Asian-Aust. J. Anim. Sci.
Vol. 20, No. 3 : 373 - 377
March 2007

www.ajas.info

Effects of Alfalfa and Brown Mid-rib Corn Silage and Level of Forage Neutral Detergent Fiber on Animal Performance of Lactating Cows in Michigan

Doo-Hong Min*, Herb Bucholtz[1] and Paul Naasz

Michigan State University, Upper Peninsula Experiment Station, Chatham, Michigan 49816, USA

ABSTRACT : Alfalfa silage and corn silage are the major dairy feeds in most dairy operations in Michigan, USA. In recent years, the need to improve digestible fiber and dry matter intake of forages to meet the nutrient requirements of high yielding dairy cows and the willingness to plant corn specifically for silage has led plant breeders to focus on the brown mid-rib (BMR) trait. The objective of this study was to investigate the effect of different ratio of alfalfa to BMR corn silage and ration level of forage neutral detergent fiber (NDF) on animal performance of lactating cows in the Upper Peninsula of Michigan. This study was conducted at the Upper Peninsula Experiment Station of Michigan State University in Chatham, Michigan, USA. Two different ratios of forage type (high alfalfa silage/low BMR corn silage, AS, and high BMR corn silage/low alfalfa silage, BMRCS) and two different dietary NDF contents (27% NDF, 27 = low forage/high grain feeding, and 33% NDF, 33 = high forage/low grain feeding) were used. The experimental design was a 4×4 Latin Square with 20 milking cows (12 multiparous and 8 primiparous). This trial had four 21-day periods with 14 d adaptation and 7 d data collection. Milk yield and body condition score (BCS) on the AS-27, BMRCS-27 and BMRCS-33 treatments were significantly ($p<0.05$) higher than on the AS-33 treatment. Dry matter intake of the AS-27 and BMRCS-27 treatments was significantly ($p<0.05$) higher than for the AS-33 and BMRCS-33 treatments. Milk urea nitrogen (MUN) on the AS-33 treatment was significantly ($p<0.05$) higher than on the other diet treatments. A key finding of this study was that the BMRCS-33 (higher amounts of brown mid-rib corn silage than alfalfa silage, high forage and low grain feeding diet at 33% NDF) led to the equal highest milk production whilst having the equal lowest dry matter intake. This study demonstrated that the diet with higher ratio of highly digestible NDF forage such as brown mid-rib corn silage to alfalfa silage could lower grain feeding in the ration. (**Key Words :** Alfalfa Silage, Brown Mid-rib Corn Silage, Neutral Detergent Fiber)

INTRODUCTION

It is important to feed highly digestible forages to high producing dairy cows to maximize milk production thereby resulting in increased farm profitability. Selecting highly digestible forages for dairy cows and other livestock is a big challenge, depending on climate, soils, and economic situations. Some Asian countries use subtropical forages, oil crop by-products, shrubs, tree leaves, forage oats, potato by-products, or berseem clover silage for dairy and livestock feeds (Sarwar et al., 2005; Paengkoum et al., 2006; Pen et al., 2006). Often, dairy farmers select, manage, and harvest forages that are not as highly digestible as they potentially can be. This sometimes results in buying more grains and thus increasing feed costs in the dairy operation. The name "brown mid-rib" (BMR) corn was attributed to the trait of reddish-brown coloration of the center mid-rib on the underside of the leaf. This interesting trait in BMR corn for silage reduces the lignin content of the corn, thereby potentially increasing NDF digestibility (Cherney et al., 1991) and consequently increasing dry matter and energy intake (Eastridge, 1999; Oba and Allen, 1999). This highly digestible NDF trait in BMR corn for silage therefore has potential to increase milk production (Oba and Allen, 1999; Greenfield et al., 2000; Oba and Allen, 2000). Other researches, however, reported that there were minimal benefits in milk yield from the feeding of BMR corn silage (Bal et al., 2000). Another concern of growing BMR corn is lower yield per unit area than other regular corn for silage. The forage yield for BMR corn was 10.4% lower than for the controls (Eastridge, 1999). Alfalfa silage is the common base component in Michigan dairy operations with corn silage. In the Upper Peninsula of Michigan, however, there is an abundance of available cropland at reasonable cost to

* Corresponding Author: Doo-Hong Min. Tel: +1-906-439-5188, Fax: +1-906-439-5698, E-mail: mind@msu.edu

[1] Michigan State University, Department of Animal Science, East Lansing, Michigan 48824, USA.

