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BEEF MANAGEMENT PRACTICES

When Forages are in Short Supply Because of Drought

When environmental conditions are less than ideal, forage production will be reduced. The most common cause of low forage yield is drought caused by less than average rainfall in the late spring and summer. Dry weather is often accompanied by high environmental temperatures which accentuate the concern of low rainfall (Figure 1).

Unfortunately, there are no cheap, easy fixes for beef producers who have both short pastures and limited hay supplies. Good management means beef producers should develop and implement a strategy that specifies what to do with pastured animals, and where winter feed supplies will come from, long before the last blade of grass or bale of hay disappears. If not properly managed, a drought year can affect the bottom line for three years:

- First year: feed costs increase and calf weaning weights are typically decreased.
- Second year: calf vigor, colostrum quality, milk production, calf weaning weight, cow reproductive performance, and forage production can be affected.
- Third year: calf crop weaned and forage production can still be impacted.

Proper planning and management can minimize the longer-term economic impact.

Figure 1. Drought-stricken, overgrazed pasture with predominantly weeds and remnants of old seed heads.

This publication was created as a check list of management tools that can be used when forage supplies are limited. There is a review of 18 management practices that can be used in various combinations to reduce the negative consequences of low forage supplies. As you read through these management practices, place a check mark in the boxes of each section that pertain to your unique situation. The checked boxes will serve as management practices that either need to be implemented or deserve more investigation before put into practice.

When forage supplies are low, producers should consider one or more of the following:

- ☐ 1. Monitor cow body condition as a barometer of nutritional status.
- ☐ 2. Employ rotational grazing and avoid overgrazing.
- ☐ 3. Provide clean, cool water to reduce heat stress and maintain herd health.
- ☐ 4. Creep feed calves to obtain near normal weaning weights.
- ☐ 5. Early wean calves to take pressure off both cows and pastures.
- ☐ 6. Identify and manage poisonous plants in pastures and hay fields.
- ☐ 7. Establish summer annuals to increase late-season forage production.
- ☐ 8. Pregnancy check and market cull cows earlier than normal to reduce feed needs.
- ☐ 9. Inventory hay and other feed resources.
- ☐ 10. Use a hay feeder design that reduces waste.
- ☐ 11. Analyze feeds for nutrient profiles to help determine supplemental feed needs.
- ☐ 12. Use alternative feeds to supplement and stretch forage supplies.
- ☐ 13. Limit hay access time to stretch forage supplies.
- ☐ 14. Limit-feed a nutrient-dense diet to stretch forage supplies.
- ☐ 15. Use drought-stressed corn for silage, greenchop, hay, or grazing.
- ☐ 16. Graze corn residues and stockpiled forages to reduce harvested feed needs.
- ☐ 17. Feed an ionophore to increase feed utilization.
- ☐ 18. Add moisture around electric fence ground rods to maintain a good electrical ground.

☐ 1. Monitor Body Condition of Cows as a Barometer of Nutritional Status

Use body condition scores (BCS) as a composite management tool to determine if the cow's nutritional status is in balance with her environment. BCS is an easy, economical way to evaluate the body energy reserves of the cow herd, and it is a better indicator of nutritional status and reproductive performance than weight. Cows should be maintained near a moderate body condition score of 5 (1 to 9 scale; Figure 2). A video on how to assign a body condition score is available at the Purdue beef website (www.thebeefcenter.com).

Figure 2. Cows need to be evaluated individually for BCS to assess the nutritional status of the herd. Body condition scores of cows within a herd can be averaged to determine the nutritional status of the herd, in addition to identifying any outlier(s) cows. The cow depicted here is a BCS 5. To avoid compromising cow production and/or performance, cows should be maintained between a BCS of 5 to 6 on a scale of 1 to 9, with one being the thinnest and nine being the fattest.

Condition scoring allows a producer to manage feed resources by sorting cows into groups and then feeding them according to their nutritional needs. In order of importance, beef cattle use nutrients for basic body maintenance, fetal development, lactation, growth, conception, and fat deposition. As an animal satisfies each requirement, any excess nutrients are available to the next higher priority. When nutrients are limited, reproductive performance is the first to be compromised, followed by animal growth and milk production (calf weaning weight).

☐ 2. Employ Rotational Grazing and Avoid Overgrazing

Forage plants need a rest period between grazing cycles to replenish carbohydrate reserves in their storage organs. Without rest, plants will weaken and take longer to recover. Pastures that are continuously

Figure 3. Overgrazing a pasture can have long-term negative consequences on future plant health and pasture productivity.

overgrazed typically lose many of the desirable high-yielding forage species. During a drought, this result will be magnified, and it is very likely to take several years for the pastures to return to normal, even when properly managed (Figure 3).

The recommendation to "graze half and leave half" is still good advice (Figure 4). The problem during droughty periods is that regrowth is limited in pastures, even when they have been rested for 30 to 45 days between grazing cycles. Ideally, cattle should be removed from pastures when perennial cool-season grasses and legumes are grazed to a stubble height of 4 inches (Figure 5). This will allow enough leaf vegetation for photosynthesis to occur and accumulation of carbohydrate reserves in the plant storage organs to allow more rapid regrowth when environmental conditions improve.

If all perennial cool-season grass/legume pastures have been grazed to a 4-inch stubble height and no regrowth has occurred, it is recommended to drylot cows, or designate a sacrifice area within a pasture with temporary fence, and provide alternative feeds. Resumption of grazing in any given pasture should be delayed until plant regrowth reaches 8 to 10 inches in height to minimize long-term damage. Pastures that are managed properly will need significantly less time to recover when environmental conditions improve. An example of how one large area of grazeable acreage has been divided into 10 individual paddocks is shown in Figure 6. Grazing systems similar to that shown is a tool to allow pastures proper rest and recovery to extend the grazing season and preserve available forage during dry periods.

Figure 5. Orchardgrass regrowth varies on the right and left photographs when clipping occurred at 4 inches or ½-inch, respectively. The 4-inch clipping simulates proper residual forage after grazing; the ½-inch clipping represents extreme overgrazing.

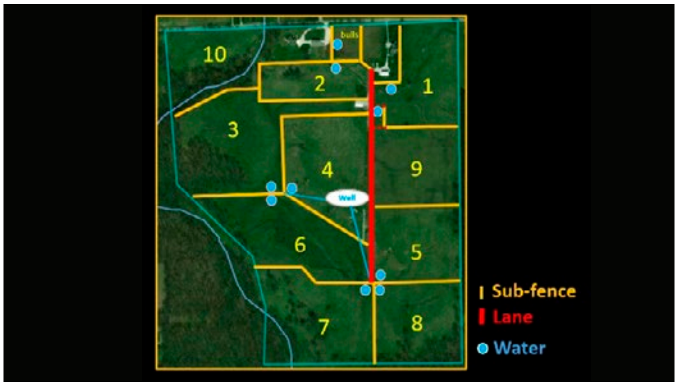

Figure 6. Layout of a 10-paddock rotational grazing system with water sources (blue) and a centralized alleyway (red).

Figure 4. The pictures above (from left) are prior to grazing, severely overgrazed, and an ideal amount of forage residue remaining post grazing. Pictures are courtesy of Jim Gerrish, American Grazing Lands Services, LLC.

☐ 3. Provide Clean, Cool Water to Reduce Heat Stress and Maintain Herd Health

Water is a critical nutrient that plays a major role in animal metabolism, thermal regulation of body temperature, and animal performance (health, growth, reproduction, and milk production). During droughty conditions, the moisture content of grazed forages will be significantly lower than during a normal year. Cattle will drink considerably more water when environmental temperatures are high, dietary ingredients are low in moisture content, and cows are lactating. Provisions need to be made to accommodate this increased water consumption. Free-choice access to clean, fresh water is extremely important to support not only adequate feed intake but also to maintain animal performance and health (Figure 7). Stagnated stock ponds and creeks under drought conditions are often murky and contaminated with high nutrient levels, microbes and algae which can affect water intake and animal performance.

Figure 7: Tanks should be sized for the number of cattle being watered and filled with clean, cool water to help reduce heat stress and maintain healthy cattle.

Several kinds of algae that can grow in water tanks and stock ponds can affect water intake and animal performance. The greatest concern during hot, dry weather is the potential for cyanobacteria, or blue-green algae. It can not only reduce water consumption but also be toxic to livestock. In the case of algae blooms on stock ponds, producers may find it necessary to find alternative water resources, such as moving cattle to provide access to well water, or obtaining water from a well and hauling it to the cattle. In the case of automatic waterers and water tanks, they should be: a) designed to eliminate urine and feces contamination; b) placed in a shaded area to reduce water temperature and algae growth; c) routinely drained and cleaned with a scrub brush; and d) routinely and safely treated with two to three ounces of unscented household bleach per 50 gallons of water. Laboratory analysis of water nitrate concentrations and pH are also recommended. Algae prefer a high pH (8.0 to 8.5). A pH of 6.5 to 7.0 will help reduce algae growth.

☐ 4. Creep-Feed Calves to Create Near Normal Weaning Weights

It is important to understand the objective of creep feeding. When nursing calves are provided supplemental feed, it takes some pressure off the cows and can boost calf weaning weights, but it has minimal effect on stretching forage supplies. If the objective is to stretch forage supplies, early weaning of calves is a better option. If the goal is to improve calf weaning weights without dry lotting calves, creep feeding (Figure 8) may be the more desirable option. Purdue data suggests that creep feeding calves for approximately the last three months prior to weaning (starting at about 120 days of age to normal weaning) can increase calf weights by an average of 30 to 50 pounds (variation of 0-125 pounds) and cow weights by 30 to 50 pounds (variation of 0-200 pounds) by normal calf weaning time.

Figure 8. When forage inventory is low or deficient in nutrient supply, use of creep feeding can improve calf gain and growth efficiency.

The variable response to creep feeding depends on forage quality, forage availability, and location of the creep feeder. In years when forage quality and/or quantity is limited, the response to creep feeding (calf gain, cow weights, and feed efficiency) is higher than when forage quality and quantity are both high. Creep feed conversion to additional calf gain ranges from a

Table 1. Creep feed example rations (%, as-fed basis) [1]

Ingredient	Ration 1	Ration 2	Ration 3[2]	Ration 4
Corn, cracked	40.0	32.7	—	32.75
Oats, crimped	40.0	32.7	—	—
Soybean meal, 48%	18.0	—	—	—
Soybean hulls, pelleted	—	—	49.2	32.75
Dry corn gluten feed, pelleted	—	—	49.2	32.75
Dry distiller's grains + solubles	—	32.7	—	—
Limestone, feed grade	2.0	1.9	1.6	1.75

[1]To be fed to nursing calves with free-choice forage and high-quality cow mineral, fortified with vitamins A and E, magnesium, copper, zinc and selenium.

