Production and Utilization of Pastures and Forages in North Carolina

North Carolina Agricultural Research Service
North Carolina State University
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Technical Bulletin 305

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Cover photos: Cutting management trial of alfalfa (top); ladino clover in full bloom in May (center); cattle grazing hybrid bermudagrass in mid-summer (bottom); cattle grazing a tall fescue-ladino clover pasture (background photo; by Dwight Fisher).

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Several of the legume sketches are modified from *Legume Culture and Picture Identification: Seedling to Maturity*, by Herbert B. Hartwig, Agronomy Department, Cornell University, Ithaca, New York.

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Preface

This publication addresses a wide spectrum of forage production and utilization principles and practices. Contributions to this effort were made by 37 authors from four organizations: Agricultural Research Service, USDA; North Carolina Department of Agriculture; North Carolina State University (researchers and extension specialists from eight departments); and Soil Conservation Service, USDA. We hope the information provided here will prove fruitful for the producers in our state.

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Chapter 1

THE IMPORTANCE OF FORAGE CROPS

J. Paul Mueller and Douglas S. Chamblee

Agricultural statistics tell us little about the importance of forage crops. Most forages are not widely marketed because they are consumed on the farms where they are produced. Nevertheless, the value of forages, based on their contribution to human food of animal origin, probably exceeds that of any other crop. The food-producing system represented by forage crops and ruminant animals (cattle, sheep, and goats) is of immense importance to our nation's agricultural economy. Ruminants get from 30 to 80% of their nutrients from forages; at 80%, beef cattle rank the highest. Because of their multi-chambered stomachs and the bacteria that live there, ruminants can digest forage plants with high cellulose content. Animals with a single-chambered stomach—such as pigs, poultry, and humans—must rely heavily on concentrate feeds like cereal grains, fruits, and selected vegetables.

A key element in understanding the contribution of forages to food production and agricultural stewardship is that forages can be grown on land that is unfit for row crop production because it is too steep, rocky, sandy, shallow, or wet. This marginal land can contribute to food production without the destruction of our soil resource base only through the forage-ruminant system.

On the other hand, forages are often grown (and should be grown much more) on good land, and play an important role in reducing soil erosion, conserving water, and providing an optimal economic return. The use of forages on steep land in rotation with other crops is key to sustainable agriculture. In the *Grass Yearbook of Agriculture*, 1948, Dr. P.V. Cardon said, "for around grass, farmers can organize general crop production so as to promote efficient practices that lead to permanency in agriculture." He was using the word "grass" in a broad context which included legumes. Gerald McCarthy, in North Carolina Agricultural Experiment Station Bulletin 73, 1890, said "Ever since agriculture became an improved art, grass and clover have been regarded as the foundation of all enduring, prosperous farming." Without doubt, forages have a key role to play in the sustainability of our agricultural resource base.

In North Carolina as many as 15 different species of grasses and legumes are routinely used as forage crops. Forages, (pasture, hay, and silage) cover about 2.5 million acres and are valued at more than $300 million (Table 1). The estimated acreage of a few of our most important forages is tall fescue —1,000,000; ladino clover (in mixtures)—300,000; orchardgrass (alone and in mixtures)—100,000; and hybrid bermudagrass—100,000.

Table 1. Production and value statistics for forage in North Carolina.
(1991 NCDA agricultural statistics.)

		Yield	Value of production	
Forage crop	**Acres**	**Tons/acre**	**$/ton**	**Total $ (M)**
Improved pasture	1,006,778	2.5	60	160.1
Unimproved pastures	855,384	1.0	40	34.2
Hay, all	470,000	2.1	60	59.2
Hay, alfalfa	30,000	2.9	100	8.7
Silage, corn	85,000	12.0	25	25.5
Silage, sorghum	20,000	9.0	15	2.7
Small grain not harvested for grain[1]	170,000	1.5	60	15.3
				305.7

[1] Wheat, barley, oats.

Chapter 2

ROLE OF FORAGES IN SOIL AND WATER CONSERVATION

James T. Green, Jr., Bobby G. Brock, and Michael G. Wagger

The past is the key to the future. History has shown that many civilizations have disappeared from the earth because of human's abuse of soil, water, trees, and other basic resources. Several years ago, the House Appropriations Subcommittee on Agriculture noted the following in its report: "We have taken the silver out of our coins and removed the gold from behind our currency. If we permit the fertility to be taken out of our soil we will have nothing left to support our money and our economy." According to the 1987 USDA-SCS resource inventory, erosion loss in North Carolina was 6 tons/acre from crop land and 1 1/10 ton/acre from pasture land.

The Conservation Title of the 1985 Food Security Act has placed significant attention on highly erodible lands and wetlands. The associated compliance regulations require more emphasis on practices such as no-till planting, crop residue management, and crop rotations with forage crops, all of which improve soil productivity, reduce water runoff, and lessen energy inputs.

The protective action of sod-forming forages is important in maintaining good water infiltration, curbing runoff, and minimizing sedimentation in streams. Grassed waterways and buffer zones are critically important in watershed protection.

Influence of vegetation type and canopy on runoff

Leaves and stems of plants intercept rainfall and reduce its impact on soil particles. Haynes (1940) found that alfalfa intercepted about 30% of 10.7 inches of rain between April 27 and September 15, whereas corn intercepted 15% of the 7.1 inches from May 27 through September. Browning and Sudds (1942) reported 1.3 inches of runoff from heavily grazed pasture with poor sod, compared to only 0.1 inch from lightly grazed pasture with an excellent sod.

Browning and Sudds (1942) reported that the rate of water penetration in an undisturbed fruit orchard sod was about five times that of adjacent cultivated fields because of worm and insect burrows and the mass of live and decaying roots near the soil surface.

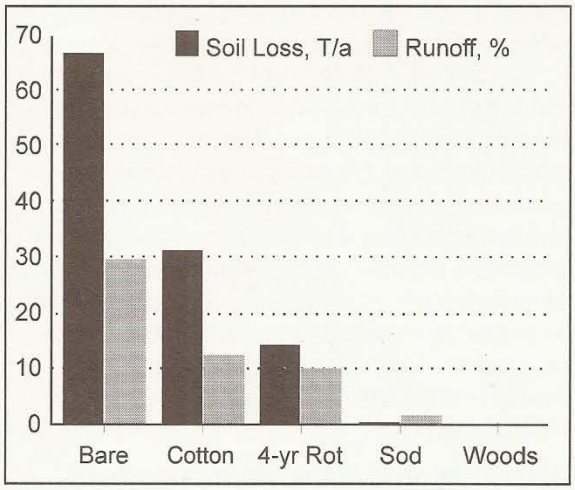

Figure 1. Effects of crop rotation on soil loss and runoff over an eight-year period in North Carolina.

Role of rotations and their impact on soil loss and nitrogen management

The effectiveness of different cropping systems on soil erosion and runoff was determined from an eight-year experiment at Statesville, North Carolina (Copley et al. 1944) on a Cecil soil with 10% slope. The use of wheat and annual lespedeza in a four-year rotation with cotton and corn reduced soil loss to an average of 14 tons/acre compared with 31 tons for continuous cotton, 66 tons for bare land, and 0.3 tons/acre for permanent sod (Figure 1). The effect of the sod continues into the second row crop year but affords less protection than in the first year. A Georgia study indicated that soil loss from a Cecil soil during the first year of corn following two years of fescue was only 1 to 2 tons as compared to more than 20 tons of loss under continuous corn.

In addition to soil and water control, cropping systems have an impact on the nitrogen management aspects of a watershed. Farmers face a difficult task as they seek to ensure an adequate supply of nitrogen to the crop without providing excessive levels which could move to ground or surface water

through leaching or runoff. Modifying the cropping system to take advantage of nitrogen-conserving and nitrogen-fixing crops are ways to meet these needs.

Edwards et al. (1988) reported that soybean yields (six-year average of continuous cropping) were increased 23% when wheat was included as a winter cover crop. When soybeans were rotated with grain sorghum and wheat as a winter cover crop, yields were increased by 52%. After three years of fescue sod, soybean yields were increased by 68%. The rotation effects on soybean yields appear to be related to the reduction in soybean cyst nematode populations after two to four years of grasses. Similar benefits have been observed with tobacco planted after fescue.

Specific nitrogen management aspects of forage crops

- Corn planted after three years of alfalfa or clover-grass may yield the same as continuous corn fertilized with 100–150+ pounds of nitrogen per acre.
- A rye cover crop planted after corn is capable of using the residual soil nitrogen which could otherwise be leached into groundwater.
- Winter cover crops of hairy vetch or crimson clover will provide 60–100 pounds of nitrogen per acre for the subsequent corn, sorghum, or millet crop.

Characteristics of forage crops that make them useful in protecting soil, water, and the environment

Forages are dense and grow close to the ground, providing a cover above the soil surface and a fibrous root system below the surface which

- tends to result in better soil tilth, water holding capacity, cation exchange capacity, and soil microorganism populations, including earthworms, rhizobia, and bacteria.
- reduces the impact of raindrops on the soil surface, which decreases soil crusting, water runoff, and movement of soil particles off-site, thus less movement of fertilizer and pesticides into streams.
- extends the amount and depth of root exploration of the soil volume, which indirectly relates to plant water use and nutrient uptake.

Many forage crops are perennial which means that they may be maintained with relatively low inputs of fertilizer, cultivation, and pesticides.

Many forage crops are adapted to a wide range of soil, pest, and environmental conditions which

- makes them an excellent choice for widespread use in crop rotations for control of soil erosion, diseases, insects, and weeds.
- makes them ideal for receiving wastes from municipalities, industrial by-products, and animal confinement farms (swine, poultry, dairy).

In summary, the sustainability of agriculture will depend on more integrated use of perennial sod-forming crops and livestock with row cropping systems.

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LEGUME-GRASS PASTURES AND GRASS PASTURES: *Principles of Fertilization, Use, and Nutritive Value*

Douglas S. Chamblee, James T. Green, Jr., and J. C. Burns

Cool—ladino-fescue or ladino-orchard

Warm—hybrid bermuda, flaccidgrass, switchgrass, pearlmillet, sudangrass, or sorghum-sudan hybrid

Cool—pure stand of tall fescue

Warm—same as above

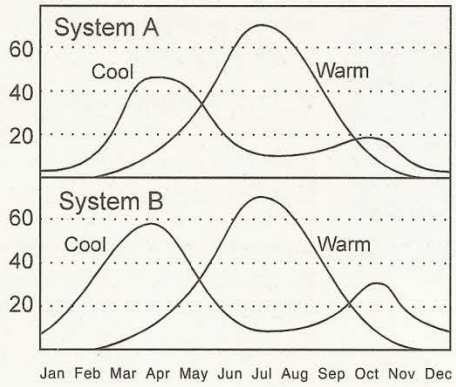

Figure 1. Relative production for warm- and cool-season

In most areas of North Carolina, pastures contain several plant species growing together, called mixtures. These mixtures may include a legume with one or more grasses or they may contain several grasses growing together. Usually we plant either a legume-grass mixture such as ladino clover with tall fescue, or a single grass in pure stand, such as tall fescue or bermudagrass (Figure 1, Systems A and B). Most farms should have both systems A and B, that is both legume-grass pastures (A), and pure grass pastures (B) in the cool part of the year. After a few years most legume-grass mixtures lose the legume component. Once the legume component is no more than 15 to 20%, these pastures should be fertilized and managed as a pure grass pasture, or reseeded to legumes. Most pure grass stands become a mixture of grasses. For example, a seeding of pure tall fescue in much of North Carolina will become a mixture of tall fescue, bermudagrass, and crabgrass in a few years.

Livestock farms have wide variation in soil types, topography, animal requirement classes, and management capabilities; such environments make it necessary to use many different plants to meet the monthly feed requirements of animals. Although pure grass and grass mixtures make up the majority of pastures, there are soil and management conditions where legume-grass pastures will better serve the needs of the enterprise. Fertilization, grazing, and harvesting management, costs, quality, and persistence differ greatly for legume-grass mixtures and pure grass stands because of individual plant requirements (Table 1).

When to Use Pure Grass or Grass Mixtures

Perennial and annual grasses in pure stands or grass mixtures (Figure 2) should be used under the following situations:

- On sites where it is not feasible to grow legumes because of insects, diseases, nematodes, drainage, or low fertility, and where long-term stands (three to 20 years) are desired.
- Under economic situations where the price of nitrogen fertilizer is low relative to the price being received for products (beef, milk, wool, etc.) being sold.
- On sites where a legume has disappeared and forage must be produced during the rotation period.
- When stockpiling (accumulating forage from August to November) tall fescue or orchardgrass for late fall-winter grazing.
- On farms where efficient use of animal waste is desired.
- In production situations where animal product per acre is more important than daily animal performance.
- Where "emergency" crops are needed to provide rapid forage growth of high-quality annuals such as sorghum-sudangrass, pearlmillet, crabgrass, cereal grains, and Italian ryegrass. They may serve to break the disease cycle when renovating old plantings of legumes such as ladino clover, red clover, or alfalfa. They can effectively utilize the nitrogen buildup produced by legumes.

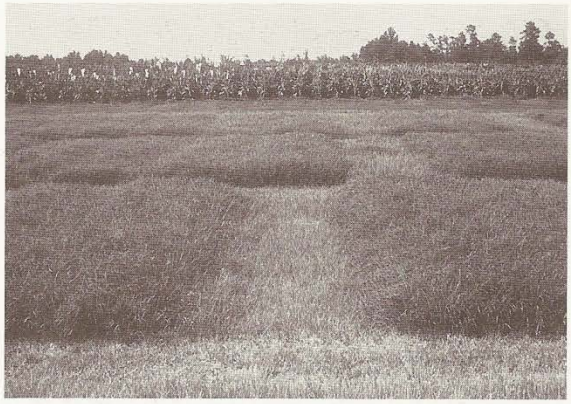

Figure 2. Grasses are especially responsive to nitrogen. Note no nitrogen strip in center.

Advantages of Using Pure Grass or Grass Mixtures

- Adapted grasses persist and are productive for three to 20 years compared with three to five years for most legumes.
- Perennial grasses potentially have a higher carrying capacity if highly fertilized (above 160 pounds of nitrogen per acre) and usually produce more product per acre than clover-grass.
- Grasses are easier to manage to retain good stands, because they are usually more tolerant of over- or undergrazing than legumes grown in mixture with grasses.

Table 1. General adaptation and management characteristics of legume-grass mixtures compared to pure grasses.

Characteristics	Legume-grass mixture	Pure grass
Fertility requirements (P, K, Ca)	Medium-High	Medium
Nitrogen requirements	Low	High
pH requirements	6-6.5	5.8-6.2
Stand longevity	3-5 years	3-20 years
Hay yields/acre	High	High
Forage quality	High	Medium
Animal performance (ADG[1] or milk/day)	High	Medium
Quality change with age	Slow	Rapid
Drying rate of hay	Slow	Faster
Quick production potential	Low	High
Stockpiling potential	Low	High
Bloat potential	High	Low
Endophyte toxicity	None	High (fescue)
Nitrate toxicity potential	Low	Medium-High
Grass tetany potential	Low	Higher
Insect susceptibility	High	Low
Disease susceptibility	High	Medium
Tolerance, weed competition	Low	Medium
Management level needed to maintain stands	Medium-High	Medium
Relative cost/animal output	Low-Medium	Medium-High

[1]ADG = Average daily gain.

When to Use Legumes in Mixtures

Legume-grass perennial pastures (containing either ladino clover, red clover [Figure 3], birdsfoot trefoil, or alfalfa) are best used under the following situations:

- Where high daily animal performance is desired, especially if endophyte-infected fescue is the base forage.
- Under economic situations where the price of nitrogen fertilizer is high relative to the price being received for the product (beef, milk, wool, etc.) being sold, and where animal waste is not readily available.
- On sites where the conditions are favorable for growth and survival of a legume for two or more years. Ladino clover has some basic weaknesses, including low summer production and a short life of three or fewer years.
- On soils where short rotation with corn or other annual crops is desired for pest and nutrient management, erosion control, and soil improvement.

Advantages of Legumes in Mixtures

- The quality of ladino clover forage is superior to most pure grasses and results in higher daily animal performance. Steers generally gain 0.4 to 0.5 pound more per day when grazing mixtures of ladino-tall fescue rather than pure stands of tall fescue. Also calves will gain about 0.25 pound more per day on the legume-grass mixture.
- Adding clover in old tall fescue pastures infected with endophyte will dilute the toxic effects and enhance daily gains as noted above.
- The cost of production is often lower compared with pure grasses in short rotation since no nitrogen topdressing is needed.

Maintenance Fertilization

The fertilization requirements of legume-grass mixtures and pure grass stands are different. To get the best recommendation for fertilizer, have the soil tested.

General Recommendations: The annual maintenance requirement under grazing for a perennial pure grass sod (tall fescue, orchardgrass, hybrid bermuda) on average soils with medium phosphorus and potassium is about 150 pounds nitrogen, 50 pounds P_2O_5, and 100 pounds K_2O. In comparison, mixtures such as ladino clover-grass grown on similar soils would need only 50 pounds P_2O_5 and 100 pounds K_2O.

Figure 3. A perennial legume-grass mixture.

If ladino clover and tall fescue are adapted to a site it would take approximately 150 pounds of nitrogen applied to a pure sod of tall fescue to obtain the dry matter production that can be obtained from ladino clover-tall fescue mixture without the nitrogen (Figure 4).

When poultry and swine waste are available, their primary use should be on grass fields. Recent research, however, suggests that alfalfa may be an exception and could serve effectively to receive animal waste. Application of nitrogen fertilizer or animal waste to pastures where legumes are desired can result in reduced legume growth and will require relatively frequent and close grazing management to avoid grass dominance.

Knowing the Composition of Pastures

The amount of legume in a mixture varies widely over the years, and there is confusion about what constitutes a satisfactory mixture. It is important to know the amount of legume so that the pasture can be properly fertilized. Inspect the stand several times during the

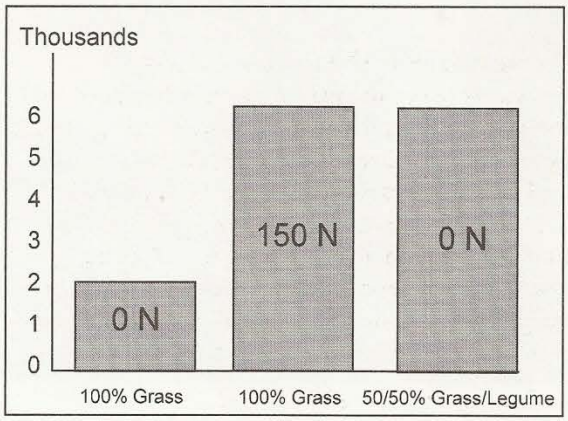

Figure 4. Effects of nitrogen (N) on dry matter yield of pure grass or grass-legume mixture.

active growing periods because mixtures tend to fluctuate in composition depending on environmental and management impact.

Once a legume contributes less than 20% of the ground cover, consider the pasture a stand of pure grass, fertilize it as recommended for grass, and manage it accordingly.

For example, fertilizing a ladino clover–grass pasture that has less than 20% clover with an 0-10-20 fertilizer will result in the production of about 1 to 1½ tons of dry forage per acre. On the same pasture the application of 150 pounds of nitrogen per acre in split application plus 0-10-20 would result in yields of about 3 tons of dry forage per acre (Figure 4). The introduction of additional ladino clover resulting in 35 to 40% clover by no-till methods would result in yields of 3 tons of dry forage per acre with the same amount of 0-10-20 **without** nitrogen.

Problems in Grazing Management That Cause Loss of Legumes in Pastures

Managers can have a significant impact on the sward composition, yield, and quality of pastures by controlling the frequency and intensity of grazing or harvesting and the timing and amounts of fertilizer or manure.

White clover (intermediate or ladino types) can tolerate close grazing (1 inch for intermediate; 2 inches for ladino types) because of the location of growing points and because much of its carbohydrate storage is in the stolons (horizontal stems) which lie close to the ground surface. In mixture with a grass such as tall fescue, orchardgrass, or Kentucky bluegrass, lax grazing management (permitting the forage to reach heights of 8 to 12 inches between grazings) is detrimental to the legume component. Close grazing to heights of 1 inch for a mixture of grass with intermediate white clover and to 2 inches for a mixture with ladino white clover favors the legume component.

Alfalfa generally responds better to short grazing periods with long rest periods (20 to 35 days), because its regrowth depends more on reserve energy from its tap root than on the amount of leaf area in stubble.

What to Do If Legume Disappears from Mixtures

When the clover is essentially lost, do either (or, preferably, a combination) of the following: (1) Reestablish clover into a large portion of the acreage by no-till procedures; many soils will produce volunteer clover when fertility and grazing management are favorable; (2) maintain a portion of the pasture as if it were a pure grass stand and fertilize it accordingly with appropriate levels of nitrogen, phosphate, and potash; (3) plant a portion of the pasture to corn, sorghum, millet, or small grain for a year or two, and re-seed to ladino clover-grass; and (4) use a combination of the above systems, with a portion of the pure grass (tall fescue, orchardgrass) for intensified grazing in late fall, winter, and early spring. Fungus-free fescue and orchardgrass are not as competitive against clover as is infected Kentucky 31 (KY31) fescue, therefore maintaining mixtures should be simplified in the future.

The important thing is to decide when the clover is not making an economical contribution to the mixture; then make adjustments in fertilization and grazing management.

Chapter 4

CONTROLLED GRAZING

J. Paul Mueller, James T. Green, Jr., Matthew H. Poore, and Kevin R. Pond

What Is Controlled Grazing?

Controlled grazing is a method for regulating how often and how much to graze in order to control the quality, yield, consumption, and persistence of forage from pasture. Controlled grazing attempts to optimize animal performance or limit intake to a desired level and reduce wasted forage. The area of fresh pasture provided to a set number of animals for a given period (known as stock density) is changed to control the amount of forage eaten, its quality, and how long each pasture is rested between grazings. In this way, it is possible to match pasture growth with animals' requirements. Surplus growth is conserved as hay or silage, while growth shortages are made up by careful feeding of supplements.

What Is Its Purpose?

The purpose of controlled grazing is to improve efficiency of forage use, eliminate negative environmental impact, and improve net farm return.

TEN TIPS FOR DESIGNING A CONTROLLED GRAZING SYSTEM

1. Select plants adapted for year-round grazing.
Develop a perennial pasture system based on warm- (20 to 30% of land area) and cool- (70 to 80%) season species that are productive and persistent for your soils, climate, and management system.

Use legumes such as clovers and alfalfa in mixture with grasses to the extent that soils will permit legume growth.

2. Minimize land dedicated only to hay making.
In some situations, because of remote location or terrain considerations, surplus forage must be obtained by cutting hay or silage from the same field year after year. In this case, there is less recycling of nutrients. Making hay of surplus growth from grazing paddocks can help in weed and parasite control, but the use of dedicated hay fields reduces the flexibility of management because these fields are off limits to grazing animals.

3. Use lime and plant nutrients wisely.
The yields of pasture plants are directly related to the nutrients supplied by the soil's organic matter, or by inputs of fertilizer, manure, and lime.

Use controlled rotational grazing to provide a uniform grazing pattern and to recycle nutrients from urine and manure. From 75 to 85% of the nutrients consumed from pastures are excreted by the grazing animals. Over several years this management will reduce the fertilizer requirement.

4. Manage to grow green leaves.
Young, green leaves are 70 to 80% digestible, whereas brown leaves and mature seedheads are only 30 to 40% digestible.

Have animals with high nutritional requirements—such as milking dairy cows, cows with calves, and heifers and stocker cattle—graze leafy, vegetative paddocks.

Use animals that have low nutrient requirements—such as dry, pregnant brood cows, ewes, or mares—to graze dead plant tissue and stems containing seedheads.

Clip or mow pastures to regenerate new vegetative growth only when they can not be grazed or harvested for hay or silage.

5. Subdivide the grazing unit and cross fence to control the grazing pattern.
Create 10 to 20 permanent pastures or paddocks. The optimum number of paddocks on a farm will vary with topography, soils, and plant types.

Use fences to separate pastures that differ in growth rate, palatability, and exposure (north versus south slope). Subdivide fields to separate

- hill land from bottom land
- sunny slopes from shady slopes
- shallow soils from deep, productive soils
- areas planted with different plant species

Use electric power fences to confine animals to the farm and to subdivide pastures. Boundary fences must be substantial enough to retain animals on the farm even if power fails.

Use internal cross fencing to ration forage to the animals. In many cases one or two temporary electric wires will be sufficient. Use new technology materials such as reels, tread-in posts, and polywire or polytape to reduce fencing costs.

6. Graze each area rapidly.
Put enough animals on a paddock to graze to the desired stubble height in one to three days. A high stock density, equivalent to 20 to 70 animal units per acre (20,000 to 70,000 pounds of live weight per acre) is usually needed to reduce wasted forage and obtain uniform grazing (Table 1). Many pasture weeds will be grazed at an immature stage with this management, thus reducing the need for weed control measures.

When you move animals from one paddock to another depends on plant height. For example, for tall fescue-clover, move the animals into the pasture at 6 to 8 inches and out of the pasture at 2 to 3 inches.

7. Anticipate changes in pasture growth.
If pastures accumulate more than 8 to 10 inches of growth, take paddocks out of the grazing rotation and harvest this surplus as hay or silage at the correct stage of maturity.

Offer supplemental feed if supply of forage from pastures is limiting. Use temporary electric wire to ration tall fescue that has grown during autumn.

8. Provide a sacrifice area.
A sacrifice area is often a drylot, woodlot, or pasture scheduled for renovation. A sacrifice area may be permanent. Keep animals in a sacrifice area when pastures are extremely wet or when pasture growth is insufficient to permit grazing.

Provide shade and water in the sacrifice area and use the area for supplemental feeding, thereby reducing treading damage or severe overgrazing of the paddocks. Plant growth in the sacrifice area will be severely damaged or eliminated altogether.

9. Be flexible.
You must be prepared to make adjustments in the grazing or feeding program because pasture growth rate and animal requirements are continually changing.

Let the rate of grass growth and the amount of forage present determine when a paddock or area is to be regrazed.

The rule of thumb for controlled rotational grazing is when grass is growing fast, use a short rotational grazing cycle (12 to 20 days) and harvest the surplus growth as hay or silage; when growth slows, use a long cycle (30 to 60 days or more) and feed supplemental forage if needed. For example, during winter, tall fescue may need 90 to 120 days (November to March) to regenerate enough growth to graze.

10. Get started.
Begin by using only a part of the herd or a small part of the farm. You can expand after you have gained experience with the management system.

Keep the stocking rate on the farm about the same. Subdivide pastures and plan your management schedule to allow the forage in each paddock to be grazed in one to three days.

Keep records of the amount of surplus forage harvested, the number of days each pasture is grazed, the sequence and length of the rotational grazing cycle, and seasonal animal performance.

How to Use the Information in Table 1.

The information in Table 1 is general and may need modifications to fit specific environments. This table provides estimates of (1) the approximate height at which grazing should start and stop in order to provide good quality feed and rapid regrowth of the plants and (2) approximately how many days it will take during various seasons to allow enough regrowth for grazing again.

REMEMBER:

The information presented in this publication is intended as a general guide to controlled grazing. Adjust it to your local conditions and management style.

Table 1. Generalized grazing management guidelines for plant species in the mid and upper South.

Species[1]	Months	Height[2] (inches) To begin	Height[2] (inches) To stop	Days of rest before regrazing
fescue-clover	Feb-Mar	4-6	2-3	30-45
fescue-clover	Apr-Jun	6-8	2-3	14-30
fescue-clover	Jul-Aug	6-8	3-4	30-60
fescue-clover	Sep-Oct	6-8	2-3	21-35
fescue-clover	Nov-Jan	4-12+	2-3	60-120
bermudagrass	Apr-May	2-4	2	21-30
bermudagrass	Jun-Jul	2-4	1-2	10-21
bermudagrass	Aug-Sep	2-4	1-2	20-40
switchgrass	May-Aug	18-22	5-6	21-28
switchgrass	Nov 15-Dec	12-16[3]	6-8	(until April)
Eastern gamagrass	May-Aug	20-24	6-8	21-28
Eastern gamagrass	Nov 15-Dec	12-16[3]	6-8	(until May)
flaccidgrass	May-Aug	12-16	4-5	28-35
flaccidgrass	Nov 15-Dec	12-16[3]	6-8	(until April)
Caucasian bluestem	May-Aug	8-12	3-4	14-21
Caucasian bluestem	Nov 15-Dec	10-14[3]	4-5	(until May)
alfalfa	Apr-May	6 to bud	3-4	10-21
alfalfa	Jun-Oct	bud-bloom	2-3	21-40
alfalfa	Nov-Dec	before leaf drop	2-3	90-120

[1]Tall fescue and orchardgrass in pure stands should be grazed similarly as shown for a fescue-clover mixture. These grasses are more suitable than fescue-clover for fall stockpiling (August to November 1). Alfalfa grazed before bud stage should be permitted to reach 10 to 25% bloom before the next grazing cycle. Only a small portion of the alfalfa

[2]Strive to graze the forage in a field within three days (to minimize waste and quality changes).

[3]Graze accumulated frosted growth during late fall (October to November).

Chapter 5

PRINCIPLES OF FORAGE MANAGEMENT FOR PASTURES, HAY, AND SILAGE

J.C. Burns, Kevin R. Pond, and Dwight S. Fisher

To gain an economic edge, producers should learn to properly manage pastures and store forage. This chapter addresses principles underlying the management of forages for additional profit. Emphasis is directed toward available energy contained in forage dry matter (dry matter digestibility) and its utilization by the animal (metabolizable energy).

Why Manage Forage for Grazing and Storage?

To realize maximum economic gain, producers must develop a plan for the daily response of each class of animal in their enterprise. All growing animals have a daily maintenance energy requirement that normally ranges from 62 to 75% of the daily energy intake which must be met before energy is available for growth. Likewise, lactating or pregnant animals have special maintenance energy requirements; because the mammary gland or fetus has priority, the pregnant animal will lose weight at reduced levels of digestible energy intake. The pounds of original daily dry matter intake left for productive purposes after accounting for this maintenance requirement are shown in Table 1. When fed a full feed of concentrate and forage, a 1,000-pound animal would consume about 3% (or more) of its body weight. Animals grazing high-quality pasture would consume 2.5 to 2.8% of their body weight. When forage intake is 2.5% of body weight, a 1,000-pound animal consumes 25 pounds of dry matter. If the dry matter is 70% digestible, then 17.5 pounds of the dry matter can be utilized as energy by the animal for maintenance and production with the other 7.5 pounds excreted (Table 1). Of that 17.5 pounds, about 61% of its energy is used for maintenance and 39% or 6.8 pounds of daily intake is left for productive purposes. If dry matter digestion falls to 60%, digestible energy in only 5.4 pounds of dry matter intake is available for productive purposes. Maintenance now consumes 64% of the daily energy intake. Limiting dry matter intake to 2% of body weight when forage is 70% digestible (Table 1) leaves only 4.6 pounds of daily energy intake left for productive purposes with 67% devoted to maintenance. Feeding forage that is only 50% digestible will reduce dry matter intake to about 1.5% of body weight. Although maintenance requirements are reduced some, 76% of the daily energy consumed is utilized for this purpose, leaving only 24% for

Table 1. Relationship between daily forage dry matter intake, forage digestibility, and dry matter left for productive purposes (1,000-lb animal).

Forage intake			Allocation, dry matter intake				
% Body Weight	Per Day (lb)	Forage Digestibility (%)	Total Digestible (lb)	Used for Maintenance (lb)	(%)	Left for Production (lb)	(%)
2.5	25	70	17.5	10.7	61	6.8	39
		60	15.0	9.6	64	5.4	36
2.0	20	70	14.0	9.4	67	4.6	33
		60	12.0	8.8	73	3.2	27
1.5	15	50	10.0	7.6	76	2.4	24
		40	6.0	6.3	100+	-0.3	—

production purposes. The feeding of very low-quality forage (40% digestible) will further reduce dry matter intake (Table 1) with all the resulting digestible energy intake used in body maintenance.

These relationships are applicable to animals consuming hay or silage as well as when grazing. The latter case is demonstrated in Figure 1. When pastures are understocked, animals' daily weight gain will be high on legume-dominated pastures. On pure stands of grass, daily gain usually declines because of increased plant maturity and reduced dry matter intake. Mature pastures have reduced quality and an associated high proportion of dead material. Animals may increase their grazing time and restrict their dry matter intake by selecting the high-quality green leaf. Daily gain is reduced because the energy concentration of the dry matter is reduced and dry matter intake, hence energy intake, is limited.

Increasing the stocking rate so that herbage mass is maintained for optimum pasture growth (leaf production) and providing a high-quality diet (slightly right of center, Figure 1) will result in some decline in daily gain because of constraints on maximum daily intake, but gain/acre will increase greatly. A trade-off occurs between maximum daily gain and maximum gain/acre. This is shown in Figure 1 (right of center) as an increase in gain/acre as stocking rate increases. Because animals are graded individually and sold based on their grade, the reduced daily gain at maximum gain/acre may reduce an animal's body condition sufficiently to reduce its grade and, hence, selling price. Consequently, the economic optimum frequently occurs when neither daily gain nor gain/acre are at a maximum, but where the two responses intersect (near center, Figure 1). Overgrazing (see right side, Figure 1) by stocking too many animals/acre will result in inadequate herbage mass, but growth of leaves with extremely high quality (73 to 80% digestibility) will continue. However, dry matter intake and digestible energy intake will be so limited that animals will use all of the energy consumed for maintenance (Table 1) and weight loss will occur, giving zero gain/acre. In such cases, the system will crash as most plants will be defoliated so frequently

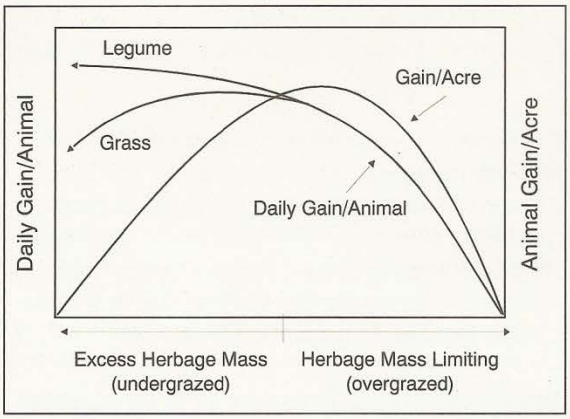

Figure 1. Relationship between herbage mass and daily gain per animal and gain per acre. Adapted from Mott 1960. VIII International Grassland Conference.

that stands will die. Effective forage management must address maintenance requirements and ensure that the concentration of available energy (digestibility) of the forage is adequate at the daily quantity consumed to obtain the planned animal response.

A Plan for Forage Utilization

Plan to provide the class of animal producing saleable products (meat, milk, or fiber) with the highest quality (intake and digestibility) forage in sufficient amounts to maximize daily digestible forage intake. Such forage generally will contain adequate protein and minerals. Animal classes that have intermediate production requirements, such as replacement heifers or stocker cattle, should be fed intermediate-quality forage. Classes that have only maintenance requirements, such as dry cows, should be fed low-quality forage. High-quality forage fed to moderate- or low-producing stock will result in excessive body condition, which generally is not cost-efficient. (The dry dairy cow may be an exception). The strategy chosen must compromise between maximum response per animal and maximum animal production per land area to optimize the profitability of the enterprise.

Principles of Grazing Management

Grazing management does not mean simply closing the pasture gate on a group of stock for the season. Such set stocking (stock left to continuously graze the same area all season) in our environment has little role for the serious producer. Static systems in dynamic environments are doomed to eventual failure. Management is the judicious use of means to accomplish an end. Each grass species and grass-legume mixture differs in its response to defoliation. Different defoliation intensities (stubble heights) and frequencies (rest periods) are needed to achieve a rate of regrowth that assures enough herbage mass (pounds/acre) to maximize daily dry matter intake while maintaining overall stand persistence.

The Concept

Ideally, the manager would control the nutritive value and quantity of the diet consumed by the grazing animal as is practiced when the animal is confined (ration formulation). When grazing, however, the animal selects its own diet (see Chapter 6) from within the constraints set by the pasture, thereby determining for itself both nutritive value and quantity consumed. The manager regains control through timely selection of plant species, applying appropriate cultural practices, and regulating the quantity of herbage mass (lb/acre) from which the animal selects its daily diet.

Herbage Mass (HM)

Controlling HM is the key to successful grazing management (see Chapter 4) as illustrated in Figure 1. Measured either to the soil surface or to some defined stubble height, HM is expressed simply as the pounds of fresh forage or dry matter/acre at a specific time. Forage species that are properly grazed will show a close relationship between HM and herbage height (from soil surface to top of pasture), making height measurements a useful and readily obtainable index of HM.

Because animals selectively graze green leaves in preference to stems and dead material (see Chapter 6), the density of the HM and the proportion of the HM that is accessible as green leaf influence daily dry matter intake. Pastures can be leafy, high in quality, and very productive, yet result in no daily gain or possibly even result in weight loss if overgrazed (HM < 1,000 pounds/acre, dependent on species) to the point that daily dry matter intake is limited (Table 1, Figure 1). In other words, we could develop a pasture species that is two times more productive and 50% more digestible than any species currently available, yet no product per acre (beef/acre, milk/acre, or fiber/acre) would be obtained if the pasture was so overstocked that daily dry matter intake was greatly reduced (right side of Figure 1). Likewise, pastures with plentiful HM (>2,500 pounds/acre) but with a complex canopy, such that green leaf is not easily selected (i.e., bermudagrass), or with low green leaf density, will likely result in only modest daily animal performance. In the former case, forage quality may be limiting, whereas in the latter case, the time required to select the green leaf from the forage canopy may become excessive (see Chapter 6) and limit dry matter intake.

Method Of Choice

The serious grazier must formulate a plan that estimates the daily response for each class of livestock. The principle is to match the nutritional requirements (maintenance plus production) of each animal class with the nutritional value of the diet to be selected by the animal.

Flexible, rotational stocking that incorporates creep grazing (special pastures established for high-quality forage species adjacent to base pastures fitted with gaps to permit young stock to step through), including forward creep grazing (creep gaps placed in the rotation such that calves can graze ahead of the dam), first and last grazing (high-producing stock graze ahead of low-producing animals), and aspects of deferred grazing (stockpiling tall fescue for fall) would likely be the choice of a cow-calf producer. Use such flexible management strategies throughout the growing season. In the spring, when forage quality is high, creep grazing may be less important than in the summer.

Dairy producers who recognize the value of forage in reducing feeding costs can gain maximum flexibility by integrating the use of pasture and stored feed. Ration grazing or strip grazing would be the method of choice and could provide lactating cows with a new allotment of pasture after each milking (see Chapter 4). Providing stored feed in dry lot during the day and pasture at night seems a worthy integration. The key to controlling HM is through a rotational scheme (including the harvest of excess pasturage) by adjusting the period of stay (grazing) and the period of rest as the season advances. If HM of such pastures as tall fescue - ladino clover, tall fescue, or bermudagrass becomes excessive (>3,000 pounds/acre), daily animal response will be suppressed if animals are forced to a high degree of forage utilization. This is because daily intake and the digestibility of the ingested forage will be reduced as stock are forced to consume the lower quality, stemmy, and dead material toward the end of the grazing interval. When HM is maintained at about 1,900 pounds/acre, the animals generally will have a pick of high-quality forage, but careful management must be exercised so as not to overgraze and limit daily dry matter intake (Table 1).

Principles of Harvesting Forage

Grazing should be the primary goal in forage utilization. Storing forage should be viewed only as a hedge against stress (drought or cold) periods. Essentially all forages adapted to North Carolina conditions can be readily harvested and preserved as either hay or silage (direct cut or wilted and without preservatives). In the case of grass, ensiling requires special care through chopping and packing to exclude as much oxygen as possible (see Chapter 9).

The Concept

Harvest so that quality of the stored forage is adequate when fed to animals at full daily intake to permit the daily response desired. Hungry animals are difficult to manage.

