Accepted for publication 17 December 2007. Published 13 March 2008.

Grass Yield and Quality Affect Potential Stocking Rate and Milk Production

Geoffrey E. Brink, Mary Beth Hall, David R. Mertens, and **Michael D. Casler,** USDA-ARS, United States Dairy Forage Research Center, 1925 Linden Drive West, Madison, WI 53706

Corresponding author: Geoffrey E. Brink. geoffrey.brink@ars.usda.gov

Brink, G. E., Hall, M. B., Mertens, D. R., and Casler, M. D. 2008. Grass yield and quality affect potential stocking rate and milk production. Online. Forage and Grazinglands doi:10.1094/FG-2008-0313-01-RS.

Abstract
Emphasis placed on pasture yield may lead producers to disregard the potential influence of forage quality on animal performance. Our objective was to compare yield and quality, and potential stocking rate and milk production of four temperate grasses. Meadow fescue, orchardgrass, quackgrass, and reed canarygrass were each harvested at 10-inch height in the spring, summer, and fall and yield, cell wall concentration, and cell wall digestibility were used to calculate potential stocking rate and daily milk production. Quackgrass and reed canarygrass would support a 40 to 90% greater stocking rate during the spring and summer than meadow fescue or orchardgrass, while cows grazing meadow fescue would produce 5 to 12 lb more milk per day than those grazing the other grasses. Translating forage quality into potential milk production allows producers to assess the potential trade-offs between animal and forage productivity when considering the value of a pasture grass.

Introduction
The agronomic and economic value of a temperate perennial grass in a pasture-based dairy system is based on its capacity to provide a consistent supply of forage of appropriate quality throughout the grazing season. Performance of a particular grass will be governed by its adaptation to local soil and climatic conditions, its response to management, and its inherent physiological and morphological traits governing forage quality, animal consumption, and seasonal yield distribution.

Performance of grazing dairy cows is dependent primarily on dry matter intake (1), and quantity of available pasture is the most reliable predictor of intake (19). Other studies suggest that additional factors influence dry matter intake. These include sward height and density (2,7), cell wall or neutral detergent fiber concentration (11), the digestibility of the cell wall (15), and factors related to animal preference for a feed (3). Factors other than the quantity of available pasture may have influenced results in a study by Casler et al. (6), who found that apparent intake of orchardgrass and meadow fescue by dairy cows often exceeded that of tall fescue despite having lower available forage.

In the absence of evaluation under grazing, a laboratory estimate of grass productivity and quality, and its capacity to support lactation, would assist producers as they make decisions regarding pasture management and renovation. Our objective was to compare the yield and quality of four temperate grasses and their influence on potential milk production and stocking density during the spring, summer, and fall.

Grass Establishment and Harvest

The experiment was established in April 2003 at the University of Wisconsin Arlington Agricultural Research Station (43.30°N, 89.35°W) on a Plano silt loam (fine-silty, mixed, superactive, mesic Typic Argiudoll) that tested high in all major nutrients and had a pH of 6.7. 'Bartura' meadow fescue (*Festuca pratensis* Huds.), 'Bronc' orchardgrass (*Dactylis glomerata* L.; medium maturity), common quackgrass [*Elymus repens* (L.) Gould], and 'Rival' reed canarygrass (*Phalaris arundinacea* L.) were broadcast-seeded at 10, 10, 20, and 6 lb/acre, respectively, in 15- by 20-ft plots on a prepared seedbed.

Plots were mowed in late April of 2004 and 2005 to a 10-cm stubble to remove residue, and fertilized with 50 lb of N per acre as ammonium nitrate. All grasses were in a vegetative state when harvested in May (spring, Table 1). When the mean non-extended leaf height of each grass reached a recommended grazing height of 25 cm (18), or approximately 10 inches, a 25- by 100-cm quadrat was placed in two random locations in the plot and the herbage was harvested to a 10-cm stubble. After all grasses were sampled in the spring, plots were clipped to a 10-cm stubble with a mower and permitted to grow for approximately 21 days, at which time plots were again clipped to a 10 cm stubble and fertilized with 50 lb of N per acre as ammonium nitrate. Subsequent growth was sampled in July (summer, Table 1) as described above. Following the summer harvest, grasses were managed in a manner similar to that following the spring harvest before being sampled in September (fall, Table 1). Yield of forage produced immediately after the spring, summer, and fall harvests was not measured due to variable regrowth periods and the requirement that the forage of each grass constitute primary growth at the time of sampling. A more detailed description of the harvest protocol was reported by Brink et al. (4).