[2]This is a 50:50 blend of soybean hull pellets/corn gluten feed pellets, but Purdue data concludes that the ratios of 40:60 and 60:40 will create similar performance. Proportions used should be based on least cost.

low of 5:1 to more than 15:1. If creep feed cost is $300 per ton ($0.15/lb); with a feed to gain conversion of 5, 10 and 15:1, then the feed cost of additional calf gain, respectively, is $0.75, $1.50 and $2.25 per pound. To maximize calf gain response, creep feeders should be placed where cows congregate, such as near water, mineral feeder, and shade. It is important to note that a feeder calf price discount can be experienced if creep feeding causes excess body condition. The objective should be to grow muscle and bone without creating excess body fat.

More information on creep feeding can be viewed at www.thebeefcenter.com with a video and decision maker Excel spreadsheet.

Implants contain natural or synthetic compounds that produce physiological responses in the animal similar to natural hormones. Implanting calves has the potential to increase calf average daily gains by up to 10%. Therefore, if calves are gaining 2.0 pounds per day as a result of creep feeding, a 20-pound increase in weaning weight and a 10:1 return on investment could be expected over the last 100 days before weaning. It is recommended that all steers and non-replacement quality heifers be implanted. Implanting is not recommended, however, for heifers and bulls that are retained for breeding since future reproductive performance can be compromised, or if calves are destined for an all-natural or no hormone treated value-added marketing program.

Table 1 provides sample creep rations that should support calf gains of approximately 2.0 pounds per day. Calves should be vaccinated for overeating disease (clostridia type C&D antitoxin) preferably a minimum of two weeks prior to the start of creep feeding. Once creep feeding starts, care should be taken to not let the creep feeder run empty. If feeders run empty, calves are at risk of overeating when feed is reintroduced, which can cause digestive upsets such as bloat and/or acidosis. Purdue research has compared creep diets that contained a mixture of soybean hull pellets and corn gluten pellets. The ratios compared were 60:40 and 40:60. Calf gain, feed required per pound of additional gain, and cow performance (weight and body condition change) were similar between treatments. Ration 3 in Table 1 reflects a 50:50 ratio of these two pelleted feeds.

☐ 5. Early Wean Calves to Take Pressure Off Both Cows and Pastures

Early weaning calves is a viable option for conserving short forage supplies. Early weaning not only lowers forage intake of cows, but also improves cow body condition by removing the nutrient requirements associated with lactation. In addition, early weaning eliminates pasture forage consumption and trampling losses associated with the calves (Figure 9). Based on Purdue data, early gestation cows that have their calves early weaned will consume approximately 25 percent less dry matter than cows nursing calves. When all factors are considered collectively, it is very realistic to conserve more than 30 percent of a pasture resource by early weaning calves.

When forage resources are limited, non-lactating cows in the first and second trimester of pregnancy (a period of low nutrient requirements) can maintain or gain body weight and condition much more easily than cows in late gestation or early lactation. In a normal year, it is not uncommon for spring calving

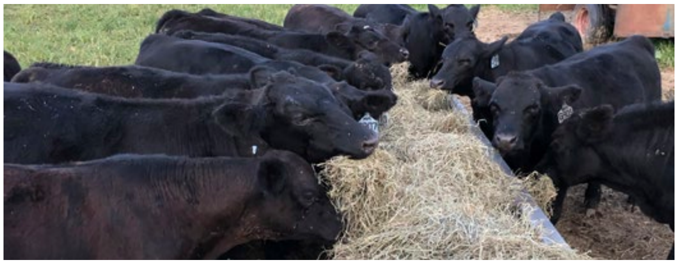

Figure 9. Early weaning calves can conserve more than 30 percent of pasture resource for use by cows.

cows that had their calves early weaned to enter the winter with a 0.5 to 1.0 body condition advantage (40 to 100 pounds) compared to cows that have normal weaned calves. More cow body condition (and weight) difference would be expected in a hot, dry year if normal weaning occurs. In addition, early weaned calves are much more efficient in converting feed to gain (about 4:1) than feeding cows to support lactation and calf gain.

Based on Purdue research, it is recommended that individual calves need to be at least 70 days old when weaned. In most cases, beef calves weaned at younger ages do not have sufficient rumen development to prevent stunted growth that results in a pot-bellied, orphaned calf appearance. Ideally, calves should be vaccinated for Infectious Bovine Rhinotracheitis (IBR), Parainfluenza Virus 3 (PI3), Bovine Viral Diarrhea (BVD), Bovine Respiratory Syncytial Virus (BRSV) and clostridia prior to weaning, and then receive booster vaccinations before or at weaning, and again when calves are about 7 months of age to prevent sickness. It should be noted that creep feeding calves for a short period of time (14 to 28 days) prior to early weaning can ease the weaning transition by acclimating calves to eating a dry, nutrient dense feed from a feeder.

Table 2 provides sample early wean rations that should support gains of about 2.4 lb/day when fed to a 350-pound calf at 2% of its body weight per day (e.g., 350 x .02 = 7 lb/day) and allowed free-choice access to good quality grass or grass-legume hay, a good commercial vitamin-mineral mix, and fresh water. Adding an ionophore (Rumensin® or Bovatec®) to the early wean ration will help stabilize intake, minimize coccidiosis, reduce the risk of bloat, and improve feed efficiency. Cost of gain should always be calculated when selecting a ration to use.

If calves were not creep-fed before weaning, begin feeding the grain mix at 0.5 percent of body weight per day (e.g., 350-pound calf x 0.005 = 1.75 lb/head daily) with free-choice access to good-quality grass or grass-legume hay. Increase grain mix gradually over the next 10 to 14 days to equal approximately 2 percent of body weight (e.g., 350-pound calf x 0.02 = 7.0 lb/

Table 2. Early wean example rations (%, as-fed basis)[1]

Ingredient	Ration 1	Ration 2	Ration 3	Ration 4
Corn, cracked	40.0	32.5	—	32.75
Oats, crimped	40.0	—	—	—
Soybean meal, 48%	18.0	—	—	—
Dry corn gluten feed, pelleted	—	32.5	49.2	—
Soybean hulls, pelleted	—	32.5	49.2	32.75
Dry distiller's grains + solubles	—	—	—	32.75
Limestone, feed grade	2.0	2.5	1.6	1.75
Vitamin-Mineral mix [2]	FC	FC	FC	FC
High-quality grass, grass/legume hay[3]	FC	FC	FC	FC
Estimated ADG, lb per day	1.7	1.7	1.84	2.21

[1]Adding an ionophore, such as Rumensin® (monensin) or Bovatec® (lasalocid), to the early wean ration will improve feed efficiency and reduce the risk of coccidiosis. Ionophores are often packaged in a concentrate form. For example, Rumensin 80 refers to a feed additive concentration of 80 grams monensin per pound of product. Adding 0.5 pounds of Rumensin 80 premix per ton of early wean ration will provide 20 mg monensin per pound of early wean ration (i.e., 6 pounds of early wean ration intake = 120 mg of monensin per day) and should increase average daily gain (ADG) by at least 10%.

[2]Free-choice (FC) high-quality mineral fortified with vitamins A and E, magnesium, copper, zinc and selenium.

[3]Free-choice (FC) hay at 60% TDN, 12% CP, 50% NDF. This information is found on a forage analysis.

Figure 10. Poisonous plants that can frequent pastures in Indiana: a) poison hemlock, b) white snakeroot, c) perilla mint, and d-e) horsenettle.

head daily). A rule of thumb for increasing the grain mix on early weaned calves is to add approximately 0.5 lb/head every other day. If calves were creep-fed prior to weaning, begin feeding grain mix at 1 percent of body weight. Ideally, the early wean ration would be the same, or very close to the same, as the creep ration, which can then be gradually transitioned to a new ration. When hand feeding (vs. free-choice access) an early wean ration, a good rule of thumb after transitioning calves is to not exceed 2 percent of body weight of supplemental feed mix per day (e.g., 350-pound calf = maximum 7.0 lb/head daily). As calves increase in weight, continue adjusting amount of feed mix delivered per day to approximate 2 percent of body weight.

☐ 6. Identify and Manage Poisonous Plants in Pastures and Hay Fields

Animals typically avoid consuming poisonous plants when forage quantity and quality are adequate. However, poisonous plants can become a concern if they are included in harvested forage, or when pastures are overgrazed (Figure 10). Avoid overgrazing pastures that contain poisonous plants. For more information about managing poisonous forage plants, see *Guide to Toxic Plants in Forages* (Purdue Extension publication WS-37) available from the Purdue Extension Education Store, and *Ohio, Indiana, Illinois, and Missouri Weed Control Guide*. Additional aids for plant identification could include an app such as iNaturalist, using Extension Educators, and the Plant & Pest Diagnostic Laboratory.

☐ 7. Establish Summer Annuals to Increase Late-Season Forage Production

Annual warm-season grasses (such as sudangrass, sorghum-sudangrass, and pearl millet) are popular choices for picking up the summer slump and adding late-season grazing (Figure 11), but soil moisture is required for seed to germinate and plants to grow. Low-lignin, brown midrib varieties (BMR) hybrids will provide more favorable animal performance compared to normal varieties. Other warm-season grasses to consider include foxtail millet and teff grass, especially if more hay production is needed.

If seeding annuals is part of a drought strategy to stretch available forage, seed should be purchased early since supplies can become quickly exhausted. If these forage grasses are not sown before mid- July, it is unlikely that the resulting value of the growth will exceed the costs of production. Another option would be to seed spring oats by mid-August. If the forage is to be grazed, adding forage turnip with oats could be an alternative. Purdue Extension publication ID-317, *Forage Field Guide*, provides suggested seeding date, seeding rate and best use practices.

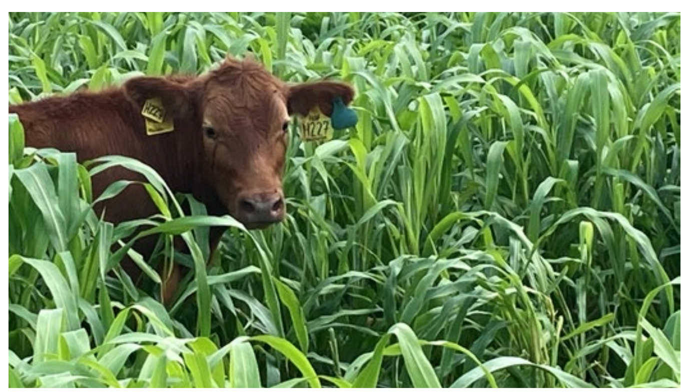

Figure 11. Warm-season annual grasses seeded by mid-July can provide a forage for late-season grazing.

Wheat acreage harvested for grain provides an opportunity for establishing these summer annual crops. *Sorghum species also have the concern of prussic acid if grazing occurs during severe drought or within a week after a killing freeze.* Purdue publication "Managing the Prussic Acid Hazard in Sorghum" (AY-378-W) discusses how to minimize the concern.