Changes With Maturity

Quality is highest when the plant is immature (vegetative stage) and declines, but at a variable rate, through seed set while dry matter yield (pounds/acre) increases. Dry matter digestibility and crude protein concentrations of mature forage can be so low (42 to 48% and 5 to 8%, respectively) that animals will not consume enough dry matter to supply maintenance requirements (energy and protein). In the case of grasses, the decline in forage dry matter digestibility and intake with advancing maturity follows similar trends but is species-specific. The general trend is highest quality during the early vegetative stage (digestibility = 70 to 80% and intake = 2.8 to 3.2% of body weight) with a slight decline noted up to stem elongation, which begins the booting phase. During early booting (just before inflorescence), digestibility and forage intake fall precipitously and then plateau until seed heads emerge.

Another decline follows after heads have emerged through seed set. Plant cell walls thicken during maturation and are not easily degraded. Corn for silage is a noted exception to this general trend because development of the ear (grain) offsets the reduced quality of the forage portion of the plant. The effects of plant maturity on daily animal performance for several of our major forage species are shown in Appendix E.

In contrast to grasses, legumes show different trends with maturation. The dry matter digestibility and intake of alfalfa declines, as noted for grasses, as it matures from the vegetative stage to bud, to early bloom, to mid-bloom and to seed set. However, the changes are more moderate through the mid-bloom stage. Ladino clover, on the other hand, shows little change in quality from vegetative through the late bloom stage. The decline in alfalfa quality is mainly attributed to the stems becoming fibrous (thickening of cell walls) with maturation, which reduces digestibility. The petiole of clover remains succulent even while the plant is flowering.

Making Matches

It is not always possible to harvest forage at the proper maturity. Management practices can help overcome mismatches when they occur.

When the quality of stored feed far exceeds animals' daily requirements when fed a full feed, a limited feeding is recommended. Feed enough high-quality forage to provide the necessary energy and protein, then supplement with enough additional low-quality forage (hay or silage) or roughage (crop residues) to satiate animals, but avoid excessive body condition.

Few options are available if mature forage must be fed to animals with high energy demands. It is possible to provide 50% excess feed daily and allow animals to select the better quality portion (leaves); then the refused forage can be fed to brood animals. Another option is to correct the mistake by purchasing and feeding an energy and protein supplement, or improve the digestibility and dry matter intake of the forage through chemical (sodium hydroxide or anhydrous ammonia) treatment. Supplemental energy may still be required. The best solution is to avoid the mistake by harvesting at the proper maturity stage.

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Chapter 6

BEHAVIOR OF GRAZING ANIMALS

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When designing any livestock operation, it is important to have a good understanding of animal behavior. This is especially true with grazing livestock. Understanding when and how an animal grazes, and the differences in grazing among animal species, is important in order to match the animal's needs to the forage supply. When and how long an animal grazes is determined by a number of factors, some of which are under the control of livestock producers and some of which are not.

Beef cattle graze about 9 hours per day, dairy cattle about 8 hours per day, sheep about 10 hours per day, and horses about 12 to 16 hours per day. Depending on the grazing conditions and the animal's needs, the daily number of bites and chews (grazing and ruminating) can be as high as 51,000 for cattle and 34,000 for sheep. In ruminant animals, the longest grazing periods usually occur at sunrise and sunset. There is also a difference between European types of cattle and exotic types such as the Brahman or Zebu cattle, in that Brahman cattle will typically graze longer than the European types. Grazing time can be influenced by several factors including the season of the year, the temperature and humidity, the topography of the land, the nature of the plant canopy, pasture availability, and social interaction among animals. Seasonal changes, with accompanying changes in day length and intensity of sunlight, cause animals to graze in different patterns.

At mean temperatures below 50°F, grazing animals spend very little time grazing at night, but daily intake may increase in cold weather. At mean temperatures above 50°F, some grazing time occurs at night; when mean temperatures exceed 77°F, one or more grazing periods will occur at night. During hot weather, heat stress may cause animals to decrease their forage intake. The topography and size of the pasture also affect grazing time, as do forage availability and ease of forage removal. Animals take more time to graze in pastures where they have urinated or defecated because they try to avoid the wastes. Socially, animals generally behave as a group. Often, if one animal gets up to graze others will follow. Species of animals have different patterns of grazing and resting and, in some cases, breeds within species also have different patterns as has been observed with the European breeds versus the Brahman breeds of cattle.

Animals select forage based on availability, type of plant species (some species are preferred over others), plant part (leaves are preferred over stems), and growth stage (young vegetative parts of plants are preferred over more mature parts). The time spent grazing and the rate of feed intake during grazing are also affected by the nutritional demands of the animal, the digestibility or quality of the plant, and the prior experience of the animal with the forage being grazed. In general, the higher the nutrient demand, the higher the quality of intake.

The methods of forage prehension differ among animal species. In addition, ruminant animals have a dental pad instead of upper front teeth (upper incisors), whereas horses have both upper and lower incisors.

In cattle, the main organ of prehension is the tongue when the length of the forage is greater than approximately 4 inches. The tongue extends, curls around the forage, and brings the forage into the mouth. Then the bottom incisor teeth and upper dental pad sever the forage with a ripping action. However, the tongue is not used to prehend forage when cattle are grazing short pastures. When sufficient bites are taken to form a large enough bolus (forage mass), the whole bolus is swallowed. Because cattle have no upper incisors they cannot prehend forage that is less than a ½ inch high. In addition, intake by cattle is severely limited at forage heights below 1 inch, and this may aid in plant survival (Figure 1).

Sheep take smaller bites than cattle and do not use their tongue to the same extent. Sheep have a mouth with a split upper lip that permits grazing closer to the ground or to the plant part to be consumed. In addition, sheep have a narrow muzzle, enabling them to select leaves within a plant. Sheep can graze within ⅓ of an inch from the ground and tend to bite grass off near the soil surface rather than

Figure 1. Because cattle have no upper incisors, they cannot prehend forage that is less than a ½ inch high.

graze from the top of the canopy. In a pasture with several plant species, sheep can select the plant species they prefer, leaving the other plant species untouched, which can result in spot grazing.

Goats have a narrower muzzle than sheep. Their split upper lips are especially adapted for seizing or grasping and enable them to select plant parts and to ingest material of the highest quality. Goats tend to graze from the top to the bottom of plants and do not like to graze near the soil surface. Therefore, goats will more uniformly graze a canopy than will other ruminants.

What ruminant animals consume can also differ greatly among species. Cattle prefer grass, and sheep may prefer both grass and some browse (shrubs, woody vines, and trees), whereas goats prefer browse, forbs, and seed heads rather than vegetative forage. Given a choice, grazers select green leaves rather than brown leaves or stems, younger plants rather than older plants, and plants having high sugar concentrations. In addition, grazing animals tend to avoid plants with high tannin and alkaloid concentrations; cattle and sheep have shown a preference for low-endophyte varieties of fescue. Goats, however, are more likely to select plant parts containing tannins. Goats will also sometimes use a bipedal stance to consume a wider variety of material by standing on their hind legs and extending upward to reach tree limbs. Goats sometimes even climb into trees or shrubs to consume the desired forage. In spite of their grazing preferences, however, cattle and sheep can be encouraged to browse and goats can be grazed on pasture alone. Some studies have shown that sheep with little or no experience in grazing had lower intake on pasture than sheep that had been grazing since birth; this effect was evident for two years. Finally, animals may get used to, or may be forced to, graze certain unpalatable pasture mixtures to satisfy their nutritional demands; once accustomed to these particular pastures, their performance may be satisfactory.

Horses have both upper and lower incisors which permit grazing closer to the soil surface than any of the ruminant animals. The organ of prehension in the horse is not the tongue but the lips. The lips move the forage to the mouth and the forage is consumed when the horse brings its teeth together and jerks its head to rip the forage from the plant base. Horses also use their upper lips to manipulate plant parts during selective grazing. Because of the angle of their incisors, horses can graze to within $^1/_3$ of an inch or less of the soil surface and sometimes eat stolons and roots of certain forage species.

Having several animal species graze the same pasture can often maximize its use because of the species' different grazing preferences and patterns. In addition, animals tend not to graze as close to pads of their own dung and urine as they do to pads of other animal species. Cattle and sheep will generally graze apart, but cattle and horses will often graze together. Horses will graze closer to sheep than cattle will, but horses often will run the companion animals for fun.

The relationship of grazing time, the size of each bite, and the number of bites ingested all have an effect on the daily intake of the animal. In short pastures, animals take many bites to form a bolus before swallowing because the availability of pasture is low. In taller pastures, animals are able to consume a sufficient quantity to form and swallow a bolus with just a few bites. In the latter case, animals can become full with less grazing time and fewer bites than animals grazing very short pastures. The type of pasture canopy has dramatic effects on time of grazing and intake. If the canopy is very tall and

stemmy, animals spend more time trying to select high-quality leaves and avoiding the lower-quality stems, and they graze for a longer period of time than animals grazing a medium or short pasture where better-quality material can be consumed with much less selection.

On very short pastures or on pastures with a tall and stemmy canopy, animals consume less forage per bite, but will attempt to ingest sufficient feed to meet their nutritional requirements by extending the time spent grazing. This is effective up to a point; however, animals eventually tire and stop grazing before becoming full, which results in decreased performance. On pastures having a sparse canopy, a canopy that is very tall and stemmy, or a combination of both, a large portion of the increase in grazing time is actually spent walking. Under those circumstances, the time spent actively consuming forage may be reduced, further decreasing daily intake and performance. Finally, animals grazing a uniform canopy and consuming a sufficient quantity of forage to form and swallow a bolus with just a few bites do not necessarily achieve high performance if the forage is very fibrous or mature (low in quality). Under this scenario, animals fill the physical capacity of their rumen and stop grazing before meeting all of their nutritional demands.

Additional management decisions can influence animal intake and thus performance. Moving animals frequently to fresh pasture can result in a 20% increase in intake because of physiological stimuli and social aspects within the herd. Finally, supplements above 0.5% of body weight may substitute for pasture feed; therefore, to minimize substitution effects, it may be best to feed any supplement late in the day, if possible after the late afternoon/sunset heavy grazing period.

By understanding the grazing behavior of herbivores, graziers can effectively make production and management decisions that will allow animals to achieve the desired level of performance.

Chapter 7

FORAGE PHYSIOLOGY

Dwight S. Fisher and J. C. Burns

The feed resource harvested from pastures and hay fields is the product of many interesting chemical processes. A basic grasp of some of the fundamentals of the physiology (or chemistry) of forage growth can help graziers understand which production practices are appropriate and likely to be beneficial in a particular situation. Your pastures and hay fields should be thought of as factories that produce the feed you must have to profitably operate your livestock enterprise. Consequently you must manage this land area to provide the quantity and quality of forage needed to meet the production goals you have set for your herds (see Chapter 5). To begin with, producers need to understand the natural advantages of each species as determined by their chemistry. For example, the use of the term "cool season" for temperate forages such as tall fescue, orchardgrass, ryegrass, alfalfa, and ladino clover, and "warm season" for subtropical forages such as bermudagrass, switchgrass, flaccidgrass, caucasian bluestem, and gamagrass should not be taken to mean that the forages grow only in the spring and fall or only in the summer. These terms give an indication of the season in which the chemistry of each forage makes it most reliable and productive under the usual climatic conditions.

Importance of Green Leaf

The primary requirement for a productive pasture is the presence of green leaves. The ratio of leaf area to ground area is sometimes calculated as an index of how much leaf area is present in a pasture or hay field. Most grasses produce additional leaf area rapidly until there is approximately five to seven times as much leaf area as on a unit of ground area (i.e., 5 to 7 square feet of leaf area from the pasture on 1 square foot of ground). Most broadleaf plants like clover and alfalfa only produce additional leaf area until there is approximately three to four times as much leaf area as ground area. After this much leaf area accumulates, the older leaves begin to yellow and die. Green leaf is a highly preferred component of the grazing ruminant's diet. As a result, while you need green leaf to produce more leaves and dry matter, you must also harvest it as a feed resource. In addition, because of the growth habit of most pasture species and the high palatability of young leaves, the grazing animal usually selectively harvests the younger material, leaving the older, less productive leaves to accumulate in the pastures. This is why it can be difficult to maintain legumes and grasses in the same pasture. A relatively higher proportion of the legume leaves is typically consumed during grazing, giving the grass a competitive advantage in the mixture unless defoliation is carefully managed.

Grazing, compared with hay making, usually results in less dry matter production per acre. This is partly due to more efficient harvest with haying equipment and partly due to trampling and fouling of forage when grazed. Stemmy and dead portions of a forage crop can be removed by hay harvest, whereas they would be nearly impossible to remove by grazing. However, forage harvested as hay provides a lower-quality diet and may be as much as 10 to 30 units lower in digestibility than the diet of an animal grazing the same land area. This is because animals prefer green leaves, and plant material loses digestibility as it is dried or ensiled.

Carbohydrate Reserves

Since leaf area is required to produce new leaves, you may wonder how plants can start growing in the spring or recover during the growing season if most of the leaves are removed. This is possible because the plants, if properly managed, have reserves of carbohydrates they can draw on for regrowth. The location of the carbohydrate reserve varies with different species from roots to rhizomes to stem bases. For example, the primary storage organ or location for orchardgrass and tall fescue is the stem base; for Kentucky bluegrass, the rhizomes; for bermudagrass, the rhizomes and stolons; for red clover and alfalfa, the roots; and for ladino clover,

the stolons. There is even some carbohydrate stored in the leaves themselves. Repeated severe defoliation can deplete these reserves and delay regrowth or even result in stand losses.

Relationship of Leaf Area and Carbohydrate Reserves to Management

Producers who practice rotational grazing can take advantage of these principles by carefully controlling their animals to manage the defoliation of each pasture before moving on to the next. If the defoliation is not frequent enough, then both young and old leaves will be removed (as well as some stem material), and the initial regrowth will be from basal buds and carbohydrate reserves. Timely defoliation of pastures (species dependent) prevents excessive pasture growth that may shade the base of pasture plants, reducing tillering and leaf development near the soil surface. Consequently, the effects of defoliation in a properly managed pasture may be less severe because more leaf area remains after grazing. As a result, regrowth comes from both residual leaves and carbohydrate reserves. Under appropriate rotational grazing management, or if harvested for hay or silage, reserves are replenished during the regrowth phase as the pasture nears its maximum leaf area. If a pasture is continuously grazed, the residual leaf area should always be high enough to contribute to growth, but because the younger leaves are generally harvested during grazing, the population of leaves tends to increase in average age and decrease in overall productivity.

Under lax management, pastures grow until they approach their maximum leaf area per unit ground area and then the older leaves begin to yellow and die. This may seem as if you are managing the pastures in a way that would maximize stand persistence, but that is not the case. Lax management can result in increased disease problems, and it also reduces the amount of light that penetrates to the base of the pasture plants. This principle is very important in many pasture species because under low light conditions they greatly reduce their production of lateral tillers. This means that you may be losing ground cover as you manage a pasture for a hay crop if you allow the material to stand several days beyond the stage of growth recommended for harvesting. Periodically grazing pastures short (1- to 6-inch stubble, depending on the species) will encourage tillering and improve ground cover. Some of the reported stand problems with the endophyte-free fescues may be associated with lax management or allowing too much forage to stand during the summer. However, it is important to keep in mind that the consequences of overgrazing can also be serious. Overgrazing can lead to reduced productivity, stand loss, weed encroachment, and soil erosion.

Bernie Davis, a New Zealand dairyman who fed nothing but pasture and won awards for the productivity of his system, said repeatedly, "You have to graze grass to grow grass and you have to leave grass to grow grass." He knew very little about the chemistry of forage growth, but he had discovered by observation many principles that are soundly based in the physiology of forages. The appropriate timing and severity of defoliation are key management decisions that can make the difference between profit and loss in any forage enterprise.

Chapter 8

PRINCIPAL FORAGES OF NORTH CAROLINA: *Adaptation, Characteristics, Management, and Utilization*

Douglas S. Chamblee, James T. Green, Jr., and J. C. Burns

There are many forage plants useful to North Carolina growers. Listed in Table 1 are the legumes and grasses discussed in this chapter. Some of the plants listed, however, are not suitable for general use; specific recommendations are provided for each species. Adaptation, habit, season of growth, compatibility, nutritive value, use, fertility requirements, establishment and management, and cultivars are discussed. The relative monthly growth rates (pounds of forage per acre per day) are shown (Figure 1) for many important forages.

Cool-Season Perennial Legumes

Ladino Clover (*Trifolium repens*, Figure 2)

Adaptation: Widely adapted to imperfectly drained and well-drained soils, but not to deep (dry) sandy soils. Difficult to get ladino to grow in some of the northern mountain counties on the dryer slopes with shallow soils. However, every county of the state has areas where ladino clover can be grown successfully. Persists about three years.

Habit and Season of Growth: It is a rapid-growing perennial that spreads by fleshy, creeping stems that root at the nodes. It is a giant strain of white clover and is more productive and more drought resistant than intermediate types of white clover. More than 50% of yield occurs from March to June, but it may grow some in each month; annual yield is 3 to 4 tons per acre. Ladino will frequently volunteer successfully after the stand is thinned by prolonged drought, flooding, disease, insect infestation, or poor management.

Table 1. Major legumes and grasses of North Carolina.

LEGUMES

Perennials

COOL SEASON	*WARM SEASON*
Ladino clover	Sericea lespedeza
Alfalfa	Kudzu
Red clover	
Birdsfoot trefoil	
Crown vetch	

Summer Annuals	**Winter Annuals**
Kobe lespedeza	Crimson Clover
Korean lespedeza	Hairy Vetch
	Hop clovers
	Arrowleaf clover
	Sub clover
	Berseem clover

MISCELLANEOUS PLANTS

Turnips, Rape, Kale, and Swedes

GRASSES

Perennials

COOL SEASON	*WARM SEASON:*
Tall fescue	Hybrid bermudagrasses
Orchardgrass	Switchgrass
Kentucky bluegrass	Flaccidgrass
Redtop	Dallisgrass
Timothy	Common bermudagrass
Perennial ryegrass	Bahiagrass
Rescuegrass	Carpetgrass
	Gamagrass
	Caucasian bluestem
	Johnsongrass

Summer Annuals	**Winter Annuals**
Pearl (Cattail) millet	Italian ryegrass
Other millets	Small grains
Sorghum-sudan hybrids	
Sudangrass	
Crabgrass	

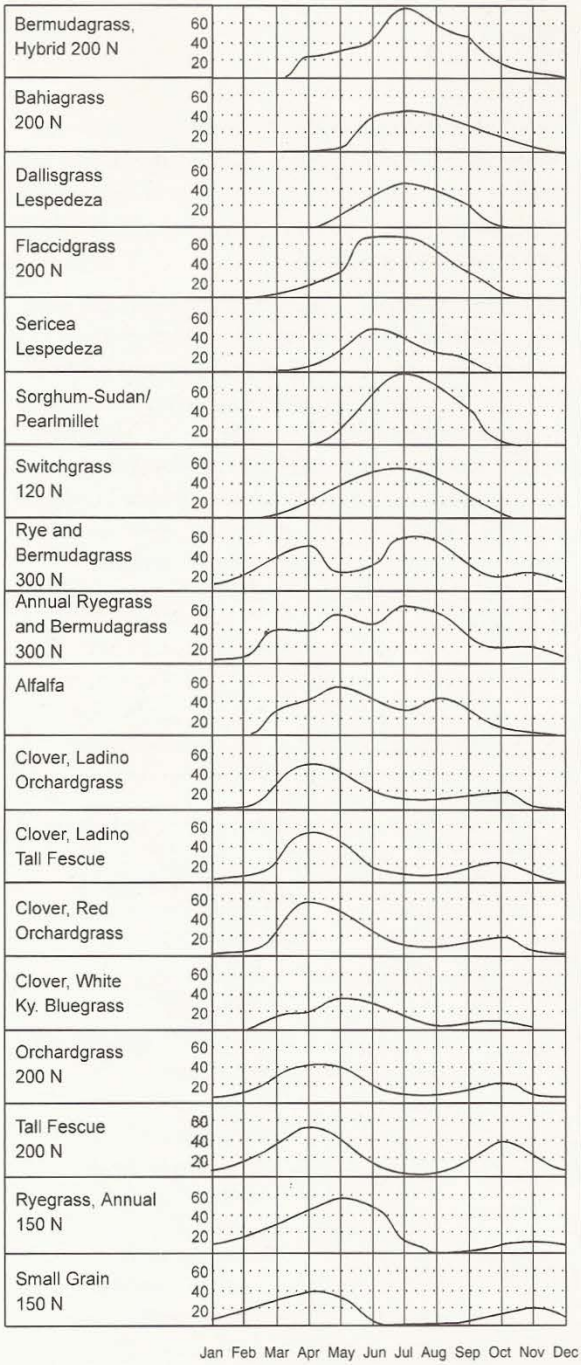

Figure 1. Relative growth rates for forage crops (pounds/acre/day).

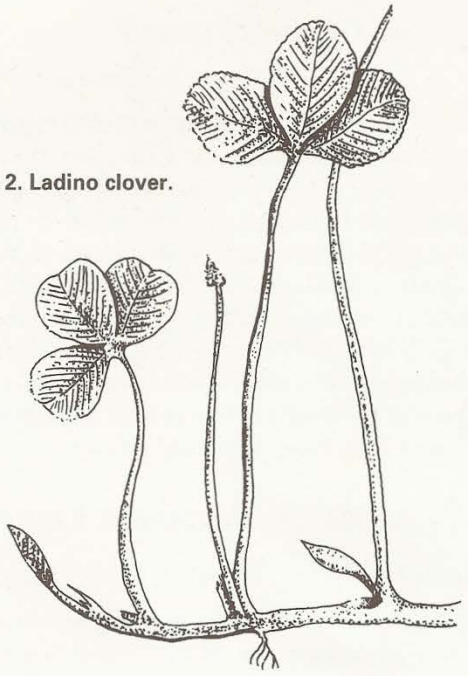

Figure 2. Ladino clover.

Compatibility: Grows well with orchardgrass or tall fescue. Clover will thrive better with the less competitive orchardgrass or endophyte-free fescue.

Nutritive Value: Extremely high quality (greater than 80% digestible and 25% crude protein) and maintains quality with maturity. Petioles are also very digestible. It contains high calcium, phosphorus, and magnesium. Dry matter intake is high.

Use: Primarily grown in mixture with adapted grasses for grazing, but mixtures also may be used for silage, hay, soil improvement, and wildlife.

Fertility Requirements: Get soil test. It has medium to high lime, phosphorus, and potassium requirements. For average conditions (that is a soil that might test medium in phosphorus and potassium), apply 400 to 500 pounds of 4-24-24 per acre at seeding. On newly cleared land, 500 to 600 pounds of superphosphate also is often needed. Apply annually 400 to 600 pounds of 0-10-20 or 0-9-27 per acre. This top-dressing usually should be applied just before growth starts in late winter. However, any time that fertility level is low it should be corrected, regardless of time of year.

Figure 3. No-till drilling of ladino clover into a sod of tall fescue.

Establishment and Management: See Chapter 11. Inoculate seed. Prepare firm seedbed or no-till plant. May be planted into existing sods in fall or winter (Figure 3). To sod seed, plan ahead and correct pH and phosphorus. Correct potassium at time of seeding. Graze existing sod to 1 to 2 inches. Kill about 50% of sod with gramoxone or glyphosate four weeks before fall seedings, and seed about September 1 in piedmont and coastal plains if insect population is low and moisture is ample; otherwise seed about October 15 to avoid serious insect problems. In the mountains, seed two to four weeks earlier in the fall, and two to four weeks later in the spring. Make furrows about ¾ to 1 inch deep. This will result in seed being covered with ¼ to ½ inch of soil. For winter seedings, because of ample moisture, there is less advantage than for fall seeding in killing 50% of the sod. You may realize moderate yield increases (20%) of the clover component in some years. To effectively kill the sod, you must apply chemicals in October or early November before seeding. Seed February 15 to March 15 (except in the mountains) in closely grazed sod (1 to 2 inches) either by drilling or surface. Drilling is better. Good stands can be obtained by surface seeding at slightly higher rates. Do not graze below 2-inch stubble in dry or cold weather.

Cultivars: Will, Regal.

Alfalfa *(Medicago sativa,* Figure 4)

Adaptation: Requires well-drained soils. Grows best in deep, fertile soil, but does well on most upland soils and fairly deep sands when fertility level is carefully maintained. Produces well for three to five years.

Habit and Season of Growth: Hay types are erect, with 5 to 25 stems per plant, nonspreading and deep rooted. Grazing types have more lateral and crown buds. Tap roots range from 3 to 8 feet, and growth recovers quickly following drought. Growth occurs in March through November; peak growth occurs in April and May. Annual yields range from 4 to 7 tons per acre.

Compatibility: Grows well with orchardgrass but not as well with tall fescue.

Nutritive Value: High quality when immature (63 to 72% digestible and 18 to 25% crude protein). Quality declines with maturity because of increased fiber (52 to 56% digestible). Cattle graze both leaves and stems. Sheep will select leaflets. Dry matter intake is high, 2 to 3% of body weight, when leafy. A good source of crude protein, calcium, magnesium, and phosphorus.

Use: Primarily used for hay, but highly suited to grazing. Usually seeded in pure stand for hay, but may be used with orchardgrass as a combination

Figure 4. Alfalfa.

hay, silage, and grazing crop. Should be rotationally grazed for highest gain per acre. Manage to minimize bloat.

Fertility Requirements: Alfalfa has relatively high requirements for phosphorus, potassium, boron, and calcium; pH should be 6 to 6.5. Apply 2 to 3 pounds per acre of boron at seeding and annually. A small amount of nitrogen (15 to 25 pounds) at seeding is helpful in supporting growth until inoculation can become effective. At seeding, apply 400 to 500 pounds of 4-24-24 plus borax per acre on soils medium in phosphorus and potassium. On soils low in phosphorus apply 500 pounds of superphosphate per acre in addition to the above. Apply annually 600 to 1,000 pounds of 0-9-27, 0-10-20, or 0-25-25 depending on the level of phosphorus and potassium in the soil with 2 to 3 pounds of boron. Use 0-9-27 or 0-10-20 on most coastal plain soils. Sulfur may be needed on sandy soils. Maintenance fertilizer may be applied most any time on clays but should be applied in the spring on sandy soils.

Establishment and Management: See Chapter 11. Proper inoculation is always essential. For conventional planting prepare a firm, granular seedbed. A cultipacker equipped with a small seed attachment is one of the best methods. May be seeded into existing sods in the fall (September 1 to October 15) or winter (February 15 to March 15) in piedmont and coastal plain. See ladino section for time of seeding in the mountains. Fall seeding is often preferable, except where *Sclerotinea* is a problem. Plan ahead and correct pH and fertility. Graze existing sod to 1 to 2 inches. Kill 90 to 100% of sod for fall or winter seedings with gramoxone or glyphosate. For winter seeding, kill sod in October or early November before seeding. Cannot effectively kill in winter months. Do not surface seed.

Cutting or grazing practice must permit replacement of food reserves after each defoliation. The first harvest should be made in mid- to late-bud stage. After the first harvest, cut alfalfa in the early-bloom stage (10 to 25% bloom) or when new basal shoots appear (about every three to five weeks).

Grazing interval should approximate cutting stages once a stagger in regrowth has been developed. Graze the growth in a particular paddock in one to three days. Permit crop to reach bud to 10% before regrazing. Alternating cutting for hay and grazing is a good practice. The last cutting in the fall should be made early enough to allow 12 to 18 inches of regrowth or 45 days regrowth before the first killing frost (28°F). Remove this growth by ensiling or grazing.

Cultivars: There are dozens available and most companies have a suitable variety. See Forage Crops Variety Testing Report, published annually, for North Carolina yield comparisons. (See Bibliography.)

Red Clover (*Trifolium pratense*, Figure 5)

Adaptation: Best adapted on fertile, well-drained soils of piedmont and mountains. Occasionally grown on better-drained heavy soils of tidewater area. Stands usually last about two years.

Habit and Season of Growth: It is an erect, short-lived perennial (two to three years) legume, with numerous stems arising from a thick crown. Growth occurs from March to November, with about 50% yield in April to June; annual yields range from 3 to 4 tons per acre.

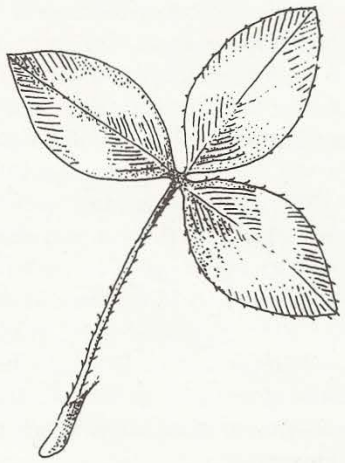

Figure 5. Red clover.

Compatibility: When grown for hay, red clover is usually grown in mixture with orchardgrass, but is often mixed with tall fescue.

Nutritive value: Hay quality ranges from 60 to 65% digestible and 12 to 16% crude protein, but declines rapidly with maturity (52 to 56% digestible). In pastures the vegetative growth is more than 70% digestible and 18% crude protein. It also contains relatively high calcium, phosphorus, and magnesium. Cattle graze both leaves and stems. Dry matter intake is high.

Use: Primarily hay, pasture, and soil improvement, in rotation with other crops. Usually grown in mixture with grass.

Fertility Requirement: It has relatively high requirements for phosphorus, potassium, and lime. Similar levels to ladino clover. Apply 500 pounds of 0-10-20 annually on soils medium in phosphorus and potassium.

Establishment and Management: See Chapter 11. Inoculate seed. Seedbed requirements similar to alfalfa. If seeded by no-till methods, follow recommendations for ladino clover, except do not delay seeding until October, because red clover seedlings are less winter hardy than ladino clover. May be cut two to four times annually in early bloom stage.

Cultivars: Kenland, Redland, Kenstar, Redman, Chesapeake.

Birdsfoot Trefoil *(Lotus corniculatus,* Figure 6*)*

Adaptation: Best adapted to upland loams of the mountain area. Not well adapted to wet land. Shows some promise on upland loams throughout state, and shows more promise in upper mountain area. Subject to severe damage from *Rhizoctonia,* particularly in eastern two-thirds of the state. Persists two to five years. Try on small acreage only.

Habit and Season of Growth: Semi-erect, fine-stemmed perennial legume with small tap roots. Has neither rhizomes nor stolons. Growth period is April to November. Peak growth occurs in May to July. Slow to become established. Yields 2 to 3 tons per acre in mixtures.

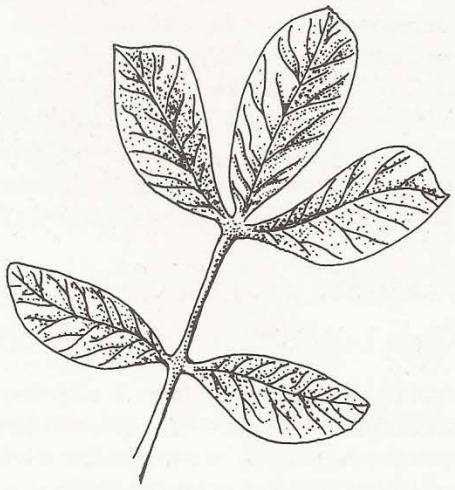

Figure 6. Birdsfoot Trefoil.

Compatibility: Grows well with orchardgrass and with Kentucky bluegrass. Tall fescue is often too competitive for birdsfoot.

Nutritive Value: The nutritive value is equal to or greater than that of alfalfa. High in quality (70 to 78% digestible). Quality declines slightly as plant matures. Animals graze both leaves and the herbaceous stem, which remains highly digestible. Plants are highly palatable but contain tannin that prevents bloat. A good source of crude protein and calcium, phosphorus, and magnesium.

Use: Primarily grown in mixtures with grass for grazing.

Fertility Requirements: Responds to lime and fertilizer but has slightly lower requirements than ladino.

Establishment and Management: See Chapter 11. Requires special inoculum. Birdsfoot trefoil persistence and yield of animal products per acre will be greater if grazed rotationally. Natural re-seeding (volunteering) contributes to persistence, so pastures should be managed to permit seed formation.

Cultivars: Fergus, AU-Dewey, and Douglas have been tested and performed satisfactorily.

Crown Vetch *(Coronilla varia)*

Seedling vigor is poor. Requires special inoculant. March seedings are usually preferred. Quality is high (68 to 72% digestible), but leaflets contain soluble phenolies which require an adjustment period. Persistence has been a major problem under grazing. Frequent trampling and defoliations seem to lead to greater disease (crown and root) problems.

Warm-Season Perennial Legumes

Sericea Lespedeza *(Lespedeza cuneata)*

Adaptation: Grows on medium- to well-drained soils throughout the state. Not used extensively as a forage in piedmont and mountains, but is adapted to sandy loams and deep sands (sandhills) as well as eroded areas. It persists for many years, especially on low-maintenance areas.

Habit and Season of Growth: Sericea is an erect, deep-rooted perennial legume. It usually grows only 6 to 12 inches the first year. It does not spread by rhizomes and stolons. The first growth in the spring arises from crown buds. New growth after cutting or grazing arises from buds on the stubble and not the crown. General growth period is April to November 1. Peak growth period is June, July, and August with annual yield of 2 to 3 tons per acre. Does not self-destruct if not used.

Compatibility: Preferably seeded alone. Does not compete well with other plants. May be grown in mixture with bermudagrass or fescue, or may be overseeded with winter annuals if carefully managed.

Nutritive Value: Moderate quality (50 to 55% digestible and 12 to 16% crude protein) and moderate intake unless carefully managed. Animals graze leaves and tender stems. If cut when 12 inches tall, or grazed when 6 to 8 inches tall, it is palatable and eaten well by livestock. If allowed to reach 18- to 24-inch growth or more, it becomes woody, stemmy, and high in both fiber and tannin, and livestock will not eat it. Tannin concentrations decline when sun cured. Lime and fertilizer improve palatability. Steers gained an average of 2 pounds per day when grazing improved selections (AU-Lotan) from Alabama.

Use: Can be used for hay, grazing, or seed production. It is an excellent soil improver and is used most widely for long-term soil cover on low-maintenance areas.

Fertility Requirement: Sericea will grow at low pH (5 to 5. 5) and fertility level (phosphorus and potassium), but better production is obtained if properly limed and fertilized. At seeding, use about 300 pounds of 0-25-25 per acre on average soil conditions. Lime according to soil test; seldom use more than 1 ton. Annually apply 300 to 400 pounds of 0-10-20 or 0-25-25 per acre, depending on phosphorus and potassium levels in the soil.

Establishment and Management: See Chapter 11. Inoculant usually present in the soil. Control the use of nitrogen or manure before spring planting, as this increases weed competition in seedling year. Has weak seedling vigor. Do not graze or cut for hay the first year. In subsequent years two or three cuttings per year may be obtained. It cures rapidly and leaves shatter easily; windrow soon as wilted. Frequently one cutting is taken for hay or grazed until mid-July and the next crop is allowed to make seed. Yields of 300 to 400 pounds of seed per acre are not uncommon.

Graze when 6 to 8 inches high, back to 3 inches, and cut for hay when 10 to 15 inches. Sericea will not stand close, continuous grazing.

Cultivars: Common, Caricea, AU-Lotan, AU-Donnelly.

Kudzu *(Pueraria lobata)*

Adapted to deep, well-drained soils throughout the state, except in high mountain areas. Subject to winter injury in the mountains. Kudzu is well adapted to upland sandy loams and grows fairly well on deeper sands.

Kudzu is a deep-rooted, vigorous, perennial leguminous vine which spreads by stolons. Kudzu has an indeterminate type of growth. Can graze it or leave it with little deterioration. Peak production

occurs in June, July, and August. Considered a pest by many. It is high in quality (68 to 74% digestible).

It is established by use of vegetative crowns. Direct seeding may be used, but this method is not as dependable. Transplant during dormant season, February and March. Production of forage per acre is equal to only 1 to 2 tons of alfalfa hay equivalent. Not as productive as it appears. Should graze rotationally or very moderately if continuously grazed. Close continuous grazing will kill stands.

Summer Annual Legumes

Kobe and Korean Lespedezas *(Lespedeza striata,* Figure 7, *and L.stipulacea,* Figure 8*)*

Adaptation: Adapted on most North Carolina soils except deep, dry sands. Kobe generally is best adapted to soils of the coastal plain, and Korean types are best adapted to the mountains. Both well adapted to piedmont.

Habit and Season of Growth: Erect to prostrate depending on management. Kobe tends to be more erect than Korean. Kobe matures three to five weeks later than Korean. General growth period is May 1 to October 15. Peak growth months are June, July, and August. Volunteer freely even when cut for hay. Yields range from 1.5 to 2 tons per acre in pure stands and from 2 to 3 tons mixed with grass.

Nutritive Value: High in quality (60 to 65% digestible and 14 to 18% crude protein). Early cut hay may be equal to alfalfa hay. Dry matter intake is high. Cattle graze both leaves and stems. Contains relatively high amounts of phosphorus, calcium, and magnesium.

Use: Hay, grazing, seed, soil improvement, and wildlife food.

Fertility Requirements: Will tolerate low pH (5 to 5.5) and fertility level (low to medium phosphorus and potassium) but responds well to fertilization and moderate liming. Generally apply about 300 pounds of 0-10-20 or 0-25-25 per acre annually, depending on level of phosphorus and potassium.

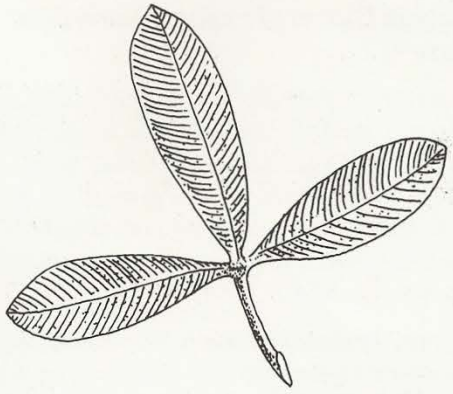

Figure 7. Kobe Lespedeza

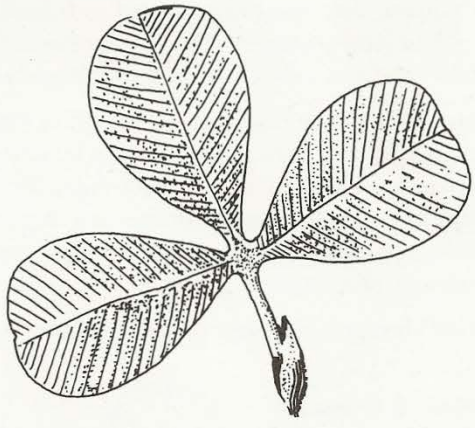

Figure 8. Korean Lespedeza.

Establishment and Management: See Chapter 11. Inoculant usually present in soil. Cut for hay once when in early bloom or when about 12 inches tall and lower leaves begin to shed. If grown for seed, harvest soon after pods turn brown. Often produce 200 to 300 pounds of seed per acre.

Cultivars: Yadkin, Summit, and Marion (Korean types). Kobe.

Winter Annual Legumes

Crimson Clover (*Trifolium incarnatum*, Figure 9)

Adaptation: Adapted to most North Carolina soils, except dry, sandy, and very poorly drained soils. Well adapted to upland loams and low-lying medium, well-drained soils. In general, it is preferable to other winter annual legumes (Figure 10) except hairy vetch, which usually proves superior on deep, sandy soils.

Habit and Season of Growth: It is an erect winter annual with shallow tap root. General growth period is October to June. The peak months of production are November, March, April, and May. Crimson clover matures and dies in early June, with 75% of its total production being March to May. Yields average 1 to 2 tons per acre.

Compatibility: Frequently seeded with small grain and/or Italian ryegrass. Also no-till planted into bermudagrass sods to extend the grazing season.

Nutritive Value: Very high quality (70 to 75% digestible with 16 to 22% crude protein) when immature, but declines (58 to 68% digestible) with maturity. Cattle graze both leaves and stems. Dry matter intake is high. A good source of phosphorus, calcium, and magnesium.

Use: Hay, grazing, silage, and soil improvement.

