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Chapter 18

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Alfalfa Grazing Management

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Grazing alfalfa with dairy or beef animals is not a common practice in California or even in the United States. Although a limited number of alfalfa acres are grazed in the humid Midwest and East, it is rare in the West, and the ruminant alfalfa forage systems throughout the United States consist of hay- and haylage-based harvest methods. However, there is increased interest in grazing in North America due to harvest cost issues, environmental benefits, and interest in organic, natural, or grass-fed products in the market, and animal welfare. Since some component of grazing is required for organic certification, grazing of alfalfa has received increased interest.

Grazing alfalfa is a more common practice in Australia, New Zealand, and Argentina. Argentina grazes more alfalfa than any country. Milk and meat production systems are based primarily on grazing alfalfa, especially in the rainfed regions of the Pampas. Producers in the Pampas use more than 5 million hectares (12 million acres) of alfalfa for grazing. Alfalfa varieties and growing conditions in the Pampas are remarkably similar to California. Here we discuss important concepts of alfalfa grazing management for efficient milk and meat production, based

primarily on the Argentine experience, especially as they may relate to California conditions.

Principal Benefits and Limitations of Grazing Alfalfa

Some comparative economic studies on dairy farms indicate that intensive grazing systems may be a viable management tool for improving dairy profitability compared to a confinement system. A recent study indicates that using rotational grazing decreases animal production costs compared with harvested forage systems. There are a range of potential benefits, chiefly lower investment and production costs, but also lower culling rates, improved herd health, and environmental benefits from better recycling of wastes and reduced nutrient concentration at a single location. Stocker steers from 400 to 600 pounds (181 to 272 kg) may gain from 1.75 to 2 pounds (0.8 to 0.9 kg) per day and even as high as 3.0 pounds (1.4 kg) per day on alfalfa pasture. Animals generally have fewer hoof and leg problems or mastitis problems on pasture compared with cramped cement feedlots. Alfalfa pasture returns more nutrients to the soil than hay crops. Nutrient cycling is accomplished by the animals themselves in grazing systems, but distribution for plant uptake and control of wastes in grazing systems may not be optimal. There are likely to be public acceptance and animal welfare benefits of grazing systems as well, compared with feed-lot type dairies, as consumers become more interested in the origin of their food. There are lower fossil fuel energy requirements, since use of harvest machinery is minimal in grazing systems.

In general, compared to intensive, free-stall feeding systems, the main limitation of grazing systems is lower milk production per cow. Grazers have less control of forage yield and quality over the season. This creates challenges for ration balancing to optimize milk production. There is an energy cost to the animal walking to and from pastures that results in lower production. Weeds and compaction from animals' hooves can be significant problems that result from grazing under suboptimum conditions. Labor requirements for management of fences and animals are higher, and there is a logistical limit to farm size in grazing units. These disadvantages may be mitigated by integration of intensive grazing management with feeding practices that include silages and hay forage products to adjust quality and intake of feeds to improve milk production.

In the most productive Argentine systems, approximately half of the diet is typically composed of silages, grains, and by-products that supplement grazing. Potential milk yield of high-stocking-rate alfalfa grazing systems could be 25 to 30 kilograms (55 to 66 lb) of milk per cow per day, or 8,000 to 9,000 kilograms (18,000 to 20,000 lb) of milk per cow

Advantages and Disadvantages of Grazing vs. Feedlot Forage Systems

Advantages

- Low cost
- Low fossil fuel requirement
- Animal health
- Animal welfare
- Reduced waste issues—dispersed nutrient cycling
- Consumer preference in some markets
- Sustainability of agricultural systems

Disadvantages/Challenges

- Lower per-animal productivity
- Bloat risk
- Variable yield over season
- Lack of control over quality
- Labor requirements
- Compaction of soil, plant damage
- Need for higher level of management
- Weed intrusion
- Difficulty in balancing rations
- Control of manures from pastures

annually. Under these conditions, dietary balance through supplementation integrated with careful grazing management plays a critical role.

Practical Concepts and Principles for Managing Alfalfa Pastures

Growth and Defoliation of Alfalfa

As alfalfa grows and develops, a range of morphological changes affects forage quality, yield, and therefore milk production, as well as stand persistence (see Chapter 3, "Alfalfa Growth and Development," and Chapter 16, "Forage Quality and Testing," for details). An alfalfa pasture is made up of a population of stems of varying ages; some more mature, and some less mature, and this population changes over time as the crop transitions from high to low quality as it matures. Defoliation results in the need for regeneration of alfalfa shoots, which requires root reserves of carbohydrates and protein; frequent and early harvests improve quality but deplete stand vigor (See Chapter 13, "Harvest Strategies").

In addition, weeds and/or other forage species (e.g., grasses) that compete with alfalfa may be present. There is competition for light, nutrients, and water between species and individuals within species. Grazing affects these competitive relationships as well as subsequent regrowth from crowns. Over time, these competitive relationships produce changes in botanical composition, resulting in changes in forage mass, quality, seasonal production, and, consequently, animal production. For that reason, grazing managers should consider the morphogenic characteristics of the alfalfa over the season and over years, as well as grazing impacts on other forage species and/or weeds.

Plants have two mechanisms to survive defoliation under grazing conditions: (a) chemical or physical defenses, or (b) tolerance of its consequences. Some plants have evolved chemical defenses, such as alkaloids or tannins, or physical barriers to grazing, such as spines or needles, that reduce plant palatability. Alfalfa is a plant which lacks these defense mechanisms (which is why it is such an important forage) but has evolved the grazing tolerance mechanisms of rapid foliage regrowth after defoliation and abundant root reserves to allow regrowth. These allow the plant to survive multiple harvests (within limits) over the season, and over many years. In the case of alfalfa, the leaves, stems, buds, and apical meristems are always susceptible to defoliation by grazing, but very frequent defoliation results in depletion of plant root reserves. Subsequent regrowth after cutting or grazing originates primarily in the crown buds (at the top of the root) or in the basal part of the remaining stems.

During each growth period, alfalfa foliage produces energy (sugars and starches) and protein reserves that are exported to the roots to enable further root development. Root storage reserves are important to subsequent regrowth. It is estimated that alfalfa begins the process of translocating reserves to the roots only after about 15–18 days of growth; thus early, frequent, and intensive grazing may have significant negative effects on subsequent regrowth and stand persistence due to depletion of root reserves.

Forage Accumulation Patterns

After defoliation, alfalfa regenerates both leaf and stem material. As the crop becomes more mature, the stem portion increases significantly, but the leaf material remains constant, and toward the end of the growth period, dead material accumulates (Fig. 18.1). After about 42 days of regrowth, the amount of new leaf production may be similar to the amount of accumulated dead plant material. The forage accumulation rate depends on the season and the length of the accumulation period. Generally, maximum forage accumulation rates (mass per unit area per day) are highest in early summer (until high temperatures become limiting), somewhat slower in spring, slower yet in fall, and very slow in winter (Fig. 18.2). Additionally, alfalfa variety (particularly fall dormancy rating), fertility, irrigation, and other factors affect growth rates. Pasture management systems need to be continually adjusted

FIGURE 18.1

Alfalfa dry matter accumulation patterns during spring regrowth.