Pearl millet typically yields somewhat less tonnage than sudangrass or sorghum-sudangrass but does not carry the same risk of prussic acid poisoning. However, if there is an extreme drought, one additional concern is that sorghum-type forages, corn, and pearl millet all have the potential to accumulate nitrates when placed under environmental stress. More detail on nitrates can be found in section #15 below.

Additionally, it is critical to review labels of herbicides recently used to make sure that the time interval between herbicide applications and seeding of the desired crop has been met. If it has not, the desired crop may die because of residual herbicide remaining in the soil. It's also important to realize that herbicide residues are likely to be greater than label directions in a drought year.

☐ 8. Pregnancy Check and Market Cull Cows Earlier Than Normal to Reduce Feed Needs

Feeding non-productive and less productive cows will increase costs and decrease profitability. Most large-animal veterinarians, or the newer commercially available blood tests, can accurately determine pregnancy in cows that are over 30 days pregnant. If the calving/breeding season was longer and later than desired, one might consider selling the late-calving cows (regardless of pregnancy status, with or without calf at side) and pregnancy checking only those cows that calved early.

Consider culling beef females that:

- failed to conceive, or conceived late
- lost their calves
- bad attitudes
- soundness issues caused by age, arthritis, disease, or injury
- history of weaning lightweight calves (late calvers, slow growth rate).
- will not create a return on investment for two years, such as marginal replacement heifers.

Historically, cull cow prices decline in the fall (September through November) when the cull cow market has many cows being sold following weaning of their late winter and spring-born calves. During a widespread forage shortage, cow prices often become depressed earlier. Therefore, identifying and selling cull cows earlier, rather than later, can also return more dollars and reduce feed costs. When cow prices are depressed, producers must decide if it is more profitable to sell cows, or buy feed in anticipation that good prices will return later. For producers that have feed, buying good quality, young, pregnant cows that are culled from well-managed herds when prices are depressed may increase profits in the longer term.

Replacement heifers that fail to conceive are logical early cull candidates. By performing an early pregnancy diagnosis, producers have an opportunity to take advantage of selling yearling heifers that can be fed-out to reach the Choice quality grade market. If these open heifers are retained, and then subsequently fail to calve, their age will place them into the older cattle market and they will sell at cull cow prices instead of feeder cattle prices. Additionally, consider keeping only the highest genetic value replacement females because heifer development is expensive and weanling heifers won't generate any income for two years.

☐ 9. Inventory Hay and Other Feed Resources

An appropriate feeding strategy can be developed when inventorying how much hay and other feed resources are on-hand for use. For planning purposes, one can assume that a cow will consume about 2.5 percent of her body weight of average-quality hay per day on a dry matter (DM) basis. Hay stored outside will have about a 20 percent waste factor; hay stored inside will have about a 7 percent waste factor (Figure 12). For example, the estimated forage needs for a herd of 30 cows with an average cow weight of 1,400-pounds consuming average-quality hay stored outside for a 150-day feeding period would be calculated as follows:

Figure 12. Determining how much hay or other feed resources are in inventory will help determine an appropriate feeding strategy to stretch the forage resource.

(1,400-pound cow x .025 x waste factor of 1.2) =
42 lb of hay DM disappearance per day

If the hay feeding period is from December 1 to May 1 (150 days), then each cow will need:

(42 lb of hay DM per day x 150 days) =
6,300 lb of hay DM/cow for the feeding period

Bales stored inside will typically contain 88 percent DM, while bales stored outside will typically contain about 80 percent DM. If bales stored outside weigh 1,200 pounds, then the bale DM weight in this example would be:

(1,200 lb per bale x .80) = 960 lb of hay DM per bale

Each cow in this example would need:

(6,300 lb of hay DM ÷ 960 lb of hay DM per bale) =
6.6 bales for the feeding period

If there are 30 cows, then:

(6.6 bales per cow x 30 cows) =
198 bales would be the estimate of hay needed for the winter-feeding period

☐ 10. Hay Feeder Design Can Affect Hay Waste

When using round bales, a hay feeder significantly reduces the amount of hay waste compared to no bale feeder (5 to 20% vs. 20-50%). Figure 13 provides a graphic comparison of the amount of hay wasted when using various hay feeder designs (Figure 14). The data consistently suggests that open bottom steel (OBSR), open bottom polyethylene (POLY) ring feeders, and the cradle (CRAD) type feeders result in the greatest amount of hay waste. One study suggested a trailer style design (TRAL) had intermediate hay waste, while the bale ring with a skirted bottom (RING), skirted lower section with slanted feeding stations and tapered sides (TAPR), and cone (CONE) type feeders result in the least amount of hay waste. While the CONE type feeder has a higher initial cost, the data would indicate that reduced waste could offset the initial increased cost in two to four years, depending on the price of hay. Additionally, at least one study suggests that higher-quality hay has less waste than lower-quality hay across several feeder designs.

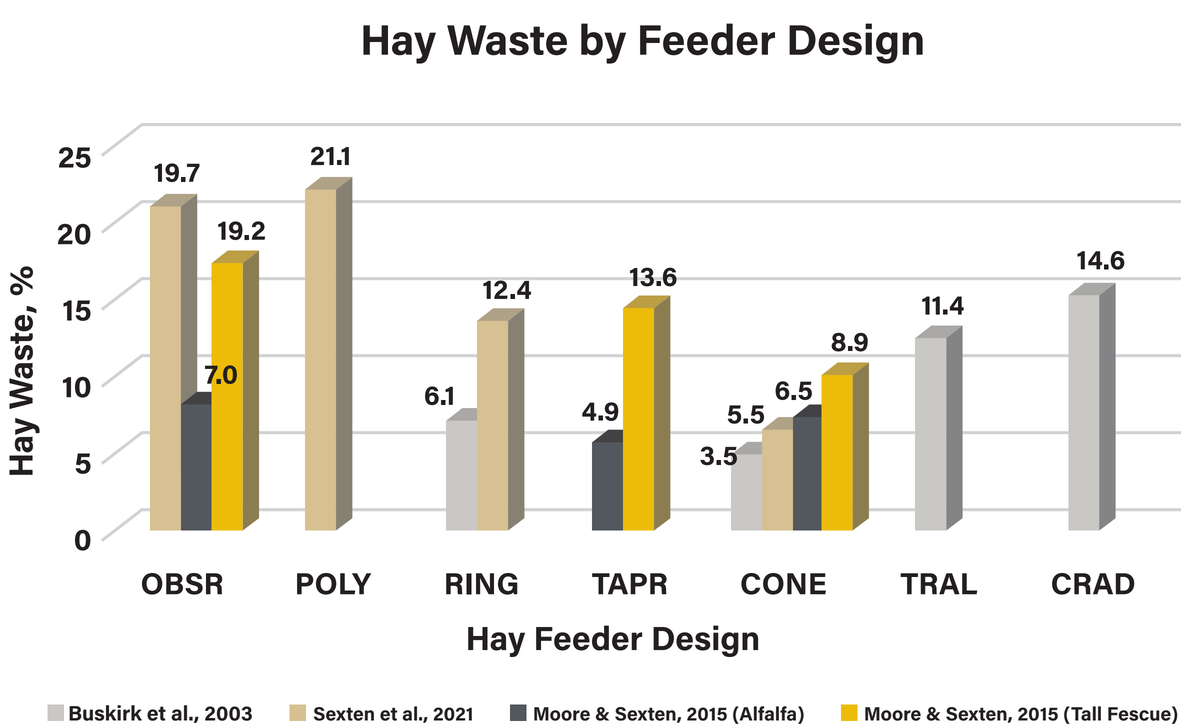

Figure 13. The effect of hay feeder design on waste expressed as a percent of bale weight (DM basis). Where: **OBSR** = Open bottom, steel ring; **POLY** = Open bottom, polyethene ring; **RING** = Steel ring skirted at the bottom, with individual feeding spaces; **TAPR** = skirted lower section with slanted feeding stations and tapered sides; **CONE** = cone type feeder where bale is supported by bars or chains inside the feeder to increase inside feeder space and prevent animals from eating over the top, and individual feeding spaces created by slant or curved bars; **TRAL** = trailer type with individual feeding spaces with double slanted bars; **CRAD** = feeder design where bale is cradled above the ground on a stand.

Figure 14. Hay feeder design affects the amount of hay wasted when fed. Shown above are feeder designs of a) open bottom steel (OBSR), b) open bottom polyethylene (POLY), c) sheeted bottom slanted feeding stations (RING), d) tapered sides (TAPR), e) sheeted bottom cone (CONE), f) trailer (TRAL), g) cradle (CRAD). Pictures a-b-d are those described by Moore and Sexten, 2015, and Sexten et al., 2021. Pictures c and e are courtesy of Buskirk et al., 2003.

The key to bale feeder design needs to consider orientation of the animal's head and how the mouth accesses hay. Factors to consider include: a) Bale feeder height and organic matter buildup around a bale feeder that allow larger animals access to hay over the top of the feeder increases the amount of hay wasted. b) Feeding space, defined as the distance between the outside of the feeder and the hay inside the feeder (e.g., a 6-foot vs. 8-foot diameter bale ring) affects whether the animal's head is inside or outside the feeder when eating. Increasing the feeding space reduces the amount of wasted hay by keeping the animal's head inside the feeder. c) Individual feeding spaces around the feeder reduce waste compared to a limited number of vertical bars. Feeders designed with curved or angled bars (vs. vertical bars) that allow only one animal per feeding space will reduce waste. The logic here is that the animal needs to turn its head to enter and exit the feeding space. When this occurs, it is less likely for the cow to grab a bite, pull back, and allow hay to fall to the ground.

Another consideration is how much hay is made available to the animals per day. Feeding hay daily in the quantity that can be consumed in one day reduces hay waste compared to feeding larger quantities of hay that will last multiple days. When animals are given a choice, they will spend more time sorting and looking for the "chocolate cake hidden inside the broccoli and Brussel sprouts" and waste more hay in the process.