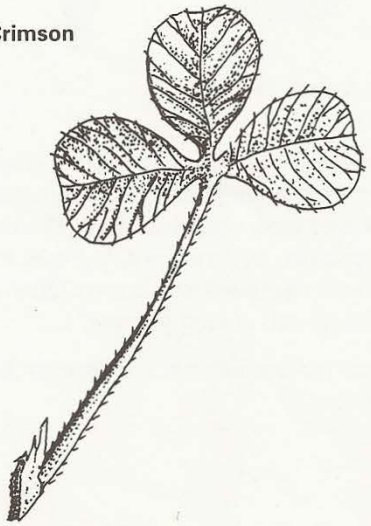

Figure 9. Crimson clover.

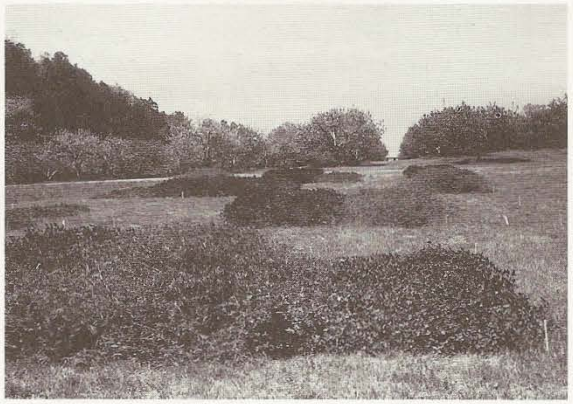

Figure 10. Winter annual and perennial legumes in April overseeded into hybrid bermudagrass in September.

Fertility Requirements: Requires pH of 5. 5 to 6. 0 with medium phosphorus and potassium. Apply 200 to 300 pounds of 0-10-20 or 0-25-25 per acre in pure stand depending on phosphorus and potassium levels in the soil. In mixture with small grain or ryegrass apply 300 to 400 pounds of 10-10-10 per acre.

Establishment and Management: See Chapter 11. Inoculation usually necessary. May graze lightly in November and December if 6-inch growth is present.

Crimson may be grazed to 2 to 4 inches when growth reaches 6 to 8 inches. Hay or silage is usually cut at early flower. Natural re-seeding of some cultivars can be accomplished by managing to permit some plants to form seeds in late May to early June; the perennial companion crop will have to be closely grazed in the fall. Graze closely in early spring if seeded with warm-season perennial grass because crimson is highly competitive with the perennial in early spring.

Cultivars: Tibbee, Dixie.

Hairy Vetch (*Vicia villosa*, Figure 11)

Hairy vetch will grow on a wide range of soil types and grows better than crimson clover on extremely sandy soils. Not frequently used in piedmont since it becomes a pest in small grain, and other legumes offer more potential.

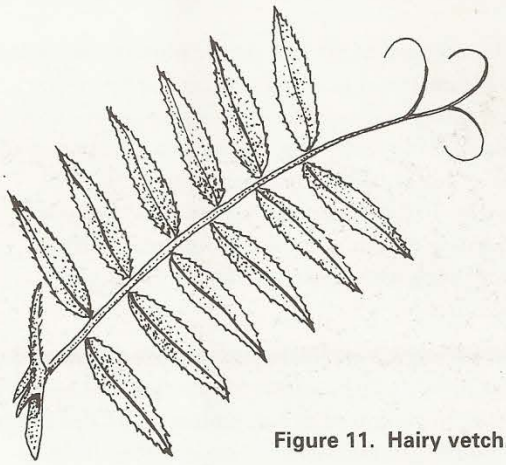

Figure 11. Hairy vetch.

Hop Clovers—Large hop (*Trifolium agrarium*) and small hop (*Trifolium dubium*)

Hop clovers have yellow flowers and grow throughout the state on most well-drained soils. The seeds have been widely distributed. They volunteer frequently and are much less productive than crimson clover.

Arrowleaf Clover (*Trifolium vesiculosum*)

Arrowleaf clover produces growth four to six weeks later in the spring than crimson clover. This legume has performed poorly in North Carolina compared with crimson or other legumes.

Subclover (*Trifolium subterraneum*)

Subclover has been erratic in its performance in North Carolina. Several successful plantings have been made, but volunteering is not always dependable. Late summer showers cause germination, but plants die during hot, dry periods in August and September. It has an advantage in that it can be closely grazed and still produce seed for volunteering. Not as productive as crimson, but the advantages for crimson will be fewer under close intensive grazing. Mt. Barker is one of the better cultivars.

Berseem Clover (*Trifolium alexandrinum*)

This legume has not proven dependable in its performance in North Carolina.

Cool-Season Perennial Grasses

Tall Fescue (*Festuca arundinacea,* Figure 12)

Adaptation: Adapted throughout North Carolina on all soils except the dryer sands. Grows well on soils too wet for orchardgrass. The presence of endophyte fungus (*Acremonium coenophialum*), found in more than 90% of the old Kentucky 31 tall fescue pastures in North Carolina, has been associated with persistency, animal health disorders, and poor animal performance. Persistence of endophyte-free tall fescue cultivars is usually less and more variable than endophyte-infected Kentucky 31. Endophyte-infected stands have persisted more than 20 years. We have observed endophyte-free tall fescue for only 10 years. In observations to date, endophyte-free stands have persisted three to 10 years in North Carolina.

Habit and Season of Growth: Semi-erect bunch-type grass, with short rhizomes. Spreads very slowly by rhizomes. Remains green throughout much of the year in North Carolina. Peak production months are March, April, May, September, October, and November. Tall fescue makes fair growth in mid-summer when fertility and moisture are ample, but frequently becomes dormant after 14 to 21 days of no rain. Yields range from 3 to 5 tons per acre.

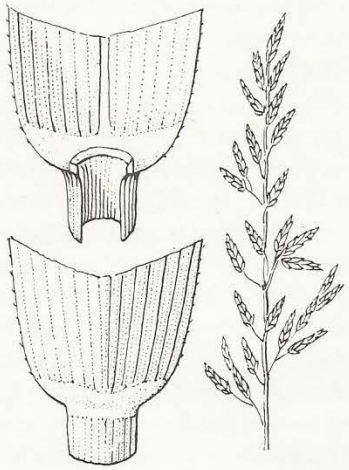

Figure 12. Tall fescue.

Compatibility: Grows well with ladino clover and red clover, but endophyte-infected Kentucky 31 is too competitive with alfalfa.

Nutritive Value: High in quality (70 to 80% digestible) when immature and leafy, but declines (55 to 60% digestible) when allowed to head. Dry matter intake is high. When compared with endophyte-free, endophyte-infected Kentucky 31 tall fescue has produced decreases in daily gain of 0.5 to 1.0 pound when grazed throughout the spring and summer in the southeastern United States. Daily performance of beef cattle will not be as greatly reduced from animals grazing infected fescue if they are moved to warm-season species when maximum ambient air temperatures consistently exceed 85°F (mid-June). Fungus-free cultivars should be used if fed to lactating dairy cows or pregnant mares.

Use: Grown alone or as a companion grass with ladino clover or other legumes for grazing, hay, silage, and erosion control. Suitable for fall accumulation for winter grazing.

Fertility Requirements: When grown with ladino clover, the lime and mineral nutrient requirements recommended for ladino-grass mixtures are generally sufficient. Tall fescue is frequently used in pure stand (apply about 600 pounds of 10-10-10 per acre at time of establishment). Where legume composition is less than 20%, or when seeded in pure stand, tall fescue cut one or more times for hay should be fertilized with about 160 pounds (clay and silt loams) to 200 pounds (sandy soils) of nitrogen per acre annually in split applications. The range is to allow for variation in desired yields and for soil production potential (use higher rates on sandy soils and about 20% less on clay and silt loams). When applying 200 pounds of nitrogen, apply approximately 500 pounds per acre of a 0-10-20 on soils medium in phosphorus and potasssium, and proportionately less if less nitrogen is used. The rates of nitrogen and other fertilizers applied should be reduced about 25% when grazed throughout the season. All forages produce less when grazed than when cut the optimum number of cuts for hay. Also, some of the nutrients in the animal waste are effectively returned to the sod. Apply nitrogen February 1 to March 1, and in August or September, using equal amounts at each date. The phosphorus and potassium fertilizers may be applied in February (or later) at the same time as the first application of nitrogen. In the piedmont and mountains, a good target date for late summer is August 7. In the coastal plain, this date should be delayed until September 1.

Establishment and Management: See Chapter 11. Fall is usually the best time for seeding, but a March seeding in piedmont and mountain areas also can be successful. To start vegetative regrowth, clip pastures whenever grass heads. In pure stand, accumulate growth in August, September, and October on a portion of the acreage. Graze heavily in November, December, and January. Also graze in March, April, and May, with light mid-summer grazing. Graze to 2-inch stubble. To reduce or eliminate toxicity problems in existing endophyte-infected pastures of tall fescue, add ladino clover, do not graze during mid-summer (use warm-season alternatives), and do not graze seedheads or below 2-inch stubble.

Cultivars: Use endophyte-free such as AU-Triumph, Forager, Cajun, Phyter, and several others.

Orchardgrass *(Dactylis glomerata,* Figure 13*)*

Adaptation: Requires medium- to well-drained soils. Well adapted to piedmont and mountain areas. In lower piedmont and coastal plain, stands usually thin out after about three years. In upper piedmont and mountains, stands are thinning by the fifth year due to disease and lack of good grazing management.

Habit and Season of Growth: It is a tall, erect, bunch-type grass without rhizomes or stolons. Grows from March to November. More than 60% of production is during March to June and September. Grows some throughout summer when moisture is adequate. More susceptible than tall fescue to leaf deterioration from frost. Yields an average of 3 to 5 tons per acre.

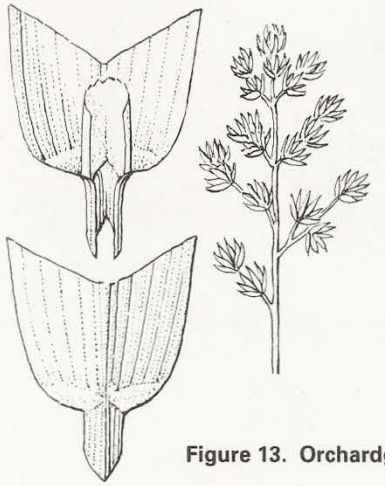

Figure 13. Orchardgrass.

Compatibility: Grows well with legumes, particularly ladino clover, red clover, or alfalfa. It is more competitive in the western third of the state.

Nutritive Value: High quality when immature (73 to 78% digestible and crude protein of 14 to 20%), but declines with maturity (58 to 65% digestible at full bloom) and when foliage is damaged by leaf diseases. When immature, dry matter intake is high.

Use: Grazing, silage, or hay, in a pure stand or with ladino clover, red clover, or alfalfa. Makes better hay and more summer growth than tall fescue, and is easier to manage than tall fescue in mixture with ladino in upper piedmont and mountains.

Fertility Requirements: When grown with ladino clover or alfalfa, lime and mineral nutrient requirements recommended for ladino-grass or alfalfa-grass mixtures will be sufficient. Where legume stands are less than 20%, nitrogen and other fertilizers should be applied similarly to that applied to pure stands of tall fescue.

Establishment and Management: See Chapter 11. Establishment time and methods are similar to fescue. Because orchardgrass is an erect, bunch-type plant, it will not withstand frequent close grazing (closer than 2 inches). Individual plants do not "fill in" because of lack of rhizomes and vigorous tillering. Stand loss from overgrazing is most likely during mid- and late summer. Harvest seedheads to initiate new vegetative regrowth, and to improve palatability and quality.

Cultivars: Boone, Hallmark, Shiloh, and Benchmark.

Kentucky Bluegrass (*Poa pratensis*, Figure 14)

Adaptation: Best adapted to mountain and upper piedmont areas. It is the dominant grass found in old pastures throughout the mountain area. In areas where renovation is practical, orchardgrass is preferred because of higher yield. Requires medium drainage and grows best on soils of medium to high productivity.

Habit and Season of Growth: Has narrow, soft, smooth leaves and forms a dense sod because of its rhizomes. Volunteers readily in all new seedings of mountain and upper piedmont areas. General period of growth is March 15 to November 1. Peak months of production are March to May and September. Grows very little during mid-summer months. Uneven seasonal production is its major weakness. Not as productive as orchardgrass or tall fescue. Yields of predominately bluegrass-white clover pastures range from 2 to 3 tons per acre.

Compatibility: Very competitive, but can be grown with white clover.

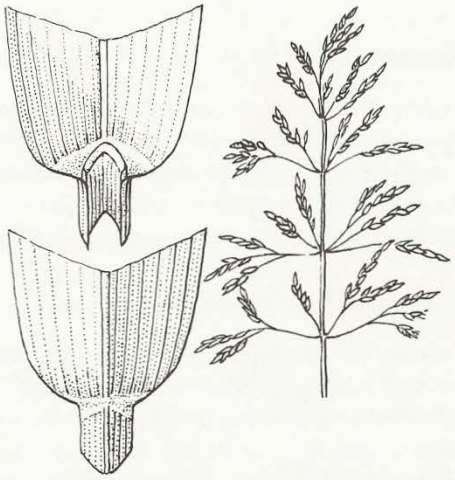

Figure 14. Kentucky bluegrass.

Nutritive Value: Very palatable and high in quality (75 to 80% digestible and 14 to 20% crude protein) when properly fertilized and in a vegetative stage. Quality declines in mid-summer (59 to 63% digestible) or if allowed to head (52 to 58% digestible).

Use: Used almost exclusively for grazing.

Fertilization: Kentucky bluegrass performs best when pH is 5.8 to 6.2, and it responds directly to liming and other nutrients. Because bluegrass is primarily grown with white clover, it is fertilized to suit the clover's needs. White clover is also encouraged by liming and fertilizing. Application of 1 to 2 tons of lime and about 200 pounds per acre of 0-25-25 will usually result in successful establishment of volunteer white clover where adapted. When Kentucky bluegrass is used primarily in pure stand, approximately 65% of the nitrogen and other nutrients recommended for tall fescue should be applied because Kentucky bluegrass produces about 65% as much forage as tall fescue (see tall fescue section in this chapter).

Management: It volunteers readily if lime and fertilizers are applied. Kentucky bluegrass-white clover pastures must be grazed fairly closely (from 4 to 6 inches back to 1 to 1.5 inches) in early spring to maintain the white clover. However, very close grazing in summer and fall reduces yields, causes soils to dry out, and accelerates runoff and erosion.

Redtop (*Agrostis gigantea*, Figure 15)

Redtop is a cool-season, rhizomatous perennial grass adapted to most soils except dry sands. It withstands considerable drought and wetland conditions, but is not as productive as tall fescue or orchardgrass and has been replaced by those grasses in pastures.

Timothy (*Phleum pratense*, Figure 16)

Timothy is best adapted to a cool, moist climate. It is not well adapted in North Carolina except on a few of the better soils along the streams in the mountain areas. Primarily used for hay. It produces 60 to 70% of annual yield by June and very little regrowth. Will not withstand close continuous grazing.

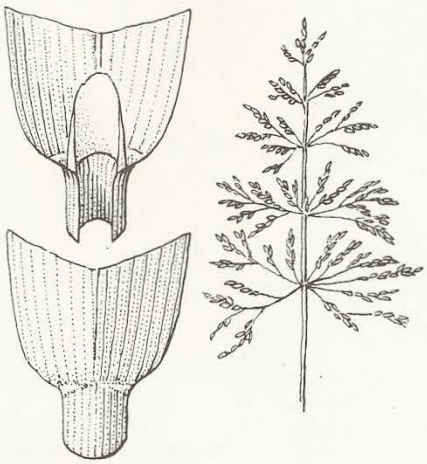

Figure 15. Redtop.

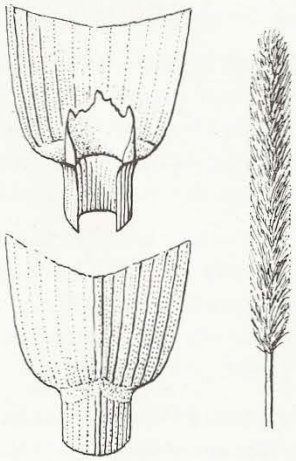

Figure 16. Timothy.

Perennial Ryegrass (*Lolium perenne*, Figure 17)

Perennial ryegrass is a cool-season, bunch-type perennial grass that is very high in quality (74 to 80% digestible). It grows best on fertile, well-drained soils (except dry sands), but will also grow on poorly drained sites. It usually persists only two years in this state because of disease buildup; primarily *Rhizoctonia solani*. Very high yield first year; same as fescue second year; less than fescue third year. Fertilize similarly to tall fescue.

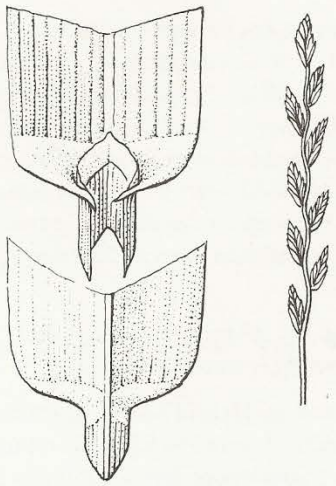

Figure 17. Perennial ryegrass.

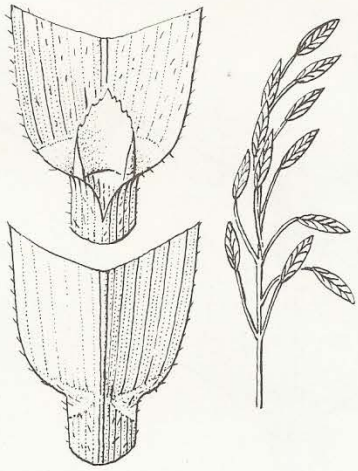

Figure 18. Rescuegrass.

Rescuegrass (*Bromus catharticus*, Figure 18)

Adaptation: Rescuegrass is widely adapted to well-drained clay and loam soils. It does not do well on poorly drained or coarse sands. Most widely found in piedmont and mountains. Is found as a volunteer in meadows and along field borders and roadsides.

Habit and Season of Growth: It is a short-lived (two to three years) cool-season perennial providing excellent yields during the first year. It is necessary to allow it to re-seed to maintain stands after the second year. Makes excellent fall and early spring production. It produces flowering stems from late spring throughout the summer and is a prolific re-seeder with strong seedling vigor.

Compatibility: Grows well with legumes and other grasses. It may be overseeded onto bermuda for winter and spring grazing, but it will be very competitive during the late spring.

Nutritive Value: Is relatively high-quality grass (65 to 70% digestible and 12 to 20% crude protein) that holds its quality during maturity better than most cool-season grasses. Animals readily graze the young stems and seedheads and will selectively graze the vegetative growth when given the opportunity.

Use: Primarily pasture, also hay or silage.

Fertility Requirements: Fertilization should be similar to tall fescue.

Establishment and Management: Planting techniques for pure stands or mixtures with clovers are similar to those for tall fescue, but the seeding rate is 20 to 30 pounds per acre.

It is best to rotationally graze or cut it about every four to six weeks rather than to let it accumulate large masses, especially during the fall and winter.

It fits best as a short rotation pasture or hay crop between row crops or as part of a pasture renovation process. Because of its seedling vigor and reseeding characteristics, it could become a pest in small grains or other fall-seeded forages.

Cultivars: Matua; it is a bromegrass called prairiegrass and rescuegrass.

Warm-Season Perennial Grasses

Hybrid Bermudagrass (*Cynodon dactylon*, Figure 19)

Adaptation: Adapted throughout the coastal plain, piedmont, and lower mountains except on poorly drained soils. Subject to winter injury in the mountain area, especially the upper mountains. They are particularly well adapted to sandy soils and grow

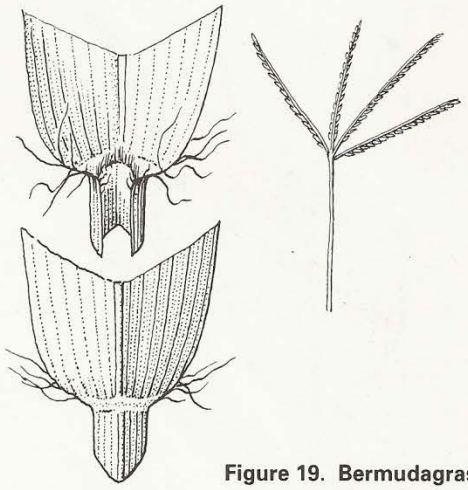

Figure 19. Bermudagrass

well on deep sands. Tifton 78 is well adapted in the southeastern coastal plain, but is subject to severe winter injury in the northern portions. In the lower eastern piedmont and coastal plain both Tifton 44 and Coastal are well adapted. Tifton 44 is better adapted to the central, northern, and western piedmont and lower mountains than other cultivars because it is more hardy in the winter.

Habit and Season of Growth: Hybrids are similar in general appearance to common bermuda but are taller and usually yield more forage. Unlike common bermuda, which spreads by seed, hybrid bermudagrasses produce no live seed, spreading instead by rhizomes and stolons. General growth period is April to October. Peak months of production are June, July, and August. Yields range from 3 to 6 tons per acre.

Compatibility: It is difficult to grow a summer legume with bermudagrass, but it is possible to overseed with crimson clover, red clover, ladino clover, cereal grains, or Italian ryegrass for winter or early spring grazings.

Nutritive Value: Quality is moderate (60 to 63% digestible and 12 to 16% crude protein) if kept immature and leafy (under 4 inches), but is of fair quality (48 to 52% digestible) if allowed to reach 12 to 14 inches or get older than four weeks of age. Generally very palatable and with high dry matter intake. Short grazing to maintain high quality may limit daily dry matter intake. Daily gains for steers are less for bermudagrass (0.7 to 1.0 pound) than for continuously grazed switchgrass (2.0 to 2.3 pounds) and flaccidgrass (1.6 to 1.9 pounds). Excellent beef gains per acre (over 1,200 pounds) can be obtained because stocking rate needs to be high (up to 10 steers per acre) because of its high productivity to keep it vegetative compared with switchgrass and flaccidgrass (three to four steers per acre).

Use: For grazing, hay, silage, and erosion control. Very useful for sandy textured soils.

Fertility Requirement: Hybrid bermudagrasses tolerate fairly acid soils (pH 5 to 5.5), but respond to liming. During establishment, fertilize initially with 200 to 300 pounds of 0-25-25 per acre in row when "sprigged in." During April and July of the first year, apply a total of 60 to 100 pounds of nitrogen per acre in split applications. After the first year, hybrid bermudagrasses cut for hay (usually three times) should be fertilized with approximately 180 pounds (clay and silt loams) to 225 pounds (sandy loams) of nitrogen per acre annually in split application in April, and after the first and second cuts (usually made in June and July). The range is to allow for variations in desired yields, and/or soil production potential (use higher rates on sandy soils and about 20% less on clay and silt loams). When applying 200 pounds of nitrogen, apply approximately 500 pounds per acre of a 0-10-20 on soils medium in phosphorus and potassium, using more or less proportionately, depending on the amount of nitrogen applied. The phosphorus and potassium fertilizer is usually applied in April at the same time as the first application of nitrogen. On some of the better soils of the coastal plain counties, particularly in the southeast, the rates of nitrogen for hay production may be increased up to 300 pounds per acre. The rates of nitrogen and other fertilizers applied should be reduced about 25% when grazed throughout the season.

Establishment and Management: See Chapter 11. Hybrid bermudagrasses must be established from sprigs. DO NOT let sprigs dry in sun or wind before planting. Best planted when dormant in February, March, and early April. Can also be planted in late

spring and summer whenever moisture is ample. When sprigging Coastal or Tifton 78, use at least 10 bushels of sprigs per acre in rows 3 to 4 feet apart, and sprigs spaced 2 to 3 feet in the row.

Tifton 44 is slower to establish than Coastal, therefore double the sprigs per row and cut in half the row spacings (about 40 bushels per acre).

With commercial planters, hybrid bermudagrass may be planted in 18- or 20-inch rows by off-setting and going over the field twice. Use from 40 to 75 bushels of sprigs per acre. On farms where sprigs are plentiful, stands can be established by broadcasting liberal quantities (75 to 100 bushels per acre) in late winter and disking in. One bushel equals approximately 1.25 cubic feet and contains about 1,200 sprigs.

Common bermuda is established by seeding sometime around corn planting time into a prepared seedbed. Acceptable stands are generally obtained in six to eight weeks. For both hybrid and common bermudagrass, care should be exercised to control weeds, particularly crabgrass in the first year, by cultivation, mowing, or careful grazing. After establishment, graze when 4 to 10 inches tall. Close grazing will reduce yields of bermuda in first year. After first year, graze when 6 inches back to 1-inch stubble. Harvest hay at height of 12 to 15 inches or at four- to six-week intervals during growing season. Bermudagrass should go into the winter with 3 to 4 inches of growth to serve as insulation against winter damage. Burn residue in late February or early March. Necessary to graze or mow very closely and disk lightly in order to establish legumes after sod has become thick.

Cultivars: Coastal, Tifton 44, Tifton 78, Guymon (common), and Pasto Rico (common).

Switchgrass (*Panicum virgatum*, Figure 20)

Adaptation: Grows throughout the state. Grows best on well-drained soils with good moisture supply; however, it will grow on droughty or moderately wet soils and will tolerate occasional flooding. Long-term perennial (15 years in Raleigh, N.C.) once established and properly managed. Carrying (stocking) capacity not as high as hybrid bermudagrass. Yields range from 3 to 5 tons per acre.

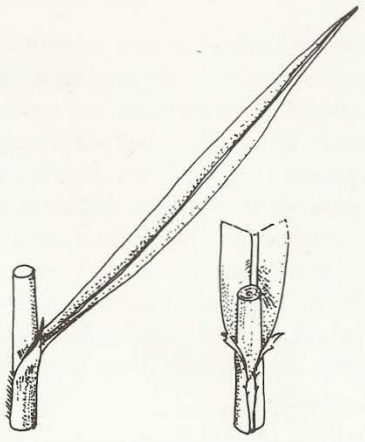

Figure 20. Switchgrass.

Habit and Season of Growth: Erect, bunch-type grass with medium to large stems and short rhizomes. Under grazing, leafy regrowth develops from basal and axillary tillers. Plants are ready for grazing in the lower piedmont about four weeks earlier than Coastal bermuda. Peak production months are May to July. Cultivars vary widely in heading dates, ranging from June to early August. Weak seedling vigor.

Nutritive Value: Very high-quality grass (70 to 78% digestible and 10 to 15% crude protein) when continuously grazed to a 6-inch stubble. During June to August in Raleigh, steers gained 2 pounds per day on switchgrass and 0.9 pound per day on Coastal bermudagrass (three years). It is very palatable and intake is high. If harvested for hay or silage (direct cut or wilted to 60 to 65% moisture), digestibility of 60 to 64% is possible if cut at late vegetative stage, but declines rapidly (to 54%) as stems elongate for the boot stage (grazing and harvest data all from the cultivar Kanlow). Carrying (stocking) capacity not as high as hybrid bermudagrass.

Use: For grazing, hay, silage, biomass, erosion control, and wildlife.

Fertility Requirements: Switchgrass requires less nitrogen per pound of growth than does hybrid bermudagrasses, but under grazing it will not produce as much total dry matter. Use 25 to 30% less nitrogen,

phosphorus, and potassium than recommended for hybrid bermudagrasses for establishment and maintenance. To minimize competition from weeds during establishment, do not apply nitrogen at planting; apply about 40 pounds of nitrogen per acre when seedlings are 6 to 8 inches tall. Usually no additional nitrogen is needed first year. For annual maintenance, apply first application of nitrogen and necessary phosphorus and potassium about one month earlier (usually March) than for hybrid bermudagrass. Established stands rarely respond to more than 100 to 140 pounds of nitrogen per acre.

Establishment and Management: See Chpater 11. Frequently 20 to 40% of the switchgrass seed are dormant in the first six to nine months after harvest. Standard germination tests can be misleading because dormancy is artificially broken by a wet prechill treatment when tests are conducted. Buy two-year-old seed or keep new seed stored at room temperature for five to six months (buy seed in December to seed in May), or pre-soak and chill to break natural dormancy. Switchgrass seedlings lack vigor, and growing weeds can offer severe competition. No-till planting can reduce weed competition. When seeding into a rye, wheat, or tall fescue stubble, clip or graze to 2-inch stubble and kill sod at least four to six weeks before seeding. Advantages have been realized from killing a fescue sod in September (rather than waiting until April) before seeding switchgrass in May. Also seeding into a stubble of last year's millet or sorghum has strong advantages. In year of seeding, permit switchgrass to reach full seedhead stage (seed in dough or later) before grazing or cutting for hay (back to 6-inch stubble). After establishment year, two to three hay cuttings annually are expected. Graze after first year continuously at 5 to 10 inches, or rotationally 18 to 22 inches back to 5 to 6 inches.

Cultivars: Alamo, Kanlow, Cave-In-Rock.

Flaccidgrass (*Pennisetum flaccidum*)

Adaptation: Adapted to all areas of the state, and to most soils except extremely wet soils. Adaptation in sandhills has not been evaluated. A long-term perennial (greater than 12 years) if properly managed.

Habit and Season of Growth: Erect, upright with short, stout rhizomes. Will grow to 3 to 5 feet. Under grazing, leafy regrowth develops. Peak growth months are May and June with some decline in July and August. Begins heading in June; heads profusely in July and August. Begins spring growth in lower piedmont three to four weeks earlier than coastal bermudagrass. Yields range from 3 to 6 tons per acre.

Nutritive Value: High quality (70 to 78% digestible and 10 to 15% crude protein) and intake is high. Average daily gains of steers on flaccidgrass were 1.98 pounds, compared to 1.27 for a tall fescue/coastal bermudagrass system. Animal carrying (stocking) capacity is 30 to 40% as much as hybrid bermudagrass.

Use: For grazing, hay, and silage.

Fertility Requirements: Slightly lower than hybrid bermudagrass. For establishment and maintenance, use 10 to 20% less nitrogen, phosphorus, and potassium than for hybrid bermudagrass. At planting, wait until flaccidgrass is 6 to 8 inches tall to apply 40 pounds of nitrogen per acre. Apply additional 60 pounds of nitrogen during summer of first year. For annual maintenance, apply first application of nitrogen and necessary phosphorus and potassium about three weeks earlier than for hybrid bermudagrass.

Establishment and Management: See Chapter 11. May be established vegetatively from sprigs (when dormant in March) or from seed. No-till seeding should be done in May. In establishment year, graze rotationally from 24 to 30 inches back to 6 inches. In subsequent years, graze continuously between 4 and 7 inches, or rotationally 16 inches back to 4 to 5 inches in two to five days. For hay, take first cutting when plants are between boot stage and head emergence (24 to 36 inches tall). Subsequent cuttings can be taken in 30 to 40 days or when plants are more than 24 inches tall. Leave 10 to 18 inches in fall and burn in late winter. Stand damage may result from soil compaction by grazing animals or heavy equipment when soil is wet. Not suited to overseeding with winter annuals.

Cultivars: Carostan.

Dallisgrass (*Paspalum dilatatum*, Figure 21)

Dallisgrass is a warm-season perennial bunch grass of good quality (63 to 68% digestible). It grows on most soils of the piedmont and coastal plain but is best adapted to moist soils. Lacks seedling vigor and is difficult to obtain a stand. For the most part, this grass has been replaced in this state by other grasses.

Common Bermudagrass (*Cynodon dactylon*)

Common bermudagrass is adapted on well-drained soils of the piedmont and coastal plain. May be established by seeds. Local ecotypes vary greatly in productive capacity. Some are very good producers of dry matter and may be of good quality (57 to 62% digestible) when kept immature and managed to maintain new growth. Can become a serious pest because seed are distributed in dung of stock and birds. Fertilize with 60 to 75% of the rates of nitrogen, phosphorus, and potassium recommended for hybrid bermudagrasses.

Bahiagrass (*Paspalum notatum*, Figure 22)

Bahiagrass is a rhizomatous, warm-season perennial grass that is mainly adapted in the coastal plain area, of moderate quality (58 to 62% digestible), and subject to winter injury. It is adapted to a wide range of soil conditions, growing on droughty upland sandy soils and those that are medium wet. It is established by seed. Pensacola bahiagrass is not as productive as hybrid bermudagrasses at high fertility levels but similar in performance at low to medium (50 to 100 pounds) levels of nitrogen. Fertilize with about 60 to 75% of the rates of nitrogen, phosphorus, and potassium recommended for hybrid bermudagrass. Pensacola bahiagrass is adapted but subject to occasional winter kill. (As much as 80% winter kill if temperatures reach minimums of 10 to 16°F on a few days.) Tifton 9 bahiagrass was developed from Pensacola bahiagrass and has greater seedling vigor; produces 35 to 50% higher yields. At Tifton, Georgia, it has slightly outyielded Coastal bermudagrass and is of higher quality. Should be similar to Pensacola in winter hardiness. Tested on limited basis in North Carolina. The Wilmington strain is more hardy but not readily available.

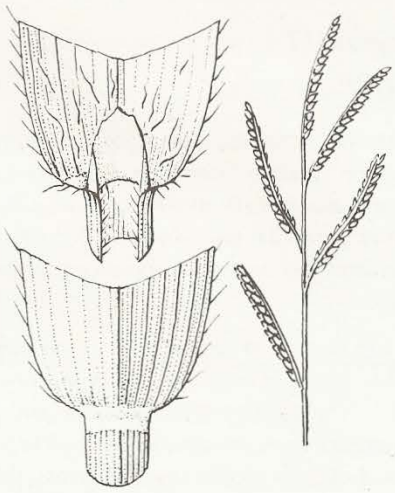

Figure 21. Dallisgrass.

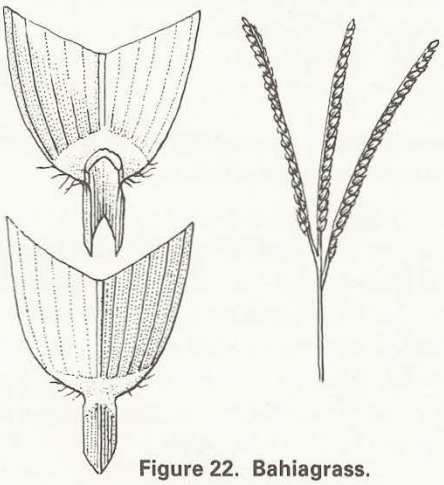

Figure 22. Bahiagrass.

Carpetgrass (*Axonopus affinis*)

Carpetgrass is a stoloniferous warm-season perennial, adapted to most coastal plain soils except dry sands. Very poor yield potential. This grass should be replaced in pastures.

Gamagrass (*Tripsacum dactyloides*)

Eastern Gamagrass

Adaptation: Native to North Carolina and grows throughout the state. Grows on well-drained uplands, but also persists on wet-natured soils. It is a long-lived perennial that produces 4 to 6 tons of hay per acre from two to three harvests or several grazings.

Habit and Season of Growth: It is a tall, erect bunch grass that grows in large clumps from 1 to 4 feet in diameter. It spreads by short rhizomes and produces seed from July to September on stems 3 to 9 feet tall. Its growth cycle is similar to switchgrass, which is about three to four weeks earlier in the spring than bermudagrass.

Nutritive Value: Palatable, nutritious, and readily eaten by all types of livestock. Young, actively growing leaves are 65 to 72% digestible and 12 to 18% crude protein.

Uses: Primarily for grazing, but also for hay, silage, erosion control, and wildlife.

Establishment: Seed dormancy is high, so special treatment is needed before planting. Plant wet-chilled seed about 1 to 1.5 inches deep after the soil temperatures reaches 60 to 65°F. The best stands are obtained when the seeds are planted in 6- to 10-inch rows using conventional or no-till drills. A corn planter may be used, but the row spacings should be no more than 18 inches apart.

Management in seedling year: Expect very little use for hay or pasture during the establishment year. Fertilization during establishment year should include about 30 to 50 pounds of nitrogen per acre after the seedlings are greater than 10 inches tall.

Management of established stands: Burn old frosted residue in late winter. Grazing should begin when the plants are 16 to 24 inches tall and never grazed closer than 6- to 8-inch stubble. For hay, the plants may be allowed to reach 24 to 36 inches tall before cutting to a 4- to 6-inch stubble.

Fertility requirements: It will respond to similar levels and timing of nitrogen as bermuda. The phosphorus and potassium requirements are about the same as for bermuda.

Cultivars: Seed is readily available of Pete and Iuka.

Caucasian Bluestem (*Bothriochloa caucasica*)

Adaptation: It is well adapted to most soil types but grows best on finer texture soils such as loams, clay loams, and silt loams. It will, however, grow acceptably on sandy-loam soils. It is ideally suited for marginal cropland areas. No serious disease problems have been reported.

Habit of growth: It is a warm-season, long-lived perennial bunch grass. It is an erect, fine-stemmed, leafy bunch grass which produces many seedheads above the leaf base throughout the summer. Its leafy growth habit is more similar to bermuda or orchardgrass than to other native warm-season grasses. Plants are ready for grazing in the lower piedmont about three weeks later than switchgrass and one week earlier than Coastal bermudagrass.

Nutritive Value: When it is grazed in the vegetative leafy condition, animal performance is excellent; however, mature and old growth will be very low quality. Crude protein ranges from 8 to 15%, and it is 60 to 70% digestible. Animal gains in summer will range between 1.25 to 2 pounds per head per day.

Use: Primarily for pasture, but also for hay.

Establishment and Management: The seeds are extremely chaffy and light and number about one million per pound. Plant at 2 pounds live seed (PLS) per acre using equipment or methods that will ensure that seeds get into proper contact with soil. Plantings are usually made into prepared, firm seedbeds where the seeds are placed at a depth of ¼ inch. However, plantings may be made using no-till procedures if the sod residue is highly weathered and very short (less than 2 inches tall). Plantings should be made after soil temperature reaches 65°F, usually in May in most parts of the state.

Old growth from the previous year can be burned in February or March, and will assist in weed and disease control. If burning is not possible,

mow the dead residue as short as possible. Grazing can begin when growth reaches 8 to 10 inches in spring, or the first growth may be cut for hay followed by grazing. Stubble height should be about 3 to 4 inches for most rapid regrowth.

Fertility requirements: Caucasian is tolerant of fairly acidic, infertile soils, but best production will require medium levels of phosphorus and potassium and pH of 5.8 to 6.2. Nitrogen during the establishment year is usually low (less than 50 pounds per acre), especially if competition from "grassy" weeds is severe. On established stands apply about 50 pounds of nitrogen per acre at green-up and once or twice more at four- to six-week intervals, depending on soil moisture conditions. Fertilize with nitrogen, phosphorous, and potassium at rates similar to those of switchgrass.

Cultivars: Caucasian.

Johnsongrass (*Sorghum halepense*)

Adaptation: It is best adapted to fertile heavy clay or loam soils that have good internal and surface drainage; however, Johnsongrass will grow on most soils with adequate fertility.

Habit and Season of Growth: It is a tall, upright-growing, warm-season perennial capable of spreading rapidly from rhizomes and seed. Rhizome development is most pronounced as seedheads are produced. It provides abundant forage during summer months.

Nutritive Value: Hay cut in boot stage or pasture grazed just before boot stage would be about 12 to 15% crude protein and 60 to 65% digestible. When mature (seedheads formed), its crude protein drops to 6 to 9% and digestibility drops to 40 to 55%. In general, its quality is similar to sudangrass or sorghum-sudangrass hybrids. The potential of prussic acid is similar to all sorghum species and it may be hazardous to livestock if grazed or green-chopped immediately after a killing frost. Precautions normally taken for sorghum-sudan hybrids should be taken when grazing Johnsongrass.

Establishment and Management: If Johnsongrass is to be managed as a forage plant, volunteer stands must be maintained since seed laws prohibit seed sales in many states. Renovating old stands requires cultivation every two to five years. Stands have been thickened by early spring disking. Frequent, heavy grazing weakens stands because it does not allow rhizome formation, which primarily occurs during heading. Allowing 20 to 30 days rest between cutting or grazing favors its survival. At least one cutting per season should be allowed to reach bloom.

Fertility requirements: Its responses to nutrients are similar to the responses of sudangrass or sorghum-sudangrass hybrids.

Use: Primarily for hay or silage but also for pasture.