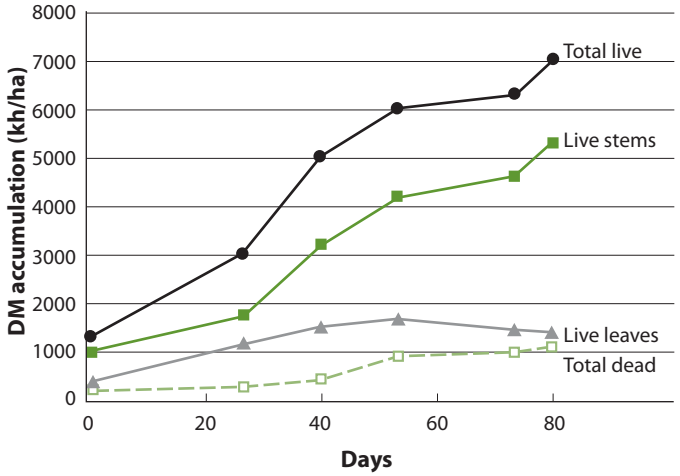
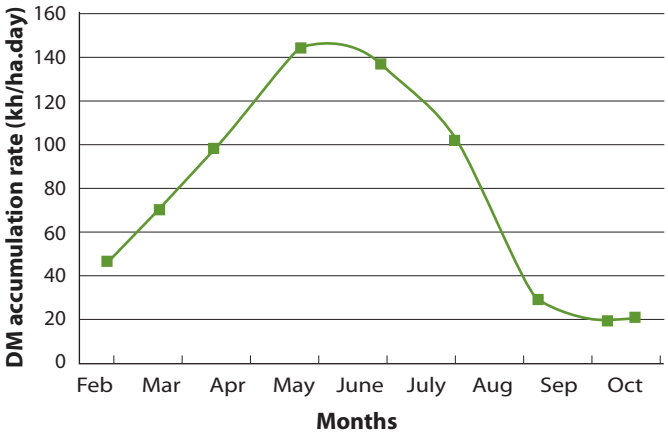


FIGURE 18.2

Seasonal changes in alfalfa dry matter accumulation rates under irrigation.



for growth patterns, depending on crop status and time of year.

Defoliation Management Under Grazing

Grazing of alfalfa involves three important factors: (1) *frequency*, or the time between two consecutive defoliations; (2) *intensity*, measured as the quantity of forage mass removed. This is also referred to as the efficiency of pasture utilization, or as the percentage harvested. Since animals are selective for both species (weed, grass, or alfalfa crop) and plant parts (leaves vs. stems), intensity influences both yield and quality; and (3) *timing*, related to the phenological stage of the plants at harvest.

Generally, alfalfa should be grazed at the beginning of flowering or when the first new regrowth appears in the crown (this may occur before flowering in some environments). Nevertheless, to simplify management practices, growers often graze at specific intervals. Similar to hay cutting schedules, grazing frequency should maintain a good level of root reserves after defoliation through providing an adequate "rest regrowth period," which leads to high dry matter production, quality, and stand persistence through time.

Grazing intensity may be estimated from the stubble height remaining after defoliation. After defoliation, the crown buds and basal shoots from the crown are the main growing points from which regrowth is generated. Shoots originated from axilar buds in the remaining stubble are less important. It is suggested that a stubble height of 5–7 centimeters (2–3 in.) is enough to sustain a high rate of regrowth and to strike a proper balance between high rates of regrowth and pasture utilization. However, stubble height (intensity of grazing) has a profound effect on forage quality.

Rest Periods, Rotations, and Schedules

Research has demonstrated that recommendations for managing alfalfa under grazing conditions should be similar to those for hay production (see Chapter 13, "Harvest Strategies for Alfalfa," for cutting schedule recommendations). Increasing grazing frequency (less time between defoliation) by using short rotation frequency decreases forage yield and persistence of the plants significantly, but forage quality is better. Continuous stocking at high stocking rates without rotation is an extreme case that causes severe stand loss and is not recommended (Fig. 18.3). Rotational grazing management with rest periods of at least 35 days allows recovery of the alfalfa before subsequent defoliation.

This rest period should be adjusted according to seasonal effects and factors such as drought, variety, and fertility. The objective is

to maintain a high forage value and avoid grazing the new regrowth coming from the crown.

Rotational grazing entails division of a field into paddocks of appropriate size and control of animals, often by use of temporary fencing or the use of existing fields in a system of pastures. The basic principle is managing livestock for defoliation at specific plant maturity, followed by a rest period before subsequent defoliation. A grazing cycle consists of a grazing period that is followed by a rest period, which can be of various time sequences (Table 18.1). Both the rest period and the grazing time are important to crop productivity and animal performance.

Long, intensive grazing periods where plants are grazed close to the ground increase harvest efficiency but may reduce plant survival and result in harvests of lower quality. Short grazing periods are used for dairies; the electrical fences are moved each day (for example, one paddock per day) or even each half day. These systems are more labor intensive and when moderately stocked, result in lower harvest efficiency but higher milk production. In a rotational stocking program, a grazing period of 7 to 10 days with at least 35 days of rest is considered safe for the alfalfa pasture and adequate for animal production. There is a range of combinations for grazing and rest periods that achieves a grazing cycle of 40 days (Table 18.1). Generally, no more than six to eight paddocks or fields should be included in the rotational grazing system. Adjustments can be made for each farm, based on season, alfalfa variety, level of supplements in the diet, field shape, availability of drinking water, and labor force availability.

FIGURE 18.3

Alfalfa stand percentage (as a function of the initial number of plants) is affected more by continuous grazing compared with rotational grazing (7 days grazing followed by 35 days resting).

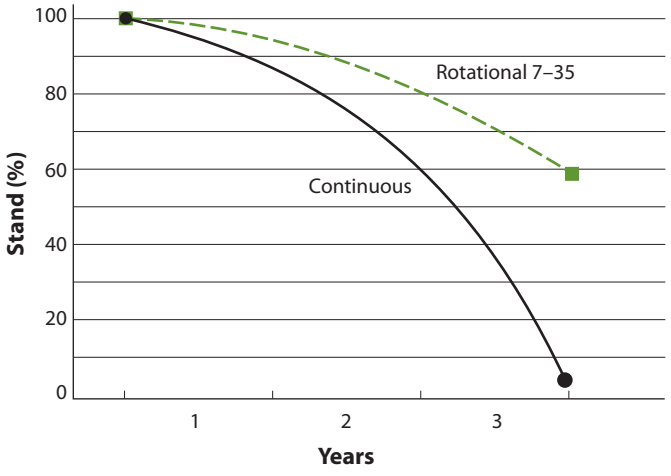


TABLE 18.1

Relationship between the numbers of subdivisions (paddocks), and grazing and resting days, for a grazing cycle of 40 days

Number of subdivisions (paddocks)	2	4	6	8	10	12	14	16
Grazing period (days)	20	10	6.7	5	4	3.3	2.9	2.5
Resting period (days)	20	30	33.3	35	36	36.7	37.1	37.5

Watering, Rainfall, and Compaction

Watering cattle on pasture is often a challenge for grazing systems since foot traffic can create problems due to mud, trails, and compaction. Feasibility of watering infrastructure may be a limiting factor in a grazing system. On fields that are irrigated with a center pivot, it is advisable to place the waterer at the center and separate the grazing subsections in a bicycle-spoke fashion.

Care must be taken not to graze wet fields. Soil compaction caused by cattle will diminish future yields and reduce stand persistence. Animals should be removed from alfalfa fields during rainfall events or irrigation; cattle should not be moved onto the field as long as the field is wet. However, the effect of foot traffic is highly dependent on soil type and amount of moisture. To reduce soil compaction after a rainfall event or an irrigation, the top 1 inch (2.5 cm) of soil (for loams or heavier soils) should be dry before moving cattle onto the field. Grazing cattle tend to naturally congregate around water. If possible, every cattle move onto new field subsections should be accompanied by a corresponding move of the cattle's water supply,

to prevent soil compaction around the water basin. Concrete aprons around water supplies are advisable.