Received March 24, 2006; Accepted October 27, 2006

Table 1. Ingredients and nutrient composition of experimental diets

Ingredients	AS-27	BMRCS-27	AS-33	BMRCS-33
Ration ingredient composition (% of DM)				
BMR corn silage	14.2	32.3	18.0	42.7
Alfalfa silage	32.3	14.2	42.7	18.0
HM-corn	32.3	27.5	17.1	10.9
SBM	12.3	17.1	7.6	13.8
Min/protein mix	5.1	5.1	5.1	5.1
Cottonseed	1.9	1.9	7.6	7.6
Ration nutrient composition (g kg^{-1})				
Crude protein	178	179	179	179
Neutral detergent fiber	266	269	330	334

AS-27 = High alfalfa silage (69.5%)/low brown mid-rib (BMR) corn silage (30.5%) at the 27% diet NDF level: BMRCS-27 = High BMR corn silage (69.5%)/low alfalfa silage (30.5%) at the 27% diet NDF level: AS-33 = High alfalfa silage (64.5%)/low BMR corn silage (35.5%) at the 33% diet NDF level: BMRCS-33 = High BMR corn silage (64.5%)/low alfalfa silage (35.5%) at the 33% diet NDF level. HM; High moisture. SBM; Soybean meal, Min; Mineral.

Table 2. Feed cost for experimental diets with two neutral detergent fiber (NDF) levels and two levels of alfalfa and BMR corn silage

Treatments	Feed cost ($/d/cow)	Feed cost/kg milk ($)
AS-27	3.96	0.098
BMRCS-27	3.82	0.096
AS-33	3.61	0.098
BMRCS-33	3.56	0.091

AS-27 = High alfalfa silage (69.5%)/low BMR corn silage (30.5%) at the 27% diet NDF level: BMRCS-27 = High BMR corn silage (69.5%)/low alfalfa silage (30.5%) at the 27% diet NDF level: AS-33 = High alfalfa silage (64.5%) /low BMR corn silage (35.5%) at the 33% diet NDF level: BMRCS-33 = High BMR corn silage (64.5%) /low alfalfa silage (35.5%) at the 33% diet NDF level.

compensate for the lower yield of BMR corn compared to non-BMR corn for silage. Our previous study indicated that the BMR corn silage produced higher milk yield than non-BMR silage at the Upper Peninsula Experiment Station of Michigan State University in Chatham, Michigan (unpublished). The objective of this study was to investigate and demonstrate the effect of alfalfa and BMR corn silage and ration level of forage NDF on performance of lactating cows in the Upper Peninsula of Michigan in the USA.

MATERIALS AND METHODS

Cows, experimental design, and treatments

Two different dietary contents of NDF and two levels of alfalfa silage (AS) or BMR corn silage were fed to lactating cows. The diets were formulated to contain 27 and 34% NDF, respectively and 19% CP (Table 1). Dietary treatments were: AS-27 (27% diet NDF, 69.5% AS/30.5% BMRCS), BMRCS-27 (27% diet NDF, 30.5% AS/69.5% BMRCS), AS-33 (33% diet NDF, 64.5% AS/35.5% BMRCS) and BMRCS-33 (33% diet NDF, 35.5% AS/64.5% BMRCS). Diet ingredient composition and ration nutrient composition analysis is given in Table 1 and the ratio of forage to grain varied across treatments.

