requirements for net energy for lactation above maintenance; daily intakes by the three groups averaged 3.5, 7.7, and 11.5 kg. Refusal of concentrate tended to increase with supplementation. Average milk production was 19.2, 20.4, and 21.5 kg. When individual yields were compared with an initial 2-wk period prior to trial, there was no difference in decline in milk flow, except for one 28-day period in midsummer when decline by the 33% group was greater than that by the 100% group. Milk fat yields were similar. Milk protein yields by the 100% group were significantly higher than those by the 33% group. Body weight changes were similar among groups. Quality of forage was high, and yields were adequate. Changes in milk flow attributable to movement of cows to fresh pastures were +1.35 kg per cow daily. Variations in in vitro dry matter disappearance, crude protein, and dry matter of forage were positively associated with changes in milk flow.

INTRODUCTION
Future need for feed grains and plant proteins as human food and increasing costs for energy may dictate that dairy cows will be fed less concentrates. Concentrate production is energy intensive. In the United States there has been relatively little pasture research in recent years, due partly to the assumption that good land can be more profitable if used for intensive cropping (10). However, it appears that well managed, high quality pasturage has the potential to supply a major portion of the nutrient needs of cows of moderate production. Such usage assumes added importance for land unsuited for intensive cropping. Conrad and Van Keuren (3) reported that when dairy cows grazed high quality pastures without concentrate supplementation, 20.2 kg of milk was produced daily per cow. Other reports agree (4, 5, 6, 11). Bryant et al. (2) grazed cows on Ladino clover-orchard grass and reported that top grazers averaged 19.8 kg of milk per day as compared with 16.0 kg for bottom grazers. Holloway et al. (7) found that Angus cows grazing high quality pastures consumed 1.7 kg more dry matter (DM) per day than those grazing pasture of lower quality. High quality forage and adequate grazing management are important to efficient use of pasture resources with dairy cattle.

The objective of this study was to determine the extent to which good quality grass pasture can support production of cows in midlactation.

EXPERIMENTAL PROCEDURES
Multiparous cows, 21 Holsteins and 3 each of Jersey, Ayrshire, and Brown Swiss breeding, were on trial for 140 days. They were in three groups based on individual requirements for energy (net energy for lactation, NE\textsubscript{L}) calculated on basis of milk yield, milk fat percentage, and body weight immediately prior to start of the trial (8). Cows were allotted randomly from each group to the three treatments. They averaged 130 days (range 54 to 192) in milk at start of the trial on May 25. Initially they were fed concentrate to supply 33, 66, or 100% of
NE\textsubscript{L} needs above maintenance. Each cow's calculated daily allowance of concentrate was given in two equal feedings for the first 28 days. At that point and at the end of each succeeding 28-day period concentrate was reduced by .36 kg/day per cow in anticipation of declining lactation. The concentrate was a standard mixture averaging 19.3% protein in dry matter to insure adequate intake of protein. To avoid grass tetany 56.7 g magnesium oxide were top dressed on the concentrate for each cow daily.

Two weeks prior to the trial, cows were changed from indoor feeding (corn silage, haylage, and concentrate) to pasture and indoor feeding. After the trial started, cows grazed day and night except for removal from the pasture twice daily to an artificially ventilated barn for 2 h just prior to milking. Concentrate was weighed and fed to each cow in the barn according to treatment, and refusals were collected once a day after morning feeding. Samples of concentrate were collected once weekly for determination of crude protein and moisture.

Orchard grass (Dactylis glomerata L.) and Kentucky blue grass (Poa pratensis L.) pasture was divided into three plots of 3.0, 3.4, and 4.3 ha. During the summer two additional plots (6.0 and 3.4 ha) each were grazed for 11 days to compensate for slow herbage growth. Plots were grazed in rotation by the 30 cows. They were moved whenever available forage was reduced (average pasture canopy height of 15 cm). Pastures were clipped after grazing and allowed at least 3 wk recovery time. There were 14 grazing periods, 7 to 14 days. The amount of pasture herbage offered to the cows was estimated at the beginning, middle, and end of each grazing by clipping twenty .1076 m\textsuperscript{2} samples to ground level at random sites within each pasture. At the same time, heights of the herbage also were measured, and 21 additional herbage samples were obtained. These were combined into one bulk sample for measure of forage quality and proportions of leaf and stem. Herbage samples were dried to a constant weight in a forced draft oven at 80\degree C, and forage dry matter availability was determined. Protein (Kjeldahl) and in vitro dry matter disappearance (IVDMD, 1) determinations served as measures of forage quality. Soil samples taken from the three plots at beginning and end of the trial were analyzed at the Penn State Soil Testing Laboratory by standard procedures.