☐ 11. Analyze Feeds for Nutrient Profiles to Help Determine Supplemental Feed Needs

From a forage analysis, a safe diet can be formulated to meet the animal's requirements in a cost-effective manner to optimize performance. Obtain representative forage samples with a hay probe (Figure 15) from each field and harvest date, and then have a certified forage testing laboratory analyze them for their nutrient profile. Many Purdue Extension county offices and/or local cattlemen's groups have a hay probe that can be borrowed. Testing laboratories can be found on the National Forage Testing Association website (www.foragetesting.org). A basic nutrient analysis should contain the amount of dry matter (DM), energy (TDN and NE), adjusted crude protein (adjusted for heat damage), neutral detergent fiber (NDF), calcium, phosphorus,

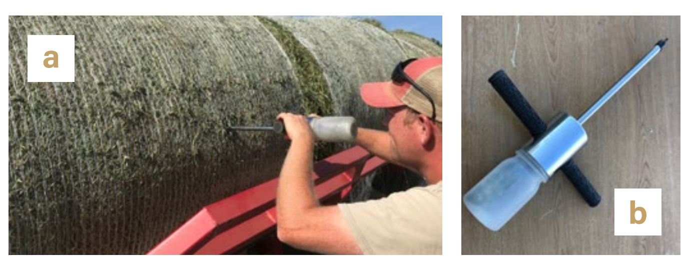

Figure 15 (a and b). Sampling hay with a hay probe.

potassium, and magnesium. In the case of drought stressed corn, sorghum, or millet, a nitrate analysis would also be justified. More detail on nitrates can be found in section #15 below. For high moisture forages (silage, baleage, haylage), it is also advisable to request a pH test. Fermented forages with pH above 4.5 are more susceptible to proliferation of *Clostridium botulinum* resulting from soil contamination (elevated ash content) or too high forage moisture at harvest. A qualified nutritionist, Extension Educator, or feed sales representative should be contacted for any questions regarding nutrient analysis or ration formulation.

☐ 12. Utilize Alternative Feeds to Supplement and Stretch Forage Supplies

In severe situations, counties may receive a release of Conservation Reserve Program (CRP) acres for grazing and possibly hay harvest. Typically, the quality of forage from these acres is very low, but it is a resource that should not be overlooked. If CRP acres are a consideration, make sure to check with the local Farm Service Agency (FSA) office for requirements and restrictions.

When forage supplies are short, crop residues such as wheat straw and corn stover should also be considered. Crop residues are not a direct substitute for high-quality pasture or hay, but when properly supplemented, these resources can satisfy cow requirements during both gestation and lactation. The most common strategy is to use crop residues as a roughage resource that can be supplemented with byproducts. Since crop residues and other low-quality, mature forages are characteristically low in both protein (typically 4 to 5 percent crude protein; CP) and energy (45 to 50 percent total digestible nutrients; TDN), byproducts such as soybean hulls, corn gluten feed and distiller's grains become attractive sources of these two nutrients. Table 3 provides several crop residue ration examples.

For comparison, the CP requirement of beef cows is about 8 percent during mid-gestation, 10 percent during late-gestation, and 12 percent during early-lactation; the TDN requirement is about 53 percent during mid-gestation, 56 percent during late-gestation, and 63 percent during early-lactation and then tapers down after peak lactation (about 60 days post-calving), to about 56% in late lactation. When added to a high forage diet (dry matter basis), the energy available to the animal is very similar (about 90% TDN) between corn (8% CP), soybean hulls (12% CP), corn gluten feed (22% CP), and distiller's grains plus solubles (30% CP), but the protein concentrations are considerably different among the various feedstuffs.

Corn and corn byproducts need to be fed to cows with caution. Overfeeding corn (above 0.3 percent of body weight (e.g., 1,400-pound cow x .003 = 4.2 lb) can lower rumen pH and reduce forage digestibility. Overfeeding distiller's grains has the potential to result in excessive amounts of dietary fat (which can negatively affect rumen fermentation), sulfur (which can bind with copper and reduce reproductive performance), and nitrogen (which has the potential to increase calf birth weights when cows are fed an excessive concentration of protein during late-gestation and lower fertility/reduced embryo survival when fed during the breeding season). Table 3 provides sample rations that are safe for a 1,400-pound non-lactating cow in mid-gestation maintaining weight in an environment that is free from heat and cold stress.

Table 3. Crop residue example rations (lb/day as-fed basis)[1] for a 1,400-pound, BCS 5, non-lactating, mid-gestation cow with the genetic potential for moderate milk production potential.

Ingredient	Ration 1	Ration 2	Ration 3	Ration 4
Wheat straw	Free-choice	Free-choice	—	—
Corn stover	—	—	Free-choice	Free-choice
Dry corn gluten feed, pelleted	5.0	—	3.75	—
Dry distiller's grains + solubles	—	4.0	—	2.75
Limestone, feed grade	0.20	0.10	0.10	0.10
Vitamin-Mineral mix[2]	Free-choice	Free-choice	Free-choice	Free-choice

[1]*Assumes a 1,400-pound non-lactating cow, 2-6 months pregnant in a 75° F environment and maintaining weight.*

[2]*High-quality mineral fortified with vitamins A and E, magnesium, copper, zinc, manganese and selenium.*

Figure 16. Soybeans should be harvested as a forage resource before the R6 growth stage. At the R6 growth stage the soybean seed will be fully expanded and green in the pod and there will be no visible leaf yellowing.

Soybean was first introduced into the U.S. as a forage hay crop, and it can be used in beef rations. Soybean, however, has tremendous capacity to flower over an extended period of time, which allows them to still make a grain crop worthy of harvest during moderate drought conditions. If soybean fields are abandoned as a grain crop in times of a severe, prolonged drought, they can have a nutrient profile comparable to either good alfalfa hay or twigs on a tree. Variation in the nutrient profile is largely determined by stage of plant maturity and the amount of leaf material that can be harvested. Harvest should occur before leaves turn yellow and the soybean seed in the pod is maximally full green seed size (Figure 16; R6 growth stage). Making good-quality soybean hay can be difficult because the stems and pods cure slowly, and leaf loss can become an issue. Crimping the hay will help speed drying. Making haylage or baleage is an attractive alternative that will reduce the challenges of both dry down and leaf loss. A forage analysis will provide valuable information when formulating diets. There are two important considerations before harvesting soybean as a forage crop.

- Check with the crop insurance agent to completely understand the rules and requirements of the policy so that coverage is not jeopardized.
- Read the label on all pesticides used, since there are many label restrictions that prevent soybean use as a forage crop.

Soybean straw following the combine is extremely low quality and is not recommended as a primary feed. It may have some value as a roughage factor when limit feeding a nutrient dense diet, or when it is used as a low nitrate diluter feed fed in combination with a high nitrate feed. (See Section #15 for more discussion.) Free-choice intake of soybean straw will be low and a protein supplement will be required for optimal utilization. When used to dilute nitrates, or as a roughage factor in nutrient dense diets, it is best blended into a total mixed ration (TMR).

☐ 13. Limit Hay Access Time to Stretch Forage Supplies

Results from several Purdue studies with dry, gestating beef cows indicates that beef producers can stretch their supplies of moderate-quality orchardgrass-alfalfa hay by limiting cow access time to large round bales. In 90-day studies, late-gestation cows were allowed 4-, 8-, 12-, and 24-hour per day access to medium-quality, large round bales fed in a hay feeder. Feeder space was adequate to allow all cows in each treatment simultaneous access to hay. In those studies, total hay dry matter disappearance was reduced by 37.2 percent when cows had access to hay for only four hours per day compared to cows that had 24-hour per day access. Limiting cow access time to eight hours per day reduced hay disappearance by 17.6 percent, while limiting access time to 12 hours/day reduced hay disappearance by only 4.4 percent. A significant amount of the reduction in hay disappearance was due to sorting and wastage of hay outside the bale feeder. Figure 17 is an example design constructed at the Purdue University Beef Unit for limiting access time to large bales, using a single hot wire. Cows eagerly entered the hay feeding area when the electric hot wire was opened and eagerly exited when fed their daily supplement in a bunk outside the hay feeding area.

Figure 17. Limiting access to hay can easily be accomplished using temporary fencing. Note: Yellow lines highlight where the strand of temporary fencing is positioned to prevent cows access to hay.

Cow weight change and change in body condition score were not significantly affected by length of access time, and all cows gained weight in these studies. Based on other published research, the reduction from 24-hour access per day down to 6-hour access increased digestibility of moderate-quality hay from 48% to nearly 54%. This happens because of increased rumen retention time and decreased rate of passage through the intestinal tract that results in improved hay digestibility.

In a second set of Purdue studies, access time was limited to 1, 2 and 4 hours per 24-hour period of a low-quality grass hay, a moderate-quality mixed grass-legume hay, and a high-quality grass hay. While the low-, moderate- and high-quality hays varied slightly across studies within each quality category, they averaged (respectively) about: 50, 55 and 60 percent TDN; 8, 12, and 16 percent CP; and 60, 55, and 50 percent NDF (DM basis). Amount of hay disappearance varied slightly (Figure 18) across the different hay qualities, but averaged about 0.6%, 1.1%, 1.7%, and 2.2% of the cow's body weight on a dry matter basis, respectively, across the four access times. This resulted in hay savings of roughly 75%, 50% and 25%, respectively, compared to 24-hour per day access (Figure 19). When hay intake can be accurately estimated, then a nutrient dense supplementation strategy can be developed to meet cow requirements. An equation was developed from the Purdue studies to estimate hay dry matter intake as a percent of body weight for mature cows with hay access times of 1, 2, and 4 hours per day:

Hay DMI (expressed as a percent of cow body weight) = 0.30 x hours access time per day – (.02 x Hay NDF%) + 1.34

Where: body weight is for a moderate body conditioned cow at weaning time, and NDF is the percent neutral detergent fiber value from a forage analysis on a dry matter (DM) basis.

Using a 1,400-pound mature crossbred cow with moderate milk production potential in body condition 5 (moderate) and being fed in an environment without heat or cold stress (thermal neutral), the data presented above is used to create a supplementation strategy to maintain body condition. Example supplementation strategies are shown in Figures 20, 21, and 22 using soybean hulls (SBH) for cows with 4-hour and 8+-hour access to hay. The reason for using SBH is that the energy comes from a highly digestible fiber instead of starch that would come from corn. When corn is fed above 0.3 percent of body weight (e.g., 4.2 pounds of corn for a 1,400-pound cow), the pH of the rumen will decrease and have a