This experiment was approved by the All-University Committee on Animal Use and Care at Michigan State University and was conducted at the Upper Peninsula Experiment Station in Chatham (46°33' N, 86°55' W), Michigan, USA. The experimental design was a 4×4 Latin Square with 20 lactating cows in early- to mid-lactation (12 multiparous and 8 primiparous). Cows were fed their respective dietary treatment for four 21-day periods (Day 1-14 adaptation period and Day 15-21 data collection period). Cows were housed in individual tie stalls and fed twice daily at 0900 and 1600 h to permit *ad libitum* intake. Cows were milked at 0500 and 1500 h, and milk yield of individual cows was recorded at each milking. Composite daily milk samples were collected during the 7 d collection period and were analyzed for protein, butterfat, and milk urea nitrogen (MUN) by Michigan Dairy Herd Improvement Association (DHIA, East Lansing, MI). Feed ingredient samples were obtained daily to adjust diet ingredient DM inclusion. Daily samples of each diet were composited at 3-wk intervals and analyzed for DM, CP, ADF, and NDF. Moisture content of the diet was determined by measuring dry weight from a 500 g wet weight sample dried at 60 degrees C for 72 h. Total nitrogen was determined by the Hach modified Kjeldahl procedure (Wakins et al., 1987) and crude protein was estimated by multiplying total nitrogen by 6.25. The ADF and NDF were analyzed using the Goering and Van Soest (1970) procedure. Orts were recorded twice daily after the morning and afternoon feedings. The DMI was calculated from feed offered and orts. Body condition score (BCS) on each cow was determined every 2 wk by four trained investigators using a five-point scoring scale (1-thin to 5-fat) on 1 d prior to the start of the first period and on the last day of each other period (Wildman et al., 1982). Fecal samples were collected from each cow in each period and were composited for the same diet treatment for the analysis of total nitrogen in manure.

Feed costs ($/d/cow) at the 27% NDF diet in both AS and BMRCS were higher than the 33% NDF diet in both

Table 3. Mean (±SEM) milk yield, dry matter intake (DMI), and body condition score (BCS)

Treatments	Milk yield	DMI	BCS (Δ/d)
	---------- kg/d ----------		
AS-27	40.5[a] ±7.4	24.4[a] ±3.2	+0.025[a]
BMRCS-27	39.9[a] ±9.9	24.1[a] ±5.5	+0.056[a]
AS-33	37.0[b] ±9.8	22.0[b] ±4.6	-0.100[b]
BMRCS-33	39.3[a] ±7.8	22.6[b] ±3.2	+0.075[a]

AS-27 = High alfalfa silage (69.5%)/low BMR corn silage (30.5%) at the 27% diet NDF level: BMRCS-27 = High BMR corn silage (69.5%)/low alfalfa silage (30.5%) at the 27% diet NDF level: AS-33 = High alfalfa silage (64.5%)/low BMR corn silage (35.5%) at the 33% diet NDF level: BMRCS-33 = High BMR corn silage (64.5%) /low alfalfa silage (35.5%) at the 33% diet NDF level.

* Means with different superscripts in the same column differ significantly ($p<0.05$).

* SEM: standard error of the mean.

AS and BMRCS. Even feed cost at the BMRCS-27 was lower than the AS-27 diet treatment (Table 2). The BMRCS-33 ($3.56) had the lowest feed cost per day per cow as compared to AS-27 ($3.96), BMRCS-27 ($3.82), and AS-33 ($3.56). In particular, feed cost per 100 pound milk at the BMRCS-33 ($4.11) was the lowest as compared to AS-27 ($4.45), BMRCS-27 ($4.34), and AS-33 ($4.45). There was no feed cost difference per kilogram milk between the 27 and 33% NDF ration fiber levels in high alfalfa silage based diets than the brown mid rib corn silage diets although milk yield and fat-corrected milk at the AS-27 diet was significantly higher than the AS-33 diet. Feed costs ($/d/cow) at the 27% NDF diet in both AS and BMRCS were higher than the 33% NDF diet in both AS and BMRCS because the 27% NDF diet had higher grain fed to cows than the 33% NDF diet. By feeding the BMRCS-33 diet ($3.56), dairy producers might be able to save feed cost by 0.26-0.40 dollars per day per cow as compared to AS-27 ($3.96) and BMRCS-27 ($3.82). This was the same trend for the feed cost per kilogram milk. This indicates that feeding dairy cows with high digestible NDF forage such as brown mid-rib corn silage with less grain feeding was more economical than the diets having a higher ratio of alfalfa silage to brown mid-rib corn silage. Even feeding high digestible NDF corn silage was more profitable in terms of feed cost per kilogram milk than feeding more alfalfa silage at the same ration fiber level (33% NDF diet).