Cultivars: There are no varieties of Johnsongrass because of its potential as weed and because existing seed laws classify it as a noxious weed.

Summer Annual Grasses

Pearlmillet (*Pennisetum americanum*)

Adaptation: Adapted to most medium- or well-drained soils of the state except deep, sandy soils. Has proven superior to sudangrass and sorghum-sudan hybrids on sandy loams of the coastal plain.

Habit and Season of Growth: Erect summer annual. More leafy than sorghum-sudan hybrids. Grows 3 (dwarf cultivar) to 6 feet tall. General growth period is May 1 to October 1. Peak production months are June, July, and August. Will produce 3 to 4 tons of dry forage per acre.

Nutritive Value: Good quality (60 to 65% digestible and 14 to 18% crude protein) if grazed when 12 to 24 inches tall. Becomes less palatable and cattle consume mainly leaves when allowed to head.

Use: Grazing, hay, or silage.

Fertility Requirement: Performs best in a soil of pH 6.0 to 6.5 and medium phosphorus and potassium. Apply 400 to 500 pounds per acre of complete fertilizer such as 10-10-10 at planting. Topdress with 40 to 50 pounds of nitrogen per acre when 6 to 8 inches high and again after first grazing period, or

after every cutting for hay except the last. (Total nitrogen per acre per year should not exceed 160 pounds.)

Establishment and Management: See Chapter 11. Graze rotationally with one- to three-day durations. Permit 14 to 24 inches of growth before each grazing period; graze to 6- to 8-inch stubble. Does not produce prussic acid. The dwarf selection (Tifleaf) is much easier to manage for grazing. It has less stalk with the same number of leaves as the tall form.

Cultivars: Tifleaf (dwarf). Tifleaf is more leafy and less erect. See Forage Crops Variety Testing Reports. Many good cultivars available. Pearlmillets can be classified into three categories: dwarf (less than 4 feet), semi-dwarf (4 to 6 feet), and tall (6 to 8 feet). The taller the millet, the more stemmy the growth. Although the tall types may yield more dry matter, they do not necessarily produce more milk or gain per acre, and they definitely do not give as much daily performance. Dwarf types include Tifleaf-I and Tifleaf-II; semi-dwarf types include Leafy-20 and 3-Mil-X; and tall types include Mil-Hy, Pearlex, Millgreen-79, and Hybrid Pearl (variety not stated).

Other Millets

Foxtail millet or Italian millet (*Setaria italica*) has slender, erect, and leafy stems reaching 2 to 5 feet tall. It matures quickly but lacks the ability to regrow after being harvested or injured by drought. Because of its shallow root system it is one of the first crops to show the effects of drought. Yields are 50 to 75% of pearlmillet. The hay contains a glucoside, called setarian, which acts as a diuretic on horses that consume it continuously as the sole roughage. The hay can be fed to cattle or sheep without danger. The most common variety is German; other varieties include Siberian, Hungarian, Turkestan, Empire, and White Wonder.

Japanese barnyard millet (*Echinochloa crusgalli* var. *frumentacea*) grows 2 to 4 feet tall. The cultural methods are similar to those for the foxtail millets. It is used as a pasture or hay crop, but its thick stems make it difficult to cure. Japanese barnyard millet hay is palatable when cut before the plant heads, but much less so as it approaches maturity. This millet probably originated from the common weed, barnyardgrass (*E. crusgalli*), which it closely resembles. It is not planted often in North Carolina.

Browntop millet (*Panicum ramosum*) is a quick-growing summer annual, reaching 2 to 4 feet tall. It is grown for hay or pasture as well as to provide feed for quail, doves, and other wild game birds. It is finer stemmed than pearl, but less productive. It is a heavy seed producer and will volunteer readily, causing it to become a weedy pest in some cultivated crops.

Sorghum-Sudan Hybrids and Sudangrass (*Sorghum bicolor*, Figure 23)

Adaptation: Adapted to most medium- to well-drained soils in the state. Pearlmillet is superior to sorghum-sudan hybrids or sudangrasses on sandy loams of the coastal plain. The sorghum-sudan hybrids usually yield more than pearlmillet on the heavier textured piedmont soils.

Habit and Season of Growth: Erect summer annuals. Grows 4 to 8 feet tall. Sudangrass is shorter and has finer stems than most sorghum-sudan hybrids. General growth period is from May 1 to October 1. Peak production months are June, July, and August. Hybrids of sorghum-sudan will produce 3 to 5 tons of hay if cut four to five times (Figure 24) and 7 to 8 tons dry matter equivalent if cut for silage.

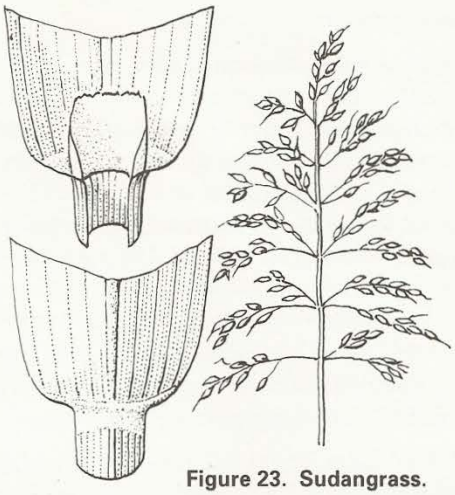

Figure 23. Sudangrass.

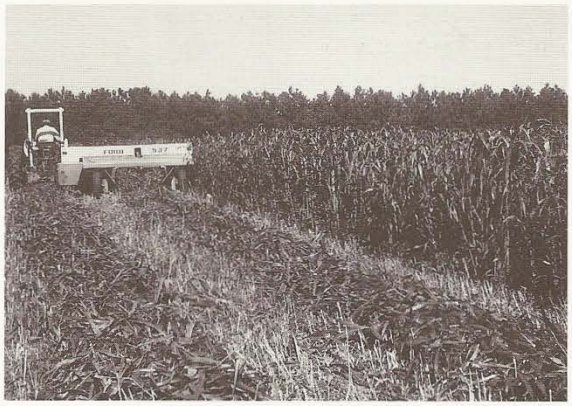

Figure 24. A sorghum-sudan hybrid on June 20, six weeks after seeding.

Nutritive Value: Good quality (59 to 63% digestible) and high dry matter intake. These annuals usually contain about 15% protein, but have potential for prussic acid poisoning.

Use: Hay, silage, and grazing.

Fertility Requirements: Similar or slightly higher than pearlmillet.

Establishment and Management: See Chapter 11. Similar to pearlmillet. Potential for prussic acid poisoning exists; avoid grazing young seedlings, young regrowth shoots, stunted growth, and frosted plants. There is no prussic acid danger from feeding hay or silage made from these plants. When making silage, delay feeding for six to eight weeks after ensiling.

Cultivars: See Forage Crop Variety Testing Reports. Many good cultivars available.

Crabgrass (*Digitaria sanguinalis*)

Adaptation: Large or hairy crabgrass is widely distributed and well adapted to most soils, but does not tolerate water-logged conditions. It is drought tolerant and responds to moisture more quickly than do many summer grasses.

Habit and Season of Growth: Semi-erect growth with prostrate stems which often root at the nodes when in prolonged contact with moist soil (resembles stolons). It is a warm-season annual that volunteers readily from seed. It produces good growth from June through September. Yields range from 3 to 5 tons per acre.

Compatibility: It is very competitive with other grasses, especially with slower-growing species.

Nutritive Value: Crabgrass is a highly palatable plant and usually provides higher quality forage than bermudagrass and bahiagrass. Digestibility is usually 5 to 8% higher than bermudagrass at equivalent stages of maturity (ranges from 62 to 72%). Crude protein ranges from 7 to 18% depending on stage of growth and nitrogen fertilization. Stocker steers have gained between 1.5 and 2.0 pounds per day in most situations.

Establishment and Management: Crabgrass can be planted into prepared seedbeds immediately after the last spring frost. Disking or other tillage during the dormant season (fall-winter) appears to be essential for productive reseeding stands. Breakdown of the previous year's residue is important because crabgrass is self-toxic (autoallelopathic). A procedure for double cropping: cut or graze crabgrass completely by September 1; disk, drag, and plant rye as soon as possible; graze rye to completely use growth by about May 1; if crabgrass volunteers in the pasture before May 1 (or end of grazing) do not till the pasture. If not present at rye graze-out, disk and drag pasture; as soon as grass is up and beginning to tiller, apply 70 to 80 pounds of nitrogen per acre. Repeat nitrogen application in late June or early July; begin grazing when grass is about 4 inches tall. Since the stand must be allowed to produce seed sometime during summer, rotational grazing is a good method.

Fertility Requirements: Lime, nitrogen, phosphorus, and potassium requirements are similar to bermudagrass. Nitrogen is most efficiently used in split applications at 50 to 75 pounds per acre for two to three times. An initial preemerge nitrogen application is very beneficial to stand development and productivity. Applying nitrogen to young grass in the one- to four-leaf stage can sometimes damage stands, especially under wet conditions.

Use: Primarily for pasture but also for hay or silage.

Cultivars: Red River is the only one available.

Winter Annual Grasses

Italian Ryegrass (Annual Ryegrass) (*Lolium multiflorum*, Figure 25)

Adaptation: Most soils of the state.

Habit and Season of Growth: Has bunch-type leafy growth but tillers profusely. Volunteers readily. Peak season of growth is later in spring than winter rye, and suppresses early summer growth of bermuda more than rye. Yields range from 2 to 4 tons per acre with more than 50% in April to May.

Compatibility: Very competitive in seedling stage. May become a pest in cereals for grain, perennial legumes, and cool-season perennial grasses. Works well for mixtures of winter pastures.

Nutritive Value: Very high quality (77 to 82% digestible and 14 to 20% crude protein) with high daily dry matter intake when in vegetative stage. Quality declines similarly to orchardgrass as plant matures.

Use: Primarily grazing. Overseeded in bermudagrass to extend season.

Fertility Requirements: For average phosphorus and potassium conditions, apply 500 to 600 pounds of 10-10-10 at planting. On sandy soils make additional applications of 60 to 80 pounds of nitrogen per acre when plants are 2 to 3 inches tall in November, and topdress with 50 pounds of nitrogen on or near February 15.

Establishment and Management: See Chapter 11. May be seeded into soybeans after frost, or bermuda before frost, to extend the grazing season.

Cultivars: Many available. See Forage Crops Variety Testing Reports.

Small Grains

Small grains will produce 1,500 to 2,500 pounds of forage between early fall and April 1 if seeded early and topdressed with sufficient nitrogen. Another 1,000 to 2,000 pounds of forage are usually produced after April 1.

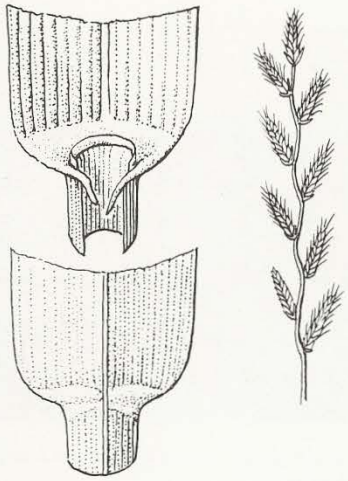

Figure 25. Annual ryegrass.

Frequently, the small grains, particularly rye, barley, and oats, are seeded early and grazed throughout the growing season. All small grains are high in quality (70 to 80% digestible and 15 to 20% crude protein) when grazed and kept vegetative; dry matter intake is high. If grain harvest is desired, considerable grazing can be obtained between November 1 and February 15 without materially reducing grain yields. Barley matures earlier than wheat, which can be of major importance as a source of silage in a double cropping system. In general, wheat will not produce as much forage during fall and winter as other small grains.

Rye produces more forage than barley on sandy land, whereas barley frequently is more productive on the clay soil of the piedmont. See Italian ryegrass for fertilization recommendations.

Miscellaneous Plants

Turnips, Rape, Kale, Swedes

These crops are members of the mustard family and belong to the genus *Brassica*. The forage Brassicas are readily eaten by livestock and can be divided into two groups:

■ **Leafy Brassicas** — include rape and kale which provide forage from leaves and stems.

■ **Root Brassicas** —include turnips and swedes which provide forage from leaves, stems, and roots.

Under favorable growing conditions, rape and turnips are ready for grazing earlier than kale and swedes, but yield less. Brassicas can provide much needed high-quality forage during periods when the perennial forage supply is limited (October to December). They should not be used as the sole source of feed because they contain more than 90% water, are very low in fiber content, and contain substances that may become toxic upon prolonged (several weeks) feeding of an all-Brassica diet. Flowers of turnips have a high content of mustard oil which can be toxic to animals. Also, turnips may cause an off-flavor in milk. Immature rape can be high in nitrate, especially with high nitrogen fertilization. Brassicas will grow on a wide range of well-drained soils.

Chapter 9

SILAGE PRODUCTION

James T. Green, Jr. and J. Paul Mueller

What Is Silage?

Silage is the result of partial fermentation of a crop containing high moisture. It is preserved as a result of acid production.

What Crops Can Be Ensiled?

Ensiling is the process of making silage. Practically speaking, most crops grown for livestock feed can be ensiled successfully (Table 1). The crop management practices necessary to obtain good silage yields vary, but the principles of making good silage are similar for most crops.

Principles of Making Silage

Three interacting factors that govern the outcome of silage making include chemical composition of the plant, air, and bacteria. The chemical composition is primarily controlled by plant type and the stage of growth at harvest. Air in silage is controlled by the size of chop, moisture content, amount of packing, silo size, and extent of silo sealing.

What Happens During Ensiling

Phase 1. The live plant tissue put into the silo continues to respire as a result of plant enzymes and oxygen-living bacteria using plant carbohydrates and oxygen to produce carbon dioxide and heat. Silage temperature is elevated to about 90°F. Water may be lost (as seepage) because of respiration and compaction.

Phase 2. When the air is used up, oxygen-free bacteria use plant carbohydrates to produce lactic, propionic, acetic, and other organic acids. This phase may continue for three to four days as the pH drops from about 6.0 to 4.2.

Phase 3. From days four to 21, another group of bacteria (lactobacilli and streptococci) convert carbohydrates into lactic acid, resulting in a pH of less than 4.0 and a decline in silage temperature.

Phase 4. Silage becomes stable (about two days) and will remain of good quality for long periods if kept free of air.

Moisture Content

Silages are often classified by moisture content of the ensiled crop. The following section explains these classifications.

High-moisture Silage (70% or higher)

When silage is too wet, has a high pH, or has oxygen present, undesirable bacteria (clostridia) can multiply, producing butyric acid and nitrogen compounds which reduce the quality and acceptability. Additives are needed to improve quality.

Wilted Silage (60 to 70% moisture)

If a standing crop forage contains more than 75% moisture, it is necessary to allow the forage to dry in the swath or windrow until moisture drops to 60 to 70%. Wilted crops ferment and rely on lactic acid for preservation to a lesser degree than direct cut crops. Usually a pH of 4.5 or less is indicative of good-quality wilted silage.

Haylage (40 to 60% moisture)

When forages are allowed to wilt to 40 to 60% moisture, preservation depends on maintaining air-free conditions. At this relatively high dry matter content, little bacterial growth and fermentation takes place. Thus, pH is not a good measure of silage quality. If air infiltrates the silage, mold growth and heating will take place. This can result in fires or in the formation of indigestible protein and reduced energy values for the silage. A brown- or black-colored silage with a tobacco or caramelized odor is an indicator that heat damage has occurred.

Table 1. Recommended stages to harvest various crops for silage, and the dry matter (DM) and yield estimates.

Crop	Stage to harvest		Dry matter at harvest (%)	Yield (tons/acre)		Management suggestions and characteristics of good silage
	1st harvest	2nd and subsequent harvest		Dry matter per harvest	65% moisture per year	
Alfalfa	Bud–10% flower	Bud–10% flower	25–35	1.0–1.5	11–17	Dark green; pH <6.5; wilt to 56–65% moisture
Bermuda	Pre-head (12–15" tall)	30 days–Pre-head or 12–15" tall	30–35	0.5–1.2	10–17	Pale green; pH <6; wilt to 55–65% moisture; use additives
Fescue, Orchardgrass, Ryegrass	Boot to heading	Every 30 days[1] (12–15")	25–30	0.7–1.2	8–14	Dark green; pH <6; wilt to 55–65% moisture; use additives
Wheat, Barley	Boot (B) to softdough(SD)	Regrowth in boot	25(B)–35(SD)	0.7–3.0	8–16	Boot = best quality, requires wilting to 55–65% moisture Softdough = high yield direct cut
Rye	Boot (pre-head)	Boot	20–25	0.7–1.5	6–9	Wilt in boot to 55–65% moisture.
Sudan, Sorghum-Sudan, Millet	Boot to 36" height	Boot to 36" height	25–30	1.0–2.0	8–14	Wilt to 55–65% moisture
Forage Sorghum	Boot or softdough	Boot or softdough	20–35	1.0–5.0	8–20	Wilt to 55–65%; direct cut in softdough
Soybean	Pre-pod to bean farming	Usually one harvest	25–40	1.0–3.0	5–8	Wilt pre-pod to 55–65% moisture pre-pod; direct cut at bean fill
Corn	Grain in dent, black layer forming, ½ milkline	—	30–35	4.0–8.0	11–25	Direct cut
Tropical Corn	Late autumn milk-dough	—	26–32	4.0–7.0	11–20	Direct cut, but delay until moisture drops in stalk to 28–32% if possible

[1] These grasses produce most hay or silage when heading in mid-spring. May make second cut economically from fescue and orchardgrass in some years and then graze remainder of season.

Growing Phase Management

Crop management is much the same regardless of how the crop is to be preserved and stored. The following paragraphs present information that is crop-specific. See Chapter 11 for specific information on dates and rates of seeding.

Hay-Type Crops (alfalfa, clovers, fescue, orchardgrass, ryegrass, millet, sudangrass, soybeans)

These crops should be managed the same whether they are grown for silage or hay. The only exception is soybeans, which may be planted in narrow rather than wide rows and which have a higher seeding rate.

Small Grains

When used for silage rather than grain, the nitrogen rate will usually be 25 to 50% higher, the planting rates will be about two times higher, the planting dates may be earlier, and varieties are more vegetative and taller.

Sorghums

The forage sorghums may be drilled in narrow rows (6 to 10 inches) if harvested in the boot stage, but the seeding rate is about twice that of wide row plantings (36 inches). Sorghums to be harvested in soft-dough stage are usually planted in wide rows. Sudangrass and its hybrids are usually planted in narrow rows or broadcast; they are usually harvested in boot to early heading stages of growth.

Corn (conventional hybrids)

Production practices for corn silage are similar to those normally used for grain. For example, pest control (weeds, insects, disease), residue management, tillage practices, and planting practices are essentially the same for both uses. Corn for silage is usually planted at populations of 24,000 to 30,000 plants/acre, which is about 25% higher than recommended for grain. The fertilizer rate is usually higher for silage because the whole plant is removed from the land. Nitrogen, phosphate, and potash rates are about 25 to 50% higher for silage than for grain.

The highest grain-yielding hybrids do not always provide the most total digestible nutrients or silage yield. Generally it is best to choose a tall, leafy, full-season hybrid. However, mid- to short-season hybrids or tropical hybrids may be desired when double cropping with small grains for silage or when attempting to extend the harvesting period over which the optimal ensiling stage occurs. Some companies have special "silage hybrids" available.

Tropical corn

These hybrids are adapted to late-season planting because they have high tolerance to moisture stress and late-summer insect pests. They are extremely sensitive to day length, and should be planted between June 1 and July 10, or they will grow so tall that lodging and harvesting become a severe problem. Tropical corn is especially valuable for double cropping with small grain or following first cutting of some perennial crop. Otherwise, the cultural practices are similar to those of conventional hybrids. Nitrogen rates for tropical corn should be 100 to 200 pounds of nitrogen per acre; phosphorus and potash applications shoud be 80% of that used for conventional silage corn.

Harvesting and Storing Phase of Silage Making

When plants reach the stage for ensiling (as discussed earlier), the optimum time for harvest may last only five to 10 days. Therefore, it is critical that equipment be in good operational condition to avoid large changes in plant moisture content.

Specific Harvesting and Storing Recommendations for Corn

Stage to harvest (conventional hybrids)

The dry matter content should be 30 to 42%. The lower leaves and husks will exhibit some browning and ears will have fully dented kernels. As the plant and kernels mature to the full dent stage, a distinct "milk" line can be seen on the endosperm face of the kernel. At maturity, several layers of cells at the tip of the kernel die, forming a "black layer." Conventional hybrids should be harvested while the black layer is forming, but before the milk line recedes below the 50 to 75% position. This usually occurs when kernels are well dented. If harvesting is delayed until the black layer is fully formed, the forage may be too dry for ensiling. In drought stress, plants are wetter than they appear.

Harvest stage for tropical hybrids will usually be later and moisture content will be higher at harvest than conventional hybrids; seepage losses from silos may be more evident than from conventional corn hybrids. Grain content will usually be low, but the digestibility and protein composition will be comparable to or slightly higher than conventional hybrids.

Making Wilted Hay Crop Silage

With hay crop silages, such as alfalfa, fescue, orchardgrass, and bermudagrass, the optimum moisture content for direct cut ensiling is not reached until nutritive value has greatly decreased. However, cutting these crops and letting them wilt before ensiling is a way to obtain the correct moisture at the favorable stage for high nutritive value.

- Harvest at proper stage to optimize quality and yield (Table 1).
- Wilt to 55 to 65% moisture by windrowing the forage for a few hours (2 to 8 hours).
- Chop the material through a 3/8 - to ½-inch cutter. If an additive is to be used, apply it at the chopper to improve distribution in the silage mass.
- Fill the silo quickly (one to three days) and pack tightly. Deep narrow trench silos are easier to pack than wide shallow ones. It is more difficult to make stacks on the ground because the sides cannot be packed easily.
- Cover the silage mass immediately with 6-millimeter black polyethylene plastic and use something to hold the plastic in place.

Round Bale Silage

- Harvest at proper stage of growth and use a round baler that can handle wet forage. Usually the bales are about 60 to 75% of normal size because of their weight.
- Wilt to 50 to 60% moisture, which is slightly dryer than when chopping and ensiling. If additives are used, they should be applied at baler.
- Seal the bales as quickly as possible (within a few hours of baling) by putting them into plastic bags or wrapping with a bale wrapper.
- Be careful not to break the plastic wrap or allow rodents to penetrate because air will cause silage to spoil.
- Because it is difficult to keep the bales sealed for more than a few months, this silage should be fed before other silage. The price of plastic and wrapping makes this storage method relatively expensive, but it offers opportunity to save hay crops which may otherwise be lost because of weather damage.

Silage Additives

Several different types of additives are available to supplement silage making, but do not substitute them for good harvest and ensiling management practices. Additives should do at least one of the following:

- provide fermentable carbohydrates
- furnish additional acids directly to decrease pH
- inhibit the undesirable types of bacteria
- reduce the amount of oxygen present
- modify the moisture content of the silage
- result in savings that exceed the cost of their use

Table 2. Materials that provide energy sources for production of acids that preserve silage.

Material	Lb/ton of silage
Ground corn, wheat, barley	100 to 200
Molasses	60 to 80
Dry citrus or beet pulp	100 to 200
Dry whey	30 to 50

Examples of silage additives are

Carbohydrates. These materials (Table 2) provide energy sources for production of acids which preserve the silage. They are most often beneficial with immature grasses and legumes. Such additives retain more than 75% of the feeding value in the silage, unless seepage losses occur.

Bacteria, enzymes, and antibiotics. The bacteria are mainly *lactobacillus* and/or *streptococci*, which produce lactic acid from plant sugars; this lowers pH quickly. The enzymes speed up the initial fermentation process. The purpose of antibiotics is to counteract, or stop, the bacteria, yeasts, and molds, which deplete lactic acids and diminish the silage's quality.

Research results from using the inoculants are quite variable, although it is generally accepted that these products should be considered for hay-crop type silages, and perhaps sorghums, but not for corn.

Propionic acid. Propionic acid is used primarily as a fungicide and to reduce the pH of silage. It is most often added to the top of the silo to reduce surface spoilage.

Nitrogen and calcium. Urea and anhydrous ammonia are used, especially on corn silage, to increase protein, improve digestibility, improve packing, and extend bunk life. Urea and anhydrous ammonia are usually added at 7 to 10 pounds/ton of silage. They are not usually added to high protein crops because there have been some adverse animal responses. Limestone, at 10 pounds/ton of silage, has been used to increase the calcium and lactic acid in silage.

Absorbent materials. Another important fuction of silage additives is to help manage the silage's moisture content. Moisture content of the ensiled crop is very important to the success of silage making. Harvesting on time, wilting, and planting cultivars with different maturity dates are the best ways to control the moisture content of ensiled material. However, it is often necessary to add water or "absorb" excess moisture because things could not be done on time.

If a crop is too wet at ensiling, a practical way to reduce seepage is to add an absorbent to the silage (Table 3) to absorb water and improve silage quality. Harvesting crops before the dry matter content is satisfactory for ensiling can result in seepage and poor fermentation.

Water. If a crop is too dry, water can be added to bring dry matter content to at least 40%. Water uniformly mixed with the forage at roughly 7 gallons of water per ton before ensiling will increase the moisture content by about 1%. Changing the moisture content of silage is probably impractical if moisture needs to be changed beyond about 5%.

Table 3. Materials to be used for absorbing excessive water in silages.

Material	Water absorbing capacity/lb of material applied	Lb of material to absorb 100 lb water
	lb	
Beet pulp	2.9	34
Ground alfalfa hay	2.3	43
Ground dry corn cobs	2.0	50
Ground ear corn	1.3	77
Ground shelled corn, wheat	0.7	142

Characteristics of Good Silage Quality

Laboratory analyses are very helpful in assessing the potential nutritional value of silage, which is directly related to animal performance. However, there are some visual characteristics that indicate quality of certain silages:

- **Stage of growth** at harvest has significant impact on quality.
- **Color** indicates amount of heating or mold content. Corn should be green to yellowish-green, and hay crops should be light to dark green. Dark brown or black indicates excessive heating; whitish or grayish color indicates mold.
- **Odor** indicates degree of fermentation and excessive heating. A slight vinegar or yeasty odor is acceptable, but a tobacco-like aroma is a sign of excessive heat damage.
- **Moisture** indicates degree of fermentation and amount of seepage. A ball of silage squeezed in the hand should leave no free water.
- **Chop** indicates ease of packing and should be short, ¼ to ¾ inch, with crisp, sharp cut edges.

Steps to Producing High-Quality Silage

- Harvest the forage at the proper stage of maturity and moisture content to attain the maximum quantity of a nutritious product.
- Exclude air from the silage mass by chopping the forage fine, ¼ to ¾ inch; filling the silo rapidly (one to three days); packing tightly in horizontal silos; and covering and sealing the silo immediately

Table 1 presents the crops that are most often ensiled, the suggested stage to harvest, and some characteristics of the crops at those stages.

Chapter 10

SEED QUALITY

Janet M. Ferguson

Variety selection and seed quality contribute significantly to forage yield and quality. The use of high-quality seed of adapted varieties is therefore basic to establishing or renovating pastures. Poor-quality seed can lower yields, reduce forage quality, increase management costs, and result in crop failures.

Seed Quality Components

Seed quality is composed of four key components: germination, genetic purity, crop purity, and seed health. The importance of each component is described in the following section.

Germination. Germination is the stage when growth resumes, leading to the development of a young plant. The process of germination is regulated by temperature and moisture. Forage seed must have adequate moisture immediately after seeding to promote germination and seedling growth. Temperature can be equally important. Each forage species has a specific range of temperatures at which germination occurs. If the temperature at planting falls outside this range, germination may be slowed or prevented or the seedlings may be killed. Excessively high or low temperatures can also increase seed dormancy, causing a delay in germination and pasture establishment. It is therefore important for growers to be aware of the germination requirements of the species they are planting and sow fields when conditions are favorable. These conditions are listed in Chapter 11.

Genetic purity. Varieties are adapted for specific uses and production areas. The genetic constitution of a variety will dictate disease and insect resistance, plant response to climatic extremes, forage quality, and many agronomic characteristics. Growers should purchase seed of a known variety and be certain that the seeds are genetically pure. The best assurance of obtaining genetically pure seed is to buy certified or professionally grown seed.

Genetic purity, or trueness to variety, is established and maintained by special purification and seed increase programs, by field and seed inspections, and by pedigree records. The blue certified seed tag assures genetic integrity and is issued only to seed lots that meet specific genetic, physical and physiological quality standards.

Crop purity and seed health. Seed lots with even small amounts of weed seed or other crop seed can cause serious economic losses and lower forage quality. Weeds and other crop plants compete with the desired species for nutrients, space, and soil moisture and are often difficult or expensive to control. Some weeds, such as serrated tussock, Canada thistle, or horsenettle, can be harmful to cattle or can cause a direct threat to pasture value. Other weeds that are frequently found in forage seed include dock, sedge, wild garlic, and wild onion.

Some seed lots may be infected with an endophyte that can cause serious economic losses. To avoid contaminated seed lots that lower pasture value, growers should select seed carefully and purchase seed only from a reputable dealer.

Seed Analysis Tag

The seed tag or label (Figure 1) contains information about the contents and quality of the seed lot and must be displayed on all agricultural seed sold in North Carolina. The North Carolina Seed Law prohibits the sale of forage seed that 1) fall below 70% germination, 2) contain more than 1% weed seed, or 3) contain excessive amounts of *restricted* noxious weeds. Seed lots that contain any *prohibited* noxious weed seed may not be sold or offered for sale.

Seed Selection

Forage yield and quality, as well as animal performance, can be influenced by the species and variety selected and by the quality of the seed purchased. Growers should read the seed tag carefully and only purchase seed lots of adapted varieties that meet quality standards known to promote a healthy, weed-free, high-quality pasture.

Figure 1. The seed tag or label serves as a means of communication between the buyer and seller.

Kind:_____ Variety: _____ Origin: _____

Lot Number: _____ Vendor: _____

Net Weight (lb): _____ Pure Seed (%): _____

Germination (%): _____ Inert Matter (%): _____

Hard Seed (%): _____ Weed Seed (%): _____

Test Date: _____ Other Crop Seed (%): _____

Noxious Weed/lb: _____

PLANTING GUIDE FOR FORAGE CROPS IN NORTH CAROLINA

James T. Green, Jr., J. Paul Mueller, and Douglas S. Chamblee

This chapter provides the best available information about planting rates, depths, and stand evaluation for forage crops commonly grown in North Carolina (Table 1).

Planting Region

The climate and soils of North Carolina vary considerably across the state. The planting dates in this guide are listed for the major regions and are based on normal growing conditions (Figure 1).

Planting Time

Establishing a successful forage crop depends partly on weather conditions shortly before and after planting. Delaying planting until the last possible dates indicated in the table may reduce the chance of getting a good stand by 30 to 50%.

With a few exceptions, the perennial cool-season forages can best be established by planting in the late summer or fall. Here are some points to remember about fall planting:

- Cool-season grass seedlings are more tolerant of freezing temperatures and heaving than are legumes.
- In prepared seedbeds, alfalfa and ladino clover should have five to seven true leaves present when frequent freezing weather occurs. In a sod, one to two true leaves will usually suffice.
- In prepared seedbeds, grasses should have three to four leaves before freezing weather occurs. In a sod, one to three leaves will suffice.

Sod Seeding—Fall and Winter

Fall plantings can be made later in sod than in prepared seedbeds because the existing sod provides protection for the developing seedlings during the winter. Delaying planting until about October 15 in the coastal plain and piedmont, for example, results in much less insect damage.

When planting ladino clover or alfalfa in an established sod of tall fescue or other cool-season grass, late winter or early spring (February to March) plantings are often a good alternative to fall plantings. Planting legumes in the winter deters seedling diseases that often attack fall plantings. If alfalfa is sod-seeded in winter, the existing cool-season grass must be killed between October and November before seeding. When planting low-

Figure 1. Average date of first freezing temperature in fall.

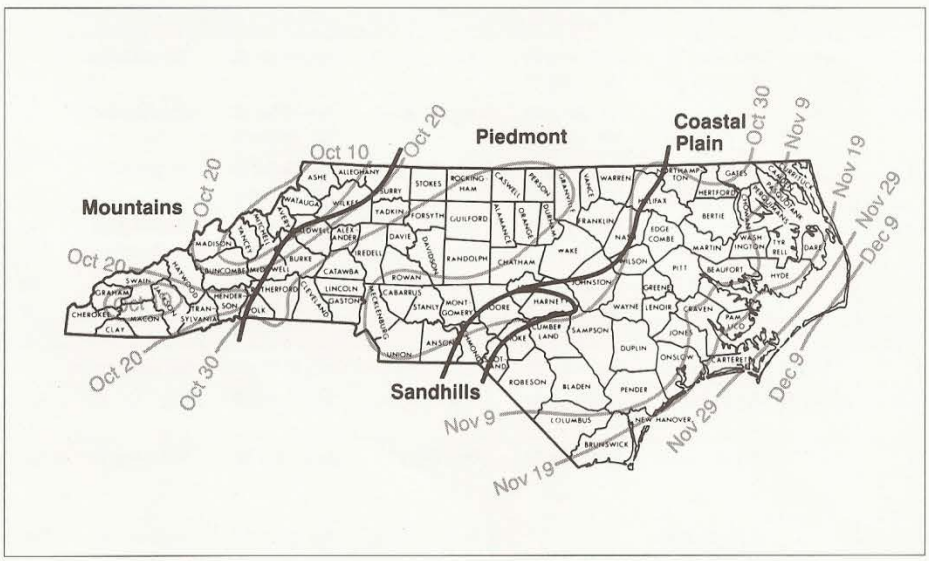

Table 1. FORAGE PLANTING GUIDE FOR NORTH CAROLINA

Crop	Seeding Rate (lb/acre) B: broadcast D: drill (4- to 9-inch rows) R: row (30+ inches) PLS: pure live seeds	Planting Depth (inches)	Mountains (above 2,500 ft elevation)[1] See footnote for below 2,500 ft		Piedmont and Tidewater[2]		Coastal Plain[2]	
			Best Dates	Possible Dates	Best Dates	Possible Dates	Best Dates	Possible Dates
PERENNIAL GRASSES								
Bahiagrass	B:15-25; D:10-20	¼ - ½	Not adapted		Not well adapted		Feb 15-Mar 15	Feb 1-Mar 31
Bermudagrass (Hybrid) Sprigs - bu. = 1.25 ft³	B:25-40; R:5-15 bushels	1 - 3	Not adapted		Mar 1-Mar 31	Feb 15-May 1 or thru Jul if irrigated	Mar 1-Mar 31	Feb 15-Apr 15 or thru Jul if irrigated
Bermudagrass (Common—seed only)	B:6-8; D:5-7	¼ - ½	Not adapted		Apr 15-May 15	Apr 1-Jun 15	Apr 1-May 15	Mar 15-Jun 7
Big Bluestem	D:8-10 PLS; B:10-12 PLS	¼ - ½	May 25-Jun 15	May 7-Jun 30	May 7-May 20	May 1-Jun 30	May 1-May 15	Apr 15-Jun 30
Bluegrass	B:10-15; D:8-12	¼	Jul 25-Aug 10	Jul 15-Aug 25	Not well adapted		Not well adapted	
Caucasian Bluestem	D:2 PLS; B:4 PLS	¼	May 25-Jun 15	May 7-Jun 30	May 7-May 20	May 1-Jun 30	May 1-May 15	Apr 15-Jun 30
Dallisgrass	B:20-30; D:15-20	¼ - ½	Not adapted		Not well adapted		Mar 1-Mar 30	Feb 15-Apr 15
Eastern Gammagrass	D:8-10 PLS; B: Do not broadcast	¾ - 1	May 25-Jun 15	May 7-Jun 30	May 7-May 20	May 1-Jun 30	May 1-May 15	Apr 15-Jun 30
Flaccidgrass	D:2-4; Sprig: 3-5/ft in 18" rows; Tillers: 6-8/ft	¼ - ½ 2 - 3 root cover	May 25-Jun 15 Mar 1-Apr 7 May 15-Jun 15	May 15-Jun 30 Feb 15-Apr 15 May 1-Jul 15	May 7-May 20 Feb 20-Mar 15 Apr 25-Jun 1	May 1-Jun 30 Feb 1-Mar 30 Apr 15-Jul 15	May 1-May 15 Feb 15-Mar 15 Apr 20-May 20	Apr 15-Jun 15 Feb 1-Mar 30 Apr 15-Jun 10
Indiangrass	D:8-10 PLS; B:10-12 PLS	¼ - ½	May 25-Jun 15	May 7-Jun 30	May 7-May 20	May 1-Jun 30	May 1-May 15	Apr 15-Jun 30
Orchardgrass	B:12-15; D:8-12	¼ - ½	Jul 25-Aug 10 Mar 20-Apr 20	Jul 15-Aug 20 Mar 1-May 15	Aug 25-Sep 15	Aug 25-Oct 25 Feb 15-Mar 31	Not well adapted	
Reed Canarygrass	B:5-10; D:4-8	¼ - ½	Jul 25-Aug 10 Mar 20-Apr 20	Jul 15-Aug 20 Mar 1-May 15	Aug 25-Sep 15	Aug 25-Oct 25 Mar 1-Mar 31	Not well adapted	
Rescuegrass	D:20-25; B:25-35	½ - ¾	Aug 20-Sep 7 Mar 15-Mar 30	Aug 15-Oct 1 Mar 1-Apr 30	Sep 1-Sep 15 Mar 1-Mar 30	Aug 25-Oct 15 Feb 15-Apr 30	Sep 1-Sep 30	Aug 25-Oct 15
Smooth Bromegrass	B:10-20; D:8-15	¼ - ½	Jul 25-Aug 10 Mar 20-Apr 20	Jul 15-Aug 20 Mar 1-May 15	Not well adapted		Not adapted	
Switchgrass	D:6-10PLS	½	May 7-Jun 7	Apr 25-Jun 30	Apr 7-May 7	Mar 20-Jun 30	Apr 1-May 1	Mar 7-Jun 30
Tall Fescue	B:15-20; D:10-15	¼ - ½	Jul 25-Aug 10 Mar 20-Apr 20	Jul 15-Aug 20 Mar 1-May 15	Aug 25-Sep 15	Aug 25-Oct 25 Feb 15-Mar 31	Sep 1-Sep 30	Sep 1-Oct 31 Feb 15-Mar 20
Timothy	B:10-12; D:8-10	¼ - ½	Jul 25-Aug 10 Mar 20-Apr 20	Jul 15-Aug 20 Mar 1-May 15	Not well adapted		Not adapted	
MIXTURES								
Orchardgrass + Alfalfa	B:5 + 20; D:3 + 15	¼	Jul 25-Aug 10 Mar 20-Apr 20	Jul 15-Aug 20 Mar 1-May 15	Aug 25-Sep 15	Aug 25-Oct 15	Not well adapted	
Orchardgrass + Ladino Clover	B:12 + 4; D:9 + 3	¼	Jul 25-Aug 10 Mar 20-Apr 20	Jul 15-Aug 20 Mar 1-May 15	Aug 25-Sep 15	Aug 25-Oct 15 Feb 15-Mar 31	Not well adapted	
Orchardgrass + Red Clover	B:12 + 10; D:9 + 8	¼	Jul 25-Aug 10 Mar 20-Apr 20	Jul 15-Aug 20 Mar 1-May 15	Aug 25-Sep 15	Aug 25-Oct 15 Feb 15-Mar 31	Not adapted	
Tall Fescue + Ladino Clover	B:10 + 4; D:8 + 3	¼	Jul 25-Aug 10 Mar 20-Apr 20	Jul 15-Aug 20 Mar 1-May 15	Aug 25-Sep 15	Aug 25-Oct 15 Feb 15-Mar 31	Sep 1-Sep 30 (heavy soils only)	Sep 1-Oct 25 Feb 15-Mar 20
Tall Fescue + Red Clover	B:10 + 8; D:8 + 6	¼	Jul 25-Aug 10 Mar 20-Apr 20	Jul 15-Aug 20 Mar 1-May 15	Aug 25-Sep 15	Aug 25-Oct 15 Feb 15-Mar 31	Sep 1-Sep 30 (heavy soils only)	Sep 1-Oct 25 Feb 15-Mar 20
ANNUAL GRASSES								
Barley	B:140; D:100	1 - 2	Aug 1-Aug 20	Aug 1-Oct 10	Aug 25-Sep 15	Aug 20-Oct 31	Not well adapted	
Millet, Pearl (Cattail)	B:20-25; D:15-20; R:6-10	½ - 1 ½	May 15-May 31	May 1-Jun 30	May 1-May 31	Apr 25-Jun 30	May 1-May 15	Apr 20-Jun 30
Millet, Foxtail, and Japanese (Not as productive as Pearl)	D:10-15; R:5-7	½ - 1 ½	May 15-May 31	May 1-Jun 30	May 1-May 31	May 1-Jun 30	May 1-May 15	Apr 20-Jun 30
Oats	B:130; D:100	1 - 2	Not well adapted		Aug 25-Sep 15	Aug 20-Oct 31	Sep 5-Sep 30	Sep 1-Nov 15
Rye	B:120; D:100	1 - 2	Aug 1-Aug 20	Aug 1-Oct 10	Aug 25-Sep 15	Aug 20-Oct 31	Sep 5-Sep 30	Sep 1- Nov 15
Ryegrass	B:30-40; D:20-30	¼ - ½	Jul 25-Aug 10	Jul 15-Aug 31	Aug 25-Sep 15	Aug 20-Oct 31	Sep 1-Sep 30	Sep 1-Oct 31