Determining Stocking Rates and Grazing Strategies

The grazing process may entail division of a field into paddocks of appropriate size, facilitated by use of temporary or permanent fences to control animals. Alternatively, several fields may be used together as a grazing unit or system for management purposes. Animals are moved to paddocks each day, frequently twice per day. In a grazing period (½, 1, 3, or more days long), once a field is grazed a rest period follows. A second harvest or grazing may follow the same pattern in sequence so that the same rest period (usually about 35 days) is followed for all paddocks. Grazers may further subdivide a paddock during a grazing period to intensify grazing in one section (e.g., half of the grazing on one side), followed by another section a few hours later, depending on labor availability.

Grazers may choose paddock size and stocking rate by trial and error but may also use a formula. The first step in using a formula is to estimate the dry matter intake needs of the animal. Secondly, it is important to estimate the total dry matter available in the field at the time of grazing. The third step is to know the percentage of the pasture to be utilized. Lastly, it is useful to know the quantity and quality of available supplements, as well as the quality of the forage available for grazing. The latter information may be useful only for a more sophisticated nutritional approach to grazing, requiring a higher level of management and ration balancing.

To estimate stocking rates, paddock sizes, and grazing duration, an assessment of alfalfa grazing resources would be helpful. A "grazing management unit" (the aggregate collection of fields and/or paddocks) should be selected. This is the grazing land area that will be used to support a group of animals for an entire grazing season, considering pasture allowance, the grazing and resting periods, and the number of cattle. Then, the stocking rate (or the number of animals/day/area of land) can be calculated, as follows:

1. **Determining an animal's requirements.** The diets should be balanced according to animal requirements and feed availability (including stored forages, concentrates, and pasture). For example, according to nutritional recommendations, it may be estimated that the animals will require a total dry matter intake (DMI) of 20 kilograms (44.1 lb) per cow, per day and 50 percent of the diet (10 kg [22.1 lb] DMI) is projected to be provided by the alfalfa pasture.

Determining Alfalfa Pasture Requirements for a Group of Animals (example)

Dietary needs of animal:

= 20 kg (44 lb) DM/cow/day
50% to be obtained from pasture:
= 10 kg (22 lb) /cow/day

Available forage (measured or from experience):

= 0.224 kg/m^2 (e.g., about 1 ton/acre dry matter)

Grazing intensity: 60%

= 0.135 kg/m^2 harvested

Area needed for one animal:

= 74 m^2 per cow per day (10 kg divided by 0.135 kg/m^2)

Area needed for 100 animals:

= 7,400 m^2 (0.74 ha or 1.66 acres) per day (74 m^2 × 100)

Remember:

- Adjust for moisture content.
- Consider number of harvests/year (calculate on a DM basis).
- Consider additional acreage needed for stored forages.

2. **Forage mass and pasture utilization**. There are several methods to assess the yield (standing forage) of the pasture, such as cutting and weighing small portions, disc meter, eye calibration, and so on. A detailed description of yield estimation techniques is out of the scope of this chapter. Experience may be the best guide. Plant height has a good relationship to yield, but this can be misleading as well. Use cutting samples from small quadrats, and a microwave oven to adjust for dry matter. This method may be useful to calculate dry matter yields until enough experience is gathered to determine yield for a field from visual estimates. After yield per unit area and total area is estimated, the pasture utilization (which is almost always less than 100%) should be estimated. Pasture utilization efficiency is often estimated at 60 percent or less (e.g., 45%–60%) for dairy animals, greater for beef cows, dry cows, sheep, or heifers. These estimates should be checked by verifying actual pasture offered versus pasture refused, by measuring stubble clippings over the season. Adjust for moisture content (e.g., all calculations on a dry-matter basis).

3. **Daily paddock estimations (see sidebar on previous page).** If a grower can produce about 1 ton per acre (100% DM basis) forage per harvest (equivalent to 2.24 Mg/ha), then 0.224 kilograms (4.9 lb) per M^2 alfalfa is determined to be available for grazing. With 60 percent utilization, 0.134 kg per M^2 will be harvested per animal, per day by grazing. To satisfy the 10 kilograms (22.1 lb) per day animal requirement, we will need about 74 M^2 (800 ft^2) per animal, per day. For a group of 100 dairy cows, it will then be necessary to provide grazing from 7,400 M^2 (0.74 ha [1.8] acres per day) of alfalfa forage.

These calculations provide a rough estimate of dry matter intake needs for cows but do not take into account forage quality and forage intake differences across the season, and other factors, such as quality of the supplements. These estimates must be adjusted to accommodate seasonal changes in productivity and quality, for specific classes and breeds of animals, and by experience with specific fields.

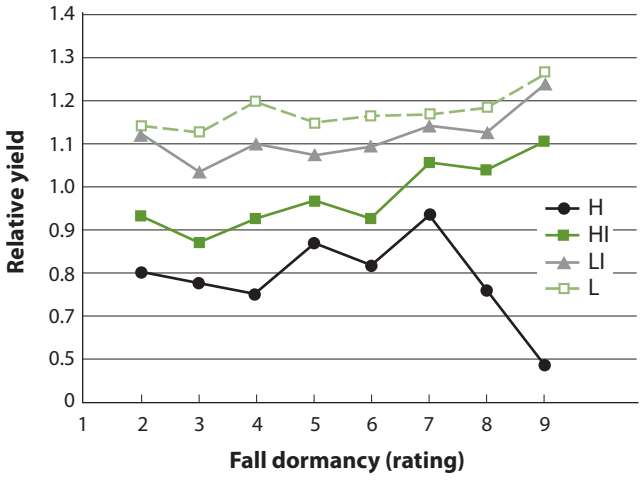
Variety and Grazing Intensity Interactions

Defoliation frequency is one of the most important variables for maintaining high pasture yields and persistence. The defoliation frequency (by cutting and/or grazing) may have different effects, depending on the fall dormancy class of the variety. Nondormant varieties generally demonstrate higher productivity with low defoliation frequencies (30 days or more; Fig. 18.4). However, defoliation frequencies of 25 days or less significantly decrease the performance of nondormant alfalfa varieties (class 8–10), which are usually less persistent.

Nondormant varieties have also been more sensitive than intermediate dormancy varieties to frequent defoliation in autumn due to higher growth. The high defoliation frequency in autumn–winter of nondormant varieties negatively affects and delays the regrowth in the following spring. Nondormant varieties are likely to be much more sensitive to intensive grazing conditions when compared to dormant varieties. The causes of these variety

FIGURE 18.4

Relative forage yield of alfalfa affected by varieties with different fall dormancy ratings and frequency of defoliation. H = high frequency (21-25 days), HI = high - intermediate (28-29 days), LI = low – intermediate (33-35 days), L = low (37-42 days).



differences under grazing conditions are not clear but could include diseases, root nitrogen or carbohydrate reserves, or crown bud metabolism. These results are likely to be applicable to most regions within the Central Valley and deserts of California, but no research has been done on alfalfa variety–grazing interactions in California.

Managing Alfalfa–Perennial Grass Mixtures

Alfalfa for grazing is frequently mixed with grasses, like perennial ryegrass, orchardgrass, fescue, bromegrass, and timothy. Some advantages for these mixes are: (1) higher production and pasture distribution throughout the year; (2) lower variation between years; (3) better dietary balance or energy–protein ratio; (4) reduction in weeds; and (5) lower risk of bloat. The most appropriate grass will depend on location and expectation of animal performance.

The main disadvantages of mixing alfalfa and perennial grasses are: (1) increased complexity of grazing (animal selection, diet impacts); (2) maintaining the competitive balance between the pasture's components; (3) differential nutritional changes based on phenology stage and the relative contribution of species; and (4) difficulty in obtaining high-quality forage reserves (hay, silage) and, consequently, lower animal responses.