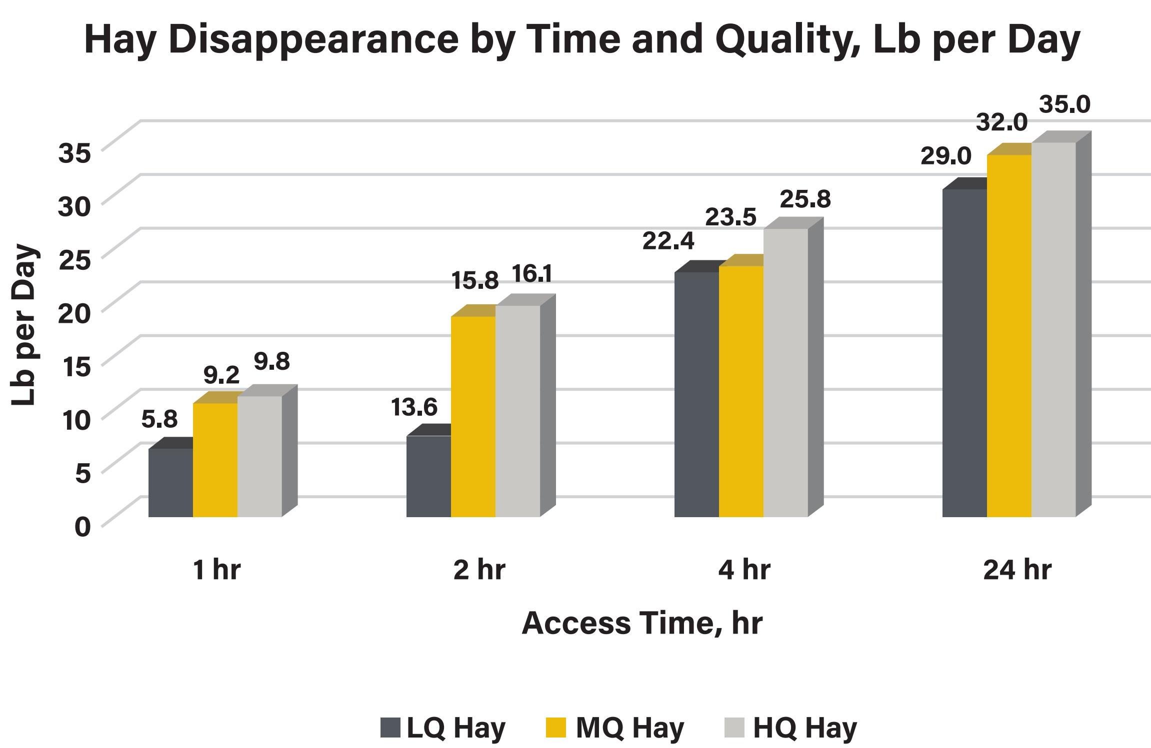

Figure 18. Hay DM disappearance (lb per day) for a 1,400-pound, body condition score 5 cow with access times of 1, 2, and 4 hours per day across three different hay qualities compared to 24-hour free-choice access. Where: DM is dry matter; LQ is low-quality (50% TDN, 8% CP, 60% NDF); MQ is medium-quality (55% TDN, 12% CP, 55% NDF); and HQ is high-quality (60% TDN, 16% CP, 50% NDF). This information is found on a forage analysis.

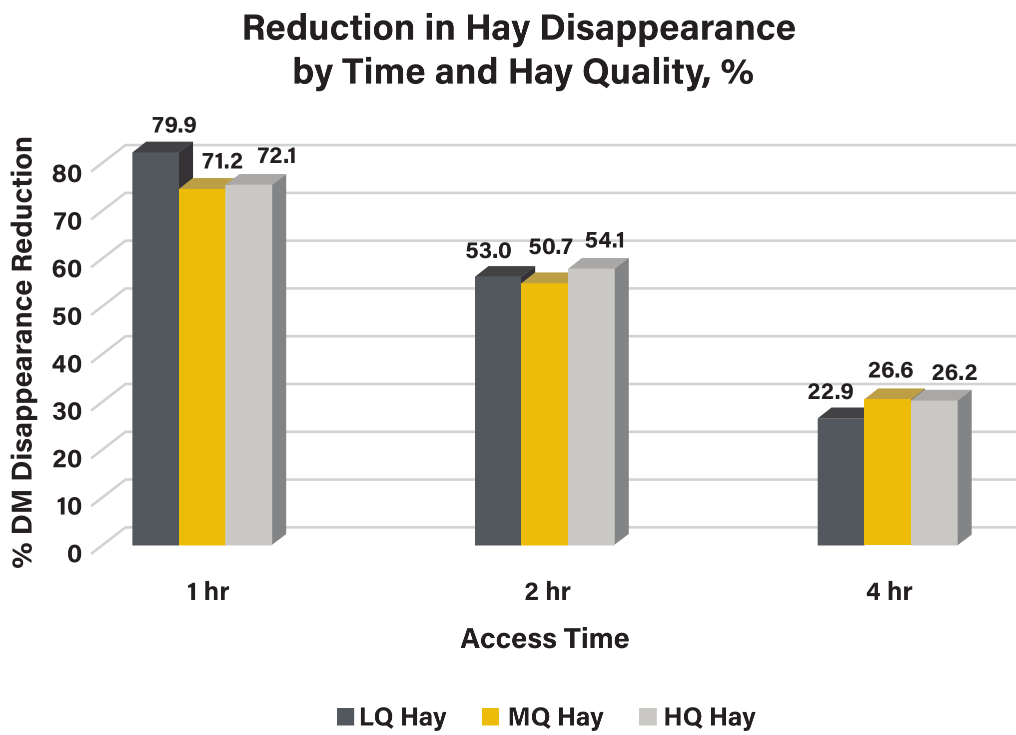

Figure 19. Percent reduction in hay DM disappearance for a 1,400-pound, body condition score 5 cow with access times of 1, 2, and 4 hours per day across three different hay qualities compared to 24-hour free-choice access. Where: DM is dry matter; LQ is low-quality (50% TDN, 8% CP, 60% NDF); MQ is medium-quality (55% TDN, 12% CP, 55% NDF); and HQ is high-quality (60% TDN, 16% CP, 50% NDF). This information is found on a forage analysis.

negative effect on hay (fiber) digestibility. The Purdue data is confirmed by research conducted at other universities that says a cow will eat all she can eat in six to eight hours of hay access time per day. Allowing more than eight hours access will result in more waste and hay disappearance, but no more dry matter intake during a 24-hour period.

In Figure 20, SBH supplement needs are shown for the second trimester of gestation following calf weaning (e.g., lactation has been terminated) for low-, moderate-, and high-quality hay fed for either four hours per day or eight plus hours per day. During the second trimester of gestation, cow requirements for energy and protein are the lowest of the yearly production cycle. This is where the lowest quality hay needs to be fed to save higher quality hay for the late gestation and lactation production phases where requirements are higher. When limiting hay access time to four hours per day, SBH supplementation is reasonable for all three forage qualities and do not violate the rule-of-thumb that says no more than 1 percent of body weight supplementation of pelleted SBH per day (e.g., 14 pounds for a 1,400-pound cow) should be fed. The reason for this recommendation is that the chance for bloat increases when pelleted SBH is fed above 1 percent of body weight.

Figure 21 illustrates the increase in requirements and need for SBH supplementation for cows in the third trimester of gestation on all qualities of hay compared to second trimester of gestation shown in Figure 20. *Note that limiting access time of both low- and medium-quality hay to four hours per day violates the SBH rule-of-thumb and is not a recommended option.* Allowing access to at least six hours of medium- and high-quality hay per day, and preferably 8 hours, still reduces hay waste while providing enough hay intake to keep SBH supplementation in the recommended range.

Figure 22 illustrates the further increase in cow energy and protein requirements for cows in late lactation (last 70 days before calf weaning at 7 months of age). The only hay that does not violate the SBH rule-of-thumb is high-quality hay fed for at least 6 to 8 hours per day. Limiting access time to 4 hours per day violates the 1 percent of body weight SBH rule. If cows are in late-lactation and stretching forage supplies is the goal, then early weaning the calf to terminate lactation and lower the cow's requirements

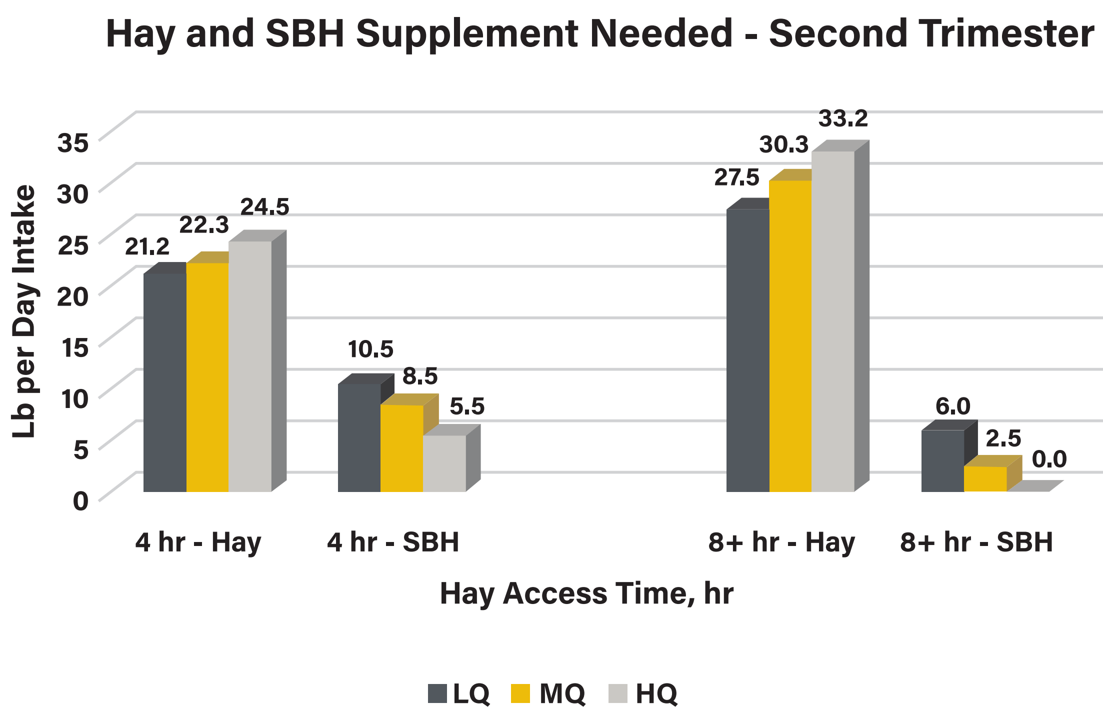

Figure 20. Expected hay consumption and amount of soybean hull supplement needed (DM basis) for a 1,400-pound, body condition score 5 cow during her second trimester of gestation. Where: Second trimester is immediately following calf weaning; SBH is pelleted soybean hulls; hay access time is either 4 hours per day or 8+ hours per day; LQ is low-quality (50% TDN, 8% CP, 60% NDF); MQ is medium-quality (55% TDN, 12% CP, 55% NDF); and HQ is high-quality (60% TDN, 16% CP, 50% NDF). Hay quality information is found on a forage analysis.

