Dairy Grazing

Managing Pasture for Yield, Quality, Persistence and Intake

Dairy farmers across the United States use pasture as a primary feed source. In a well-managed system, pasture can equal or surpass the quality of stored forages. However, attainment of high-quality pasture relies on a forage management system that meshes with the plants' growth characteristics.

A pasture system is a compromise between the cattle's nutritional requirements and the forage species' nutrient content. In a well-managed system, this compromise has little impact on milk production or forage yield, quality or longevity.

This publication explains how to manage a pasture system for yield, quality, persistence and intake so you can minimize your feed costs while feeding your dairy cattle high-quality pasture.

Understanding the plant

Producers who understand the growth characteristics of the plants in their pastures know when and how long to let their dairy cows graze without sacrificing pasture longevity or dry matter intake (DMI). They also attain optimal-quality plants and higher yields.

For instance, individual tillers on plants such as perennial ryegrass and tall fescue maintain only three live leaves (Figure 1). Once a fourth leaf begins to grow, the first leaf begins to age and declines in quality, a process called senescence. For optimal use of a perennial ryegrass or tall fescue pasture, allow cows to graze the paddock after the third leaf has begun to emerge (a period called the two-and-a-half- to three-leaf stage) and until plants are about 2 inches tall. For maximum yield, the postgrazing height of these plants should be 2 to 2½ inches because 80 percent of the water-soluble carbohydrates in the plants reside below that point. The plants require these stored carbohydrates to initiate the emergence of the first leaf after having been grazed. The emergence of this new leaf allows photosynthesis and carbohydrate storage to resume. By the two-and-a-half-leaf stage, carbohydrate stores are replenished and grazing can resume without risk of weakening the plants.

Revised from M168, *Dairy Grazing Manual*, by
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Dairy grazing publication series

This publication is one in a series about operating and managing a pasture-based dairy. Although these publications often refer to conditions in Missouri, many of the principles and concepts described may apply to operations throughout the United States. A list of the publications in this series is available online at ***http://extension.missouri.edu/m168***.

Low postgrazing heights (1 to 3 inches) out-yield high postgrazing heights (4 to 6 inches) in tall fescue and perennial ryegrass, and in perennial ryegrass, the third leaf provides 40 to 50 percent of the total dry matter yield. Therefore, grazing ryegrass and fescue at the two-and-a-half- to three-leaf stage and leaving a 2-inch stubble will help optimize quality, yield, persistence and DMI.

In contrast to perennial ryegrass and fescue, jointed plants, such as bromegrass, may be grazed down to a 4- to 5-inch stubble when they have five to six leaves. This taller stubble helps the plant maintain stand vigor and promotes quicker regrowth, thus increasing dry matter yield.

Consult MU Extension publication M181, *Selecting the Right Forage*, for information — including seasonal growth patterns, when to allow grazing to begin, and optimal postgrazing heights — on 34 forage species used in Missouri.

To optimize both yield and quality, producers need to understand the growth characteristics — specifically, leaf stages — of their forage species. Monitoring leaf stage can be crucial for optimizing yield and quality of the plants throughout the grazing season. By managing for yield and quality, you will be indirectly managing for pasture intake.

Measure, monitor and manage

University of Missouri Extension's Pasture-Based Dairy Program has developed a tool for measuring, monitoring and managing pasture-based beef and dairy systems (see *Additional resources*). This Web-based grazing wedge program allows producers to enter weekly measurements of individual paddocks and provides a grazing wedge they can use to make proactive decisions about the allocation and feeding of pasture. A grazing wedge ranks paddocks on pounds of dry matter per acre and calculates average farm

Figure 1. Leaf stage and water-soluble carbohydrate levels (indicated by red line).

forage mass and average growth rate. (The *Determining Pasture Yield* publication listed under *Additional resources* describes two rapid methods of estimating dry matter in a paddock.)

Average forage mass, which producers commonly refer to as cover, is calculated by dividing *the total amount of dry matter on the farm* by *the total acres at that time*.