Canopy Structure: How Do Animals Harvest Alfalfa Pasture?

Before flowering (during vegetative stages), plants have a higher concentration of leaves on the top layers. Close to flowering, leaves are concentrated on the medium to upper layers, and the stem proportions dominate at the lower layers (Fig. 18.5). Leaves do not change much in quality within the canopy, whereas stems decrease significantly in dry matter digestibility and crude protein from the top to the bottom of the canopy (Table 18.2). This indicates that the quality of the whole plant is mainly affected by stem quality, which is dramatically affected by plant maturity over time.

The changes from the top to bottom layers are important for grazing and may affect diet selection by animals, daily intake, and efficiency of pasture utilization. Stem digestibility varies a great deal not only within years, but also between years. During hot summers, the digestibility of stems could be low—less than 40 percent digestible.

Grazing animals do not uniformly

FIGURE 18.5

Vertical distribution of leaves and stems in alfalfa plants close to flowering. The alfalfa canopy has a significantly greater leaf percentage on the upper portion than on the lower portions of the canopy. Each curve represents about 100% of leaves and stems yield added at different heights.

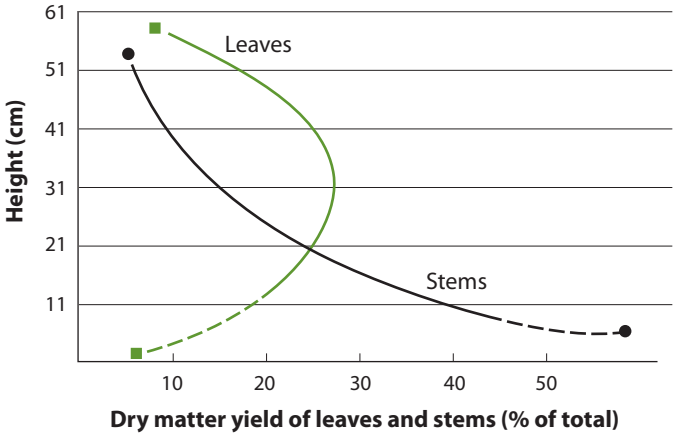


TABLE 18.2

In-vitro dry matter digestibility (IVDMD) and crude protein (CP) contents of leaves and stems at different vertical layers in a spring alfalfa pasture

Layer (cm [in.] above ground)	Leaves		Stems	
	IVDMD (%)	CP (%)	IVDMD (%)	CP (%)
> 30 [12]	74.3 ± 0.9[a]	26.4 ± 0.7[a]	66.8 ± 0.6[a]	13.8 ± 1.0[a]
20–30 [8–12]	69.3 ± 0.5[b]	27.4 ± 1.1[a]	58.2 ± 0.4[b]	9.0 ± 1.4[b]
10–20 [4–8]	68.8 ± 0.7[b]	28.0 ± 0.5[a]	53.9 ± 0.3[b]	9.0 ± 0.2[b]
< 10 [4]	68.4 ± 1.8[b]	28.3 ± 0.6[a]	40.7 ± 1.8[c]	8.1 ± 0.1[b]

[a–c] Means within columns followed by different letters are significantly different ($P < 0.05$).

harvest alfalfa. They do not quickly graze to the ground like mechanical harvests, but instead harvest sections of the canopy. The amount (weight) of these sections (or "bites") can be estimated using the proportion (percentage) of the area covered, the forage height, and its density (kg/ha per centimeter [t/a per inch] of height) (Fig. 18.6). The bite essentially determines harvested yield, animal intake, and forage quality. Animals usually consume alfalfa forage by horizons, according to the depth of each bite. During a first grazing, bovines consume about 50 percent of the available forage by volume from the top of the canopy (Fig. 18.6), independent of the cattle's body weight. In subsequent grazings, animals consume about 50 percent of the available remaining forage. For example, animals may consume a first horizon (H_1) of 15.6 centimeters (6 in.), leaving 2,625 kilograms (2.9 tons) dry matter per hectare with 14.4 centimeters (5.7 in.) of height (Fig. 18.7). This second horizon (H_2) will have a bite with 7.6 centimeters (3 in.), and so on (Fig. 18.7). Forage quality will also reduce significantly from top to bottom of the canopy (Fig. 18.8), as animals select the best parts of the plants first, and then the stemmy, fibrous portions of the plant at the bottom. Thus, during a grazing event, animals will consume less when they graze the lower layers of the pasture, and this forage is progressively lower in quality. This sequential grazing process has major implications on grazing management.

FIGURE 18.6

Bite dimensions and bite mass of a grazing bovine. Generally, in a first grazing, animals will consume 50% of the available forage by weight or volume.

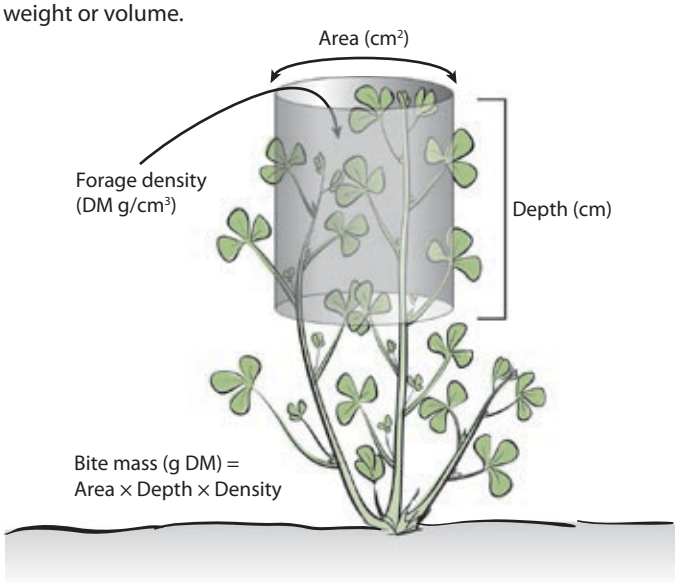
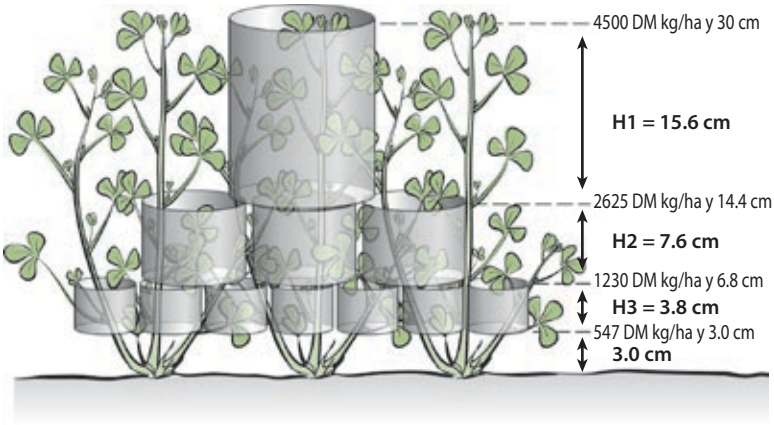


FIGURE 18.7

After the first grazing, herds will graze another approximately 50% of the available forage in the second grazing, and in a third grazing, again about 50%.