Milk yields were recorded daily, and a composite sample of morning and evening milkings was obtained for each cow at 14-day intervals. Analysis for percent milk fat and protein was by machine methods (Foss Milk O-Tester and Pro-Milk). Cows were weighed on 2 successive days immediately prior to the trial and at 28-day intervals or when an individual was terminated on trial. Because of approaching parturition, a few cows were terminated prior to the end of the fifth interval. Production data were summarized by five 28-day periods. For statistical analysis each treatment was analyzed as a randomized design within breeds.

RESULTS AND DISCUSSION

Performance of cows supplemented with three percent of concentrate did not differ greatly (Table 1). Those in the high-grain group tended to produce slightly more milk of higher protein content and to gain more body weight. Differences were not statistically significant. These results agree with those of Hoden et al. (6), Donker et al. (4), and Pres (11), who concluded that 20 to 23 kg of milk per cow daily may be produced by cows fed high quality pasture and small amounts of grain.

Because of the wide range between cows for stage of lactation, production of milk, milk fat, and protein by each cow was compared with that during the 2 wk prior to the trial. There were five 28-day periods, and production in each period was compared with the pre trial mean. In Figure 1 are mean reductions by period. There was no significant difference in milk output between treatments except in period 2. At this point milk output by the low-grain group had declined more rapidly than that by the high-grain group \((P<.05)\). The change in direction of the curve for the medium-grain group between periods 4 and 5 was the result of drying off two cows. Differences in the rate of decline of fat production were not significant. Protein output by the high-grain cows declined less rapidly throughout, with the difference between the high and low grain
Figure 1. Reduction of yields of milk (A), milk fat (B), and milk protein (C) by 28-day periods compared with period 0. Treatment differences by periods were significant (P<.05) only in period 2 for milk and periods 1 through 4 for protein.

Table 1. Mean milk yield and composition, grain intake and refusals, and body weight change by pastured cows on three percents of supplement (grazing period 140 days).

<table>
<thead>
<tr>
<th>Component</th>
<th>Low grain</th>
<th>Medium grain</th>
<th>High grain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cows</td>
<td>10</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Grain intake (kg/cow per day)</td>
<td>3.5</td>
<td>7.7</td>
<td>11.5</td>
</tr>
<tr>
<td>Grain refusal (kg/cow per day)</td>
<td>.1</td>
<td>.2</td>
<td>.7</td>
</tr>
<tr>
<td>Milk:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily production (kg)</td>
<td>19.2</td>
<td>20.4</td>
<td>21.5</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>4.0</td>
<td>3.7</td>
<td>3.9</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>3.4</td>
<td>3.3</td>
<td>3.5</td>
</tr>
<tr>
<td>Greatest weight loss (kg) b</td>
<td>12.3</td>
<td>3.4</td>
<td>5.7</td>
</tr>
<tr>
<td>Body weight gain (kg) c</td>
<td>23.4</td>
<td>21.6</td>
<td>33.0</td>
</tr>
</tbody>
</table>

aConcentrate to meet 33% (low), 66% (medium), and 100% (high) of requirements above maintenance, based on net energy for lactation (NEj).

bMeans are initial minus lowest body weights.

cFinal minus initial weights.

Grain intakes by the low-, medium-, and high-grain groups averaged 3.5, 7.7, and 11.5 kg per cow daily (Table 1). There was a significant difference in grain refusals among the three percents (P<.01) with the extent of refusals increasing with amounts offered. Range of refusals by the high grain group was .1 to 2.6 kg, that by the medium grain group 0 to .7, and that by the low-grain cows 0 to .3 kg. The latter group derived a larger portion of required nutrients from pasturage.

Most of the cows lost body weight in the early part of the trial with the trend more pronounced in the low-grain group (Table 1). In general, cows tended to gain weight thereafter so that they averaged 26 kg heavier at the end of the trial than at the beginning; however, the range was -30 to +68 kg. Treatment differences in weight gains and losses were not statistically significant.

Health problems were minimal during the trial. There were a few mastitis flareups and a single case of grass tetany that was complicated further by development of a displaced abomasum, which required corrective surgery. Data from this animal (a Jersey) were not included in the analyses.
Pastures were excellent throughout. The growing season was characterized as cool and moist. Mean temperatures for May, June, July, August, September, and October were 15.1, 18.8, 21.2, 20.8, 17.0, and 10.7°C. Rainfall was 10.2, 5.8, 7.4, 13.2, 14.7, and 11.3 cm during the same months. Soil tests prior to and at the end of the trial indicated that soil nutrient status was adequate.