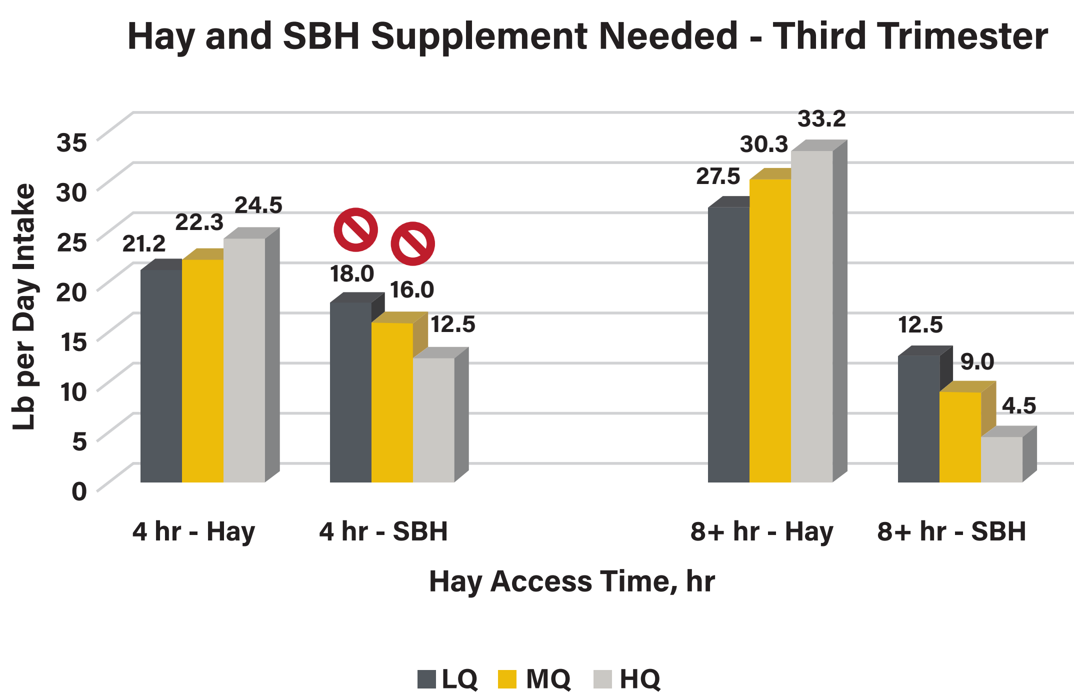

Figure 21. Expected hay consumption and amount of soybean hull supplement needed (DM basis) for a 1,400-pound, body condition score 5 cow during her third trimester of gestation. Where: Third trimester of pregnancy is the last 90 days before calving; SBH is pelleted soybean hulls; hay access time is either 4 hours per day or 8+ hours per day; LQ is low-quality (50% TDN, 8% CP, 60% NDF); MQ is medium-quality (55% TDN, 12% CP, 55% NDF); and HQ is high-quality (60% TDN, 16% CP, 50% NDF); and 🚫 is for both low- and medium-quality hay with 4-hour access time that requires a level of SBH supplementation that is not recommended because it violates the 1% of body weight rule. Hay quality information is found on a forage analysis.

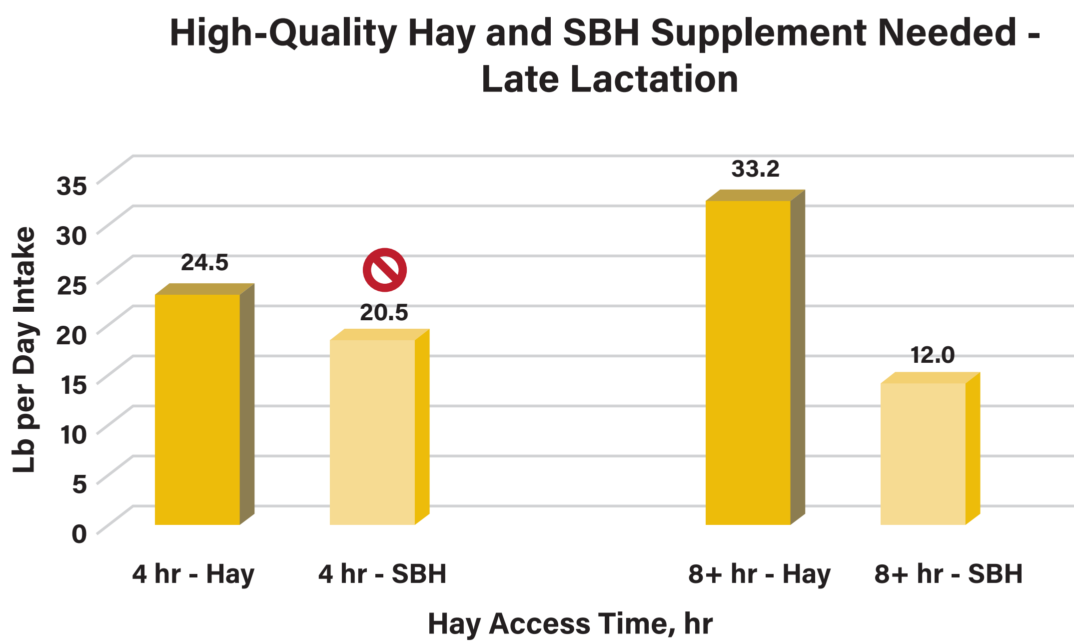

Figure 22. Expected hay consumption and amount of soybean hull supplement needed (DM basis) for a 1,400-pound, body condition score 5 cow during late lactation. Where: Late lactation is the last 70 days before calf weaning; SBH is pelleted soybean hulls; hay access time is either 4 hours per day or 8+ hours per day; and HQ is high-quality (60% TDN, 16% CP, 50% NDF); and 🚫 is high-quality hay with 4-hour access time that requires a level of SBH supplementation that is not recommended because it violates the 1% of body weight rule. Hay quality information is found on a forage analysis.

makes economic sense. This would reduce cow supplementation back to quantities shown in Figure 20, and feeding the calf directly would result in a very efficient feed to gain conversion.

It must be noted that a good-quality vitamin-mineral supplement is also a requirement of cows on a daily basis. When cows have limited access time to hay, free-choice consumption of a vitamin-mineral mix can exceed the desired level of about 4 ounces per day. To control free-choice vitamin-mineral intake, it may be necessary to add additional salt as an intake limiter to achieve the desired level of vitamin-mineral intake. It is entirely likely that total mineral (salt plus vitamin-mineral mix) consumption could approach one or more pounds per day. This is where a total mixed ration (TMR), where mineral is included at the appropriate concentration, has an advantage over free-choice vitamin-mineral supplementation.

Limiting access time to hay that contains high-nitrate concentrations is a strategy that can be used under very careful management. More detail on nitrate poisoning can be found in #15 below. Proper sampling of the forage resource is important, and requesting a nitrate analysis along with other quality measures will be needed. With this information, a strategy can be developed that will not only adapt the rumen to tolerate higher nitrate levels, but also limit intake of the high-nitrate feed. It will allow producers to extend their supply of low nitrate forages and allow use of high-nitrate feeds that would otherwise be dangerous to feed if fed individually. Diets can be formulated to also use byproducts that will help reduce nitrate intake. Contact a qualified nutritionist, Extension Educator or feed representative for assistance in developing a ration that uniquely fits your situation.

☐ 14. Limit Feeding a Nutrient-Dense Diet to Stretch Forage Supplies

Purdue research suggests that limiting daily hay intake (or access times to four hours or less per day) can meet cow requirements when fed a properly formulated, nutrient-dense supplement. This strategy requires careful management and 30 inches of bunk space per cow to provide equal access to limited amounts of nutrient dense feed. Cows should be separated into at least two feeding groups:

- young, subordinate, thin, and old cows, and;
- mature cows in moderate body condition.

It is important to observe the dominant-subordinate relationships between cows within a group when they are fed, and it may be necessary to reassign some animals to another feeding group to optimize herd performance and minimize expenses. Similar to starting feedlot cattle on feed, cows need to be started slowly on well formulated nutrient dense feed, and the amount delivered per cow must be increased gradually over time. A good rule of thumb is to begin by feeding hay free-choice with a nutrient-dense feed at four pounds per cow daily. Increase the nutrient-dense feed amount by one lb/head on an every-other-day basis. When cows reach the desired level of supplement feeding, begin to gradually reduce the amount of hay fed to the designated level. When limit-feeding is initiated, cows will bawl and think they need to be fed more. Cows will adapt to not having a full rumen in several days, but expect them to come running when the next feed delivery is made.

Sample rations for a 1,400-pound cow maintaining weight during early to mid-gestation in an environment without heat or cold stress (thermal neutral) are shown in Tables 4 (non-lactating) and 5 (lactating). Note that free-choice trace mineralized salt will not meet the cows' mineral or vitamin requirements. Magnesium, copper, zinc, manganese and Vitamin A are deficient in all of these limit-fed diets; therefore, a high-quality mineral mix that contains these minerals and Vitamin A needs to either be added to the concentrate mix, or provided free-choice. When corn-based byproducts are in the diet, it is important to supply a mineral mix that contains additional calcium (feed grade limestone or calcium carbonate) to balance the calcium:phosphorus ratio. In contrast, when corn-based byproducts are not included in the diet, more phosphorus (dicalcium phosphate) may be needed in the mineral mix.

☐ 15. Use Drought-stressed Corn for Silage, Greenchop, Hay or Grazing

Before using drought-stressed corn as a forage resource, several items need to be considered:

- If corn is covered as a grain crop by crop insurance, it is imperative that policy holders check with their insurance agent prior to harvesting plant material as a forage crop. There are a number of variations in how crop insurance coverage is defined, and there needs to be complete understanding of the policy rules before harvest so that settlement is not jeopardized. In many cases there is a requirement to have an adjuster appraisal and/or leaving test strips to provide a yield estimate before a fair insurance settlement can be determined.

Table 4. Limit-fed ration (lb/day, as-fed basis) examples for a 1,400-pound, BCS 5, non-lactating, mid-gestation cow with the genetic potential for moderate milk production potential[1]

Ingredient	Ration 1	Ration 2	Ration 3	Ration 4	Ration 5
Grass hay, moderate quality[2]	18.6	13.7	13.7	13.7	13.7
Estimated hay access, hr[3]	3.0	2.0	2.0	2.0	2.0
Estimated hay saving, %[4]	45	60	60	60	60
Corn, cracked	2.5	—	—	—	—
Soybean meal, 48%	—	—	—	—	—
Soybean hulls, pelleted	—	5.25	—	—	2.5
Dry corn gluten feed, pelleted	—	—	5.25	—	2.5
Dry distiller's grains + solubles	—	—	—	5.0	—
Limestone, feed grade	0.10	—	0.20	0.30	0.10
Vitamin-Mineral mix[5]	FC	FC	FC	FC	FC

[1]Assumes: a) a 1,400-pound non-lactating, cow in a BCS 5 that is 4 months pregnant in a 75° F environment (average daily temperature) and maintaining weight, and b) cows are fed a moderate-quality grass hay stored inside with 86% dry matter.

[2]55% TDN, 12% CP, 55% NDF, 86% dry matter. Hay quality information is found on a forage analysis.

[3]Estimated hay access time (hours per day) to achieve desired level of hay intake for this hay quality.

[4]Estimated hay savings based on predicted hay intake from NDF calculation.

[5]Free-choice high-quality mineral fortified with vitamins A and E, magnesium, copper, zinc, manganese and selenium. Salt may need to be added to lower the vitamin-mineral mix consumption to 0.25 lb/day (Note- total consumption with the added salt could be 1 lb or more per day).