Table 1. Harvest dates for grasses grown during two years at Arlington, WI.

Season	Grass	Harvest date	
		2004	2005
Spring	Meadow fescue	12 May	16 May
	Orchardgrass	13 May	16 May
	Quackgrass	9 May	13 May
	Reed canarygrass	15 May	18 May
Summer	Meadow fescue	19 Jul	22 Jul
	Orchardgrass	9 Jul	14 Jul
	Quackgrass	14 Jul	*
	Reed canarygrass	14 Jul	18 Jul
Fall	Meadow fescue	4 Oct	19 Sep
	Orchardgrass	27 Sep	19 Sep
	Quackgrass	*	*
	Reed canarygrass	4 Oct	*

* Inadequate forage produced for sampling.

Forage Quality Analysis

Herbage samples were ground to pass a 1-mm screen in a Wiley mill before being analyzed for quality by calibrated near infrared reflectance spectroscopy. Neutral detergent fiber (NDF) was measured by the method of Mertens (12). *In vitro* neutral detergent fiber digestibility (IVNDFD) was measured by the method of Goering and Van Soest (8) (48-h incubation) using rumen fluid collected from four lactating cows and blended in equal parts. Diet of the confined canulated cows consisted of alfalfa haylage, corn silage, temperate grass hay, and concentrate in equal proportions. Calibration statistics were the following: NDF, standard error of prediction corrected for bias [SEP(C)] = 1.1 and R^2 = 0.98; IVNDFD, SEP(C) = 2.43 and R^2 = 0.83. The NDF and IVNDFD concentrations were used to calculate potential intake quantity, net energy of lactation (Mcal), and milk production (lb 3.5% fat corrected milk) of an 1100 lb dairy cow (13). Potential stocking rate, or the number of cows that could be supported by one acre of each grass for 24 h assuming a 50% harvesting efficiency (1), was calculated as dry matter yield/(potential intake × 2).

The statistical design was a randomized complete block with four replicates. Data were analyzed by the General Linear Models procedure of SAS (SAS Institute Inc., Cary, NC) using a split-plot-in-time model. Block and year were assumed to be random effects, while grass and season were assumed to be fixed effects. Means for each grass were compared using Fisher's LSD ($P \leq 0.05$).

Herbage Yield and Quality

A year × season × grass interaction existed for herbage yield and quality, due primarily to differences in monthly precipitation between 2004 and 2005 (Table 2). Despite this interaction, quackgrass had greater yield than meadow fescue, orchardgrass, and reed canarygrass in the spring of both years, providing 40 to 90% more DM than the other grasses (Table 3). Although quackgrass is considered a weed in most agronomic crops, the superior early-spring forage yield observed here should be considered one of its most desirable attributes in a pasture system. In terms of forage quality, however, quackgrass usually had greater NDF and lower IVNDFD in the spring than the other grasses (Table 3). Meadow fescue, however, had greater forage quality (NDF and IVNDFD) in the spring than all grasses except orchardgrass in 2005.

Differences in yield among grasses in the summer were largely due to differences in precipitation during April, May, and June; when precipitation was 49% above average in 2004 (Table 2), meadow fescue had greater yield than all grasses except reed canarygrass (Table 3). When precipitation was 46% below average in 2005, reed canarygrass had greater yield than any grass. Precipitation appeared to have little influence on forage quality in the summer. In both years, meadow fescue had lower NDF than orchardgrass and reed canarygrass, but similar IVNDFD (Table 3). When present in sufficient quantity for sampling, quackgrass NDF was intermediate to meadow fescue and orchardgrass, but lowest in digestibility.

Table 2. Monthly average (1970-2000) and actual precipitation and temperature during two years at Arlington, WI.