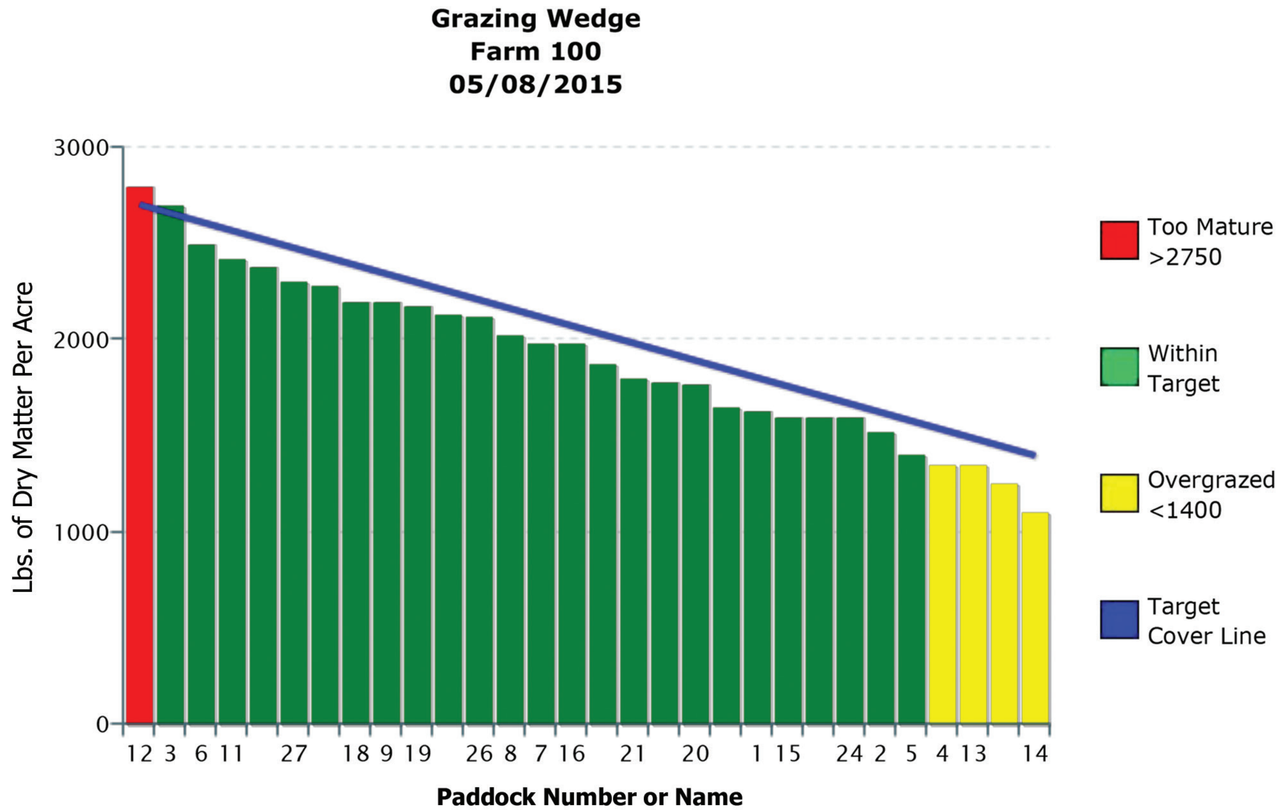
Average growth rate is calculated by subtracting *the individual paddock's forage mass* from *the previous week's forage mass* and dividing the result by *the number of days between the two measurements*.

To generate this information for your grazing wedge, input forage mass measurements for each paddock weekly. The wedge allows the you to evaluate the week's pasture feed supply and make management decisions about supplemental feeding, nitrogen applications, mechanical harvesting and grazing schedule.

For example, if you were stocked at 1.25 cows per acre and were expecting 30 pounds of dry matter of pasture intake for each animal, including wastage, then the demand for your farm would be 37.5 pounds of dry matter per acre per day: 30 pounds per cow × 1.25 cows per acre = 37.5 pounds of dry matter per acre per day. The grazing wedge program calculates the average growth rate (Figure 2). If the actual growth rate is below 37.5 pounds of dry matter per acre and you do not adjust current management (for example, you don't increase supplemental feeding, lower stocking rate or apply nitrogen), then average forage mass will decrease. Conversely, if the growth rate is above 37.5 and you do not decrease supplements, add livestock or remove paddocks from the system for harvest, then average forage mass and postgrazing heights will increase and forage quality will decrease.