Table 5. Limit-fed ration (lb/day, as-fed basis) examples for a 1,400-pound, BCS 5, late lactation, mid-gestation cow with the genetic potential for moderate milk production potential[1]

Ingredient	Ration 1	Ration 2	Ration 3	Ration 4	Ration 5
Grass hay, moderate quality[2]	28.3	13.7	13.7	13.7	13.7
Estimated hay access, hr[3]	5.0	2.0	2.0	2.0	2.0
Estimated hay saving, %[4]	20	60	60	60	60
Corn, cracked	2.75	—	—	—	3.25
Soybean hulls, pelleted	—	9.75	5.5	—	3.25
Dry corn gluten feed, pelleted	—	—	5.5	—	3.25
Dry distiller's grains + solubles	—	—	—	10.0	—
Limestone, feed grade	—	—	0.20	0.50	0.20
Vitamin-Mineral mix[5]	FC	FC	FC	FC	FC

[1]*Assumes: a) a 1,400-pound lactating cow in a BCS 5 that is 4 months pregnant in a 75ºF environment (average daily temperature) and maintaining weight and b) cows are fed a moderate-quality grass hay stored inside with 86% dry matter.*

[2]*55% TDN, 12% CP, 55% NDF, 86% dry matter. Hay quality information is found on a forage analysis.*

[3]*Estimated hay access time (hours per day) to achieve desired level of hay intake for this hay quality.*

[4]*Estimated hay savings based on predicted hay intake from NDF calculation.*

[5]*Free-choice high-quality mineral fortified with vitamins A and E, magnesium, copper, zinc, manganese and selenium. Salt may need to be added to lower the vitamin-mineral mix consumption to 0.25 lb/day (Note- total consumption with the added salt could be 1 lb or more per day).*

- Review pesticide (herbicide, insecticide, and fungicide) product labels used in the cornfield to minimize any potential residues present in forages. Herbicide residues would be expected to be more of a concern in a dry year compared to a normal year.
- There are many types of storage structures available for silage (bunker silos, upright silos, silage bags, baleage (individual wrapped or in-line wrapped), and stacks (or piles) covered with plastic. For small-scale operations, the best option for making silage is the use of silage bags. Baleage made by wrapping with plastic in an in-line tube or individually wrapped at the proper moisture (40-60%) is probably the second-best alternative for smaller operations. If bagging forages as silage or baleage, it is important to follow guidelines listed on boxes containing the bags and wrap to reduce tears or holes.

  Placing a stack or pile on the ground and covering it with plastic is the least desirable method of storage because it is harder and more dangerous to pack, there is the potential to have excessive losses due to spoilage resulting from a larger surface area being exposed to the air, and there is an increased probability of leachate (Figure 23).
- Drought-stressed forage (Figure 24) from corn, sorghum, millet, and oats has the potential to contain

Figure 23. If chopped forage is put into a silo too wet, seepage of nutrients and moisture will occur. Seepage is an environmental concern as it kills vegetation and fish if it gets into water resources.

Figure 24. Drought-stressed corn has value as a feed resource if utilized properly.

high concentrations of nitrate, which can be toxic if not managed correctly. Weeds such as pigweed, common lambsquarters, and Johnsongrass can also contain high levels of nitrates. Cool-season grasses such as tall fescue, orchardgrass, brome, and timothy typically do not accumulate significant amounts of nitrate, and legumes are seldom a problem. Nitrate poisoning risk increases when unadapted, hungry animals are fed large amounts of the potentially dangerous forages.

Nitrate Poisoning Symptoms:

Acute nitrate poisoning symptoms are related to the lack of oxygen transport to tissues caused by a rapid conversion of hemoglobin to methemoglobin in the blood. Acute nitrate toxicity symptoms include depressed appetite, belligerent or disoriented behavior, uncoordinated hindquarter movement, inability to stand, frequent urination, increased heart rate, difficult or rapid breathing, silent heats, blushed skin, coma, and death. Less severely affected animals may be listless and only show rapid respiration when exercised. Chronic cases of nitrate toxicity may go undetected but often result in reduced milk production, animal performance, feed conversion, and reproductive efficiency. Nitrate-related abortions have been reported during early gestation due to interference with fetal implantation within the uterus, and during late gestation resulting from a lack of oxygen and nutrient transfer across placental membranes. Symptoms of nitrate toxicity in calves are that they can be born one to four weeks early and often die within 24 hours. A postmortem examination of what appears to be a normal calf sometimes reveals heart defects; hemorrhaging in the heart and trachea; general vascular, ruminal and abomasal congestion; dark red to coffee brown blood color within 1 to 2 hours after death; and nitrate presence in eye fluid.

In animals where nitrate toxicity is suspected, an examination of mucous membranes around the eyes, and between the lips of the vulva of cows, often reveals a color change from pink to blue-grey. This color change is an indication that oxygen transport to these tissues is being impaired. Veterinarians have various drugs and antidotes that can be administered to relieve acute nitrate poisoning symptoms. Chronic symptoms are not cured by these drugs or antidotes. The most common treatment of acute nitrate toxicity is the intravenous administration of methylene blue, which is capable of converting blood methemoglobin back to hemoglobin.

Recommendations to Minimize Nitrate Poisoning:

- The first rule of managing feeds that have potentially high nitrate concentrations is to obtain a nitrate analysis from a certified laboratory. Testing laboratories can be found on the National Forage Testing Association website (www.foragetesting.org). Knowing the nitrate concentrations in feeds and water provided to the animals is an important first step in creating a diet that is safe to feed.
- The second rule is to make sure cows are full before introducing a suspect feed. The risk of nitrate toxicity increases when unadapted, hungry animals consume large quantities of high-nitrate feeds in a short period of time. Thin cattle in poor health, or cattle suffering from respiratory distress are more susceptible to nitrate poisoning than moderately conditioned cows fed a nutritionally adequate diet in a stable environment with minimal expenditure of energy. Animals suspected of nitrate poisoning should be kept as calm as possible to minimize respiratory distress. A veterinarian should be called immediately to formalize a diagnosis and intravenously administer methylene blue as an antidote.
- The third rule is to start feeding suspect feeds in small amounts. Gradually introduce cattle to forages suspected to be high in nitrates over seven to 10 days. The objective is to give the rumen microbes an opportunity to adapt to the higher nitrate intake. Never allow hungry, unadapted cattle access to suspect feeds. Over one to three days make sure cattle are full and consuming a significant quantity of a bulky, low-nitrate forage such as good-quality grass hay. Then, introduce suspect high-nitrate feed *slowly* into their diet over the next seven to 10 days while keeping them full with low-nitrate feeds.
- The fourth rule is to dilute suspected high-nitrate feeds with low-nitrate feeds. Providing perennial grass or grass-legume hay, or feeding two to three pounds of corn, soybean hulls, corn gluten feed pellets, or dry distiller's grains per cow daily provides extra energy to stimulate microbial conversion of nitrate to non-toxic nitrogen compounds. Total mixed rations are safer than feeding feeds separately.
- Making silage from whole plant corn suspected of containing elevated nitrate concentrations is the safest way to feed it since good silage fermentation has the potential to reduce nitrate levels by 40 to 60 percent. Leaching of solubles (leachate) from silage made too wet (Figure 23) is an environmental risk to aquatic life if it finds its way to streams and creeks.

If leachate is noticed surrounding a stack/pile, dry baled forage can be placed along the perimeter to serve as a temporary dike and to absorb excess runoff of moisture and nutrients. Extremely dry crops that are ensiled may lose only 20 percent of the nitrate they contain. In cases where fields have been declared a loss, and acres are not a limiting factor, the cutter bar should be raised to at least 12 inches above the ground to eliminate harvesting the lower stalk material which has the highest potential for nitrate accumulation. A quick way to determine if the plant contains too much moisture is to firmly hand-squeeze a representative sample collected from the forage chopper; if water drips from the sample, it is too wet for ideal fermentation. Green, barren corn plants will typically be wetter than they appear in the field and can contain well over 70% moisture. An easy, accurate way to estimate moisture of the standing crop is to cut at least 20 stalks that represent the field, chop them using a chipper/shredder used to process tree branches, mix the chopped material to get a representative sample, and then use a vortex dryer or microwave oven to dry the samples and a gram scale to weigh samples.

- Feed value of drought-stressed corn silage, if made properly, can be 80 to 100% of normal corn silage for beef cattle. Drought-stressed corn silage will likely have 1 to 2 percent more protein, slightly more fiber, and slightly less energy than normal corn silage. Drought-stressed corn with little or no grain, harvested at 65% moisture, will yield about one ton of silage per foot of plant height.
- During the ensiling process, toxic gases of nitric oxide (NO) and nitrogen dioxide ($N0_2$) are produced. Nitric oxide is colorless and nitrogen dioxide is reddish brown (Figure 25). These gases have caused permanent lung damage in people and have killed both livestock and humans. These silo gases float down a silo chute and into a barn or confined area. Whenever toxic gases are a possibility, care must be taken to protect both humans and animals. Make sure that enclosed areas around the feed storage area (feed rooms, silos, and animal pens) are well ventilated and safe before entry. Doors and windows to enclosed areas should be opened, and silo blowers should run before any attempt is made to enter a silo. If there is any doubt about toxic gases being present, a properly fitted oxygen mask should be used in and around the feed storage area.

Figure 25: Photo shows nitrogen dioxide, a reddish-brown gas produced during the ensiling process. It can be fatal to humans and livestock.

- If drought-stressed corn, sorghum or millet is to be harvested as hay or green-chopped from high-fertility soils, it should be tested for nitrates before harvest, especially if the crop experienced a short period of rapid growth, due to improved environmental conditions, such as rainfall, just prior to harvest. Nitrate levels are highest during the first several days after a drought-ending rain and then come down over the course of the next seven to 10 days as plant metabolism returns to approaching normal. Getting cut whole-stalk corn to dry to a safe moisture content, less than 18 percent as large round bales, to prevent mold while in storage as hay is challenging. Hay equipment will have more wear and tear as compared to making hay from more traditional forages. Nitrates do not dissipate during the drying process. Additionally, dry hay contains less moisture and more of the dry matter is digested and absorbed as compared to a fresh forage. It has been estimated that dry hay releases 80% of its nitrates in the first 20 minutes after consumption, while fresh forages release only about 30% over the same time period.
- When using suspect forages such as greenchop, harvest only the amount to be fed immediately. Storing green chopped forages on wagons for later use can result in feeds that are significantly more dangerous because of the conversion of nitrate to nitrite, which is substantially more toxic than the original nitrate. When first introducing greenchop into a ration, raise the cutter bar to at least 12 inches when harvesting during the first few days to reduce high nitrate levels that accumulate in the lower stalk. Once feeding greenchop, raise the cutter bar to 12 inches or more following a rain when nitrate concentrations would be expected to increase. Feeding greenchop twice per day as compared to one larger feeding will also help the rumen adapt and minimize the negative effects of nitrate.