	Precipitation (inches)			**Temperature** (°F)		
Month	**Avg.**	**2004**	**2005**	**Avg.**	**2004**	**2005**
January	1.1	0.3	1.4	16.0	15.7	19.4
February	1.1	1.2	1.1	20.6	24.2	29.3
March	2.0	2.7	1.8	32.3	38.4	32.7
April	3.2	1.9	0.8	45.4	48.1	51.1
May	3.4	9.8	3.3	56.5	57.5	56.0
June	4.0	4.1	1.6	66.2	65.5	72.5
July	3.8	4.3	4.4	71.0	69.2	72.3
August	4.2	2.8	3.1	68.3	65.2	70.3
September	3.6	0.5	4.7	59.8	65.2	66.4
October	2.4	3.2	0.6	48.9	51.4	51.3
November	2.4	1.6	3.8	35.4	40.3	38.3
December	1.3	1.6	0.9	21.7	25.8	19.6

Table 3. Yield, neutral detergent fiber (NDF), and *in vitro* neutral detergent fiber digestibility (IVNDFD) of four temperate perennial grasses sampled at 10-inch height (4-inch stubble) in the spring, summer, and fall of two years.

Season	Grass	Yield (lb DM/acre)		NDF (%)		IVNDFD (%)	
		2004	2005	2004	2005	2004	2005
Spring	Meadow fescue	1030 b	810 b	46.3 d*	43.1 b	86.5 a	86.4 a
	Orchardgrass	1010 b	710 b	49.5 b	42.2 b	84.0 b	86.3 a
	Quackgrass	1940 a	1210 a	50.6 a	44.9 a	79.6 c	79.0 c
	Reed canarygrass	1210 b	880 b	47.8 c	43.5 ab	84.8 b	84.2 b
Summer	Meadow fescue	1640 a	890 b	45.3 c	46.4 c	84.0 a	73.7 a
	Orchardgrass	660 c	940 b	49.1 ab	50.1 b	84.5 a	72.5 a
	Quackgrass	1180 b	ns	47.2 bc	ns	78.3 b	ns
	Reed canarygrass	1470 ab	1460 a	49.6 a	52.4 a	83.4 a	74.3 a
Fall	Meadow fescue	840 a	740 a	43.5 b	43.2 b	76.0 a	72.2 a
	Orchardgrass	820 a	840 a	48.4 a	47.9 a	77.1 a	69.8 b
	Quackgrass	ns	ns	ns	ns	ns	ns
	Reed canarygrass	1000 a	ns	43.2 b	ns	76.3 a	ns

* Means within a column and season followed by the same letter do not differ ($P \leq 0.05$).
ns = Inadequate forage produced for sampling.

In the fall of both years, quackgrass produced little or no forage, and reed canarygrass produced sufficient growth for sampling in one year (Table 3). Although there were no differences in yield among the other grasses either year, meadow fescue had lower NDF than orchardgrass (Table 3). Differences in IVNDFD among the grasses were not consistent from year to year.

Potential Milk Production and Stocking Rate

Potential milk production of a dairy cow grazing each grass relative to its potential stocking rate during the spring, summer, and fall is represented in Figs. 1, 2, and 3, respectively. Given the superior yield of quackgrass in the spring of both years, and generally greater NDF and lower IVNDFD (Table 3) that would act to reduce intake, it had greater potential stocking rate than meadow fescue, orchardgrass, or reed canarygrass, which had similar stocking rates (Fig. 1). Based on NDF and IVNDFD concentration, however, a cow grazing quackgrass exclusively in the spring would provide 4 to 12 lb less milk per day than a cow grazing the other grasses in 2004 and 6 to 10 lb less milk per day in 2005 (Fig. 1). Among the other grasses, milk production potential of meadow fescue was greater than (2004) or equal to (2005) that of reed canarygrass and orchardgrass.