Management decisions made for a specific week have significant implications for the quantity and quality of forage on the grazing platform for the next three to five weeks. Using this tool can help you manage your pasture more proactively.

In the sample grazing wedge generated by the Pasture-Based Dairy Program's online tool (Figure 2), the average growth rate is 66 pounds of dry matter per acre per day and pasture demand is 41 pounds of forage per acre per day. Growth exceeds demand by 25 pounds per acre per day, so a management decision to remove paddocks from the grazing rotation for hay or silage would be appropriate.



Summary of KEY INDICATORS for Grazing Management and Animal Performance		
Livestock Class		**Dairy Milking**
Estimated Growth Rate (lbs of dry matter accumulation per acre per day)		**66**
Forage mass when cows turned onto a paddock (lbs DM/acre)	Actual: **2800**	Ideal: **2750**
Forage mass when cows removed from paddock (lbs DM/acre)	Actual: **1100**	Ideal: **1400**
Average Pasture Mass (lbs DM/acre)	Actual: **1915**	Ideal: **2075**
Rotation length current (days till cows return to given paddock)		**22**
Milk production (lbs per day)		**61**
Lbs of hay for milking herd currently being fed (per cow per day)		**0**
Lbs of grain for milking herd currently being fed (per cow per day)		**8**
Lbs of hay for dry cows currently being fed (per cow per day)		**0**
Lbs of grain for dry cows currently being fed (per cow per day)		**0**
Critical issues right now: Very cool and wet. Added nitrogen to one-third of pads.		

Figure 2. Sample grazing wedge generated by the University of Missouri Extension Pasture-Based Dairy Program's online tool.