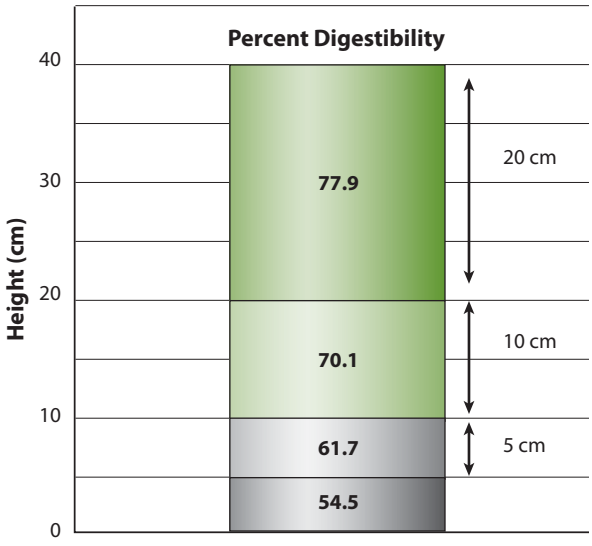


Intake Under Alfalfa Grazing

Dry matter intake of forages is a critical aspect of forage quality and animal performance (see Chapter 16, "Forage Quality and Testing"). Dry matter intake may be an important limitation when grazing high-moisture pastures. At

FIGURE 18.8

Digestibility of alfalfa pastures varies significantly by location in the canopy, with the highest quality at the top, lowest at the bottom.



identical dry matter digestibility, the animal's intake and animal production from alfalfa is nearly always higher than from grasses. This is due to the higher rumen rates of degradation of alfalfa (rumen breakdown) and grazing selection preference for alfalfa leaves versus stems. These factors enable grazed alfalfa to maintain its quality even in the advanced maturity stages of the plants. However, maintenance of quality is dependent on grazing pressure.

Trade-off Between Forage Quality, Animal Performance, and Forage Utilization Efficiency

With dairy grazing systems, there is a clear trade-off between maintaining high milk production through grazing high-quality forages and more intensive grazing to maximize harvest efficiency. A third (and important) factor is maintaining stand life or persistence over time, which is affected by grazing intensity.

The highest pasture utilization is achieved through the most intensive grazing pressure (grazing plants completely to the ground), but does not necessarily result in the highest animal performance. Intensive grazing maximizes forage yield and efficiency (percentage of the crop harvested). However, grazing alfalfa when the pasture has mostly low-quality stems at the bottom of the canopy forces the animals to consume a diet with significantly lower quality. This decreases total daily intake, affecting body weight gain or milk yield per animal.

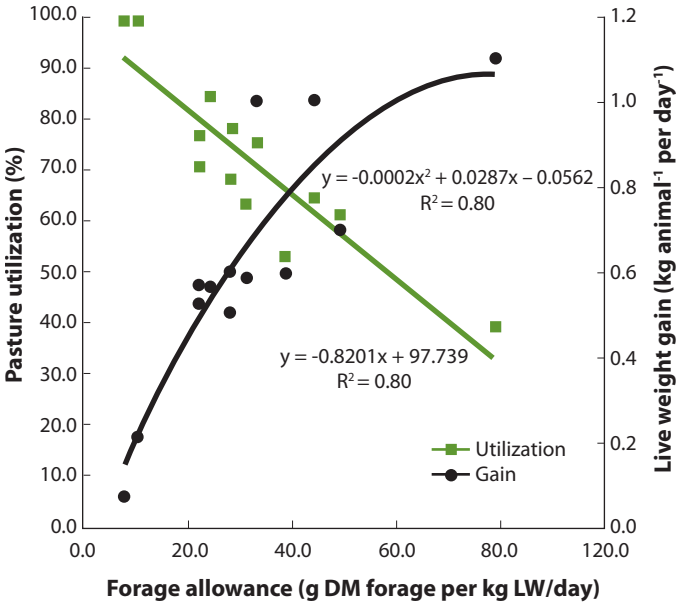
There is a trade-off between complete forage utilization (yield and harvest efficiency) through intensive grazing and the animal´s performance, daily gain, or milk production (Fig. 18.9). Frequently, less intensive, shorter grazing periods will benefit milk production or daily gain, but of course, complete forage utilization is compromised and increased labor is required. As forage allowance (the amount of forage available per grazing animal, per day) increases, energy intake and animal daily gain increases from less than 0.3 kilogram (0.7 lb) to more than 1.2 kilograms (2.6 lb) of daily liveweight gain, but pasture utilization efficiency decreases constantly (Fig. 18.9).

From this general relationship we could conclude that to get 1 kilogram (2.2 lb) of daily liveweight gain, the efficiency of pasture utilization has to be low (about 30%) and the forage allowance high, near 60 grams (0.13 lb) of dry matter per kilogram of liveweight. This relationship is far from being universal. In spring, high pasture utilization (more than 70%) or a low daily forage allowance (30 g [0.07 lb] of dry matter per kilogram liveweight) is compatible with liveweight daily gain of more than 1 kilogram (2.2 lb). At the end of summer or autumn this same utilization rate may provide less than 0.5 kilogram (1.1 lb)/day of daily gain.

It is not possible to define a forage allowance that applies to all pasture conditions and animal requirements. In Fig. 18.10, two simulations are presented to evaluate the animal's daily intake in a 7-day rotational grazing system. The forage allowance was the constant, and the forage mass and digestibility were variables. In Fig. 18.10a, steers were decreasing the rate of intake (grams of dry matter per minute) but maintained the estimated potential intake. Figure 18.10b indicates that after 4 days steers decreased both intake rate and digestible dry matter intake, and could not maintain

FIGURE 18.9

Forage allowance, daily gain of steers, and efficiency of utilization of pure and mixed alfalfa pastures.



the potential intake, even though they grazed a higher digestibility pasture. The same factors are important for milk production as for daily gain.

Therefore, grazing duration will need to be adjusted, depending on both the available forage mass and its estimated quality. Seasonal variation in forage yield and quality is one of the greatest challenges for producing milk under grazing conditions.

Balancing Diets Under Alfalfa Grazing

Successful grazing management systems usually incorporate some component of supplementation to improve animal health and performance. Pasture supplementation provides additional nutrients to satisfy the animal's requirements for energy, protein, minerals, and improved intake, and enables production during seasonal reductions of forage from pastures. The main advantages of supplementation are: (1) increased animal performance (health, reproduction, milk yield and composition, or liveweight gain); (2) greater stocking rate and efficiency of pasture utilization; (3) compensation for seasonal lack of forage and (4) increased farm profitability.