Table 1. FORAGE PLANTING GUIDE FOR NORTH CAROLINA *(continued)*

Crop	Seeding Rate (lb/acre) B: broadcast D: drill (4- to 9-inch rows) R: row (30+ inches) PLS: pure live seeds	Planting Depth (inches)	Mountains (above 2,500 ft elevation)[1] See footnote for below 2,500 ft		Piedmont and Tidewater[2]		Coastal Plain[2]	
			Best Dates	Possible Dates	Best Dates	Possible Dates	Best Dates	Possible Dates
Ryegrass (With small grain or clover mixture)	Reduce ryegrass rate by 50%	See ryegrass, grain, or clover	See small grain or clover		See small grain or clover		See small grain or clover	
Sorghum (Sudan)	B:35-40; D:20-30; R:15-20	½ - 1	May 15-May 31	May 1-Jun 30	May 1-May 31	Apr 25-Jun 30	May 1-May 15	Apr 20-Jun 30
Sorghum, Forage (Silage)	R:4-6	1 - 1½	May 15-May 31	May 1-Jun 30	May 1-May 31	Apr 25-Jun 30	May 1-May 15	Apr 20-Jun 30
Sudangrass	B:30-40; D:20-25	1 - 2	May 15-May 31	May 1-Jun 30	May 1-May 31	Apr 25-Jun 30	May 1-May 15	Apr 20-Jun 30
Wheat	B:120; D:100	1 - 2	Aug 1-Aug 20	Aug 1-Oct 10	Aug 25-Sep 15	Aug 20-Oct 31	Sep 5-Sep 30	Sep 1-Nov 15
Small Grain Mix (2 Grains)	Reduce each selection by 50%	1 - 2	See dates for grains		See dates for grains		See dates for grains	
Small Grain Ryegrass Mix	Reduce each selection by 25%	½ - 1	See dates for grains and ryegrass		See dates for grains and ryegrass		See dates for grains and ryegrass	
PERENNIAL LEGUMES								
Alfalfa	B:20-25; D:15-20	¼	Jul 25-Aug 10 Mar 1-Apr 7	Jul 15-Aug 20 Mar 1-Apr 15	Aug 25-Sep 15	Aug 25-Oct 15 Mar 1-Mar 31	Sep 1-Sep 30	Sep 1-Oct 31
Alfalfa (For sod seeding into grass)	D:15-20	¼ - ½	Jul 25-Aug 10[3] Sep 15-Oct 1[3]	Jul 25-Oct 15	Aug 25-Sep 15[3] Oct 10-Oct 20[3]	Aug 25-Oct 20	Sep 1-Sep 30[3] Oct 15-Oct 25[3]	Sep 1-Oct 31
Birdsfoot Trefoil	B:8-10; D:6-8	¼	Jul 25-Aug 10	Jul 15-Aug 30	Not well adapted		Not well adapted	
Crownvetch (For erosion control)	B:15-20; D:10-15	¼ - ½	Jul 25-Aug 10 Mar 20-Apr 20	Jul 15-Aug 20 Mar 1-Apr 15	Aug 25-Sep 15 Mar 1-Mar 30	Aug 15-Oct 25 Mar 1-Apr 15	Not well adapted	
Ladino or White Clover	B:5; D:3-5	¼	Jul 25-Aug 10 Mar 20-Apr 20	Jul 15-Aug 20 Mar 1-May 15	Aug 25-Sep 15	Aug 25-Oct 15 Mar 1-Mar 31	Sep 1-Sep 30	Sep 1-Oct 25 Feb 15-Mar 20
Ladino (For sod seeding into grass)	B:5; D:3-5	¼ - ½	Jul 25-Aug 10[3] Aug 1-Sep 1[3] Mar 1-Mar 20	Aug 1-Sep 15 Mar 1-May 15	Aug 25-Sep 15[3] Oct 7-Oct 15[3] Feb 20-Mar 10	Aug 25-Oct 25 Feb 15-Mar 20	Sep 1-Sep 30[3] Oct 7-Oct 15[3] Feb 15-Feb 28	Sep 1-Oct 31 Feb 10-Mar 15
Red Clover	B:10-15; D:8-10	¼ - ½	Jul 25-Aug 10	Jul 15-Aug 20 Mar 1-May 15	Aug 25-Sep 15	Aug 25-Sep 30 Feb 15-Mar 30	Sep 1-Sep 30	Sep 1-Oct 15 Feb 15-Mar 20
Red Clover (For sod seeding into grass)	B:10-15; D:8-10	¼ - ½	Jul 25-Aug 10[3] Aug 1-Sep 1[3] Mar 1-Mar 20	Aug 1-Sep 15 Mar 1-May 15	Aug 25-Sep 15[3] Oct 7-Oct 15[3] Feb 20-Mar 10	Aug 25-Oct 25 Feb 15-Mar 20	Sep 1-Sep 30[3] Oct 7-Oct 15[3] Feb 15-Feb 28	Sep 1-Oct 31 Feb 10-Mar 15
Sericea Lespedeza (Dehulled)	B:20-40; D:15-30	¼ - ½	Mar 15-Apr 15	Mar 1-Apr 30	Mar 1-Mar 20	Feb 15-Apr 30	Mar 1-Mar 20	Feb 15-Apr 30
Sweetclover (Dehulled)	B:20-30; D:10-15	¼ - ½	Jul 25-Aug 10 Mar 1-Apr 7	Jul 15-Aug 20 Mar 1-Apr 15	Aug 25-Oct 15 Aug 25-Sep 15	Mar 1-Mar 31	Sep 1-Sep 30	Sep 1-Oct 31
ANNUAL LEGUMES								
Crimson Clover	B:20-25; D:15-20	¼ - ½	Jul 25-Aug 10	Jul 15-Aug 20	Aug 25-Sep 15	Aug 25-Oct 25	Sep 1-Sep 30	Sep 1-Oct 30
Crimson Clover (Mixed with Ryegrass or Small Grain)	B:20; D:15 Reduce grain by 1/3	¼ - ½	Same as Crimson clover		Same as Crimson clover		Same as Crimson clover	
Lespedeza, Kobe Korean	B:30-40 B:20-30	¼ - ½	Mar 15-Mar 31	Mar 1-May 15	Feb 10-Feb 28	Feb 1-Apr 30	Feb 1-Feb 20	Feb 1-Apr 20
Subterranean Clover	B:10-20; D:8-15	¼ - ½	May not be adapted		Aug 25-Sep 15	Aug 15-Oct 25	Sep 1-Sep 30	Sep 1-Oct 31
Vetch (Common, Hairy)	B:25-40; D:20-30 B:20-30; D:15-20	½ - 1 ½	Jul 25-Aug 10	Jul 15-Aug 30	Aug 25-Sep 30	Aug 25-Oct 25	Sep 1-Sep 30	Sep 1-Oct 25
OTHER SPECIES								
Rape and Turnips	B:6-8; D:3-4	¼ - ½	Mar 1-Apr 30 Jul 15-Sep 1	Feb 15-May 10 Jul 1-Sep 15	Feb 15-Mar 15 Aug 15-Sep 15	Feb 1-Apr 15 Aug 1-Oct 1	Feb 15-Mar 1 Sep 1-Oct 1	Feb 1-Apr 1 Aug 15-Oct 30

[1]May extend the fall dates by 20 days, where elevation is below 2,500 feet, and seed 15 days earlier in spring.

[2]For the black, heavy-textured soils in the tidewater region, use dates for the piedmont.

[3]The best time to sod seed depends on the prevalence of insects in late August and early September and the drought prediction for September. If insects are not evident and moisture is adequate, plant on the early dates.

Alfalfa can be successfully seeded into a sod in mid- to late winter (same as ladino) provided that the grass sod is killed the previous fall (in October or November).

endophyte fescue or orchardgrass in existing sod, it is best to plant in the fall.

Seeding Rates

Seeding rates vary because of seed size, purity, germination percentage, and seedling vigor. Under adverse conditions, only 10 to 50% of the seeds planted will establish successfully. Therefore, many seeds are needed to obtain a satisfactory stand.

Germination Rate

The percentage of seeds that will germinate generally declines with age, but if seeds are stored in a cool, dry place, germination should not decline more than 10% the first year. In general, seeds that have low germination levels also produce seedlings with poor vigor.

Drill Versus Broadcast Plantings

Planting rates for drilling are 20 to 50% less than for broadcasting. Since drilling concentrates the seeds within a furrow, they occupy a smaller area of the ground and are better able to break through the soil crust. Seed placement, soil contact, and uniformity of stands are usually better with drilling than with broadcasting, especially when planting conditions are not optimum.

Planting Depth

Generally, small-seeded crops can be planted slightly deeper in sandy soils than in clay soils. Grasses can usually be planted deeper than legumes in similar soils. On prepared seedbeds, it is important to prepare a firm seedbed before planting to conserve moisture and avoid variation in planting depth. When seeding in a sod, make a furrow about ¾ inch deep, and most seed will be covered with ¼ to ½ inch of soil. Precision planting equipment is usually required to get proper depth control for small forage seeds.

What Is a Good Stand?

In general, a good stand is one that provides 90 to 100% ground cover and will produce high yields when managed properly. The clover part of mixtures should make up at least 30% of the stand (on a weight basis) for it to significantly contribute to the mixture. Walk fields several times each growing season to make a fair evaluation of stands. Table 2 presents some general characteristics of good stands for several forage crops.

Table 2. Characteristics of good grass and clover stands.

Plant Species	Seedlings (sq ft)
Mixtures[1]	
Ladino/fescue	20 to 35 of each living in November
Ladino/orchardgrass	20 to 35 ladino and 35 to 55 orchardgrass living in November
Cool-Season Grasses[1]	
Fescue	40 to 60 living in November
Orchardgrass	70 to 100 living in November
Warm-Season Grasses	
Pearlmillet	15 to 25 living after 1 month
Sorghum-sudan	15 to 25 living after 1 month

Alfalfa

Age of Stand (months)	Minimum Number of Plants to Keep Stand	Desirable Number of Plants for Good Production
	Plants (sq ft)	
3 to 6	10[2]	50 or more
12	10[2]	25 or more
24	10	15 or more
36	5 to 8	10 or more
48 or more	3 to 5	

[1]Assumes an autumn planting date.

[2]These figures will eventually result in satisfactory stands; however, yields will be low during the first season as weeds encroach.

Chapter 12

WEED MANAGEMENT

William M. Lewis and James T. Green, Jr.

Forage crops, like all other crops, must compete with weeds. Weed control is essential to successful production. The aspects of forage quality (and, therefore, any weeds in forage) that affect animal performance are (1) digestibility and nutritive content, (2) consumption (amount and rate), and (3) toxic factors. Although some research indicates that many weeds are highly nutritious and digestible (50 to 75%), animals may not eat them voluntarily. However, strict rotational grazing with high stock density increases consumption of many weeds. Weeds may adversely affect forage quality because certain ones are toxic or poisonous to livestock; others are unpalatable and limit consumption; some cause an undesirable flavor in milk and meat, and others cause irritations that may contribute to pinkeye.

Certain weedy plants have sharp thorns, awns, or spines that cause internal injury or prick the mouth and eyes of grazing livestock, causing infections or irritations. Plants that cause these problems include horsenettle, mullen, multiflora rose, sandbur, spanish needles, spiny amaranth, and thistles. Intestinal obstructions may occur if animals eat plant parts such as the mature seed heads of crimson clover.

Plants that produce a disagreeable taste or odor in the milk and meat of grazing animals include bitter sneezeweed, buttercup, chicory, dock, dogfennel, horsetails, mustards, ox-eye daisy, ragweeds, sorrel, spurges, St. John's wort, wild garlic, and yarrow. Toxic weeds are described in "Plants Poisonous to Livestock and Pets in North Carolina," North Carolina Agricultural Research Service Bulletin No. 414.

Weeds' requirements for growth are somewhat similar to those of many forage crops. Depending on weather and soil conditions, about one pound less forage is produced for each pound of weed growth. In studies in North Carolina, the first cutting of alfalfa hay was increased annually by about 700 pounds per acre with herbicide applications for winter annual weed control. Dense infestations of winter annual little barley have been known to eliminate the first cutting of Coastal bermudagrass.

Competition for soil moisture is often severe when shallow rooted forage plants are competing with weeds. Many summer annual weeds also have high water requirements and extensive root systems for extracting soil moisture. Others use water remarkably efficiently. Clovers, bluegrass, and lespedeza cannot effectively compete with most weeds if there is not enough moisture in the soil. Legumes use nearly three times as much water as efficient plants. For example, ragweed uses three times as much water as corn per pound of dry matter produced.

Weeds' nutrient requirements for growth are also somewhat like those of many forage plants. They are strong competitors on infertile and acid soils and seem to be able to grow and reproduce much easier than forages on such soils.

Lime and phosphate fertilizer doubled the ground coverage of desirable forage and reduced weed coverage by nearly 20% in mountain pasture tests. Weeds are heavy users of phosphate and potash compared to grass and red clover. For example, weeds contain more than twice the potash and 30% more phosphate than clover. Since grasses also take up lots of potash, legumes growing in mixtures are at a tremendous disadvantage when grown on soils low in potash.

Many weeds are highly digestible and contain high protein and energy values. A few examples are curly dock, crabgrass, lambsquarters, redroot pigweed, and tall morningglory. If animals will eat the weeds, control is not as critical as it is for weeds that animals will not eat.

Methods of Weed Control

Mowing may control tall-growing annual broadleaf weeds and reduce seed production if completed just after the first flower appears. However, mowing will not control weeds that form rosettes or mats that grow close to the ground. In fact, mowing may help those weeds by reducing the competition from the desired forage plants. In most instances, weeds have done their damage (in terms of yield reduction) by

the time they can be controlled with a mower. Mowing of perennial, hard-to-kill broadleaf weeds shortens them but rarely gives satisfactory control. Mowing to control crabgrass, foxtail, and similar annual grass weeds is essentially hopeless.

Cultural Grazing. Management practices that produce a vigorous, dense stand of forage combined with judicious grazing management are excellent for reducing pasture weeds. Methods of successfully competing with pasture weeds include (1) following soil tests' guides for lime and fertilizer, (2) planting weed-free seeds of persistent varieties adapted to specific management systems and soil environments, (3) rotating crops when feasible to interrupt the life cycle of certain weeds and (4) using frequent rotations of high stock density to force grazing animals to eat or trample weeds. Mixing goats with cattle in the appropriate proportion has been effective in controlling certain weeds, such as blackberry, privet, honeysuckle, kudzu, multiflora rose, and a multitude of woody seedlings and saplings.

Herbicides. Chemical control of pasture weeds is effective and often economical. However, herbicides are only one aspect of a weed management program and should be used in combination with fertilization, liming, and grazing and harvesting management.

Weed Management with Herbicides

The success of using herbicides to control weeds in pasture and hay crops depends on plant growth factors, environmental conditions, and herbicide selection. All these factors can interact to affect the performance of foliar-applied herbicides.

Plant Growth Factors. Annual pasture weeds are easiest to kill when they are young and actively growing (3 to 8 inches tall) or in the rosette stage. Biennial plants require two years to complete their life cycle, and they are usually most easily controlled in the rosette stage, before stem elongation and flowering. Bull, musk, and yellow thistles are biennial weeds. Perennial plants live for several years. They may reproduce by seed and/or rhizome, roots, bulbs, or tubers. Early spring growth depends largely on stored food reserves. Foliar-applied herbicides may be ineffective because the herbicide is not translocated into the roots and rhizomes in sufficient amounts to prevent regrowth. Once the plant has ceased to depend on stored food reserves and begins to transport food into storage organs, control can be achieved more readily since the herbicide is transported downward with the food.

Spraying at early growth gives best control of weeds and reduces the potential loss of forage. Herbicide rates may need to be increased when weeds approach the flowering stage. More difficult to control perennial weeds may require a second spraying when regrowth appears. Foliage sprays for woody plant control should be applied after full leaf development in the spring.

Environmental Conditions. Favorable soil moisture and mild temperatures contribute to actively growing weeds. Desirable forages are usually more tolerant to herbicide application under these conditions. Herbicides are less effective when stressful conditions such as drought are present, because herbicide absorption and translocation are reduced in stressed plants.

Temperature may inhibit or enhance the effectiveness of foliar-applied herbicides. Within the range of 40 to 85°F, foliar penetration usually increases with temperature. However, volatility also increases. At temperatures above 85°F, Banvel and low volatile ester forms of 2,4-D and Crossbow may be lost to volatility. Such losses reduce weed control and may damage nearby crops and plants.

Rainfall received shortly after spraying may adversely affect the performance of the foliar-applied herbicide because the rain washes the herbicide off before it is absorbed. A rain-free period of 4 to 6 hours after application of postemergence herbicides is best for performance.

Herbicide Selection. Herbicide selection begins with properly identifying the weeds to be controlled, because various weeds respond differently to different herbicides. For an aid to proper herbicide selection, refer to Table 1 (winter and summer annuals on page 65, biennials and perennials on

page 66). Herbicide labels provide specific information on rates, grass tolerance, grazing restrictions, and other pertinent details. Table 2 outlines the waiting period required after herbicide application before treated forage can be used. All forage grasses are tolerant to Banvel, Crossbow (2,4-D + triclopyr), 2,4-D, and Weedmaster (Banvel + 2,4-D). Established grasses tolerant to Ally are bermudagrass, bluegrass, tall fescue (maximum rate 0.2 ounce per acre), orchardgrass, and timothy.

Table 1. Guide to relative response of common broadleaf weeds found in pasture and hay fields[1] to postemergence applied herbicides.

Weed	Herbicide				
	Ally	Banvel	Crossbow	2,4-D	Weedmaster
	Ratings[2]				
Winter Annuals					
Buttercup	G-E	G	E	G	G
Chickweeds	E	G	G	P	F-G
Geranium, Carolina	G-E	G-E	G	G	G-E
Henbit	E	F-G	G	P	F-G
Lettuce, Prickly	G	G	G-E	F	G-E
Mayweed chamomile	G	F-G	G	F	F-G
Mustards	E	G-E	G-E	G-E	G-E
Radish, wild	G-E	G	G	G-E	G-E
Summer Annuals					
Bitter Sneezeweed	E	G-E	E	G-E	G-E
Cocklebur, Common	E	E	E	E	E
Crotalaria	—	G	G	P	G
Galinsoga, Hairy	—	—	G	G	G
Horseweed	G-E	G	G	G	G
Jimsonweed	F-G	G-E	G	P	G
Knotweed, Prostrate	—	G	—	P	G
Nightshade, Eastern Black	F	F-G	G	F	F-G
Pigsweed, Redroot	E	E	E	E	E
Purslane	G-E	G	G	P-F	G
Ragweed	F-G	G-E	E	F	G-E
Smartweed, Pennsylvania	—	G	—	F	G
Spiny Amaranth	E	E	E	E	E

[1] Established grasses tolerant to Banvel, Crossbow, 2,4-D, and Weedmaster: bahiagrass, bermudagrass, bluegrass, timothy, tall fescue, orchardgrass, ryegrass.

[2] Ratings: N = no control, P = poor, F = fair, G = good, E = excellent.

(A portion of the response ratings from B.W. Pinkerton and E.C. Murdock, Clemson University.)

Table 1. Guide to relative response of common broadleaf weeds found in pasture and hay fields[1] to postemergence applied herbicides *(continued).*

	Herbicide				
	Ally	Banvel	Crossbow	2,4-D	Weedmaster
Weed	Ratings[2]				
Biennials					
Thistle, Bull	G	G	E	E	E
Thistle, Musk	G	G	G	F-G	G
Perennials					
Bahiagrass	E	N	N	N	N
Buttercup, Bulbous	G-E	G	E	G	G
Cherry, Black	P	P	F	P	P-F
Chicory	—	—	F	G	G
Clover, White	G	G	E	F-G	G
Common mullein	G	F-G	G	P	F-G
Dandelion	G	E	G	F-G	F-G
Dewberry/blackberry	F	G	E	P	G
Dock, Curly	E	G-E	G	F	G
Dogbane, Hemp	P	G	G-E	P-F	F
Dogfennel	F	G	F	P	G
Garlic, Wild	E	P-F	F	P-F	P-F
Greenbriar	P	F	F	P	F
Hawkweed	—	F-G	—	F	G
Honeysuckle, Japanese	P	F-G	G	P-F	F-G
Horsenettle, Carolina	F-G	F	G	G	G
Kudzu	P	F-G	G-E	P	F-G
Milkweed, Common	—	—	F	F	F-G
Multiflora Rose	G	G	G-E	F	—
Persimmon	P	F	F	P	F
Plaintains	—	P	G	G	G
Prickly pear	P	P	P	P	P
Privet	P	P-F	G	P	P-F
Sorrel, Red	G	G	F-G	P	G
Sweetgum	P	P	F-G	P	P-F
Thistle, Canada	—	F	F	F	F
Thistle, Yellow	—	G	—	—	G
Trumpetcreeper	P	G	F-G	P	G
Yellow crownbeard	—	G	E	E	E

[1] Established grasses tolerant to Banvel, Crossbow, 2,4-D, and Weedmaster: bahiagrass, bermudagrass, bluegrass, timothy, tall fescue, orchardgrass, ryegrass.

[2] Ratings: N = no control, P = poor, F = fair, G = good, E = excellent.

(A portion of the response ratings from B.W. Pinkerton and E.C. Murdock, Clemson University.)

Table 2. Waiting period necessary after herbicide application before treated forage can be used.

Herbicide (rate)	Other livestock				Lactating dairy animals		
	Grazing	Harvested green forage	Hay	Grazing before slaughter	Grazing	Harvested green forage	Hay
	Days				Days		
Ally (0.1 to 0.3 oz/A)	0	—[1]	0	0	0	0	0
Banvel							
< 1 pt/A	0	—	37	30	7	—	37
1 pt to 1 qt/A	0	—	51	30	21	—	51
1 qt to 2 qt/A	0	—	70	30	40	—	70
2 qt to 8 qt/A	0	—	90	30	60	—	90
Crossbow[2]							
< 2 gal/A	0	0	7	3	14	14	365
> 2 gal/A	14	14	14	3	365	365	365
2,4-D amine (1 qt/A)	0	—	30	7	14	—	30
Weedmaster[3] (1 qt/A)	0	—	37	30	7	—	37

[1] — indicates no information listed on product label.
[2] Crossbow (triclopyr + 2,4-D).
[3] Weedmaster (Banvel (dicamba) + 2,4-D).

Herbicide Application

Foliar-applied herbicides are applied in 10 to 30 gallons of water per acre with a boom-type sprayer equipped with flat fan nozzles to provide uniform spray coverage over the top of the weeds. The addition of a nonionic surfactant to the spray solution, at 1 to 2 pints per 100 gallons, can improve control of perennial weeds and woody plants.

Liquid nitrogen fertilizer may be used as the spray carrier for Ally, Banvel, Crossbow, 2,4-D, and Weedmaster. Always run a compatibility test before mixing these herbicides in a tank of nitrogen solution. Liquid nitrogen solution may cause the grass to turn yellow.

Do not allow spray to drift onto adjacent crops, vegetables, trees, or ornamental plants. Very fine spray, which may not be visible, may seriously injure sensitive plants.

Examples of effective application timing according to growth stage of the weed follow.

The ideal application time for control of buttercup, a winter annual, is in the rosette stage. 2,4-D amine or low volatile ester applied in December or early March is effective at 2 pints per acre. Ally, Crossbow, and Weedmaster also control buttercup. Early March applications, in general, are favorable for winter annual broadleaf control.

Spiny amaranth, a summer annual, is successfully controlled with 2,4-D amine at 1 pint per acre applied when plants are 4 to 8 inches tall. Usually when plants have reached this size, all viable seeds will have germinated. If spraying is delayed until the plants flower, it will require 2 pints per acre of 2,4-D amine for control.

Carolina horsenettle, a perennial weed, should be sprayed in late spring when plants have four or five

leaves. 2,4-D amine at 2 pints per acre provides control. Another application is frequently needed the second year. Control with Weedmaster has been similar to 2,4-D in our tests. Ally has not been as consistent in control as 2,4-D.

Yellow crownbeard, another perennial, should be sprayed when the new spring growth from the roots is 16 to 18 inches tall. By this time, the new seedlings have also emerged. 2,4-D at 2 pints per acre gives excellent control. In fact, yellow crownbeard is equally susceptible through the flowering stage.

Herbicide Effects on White Clover

Healthy white clover in a grass pasture or hay field will withstand 0.5 to 1 pint per acre of 2,4-D applied once per season. Ally, Banvel, Crossbow, and Weedmaster will injure and reduce stands of clover and other legumes.

Weedy Grass Control

In established pasture and hay grasses, no selective herbicides are available for weedy grass control, nutsedge control, or control of an undesired grass species within another. However, bahiagrass can be suppressed in bermudagrass with Ally.

Weed Control in Millet and Sorghum-Sudan Hybrids

Small annual broadleaf weeds may be controlled with 6 ounces per acre of 2,4-D amine applied over the top of millet or sorghum-sudan hybrids when 4 to 6 inches tall. Large crabgrass, foxtails, and certain broadleaf weeds may be controlled with AAtrex 4L applied preemergence in sorghum-sudan hybrids. AAtrex rates are based on highly erodible soils (as defined by the Soil Conversation Service) or soils not highly erodible. On highly erodible soils having at least 30% of the soil covered with plant residues at planting, the maximum rate is 4 pints per acre of AAtrex as a broadcast spray. If there is less than 30% soil coverage, the maximum rate is 3.2 pints per acre.

Weed Control in Hybrid Bermudagrass

When sprigging bermudagrass, Karmex 80DF (diuron) can be applied at 1.25 to 1.5 pounds per acre for preemergence control of annual grass weeds such as crabgrass, sandbur, and certain broadleaf weeds. For control of emerged annual weeds up to 4 inches tall, 1 pound per acre of Karmex 80DF may be applied with a nonionic surfactant at a rate of 2 quarts per 100 gallons of water. Sprigs should be planted at least 2 inches deep. There is a 70-day waiting period for forage use. Emerged broadleaf weeds 3 to 4 inches tall may be controlled with 1 to 2 pints of 2,4-D amine per acre.

In dormant, established bermudagrass, Gramoxone Extra (paraquat) at 13 fluid ounces per acre will control winter annual grass weeds (for example, little barley and annual bluegrass) and broadleaf weeds. A nonionic surfactant should be added to the spray mixture at 1 quart per 100 gallons of water. Do not mow hay until 40 days after treatment.

Bahiagrass can be suppressed in bermudagrass with Ally 60DF at 0.3 ounce per acre plus 1 to 2 pints of a nonionic surfactant per 100 gallons of water. Apply April 25 to May 15 after bahiagrass greens up. Ally will also control a number of winter and summer annual broadleaf weeds including perennial weeds like wild garlic, dock, and red sorrel. Weedy grasses are not controlled by Ally. There are no restrictions on forage use.

Weed Control in Alfalfa

It is very important to eliminate weeds before establishing alfalfa. Tillage is a key part of a weed management program when establishing alfalfa, and perennial weeds can be controlled with Roundup before seeding. Effective management of herbicides to control grass and broadleaf weeds in established alfalfa stands can extend the life of the stand by reducing weed competition.

Eptam is a preplant soil-incorporated herbicide for controlling annual grasses and broadleaf weeds.

Eptam must be thoroughly incorporated to a depth of 2 to 3 inches. Incorporate with a disk operating in two different directions within the field. Eptam may temporarily stunt alfalfa and seal the first leaves when applied in cool weather.

Balan is another preplant incorporated herbicide for controlling annual grass and broadleaf weeds. Balan generally does not injure nontarget plants.

Butyrac 200 (2,4-DB) is a postemergence herbicide for the control of small broadleaf weeds in seedling and established alfalfa. 2,4-DB will not control chickweed, henbit, and several other winter annual broadleaves. It is more effective on summer annuals such as cocklebur, lambsquarters, pigweed, and ragweed. It will suppress seedling mustard and dock. Application may be made in seedling alfalfa after two to four trifoliate leaves are present. In new seedings, treated forage cannot be harvested or grazed for 60 days after application. In established alfalfa, the waiting period is 30 days.

Kerb controls chickweed and other winter annual broadleaves and ryegrass and volunteer small grains in seedling alfalfa and in established dormant alfalfa. Apply after the first trifoliate leaf of alfalfa appears. The best application time is October 15 to January 15. There is a 120-day waiting period after application.

Poast or Poast Plus is a selective postemergence herbicide for annual grass control and for bermudagrass and Johnsongrass control. It does not control broadleaf weeds or nutsedge. Poast may be applied in seedling or established alfalfa. Apply when annual grasses are actively growing with sufficient leaf area present for herbicide absorption. Depending on the season this will be after the first or second cutting. For grazing and green chop there is a 7-day waiting period after application, 20 days for cutting alfalfa for dry hay.

Treflan TR 10G applied preemergence in established alfalfa stands controls several annual grass weeds. In our tests, we obtained excellent control of large crabgrass and broadleaf signalgrass. No use restrictions are stated on the label.

Other herbicides for winter annual broadleaf weed control in established dormant alfalfa are Lexone or Sencor and Sinbar. Weeds controlled include chickweed, henbit, bittercress, pepperweed, shepherdspurse, yellow rocket, and ryegrass. Preferable application time is November 15 to January 15. Do not apply when new growth appears in the spring or injury will result. Lexone and Sencor have a 28-day waiting period for forage use. No waiting period is mentioned on the Sinbar label.

Rates of herbicide products vary with the soil type and variety and size of weeds present. Consult the label for appropriate rates.

Multiflora Rose Control

Various herbicide programs for controlling multiflora rose in pastures are summarized in the following paragraphs.

Ally 60DF is applied as a foliage spray to runoff. Rate is 1 ounce per 100 gallons of water plus 2 pints of a nonionic surfactant. There are no grazing restrictions.

Banvel 4S may be sprayed with a handgun as a 1% solution plus 0.5% nonionic surfactant to completely cover the foliage before bloom. Allow the spray solution to run down the stems to the crown. Spot-concentrate applications of Banvel should be applied directly to soil as close as possible to the root crown before bud-break in the spring. Use the undiluted Banvel at ¼, 1, or 2¼ fluid ounces, respectively, for 5-, 10- or 15-foot canopy diameters. Do not graze lactating dairy animals for 60 days. There is no waiting between treatment and grazing for beef cattle or other livestock.

Crossbow is sprayed to give thorough coverage of leaves and stems. For best results, spray at early- to mid-flowering stage. Mix 1 to 1½ gallons in 100 gallons of water. There is a 14-day waiting period for grazing lactating dairy animals, none for other livestock.

Roundup 4L is sprayed as a 1% solution plus 0.5% nonionic surfactant to completely cover the foliage. Spray after bloom. There is 10-day waiting period for grazing.

Spike 20P is applied directly over the roots beneath the canopy before spring growth. Apply ¼ ounce of the pellets per 22 square feet of canopy. No grazing restrictions with less than 20 pounds per acre.

Chapter 13

BENEFICIAL AND PEST INSECTS IN FORAGE CROPS

Michael G. Waldvogel and Stephan Bambara

The Importance of Insect Pollinators

Many of our forage crops depend on or are improved by bee pollination. This is true for alfalfa, clovers, and vetches. In some states, bee colonies are rented to provide pollination on these as seed crops. Though few growers in this state produce forages for seed, the plants produce a large amount of nectar and are highly attractive to several types of bees when in bloom.

Alfalfa is normally cut for hay as flowering begins. If cutting is delayed, a field may become highly attractive to many pollinator species. The alfalfa plant may bloom for about two weeks. Individual flowers can remain open for several days, but will wilt within hours once pollinated. Vetches and clovers have flowering patterns similar to alfalfa. All species are attractive to bees and usually reach flowering stage when grown mixed with grasses. Red clover is less preferred by honey bees and more preferred by bumble bees, presumably due to the depth of the flower and the difficulty of the honey bee to reach the nectar with her shorter tongue. Varietal differences in pollinator attractiveness also exist among most of the legumes.

The presence of valuable pollinators should be considered in timing treatments and selecting pesticides for use on a forage crop or on an adjacent crop while forages are in bloom. Most insecticide labels contain a warning statement about their application hazard to bees. Very few chemicals can be applied to a crop while it is in bloom. Check the label for such a statement anytime a pesticide is used.

Management of Insect Pests

Alfalfa

The alfalfa weevil is the most important insect pest of alfalfa in North Carolina. The adults often remain active throughout much of the winter when mild temperatures persist. Although peak egg-laying occurs in December through January, unseasonably warm winters will result in earlier-than-usual larval activity and continued egg-laying into spring. In recent years, treatments for alfalfa weevil have begun as early as late February in some south-central counties. As a result, scouting is necessary for effective weevil control.

Scout for alfalfa weevil by selecting 30 stems at random throughout the field. Cut the stems carefully to avoid dislodging any larvae. Then beat them against the inside of a plastic bucket, dislodging the larvae into the bottom of the bucket where they can be counted. Young alfalfa weevil larvae are about $^{1}/_{16}$ inch long and are yellowish-green with shiny black heads; older larvae reach a length of about ¼ inch and are light green with a white stripe down the middle of the back. Finally, the length of each stem is measured and the tips are examined carefully for damage and for other larvae. Treatment decisions are based on the thresholds outlined in Table 1.

One of the factors complicating alfalfa weevil control is the unpredictable nature of the weather during the early spring. Cool or cold weather slows feeding and oviposition activity, sometimes extending weevil activity beyond the effective period of foliage protection by an insecticide treatment. Because temperatures at this time of the year are quite variable, most growers choose an insecticide with longer residual (such as carbofuran or chlorpyrifos) and reserve less persistent chemicals (such as malathion) for secondary use. Under most circumstances, a single well-timed application will provide adequate foliage protection. Fall applications are rarely needed or useful except to protect newly established stands against other pests such as grasshoppers. (See Figure 1.) Restrictions on the use of Furadan 15G for fall stand establishment in all coastal counties began in September 1991. As of 1994, Furadan 15G is no longer labeled for use on alfalfa anywhere. Other suggested chemicals for use in alfalfa weevil management can be found in the annual *North Carolina Agricultural Chemicals Manual* (NCACM). In selecting the proper insecticide for use against alfalfa pests, plan ahead and always consider

Table 1. Treatment thresholds for insect pests of forage crops.

Insect pest	Crop	Sampling method	Plant height	Number of insects	% foliar damage
Alfalfa weevil	Alfalfa	30 stems	<6 inches	1/stem	>50%
Alfalfa weevil	Alfalfa	30 stems	>6 inches	1.5/stem	>50%
Potato leafhopper	Alfalfa	100 sweeps	<6 inches	1/sweep	NA[1]
Potato leafhopper	Alfalfa	100 sweeps	>6 inches	2/sweep	NA[1]
Armyworms[2]	Grasses	10 sq. feet	NA[1]	5/sq. ft.	NA[1]

[1] NA = not applicable here.
[2] True armyworm and fall armyworm.

the preharvest or pregrazing intervals for each product.

The only other pest of occasional importance in alfalfa is the potato leafhopper, *Empoasca fabae*. Leafhoppers inject a toxin into the leaves which causes a yellowing that is commonly referred to as "hopper burn." This damage reduces stand vigor and can shorten the life span of the stand. Once hopper burn becomes apparent, it is too late to protect that cutting by spraying. Early cutting can be done in lieu of spraying if the crop is at 60% bud. However, early cutting will also reduce stand vigor and should not be done more than once per season. Potato leafhoppers are not known to overwinter in North Carolina, but they migrate north from the Gulf Coast, making their initial appearance in North Carolina in April and peaking in July to August when the weather becomes hot and dry. Spraying for leafhoppers is rarely needed and should be based on a threshold determined by taking 100 sweeps (five sets of 20 sweeps) with a sweep net across the field. Treatment thresholds for the potato leaf hopper are presented in Table 1, and suggested chemicals are listed in the NCACM.

Forage Grasses

The most important insect pests in forage grasses are the armyworm (or "true" armyworm) and the fall armyworm. Damage from these pests can kill or severely stunt grass in pastures. True armyworms are more of a problem during spring and early July,

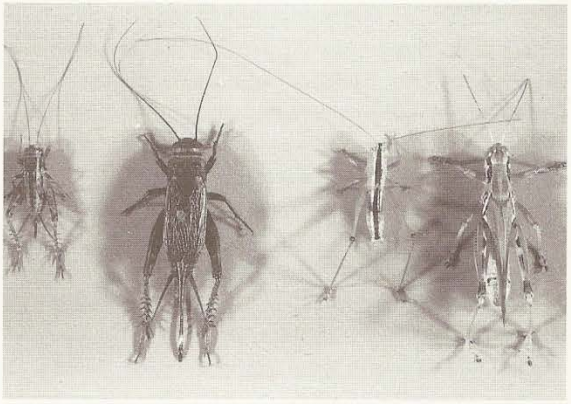

Figure 1. Some insects that damage forages, especially when in the seedling stage. From left to right: red-legged grasshopper, katydid, and field and ground crickets.

after which time, natural controls keep the population below threshold levels. Armyworms feed primarily at night and remain hidden in ground litter by day. By contrast, fall armyworms are usually a problem later in the season (July to August), after the moths have migrated northward from the Gulf Coast area. Also, the larvae are active day and night. Parasites and disease organisms will often keep fall armyworm populations in check. However, extremely hot and dry conditions reduce the activity of the fall armyworm's fungal pathogen and promote larval activity. Although fall armyworms are somewhat more difficult to control than armyworms, both species have the same treatment

Table 2. Suggested pesticides for control of forage pests.