All data were subjected to least squares ANOVA for a 4×4 Latin Square design using the general linear models procedure of SAS (1996). Means were separated by the least significant difference (LSD), and treatments were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

Milk yield, dry matter intake, and body condition score

The milk yield ranged from 37.0 to 40.5 kg/d between the diets and was significantly ($p<0.05$) affected by dietary treatments (Table 3). Milk yield for the BMRCS-33 treatment (higher amounts of brown mid-rib corn silage than alfalfa silage, high forage and low grain feeding diet at 33% NDF) was comparable to AS-27 (higher amounts of alfalfa silage than brown mid-rib corn silage, low forage and high grain feeding diet at 27% NDF) and BMRCS-27 (higher amounts of brown mid-rib corn silage than alfalfa silage, low forage and high grain feeding diet at 27% NDF). There was no significant difference in milk yield between cows fed AS-27, BMRCS-27 or BMRCS-33, but cows fed AS-33 had significantly ($p<0.05$) lower milk yield (Table 3). This indicates that feeding milking cows with the more digestible NDF in BMR corn can lead to similar milk yields to those achieved with the rations containing a higher proportion of grain. As well, for low-grain rations, feeding a higher portion of the roughage fraction as highly digestible NDF corn silage (BMRCS) led to more milk ($p<0.05$) than feeding mostly AS. This was similar to when BMR sorghum was fed to mid-lactating dairy cows in Nebraska; Grant et al. (1995) reported that cows fed the BMR sorghum silage diet produced approximately 23% more milk than the non-BMR sorghum silage diet. The lack of difference in milk yield between AS-27 and BMRCS-27 suggests that with diets that contain a higher grain fraction and lower roughage fraction, the benefits of a more digestible roughage component are not evident. It is only when the roughage fraction increases to higher levels that the attributes of the BMR trait are seen in higher milk outputs. This implies that dairy producers can partially replace grain with a highly digestible forage diet such as BMRCS (higher amount of BMR corn silage than alfalfa silage in the diet). Oba and Allen (1999) also reported that daily milk, fat-corrected milk (3.5%), and solids-corrected milk yields were higher for cows fed the brown mid-rib corn silage by 2.8, 2.6, and 2.7 kg, respectively, resulting from increased dry matter intake, than those fed silage from the control hybrid. However, this is not the case for beef steers and Tjardes et al. (2000) reported brown midrib-3 corn silage improved digestion but not performance of growing beef steers in Michigan, USA.

Dry matter intake for cows in the AS-27 and BMRCS-27 treatments was significantly ($p<0.05$) higher than the AS-33 and BMRCS-33, ranging from 22.0 to 24.4 kg/d (Table 3). Cows fed the diet containing 27% NDF had 1.8 kg/d higher feed intake than those fed the 33% NDF diet. There was no significant difference in dry matter intake between the AS-27 and the BMRCS-27, and the AS-33 and the BMRCS-33 diet treatments, respectively. The lower intake by cows fed the diets with 33% NDF, however, was only matched with a lower milk output in AS-fed cows; i.e., cows fed BMRCS-33 did not have a lower milk output despite their feed intake. This demonstrates that feeding

Table 4. Mean (±SEM) concentrations of milk protein, milk fat, manure nitrogen (MN), and milk urea nitrogen (MUN)

Treatments	Milk protein	Milk fat	MN*	MUN
	---------- g/kg ----------			mg/dl
AS-27[1]	31.9±2.9	36.2±5.9	4.3	15.39 [a]±1.9
BMRCS-27	32.0±2.8	36.5±6.1	4.2	15.47 [a]±2.6
AS-33	30.4±2.9	37.7±5.4	3.5	17.24 [b]±2.5
BMRCS-33	31.1±2.3	37.1±4.5	4.4	15.58 [a]±2.0