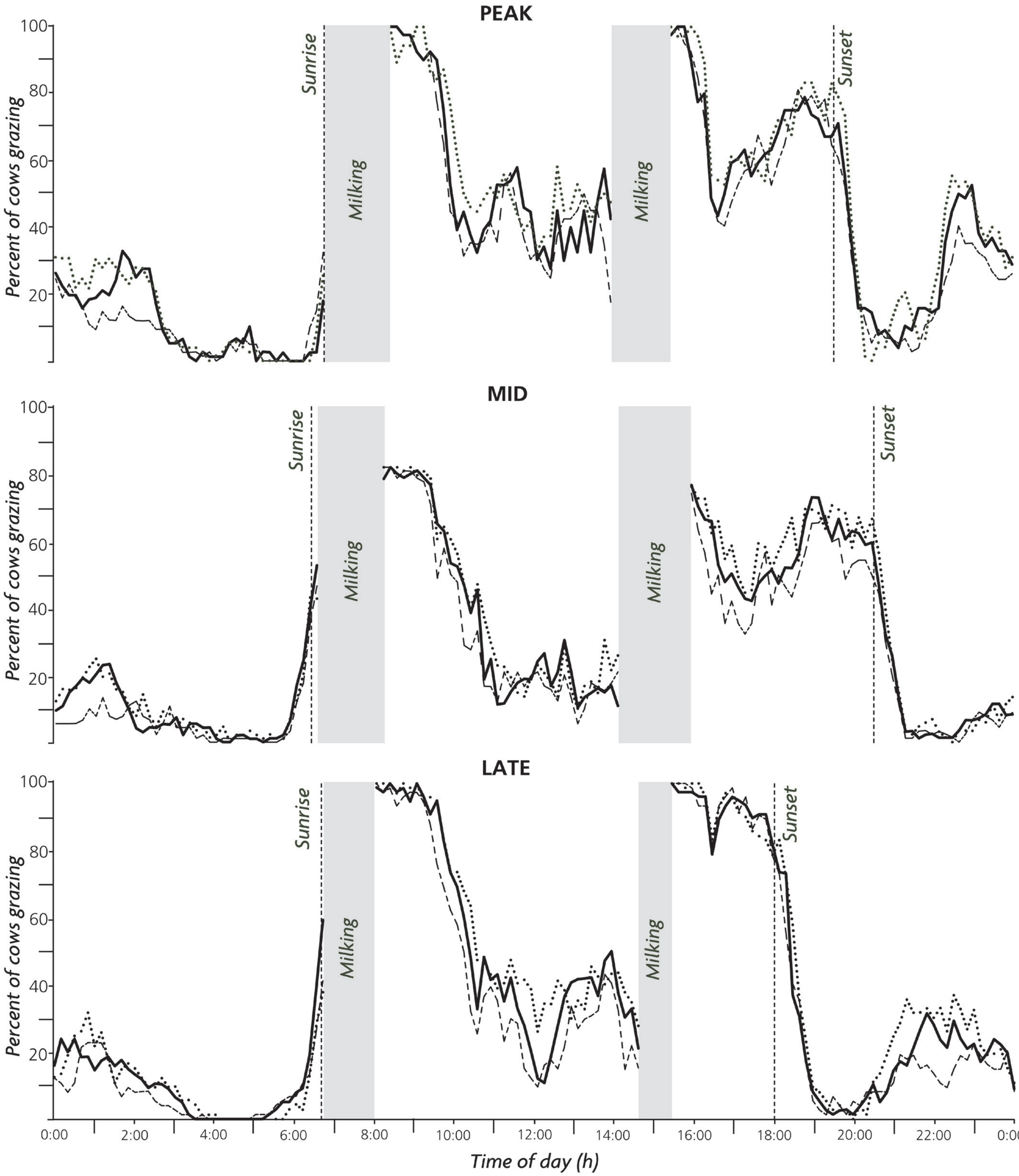


Figure 3. Daily grazing patterns of cows during peak, mid and late lactation when offered 0, 6.6 or 13.2 pounds of dry matter per day concentrate (0 pounds of dry matter per day = dotted line, 6.6 pounds of dry matter per day = solid line, and 13.2 pounds of dry matter per day = dashed line). Shading represents milking time and vertical dashed lines represent sunrise and sunset. (Figure reprinted from *Journal of Dairy Science* 94:7, A.J. Sheahan, E.S. Kolver, and J.R. Roche, "Genetic strain and diet effects on grazing behavior, pasture intake, and milk production," 3588, (2011), with permission from Elsevier.)

Dry matter intake of dairy cows

Regardless of the production system, DMI is one of the most crucial factors in dairy cow production. Intake drives the nutrients available for milk production, growth, maintenance and reproduction. Higher DMIs are generally more easily obtained in total mixed ration (TMR) feed systems than in grazing operations due to feedstuffs being more readily available throughout the day. Lower DMIs in pasture-based systems are a major limitation for milk production. In most instances, pasture-based cows are allowed to graze for a 12- to 24-hour feeding period. Lactating cows will typically graze for only eight hours a day, with milking times interrupting morning grazing bouts and day length (time from sunrise to sunset) having some effect (Figure 3). The remaining time is spent in the milking system, traveling to and from the grazing platform, and in rest and rumination.

Supplemental feeding and substitution

Generally, the objective for feeding supplements, such as grain, to grazing cows is to increase total DMI and overall energy. However, cows that are fed supplements may graze less pasture. To ensure cows consume an appropriate amount of dry matter when fed supplements, you need to calculate the amount of supplement to offer to replace the pasture that would otherwise have been grazed. This calculation requires use of a substitution rate.

Substitution rate is the amount of pasture intake displaced by feeding 1 pound of supplement. Substitution rates for North American cows have been shown to be 0.29, 0.26 and 0.17 for early, mid and late lactation, respectively.

Consider this example: The substitution rate is 0.5 for a cow that is normally fed an all-pasture diet of 30 pounds of dry matter. The 0.5 substitution rate means that **each pound of supplement** would replace **a half-pound of pasture intake**. If this cow were supplemented 10 pounds of grain, it would be taking in a total of 35 pounds of dry matter because the 10 pounds of grain would reduce pasture intake from 30 to 25 pounds. Thus, the addition of 10 pounds of grain supplement would make the total DMI 35 pounds.