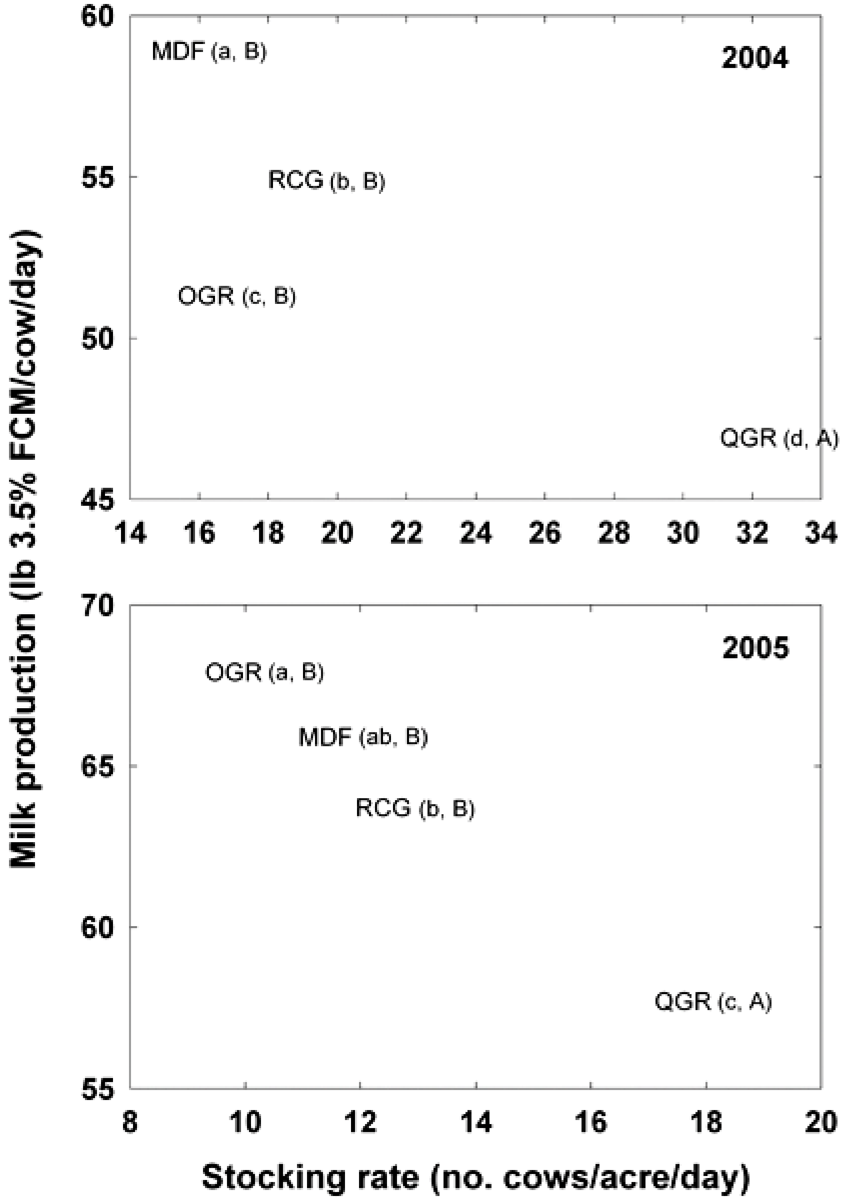

Fig. 1. Potential milk production and stocking rate of dairy cows grazing meadow fescue (MDF), orchardgrass (OGR), quackgrass (QGR), and reed canarygrass (RCG) in the spring. Small and capital letters associated with each grass indicate significant differences ($P \leq 0.05$) in milk production and stocking rate, respectively.

Reed canarygrass has been recognized for its consistent production under a range of moisture conditions (5). In this study, the potential stocking rate of reed canarygrass in the summer was equal to or greater than that of the other grasses (Fig. 2) when growth occurred during a period of above-average (2004) or below-average (2005) precipitation (Table 2). Conversely, potential milk production of a cow grazing meadow fescue exclusively was greater than that of any other grass during the summer (Fig. 2) due primarily to lower NDF concentration (Table 3).