Insect pest	Insecticide and formulation	Amount of formulation per acre	Active ingredient (lb) per acre	Minimum interval (days) between application and harvest	Precaution and remarks
Alfalfa weevil	carbofuran (Furadan) 4F[1]	½ to 2 pt	0.25 to 1.0	7 to 28	Only one application per cutting or two applications per season. The higher rate provides longer seasonal protection. Use half rate above 3,000-ft elevation.
	chlorpyrifos (Lorsban) 4EC	1 to 2 pt	0.5 to 1.0	7 to 21	Use 20 gallons of water per acre; only one application per cutting. Higher rates provide longer seasonal protection.
	malathion 57 EC	1 qt	1.25	0	
	methylparathion (Penncap-M)	2 to 3 pt	0.5 to 7.5	15	Do not apply during bloom or if weeds in treatment area are in bloom.
	permethrin (Ambush) 2E	6⅖ to 12¾ oz	0.1 to 0.2	Up to 14	Only one application per cutting.
	permethrin (Pounce) 3.2 EC	4 to 8 oz	0.1 to 0.2	Up to 14	Do not apply more than 0.2 pound active per cutting.
	phosmet (Imidan) 50 WP	2 lb	1.0	7	Only one application per cutting. Do not apply during bloom.
Clover root curculio cricket grasshoppers potato leafhopper	carbofuran 4F[1]	1 to 2 qt	1 to 2	80	Restricted for use on pure seeding establishment of alfalfa. Apply in furrow or broadcast and immediately incorporate. Do not graze or cut hay for 80 days after treatment.
Leafhopper	carbaryl (Sevin) 80 S	1¼ lb	1.0	0	Potato leafhoppers usually occur in July and August, but since they migrate from the Gulf region, high numbers may appear in June.
	chlorpyrifos (Lorsban) 4 EC	1 pt	0.5	14	
	dimethoate (Cygon) 400	1 pt	0.5	10	Do not apply more than one application per cutting. Do not apply during bloom.
	chlorpyrifos (Lorsban) 4 EC	1 pt	0.5	14	
Armyworms on hay crops and pastures	carbaryl (Sevin) 80 S	1 ⅘ lb	1.5	0	Treat when larvae are small.
Fall armyworm	methomyl (Lannate)				Use lowest rate on bermudagrass for worms less than 0.5 inch. Use lowest range for ground application and highest range for aerial application.
Bermudagrass	1.8 L	1 to 2 pt	0.25 to 0.5	7	
		2 to 4 pt	0.5 to 0.9	7	
Alfalfa	90SP	½ lb	0.45	7	

[1]Do not apply this product through any type of irrigation system. Do not plant with any crop for which carbofuran treatment is not registered for at least 10 months. Do not rotate with any crop on soil treated at greater than 3 pounds active ingredient per acre for at least 10 months. Do not use Furadan 15G.

threshold of **five larvae per square foot**. Suggested chemicals for use against both armyworm species can be found in the annual NCACM (also see Table 2). Growers are reminded to pay close attention to preharvest and pregrazing intervals and to make certain that they select a chemical that is labeled specifically for the pest species and site.

Chapter 14

FORAGE DISEASES

Leon T. Lucas

North Carolina forage crops are susceptible to a wide variety of diseases because of the many different climates and soils in the state. Some diseases do not cause economic harm to the crop; in other cases, such as alfalfa, diseases can be the major limiting factor. Since chemical controls are not labeled for the control of diseases on forage crops, it is important to select and plant the best-adapted cultivars for a given part of the state and the particular soil type. Growers must use an integrated pest management program that includes recommended cultural practices such as crop rotation, fertilization, mowing, and grazing to encourage the growth of healthy plants. Resistant cultivars of forage crops that are adapted to portions of North Carolina are the best means to help manage diseases. But even the best cultivars may be damaged by diseases in very wet or dry years.

Diseases of Legumes

Seedling diseases that are caused by *Pythium, Rhizoctonia, Fusarium, Phytophthora, Sclerotinia,* and other species of fungi can cause seed decay and damping off in wet soils. These diseases can reduce stands and result in severe weed competition and low yields. Planting high-quality seeds at the proper rate and time in soils that have been well prepared and have proper soil moisture is the best way to avoid damage from seedling diseases. Also, if effective strains of the bacterium are not present in the soil, seeds should be inoculated with the proper strains of *Rhizobium* species to encourage rapid growth of seedlings.

Root and crown diseases that are caused by many different soil-borne fungi are the most serious diseases on forage legumes in North Carolina. *Pythium, Rhizoctonia, Fusarium,* and *Phytophthora* species are often associated with the root and crown rot diseases. Phytophthora root rot can cause serious damage on many legumes if they are planted in heavy, poorly drained soils. New cultivars (especially of alfalfa) that have more resistance to these diseases should be planted to help reduce damage. Soil drainage may need to be improved in some pastures and fields. Rotations with grass or grain crops, where possible, can help reduce the level of these pathogens in the soil.

Leaf and stem diseases that include anthracnose, leaf spot, and powdery mildew can reduce stands and the quality of forage harvested. Anthracnose can attack many different legumes and usually causes lesions on the stems that cause the stems to die. This disease can move into the crowns and cause a decline of perennial legumes. The leaf spot diseases are usually more severe in wet weather and can cause many of the leaves to fall off, resulting in lower-quality forage. Powdery mildew is often a problem on red clover and causes the infected leaves to yellow and wither prematurely. Mowing severely infected fields to encourage new growth in weather less favorable for these diseases may help to increase the quality of forage harvested.

Virus diseases occur on all of the forage legumes and can reduce vigor, yields, and persistence of plants. Resistance to viruses, or tolerance in many cases, has been improved in many of the newer cultivars. These should be used where available.

All legumes are susceptible to some types of nematodes, which can cause serious damage. The root knot nematode, for instance, can harm clovers and alfalfa, especially on sandy soils. The roots of nematode-infected plants are reduced and result in a decline of the stand and production. The stem nematode can seriously damage alfalfa in heavy soils by infecting the buds and causing stunting, yellowing, and death of infected stems. The cultivars most resistant to nematodes should be used when planting in areas where nematodes might be a problem.

Field dodder can be a serious problem in legumes that are to be harvested for seeds or hay. This parasitic plant twines around the stems as it grows over the plants, forming a tangled mass of host plants and dodder. Small infested areas should be destroyed immediately with a herbicide or by burning. Use plant seed certified to be free of dodder to avoid the problem. Also, avoid spreading manure

from animals that were fed hay infested with dodder, as this can spread the weed to new fields.

Diseases of Forage Grasses

Diseases of forage grasses are divided under the topics of **cool-season** and **warm-season grasses**. Many of the diseases affect both types of grasses and are usually related to the conditions that occur where the grasses are being grown. In general, diseases caused by fungi are more severe on the cool-season grasses because of North Carolina's hot and humid summer weather.

Cool-season grasses

Drought stress is one of the most important problems on cool-season grass in North Carolina. The application of high rates of nitrogen in summer from fertilizer or from animal manure can cause additional stress and diseases that are discussed later. Desiccation during dry weather in the winter can damage both perennial and annual cool-season grasses. This type of damage may appear in early spring as poor stands on crops seeded the previous fall, or as dead leaves on older stands.

Diseases caused by *Rhizoctonia* species are the most important diseases of the cool-season grasses. Some species of these fungi can cause damage in the fall and winter and may contribute to poor stands. Other root rot and crown rot diseases caused by fungi such as *Pythium* and *Fusarium* species can cause diseases on young seedlings during the winter. Planting as early as possible in the fall will help seedlings become well established and will help reduce damage from these winter seedling diseases.

The *Rhizoctonia* diseases can severely damage tall fescue and orchardgrass pastures during the summer if the grasses are not managed properly. This disease begins as olive-colored, water-soaked lesions on the leaves that continue to develop during hot, wet weather. The lesions turn tan when the tissue dries, and the leaves die as the disease develops and girdles the leaves. High levels of nitrogen during the spring and summer increase the severity of these diseases and should be avoided. Mowing frequently for hay or grazing as recommended will help to prevent damage from this disease. Animals grazing grass heavily infected with some *Rhizoctonia* species can develop a slobbering condition.

The endophyte-free cultivars of tall fescue are more susceptible to damage from *Rhizoctonia* species than are cultivars with the endophyte. Some stands have been completely killed and had to be replanted the following fall. The damage is especially evident during wet summers when the grass is allowed to accumulate. Do not attempt to make hay from tall fescue or orchardgrass in mid-summer. Grazing will help prevent damage from this disease on the endophyte-free and other cultivars.

Several types of leaf diseases, such as the Helminthosporium leaf spot complex and rusts, develop on most of the cool-season forage grasses. Some leaves may die during favorable disease conditions, but severe damage seldom occurs. The symptoms of leaf spot are circular leaf spots on some grasses or "net blotch" symptoms such as on tall fescue. Rust appears as small yellow spots that develop into small dead spots with raised masses of orange to red spores in the center. The perennial grasses will recover from these leaf spots during cool, dry weather conditions. The best control for these diseases is to use the cultivars that are more resistant.

Warm-season grasses

The most serious damage to warm-season perennial forage grasses in North Carolina is usually from cold damage in very cold winters and drought in dry summers. Large dead areas or very poor stands in the spring where the grass was healthy last year would indicate winter damage. Proper fertilization and management will help reduce the damage from cold weather or drought.

Some leaf spot diseases occur on the warm-season grasses but usually do not cause serious damage. These diseases usually are more severe during late summer and may cause some leaves to die. If these diseases become severe, the best management would be to mow off the infected foliage to allow new healthy growth to develop. Some heavily

infected forage might cause symptoms in animals, and it would be best not to use it for feed. Use the best-adapted cultivars to help prevent damage from these diseases.

Nematodes can develop into a major problem on some warm-season grasses in sandy soils in eastern North Carolina. The sting nematode can reduce the vigor of bermudagrass pastures and hay fields during hot, dry weather. The annual warm-season grasses may be susceptible to damage from the nematode during late summer. Methods that help deter nematode damage include using the best-adapted cultivars and irrigating very sandy soils.

Summary

Many different diseases can occur on forage crop legumes and grasses in North Carolina. Growers need to be aware of the potential for problems and be able to identify the diseases in order to develop a control strategy. The most successful way to avoid these diseases is to select the best-adapted cultivars for the region of the state (including its soil type) and to use the recommended management practices.

Chapter 15

HAYMAKING

J. Paul Mueller, Matthew H. Poore, and J. C. Burns

Introduction

Hay is defined as the dried top-growth of certain grasses and legumes (and some other plants). It is used mainly to provide nutrients (energy and protein) to animals when pasturage is unavailable or as a ration component of confinement feeding systems. Haymaking is a risky operation because during the haymaking process, hay is a perishable product.

The Curing Process

Hay becomes a stable product once moisture has been reduced to about 15 to 20%. The process of reducing moisture is called curing and is normally accomplished from energy provided by the sun (field curing) or by artificial barn drying using heated or unheated air to remove moisture. The most common method is field curing. Drying begins when the plant is cut, but the rate of drying depends on many factors such as temperature, air movement, relative humidity, and moisture content of the plant. During curing, large quantities of water must be removed from the plant. The usual moisture contents of forages at the time they are harvested for hay are 70 to 75% for legumes and 60 to 75% for grasses. Young, immature plants or shoots contain more water than older, mature ones. Most hay crops contain three to four times as much water as they do dry matter. The objective of hay making is to reduce the plant's moisture concentration to the level at which the crop is least likely to spoil or deteriorate.

If evenly distributed over the soil surface, a normal hay crop's total moisture is about 0.1 inch. The problem in haymaking is not the total amount of water contained in the plant, but rather the restriction of evaporation caused by plant structure. Loss of internal plant moisture is impeded by waxy layers on plant surfaces and by membranes within the plant.

The length of time that hay must remain in the field to cure is directly related to hay quality. Curing methods that reduce hay moisture to safe levels (15 to 20%) in the shortest possible time also minimize the loss of quality factors.

Influence of Rain and Sun During Drying

Hay that is baled under good drying conditions (no rain) may lose 10 to 12% of its dry matter. However, under poor weather conditions, the loss can be as high as 30 to 35%. The sun provides energy for drying but also is responsible for the deterioration of vitamins A (beta carotene) and E and the formation of Vitamin D. The longer the hay is exposed to direct sunlight, the more pronounced the loss of green color (sun bleached). This loss of color is directly related to the retention of beta-carotene, the precursor of Vitamin A. Brown, sun-bleached hay, therefore, is associated with reduced levels of Vitamin A.

Influence of Conditioning, Tedding, Raking, and Turning

The term *conditioning* refers to mechanical or chemical treatment of the hay crop to accelerate the drying process (Figure 1). Mechanical conditioners have been designed to bruise, lacerate, crush, or crimp the plant to reduce the differential drying of stems and leaves. When hay is raked or baled, excessively dry leaves shatter; that is, dry leaves are broken into small pieces that escape harvest. This leaf loss is particularly serious because it represents the most nutritious plant tissue. Because of their morphology, legumes such as alfalfa tend to be more susceptible to leaf shattering than grasses.

Chemical conditioning is a relatively recent development that uses potassium carbonate solutions as drying agents to increase the field drying rate of legume hays. The drying agents are sprayed into the standing crop during the mowing–mechanical conditioning operation. These drying agents are not effective on grass hays.

Tedding refers to stirring, spreading, fluffing, or otherwise moving swathed or windrowed hay to expose additional surfaces for drying. As the hay swath fully settles to the soil surface some hours after mowing, air circulation becomes impeded thus

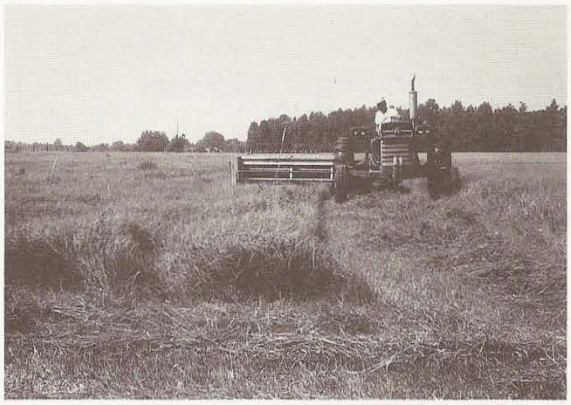

Figure 1. Cutting hybrid bermudagrass for hay in July.

slowing the drying rate. Fluffing the hay at this stage will speed drying. Tedding can be executed with some severity in the early stages of curing (50% moisture or above); however, it is essential that hay be handled gently once leaves become brittle (about 50% moisture).

Raking (Table 1) inverts the swath by rolling swathed hay over into a windrow. The objective is to increase aeration and to transfer the swath to relatively dry ground. Raking can also be used as a technique to reduce color loss and excessive shattering that may occur if hay is over-dry. The size and shape of the swath or windrow can have a large effect on the drying rate. Drying is most rapid when the windrow is wide and thin rather than thick and narrow.

Table 1. Drying rates of three methods of hayraking.

	Raking immediately after cut	Raked 4 hours after cut
Method of raking	**Hours to cure**	
Small windrow	64	50
Medium windrow	80	60
Large windrow	92	71

USDA Misc. Pub. 363

Macerated Mats

Prototype equipment is presently being researched that first shreds or macerates the hay plant, then immediately presses the macerated material into a thin mat so small hay particles are not lost. Pilot studies with alfalfa indicate that hay treated in this manner dried to 20% moisture in 2½ to 6 hours.

Heating and Spoilage

Hay that is stored at above 20% moisture favors the growth of fungi. The metabolic activity of these organisms generates heat and can increase hay temperature to about 150°F. Once hay heats beyond this point, chemical reactions may lead to spontaneous combustion and, in turn, to barn fires. Combustion is most likely to occur when hay is stored at 30 to 40% moisture.

Hay that has heated and molded as a result of fungal activity has usually undergone serious losses in quality. Even hay that is stored at 20% or less moisture may experience some quality loss. It has been estimated that dry weight loss in stored hay can average about 1% for each moisture percent above 10% at time of storage.

Factors to Consider When Evaluating Hay

Plant maturity is probably the most important factor influencing nutrient content and quality of hay. Generally, as a forage plant advances in maturity, the percent protein, energy digestibility, intake, and leafiness decrease; at the same time, the percent fiber, lignin, and stem increase. Therefore, when evaluating hay, pay close attention to the factors that indicate stage of maturity. Of course, hay that is moldy, dusty, or contains toxic plants or insects can nullify the value of proper stage of harvest.

Proportion of leaves compared to stems is another factor to

consider. Leaves contain two to three times as many nutrients as stems. Naturally it would follow that the more leafy the hay the higher the quality level.

Texture pertains to stem size (length and diameter) and softness (pliability or flexibility). Texture gives some indication of the palatability or acceptability by animals. Large, long stems that are hard and rigid are undesirable, and small, flexible stems are desired.

Color is an unreliable measure of hay quality. It is influenced by fertilization, sun bleaching, curing, moisture content, and species. All hays will gradually lose color with storage. A bright, dark-green color in hay usually indicates high vitamin and protein content. Browning of hay usually indicates a loss of nutrients. Heat-damaged hay turns dark brown, whereas unbleached hay is a lighter shade of brown.

Aroma is also an imporant factor in determining hay quality. A musty or moldy odor indicates that the hay was baled too wet. If you detect this odor, check for evidence of mold, which appears as a grayish-white, flaky substance or "dust," usually located in tightly packed sections of the bale.

The hay producer is forced to strive for the best compromise between high yields and nutritive value. As a general rule, this compromise is best reached with legumes (alfalfa, clovers) by harvesting at an early bloom stage (1/10 to 1/4). With grasses (fescue, orchardgrass), this compromise is best reached when they are just beginning to produce their seedheads.

Hay Preservatives and Drying Agents

Hay preservatives (usually organic acids such as propionic acid, urea, ammonia) are commonly applied to slightly wet hay (25 to 35% moisture) during baling so that hay can be removed from the field early. In this way, the chance of rain damage is reduced and leaf retention is high. The preservative acts to control microorganisms that would normally cause heating and spoilage (molds) in storage. Preservatives are active on both grass and legume hays.

Drying agents (usually mixtures of sodium and potassium carbonate) are applied to the hay crop during the mowing-conditioning operation and act to speed the drying process. Hay is baled at 20% moisture or below, and the drying agent helps achieve this level more rapidly. Drying agents are effective only with legumes such as alfalfa, and not on grasses.

Characteristics of High Quality for Some Hays

It is probably best to strive for top-quality hay at all times. However, even when you consistently employ best management practices, there will be times when hay quality is reduced by unexpected weather conditions. The characteristics of hays listed below should fit the needs of high-producing animals. Hays that are weather-damaged or hays that are more mature than those listed can still be used effectively if allocated to animals that have low nutritional requirements, such as those which only need to maintain present body weight. (Note that hay harvested at advanced maturity stages yields more hay per acre than early cut hay, but it will be of low nutritional value, therefore making it useful only as a maintenance feed.)

Alfalfa

Harvested in bud to 1/10 bloom stage (10% of stems showing a flower); small stems with an abundance of leaves; pale green to bright green is the natural cured color. First cutting usually contains larger stems than other cuttings.

Orchardgrass, Timothy, Fescue

Few seedheads in first cut; all regrowth harvests should be four to six weeks old and have no seedheads; pale green is the natural cured color.

Bermudagrass

Few seedheads, small stems, three to five weeks old, usually 12 to 15 inches tall; pale green to tan is the natural cured color.

Red Clover With or Without Grass

Few seedheads on grass with only 25 to 50% of clover stems having flowers. Natural cured color for red clover is light to dark brown.

Annual Lespedeza

Early bloom, with leaves still intact with stems. Usually bright green.

Millet, Sudangrass, Johnsongrass

Seedheads absent; 18 to 36 inches tall. Color is pale green. A disease known as cystitis syndrome has been reported when horses graze sorghum or sudangrass. This condition is not a problem with hays made from these grasses.

Chapter 16

USING WASTE PRODUCTS FOR FORAGE FERTILIZATION

Joe P. Zublena, James C. Barker, J. Paul Mueller, and J. C. Burns

Many waste products can serve as sources of nutrients or lime for use in forage production systems. When working with these materials, it is important to know the concentrations of different nutrients that are present, their availability for crop use and/or the liming equivalency, and the site-specific quantities required at each location.

Sampling the Waste Material

Before applying waste materials to land, have representative samples analyzed for nutrient or lime content. From several different locations, take subsamples of solid, semi-solid, or liquid materials that are uniform in consistency and do not require agitation before application. Mix the subsamples together in a plastic bucket. Liquid and semi-solid materials that are not uniform are more difficult to sample because the material must be thoroughly agitated before a representative sample can be taken. These slurry-type materials can be applied if data from similar materials are available to estimate nutrient values and subsequent application rates. Samples should still be taken after agitation and laboratory results used to back-calculate the amount of nutrients applied. This is the only way to determine whether or not supplemental fertilizer is needed. Results from analysis should be saved over time to develop a representative farm average to use for future slurry applications.

When taking manure samples, collect approximately three-quarters of a pint of material and place it in a nonmetallic flexible container, leaving adequate air space for gas expansion. If possible, refrigerate or ice the sample and deliver it to the laboratory soon after collection.

Waste samples can be analyzed for their nutrient content or liming equivalency by the North Carolina Department of Agriculture (NCDA), Agronomic Division, Plant and Waste Analysis Lab, PO Box 27647, Blue Ridge Road Center, Raleigh, NC 27611; phone 919-733-2655. The Department of Agriculture currently charges $4 per waste sample. When evaluating a sample for its liming abilities, request an analysis for the calcium carbonate equivalency. This is not a routine analysis. Other qualified private laboratories can perform similar analyses (fees vary).

Nutrient Availability

All of the nutrients applied in waste materials are not immediately available for crop use. Some of the nutrients are integral components of the organic structure and require microbial decomposition to release them. In general, only about one-half of the organically-bound nitrogen, and 70 to 80% of other nutrients becomes available to a crop during the year of application. Ammonium and urea, which are readily available forms of nitrogen, are also present in many materials. Both of these forms, however, can change into ammonia, which is volatile. When materials are applied to the soil surface and not incorporated, as much as 75% of the ammonia can be lost to the atmosphere. If the materials can be incorporated into the soil by disking or plowing within 48 hours, only about 25% is likely to be lost. Only 5% is lost if waste materials are directly injected into the soil.

To simplify the process of estimating nutrient availabilities, coefficients have been developed for most animal manures and municipal wastewater and sludges generated in North Carolina. These "availability coefficients" are multiplied by the total nutrient concentration for each element as reported in the waste analysis reports. Detailed information on availability coefficients and their use is available in the following publications: *Poultry Manure as a Fertilizer Source, Swine Manure as a Fertilizer Source,* and *Dairy Manure as a Fertilizer Source* (see the References section at the end of this chapter).

Application Rate

Land application rates should be determined by the nutrient requirements of the crop being grown. Waste materials can be applied at a particular rate to supply any of the recommended nutrients. Care must be taken, however, that the rate applied to

meet one specific nutrient requirement does not over or under apply other nutrients that can negatively impact the crop's health or water quality. If a material is applied to supply any nutrient other than nitrogen, apply the amount suggested by soil test recommendations. Since most waste materials do not contain the optimum nutrient balance required for each crop and field, it is important to check the soil recommendations for each nutrient and, if necessary, supplement with commercial fertilizer.

Application rate can not be overstressed. For example, a nitrogen loading rate experiment was conducted (Central Crops Research Station in Clayton, North Carolina) with bermudagrass in which swine lagoon effluent was applied weekly, from April to September, at approximately 0.25, 0.50, and 1.0 inches for 11 years. The 0.25-inch weekly loading rate (averaged 6.7 inches of effluent for the season) delivered total nitrogen at an average of 399 pounds/acre/year. Effluent applied at this rate of PAN also delivered annually 378 pounds/acre/year of phosphate, 571 pounds/acre of potash, 126 pounds/acre of calcium oxide, 100 pounds/acre of magnesium oxide, 240 pounds/acre of sodium, 1.0 pound/acre of copper, and 1.1 pounds/acre of zinc. While the nutrient concentrations of the forage may be acceptable for ruminant consumption, as much as 53 to 59% of such nutrients as phosphate, calcium oxide, magnesium oxide, and chlorine, and over 80% of sodium and copper were left in the soil to accumulate. Reducing the effluent loading rate to generally recommended nitrogen rates of 200 pounds/acre would essentially halve the quantity applied of the nutrients noted above and would increase removal efficiencies. Overapplication of nitrogen from lagoon effluent in both long-term experiments and on-farm evaluations have shown increased nitrate concentrations in forage and in shallow groundwater to the point where they may exceed health advisory limits.

Overapplication of nitrogen can also be a problem for forage and water quality. Long-term experiments and on-farm evaluations at sites where nitrogen was overapplied have shown increased nitrate concentrations in forage and shallow groundwater to the point where they exceed health advisory limits.

Calibration of Application Equipment

Periodic calibration of land application equipment is necessary to verify application rate. Whether the equipment is a pull-type spreader or travel-type irrigator, calibration is often the weakest link in a waste management program.

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FORAGE NEEDS FOR BEEF CATTLE IN NORTH CAROLINA

Matthew H. Poore, Ray W. Harvey, and Jerry W. Spears

Forages are the basis for most beef production systems in North Carolina. Efficient forage management is critical for profitability because most of the cost of producing beef cattle is directly related to feed. Most beef producers in the state would benefit from improved forage management, especially in the areas of strategic species selection to provide for a longer grazing season, grazing management to improve use and quality, and management of the winter feeding program. This chapter addresses the nutrient requirements of different animal groups in a beef operation, forage systems that may be useful in different regions of the state, and optimal supplementation programs for forage-based diets.

Animal Requirements

The beef industry in North Carolina is primarily composed of cow/calf and stocker operations, with relatively few finishing cattle. Table 1 shows the average nutrient requirements of the different animal classes on a typical cow/calf operation, for stocker cattle fed to gain 2.0 pounds/day, and for finishing cattle fed to gain 2.5 pounds/day.

Table 1. Nutrient requirements of beef cattle.[1,2]

	Total feed lb/day (90% dry basis)	Crude protein %	TDN %	Ca %	P %
Bulls					
Developing, 750 lb	22	11	67	0.44	0.24
Regaining condition	30	9	63	0.29	0.23
Maintenance	30	7	50	0.26	0.21
Cows					
Dry	3	8	50	0.26	0.21
Average milk	24	10	56	0.27	0.22
High milk	24	12	65	0.38	0.27
First calf heifers					
Average milk	20	11	63	0.33	0.23
High milk	20	13	68	0.40	0.30
Developing heifers[3]	15	12	68	0.38	0.22
Stockers[4]					
350 lb	10	15	68	0.72	0.32
550 lb	15	13	68	0.47	0.24
750 lb	18	11	68	0.34	0.21
Finishing cattle[5]					
850 lb	21	10	74	0.35	0.21
950 lb	22	9	74	0.31	0.20
1,050 lb	24	9	74	0.27	0.19

[1] Adapted from *Nutrient Requirements of Beef Cattle*, NRC, 1984.
[2] 1,100-pound cow, 1,800-pound bull.
[3] Medium frame, 500 pounds 1.5 pounds/day gain.
[4] Medium frame, 2.0 pounds/day gain.
[5] Medium frame, 2.5 pounds/day gain.

In general, commercial cows in good body condition should weigh from 1,000 to 1,200 pounds (frame score 4 and 5), and a reasonable goal is to wean a 550-pound calf (half the cow's body weight) when it is nine months old. This will normally require a cow with above-average, but not extremely high, milk production. Forages alone can support cows with high milk production if quality and availability is high from the time of calving through the end of the breeding season. In many situations in our state, however, very high milk production is not desirable because the feeds available do not support the body condition necessary to obtain acceptable reproductive rates. If high-quality forages are

abundant, and/or if corn silage is produced, a uniform group of cows with high milk production potential such as dairy/beef crosses may be desirable.

Maintaining uniformity in a group of cattle in terms of milking ability, stage of production, frame size, and fleshing ability is critical to nutritional management. First calf heifers should always be fed separately from the mature cows until the end of the breeding season. Stocker cattle and heifers from weaning to breeding should normally be fed to gain from 1.5 to 2.0 pounds/day. This will often require supplemental feeding on hay-based programs and on bermudagrass or fungus-infected fescue pastures. If, however, calves are grazing high-quality forages such as a winter annual, alfalfa, fungus-free fescue/clover, or orchardgrass/clover, supplementation with grain may not be necessary or desirable, depending on the intended market for the calves.

Forage Systems for Beef Cattle

The forage systems discussed here contain enough acreage (Table 2) of the suggested species to provide a 12-month feed supply for cows and their calves through weaning. Additional acreage will be needed for bulls (same as for cows) and replacement heifers (half as much as for cows). The range of acres (Table 2) allows for low to high production potential. Graziers should have available each year 1 to 1.5 tons of hay for each cow-calf unit for winter feeding and emergency feed supply; most of this can be provided by excess tall fescue or hybrid bermudagrass.

Spring Versus Fall Calving Cow Herds

One topic of frequent discussion is whether cows should calve in the fall or spring. This will largely be influenced by the type of forage system used on a given farm. Most farms in the coastal plain use fall and winter calving, whereas herds in the piedmont and mountains may use either fall, winter, or spring calving. Calving should also occur during a time of readily available labor for managing cows.

Fall Calving

For farms that have (1) cool-season perennial forages such as tall fescue/ladino clover, (2) good-quality hay for winter feeding, and (3) some winter annuals available for grazing, fall calving (September and October) may be the best choice. This system is useful primarily in the piedmont and coastal plain. Calves from such systems may be weaned from April to June. These calves can be retained for summer grazing, if available, marketed as summer stockers, or placed on contract for the summer grazing season. The dry cows are then grazed on summer growth of the cool-season forage and a relatively small acreage

Table 2. Acreage needs of each cow-calf pair under different calving systems.

Fall calving	
Fescue-ladino clover or orchardgrass-ladino	.75 to 1.25 acres
Pure fescue (for stockpiling)	.5 to .75 acres
Bermudagrass or other warm-season perennial or annual	.25 to .50 acres
Winter calving	
Cropland overseeded to rye and/or ryegrass	1 to 3 acres
Fescue-ladino clover or orchardgrass-ladino	.5 to .75 acres
Hybrid bermudagrass or other warm-season forage	.25 to .5 acres
Crop residues	0 to 1 acre
Spring calving	
Fescue-ladino clover or orchardgrass-ladino	.5 to .75 acres
Pure fescue (for stockpiling)	.5 to .75 acres
Bermudagrass or other warm-season perennial or annual	.5 to .75 acres

of bermudagrass, switchgrass, flaccidgrass, pearl millet, sorghum/sudan hybrid, or other warm-season forage until calving.

Accumulate the pure stand of fescue between mid-August and November 1 for grazing in late fall and winter. Stockpiled fescue should be grazed only after the other pastures are completely grazed. Strip grazing the stockpiled fescue will greatly improve its use. The bermudagrass may be overseeded with rye, ryegrass, or other winter annuals; if summer annuals are used, they can be grown in rotation with winter annuals. If winter annuals are used, reduce cool-season forage acreage by 0.25 acres per cow-calf unit. Feed hay to cows to supplement winter grazing, and allow calves to creep graze on rye if possible. If available hay and pasture are below protein and energy requirements, use a supplement. Creep feeding may be profitable if grain prices are low, if the calves have good growth potential, if forage availability is low, or if an early market is targeted.

Winter Calving

Winter calving may be best for farms with abundant winter grazing on overseeded cropland in addition to limited cool-season pastures and summer pastures. This system usually would be found in the coastal plain on integrated crop and cattle farms. Calving should be in January and February, which will coincide with the increasing availability of high-quality grazing from the winter annual, and labor also should be most available at this time. Before calving, pregnant cows should not be grazed on winter annuals, which, because of their high quality, can result in heavy birthweights. After calving, however, cows should be put on winter annual pasture. Once the winter annual is gone, cows should be grazed on the cool-season perennial until the warm-season forage is available for grazing. Calves are weaned September 1 and marketed as feeder cattle. Dry cows can then be grazed on crop residues and leftover warm-season pastures until calving. Growth of the cool-season perennial can be grazed at this time or allowed to accumulate until needed.

Spring Calving

Cows should begin calving a month before cool-season pastures are available in the spring, when winter feed is expensive, labor is limited, and winter pastures are not available. Calving is normally on stockpiled fescue in February and March. A good balance of cool- and warm-season forages is necessary to achieve acceptable weaning weights. After calving, cows should be fed medium- to high-quality hay with supplemental energy fed as needed to maintain body condition until there is sufficient forage available for grazing. When forage for grazing becomes available, cows are grazed on the cool-season grass/ladino clover pastures, and the stockpiled fescue acreage is harvested as hay. When warm-season forages are ready for grazing, these pastures should be incorporated into the rotation, with cool-season pastures grazed periodically during the summer to remove any growth. The cool-season pasture should not be grazed to less than a 2- to 3-inch stubble. When summer forages are used up in early fall, the cool-season pastures will again provide excellent forage. The pure stand of fescue should be accumulated from August 15 to at least November 1.

Calves are weaned from such a system in late October and marketed as feeder cattle, or wintered over and sold in the spring. Creep feeding or creep grazing may be desirable during summer droughts to prevent low weaning weights. After calves are weaned, use dry cows to clean up any residue on warm-season and cool-season pastures before putting them on stockpiled fescue around the first of January.

Mixed-Species Pastures

Mixed pastures containing both cool-season grasses such as tall fescue, Kentucky bluegrass, and orchardgrass, and warm-season grasses such as dallisgrass, bermudagrass, and crabgrass, in addition to legumes, may also work with fall, winter, or spring calving. Most old pastures evolve into this kind of a mix of species, and this is not necessarily

undesirable. If the pastures are rotationally grazed, the species composition of the regrowth will vary with season. Excess spring and summer growth is removed as hay. Winter or spring calving is best for farms where the bulk of the pastures are mixed species. Approximately 1.5 to 2.5 acres of mixed species pasture, depending on the level of fertilization, will be needed to maintain a cow and calf.

Forage Targeting

One of the best ways to make cattle production in our state more efficient is to develop a forage targeting program for the winter feeding period. This type of program will minimize, and possibly eliminate, the cost of supplemental feeding by taking advantage of the forage resources available on the farm. Most farms have hay ranging from low to high quality, in addition to a limited amount of very high-quality grazing for the winter feeding period. Because the quality of forages varies from year to year, supplementation programs need to be varied to optimize the economic efficiency of the entire operation.

These are the steps necessary to develop a forage targeting program:

1) Take inventory of the forages available for winter feeding and test them for nutrient content.

2) Group animals according to nutrient requirements—heifers, two-year-old cows, mature lactating cows, mature dry cows, etc. Most farms will have three or four groups if replacements are raised.

3) Target combinations of the available forages to best meet the nutrient needs of the different groups.

4) Buy the least expensive source of supplemental energy, protein, and minerals available.

Most Extension agents in the state have forage sampling equipment as well as the expertise needed to develop a targeting program. An efficient forage targeting program can increase profit per cow by as much as $50 compared to more traditional winter feeding programs.

Supplementation Programs

Mineral and Vitamin Supplements

Forages grown in North Carolina are often deficient in one or more minerals. Traditionally phosphorus has been the mineral thought most likely to be deficient, but forage analyses show that this is not the case in most of the state. If high levels of animal waste or commercial fertilizer are used on pastures, supplemental phosphorus may not be needed. Recent observations suggest that the trace minerals copper, zinc, and selenium, along with magnesium and salt, are the minerals most likely to be deficient.

When good-quality forages are fed, vitamin supplementation is normally not necessary. During times of extended drought, times when cattle are fed old or low-quality hay for a long period of time, or when they are fed silage, animals might suffer from a Vitamin A deficiency. Supplementing with 25,000 IU/day Vitamin A from a vitamin/mineral mix, or injecting 500,000 to 2,000,000 units is recommended when necessary.

The main problem with mineral supplementation recommendations is that minerals vary considerably between forage types and from farm to farm, so that a supplement that is needed on one farm may not be needed on another farm. Again, forage analysis can help show which minerals are needed on your farm. Some recommended levels to look for on a commercial mineral supplement tag are given in Tables 3 and 4. As a general rule, any mineral supplement

Table 3. Supplement to be fed to stocker calves grazing heavily fertilized pastures.

Ingredient	%	lb/ton
Corn (or other grain)	93.4	1,868
Feed grade limestone	1.9	38
Magnesium oxide	1.9	38
Trace mineralized salt	1.9	38
Ionophore premix[1]	1.0	20

[1] 5,000 mg/lb Bovatec or Rumensin.

Table 4. Suggested trace mineral levels in commercial mineral supplements for beef cattle.

Trace mineral levels — 4 oz/day intake.
(Levels should be twice this for minerals with consumption of 2 oz/day.)

Zinc	0.18%
Copper	0.09%
Manganese	0.18%
Iodine	0.0026%
Selenium	0.0026%
Cobalt	0.0018%

should provide a mature cow with 100 milligrams/day copper, 200 milligrams/day zinc, 200 milligrams/day manganese, 3 milligrams/day selenium, 2 milligrams/day cobalt, and 3 milligrams/day iodine. Once you have located several brands of supplements that are near the requirements, your decision to purchase can be based on price, customer service, acceptability of the supplement to the cows, and weathering ability.

The mineral supplement should be fed in a covered feeder that will keep it dry. Stir the supplement frequently to break up the lumps. Monitor cows' mineral intake to ensure adequate consumption and to prevent overconsumption. A cow should eat approximately 1 pound of supplement per week if it is labeled for 2 ounces/day intake, and 2 pounds/week if labeled for 4 ounces/day intake.

To prevent grass tetany, a high magnesium supplement should be used from several weeks before calving through the end of the lush spring period (Table 5). A thorough discussion of grass tetany prevention can be found in Chapter 21, "Forage-Related Disorders of Beef and Dairy Cattle."

Energy Versus Protein Supplements

Before purchasing supplements, producers should determine whether supplemental protein, supplemental energy, or both are needed. In general, growing animals and heavily milking cows fed low- to medium-quality forage will require additional energy and protein. Mature cows of average milking ability require about 10% protein and 56% total digestible nutrition (TDN) in the forage, whereas heavily milking cows require about 12% protein and 65% TDN. Young animals greater than 400 pounds generally require about 13% protein and 68% TDN in the forage. High-quality forage usually will meet the protein requirements but may not meet the energy requirements. Therefore, if growth rate or body condition of the cattle is less than desired when feeding medium- to high-quality forage, it is likely due to a deficiency of energy. Some forages are a good source of both protein and energy; some are a good source of protein but are low in energy; some are low in both protein and energy. Forage analysis will show what type of supplement, and how much, is needed.

Table 5. Suggested major mineral levels in commercial mineral supplements for beef cattle.

Major mineral levels — 2-4 oz/day intake

	Low- to medium-quality forage		High-quality forage	
	Regular %	High Mag %	Regular %	High Mag %
Salt	15-30	15-30	15-30	15-30
Calcium	6-12	6-12	6-12	6-12
Phosphorus	6-12	6-12	0-12	0-12
Magnesium	0-4	8-14	0-4	8-14
Sulfur	1-3	0-3	0-3	0-3

Alternative Feeds

Many alternative feeds are available that can provide protein and/or energy much cheaper than traditional (corn with soybean meal) or commercial supplements. If forage analysis shows that supplements are needed, choose

the cheapest source of the needed nutrients. Cottonseed, wheat midds, and soyhulls are examples of alternative feeds that make good supplements to forages and are often economical in North Carolina.

Pasture-Based Stocker Programs

Stocker cattle rotationally grazed on high-protein pasture such as tall fescue, bermudagrass, or summer or winter annuals will normally respond to low-level grain feeding (3 pounds/day) by increasing average daily gain by about 0.5 pounds/day. Supplementing will generally be profitable when the value of gain exceeds the cost of 6 pounds of supplement. A feed formulation to be used in these situations is given in Table 3. At least 18 inches of feeder space/head will be needed if the cattle are hand-fed. If limiting intake with salt is desirable, include 15 to 25% white salt in the mixture and provide in a self-feeder. Stocker cattle weighing 500 to 700 pounds will consume about 0.75 pounds of salt/day, so cattle would normally eat about 4 pounds/day of a 20% salt mixture.

Finishing Cattle on Pasture

In some situations, producers will want to finish calves for custom freezer beef or for home consumption. Calves can be grown to heavy feeders as outlined for stocker cattle above, and then placed on a high level of grain feeding for about 60 days, either on pasture or in a lot. Research at NCSU has shown that this type of system provides beef similar in flavor and quality to beef raised in conventional feedlot systems.

Calves to be finished can also receive a "grain-on-grass" program using either a ladino-grass mixture or pure grass through the grazing season which will result in rapid gains (2 to 2.5 pounds/day) and desirable finish on the animals. Providing a grain mix consisting of 90% corn and either 10% salt or animal fat in a self feeder, or hand feeding about 1% of the animal's body weight as corn while animals are still on pasture will result in desirable finish on these cattle. With medium frame steers, it works well to provide such a grain supplement to calves on pasture from April through September. For medium frame heifers, desirable carcasses can be produced by providing animals with only forage from April through July and then with the grain supplement from July through September. This system will minimize the overall use of grain, but will still result in beef with the characteristics desired by most consumers. If grass-fed, lean beef is desired, cattle can be grown on high-quality forages without grain until they are at the desired size for slaughter.