The substitution rate can have positive and negative impacts on pasture management. For producers not accounting for substitution rate, postgrazing heights can increase — meaning the cows are not grazing the plants down to the ideal stubble height — resulting in lower DMI from pasture. A potential cycle of increasing supplements and reducing pasture intake to maintain milk production can occur when substitution rates are not accounted for.

Conversely, substitution rate can be beneficial when the goal is to increase total DMI and pasture management is designed for correct postgrazing heights. This situation may call for reducing the grazing acreage available and using the ungrazed paddocks for silage production.

Pasture dry matter intake

Dry matter intake from pasture is closely related to pasture allowance. Pasture DMI is determined by grazing time, bite rate and bite size:

time grazed (minutes) × bite rate (bites per minute) ×
bite size (amount per bite) = DMI

This equation provides insight into the factors that affect pasture intake, only two of which producers can influence. Grazing time can be affected by management decisions on time grazed, day length and supplemental feeding. Bite size is affected by the density or total allowance of the forage offered in a feeding bout. Bite rate, which generally slows as grazing time passes, is the one factor on which producers are unlikely to have an impact.

Time grazed

Research has shown that cows will graze, on average, only about 480 minutes a day if offered the entire day and unlimited forage. Weather conditions — such as heat, cold, rain and snow — may decrease the time cows will spend grazing. Other factors that limit grazing time are neuroendocrine proteins, stretch receptors in the rumen and gastrointestinal tract (these have a limited effect if pasture is high-quality), and fatigue.

Bite rate

On average, cows will take 55 to 65 bites per minute, with bite rates generally higher early in the grazing bout and slowing later as cows tire or become full, or both.

Bite size

Bite size appears to be the major factor affecting DMI of pasture, assuming the producer is allowing full grazing time and the weather is not causing cows to eat less. Data from the University of Missouri and others suggest that the average bite size is less than one-fiftieth of an ounce.

Using the averages presented here, this bite size would suggest an average intake of about 28 pounds of pasture dry matter per day:

480 minutes (time grazed) × 58 bites per minute
× 0.016 ounce (bite size) ÷ 16 (ounces per pound)
= 27.84 pounds of dry matter

Factors affecting pasture intake

Research suggests several factors affect the DMI of grazing cows:

- Nutrient requirement of the cow or feeding drive
- Physical satiety or distension of the gastrointestinal (GI) tract
- Behavioral constraints, or limits resulting from animal or pasture factors
- Weather and environmental factors, such as heat, cold, day length, mud and humidity

- Physiological factors related to the processing of neuroendocrine proteins, which appear to regulate intake for the beginning or ending of grazing bouts

Obviously, **stage of lactation** and **daily milk yield** affect daily DMI. Producers must realize these parameters and feed accordingly to optimize milk production. Offering low-quality pasture — pasture that is high in neutral detergent fiber (NDF) and low in energy and protein — will negatively affect milk production regardless of stage of lactation. Offering pasture of adequate nutritive value during early lactation can enhance peak milk yield. Research indicates for every pound of peak milk, total milk yield increases 200 to 250 pounds for the lactation.

Neutral detergent fiber represents the total plant fiber and reflects the bulkiness of a forage. NDF has been widely accepted as affecting DMI: 1.2 percent × body weight = pounds of NDF consumed. However, a recent review of 21 studies suggests that NDF may be unrelated to pasture intake in a well-managed system — a system in which NDF concentrations in grazed forages are less than 48 to 50 percent. These studies also suggest that NDF intake and NDF as a percent of body weight increase as pasture allowance increases. This finding is substantiated by research papers reporting NDF intakes ranging from 1.5 to 1.7 percent of body weight and data from the University of Missouri research dairy indicating NDF intakes of 1.45 to 1.55 percent of body weight. These results suggest NDF concentrations will have little impact on overall DMI in well-managed pasture systems.