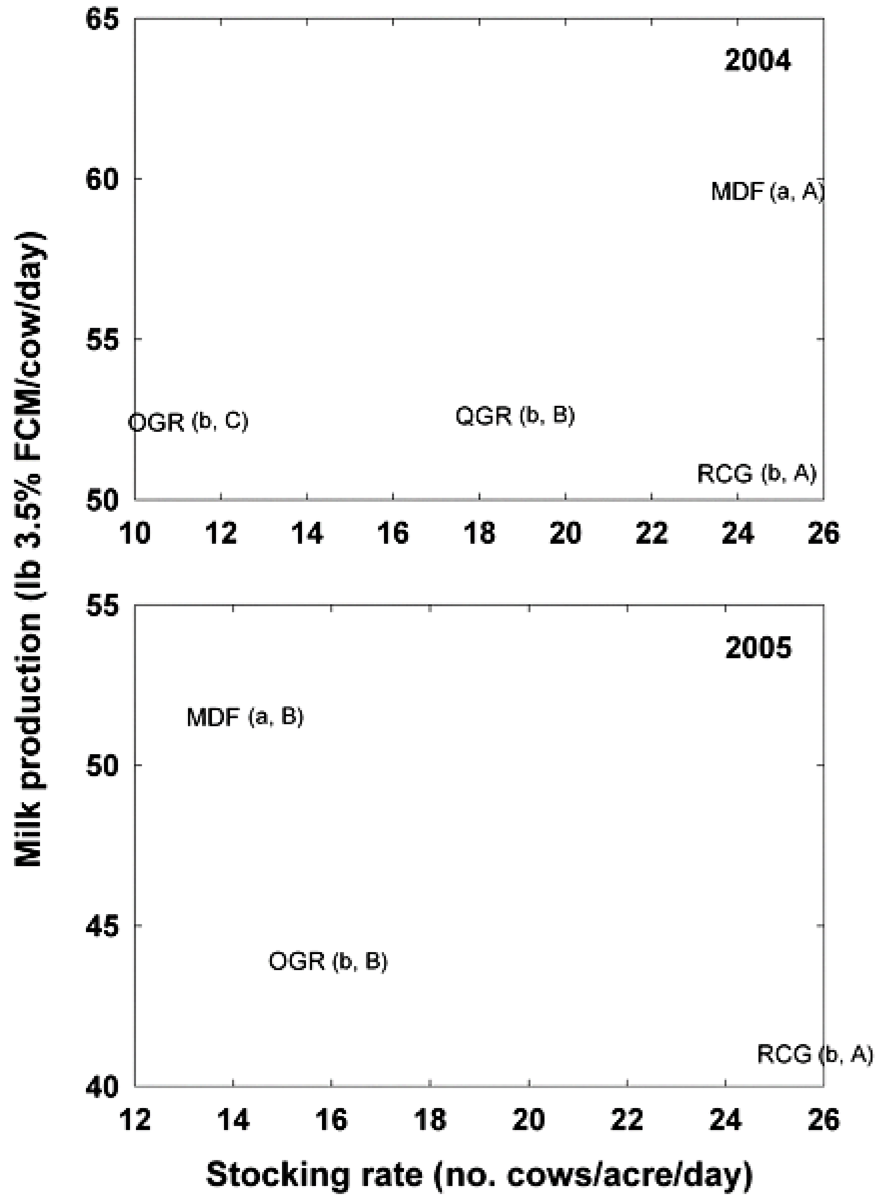

Fig. 2. Potential milk production and stocking rate of dairy cows grazing meadow fescue (MDF), orchardgrass (OGR), quackgrass (QGR), and reed canarygrass (RCG) in the summer. Small and capital letters associated with each grass indicate significant differences ($P \leq 0.05$) in milk production and stocking rate, respectively.

While temperatures in the fall (Table 2) were within the optimum range (59 to 77°F) for growth of temperate grasses (14), declining day length reduces growth compared to spring conditions (16). Potential stocking rate of grasses that provided sufficient herbage for sampling did not differ in the fall of both years, and ranged from approximately 10 to 14 cows per acre (Fig. 3). As was observed in the summer, potential milk production of a cow grazing meadow fescue was greater than that grazing orchardgrass in both years.