Summary

Improved forage management would benefit most cattle operations in North Carolina. Calving season will vary from farm to farm and should be planned so that calves are born at a time when labor is available, and when high-quality forage can be made available through the end of the breeding season. In general, many farms in the state would benefit from adding either warm-season, cool-season, or winter forages to complement the forage base that predominates.

The major limitation to winter nutritional management of herds in the state is the lack of forage analysis. The state of North Carolina provides an excellent forage analysis service, but few beef producers use it to their advantage. Analyzing forages costs $10/sample and usually not more than $60/year for a given operation. Using this information to develop a least-cost winter feeding program can save as much as $50/cow in comparison to the traditional program of supplementing without information on the nutritional value of the forages available.

Contact your Extension agent for help with grazing systems, forage sampling and analysis, supplementation programs, and the development of a least-cost winter feeding program. Additional detailed information on these topics and others can be found in the North Carolina Beef Management Handbook which is available through the North Carolina Cooperative Extension Service.

Chapter 18

SPECIAL FORAGE NEEDS FOR DAIRY CATTLE FED HIGH-CONCENTRATE DIETS

Brinton A. Hopkins, Lon W. Whitlow, Allen H. Rakes, and Steven P. Washburn

An abundant supply of high-quality roughage is essential for successful dairy farming in North Carolina. Forages are generally the most economical source of roughage and nutrients needed by dairy cattle and provide the primary source of dietary fiber and significant amounts of energy, protein, minerals, and vitamins. For the past 30 years, the relatively low cost of grain coupled with the higher production response to grain feeding has resulted in optimal dairy rations containing 50 to 60% concentrate. These rations maximize energy with grains but provide fiber levels for adequate rumen function and health. A primary means of improving these rations is through the use of high-quality forages which provide highly digestible fiber that is also adequate for roughage. This chapter focuses on the use of high-quality forages along with optimal concentrate feeding to maximize returns over cost of feeding. Roughages may be produced or purchased. (See Figure 1.)

Fiber Requirements

The measure of feed fiber used in North Carolina is acid-detergent fiber (ADF), which consists of cellulose, lignin, pectin, acid-detergent insoluble nitrogen, and acid insoluble ash (NRC 1989). Neutral detergent fiber (NDF), which includes ADF plus hemicellulose, may also be used. High-fiber forages or diets are lower in energy content (TDN or net energy) and limit feed intake. However, dairy cows generally need 19 to 21% ADF (percentage of dry matter) to prevent acidosis and disorders associated with low-fat test, such as founder, foot disorders, digestive upsets, and displaced abomasum. In practice, recommended levels of fiber depend on cow factors such as milk production, stage of lactation, and body condition; diet factors, such as fiber effectiveness, forage type, and level of added buffers; feeding method; and economics (NRC 1989). High-producing dairy cows are generally fed lower fiber rations and benefit from higher-quality forage to provide sufficient energy.

Figure 1. Dairy heifers can effectively use pastures.

Effective Fiber

One of the primary functions of a forage is to provide effective fiber or roughage value. Effective fiber results in more cud chewing which stimulates secretions of natural buffers in saliva. Salivary buffers along with dietary buffers help prevent acidosis. Fine chopping, grinding, and/or pelleting reduce cud chewing, whereas larger forage particles generally increase cud chewing. Corn silage harvesters should be set for a 3/8 inch theoretical length of cut which should allow for about 20% of the silage particles to be one inch long.

Effective fiber values have been measured for various forages and grains (Balch 1971, Sudweeks et al. 1975, Jorgensen et al. 1978, Gast 1979, Sudweeks and Ely 1979) and should be considered when formulating rations for dairy cattle (Table 1). If low effective fiber rations are fed, added buffers can help prevent acidosis.

Forage Quality

To support high levels of milk production, a forage must be digestible (provide energy) as well as provide effective fiber. High-fiber feeds such as soybean hulls have little effective fiber, but the fiber

Table 1. Effective fiber levels of selected feeds.

Feedstuff	Chewing time[1] (minutes/lb of DM)
Alfalfa	
Long	28
Silage	26
Corn silage	
Coarse chop	30
Medium chop	27
Fine chop	18
Orchardgrass hay	
Early cut	34
Late cut	41
Wheat or barley silage	
Regular chop	31
By-products	
Whole cottonseed	13
Cottonseed hulls	14
Brewer's grains	7
Wheat midds	4
Soybean hulls	4
Grains	
Ground corn	4
Ground barley	7
Soybean meal	3

[1] Estimated from Gast (1979). Proceedings of the American Feed Manufacturers Association.

is very digestible. Conversely, straw fiber is highly effective but low in digestibility. Corn or sorghum silage are both moderate in effective fiber content, but since the fiber in corn is more digestible than the fiber in sorghum, corn silage is considered the higher-quality forage. Within a forage species, stage of maturity at harvest is the main factor affecting quality. In addition to having digestible fiber and effective fiber, a quality forage must also be palatable, free of contamination, and a good source of other nutrients.

Substitution Effect of Grain for Forage

When cows consume more concentrate they eat less forage; however, total dry matter intake increases. This is called the substitution effect (Broster and Thomas 1988, Thomas 1988). Concentrates depress intake of low-quality forages more than high-quality forages, thus high-quality forages help maintain a better total feed intake. Since high-quality forages are more digestible, they also pass from the rumen quicker, making room for more feed. Thus consumption is higher. In North Carolina, the relatively low price of concentrates in relation to production responses makes it profitable to feed relatively large amounts (40 to 60% of the diet) to dairy cows. Cragle et al. (1986) summarized the relationship of increased concentrate feeding to increased profits with upper limits of concentrate feeding primarily dictated by minimum effective fiber levels. The amount and composition of supplemental concentrate is determined by the palatability, digestibility, and nutrient content of available forage.

By-Product Feeds as Forage Substitutes

Several by-product feeds available in North Carolina contain enough fiber to replace all or a portion of the forage in a balanced ration. Examples include cottonseeds, cottonseed hulls, peanut hulls, brewer's grain, and wheat middlings. Production response to use of by-products depends on quality and amounts of feeds substituted and the proper maintenance of nutrient balance.

Silage, Hay, and Pasture

Rations with large amounts of fermented feeds such as silage can support high levels of milk production, although moisture content (Chase 1979), palatability, and minimum fiber level must be taken into account when formulating diets.

Corn silage is the primary forage used on North Carolina dairy farms since it grows well, is high in quality, provides large amounts of energy and other nutrients per acre, and can fit as a double crop with

small grain silage. A disadvantage of conventional temperate corn is its sensitivity to drought stress and disease, and the need to plant it earlier than many other summer annuals.

Tropical corn hybrids are more drought tolerant, more resistant to pests and molds, and have a more favorable growing season than conventional corn silage varieties (Rakes et al. 1991). Since tropical corn is planted in early June, double cropping with small grains is more practical. Although tropical corn silage is higher in fiber and lower in grain content than conventional corn silage, the fiber in tropical corn is more digestible than in temperate corn (Johnson et al. 1981). In addition, tropical or conventional corn silage rations containing equal fiber (more supplemental concentrate added to the ration with tropical corn) will support equivalent levels of milk production (Rakes et al. 1991).

Sorghum, because of greater drought tolerance, is sometimes planted as an alternative to corn for silage especially if planting is delayed or if there is a greater need to guarantee tonnage yield than to maximize quality. Performance of dairy cattle consuming sorghum silage is generally less than with corn silage because of the lower digestibility and palatability of most sorghum silage.

Summer annuals such as pearlmillet, sudangrass, and sorghum-sudangrass hybrids can be used as short-term forage alternatives. Pearlmillet is often associated with a depression in milk fat test.

Small grains can provide excellent forage for dairy cattle. They can be grazed in late fall and early spring with regrowth harvested as silage.

When to Harvest Forages for Silage

Corn should be harvested for silage between 30 and 35% dry matter (tropical corn will be about 25 to 28% dry matter). The corn kernel should be about half starch and half milk. At this point, the bottom leaves will generally be brown or wilting.

Sorghum should be harvested for silage at the milk to soft dough stage before the grain becomes hard and undigestible and before lignification of the stalk, which also reduces digestibility.

Recommended harvest maturity for small grain silage varies among species and depends on the method of harvest. The earlier that small grains are cut, the higher the quality of the forage, although yield is reduced. With the direct cut method, oats, wheat, triticale, and barley should be harvested when the grain is at the milk stage. If the harvest practice includes cutting and wilting the forage before chopping, all small grains should be harvested at the boot stage of growth. Rye must be cut at the boot stage because the quality and palatability declines drastically after the boot stage.

Hay is often included in lactating-cow rations at low levels to ensure that the animals are getting adequate fiber. Hay is a primary forage for dry cows and heifers during the winter.

Pasture can provide an economical source of nutrients during certain periods of the year. Supplemental pastures also allow cows to get off concrete and thus may improve reproduction and hoof health. Properly managed, pastures may be higher in quality than other forages. Pasture's high moisture content and degradability of protein must be considered in ration formulation. As quantity and quality of pasture changes, rations must be reformulated to keep nutrients balanced. The economic value of pasture use is highly dependent on the cost of other feeds and forages, land, labor, and equipment.

Dairy Forage Systems

Types of forage systems include continuous grazing, rotational grazing, strip grazing, green chop (soilage) feeding, and stored feeding (hay, low moisture hay or hay crop silage, or silage).

Several types of dairy forage systems have been evaluated under North Carolina growing conditions at the Piedmont Research Station at Salisbury (Rakes et al. 1991). Compared with feeding a mixture of silage and hay during the winter and pasture during the spring, summer, and fall, cows fed all corn silage produced less in the spring and summer period but more in the fall and winter. Cows on the corn silage based rations had reduced reproductive performance probably due to continual confinement to a

dry lot. Land area requirements may be increased with the silage-hay-pasture system in comparison to corn silage alone. In areas with erodible land, important considerations are longer rotations, minimum tillage, and use of pasture.

Cows grazing endophyte-free Johnstone tall fescue that was properly supplemented with concentrates produced a similar amount of milk as cows fed a blended ration based on corn silage. Cows fed equal amounts of concentrates produced similar amounts of milk when grazing either Johnstone tall fescue or Boone orchardgrass (Rakes et al. 1991).

Several other researchers have compared pasture systems (Larsen 1959, McCullough 1959, Porterfield and Pratt 1966, Blaser et al. 1969). Pasture systems that incorporate both warm- and cool-season species allow grazing for longer periods of the year.

A dairy forage system that employs double cropping of small grain silage with conventional and/or tropical corn silage yields more dry matter per acre than other systems and works well under North Carolina conditions (Rakes et al. 1991). This system takes advantage of rainfall during fall and winter, which usually results in adequate growth of small grain for silage. Tropical corn replaces sorghum in this system which results in a higher quality forage base. Supplemental hay and pasture may also be a part of this system.

Certain legumes may be important components of forage systems as monocultures or intercropped with other forages.

Summary

An abundant supply of high-quality forage is essential for efficient milk production. Environmental factors such as soil types, climate, and topography influence decisions about forage management. Such factors have led to a reliance on corn silage as the primary forage for dairy cattle. Other forage programs include supplemental use of pastures, hay, and other silage made from grasses, small grains, sorghum-sudangrass hybrids, and some legumes.

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Chapter 19

INTEGRATING FORAGES INTO MANAGEMENT SYSTEMS FOR HORSES

Robert A. Mowrey and Kevin R. Pond

Horses evolved primarily as grazing animals and are well adapted to consume high-quality forages. Forages should be the major component in a cost-effective feeding program for horses at all production stages. Mature horses should consume at least 50% of their diet from forages as either pasture or hay to ensure normal digestive function. In most production systems forage intake can be 100% of the diet for horses at least 24 months old. Because horses younger than 12 months have a relatively small digestive tract and low microbial activity, forage intake will account for only 30 to 40% of their diet. General guidelines for expected feed consumption based on average-quality forages are presented in Table 1.

The cecum is the major site of absorption, and its position after the small intestine further limits the horse's ability to digest poor-quality forages. However, horses' ability to digest fiber is similar to that of ruminants when fed leafy, immature forages. A number of palatability and digestibility trials indicate that horses will eat a variety of high-quality grasses and legumes. Feeding high-quality, more nutrient-dense forages minimizes the need for concentrates and supplements.

Table 1. Expected feed consumption by horses consuming average-quality forages.[1,2]

	Forage		Concentrate		Total
	Body weight	Diet	Body weight	Diet	Body weight
Mature horses			%		
Maintenance	1.5-2.0	100	0-0.5	0	1.5-2.0
Mares, late gestation	1.0-1.5	70	0.5-1.0	30	1.5-2.0
Mares, early lactation	1.0-2.0	50	1.0-2.0	50	2.0-3.0
Mares, late lactation	1.0-2.0	65	0.5-1.5	35	2.0-2.5
Working					
Light[3]	1.0-2.0	65	0.5-1.0	35	1.5-2.5
Moderate[4]	1.0-2.0	50	0.75-1.5	50	1.75-2.5
Intense[5]	0.75-1.5	35	1.0-2.0	65	2.0-3.0
Growing horses					
Nursing foal (0-3 mo)[6]	0	0	1.0-2.0	50	2.5-3.5
Weaning (4-6 mo)	0.5-1.0	30	1.5-3.0	70	2.0-3.5
Short yearling (12 mo)	1.0-1.5	40	1.0-2.0	60	2.0-3.0
Long yearling (18 mo)	1.0-1.5	50	1.0-1.5	50	2.0-2.5
2-year-old (24 mo)	1.0-1.5	50	1.0-1.5	50	2.0-2.5

[1]Air-dry feed (about 90% DM).
[2]Adapted from Nutrient Requirements of the Horse. Fifth revised edition. 1989. National Academy Press. Washington, D.C.
[3]Examples include horses used in pleasure and equitation classes and recreational trail riding purposes.
[4]Examples include ranch work, roping, cutting, hunting, jumping, gymkhana events, etc.
[5]Examples include polo, endurance/competitive trail riding, race, and three-day event training.
[6]The total percent body weight includes estimated milk intake.

Pasture Use

If properly managed, a grass or grass-legume mixed pasture provides an excellent source of energy, protein, vitamins, and minerals to horses in a variety of production stages while minimizing the need for concentrate feeds (Figure 1). Broodmares in late gestation and lactation, growing horses, and horses at moderate to intense exercise may require additional supplementation with grain. Pasture quality is directly related to several factors, such as fertilization, forage species selection, pasture renovation, stocking rate, the stage of maturity of the forage, and the environment. Fortunately, most of these factors can be controlled for optimum, high-quality forage production through sound pasture management practices.

Figure 1. Horses are well adapted to consume high quality forages.

The ideal horse pasture should contain (1) a smooth surface free of potholes, trash, potentially harmful objects, and noxious plants; (2) a dense stand of nutritious and palatable forage; (3) ample area to permit grazing and exercise while maintaining a consistent rotation plan; (4) safe fences and gates; (5) free access to fresh, clean water; (6) adequate shade and shelter from adverse weather; and (7) freedom from marshes and wetlands.

Pasture or Exercise Paddock: There Is a Difference

Pastures are areas that provide ample space to maintain adequate amounts of nutrient-dense forage to meet horses' nutrient requirements. A traditional recommendation has been two acres of pasture per mature 1,100-pound horse to supply 12 months of forage for grazing and hay production. Pastures should be seeded or sprigged with a high-quality perennial forage and managed to maintain a productive stand.

Exercise paddocks or drylots are areas of one acre or less per horse. The paddocks typically are located near barns and are used only to provide exercise. Subsequently, they should be planted with a persistent forage such as tall fescue or common or hybrid bermudagrass. Exercise paddocks also can be used as a holding area during periods of heavy rainfall until pasture conditions improve. The tearing action hooves make while horses canter is destructive to extremely wet pastures. Generally, exercise paddocks are fenced areas, with limited vegetation, which have a minimum of 400 square feet. Long narrow areas (runs) are best (minimum of 14 feet wide) with the layout along land contours to minimize erosion. Horses prefer to run along fence lines; therefore, several long narrow runs will let separated horses exercise together without direct interference. Grass filter strips (minimum 25 feet wide) located downslope of an exercise area will greatly reduce any pollutants that might leave the site.

Forages planted in an exercise lot can provide nutrients to replace a portion of horses' forage requirements. The pasture management system is the determining factor on how much feed value can be realized.

Determining Pasture Size

Even very small areas measuring an acre or so can contribute to the feeding program. However, these areas cannot be used as a dry lot. Animals must be added to and removed from an area at the correct times to obtain optimum nutrition, rapid regrowth, and stand persistence. For example, a mature horse can consume up to 3% of its body weight per day in forage dry matter. Thus a 1,000-pound horse might consume about 30 pounds of forage per day. A hybrid bermudagrass (Coastal or Tifton 44) pasture is capable of producing from 10 to as much as 80 pounds of dry forage per acre per day from May through September. A conservative estimate of total dry forage production for the season might be 3.5 tons per acre (7,000 pounds). If about 3,500 to 4,000 pounds of that growth is actually eaten, then 133 pasture days of grazing are produced per acre (4,000 ÷ 30 pounds intake/day = 133 days). In reality, this means that on some days, such as during early May or late September, less than the 30 pounds needed will be available. On the other hand, during the peak growing season of June-July-August, two to three 1,000-pound horses could be grazed, or a section of pasture could be fenced off for hay production. The same basic information can be calculated for low-endophyte tall fescue-clover pastures and other appropriate pasture species.

Although it is generally accepted that about two acres of pasture per mature horse are needed to satisfy both nutritional and exercise needs, do not overlook the possibility of getting nutrition from pasture if less than 2 acres per animal are available (Table 2). The key is management flexibility. If less than 100% of the nutrients are to come from forages, the following land area allocation between nutrition and exercise may be appropriate.

Table 2. Land area and percent nutrient intake from pasture.

% nutrient intake from pasture	Land area (acres/horse)		
	For nutrients	For exercise	Total acres per horse
50	0.75	0.25	1.00
75	1.25	0.25	1.50
100	1.50	0.25	1.75

Grazing Management

Conventional rotational grazing involves dividing pastures, usually with permanent fences, into several sections (at least two or three) and rotating horses in a manner based on pasture growth. Pasture size is allocated so horses will be rotated every 14 to 21 days depending on pasture regrowth and availability. With this system, failure to maintain a proper stocking rate (number of horses per acre) will result in excess mature forage and selective or spot grazing.

The stocking rate should be maintained to ensure consumption of young leafy forage without overgrazing. A properly managed rotation system should maintain plants in a condition that permits rapid regrowth and stand persistence.

A controlled, intensively grazed rotational system is the most efficient grazing method for horses. In this system, the pasture area is subdivided into several sections, enclosures, or paddocks, and horses are rotated from paddock to paddock based on plant growth and animal nutrient needs. Usually, the period of stay in any one paddock is relatively short, (one to five days), depending on the amount of forage present before grazing starts and the rate at which the forage is consumed. Safe, inexpensive, temporary electric fencing, including electrified aluminum wire or polytape, can easily be erected and removed. Horses quickly adapt to electric temporary fencing after short exposure. In some cases, after initial shock, horses will not test the fence again. Others require a consistent and constant voltage.

Perennial Plants for Pastures

Perennial plants should be used as the foundation of a permanent pasture system. There are a variety of plants adapted to different areas and soil types in North Carolina (see Chapter 8). Whenever soil and

climate permit, cool-season grass-clover mixtures are preferred to pure grass stands. In almost every case, both warm- and cool-season pastures will be needed to provide the best year-round grazing system (for example, a bermudagrass pasture for summer and a fescue-clover pasture for fall and spring).

Annual Plants for Pastures

Temporary pastures are planted annually and are usually used within six to nine months after planting. Winter annuals such as rye, oats, wheat, and ryegrass typically are used for temporary winter pastures. They may be interseeded into bermudagrass or other warm-season pastures or planted alone in September to provide quality grazing from December through May. Pearlmillet is one of the best summer annuals for horse pastures.

The proper combination of perennial and annual pasture species will provide almost year-round grazing under ideal conditions. Only a limited supply of hay will be required in a properly managed pasture system.

Avoiding Spot Grazing

The horse grazes from the top of the canopy downward and, because of its jaw and teeth structure, is able to graze much closer to the ground than a cow. The horse's sensitive lips position and snip the forage between its upper and lower incisors. Allocating horses to areas that are too large for the animals to completely consume the forage grown will lead to "spot grazing." Spot grazing is most severe when the animals are allocated appreciably more grass than they can use within a three- to five-day period. The horses will continually graze and regraze the same areas while other areas in the same pastures are ignored and become mature, stemmy, and unpalatable. Forages located near fences or urine spots typically are not grazed. If left unchecked, this grazing pattern can reduce the effective grazing area, encourage the encroachment of weeds, and result in serious stand loss of desirable pasture plants. Subdividing a pasture area to reduce the land area available for grazing, followed by rotation to another area, will reduce the occurrences of spot grazing. In addition, when animals are removed from a rotational paddock or pasture, the area may be clipped to remove old, ungrazed plants and to stimulate new, leafy regrowth. The area can also be dragged either during or after clipping to break-up and spread manure evenly over the paddock, which will aid in parasite control and improve nutrient recycling.

Using cattle to graze in sequence after horses on the same pasture is an effective method of improving pasture utilization. Since the grazing behavior of horses and cattle differ, cattle will graze some of the forage left by the horses. Cattle can be forced to graze the more mature forages by restricting them to the area. This will help to use the pasture efficiently and to reduce the levels of parasites that affect the horses; however, it may reduce cattle's performance.

Grazing Behavior of Horses

Work conducted at the North Carolina State University Equine Educational Unit has demonstrated that mature and growing horses can be controlled by electric fence in small paddocks. Horses rotationally grazed tall fescue in the spring and summer and were effectively managed on stockpiled fescue in the fall and winter. The horses quickly adjusted to the limited area for grazing and consumed the forage in each paddock in three to five days. Short rotational grazing of the paddock reduced the incidence of spot grazing and provided more uniform grazing, which allowed for quick pasture regrowth. Calculations for annual production indicated that approximately 1.5 acres would be required to meet the annual forage needs of a 1,100-pound mare. The use of controlled, rotational grazing to regulate forage consumption and grazing time permitted the stocking rate to be increased.

Research conducted at North Carolina State University and on a producer farm indicated that horses will graze an average of 16 hours per day. The shorter the pasture, the longer a horse will graze (up to 20 hours per day). In all studies, horses spent at least 10 hours grazing. In situations where horses are turned out to graze for a limited time (less than 12 hours), it is

likely that the horse's intake will be reduced. Restricting the grazing time is an effective way to reduce intake and weight gain of obese horses.

Estimating Nutrient Intake from Pasture

The percentage dry matter of forages must be considered when calculating nutrient availability. Grazed or fresh forages, analyzed at the North Carolina Department of Agriculture Forage Testing Lab, are extremely high in moisture, containing only 20 to 40% dry matter. The high moisture content of fresh forages dilutes their nutrient content, compared to nutrient levels expressed on a dry matter (100% DM) basis. Thus, to achieve the same nutrient intake, an animal needs to consume many more pounds of fresh, grazed forage than if the same forage was dried. For example, a 1,100-pound horse would need to eat about 65 pounds of fresh grass (30% DM) or about 22 pounds of hay (90% DM) to achieve the same level of dry matter and nutrient intake.

Since horses have a relatively small digestive tract, gut fill is another factor limiting forage intake. Normally a horse can consume 3.0 to 3.5% of its body weight in dry matter before gut fill occurs and intake stops.

For example, a 1,100-pound mare grazing mature fescue pasture at maximum intake per day would have to eat 78.6 pounds to get 27.5 pounds of dry matter intake:

$$\frac{1{,}100 \text{ lb} \times 2.5\% \text{ body weight}}{100} = 27.5 \text{ lb dry matter/day}$$

$$\frac{27.5 \text{ lb mature fescue pasture}}{35\% \text{ dry matter}} = 78.6 \text{ lb fresh fescue (as fed)}$$

The following pasture feeding programs are all based on an estimated mature body weight of 1,100 pounds (National Research Council 1989). Long yearlings, two-year-olds, and mares in late pregnancy grazing immature bermudagrass or fescue-clover mixed pastures can obtain the necessary digestible energy (DE), crude protein (CP), calcium (Ca), and phosphorus (P) intake to meet their nutrient requirements by consuming 15 pounds of forage (dry matter basis) daily. However, lactating mares consuming the same amount of bermudagrass pasture will be deficient in energy, protein, and phosphorus. The same lactating mare could receive all of her nutrient requirements from 60% low-endophyte fescue, or from 40% ladino clover pasture if she were able to consume 90 pounds per day on an as-fed basis. Unfortunately, some small-framed mares do not have the capacity to consume 90 pounds per day because of the limited size of their digestive tract.

A more severe nutrient deficiency occurs in pregnant mares forced to graze mature bermudagrass pastures. Such nutrient deficiencies can be corrected by grazing earlier or supplementing a balanced concentrate mix in moderate amounts in addition to the pasture.

Trace minerals and vitamins should be supplemented free choice with water when grazing. Loose trace mineralized salt (granular form) or trace mineralized salt blocks will provide adequate trace minerals if the soil *is not* deficient in trace minerals. However, horses fed a concentrate and grazing pastures known to be deficient in trace minerals should be supplemented with a 1% trace mineral-vitamin premix added directly to a concentrate mix or in a fortified mineral supplement designed specifically for grazing horses. Trace mineralized salt alone may not provide enough trace minerals to meet animal requirements in severely deficient soils.

Calculation of nutrients supplied from immature bermudagrass pasture.

15 lb bermudagrass (DM Basis)
x 1.42 Mcal/lb DE = 21.3 Mcal DE

15 lb bermudagrass (DM Basis)
x 17.1% CP = 2.5 lb CP

15 lb bermudagrass (DM Basis)
x 0.89% Ca x 454 grams/lb = 60.6 gram Ca

15 lb bermudagrass (DM Basis)
x 0.32% P x 454 grams/lb = 21.8 gram P

Pasture Precautions

Cystitis, a condition caused by a sublethal dose of hydrocyanic acid, has been sporadically reported when horses grazed sorghum, sudangrass, and hybrids of both during drought conditions or after a frost. Cystitis can be fatal and is characterized by frequent urination, lack of coordination, and mares appearing to be in heat constantly. Hay harvested at any time, including during a drought or after a frost, can be stored for two to three months and then safely fed. Cystitis has not been reported in horses grazing pearlmillet.

Founder or laminitis is a condition characterized by inflammation of the soft laminae of the feet. It can result in chronic lameness. It is usually caused by overeating grain, but can also occur from overeating lush, succulent pasture. Horses should be switched from dry lot to lush pasture gradually over a 10-day period, which will also limit scouring or loose stools.

Sand colic can result if horses are allowed to remain on bermudagrass pastures during the late fall and winter when the grass is dormant. The animals will dig for bermudagrass rhizomes, which are high in carbohydrates. In the process, they ingest large amounts of sand, resulting in impaction colic. If bermudagrass is the only pasture available, a portion of the pasture can be overseeded with rye or ryegrass so the animals have forage available during the time when bermuda is dormant. There are a number of equine laxatives available that bind with sand and aid in its excretion from the gastrointestinal tract. Do not feed hay that has been lying on the surface of sandy soils.

Nitrates can be a problem with drought-stressed plants that have been fertilized with moderate to heavy amounts of nitrogen fertilizer. Avoid grazing drought-stressed grasses, particularly pearlmillet, until the plants recover and produce growth. Nitrate levels of 1% of the total diet or greater are considered toxic to horses. Hays high in nitrates can be diluted with other nitrate-free hay or grain to reduce the nitrate content to less than 1% of the diet.

Slobbering is caused by high levels of slaframine, a chemical substance that is produced by molds. It occurs as a result of a fungus on the leaves that forms concentric dark brown or golden rings, primarily in legumes such as red clover. The condition has also been reported in horses grazing ladino clover, white clover, and lespedeza. Slobbering can be minimized if the legume component of a mixed grass-legume does not exceed 40% of the stand, if horses are switched gradually to lush legume dominant pastures, and if the plant is not frequently clipped or grazed close to the ground. Slaframine causes saliva production, which may cause dehydration within 24 hours. Removing horses from the moldy hay or pasture relieves the condition.

Fescue toxicosis in broodmares is caused by a fungus or endophyte (*Acremonium coenophialum*) associated with tall fescue. A 1984 survey of tall fescue horse pastures in North Carolina found 95% of the tested pastures contained the endophyte at an average level of 68%. Reproductive problems have been noted in horses consuming endophyte-infested hay or pasture at 5% endophyte and higher. **Broodmares should be removed from endophyte-infected hay or pasture 90 days before foaling.** Fescue toxicosis symptoms include abortions, prolonged gestation (12 to 13 months), dystocia, thickened placental membrane, stillborns, retained placentas, little or no milk production, and reduced rebreeding efficiency. Dilution of the endophyte fescue by supplementing legume hay, grain, or interseeding clover in pastures is not effective. The unidentified toxin produced by the endophyte appears to block prolactin production at the hypothalamus. Prolactin is required for normal milk production during late gestation. The accumulation of milk in the udder is a triggering mechanism for parturition. Subsequently, prolonged pregnancies are a symptom of fescue toxicosis.

Weeds may be toxic or noxious (irritating). Horses will not consume weeds if adequate-quality forages are available. Consumption of wood posts, trees, dirt, and hair indicates a lack of fiber intake; supplement hay in such situations.

Blister beetle poisoning may result from animals consuming hays grown outside of North Carolina. Blister beetles are found in states such as Oklahoma, Texas, Arizona, and Illinois that have large populations of grasshoppers. Beetles in the hay fields are trapped and killed in the windrows of forages harvested by mower conditioners. Whether dead or alive, the beetles contain a toxic substance called cantharidin. When ingested, cantharidin causes severe gastrointestinal tract lesions. Death occurs quickly. As few as three beetles could kill a 1,000-pound horse.

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Chapter 20

FORAGE NEEDS FOR MEAT GOATS AND SHEEP

Jean-Marie Luginbuhl, James T. Green, Jr., J. Paul Mueller, and Matthew H. Poore

Forages for Goats

Goats produce milk, meat, and fiber which currently are marketable and in demand by a growing segment of the U.S. population. In addition, goats offer the potential for biological control of unwanted vegetation in pastures and forests, which will reduce dependence on certain pesticides.

Goats consume only the best parts of a wide range of grasses, legumes, and browse plants. Browse plants, which might not be consumed by other animals, include brambles, shrubs, trees, and vines with woody stems. The quality of feed on offer will depend on many things, but it is usually most directly related to the age of the plant or stage of growth at the time of grazing. The nutrient composition for several common feed types found on many farms is shown in Table 1.

Table 1. Estimated nutrient composition of various feeds.[1]

Plant type	TDN, %	Crude protein, %
Whole cottonseed	88	22
Corn	86	9
Soybean meal (48%)	82	44
Pasture, vegetative	60-76	12-24
Pasture, mature	50-60	8-10
Pasture, dead leaves	35-45	5-7
Fescue hay, 6 weeks growth	58-62	8-11
Fescue hay, 9 weeks growth	48-53	7-9
Bermuda hay, 7 weeks growth	54-58	9-11
Bermuda hay, 12 weeks growth	47-50	7-9
Alfalfa hay	50-63	13-20
Honeysuckle, leaves+buds	70+	16+
Honeysuckle, mature	68+	10+
Sumac, early vegetative	77	14
Oak, buds and young leaves	64	18
Persimmon leaves	54	12
Hackberry, mature	40	14
Kudzu, early hay	55	14
Juniper	64	6
Acorns, fresh	47	5

[1] Nutrient Requirements of Goats in Temperate and Tropical Countries. 1981. National Research Council.

Grazing Behavior

Goats are very active foragers, able to cover a wide area in search of scarce plant materials. Their small mouths and split upper lips enable them to pick small leaves, flowers, fruits, and other plant parts, thus choosing only the most nutritious available feed.

The ability to graze browse species, which often have thorns, an upright growth habit, and small leaves tucked among woody stems, is a unique characteristic of the goat compared to heavier, less agile ruminants. Goats have been observed to stand on their hind legs and stretch up to browse tree leaves or throw their bodies against saplings to bring the tops within reach.

Goats appear to select grass when its protein content and digestibility are high, but switch to browse when its overall nutritive value may be higher. This ability is most useful under conditions where there is a broad range in the digestibility of the available feeds, giving an advantage to an animal that is able to select highly digestible parts and reject materials that are low in quality.

Grazing goats have been observed to

- select grass over clover
- prefer browse over grazing
- prefer foraging on rough and steep land over flat, smooth land
- graze along fence lines before grazing the center of a pasture
- graze the top of pasture canopy fairly uniformly before grazing close to the soil level

Because of their inquisitive nature and tolerance of bitter or high tannin material, goats may eat unpalatable weeds and wild shrubs that may be poisonous, such as wild cherry or milkweed. The absence or the severity of poisoning is related to the quantity of material consumed, the portion and age of the plant eaten, the season of the year, the age and size of the animal, and a multitude of other factors. In addition, several ornamental plants that are grown outdoors or indoors are highly toxic. For example, goats should not have access to clippings of yew, azaleas, delphinium, lily-of-the-valley, and larkspur.

In a pasture situation goats are "top down" grazers. This behavior results in uniform grazing and favors a first grazer-last grazer system using a goat flock as the first group and cattle as the last group. This management is most appropriate with lactating does or growing kids.

Goats seek shelter when it is available because they do not like to get wet. Goats seem to be less tolerant of wet, cold conditions than are sheep and cattle because they have a thinner fat layer. A wet goat easily can become sick. Therefore, it is usually necessary to provide artificial shelters, such as open sheds.

Nutrient Requirements

Goats are not able to digest cell walls (high fiber portion) of plants as well as cows can because feed stays in the goat's rumen for a shorter time period. A definition of "poor-quality roughage" is needed to decide which animal can best use a particular forage. Trees and shrubs, which, because of their highly lignified stems and bitter taste, represent poor quality roughage sources for cattle, may be of adequate quality for goats. Goats avoid eating the stems, do not mind the taste, and benefit from the relatively high levels of protein and cell solubles in the leaves of these plants. Straw, on the other hand, with its high cell walls and low protein, can be used by cattle but will not provide even maintenance needs for goats.

Goats must consume a more concentrated diet than cattle because their digestive tract size is smaller relative to their maintenance energy needs. When the density of high-quality forage is low and stocking rates are low, goats will still perform well because of their grazing behavior, even though their nutrient requirements exceed those of most domesticated ruminant species. Total digestible nutrients (TDN) and protein requirements are given in Table 2. Comparing the nutrient requirements to the chemical composition of feeds shown in Table 1 should give producers an idea of how to match needs with supplies. For comparison, low-quality forages have 40 to 55% TDN, good-quality forages have from 55 to 70% TDN, and concentrates have from 70 to 90% TDN.

High-quality forage and/or browse should be available to does during the last month of gestation and to lactating does, to developing/breeding bucks, and to weanlings and yearlings. Female kids needed for reproduction should be grazed with their mothers during as much of the milk feeding period as possible and not weaned early. When the quantity of available forage and/or browse is limited or is of low quality, a concentrate supplement may be considered to maintain desired body condition, depending on cost:benefit. Whole cottonseed makes an excellent supplement for goats when fed at no more than 0.5 pound/head/day. Dry does and nonbreeding mature bucks will meet their nutritional requirements on low- to medium-quality forage (10 to 12% protein and 50 to 60% TDN).

A complete goat mineral or a 50:50 mix of trace mineralized salt and dicalcium phosphate should be offered free choice during the first 90 days of lactation in herds with a controlled breeding season (or year-round for those without controlled breeding) and for young goats. Selenium is marginal to deficient in all areas of North Carolina. Therefore, trace mineralized salt or complete minerals containing selenium should always be provided to goat herds year-round. It is sometimes advisable to provide a mineral mix that contains 20 to 25% magnesium oxide to reduce the risk of grass tetany when goats in peak lactation are grazing lush small grain or grass/legume pastures.

Forages for Sheep

Profitable lamb production depends on efficient production and use of forage crops. Having sheep harvest forage crops by themselves, with as little supplemental feeding as possible, is the most practical and economical means to ensure the

Table 2. Nutrient requirements for meat- and fiber-producing goats.[1,2]

Nutrient	Young goats[3]		Does (80 lb)				
	Weanling (30 lb)	Yearling (60 lb)	Dry (pregnant)		Lactating		Buck (80-120 lb)
			Early	Late	Avg milk	High milk	
Daily feed, lb	2.0	3.0	4.5	4.5	4.5	5.0	5.0
TDN, %	68	65	55	60	60	65	60
Protein, %	14	12	10	11	11	14	11
Calcium, %	0.6	0.4	0.4	0.4	0.4	0.6	0.4
Phosphorus, %	0.3	0.2	0.2	0.2	0.2	0.3	0.2

[1] Nutrient Requirements of Goats. 1981. National Research Council.
[2] Pinkerton, F. 1989. Feeding Programs for Angora Goats. Bulletin 605. Langston University, OK.
[3] Expected weight gain >0.44 lb / day.

success of a sheep operation. Because feed costs usually amount to 50 to 70% of the total cost of producing sheep, it is essential to develop an economical year-round forage supply.

The entire Appalachian mountain chain, extending from Maine to Alabama, is a region dominated by a mixture of Kentucky bluegrass and intermediate white clover. This region has potential for lamb production with little competition to the existing beef industry. By using good pastures (fescue/orchardgrass/bluegrass with clover or alfalfa), crop residues, wasteland forage, and hay and silage, it is possible to raise sheep economically in many livestock programs.

Grazing Behavior

Sheep are selective grazers, choosing higher-quality (and more digestible) plant parts than cattle select when both species have access to the same herbage. Therefore, when grazed alone, sheep should be stocked heavily to avoid too much trampling and soiling of the ungrazed forage. As a general rule, sheep eat more browse than cattle do, but less than goats, because sheep are not nearly as selective as goats. Sheep also make better use of rough, steep hill pastures than do cattle or goats.

Nutrient Requirements

Ewes

Nutritional needs of ewes for maintenance and for the first 15 weeks of gestation are relatively low. Most can be furnished by medium- to low-quality forage. However, nutritional needs increase about 1.5 times their maintenance needs during the last four to six weeks of gestation, and good pasture must be available or additional grain must be fed during this period. Nutritional needs increase to three times maintenance during the first eight weeks of lactation, and decrease to two times maintenance by the third month of lactation (Table 3). If the ewe is nursing twins, she will need 15% more digestible nutrients than for one lamb. Ewes with two or more lambs should be separated from the flock and given extra feed. After weaning, the ewes go back to maintenance level until flushing. The forage and supplemental feed program should be designed to fit these nutritional cycles, the lambing period, and the cost:benefit structure.

During maintenance periods, ewes can be used to clean up paddocks after lambs or other livestock. Be careful that ewes are not kept on poor-quality forage for too long, or a reduced number of lambs may be born the next spring. It is better to alternate a day of grazing low-quality pasture with a day of grazing higher-quality pasture. Grazing ewes on forage that is

Table 3. Nutrient requirements for sheep.[1]

Item	Body weight	Daily gain or loss	Daily intake	TDN	Protein	Ca	P
		lb			%		
Mature ewes, maintenance	154	0.02	2.6	55	9.5	0.21	0.20
Mature ewes, gestation, last 4 weeks	154	0.4	4.0	60	10.6	0.34	0.31
Mature ewes, lactating, suckling singles	154	–0.06	5.5	65	13.3	0.37	0.28
Mature ewes, lactating, suckling twins	154	–0.13	6.2	65	15.0	0.39	0.29
Finishing lambs	88	0.6	3.5	75	11.6	0.41	0.21
Replacement ram lambs	132	0.7	5.3	65	11.0	0.35	0.18
Replacement ewe lambs	110	0.26	3.3	60	9.1	0.32	0.16

[1] Nutrient Requirements of Sheep. 1985. National Research Council.

better than their minimal needs will result in them weighing more and consistently giving birth to more and larger lambs that gain weight faster, but can also be associated with lambing difficulties.