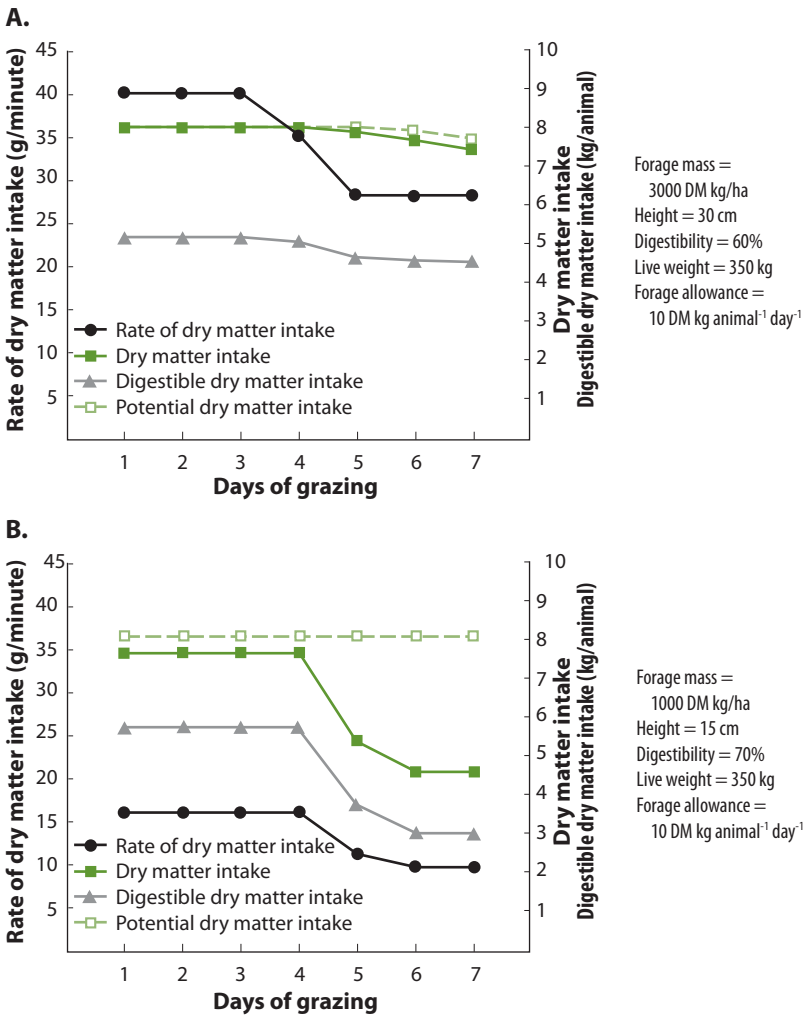
When supplementing alfalfa pasture, serious consideration should be give to balancing diets with several nutrients. First, alfalfa is generally high in crude protein concentration (17–26%) but also high in rumen degradable protein. The rate of rumen degradation of the fresh alfalfa protein is often too rapid and exceeds the requirements of rumen microbes for ammonia. Consequently, there is excess ammonia generated in the rumen, and this is usually excreted as urea through the urine and to a lesser extent through elevated milk urea levels. Second, high-quality alfalfa pasture is low in effective fiber. Effective fiber (estimated as a neutral detergent fiber requirement) often increases rumen residence time, which improves the ability of the diet to stimulate chewing and healthy rumen conditions. Third, pastures may be unbalanced for minerals (e.g., have excessive potassium or deficiencies of sodium, zinc, selenium, or copper).

Partial Mixed Rations

Nutritionists must provide a supplementation strategy to balance diets based on dietary needs of the animal for maintenance, growth, or milk

FIGURE 18.10

Rate of intake and daily intake of grazing steers in rotational stocking in two alfalfa pastures with: a) high forage mass–low digestibility; b) low forage mass–high digestibility. In both cases live weights and forage allowances were constant.



production. In grazing systems, other feed ingredients (silages, hays, byproducts, and concentrated feeds) are provided as partial mixed rations (PMR). This is similar to the total mixed rations (TMR) concept, where the total diet is integrated into one ration. Partial mixed rations are a blend of forage, grain, meals, minerals, vitamins or other supplements which are provided to the animal, not including the pasture contribution.

Protein Degradation

Under some grazing conditions, the degradation of alfalfa protein in ruminants is too rapid, and supplementation with an energy source may be necessary. The problem of rapid protein degradation in the rumen (and excretion of this nitrogen as urea) may occur with hay and particularly with alfalfa silage, but is especially a problem under grazing conditions. This problem is exacerbated by environmental conditions. Alfalfa protein often degrades much more rapidly in spring than under late summer grazing conditions (Table 18.3).

When animals graze for several hours on pasture with a high soluble nitrogen fraction and high rumen rates of degradation, amonnia levels can exceed levels that can be effectively used by rumen microbes, given the amount of energy available to them. This excess nitrogen can be wasted as urea. Energy availability and protein utilization are closely related during rumen fermentation. For that reason, some researchers suggest that supplementation with several carbohydrate sources, like soluble sugars, pectin, and starches, with different rates of rumen degradation and energy availabilities in the rumen should be more efficient than those supplements based on fewer ingredients.

For dairy cattle, PMRs should be provided to the animals after the morning milking or before animals are moved to grazing paddocks. This practice would supply dietary energy before grazing to enable rumen bacteria to consume more ammonia nitrogen from the alfalfa. Pastures tend to be more balanced (between protein and sugar content) in the afternoon, and animals are not so hungry, reducing possible bloat problems. In summertime, to minimize heat stress, grazing should occur late in the afternoon or at night; animals may recognize electrical fences and graze as efficiently as during daylight hours.

Supplementing with rumen bypass protein or undegradable protein may improve the apparent low efficiency of nitrogen utilization when grazing high-quality pasture. However, recent studies have concluded that merely increasing the supply of undegradable protein in dairy diets does not consistently improve milk production. Positive responses were obtained using undegradable proteins when feeding alfalfa silage for lactating animals, but not when supplementing grazed alfalfa. It was concluded that grazed forages are a much more effective source of protein than ensiled forages. Ensiling alfalfa tends to significantly increase the percentage of nonprotein nitrogen and enhances the degradability of the protein, making protein utilization less efficient. Balancing protein fractions according to animal requirements for energy (which allows for better utilization by microbes) is much more effective than supplying undegradable proteins. Improving protein nitrogen absorption is important from an environmental point of view, because fewer gases and nutrients are excreted.

TABLE 18.3

Rumen degradability of protein nitrogen (N) fractions in fresh alfalfa. Alfalfa protein frequently degrades too rapidly, especially in lush spring pastures

	CP	N Fractions (% CP)			Kd[4]
	%	A[1]	B[2]	C[3]	% per h
Late Summer	22.7	17.2	79.0	3.8	20.0
Spring	24.1	30.5	67.1	2.4	24.2

A[1] = Nitrogen fraction, which is very rapidly available in the rumen, and is composed of nonprotein nitrogen (peptides, free amino acids, nitrates); B[2] = True protein fraction, which is the potentially degradable fraction, degrading at the rate of Kd in the rumen; C[3] = the undegradable protein fraction that is not degraded; Kd[4] = rumen rate of degradation of "B" fraction by microorganisms in the rumen.

Supplementing Individual Feeds

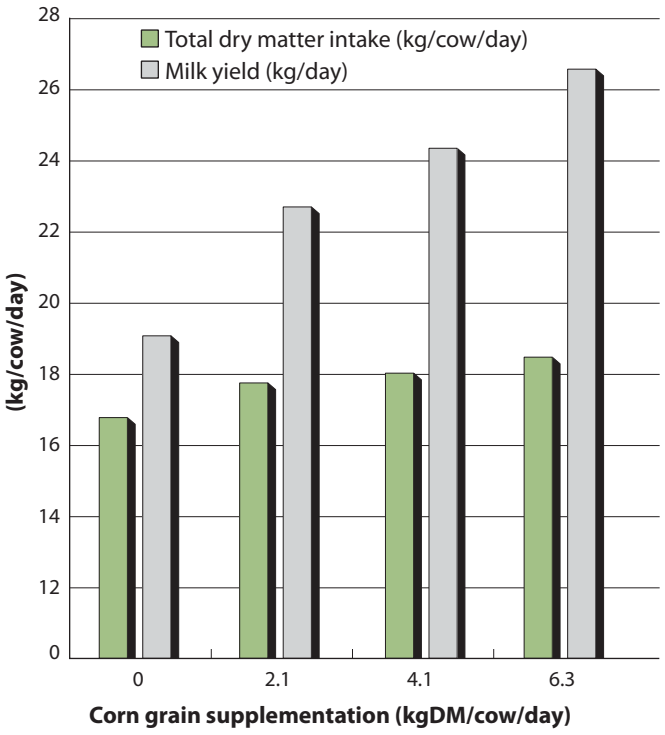
Managers may also choose to supplement pasture with individual feeds, such as concentrate (grains) or forages (hays or silages), as opposed to a PMR mixed ration. These may substitute for the dry matter intake from pasture (kilograms or pounds reduction in herbage intake per kilograms or pounds of supplement). In studies under alfalfa grazing supplemented with corn grain (from 0 to 6.3 kg [13.9 lb] of corn per cow, per day), a lineal reduction of 0.66 kilograms [1.46 lb] of grazed alfalfa per kilogram of corn grain was estimated, both expressed as dry matter (Fig. 18.11). Corn grain supplementation significantly increased total daily intake and especially milk yield.