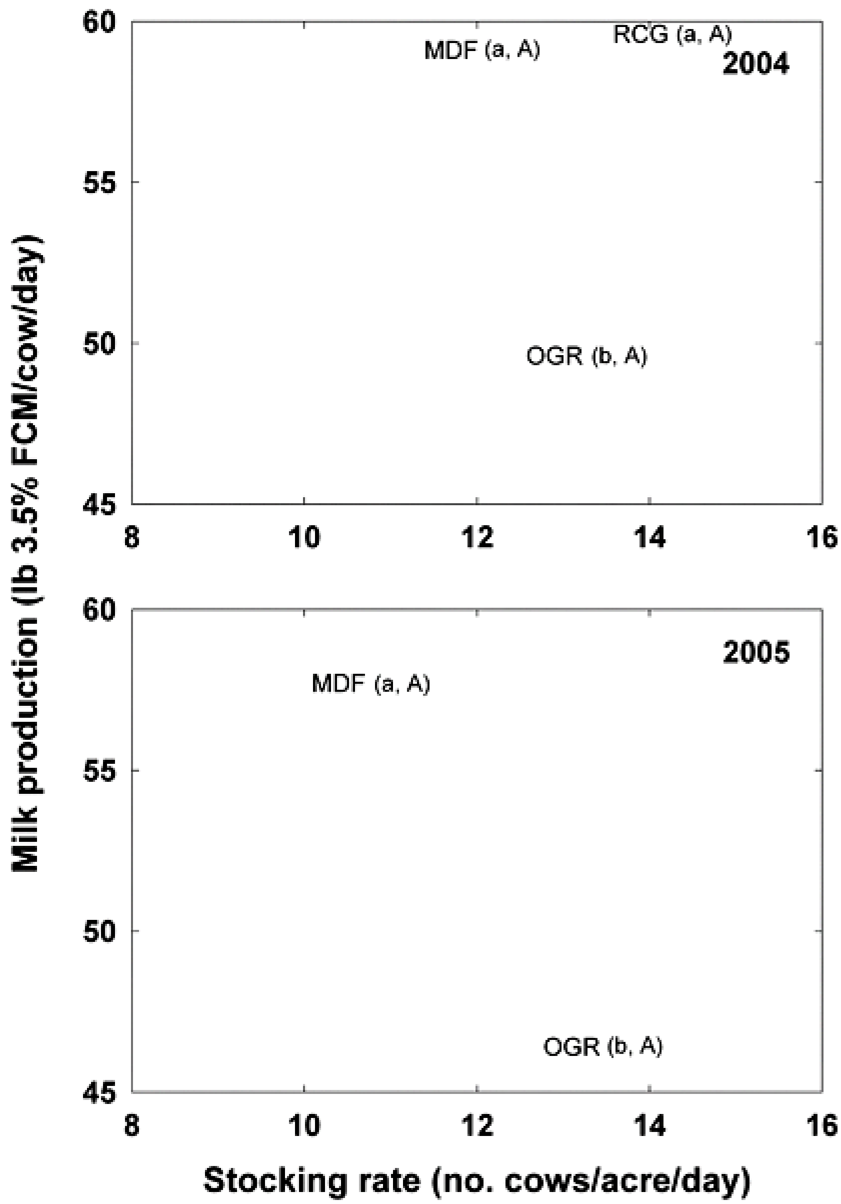

Fig. 3. Potential milk production and stocking rate of dairy cows grazing meadow fescue (MDF), orchardgrass (OGR), quackgrass (QGR), and reed canarygrass (RCG) in the fall. Small and capital letters associated with each grass indicate significant differences ($P \leq 0.05$) in milk production and stocking rate, respectively.

Conclusions

Temperate, perennial grasses utilized for pasture are typically evaluated for annual productivity and quality, but the two parameters are not usually combined to estimate performance from an animal perspective. Using standard methods to evaluate the potential of forages to support lactation (13), our calculations indicate that cows grazing meadow fescue would usually produce more milk per cow than those grazing orchardgrass, quackgrass, or reed canarygrass due to greater forage quality. A related finding was reported by Turner and coworkers (17), who found that early, repeated defoliation of a temperate grass produced higher quality forage that resulted in greater predicted average daily gain of beef steers, but also resulted in fewer predicted grazing days. Whether the increased milk production of meadow fescue adequately compensates for its lower stocking rate compared to quackgrass or reed canarygrass is a trade off the producer must consider. Given that forage is typically ample in the spring and producers often face the dilemma of utilizing grass before it becomes too mature, the productivity and quality of meadow fescue may be an advantage of this grass.

A producer must also consider the seasonal yield distribution of a grass. Despite producing the most forage in the spring, quackgrass produced little yield during a dry summer and none in the fall. However, the abundant, early spring yield suggest that a pasture containing sufficient quackgrass could be grazed earlier than the other grasses. In addition, grass is seldom the sole component of the diet of a grazing, lactating dairy cow because additional energy in the form of supplemented grain is fed to sustain higher milk production (10). Altering the nutrient density of the supplement can offset the potential disadvantages of poor-quality pasture and result in milk production equivalent to that of cows grazing a higher quality pasture (9).