Bite size is affected by the amount of forage available; lower pasture allowance equates to a lower average bite size. Maximum pasture DMI is achieved when pasture allowance is three to five times the desired pasture DMI. However, this pasture allowance would result in lower-quality pasture throughout the grazing season due to wasted pasture from postgrazing heights that are taller than optimum.

Researchers suggest offering twice the desired pasture intake or a total of 50 pounds of dry matter pasture per cow when also feeding supplements. Unfortunately, this practice would still leave pasture-use at levels many producers find unacceptable. Pastures would need to be pre- or postmown to maintain forage quality throughout the season, or a put-and-take or leader-follower method of grazing dry cows, beef animals or young stock behind lactating cows could be used. However, these practices still do not directly feed the most important livestock unit — the lactating dairy cow — with the most valuable resource — pasture. Preliminary results at the University of Missouri suggest that feeding at 1.2 to 1.4 times desired pasture intake will result in 80 percent pasture-use and intakes of 24 to 26 pounds of dry matter pasture. Pasture intake is not a linear relationship to pasture allowance. Instead, it appears pasture allowance would need to be nearly doubled to increase intake of pasture from 24 pounds to 30 pounds; that is, it appears you would need to offer 30 pounds of pasture for 24 pounds of intake versus offering 60 pounds for 30 pounds of intake. You can use these findings when making decisions about the efficiency of your grazing system and the amount of supplement you want to feed.

Other data suggest **physiological factors** related to the processing of neuroendocrine proteins play a major role in cessation of grazing in mornings, whereas **day length**, **physical factors** or both cause grazing to stop in afternoons. These findings suggest that during morning feeding bouts dairy cows stop grazing when their energy needs have been met, but during afternoon bouts they stop because of a full rumen, the lack of sunlight or both. More research needs to be done to verify these findings, as producers may find it beneficial to offer less pasture in the morning and more in the afternoon to increase pasture use.

The importance of knowing pasture intake

Pasture is a limited resource, and optimizing its use is essential to reducing system costs. Pasture systems can grow only a finite amount of forage in a season and are dependent on weather, climate, locality and species.

Estimating pasture intake allows you to maximize forage use. For example, consider a pasture that grows 4 tons of forage per acre per year. At a 90 percent utilization rate, 3.6 tons of forage per acre of pasture would be consumed by the cows. Assuming a cow requires 5.25 tons of feed annually, at a stocking rate of one cow per acre, 1.65 tons of supplemental feed would be required per cow. In contrast, if the utilization rate were 60 percent, 2.85 tons of supplemental feed would be required per cow.

Data from the University of Missouri suggest the cost of grown forage is 3.5 to 4 cents per pound of dry matter. At 90 and 60 percent utilization, the cost would increase to 3.9 and 5.9 cents per pound of dry matter, respectively, plus the expense of additional supplemental feed. These numbers demonstrate the value of measuring, monitoring and managing pasture intake.

Estimating dry matter intake from pasture

DMI of pasture in dairy cows can be determined using any of the following four methods:

- Back-calculation of intake from milk production
- Pasture disappearance using pre- and post-measurement of pasture
- Markers such as titanium dioxide and alkanes
- Esophageal fistulae

Producers can use the first two methods to estimate pasture intake, whereas most researchers use the latter two. This discussion focuses on the methods producers can use. By combining these methods, you can be relatively confident you know the amount of pasture being consumed.

Back-calculation from milk production

To back-calculate pasture intake based on milk production, first convert raw milk production to 4 percent fat-corrected milk (FCM) using this formula:

(0.4 × pounds of raw milk) +
((15 × (pounds of raw milk × percentage of butter fat)) =
pounds of 4 percent FCM

Example: Milk production at 55 pounds per cow with 4.2 percent butter fat equals 56.65 pounds of 4 percent FCM:

(0.4 × 55 pounds or raw milk) +
((15 × (55 pounds of raw milk × 0.042 butter fat)) =
56.65 pounds of 4 percent FCM

Each pound of 4 percent FCM requires 0.354 megacalories (Mcal; 1 million calories) of net energy (NEl):

pounds FCM × 0.354 Mcal of net energy = Mcal of net energy for milk production

56.65 pounds FCM × 0.354 Mcal of net energy =
20.05 Mcal of net energy for milk production