Research on production responses (kilograms of milk or meat per kilograms of supplementation with grains or forages) have been conducted worldwide to determine animals' responses under grazing conditions. A recent review of this research concluded that with high-quality pastures, milk production increases linearly as the amount of concentrated feeds increases from 1.2 to 10 kilograms (2.6 to 22 lb) per cow, per day (dry matter basis), with an overall response of 1 kilogram (2.2 lb) of milk per kilogram/pound of concentrate. Generally, milk protein content was increased, but milk fat concentrations reduced. These lower concentrations of milk fat could be related to lower dietary intake of effective fiber. For this reason, some long hay (1–2 kg [2.2–4.4] per cow, per day) or ruminal buffers in the diet are recommended when grazing high-quality pastures supplemented with concentrated feeds, especially at the higher rates. When other forages (hays or silages) are used as supplements, milk or meat responses are variable and depend on the supplement quality and dietary balance. In general, when the supplemented forages have lower quality compared to alfalfa pasture, responses are nonexistent or negative. High-quality forage supplements, with top-quality alfalfa hay or high-quality corn silage, did not affect production when substitution rates were high (about 1:1).

Some final suggestions about supplementation: (1) make a plan with your nutritionist to balance rations for each group of animals; (2) carefully analyze the daily movement, behavior, and health of animals according to PMR, grazing, and milking routines; (3) analyze the feed quality from pasture, feeds, and drinking water for animals; (4) estimate pasture offered (allowances) and refusal; and (5) to improve efficiency of protein utilization, use mixtures of different energy sources, grains, and energy byproducts.

FIGURE 18.11

Effect of corn grain supplementation on total dry matter intake and milk yield of dairy cows grazing alfalfa.



Grouping Animals and Logistics

The movement of animals in grazing systems is an important issue that requires planning for effective supplementation strategy and logistical groupings. The main limitations for grouping animals (e.g., fresh cows, or high and low milking strings) are farm facilities and labor and management availability. The distances and movements of animals from pastures to milking parlors require special attention, as long walking distances, hilly pastures, dust, and mud significantly increase

energy requirements. Some ration-balancing computer programs can account for this energy demand from walking and grazing.

There appears to be no problem with small groups of cows, but for group sizes larger than 400 cows, there is a need to reevaluate productivity, feeding, and other behaviors. Overcrowded animals in free stalls can exhibit reduced reproduction and feeding activity, and altered resting behavior. These effects have not been observed as much under grazing conditions.

Preventing Bloat

Frothy bloat is probably the greatest single fear that livestock producers have about grazing alfalfa. In spite of the great potential of animal production from grazed alfalfa, the problem of pasture bloat continues to limit the widespread adoption of alfalfa for grazing. Although bloat is a management concern for grazing alfalfa (killing animals in some cases), there are measures that can significantly reduce the risk. Millions of animals safely graze alfalfa pastures each year, and farmers and researchers have developed management tools to lessen the likelihood of bloat.

Fresh alfalfa has a higher initial rate of rumen degradation compared to most grasses. The rapid microbial colonization and digestion of alfalfa reduces particle size and increases rate of passage through the rumen, enabling animals to consume greater quantities of forage. Whereas this rapid digestion and particle size reduction is responsible for the high productivity of cattle on alfalfa pasture, it is also the characteristic of alfalfa that is responsible for bloat.

A primary plant factor contributing to bloat is the production of stable foam, which is not easily dissipated in the rumen. This is followed by obstruction of the cardia or esophagus, reducing the elimination of fermentation gases via eructation (belching). Consequently, relatively large amounts of gases are trapped in the rumen. An adult cow may produce about 400 liters (88 gal) of gas per day, and during a bloating episode most of the gas is trapped in protein-rich foam. As gas accumulates, the expanding rumen exerts pressure on the diaphragm, heart, and lungs, impairing respiration, and ultimately may result in death.

Symptoms

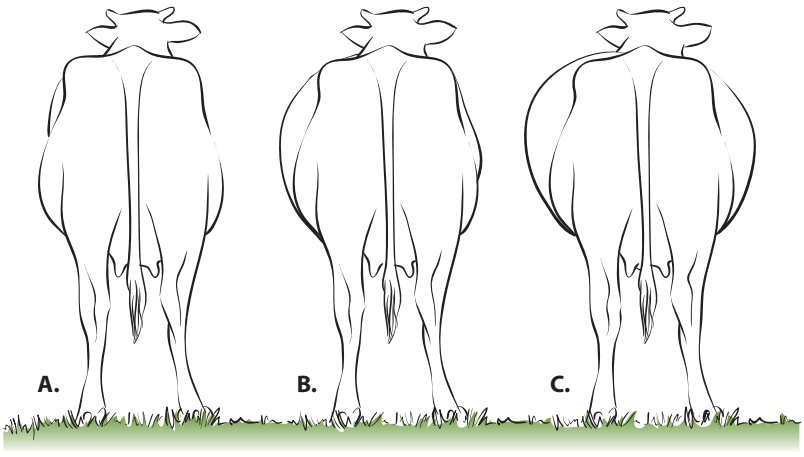
Bloat levels range from mild to severe. A mild bloat episode consists of a smooth left external distention of the rumen wall, and animals do not show apparent behavioral symptoms (Fig. 18.12a).

A moderate bloat causes a more prominent left external distention of the rumen wall (Fig. 18.12b); pinching the distended skin by hand can indicate moderate bloat, if the skin is taut. During moderate bloat, animals may present symptoms of pain, anxiety, and nervousness. Sometimes animals try to step with the front legs on higher parts of the ground to help liberate the gas. This position also alleviates the pressure of rumen content on the respiratory and circulatory systems. Animals normally stop eating until the rumen returns to normal size.

During severe bloat, both sides of the animal are distended, particularly the left side (Fig. 18.12c). The skin on the left side is tense, and it is not possible to pinch it. The animal looks tired; the mouth is open and may present asphyxia symptoms. The

FIGURE 18.12

Degrees of bloat can be estimated visually: (a) mild, (b) moderate, (c) severe.



animal breathes and walks with difficulty, and may stagger. In these extreme cases of severe bloat, an emergency rumenotomy (physically puncturing the rumen and inserting a tube) may be necessary, which is accompanied by an explosive release of rumen contents and marked relief for the animal.

Economic losses produced by bloat range from depressed milk production in cases of mild bloat to animal death in severe cases. Estimated annual death rates recorded for grazed alfalfa pastures can be 1 percent or less in well-managed systems.

Management Steps to Preventing Bloat

Management strategies for reduced levels of bloat can be divided into three main groups: (1) pasture and animal management; (2) use of bloat preventive products; and (3) use of non-bloating alfalfa varieties.

Bloat is primarily a problem when hungry animals are first released into a lush, high-quality alfalfa pasture without acclimatizing or pre-feeding to reduce hunger or using anti-bloat measures. A range of strategies can be used to mitigate the effects of bloat in grazing beef or dairy systems utilizing alfalfa. Successful managers use a combination of these techniques.