Literature Cited

1. Bargo, F., Muller, L. D., Delahoy, J. E., and Cassidy, T. W. 2002. Milk response to concentrate supplementation of high producing dairy cows grazing at two pasture allowances. J. Dairy Sci. 85:1777-1792.
2. Barrett, P. D., McGilloway, D. A., Laidlaw, A. S., and Mayne, C. S. 2003. The effect of sward structure as influenced by ryegrass genotype on bite dimensions and short-term intake rate by dairy cows. Grass For. Sci. 58: 2-11.
3. Baumont, R. 1996. Palatability and feeding behaviour in ruminants: A review. Ann. Zootech 45:385-400.
4. Brink, G. E., Casler, M. D., and Hall, M. B. 2007. Canopy structure and neutral detergent fiber differences among temperate perennial grasses. Crop Sci. 47:2182–2189.
5. Carlson, I. T., Oram, R. N., and Surprenant, J. 1996. Reed canarygrass and other Phalaris species. Pages 569-604 in: Cool-Season Forage Grasses. L. E. Moser, D. R. Buxton, and M. D. Casler. Agron. Monogr. 34. ASA, CSSA, SSSA, Madison, WI.
6. Casler, M. D., Undersander, D. J. Fredericks, C., Combs, D. K., and Reed, J. D. 1998. An on-farm test of perennial forage grass varieties under management intensive grazing. J. Prod. Agric. 11:92-99.
7. Griffiths, W. M., and Gordon, I. J. 2003. Sward structural resistance and biting effort in grazing ruminants. Anim. Res. 52:145-160.
8. Goering, H. K., and Van Soest, P. J. 1970. Forage fiber analyses (apparatus, reagents, procedures, and some applications). Agric. Handb. 379. USDA-ARS, Washington, DC.
9. Hoffman, K., Muller, L. D., Fales, S. L., and Holden, L. A. 1993. Quality evaluation and concentrate supplementation of rotational pasture grazed by lactating cows. J. Dairy Sci. 76:2651-2663.
10. Kolver, E. S., and Muller, L. D. 1998. Performance and nutrient intake of high producing Holstein cows consuming pasture or a total mixed ration. J. Dairy Sci. 81:1403-1411.
11. Mertens, D. R. 1997. Creating a system for meeting the fiber requirements of dairy cows. J. Dairy Sci. 80:1463-1481.
12. Mertens, D. R. 2002. Gravimetric determination of amylase-treated neutral detergent fiber in feeds with refluxing in beakers or crucibles: Collaborative study. J. AOAC Inter. 85:1217-1240.
13. National Research Council. 2001. Model evaluation and prediction equations. Pages 315-333 in: Nutrient Requirements of Dairy Cattle. 7th Rev. Ed. National Academy Press, Washington, DC.
14. Nelson, C. J. 1996. Physiology and developmental morphology. Pages 87-126 in: Cool-Season Forage Grasses. L. E. Moser, D. R. Buxton, and M. D. Casler. Agron. Monogr. 34. ASA, CSSA, SSSA, Madison, WI.
15. Oba, M., and Allen, M. S. 1999. Evaluation of the importance of the digestibility of neutral detergent fiber from forage: Effects on dry matter intake and milk yield of dairy cows. J. Dairy Sci. 82:589-596.
16. Stuckey, I. H. 1942. Some effects of photoperiod on leaf growth. Am. J. Bot. 29:92-97.
17. Turner, K. E., Belesky, D. P., Fedders, J. M., and Rayburn, E. B. 1996. Canopy management influences on cool-season grass quality and simulated livestock performance. Agron. J. 88:199-205.

18. Undersander, D. J., Albert, E. C., Cosgrove, D. R., Johnson, D. G., and Peterson, P. R. 2002. Pastures for profit: A guide to rotational grazing. Univ. of Wisconsin Cooperative Extension Pub. A3529.
19. Vazquez, O. P., and Smith, T. R. 2000. Factors affecting pasture intake and total dry matter intake in grazing dairy cows. J. Dairy Sci. 83:2301-2309.