- When grazing high-nitrate forages, provide a palatable, low-nitrate hay or grain supplement to dilute the nitrate. Avoid overgrazing high-nitrate potential corn plants to minimize animal intake of the lower stalk where nitrates tend to accumulate. For example, allow cattle to fill their rumens with hay for several days and then initiate grazing high-nitrate forage for less than an hour on the first day with free-choice access to a low nitrate hay during the remainder of the day to fill the rumen. On day two, increase their grazing time to an hour plus free-choice hay. Each subsequent day continue to allow animals free-choice access to hay and increase grazing time by approximately one-half hour per day until cattle reach at least eight hours of grazing per day. Once cattle are grazing over eight hours per day, it can be assumed the rumens are adapted and they can remain on the high nitrate containing forage all day, provided a low nitrate-containing hay or grain is also available free-choice to dilute the nitrate concentration.
- When grazing suspect forages, stock lightly so animals can selectively graze the leaves, and husks that have lower nitrate concentrations. Avoid overgrazing high-nitrate potential corn plants to minimize animal intake of the lower stalk where nitrates tend to accumulate. Be aware that some cows will devour an entire plant, especially when stalks are immature and small in diameter. In fields where shoots contain some grain, adapt cattle to corn before turn-out to minimize the potential of acidosis.
- Avoid using ionophores (Rumensin® or Bovatec®) in rations that have the potential of containing high nitrate concentrations. Ionophores reduce the acetate:propionate ratio in the rumen; this reduction, combined with further ratio reduction caused by the presence of nitrates, can cause a rapid shift in microbes to those that produce nitrites. This causes an increased passage rate of nitrites into the bloodstream.
- Provide large quantities of fresh drinking water that is low in nitrate concentration, since water can also contribute to the problem. It would be best to get water tested for nitrate level by the laboratory that tested the forage. Water dilutes nitrate concentrations in the rumen and helps to not only reduce the potential of toxicity, but also helps reduce heat stress and associated respiratory distress.

Typically, forages containing less than 5,000 ppm NO_3 on a dry matter basis are considered safe for most classes of beef animals. Forages containing 5,000 to 10,000 ppm NO_3 are considered potentially toxic when provided as the only feed. Forages containing over 10,000 ppm NO_3 are considered dangerous. The only way these higher nitrate-containing feeds can be fed safely is to limit their intake by diluting them with low nitrate-containing feeds.

Laboratories report nitrate content of feed and water in different forms. Consider the form for expressing nitrate levels to avoid errors in determining the potential for toxicity. Table 6 can be used as a guide for interpreting laboratory results.

☐ 16. Graze Corn Residues and Stockpiled Forages to Reduce Harvested Feed Needs

As previously discussed, harvesting wheat straw and corn stover, when available, can be used to extend limited forage resources. There is no question, however, that grazing corn stover in the field is more economical than mechanical harvesting (Figure 26). Review pesticide labels used to make sure that the crop residues can be fed to beef cattle and that the harvest restriction time has been exceeded before mechanical harvest or grazing occurs.

Table 6: Equivalent levels of nitrate when reported in different forms on a laboratory analysis

Nitrate (NO_3)		Nitrate-nitrogen (NO_3-N)		Potassium nitrate (KNO_3)	
ppm[1]	%	ppm[1]	%	ppm[1]	%
200	0.02	46	0.0046	326	0.0326
5,000	0.5	1,150	0.115	8,150	0.815
10,000	1.0	2,300	0.23	16,300	1.63

[1]*parts per million*

Figure 26. Grazing corn residues is an excellent maintenance feed for late winter/spring calving cows in adequate body condition (BCS > 5.0).

A strategy of how corn stover grazing might fit into a winter feeding program needs to be developed for each beef operation. Grazing corn stover should be done in areas that meet state law requirements for a perimeter fence and that has adequate water available. A single "hot" wire may be an adequate internal, or division, fence if cows have been trained to respect an electric fence, but should not be used as a perimeter fence along major roadways for liability reasons. Ideally, cornfields should be strip grazed using "hot" wire division fences to maximize the use of the stover, and to not only minimize trampling of the shucks and leaves, but also minimize the potential for acidosis caused by overconsuming ears of corn that may be present in the field.

There is always risk of nitrate toxicity in drought-stressed corn stover (see section #15 above), but the risk is significantly lower than when feeding the forage as greenchop or hay. The reason is that cows will often avoid eating dry, coarse stalks if they are given the opportunity to selectively graze dropped ears, overflow grain from the combine, leaves and shucks. Producers should move cows before all the leaves and shucks have been grazed. If stover is baled, cows should be given the freedom to sort and leave the bottom of the stalk in the hay feeder. Any refused material can be used as bedding. Again, transition the cows to nitrate-containing feeds slowly and provide cows with a low-nitrate feed for dilution.

Corn plant residues are highest in nutrient value in early harvested corn immediately following the combine. During the 30-day period following grain harvest, a mature, mid-gestation, spring-calving beef cow can probably meet her nutrient requirements if provided free-choice access to a high-quality mineral mix and water. Fall calving cows with calves at side will typically also need supplemental energy and protein to maintain weight, body condition, and milk production. Forage quality declines with time following harvest due to weathering and selective grazing, and there will be an increasing need to provide supplemental energy and protein as the forage quality decreases. When grazing or feeding low-quality forages, cow body condition should be monitored closely and supplement strategies adjusted accordingly.

When harvesting grain, consider disengaging the chopper on smaller combines to allow shucks and cobs to fall directly behind the combine in two or three rows. Consider baling only those two or three rows directly behind the combine where the shucks and leaves were dropped; shucks and leaves have more nutrient value and less potential nitrate accumulation than the stalks. This will provide a higher-quality forage resource with a lower nitrate concentration compared to harvesting all residue material in the field. A side benefit of leaving some residue in the field is soil erosion control.

If rains return before late August in a drought year, fall regrowth of cool-season grasses can be increased by applying 50 pounds of nitrogen per acre before early September. In normal years, this practice works well for stockpiling a forage resource that can be used in late fall to extend the grazing season. If urea is the nitrogen fertilizer of choice, it should be applied when rain is predicted since urea volatizes to the atmosphere in hot, dry weather.

☐ 17. Ionophores to increase feed utilization

Ionophores (Rumensin® and Bovatec®) have been extensively used in the cattle feeding sector of the beef industry but underutilized in the cow-calf sector. Ionophores alter rumen fermentation and the availability of energy from a given diet. In typical high-forage cow diets, feeding 200 mg of Rumensin® per day can increase energy available to the animal by 10% to 15% for each pound of feed consumed by altering the rumen microflora and shifting the volatile fatty pattern to increased propionic acid production and decreased acetate and butyrate production (Figure 27). This translates to one of two outcomes: a) cows will eat the same but gain more weight, or lose less weight, depending on forage quality; or b) cows can be fed 10% to 15% less and perform the same. There are few technologies that are as simple and cost-effective to use. *The one place where ionophores should not be used is when the diet contains high nitrate concentrations. See section #15 above for that discussion.*

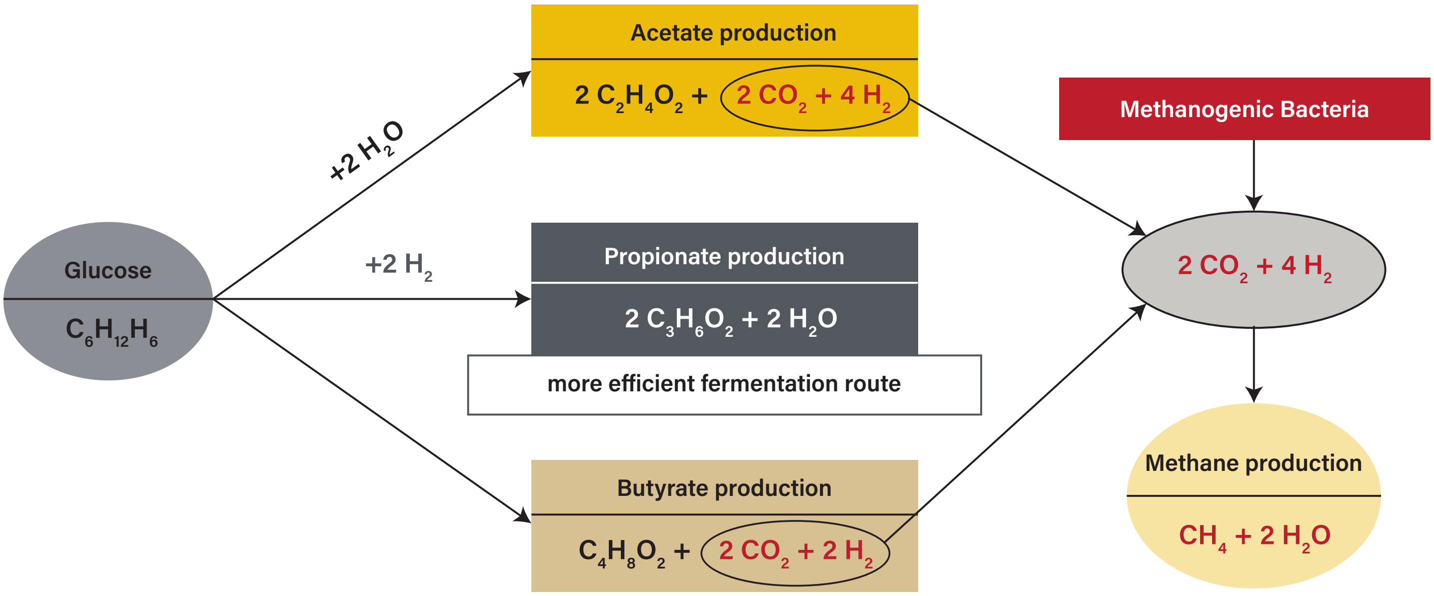

Figure 27. Propionic acid production increases with use of ionophores – and with that, there is greater energy availability to the animal (Marques and Cooke, 2021).

☐ 18. Add Moisture Around Electric Fence Ground Rods

As pasture resources are depleted, cows will be looking for greener pastures, and that is often across the fence. Electric fences require good, functional ground rods to be effective. In a hot, dry environment, it is often necessary to add moisture to the area surrounding electric ground rods for the fence to have adequate voltage and amperage (Figure 28). Neglect in this area increases the risk of cattle escapes and liability.

Figure 28. Adding water around the electric fence ground rods.

Summary

When faced with a limited forage supply, there are a number of feeding and management strategies to consider, both individually and in combination. Each operation should develop a strategy that helps control costs, maintains optimal animal performance, and preserves profitability into the future. Check marks by one or more of the management practices discussed above should either be considered for stretching forage supplies in your operation, or be an indication that more information is needed from an Extension Educator, another producer, qualified nutritionist, or veterinarian.

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