AS-27 = High alfalfa silage (69.5%)/low BMR corn silage (30.5%) at the 27% diet NDF level: BMRCS-27 = High BMR corn silage (69.5%)/low alfalfa silage (30.5%) at the 27% diet NDF level: AS-33 = High alfalfa silage (64.5%)/low BMR corn silage (35.5%) at the 33% diet NDF level: BMRCS-33 = High BMR corn silage (64.5%)/low alfalfa silage (35.5%) at the 33% diet NDF level.

* MN; Manure nitrogen was analyzed from one representative sample by compositing manure from four replications.

* Means with different superscripts in the same column differ significantly ($p<0.05$).

* SEM: standard error of the mean.

milking cows with high-digestible NDF corn silage (i.e., brown midrib corn silage) could produce more milk than with alfalfa silage at the same NDF ration fiber level in this study. This also can give an opportunity to dairy producers where plenty of land is available, such as the Upper Peninsula of Michigan, for planting the highly digestible forage such as brown midrib corn silage.

As shown in Table 3, body condition score followed the same pattern as the milk yield. Body condition scores at the AS-27 (+0.025), BMRCS-27 (+0.056), and BMRCS-33 (+0.075) were significantly ($p<0.05$) higher than the AS-33 treatment (-0.100). Although there was similar dry matter intake between the AS-33 and BMRCS-33, the BMRCS-33 had significantly ($p<0.05$) better body condition score than the AS-33 diet treatment. This suggests that feeding highly digestible NDF corn silage rather than AS when offering diets with a low proportion of grain (i.e., 33% NDF) can allow cows to maintain higher body condition.

Milk protein, milk fat, milk urea nitrogen, and fecal manure nitrogen

Milk protein and milk fat ranged from 3.04 to 3.20 and 3.62 to 3.77%, respectively and were not affected by the four diets (Table 4). This was consistent with other researchers (Keith et al., 1979; Sommerfeldt et al., 1979; Stallings et al., 1982). In contrast, other researchers reported milk fat was increased by feeding either brown midrib corn silage (Rook et al., 1977) or brown midrib sorghum silage (Grant et al., 1995). Some studies reported that milk fat was reduced when BMR corn silage was fed (Block et al., 1981; Frenchick et al., 1976). These inconsistent results may arise from the differences in dietary formulation or in the feeding conditions.

There was no difference of milk urea nitrogen in AS-27, BMRCS-27, and BMRCS-33 diets. Milk urea nitrogen in this study ranged from 15.39 to 17.24 mg/dl. Milk urea nitrogen was significantly higher ($p<0.05$) for cows fed AS-33 than for cows fed the other dietary treatments. This indicates that dietary protein was not as well utilized by the rumen microbes in cows fed the high alfalfa silage and low grain diet (AS-33).

As shown in Table 4, fecal nitrogen ranged from 3.5-4.4 g/kg and was lower in cows fed AS-33 than the other dietary treatments. Lower fecal manure nitrogen on the AS-33 diet treatment might be associated with higher milk urea nitrogen than on the other diet treatments. Manure at the AS-33 diet was also more loose and runny than with the other diet treatments, which might be possibly related to faster rate of passage of digesta at the AS-33 dietary treatment. This also implies that feeding a diet with more highly degradable protein from the alfalfa silage with lower grain feeding can have more of an environmental impact due to inefficient nitrogen utilization in the rumen.

CONCLUSIONS

This study suggests that dairy farmers with an abundance of available cropland at reasonable cost have an opportunity to increase profits by selecting highly digestible forages such as brown mid-rib corn for silage. This study also demonstrated that the diet with higher ratio of highly digestible NDF forage such as brown mid-rib corn silage to alfalfa silage could lower grain feeding in the ration.