Cows will require 9 to 11 Mcal of net energy a day for maintenance, depending on distance walked, slope of the terrain and weather. This example uses 10 Mcal of net energy for maintenance per cow per day. Use this formula to calculate total net energy required:

daily Mcal of net energy for milk production + daily Mcal of net energy for maintenance = Mcal of net energy per cow per day

20.05 daily Mcal of net energy for milk production +
10 daily Mcal of net energy for maintenance =
30.05 Mcal of net energy per cow per day

If concentrate feeding is 10 pounds dry matter (DM) at 0.87 Mcal of net energy per pound, with no other supplement because pasture is abundant, then concentrate provides 8.7 Mcal of net energy toward milk production and maintenance.

pounds DM – Mcal of net energy per pound of DM =
additional Mcal of net energy required

30.05 pounds DM – 8.7 Mcal of net energy per pound of DM
= 21.35 additional Mcal of net energy required

A forage quality analysis is recommended to determine pasture quality. Use the analysis result to calculate the pounds of DM. This example assumes pasture quality is 0.68 Mcal of net energy per pound of DM:

additional Mcal of net energy required ÷ Mcal of net energy per pound of pasture DM = pounds of DM from pasture

21.35 additional Mcal of net energy required ÷
0.68 Mcal of net energy per pound of pasture DM =
31.4 pounds of DM from pasture

The result of this back calculation from milk production indicates that pasture intake is 31.4 pounds of dry matter. This result, however, does not account for any change in body weight or lactation stage, so it can over- or underestimate pasture DMI. However, it is fairly accurate, and producers can use it to determine their overall pasture demand compared with their growth rates and to make management decisions on nitrogen application, stocking rate and supplemental feeding.

Pre- and post-measurement of pasture

Calculating pasture intake by determining pasture disappearance involves measuring the amount of dry matter in the given area before cows are allowed access for a grazing bout and again after cows have been removed from the area. Pasture disappearance results not only from grazing but also from wastage caused by cows urinating, defecating, walking and lying down; therefore, the following calculation can over- or underestimate DMI.

Example: You have a 2-acre paddock grazed by 100 cows over a 24-hour period. The pregrazing mass was 2,800 pounds of dry matter per acre, and the postgrazing mass was 1,500 pounds of dry matter per acre. Between the pre- and postgrazing measurements, 1,300 pounds of dry matter per acre disappeared, for a total of 2,600 pounds (2 acres) disappearing over a 24-hour period.

pounds pregrazing DM per acre – pounds postgrazing DM per acre = pounds DM disappeared per acre

2,800 pounds pregrazing DM per acre –
1,500 pounds postgrazing DM per acre =
1,300 pounds DM disappeared per acre

pounds DM disappeared per acre × number of acres grazed =
pounds DM grazed

1,300 pounds DM disappeared per acre × 2 acres grazed =
2,600 pounds DM grazed

pounds DM grazed ÷ number of grazing cows =
pounds DM per cow

2,600 pounds DM grazed ÷ 100 grazing cows =
26 pounds DM per cow

pounds DM per cow ÷ days grazed = pounds DM per cow per day

26 pounds DM per cow ÷ 1 day grazed =
26 pounds DM per cow per day

When using this method, ensure the same person is estimating pre- and postgrazing pasture mass and have that person repeat this process over time to gain confidence.

Summary

Management of pasture for optimal yield and nutrient content is essential for low-cost feeding of lactating dairy cows. Management of grazing to optimize intake without wasting forage and increasing costs is also essential. By understanding your forage plants' growth characteristics and measuring, monitoring and managing your pasture system, you are more likely to achieve high-quality, high-yield pastures and minimize your feed costs.

Additional resources

Determining Pasture Yield, Pennsylvania State University, College of Agricultural Sciences: ***http://extension.psu.edu/publications/uc197/view***

Grazing wedge program, University of Missouri Extension: ***http://grazingwedge.missouri.edu***

Pasture-Based Dairy Program, University of Missouri Extension: ***http://agebb.missouri.edu/dairy/grazing***

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