Plant growth during the first 28-day period (period 1) was reproductive, averaging 62 cm in height and with only 44% leaf (Table 2). Subsequent growths were vegetative. Their average heights at beginning of rotations was 37 cm with 87% leaf. Except for period 1, mean height at end of rotations was 18 cm. Crude protein contents at start of grazing on each pasture averaged 15% in period 1 and 20% during subsequent periods. Comparable for IVDMD were 67 and 72%. As an indication of selective grazing, forage remaining at the end of the grazing periods was reduced in protein, IVDMD, and percent leaf as compared with that available at initiation.

Amounts of dry matter available for grazing were calculated. Measured yields of herbage dry matter were averaged for the three samplings of a given plot and rotation. This average was divided by the number of cows and number of days cows grazed the plot. Rotations from one plot to another coincided fairly closely with the end of the 28-day periods (0 to 4 days divergence). There were three rotations represented in periods 1, 2, 3, and 5 and two in period 4. Average dry matter available for grazing during the period was the weighted mean of that available in rotations during the period. Means were 37.4, 23.2, 29.1, 15.8, and 16.2 kg dry matter available per cow daily for periods 1 through 5.

When cows were switched to a new grazing plot, actual milk production increased after 2 to 3 days, presumably from increased forage availability and selective grazing of quality herbage. Subsequently, with continued grazing, milk yields gradually declined until the animals again were changed to a new plot (Figure 2). It appeared desirable to assess the importance of variations in yield from changing pastures and to attempt to establish relationships between variations and changes in pasture quality. To establish these relationships without influences of cows drying off during the trial, we used only the milk yields of a group of 15 Holstein cows that did not dry off. Predicted milk yield was estimated for each cow by a straight-line fit by linear regression to observed daily milk yields. Because all cows were past peak lactation and because all yields declined...
TABLE 3. Change of milk yield when cows were switched from one plot to the next in the grazing rotation.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Low grain</th>
<th>Medium grain</th>
<th>High grain</th>
<th>Significance</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cows</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change (kg of milk/cow)</td>
<td>1.74</td>
<td>1.21</td>
<td>1.11</td>
<td><strong>P&lt;.05</strong></td>
<td>16</td>
</tr>
</tbody>
</table>

during the trial, the predicted yield was a straight declining curve. Deviations of daily yield from the predicted curve were the result of changes in pasture quality or of such factors as estrus, mastitis flareups, unusual refusals of grain, and other unidentified causes.

Yield variations attributable to switching to new plots were calculated. The average difference between predicted and measured milk flow during the last 2 days prior to switching was compared with that of the 3rd and 4th days after the switch. This was the net change in production due to the switch from old to new pasture. Care was exercised to exclude data from any cow that on those days was in estrus or had a health problem. There were 13 movements of cows to new plots; therefore, 13 average changes in production were calculated. Table 3 shows mean changes by cows on the three grain treatments. Switching to a new plot boosted yield by an average of 1.35 kg of milk per cow per day. The effect was more pronounced on the low-grain treatment (**P<.05**). This is interpreted as a higher dependence on grazed herbage by cows on that treatment than by those on medium or high grain.

Possible relationships between deviations in milk yield and measures of pasture quality were studied by correlation analysis. The average deviation in actual milk yield from predicted was calculated for the 2 days prior to switching to a new plot. This average was compared with forage characteristics from analysis of the herbage remaining in the old plot. Similarly, average deviations of milk yield were calculated for days 3 and 4 after the switch to a new plot. These were compared with forage characteristics in the new plot. There were 24 observations in the analysis, resulting from 12 rotations. Data from one rotation were not included because of missing observations for herbage. Caution should be used in interpreting results of this correlation analysis because of possible small errors in fitting the line for predicted milk yields. There was a high positive linear relationship (**P<.001**) between deviations of milk yield and IVDMD of forage. There also was a positive linear relationship (**P<.06**) between deviations of milk yield and crude protein contents. Linear relationship (**P<.01**) was negative between deviations of milk yield and dry matter content of herbage. No relationship was between difference of milk yield and yield of herbage dry matter available.

There was not a significant effect on milk production when concentrate was reduced. However, there was a trend for milk production and milk protein production to increase with increased concentrate. Milk fat production was not affected. Variations in IVDMD, crude protein content, and dry matter content of pasture had significant association with variations in milk output. The results corroborate other published findings that high quality pasture combined with modest amounts of concentrate can support milk yield reasonably.

REFERENCES


9 Oldenbroek, J. K. 1979. Differences in the intake of roughage between cows of three breeds fed two levels of concentrates according to milk yield. Livest. Prod. Sci. 6:147.