REFERENCES

Bal, M. A., R. D. Shaver, H. Al-Jobeile, J. G. Coors and J. G. Lauer. 2000. Corn silage hybrid effects on intake, digestion, and milk production by dairy cows. J. Dairy Sci. 83:2849-2859.

Block, E., L. D. Muller, L. C. Griel, Jr., and D. L. Garwood. 1981. Brown midrib-3 corn silage and heat extruded soybeans for early lactating dairy cows. J. Dairy Sci. 64:1813-1825.

Cherney, J. H., D. J. R. Cherney, D. E. Akin and J. D. Axtell. 1991. Potential of brown- midrib, low lignin mutants for improving forage quality. Adv. Agron. 46:157-198.

Eastridge, M. L. 1999. Brown midrib corn silage. Proceedings of Tri-State Dairy Nutrition Conference. pp. 179-190.

Frenchick, G. E., D. G. Johnson, J. M. Murphy and D. E. Otterby. 1976. Brown midrib corn silage in dairy rations. J. Dairy Sci. 59:2126-2129.

Grant, R. J., S. G. Haddad, K. J. Moore and J. F. Pedersen. 1995. Brown midrib sorghum silage for midlactation dairy cows. J. Dairy Sci. 78:1970-1980.

Keith, E. A., V. F. Colenbrander, V. L. Lechtenberg and L. F.

Baumen. 1979. Nutritional value of brown midrib corn silage for lactating dairy cows. J. Dairy Sci. 62:788-792.

Oba, M. and M. S. Allen. 1999. Effects of brown midrib 3 mutation in corn silage on dry matter intake and productivity of high yielding dairy cows. J. Dairy Sci. 82:135-142.

Oba, M. and M. S. Allen. 2000. Effects of brown midrib 3 mutation in corn silage on productivity of dairy cows fed two concentrations of dietary neutral detergent fiber: 1. Feeding behavior and nutrient utilization. J. Dairy Sci. 83:1333-1341.

Paengkoum, P., J. B. Liang, Z. A. Jelan and M. Basery. 2006. Utilization of steam-treated oil palm fronds in growing goats: 1. Supplementation with dietary urea. Asian-Aust. J. Anim. Sci. 19:1305-1313.

Pen, B., T. Iwama, M. Ooi, T. Saitoh, K. Kida, T. Iketaki, J. Takahashi and H. Hidari. 2006. Effect of potato by-products based silage on rumen fermentation, methane production and nitrogen utilization in Holstein steers. Asian-Aust. J. Anim. Sci. 19:1283-1290.

Rook, J. A., L. D. Muller and D. B. Shank. 1977. Intake and digestibility of brown midrib corn silage by lactating dairy cows. J. Dairy Sci. 60:1894-1904.

Sarwar, M., M. Ajmal Khan, Mahr-un-Nisa and N. A. Touqir. 2005. Influence of berseem and Lucerne silages on feed intake, nutrient digestibility and milk yield in lactating *Nili* buffaloes. Asian-Aust. J. Anim. Sci. 18:475-478.

SAS Institute. 1996. SAS/STAT Software: Changes and Enhancements through Release 6.11. SAS Inst. Inc., Cary, NC.

Sommerfeldt, J. L., D. J. Schingoethe and L. D. Muller. 1979. Brown midrib corn silage for lactating dairy cows. J. Dairy Sci. 62:1611-1618.

Stallings, C. C., B. M. Donaldson, J. W. Thomas, and E. C. Rossman. 1982. *In vivo* evaluation of brown midrib corn silage by sheep and lactating dairy cows. J. Dairy Sci. 65:1945-1949.

Tjardes, K. E., D. D. Buskirk, M. S. Allen, N. K. Ames, L. D. Bourquin and S. R. Rust. 2000. Brown midrib-3 corn silage improves digestion but not performance of growing beef steers. J. Anim. Sci. 78:2957-2965.

Wildman, E. E., G. M. Jomes, P. E. Wagner, R. L. Boman, H. F. Troutt, Jr., and T. N. Lesch. 1982. A dairy cow body condition scoring system and its relationship to selected production characteristics. J. Dairy Sci. 65:495-501.