- **Graze mature alfalfa.** Bloat risk is highest when alfalfa is at vegetative to early bloom stages. As alfalfa enters into the full-bloom or post-bloom stages, soluble protein levels decrease, plant cell walls thicken, lignin content increases, and the rate of digestion of alfalfa in the rumen decreases. Many experienced producers do not allow their cattle to graze alfalfa until it is in full bloom. However, during early spring or late summer grazing, even mature alfalfa pastures can result in bloat, especially at low stocking rates. Grazing at full bloom results in an obvious penalty for milk production, however, and mature alfalfa is not recommended for high-producing dairy animals.
- **Mix grasses or non-bloating legumes.** Although pure alfalfa stands can be successfully grazed, bloat problems decrease when pastures combine grasses and alfalfa, or include other non-bloating legumes, like sainfoin (*Onobrychis viciifolia* Scop.) or birdsfoot trefoil (*Lotus corniculatus* L). However, these practices may reduce animal performance, lower hay quality, and require economic evaluation.
- **Pre-feed before grazing.** Do not allow hungry animals to graze lush alfalfa pastures. Feed other forage (silage, hay, or mixed supplements) before grazing so cattle are not hungry. In some circumstances, high levels of rich starch supplements (such as ground corn, barley, or wheat) may increase the bloat problem. Short grazing intervals (3–6 hr) on new, lush pastures are more likely to result in bloat compared to cattle left on pastures. Thus, animals can "acclimatize" to bloat-prone pasture conditions.
- **Movement of animals.** Allow animals to enter a new paddock in rotational grazing at the beginning of the afternoon, when the soluble carbohydrate content of the pasture is higher. Initiating grazing in the afternoon will also increase the likelihood of slower intake due to higher air temperatures.
- **Wilting alfalfa forage.** Pre-wilting alfalfa for about 24 hours, or reducing dry matter content to 50 percent, may reduce bloat. The pasture can be mowed with a mower-conditioner, after which the animals are allowed to graze the cut alfalfa. This management strategy increases the efficiency of pasture utilization, and there is no need for a later cut to clean remaining stubble (a common practice). The disadvantage is that animals are obligated to consume all of the cut material, including stems, and don't select the high-quality material as they do when grazing fresh plants. In this case, it may be advisable to graze alfalfa before significant flowering (bud stage) to offer high-quality forage.
- **Intensify grazing, avoiding selectivity.** More intensive grazing will force animals to graze more stem material versus leaves.

However, it is difficult to manage animal selectivity, and since bloat can be produced in the first 30 minutes of grazing, intensive grazing may not be effective in preventing bloat. Additionally, increasing stocking rates affects forage intake and animal performance. It is recommended that animals be observed at the beginning of each grazing period.

- **Identify susceptible animals.** It has been suggested that the tendency to bloat is an inherited trait in animal populations. If a group of susceptible animals can be identified, they should be used as testers for bloat at the beginning of each grazing period. Conversely, culling of animals that tend to bloat has been effective in reducing herd bloating problems.
- **Observe weather patterns.** Bloat might be related to some weather conditions. For example, never graze fresh-frozen alfalfa plants; wait for 3 to 4 days after the frozen top growth is dry. Bloat might also be more of a problem under cool, wet conditions, which reduce plant fiber development and result in high-protein, high-carbohydrate leafy forage.

Use of Preventive Supplemental Products to Reduce Bloat

Several products can be used to control alfalfa bloat, such as feed additives, supplements, or pasture blocks.

- **Nonionic surfactants.** Agents that reduce foam production, like vegetable fats and minerals oils, can be mixed with feeds, in water troughs, and pasture blocks. Also, spraying these agents onto the alfalfa pasture is equally effective. This method is effective on highly controlled strip grazing when animals are not receiving supplements or other feeds. Animals should have access to paddocks that are treated daily.
- **Synthetic antifoaming agents or tension-active agents.** Several synthetic products that reduce surface tension may be used to prevent bloat. An example includes poloxalene, a synthetic polymer nonionic surfactant, which is effective at treating legume bloat and can be supplied daily, mixed with other feeds or pasture blocks.
- **Ionophore antibiotics.** Ionophore antibiotics can inhibit the growth of most gram-positive bacteria in the rumen, reducing the severity of alfalfa bloat. These compounds can be mixed with other feeds, or supplied as controlled-release rumen capsules or as pasture blocks.

Use of Nonbloating Alfalfa Cultivars

Plant breeders have recently developed alfalfa varieties with a reduced risk of bloat. These have mainly been selected for a lower rate of initial rumen degradation. Some varieties have been released in Canada and Argentina and have been evaluated in comparison to traditional alfalfa varieties. The results of field trials indicate a reduction of bloat problems. However, it is not certain whether these varieties are available in the United States in fall dormancy groups appropriate for Mediterranean and desert zones.

Another strategy to reduce bloat is to insert genes that express tannins into alfalfa. Tannins (condensed or hydrolyzable) have the potential to bind proteins in the rumen, slowing rumen protein breakdown. This research is continuing at centers in Canada, the United States, and Australia.

However, despite decades of conventional plant breeding and advances in biotechnology, researchers have not completely resolved alfalfa bloat problems. The specific factors responsible for stable foam production in the rumen are not fully understood. The key management tools are keen observation during early grazing periods on fresh, high quality forage and taking quick preventative steps. Most scientists are optimistic that genetic advancements may eventually assist in significantly reducing this risk. Currently, dairy and meat producers must use good herd and forage management practices to minimize risk and economic losses as a consequence of bloat under alfalfa grazing.

Herd Health and Environmental Effects of Grazing

Most animal scientists and herd managers have observed reduced disease exposure under grazing systems compared with feedlot-style dairies. Mastitis (a common udder infection) is generally much lower under grazing, since infected bedding is minimized. Foot and leg problems (common on cement pads in feedlots) are much lower under grazing conditions.

Environmentally, grazing greatly reduces the amount of manures in holding pens or lagoons, reducing the necessity to mechanically recycle these waste products to crops. The concentration of livestock wastes (salts, nitrogen, minerals) at feedlot-style dairy and beef operations has proved to be a significant environmental concern in California and other regions. It is a significant challenge to recycle these concentrated nutrients effectively. Grazing animals recycle nutrients to pastures directly, reducing (but not eliminating) the need for manure-management infrastructure. Distribution of recycled wastes under grazing is not always uniform, and grazed paddocks can themselves become environmental hazards. However, uniformity can be improved through controlled grazing and management.

Additionally, the fossil-fuel use in livestock-forage systems is significantly lower in grazing systems compared with feedlot-style livestock systems, due to reduction (or elimination) of machine harvesting.

On the negative side, pasture-deposited manures can contaminate surface waters through runoff if pastures are not managed to prevent runoff. Simple management practices, however, can prevent this. It is not clear whether grazing systems are necessarily better than feedlot systems in terms of air pollution (there is little research to indicate results either way). Pollutants present in grazed pastures are reduced at the source with reduced lagoon and solid manure storage systems, and with fewer processed stored feeds such as silage. Some waste gases may be readily absorbed in situ directly by the pasture, reducing those emissions.

Summary

Grazing of alfalfa, while not a common practice in California or the United States, has the potential to be viable for milk or meat production. Grazers in many parts of the world have demonstrated the productivity and viability of grazing alfalfa as a low-input milk or meat production system, which can be optimized with careful forage management strategies and the judicious use of supplements to balance animal nutritional requirements. Grazing systems, when well managed, are more complex than feedlot-type systems and require a high level of understanding of both animal and plant biology. The principle disadvantages of intensive grazing systems are fluctuations and uncertainties in forage quality and production, lower yield efficiency, generally lower milk yields, and higher labor requirements for movement of cows and fence maintenance. The principle advantages are lower costs of production, protection from severe fluctuations in feed commodity prices, lower fossil fuel requirements, improved animal health, public acceptance, and environmental benefits.

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