Lambs

Pastures for lambs should be of very high quality because of their nutritional requirements (Table 3). Forward grazing is a management technique enabling lambs to have access to the best forage. If a high-quality forage is not available for the entire flock, the lambs can be creep grazed on adjacent pastures. Fast rates of gain cannot be achieved with low-quality pasture, because the bulk of feed in the rumen will limit the intake by the lambs before enough energy has been ingested to meet their nutritional requirements.

Lambs will consume approximately 2 to 4% of their body weight in dry matter daily. Most immature, leafy, grazable forages will contain about 80 to 85% water. Therefore, lambs will consume from 10 to 20 pounds of green forage daily, depending on their body weight. The daily performance of lambs is generally improved by the addition of a legume to a cool-season grass pasture. Sheep have been shown to prefer clover when it is readily available. Suckling lambs have shown average daily gains of 0.4 pound when grazing orchardgrass pastures compared with 0.6 pound from an orchardgrass-ladino clover mixture. Data from New Zealand have shown an 18% increase in gain by sheep grazing a perennial ryegrass-ladino clover mixture compared with sheep grazing a pure stand of perennial ryegrass. Weaned lambs grazing alfalfa have had daily gains of 0.3 to 0.45 pound, even during summer months.

Pure stands of annual or perennial grasses can increase the incidence of grass tetany, especially in the early spring. This can be controlled by providing a mineral mix that contains 20 to 25% magnesium oxide. Legumes will reduce the risk of grass tetany because of their high magnesium content. It is most convenient to use a complete commercially prepared sheep and goat mineral that will provide selenium and other minerals plus phosphorus, salt, and magnesium. **Never use cattle minerals; their copper content will kill sheep!**

Grazing Management for Goats and Sheep

Grazing of forage generally provides the least expensive way of supplying nutrients to the animals (Figure 1). Therefore, it is essential to develop a year-round forage program that allows for as much grazing as possible every month of the year. The principles of

Figure 1. Sheep, goats, and cattle can graze together effectively.

controlled grazing of goats or sheep are similar to those used for cattle. The primary goal is to have enough control of the animal's grazing pattern so that one can dictate the amount and frequency of defoliation. However, good pasture management involves much more than simply turning the animals to pasture. To obtain efficient animal production over a number of years, the needs of the plants as well as the needs of the animals must be taken into consideration. Developing successful forage systems/grazing management entails several steps:

1. Adjust the number of animals grazing a certain area (stocking density) of pasture because some forage must be left at the end of the grazing period to maintain adequate plant production. Otherwise, overuse will weaken the plants and regrowth will be slower. Adjusting the stocking density requires experience, because forage growth is not uniform throughout the year or from year to year.

2. Harvest ungrazed forage at an immature stage when it is growing more rapidly than it can be grazed. This way, you can provide high-quality feed in the form of hay or silage when grazing is not available. Cross fencing will keep animals concentrated on small areas while excess growth accumulates in other paddocks. Under those circumstances, you might consider alternatives like short duration rotational grazing through a series of paddocks, or strip grazing a rapidly growing pasture by using a moveable fence to allow animals access to only enough forage to carry them for one day.

3. Overseed bermuda pastures with legumes, ryegrass, small grains, or brassicas to extend the grazing season and to provide some high-quality feed during winter and spring.

4. When in short supply, restrict the use of high-quality forage so that it supplements other low-quality pastures, hay, or silage. Let goats or sheep graze high-quality forage a few hours at the end of each day or graze the limited high-quality supply every other day.

If your aim is to kill or reduce the amount of unwanted vegetation, then increase the severity and frequency of grazing. As a rule, effective control of unwanted vegetation can be achieved in two years. Goats, for instance, will actively select major weeds at particular stages of growth. The advantages of using goats must be weighed against the disadvantages. Being browsing animals, goats stunt tree growth and prevent the regeneration of forests and thus should be managed closely in areas desired for forests. Goats could be very useful, however, in areas where regrowth of brush and trees is not desirable.

Grazing Time

Some livestock producers confine their animals at night to protect them from predators and keep them from straying. However, confinement means that grazing time is reduced and that the animals spend more time in unsanitary lots or pens. Confining animals at night is even more of a problem during the hot and humid summer months, because animals may not forage efficiently during the hottest periods of the day. If animals must be confined at night, allow them to graze during the cooler parts of the day; improved feed intake resulting from this increased grazing time should increase production.

Fencing for Goats and Sheep

Goats and sheep can be controlled with four to five strands of smooth electrified wire. Perimeter fence wires should be 6 to 8 inches apart near the ground and 8 to 12 inches apart at the top strands. Perimeter

fence height should be at least 42 inches tall. A high wire, or an offset wire set one foot inside the fence near the top, may be needed. As a rule, goats crawl rather than jump, so the bottom wire should be kept close to the ground. A grounded barb wire laid along the ground will help with predator control, especially in mountainous areas. Training animals to respect electric wire can be done effectively by forcing animals to stay in a small paddock which encourages them to test the wire.

Woven wire is effective, but costs at least twice as much as a five-strand electric fence, and horned goats frequently get caught. An electric wire offset about 9 inches from the woven wire fence and about 12 to 15 inches from the ground will reduce the number of animals caught in the woven wire fence. However, this practice also reduces control of forage growth on the fence line. Dehorning goats also eliminates this problem.

Perimeter fences should control all stock at all times. However, interior fences may be made of three to four wires, assuming animals are well-trained. Because goats like to climb, the corners of fences should not have the diagonal bracing for posts or the animals will climb out of the pasture. Corner posts should be reinforced with a deadman or H-braces.

Mixed Grazing and Stocking Rates

Cattle, sheep, and goats have unique feeding behaviors that should be considered when developing grazing plans. Most studies, for instance, indicate that greater production and better pasture use are achieved when sheep and cattle or sheep, cattle, and goats are grazed together as opposed to grazing only sheep or goats or cattle alone. This is especially true where a diverse plant population exists.

Under mixed grazing conditions (more than one ruminant species grazing in the same paddock) on fescue/orchardgrass-clover where the forage supply is low and the nutritive value is high, goats and sheep may be at a disadvantage. Under those conditions, the animal with the largest mouth (cattle, horse) has an advantage because it can grasp more material per unit of time. In addition, food intake by goats is rapidly reduced and may stop if the pasture is soiled or trampled, even with an ample amount of pasture remaining.

Generally one cow eats about the same amount of feed as six to eight goats (Table 4). Because of their complimentary grazing habits, differential preferences, and the wide variation in vegetation within most pastures, one to two goats could be grazed with every beef cow in North Carolina without adversely affecting the feed supply of the beef herd. The selective grazing habits of goats in combination with cattle would eventually produce higher-quality pastures with fewer weed problems.

In grass-legume mixtures, cattle generally graze the grass species more readily than sheep, which prefer legumes and other broadleaf species. As a rule of thumb, five to six ewes and their lambs consume as much feed as one cow and her calf. Therefore, if the area available for grazing usually carries one cow-calf pair, five to six ewes and their lambs can safely graze on the same area (Table 4).

Management of Reproduction

Goats are known as seasonal breeders, which means the female only cycles and accepts the male during times of shortening day length. Cycling usually begins by the end of August to early September and lasts through February. If not bred, does will cycle every 21 days, similarly to cows. Therefore, does should become pregnant within four weeks after the introduction of bucks. The gestation length (time from breeding to kidding) averages 150 days (five months).

Yearling goat kids may be bred in the first year at seven to 10 months of age, depending on breed, if they have grown well and are of good size and condition. Body weight, relative to breed, is more important than age and can influence lifetime performance. The doe kid may be able to reproduce at three to four months of age but should not be allowed to do so, as her growth may be permanently stunted. To prevent this, buck kids should be separated from doe kids at an early age (about four months). If breeding of doe kids is postponed much beyond 10 months of age, they will be less productive.

Table 4. Estimated stocking rates or feed needs for goats, sheep, and cattle on pasture.[1]

Pasture type	Goats	Sheep	Cow
		Head[1]	
Good quality pasture system	6-8	5-6	1
Good brush-browse system	9-11	6-7	1
		Head/acre	
Wheat/alfalfa system	10-12	8-9	1.5
Alfalfa pasture, Oklahoma	12-15	10-11	1.9

[1] Number of animals to consume similar amount of feed.

Chapter 21

FORAGE-RELATED DISORDERS IN BEEF AND DAIRY CATTLE

Matthew H. Poore and Brinton A. Hopkins

Diets containing high levels of forage cause minimal health problems in beef and dairy cattle. When diets meet nutrient requirements and contain a high proportion of forage, many of the nutritional disorders associated with feeding high levels of grain, such as acidosis, founder, liver abscess, and displaced abomasum, are minimized or eliminated. There are, however, disorders that are directly caused by forages that should be well understood by producers striving to optimize efficiency in high-forage beef and milk production systems.

Forage-related disorders commonly observed in North Carolina are grass tetany, bloat, nitrate poisoning, prussic acid poisoning, ergot poisoning, fescue toxicity, and nutrition-related calving difficulty.

Grass Tetany

Grass tetany is also known as magnesium tetany or grass staggers. It usually occurs in cows during early lactation, especially during cool weather in spring or fall when cool-season forages come out of dormancy and grow rapidly. Although the highest risk is in spring, grass tetany can occur in the middle of winter or summer when unusual weather results in rapid growth on farms where fertility (especially nitrogen) is high.

Grass tetany usually results from a low level of magnesium in rapidly growing forages, but has also been associated with nutrients that interfere with the absorption of magnesium. Often the first sign will be a dead cow that was apparently healthy the last time she was checked. During the early stages of the disease, the cow will appear nervous, with a stiff gate and possible muscle tremors. The cow will then become dull in appearance, and finally will go down and may thrash violently before death occurs. Grass tetany can also afflict stocker cattle, especially when grazed on small grain.

Tetany can be prevented by feeding cattle supplemental hay or grain, fertilizing pastures with magnesium (by applying dolomitic limestone), or providing a mineral mix or supplement containing magnesium oxide. Supplementing with magnesium oxide during moderate or high-risk periods is most practical, and 1 ounce/day greatly reduces incidence of the disease. The magnesium oxide may be provided in a home-mixed mineral (30% trace mineralized salt, 30% dicalcium phosphate, 30% magnesium oxide, and 10% dried molasses), in a commercial high magnesium mineral (10 to 14% Mg), or mixed at 6% of a grain mix to be fed at 1 pound/head/day.

When using high-magnesium mineral supplements, carefully monitor intake to ensure that cows are eating an average of 1 ounce/day magnesium oxide (usually 3 to 4 ounces/day or 2 pounds/week of mineral per cow). If necessary, increase intake of the supplement by adding grain. The high magnesium mineral should be the only source of salt available to the cattle, so other salt-containing supplements such as protein blocks or licks should be avoided when the risk of tetany is high.

Even with a well-consumed supplement, some animals may not get enough and may be susceptible to magnesium tetany. Using the 6% magnesium oxide grain mix with adequate bunk space will be the best way of ensuring that all the cattle consume enough. If supplemental protein is needed, this concentrate can be based on soybean or cottonseed meal, and if protein is not needed it can be the cheapest source of concentrate available. Two pounds/head/day of this 6% mix is recommended in situations of very high risk or following an outbreak of grass tetany.

Lactating dairy cows on pasture should be fed a concentrate supplement formulated to provide at least 2 ounces of magnesium oxide/day. Dairy heifers consuming only pasture should receive supplemental magnesium as indicated for beef cattle above.

Forage Bloat

Bloat may occur with high-quality forages, especially those with lush legumes. Bloat generally occurs when hungry cattle graze fields containing a large proportion of alfalfa or clover, especially after

a frost or when dew is still on the forage. Gas bubbles develop in the rumen and do not break down. As a result, the gas produced during digestion can not be eliminated normally and the animal will swell rapidly on the left side; in severe cases, the rumen ruptures, causing rapid death.

The best way of preventing bloat is to fill cattle up with hay before putting them on pastures containing large amounts of legume. If conditions make bloat a distinct possibility, such as with a late frost or rotational alfalfa grazing, cattle can be fed poloxalene mixed in a supplement.

Drenching the bloated animal with a defoaming agent such as mineral oil, vegetable oil, or mild detergent may be effective. In life-threatening situations, a trocar (a sharp instrument fitted inside a tube) may be used to puncture the rumen and relieve the gas pressure. The rumen should be punctured on the left side of the animal midway between the last rib and the point of the hip at the highest point of the distension. A knife can be used if a trochar is not available. This action may save the animal's life, but immediate care from a veterinarian should be sought to prevent serious complications.

Nitrate Poisoning

Nitrate poisoning is an increasing problem in North Carolina because of the widespread use of poultry litter and swine waste lagoon effluent as fertilizers. High levels of nitrogen are applied to the forage, which commonly results in a nitrate level above what is normally considered safe. When nitrate ion is less than 0.25% (dry basis), the forage is safe for all animals. At 0.25 to 0.5%, there is a slight risk of toxicity occurring, so the forage should not make up more than 50% of the total intake of pregnant cows. Forage with nitrate ion levels of 0.5 to 1.5% can cause abortion and therefore should not be used for pregnant cows and should not make up more than 50% of the ration for any animal. If nitrate ion exceeds 1.5%, it is risky to feed the forage at all, even to nonpregnant animals. Risk is greater when cattle are abruptly switched from forages low in nitrate to forages high in nitrate.

Toxic levels of nitrate in forage will generally occur when a high level of nitrogen is applied on forages such as sorghum-sudan hybrids, millet, or bermudagrass, followed by a drought or a long period of cloudy weather. There can also be a problem with other plants, especially common weeds, that accumulate nitrate in drought times. Nitrate is released more slowly from grazed forages than from hay, so a higher level may be tolerated in the grazing situation. Signs of nitrate toxicity are labored breathing, frothing at the mouth, frequent urination, diarrhea, staggering, convulsion, and a brown coloration of the mucous membranes. Cattle fed forages containing high nitrate should be supplemented with adequate levels of vitamin A.

Prussic Acid Poisoning

Prussic acid, also known as hydrocyanic acid, occurs in some plants following a stress period or during early growth. Members of the sorghum family (Johnsongrass, shatter cane, grain or forage sorghum, or sorghum-sudan hybrids) and wild cherry are the plants most responsible for prussic acid poisoning. Animals die quickly after eating a substantial amount of the toxin. To prevent prussic acid poisoning, do not allow cattle access to early growth of sorghum forages. A good rule is to not allow cattle to graze these plants until the plants are at least 15 inches tall. Also, avoid grazing sorghum forages during or shortly after a drought, when plants are wilted, or for at least two to four days after a killing frost. Also, remove cattle from these forages if there is even a risk of frost. When these crops are made into hay, the prussic acid content essentially is eliminated. When they are made into silage, the prussic acid content is greatly reduced, largely eliminating the chance of toxicity. For plants high in prussic acid, delay feeding them as silage until six to eight weeks after ensiling. If wild cherry trees are present in pastures, remove them, if possible, or carefully check around them after storms and remove broken branches.

Ergot Poisoning

Ergot can grow on seedheads of grasses during humid weather. This is especially common in dallisgrass, but also occurs in tall fescue, ryegrass, or bahiagrass. When cows are poisoned, circulation is impaired, resulting in lameness, and in tail and feet sloughing in severe cases. Cattle may also stagger, hence the illness' common name "dallisgrass staggers." Removing cattle from the ergot source is the only practical treatment. Since the fungus grows on seedheads, the best prevention is to minimize seedhead development and to clip pastures when substantial old seedheads are present.

Moldy forages such as silage and hay may contain mycotoxins that could influence performance and reproduction. Use of such forages should be avoided or carefully controlled.

Fescue Toxicity

Tall fescue is the basis for beef production in much of North Carolina. The discovery of a fungus infecting the tissues of KY-31 fescue has helped explain problems frequently encountered in raising cattle, including slow growth, low milk production, rough appearance, poor reproductive performance, and more severe syndromes such as fescue foot where the feet, tail, and ears may slough off. The development of fungus-free cultivars of tall fescue has given us an alternative to using fungus-infected fescue. Although some problems with establishment and stand persistence have been encountered with these new cultivars, if carefully managed they may prove useful in new seedings.

Despite all its problems, because of its good agronomic characteristics, KY-31 fescue is likely to remain the primary cool-season forage for grazing in North Carolina for some time to come. You can enhance the performance of cattle grazing infected fescue by following several management practices: manage to maintain significant clover stands, use minimal nitrogen fertilization during warm weather, use rotational grazing to maintain good vegetative growth, and incorporate warm-season forages into grazing systems to reduce animals' dependence on infected fescue during hot weather.

Nutrition-Related Calving Difficulty

High-quality forages ingested during the last three months of pregnancy may cause a high incidence of calving difficulty. This is especially common when spring calving cows are grazed on small grain pastures during the winter. The problem is related to both increased birthweights of calves, and overly fat cows. These problems can be prevented by feeding dry cows low- and medium-quality forages during the last three months of pregnancy. High-quality winter grazing should be reserved for young growing animals and lactating cows.

Chapter 22

DEVELOPING AND USING A PASTURE FEED BUDGET

J. Paul Mueller and James T. Green, Jr.

Feed budgeting is an advanced method of pasture management that seeks to account for the feed produced from pasture and to match it to specific animal needs. The basic idea is to determine a feed balance by estimating feed supply and matching it to feed demand.

Feed supply is determined by adding the total amount of forage present in each paddock at the beginning of the budget period to the projected amount of forage that will be grown during the budget period (accounting for the residue left after grazing).

Feed demand is represented by the average daily requirement for the animal group to be fed multiplied by the total number of days in the budget period.

Feed balance results when feed demand is subtracted from feed supply expressed as a projected feed deficit or surplus.

The next step is to devise a grazing action plan that specifies precisely how to ration out the feed from each paddock to the animal group during the budget period.

Pasture feed budgeting is most valuable in helping to plan the use of scarce pasture feed during periods of slow growth. The example of pasture feed budgeting in Table 1 was calculated for a group of beef heifers grazing stockpiled tall fescue.

Creating a Feed Budget and Grazing Action Plan

Determine Feed Supply

Determining feed supply requires a reasonable estimate of the amount of forage present in each pasture or paddock as well as knowledge of the average plant growth rate during the budget period. A key element in the pasture feed budgeting process is obtaining reasonably good estimates of dry herbage yields from pastures. This takes some practice. Initially it will help to use a frame of known area that can be laid on the pasture, and herbage within the frame can be estimated by eye or other device. The herbage is then cut to ground level with hand clippers and the material dried and weighed to obtain an accurate yield that can be compared to the estimates. All herbage estimates are made as total above-ground dry material (see Appendix G). It will also be valuable to work with an experienced grazier who feels comfortable with this method. However, even with no experience, trial and error during the first week of the budget period will help you accurately adjust your budget.

The budget may be determined on the basis of dry weight (pounds of herbage), energy (pounds of total digestible nutrients), or protein (pounds of crude protein). If the budget will be calculated on the basis of energy or protein requirements, collect forage samples from the pastures with which to obtain laboratory estimates of energy and protein concentration of the forage. The following example is calculated on the basis of pounds of dry herbage.

1. Decide on the length of the budget period (usually 30 to 90 days).

2. Estimate the yield of dry herbage (pounds per acre) in each stockpiled paddock just before the start of grazing (Table 1, bottom of column 3). Multiply estimated pounds per acre in each paddock by the number of acres in the paddock. Add up the totals for all paddocks and divide this grand total by the total number of acres to be rationed. The result is the average yield per acre or farm "cover" (Table 1, average of column 3) at the beginning of grazing.

3. The average growth rate of grass must also be estimated since several paddocks will continue to accumulate herbage while the first is being grazed (for example, a rate of 14 pounds per acre during autumn and 10 pounds during winter). Multiply the number of days of growth that will accumulate before the paddock is grazed by the average growth rate. For example, if a paddock will continue to grow for 10 days before it is grazed and the growth rate is 14 pounds per acre per day, then an extra 140

Table 1. Example of a 90-day feed budget for beef heifers grazing stockpiled fescue. This example is based on a start of grazing on 20 November 1993, 60 head of of cattle at 550 pounds each, 3% intake. *(Refer to explanation below.)*

1	2	3	4	5	6	7	8	9	10
Pad #	Acres	Herbage mass start 20 Nov 93	Growth to start of grazing	Herbage at start of grazing	Total animal needs per day	Residue after graze	Days of grazing	Date to stop graze of pad	Mass on next cycle starting 17 Feb 94
				lb/A					lb/A
1	3.5	3,600	0	3,600	990	700	10	30 Nov	1,487
2	3.5	3,600	144	3,744	990	700	11	11 Dec	1,380
3	3.5	3,600	389	3,989	990	700	12	22 Dec	1,263
4	3.5	3,400	410	3,810	990	700	11	02 Jan	1,153
5	3.5	3,400	520	3,920	990	700	11	14 Jan	1,040
6	3.5	3,200	577	3,777	990	700	11	24 Jan	931
7	3.5	3,200	632	3,832	990	700	11	04 Feb	820
8	3.5	3,000	1,096	4,096	990	700	12	16 Feb	700
Average		3,375			990	700			
	Total	Total/A Supply	Avg/A Growth	Avg/A at Start	Avg/A 90 Day Demand	Avg/A Residue	Total		Avg/A Mass
	28.00	3,146[1]	471	3,846	3,182	700	89		1,097

[1]Average yield at start (3,375 lb/A) + growth (471 lb/A) – residue (700 lb/A) = total supply/A (3,146 lb).

Explanation of Table 1.

Column 1: Paddock identification (number).

Column 2: Area of each paddock (acres).

Column 3: Estimated amount of pasture (herbage mass) at the start of grazing (20 Nov), based on clipping or eye estimates.

Column 4: Estimated amount of growth (in lb/A) that will accumulate before the paddock is actually grazed. The average growth rate for tall fescue was projected to be from 10 to 14 lb/A/day.

Column 5: The estimated amount of herbage on offer to the animal group just before grazing each paddock based on daily growth rate (Columns 3 and 4).

Column 6: The estimated daily animal group requirement: 3% of 550 lb avg weight x 60 head.

Column 7: The amount of forage left behind after grazing a paddock (residual).

Column 8: The number of days of grazing projected for each paddock (herbage on offer at start minus residual) divided by the daily animal needs of the group.

Column 9: The projected date to move the animal group to the next paddock, but will depend on how effective the grazing plan is managed.

Column 10: The amount of herbage estimated to be present in each paddock after the grazing cycle has ended (16 February in this example). This growth has accumulated since the paddock was last grazed (as indicated in column 9).

pounds per acre of herbage will accumulate. This is done for each paddock and the values summed and divided by the total number of acres to obtain an average per acre growth value (Table 1, in the area below column 4).

4. Total per acre supply is obtained by adding the projected average per acre growth for the period to average yield at the start of grazing (Table 1, area below column 5). Then subtract the amount of residual (Table 1, in the area below column 7) you plan to leave behind. Example from Table 1 for 700 pounds per acre residual:

(avg yield at start + growth) – (residual)
= Total Supply / A

(3,375 lb / A + 471 lb / A) – (700 lb / A) = 3,146 lb / A

Determine feed demand

1. Calculate feed demand from the dry matter, energy, or protein required to meet a specific animal production goal.

2. Estimate dry herbage intake at 3% of body weight for beef heifers. For example, for 60 heifers weighing 550 pounds each, 3% of 550 = 16.5 pounds per day. The per head requirement (16.5 pounds) x the total number of head (60) = per day requirement for the group (990 pounds).

Average per acre demand for the budget period is calculated by multiplying the daily demand (990 pounds) by the number of days in the budget period (90) and dividing by the total acres (28). The result is a per acre demand of 3,182 pounds (Table 1, in area below column 6).

Determine feed balance

1. The gross feed balance is calculated by subtracting demand from supply to determine feed surplus or deficit for the budget period. From the example in Table 1: the average per acre supply (in the area below column 3) minus the average per acre demand (in the area below column 6) will indicate a balance. The resulting balance (3,146-pound supply – 3,182-pound demand = –36 pounds) reveals that there is a slight deficit, but it is likely that the plan will satisfy the animal group needs for the budget period. Even if there were a serious shortfall, the balance will help the grazier to decide how to use the grass (how much to allot per day) and how much supplementary feed is needed.

2. The projected number of grazing days can then be calculated by multiplying the average per acre supply (3,146 pounds per acre) by the total number of acres (28) and dividing by the daily group demand (990). In this example the estimated number of grazing days for the group is 89 (88.97). Since the original plan was for 90 days, the budget balance indicates that there is only a one-day shortfall.

Developing a Grazing Action Plan

1. The grazing plan indicates precisely how and when to use the feed in each paddock.

2. Calculate grazing days for each paddock by subtracting the residual yield from the amount of grass at the beginning of grazing, multiplying the result by the number of acres in the paddock, and dividing by the group feed demand. Using the 700 pounds per acre residual example from Table 1:

pad 1 = [(3,600 lb / A – 700 lbs / A) x 3.5 A] / 990 lb / day = 10 grazing days

3. Allocate the forage in each paddock so that three days of grazing are offered to the group at one time. In the cited example, Paddock 1 is calculated to supply 10 days of grazing. Therefore if you divide the paddock into three to five equal portions, each portion will supply between two and three days of grazing. This process is repeated for each paddock (see Table 1).

Subdividing Pastures

Simple, temporary electric fencing such as polywire or polytape (a single wire in most cases) can be used to allocate feed within each paddock or pasture. If the grazing period in a pasture is relatively short, or if the potential for pasture regrowth is low (such as

it is for fescue in December through January or during drought), there is no need to back-fence animals off of previously grazed pasture. The fence is simply moved forward as fresh pasture is allocated.

If, however, forage is being allocated from a very large pasture and active regrowth is occurring, back-fencing is needed to keep animals from grazing regrowth too soon. In this case, a lane or corridor can be constructed to access water (if water is not available in each paddock) to prevent back-grazing.

Chapter 23

ESTABLISHMENT AND ANNUAL PRODUCTION COSTS OF MAJOR FORAGES AND SILAGES

Duane F. Neuman, Scott Mickey, James T. Green, Jr., and J. Paul Mueller

Traditionally-grown forages are among the less intensive crops grown in North Carolina in terms of the amounts of capital and labor they require per acre. Their costs of production are generally well below those of horticultural crops and the higher-valued field crops like tobacco, peanuts, and cotton. On a per-acre basis, the costs of growing forages are comparable to the costs of producing grain crops, but the forage costs cover a much larger range of values, due in part to the diversity of forage species and product forms. The cost estimates presented in this chapter do not include costs or charges for land or management services.

Perennial forages form the basis for a viable pasture and hay program in North Carolina. Once established, a stand of a perennial forage will produce a harvestable yield each year for several years. Spreading the establishment costs over several production years is a definite cost advantage for these forage species over the annuals. Productive lives vary in length among the perennials, from as short as three years for some clovers to as long as 15 or more years for some hybrid bermudagrasses and fescues.

Establishment Costs of Perennial Crops

Estimates of start-up costs per acre for some of the more commonly grown perennials are presented in Table 1. These values are based on establishment methods recommended by North Carolina Extension forage specialists and current input prices. Establishment materials and services include seed, seed inoculants, lime and commercial fertilizer and their

Table 1. Estimated capital and labor costs per acre to establish selected perennial forage crops in North Carolina, 1992.

	Cost (dollars)				
Forage crop	Materials and services	Machine operating	Machine ownership	Labor	Total
Alfalfa	190.21	11.59	16.16	6.95	224.91
Alfalfa, no till	214.10	4.19	4.17	3.63	226.09
Hybrid bermudagrass	248.84	8.99	12.86	5.83	276.52
Endophyte-infected tall fescue	111.57	11.59	16.16	6.95	146.29
Low endophyte tall fescue	122.35	11.59	16.16	6.95	157.05
Orchardgrass	118.55	11.59	16.16	6.95	153.25
Switchgrass, no till	145.73	4.19	4.17	3.63	157.72
Ladino clover and orchardgrass or low endophyte fescue	131.46	11.59	16.16	6.95	166.16
Ladino clover and endophyte-infected fescue	125.27	11.59	16.16	6.95	159.97
Red clover and orchardgrass or low-endophyte fescue	132.46	11.59	16.16	6.95	167.16

custom application, sod seeder rental, and herbicides. The estimated cost of each crop includes 10% annual interest on the cost of each item of production material from the month of application through December. Machinery operating costs consist of fuel, lubricants, maintenance and repairs, and monthly interest. Costs of owning machinery include depreciation, property taxes, insurance, and interest on investment. Labor for operating machinery and handling materials is charged at $6 per hour. Of course actual costs will vary from farm to farm.

Using these parameters, we concluded the following:

- Hybrid bermudagrass, at $277 per acre, is the most expensive forage crop to establish, and endophyte-infected tall fescue, at $146 per acre, is the least expensive.

- The other forage crops in order of decreasing cost are alfalfa ($225-$226 per acre), the clover-grass combinations ($160-$167 per acre), and the grasses ($153-$158 per acre).

Annual Production Costs

All forages require annual inputs of resources for efficient production. For perennials, these inputs consist of annual fertilizers and prorated lime, machinery and labor services, and possibly insecticides and baler twine. The annual production of perennials also includes one year of interest and depreciation on the establishment costs of the stand.

The yearly inputs for the annual forages, of course, pertain to all the inputs required by the crop, including those to establish it.

Estimates of the current annual production costs (expressed in four standard units of measure) for hay and pasture forages are presented in Table 2. In developing these estimates, we assumed that the alfalfa, bermudagrass, and clover-grass hays would be intended for possible off-farm sale and therefore would be harvested in small, rectangular bales, hauled from the fields, and stacked. Hay in grass hay and pasture combinations, on the other hand, would likely be harvested in large round bales for home consumption. Costs of pastures do not include fencing, roads, or water supply, since these needs would depend on the kind of livestock grazed.

Given these assumptions, we determined the following:

- Hay crops are substantially more expensive to produce than are the hay-pasture combinations or pasture-only crops. Much of the cost difference lies in the higher cost of harvesting hays.

- Of the four grasses in the hay-pasture combinations, switchgrass is the least costly (at 2.5 cents per pound of total digestible nutrients, or TDN), followed by endophyte-infested fescue (3.8 cents per pound of TDN), and orchardgrass and low-endophyte tall fescue (4.2 cents per pound of TDN).

- Of the pasture crops, the bluegrass-white clover combination has the lowest annual cost at 1.83 cents per pound of TDN. (No charges for establishing this crop were included on the assumption that a stand would already exist, as is common in the mountain region.) Costs of the other two clover-grass pastures at 2.2 and 2.5 cents per pound of TDN are less than the costs of the grass pastures.

- On average, the costs of reestablishing the relatively short-lived clovers in the combination crops are outweighed by the high costs of fertilizer required by the grasses. Substituting poultry litter for commercial fertilizer lowers the cost of the grass pastures, however, by about $38 per acre.

- The cost per pound of TDN for alfalfa lies approximately halfway between the costs of clover-grass combinations and grass. Although its cost per acre is the highest of the pasture crops, its cost per ton of dry matter and per pound of TDN is less than that of the grasses because of its higher yield and digestibility.

A knowledge of costs of production per unit of total digestible nutrients provides useful information; however, we must keep in mind that some of these crops grow in summer and some in winter. Also some crops are much easier to grow then others. These factors will influence your planting decisions.

Table 2. Estimated annual dry matter yield and total annual costs for capital and labor per unit of alternative measures of product for selected forage crops in North Carolina, 1992.

Forage crop[1]	Dry matter yield per acre (tons)	Total annual cost (dollars) for capital and labor per:			
		Acre	Ton of DM[2]	AUD[2]	Pound of TDN[2]
For hay:					
Alfalfa (4)	4.5	370.99	82.44	N/A	0.0665
Hybrid bermudagrass (15)	5	374.49	74.90	N/A	0.0720
Red clover (3) and orchardgrass or low-endophyte fescue (5)	3	251.47	83.82	N/A	0.0676
For hay and pasture:					
Orchardgrass (5)	1,2[3]	162.75	54.25	N/A	0.0424
Endophyte-infested fescue (15)	1,2	143.51	47.84	N/A	0.0382
Low-endophyte fescue (5)	1,2	165.71	55.24	N/A	0.0425
Switchgrass (10)	1,2.5	115.98	33.14	N/A	0.0249
For pasture:					
Alfalfa (3)	4	150.95	37.74	0.444	0.0277
Hybrid bermudagrass (15)	4	137.12	34.28	0.499	0.0312
Hybrid bermudagrass (15) over-seeded with winter annual rye	6	231.28	38.55	0.514	0.0321
Orchardgrass (5)	3	130.87	43.62	0.521	0.0326
Endophyte-infected fescue (15)	3	112.43	37.49	0.462	0.0288
Low-endophyte fescue (5)	3	134.63	44.88	0.554	0.0345
Ladino clover (3) and orchardgrass or low-endophyte fescue (5)	3	101.57	33.86	0.398	0.0249
Ladino clover and endophyte-infected fescue (15)	3	88.41	29.47	0.346	0.0217
Bluegrass and white clover	2	50.41	25.21	0.293	0.0183
Pearl millet or sorghum sudan	3.5	134.44	38.41	0.452	0.0282
Winter annual rye	2.5	102.13	40.85	0.489	0.0305

[1] The years of expected life of a stand of the perennial crop are given in parentheses following the crop's name.
[2] DM = dry matter; AUD = animal unit days of grazing; TDN = total digested nutrients.
[3] The first number for the crops harvested as both hay and pasture is the tonnage of dry matter in the hay yield and the second number is the tonnage of dry matter in the pasture yield.

Costs of Silage

Estimated production costs of the more prominent silage crops, all of which are annuals, are presented in Table 3. Two of them include double crops after a small grain. Costs per acre of these two enterprises are relatively high because two separate crops are grown in both.

■ Silage costs per pound of TDN generally fall between those of hay and pasture and are comparable to the costs of the hay-pasture combinations.

■ Sorghum and the small grain-tropical corn sequence are almost tied for the lowest cost, at 3.2 to 3.3 cents per pound. Corn and the small grain-sorghum sequence have the next greater costs, 3.6 to 3.7 cents per pound. Small grain as a single crop is estimated to have the highest cost, at 4.95 cents per pound.

Detailed cost estimates for each crop are available as *Farm Enterprise Budget Guidelines* from your county Extension Center.

Table 3. Estimated dry matter yield and total costs for capital and labor per annual unit of alternative measures of production for selected silage crops in North Carolina, 1992.

Silage crop	Dry matter yield per acre (tons)	Total cost (dollars) for capital and labor per:		
		Acre	Ton of DM	Pound of TDN
Corn	5.5	271.80	49.42	0.0363
Forage sorghum	6.4	240.74	37.62	0.0324
Small grain	3	187.10	62.37	0.0495
Small grain and double-cropped forage sorghum[1]	3, 6.4	409.50	43.56	0.0365
Small grain and double-cropped tropical corn[1]	3, 6.4	408.29	43.44	0.0327

[1]The first number is the tonnage for the small grain, and the second number is for the summer crop.

Chapter 24

ANALYTICAL, ADVISORY, AND REGULATORY SERVICES

State agencies provide a variety of forage-related testing services to North Carolina residents. These services and those related to pesticide licenses are described in the following pages along with information on taking and submitting samples and who to call for more information. Some of the services are free; others require a fee. Agencies vary on whether or not they accept samples from other states and if the fee schedule differs. These government agencies are located throughout Raleigh; many of these services are also available in other states and through private industry.

Please remember the following points when submitting a sample.

1) The personnel receiving these samples are committed to giving you the best analysis possible.

2) You need to be equally committed to the process. **The quality of the sample you submit is of utmost importance.**

3) Different labs require different types of samples, forms, and packaging material. Some labs have special boxes, bags, or other containers needed for submitting samples. County agricultural agents, regional agronomists, and other agricultural consultants can help you with the appropriate forms and packing materials. You can also call or write the labs directly for more information.

Included in this chapter is information about soil testing; plant, waste, and solution analysis; nematode assays; seed analysis; tall fescue endophyte analysis; forage testing; plant disease and insect clinics; and safety regulations and pesticide licenses.

SOIL TESTING

M. Ray Tucker

The North Carolina Department of Agriculture (NCDA) Agronomic Division provides a soil-testing service for North Carolina citizens. Soil testing provides the means for determining the proper application rates of lime and fertilizers. Supplies and sampling information are available through local agricultural advisors or at the soil-testing lab in Raleigh. This service is provided for free.

Producing high-quality forage and meeting animals' nutrients requirements demands a good liming program and a balanced soil nutrient regime. For example, dolomitic lime, in addition to calcium, supplies magnesium, which is the element used to prevent grass tetany. Nutrients analyzed by a soil test include phosphorus, potassium, calcium, magnesium, manganese, zinc, and copper. These nutrient elements are essential for good forage production and animal nutrition. The analytical data generated from the soil test are used to make specific lime and fertilizer recommendations. No other method can replace or substitute for a soil test in achieving this objective.

A soil test's reliability depends very heavily on whether the sample is representative of all the soil. To ensure that your sample is representative follow these steps:

- Make sure that the sampling instrument (preferably, but not necessarily, a stainless steel probe) and plastic collection bucket are clean.
- Remove plant material from the soil surface.
- Sample soil to a 4-inch depth.
- Take 15 to 20 cores at random across individual pastures and mix them into one representative sample.

Both annual and perennial forages require annual application of fertilizer. Forage land should be tested every two to four years, depending on soil type, to monitor the lime and fertility status. Nitrogen fertilizer applied to forage crops creates enough acidity to consume 180 to 200 pounds of lime/acre/year.

For more information on soil testing, contact your local agricultural advisor or the Soil Testing Section, Agronomic Division, NCDA, 2109 Blue Ridge Road, Raleigh, NC 27607; 919 733-2656.

PLANT, WASTE, AND SOLUTION ANALYSIS

C. Ray Campbell

Plant Analysis

Plant analysis is the chemical evaluation of the nutritional status of plants. It is used to solve nutritional problems and to monitor the status of healthy crops in an effort to enhance yield and quality while maintaining optimum production efficiency and protecting the environment. Many growers also monitor the nitrate nitrogen concentration of intensively managed forages in order to avoid nitrate poisoning of livestock.

The Agronomic Division of the North Carolina Department of Agriculture provides analytical and advisory services on plant analysis. For $4.00, concentrations of major nutrients (N,P,K), secondary nutrients (Ca, Mg, S), and micronutrients (Fe, Mn, Zn, Cu, B, Mo, Cl) are determined. Nitrate nitrogen (NO_3-N) and potentially harmful elements (Na, Ni, Cd, Pb) are also determined when appropriate and upon request. An interpretation of the laboratory results is provided along with management advice.

As with soil testing, the value of plant analysis is limited by the quality of the sample supplied to the laboratory. The top 3 inches of terminal growth is generally the best indicator sample for grasses and small leaf legumes. For larger leaf legumes, the most recent mature leaf or trifoliate is the best indicator. A double handful of plant material representative of the sample area should be supplied to the laboratory. Samples should represent uniform areas in soil type. The same general guidelines for soil sampling should be followed in taking plant samples. If you have problem plants, send comparative "good" and "bad" plant and soil samples for a more definitive diagnosis.

For best results, samples should be taken during early stages of growth or just before flowering. Samples should be placed in the sample container provided by the Agronomic Division and mailed or shipped to the laboratory as soon as possible. It is not necessary to dry samples before shipping them as long as they are not extremely wet and the container is not packed too tightly.

For additional assistance in plant analysis, contact your local agricultural advisor or the Plant Advisory Section, Agronomic Division, NCDA, 2109 Blue Ridge Road Raleigh, NC 27607; 919-733-2655.

Waste Analysis

Waste analysis is an essential component of a good waste management program. It predicts essential plant nutrients and potentially harmful elements in farm, municipal, and industrial wastes. Producers can use this information to develop sound agronomic and environmentally safe uses of these materials in production agriculture.

The Agronomic Division of the NCDA provides waste analysis and advisory services for a fee of $4.00 per sample. Concentrations of major nutrients (N, P, K), secondary nutrients (Ca, Mg, S), and micronutrients (Fe, Mn, Zn, Cu, B, Mo, Cl) are determined. Potentially harmful elements including Na, Ni, Cd, and Pb are also determined as needed. Predictions of available nutrients for the first crop are made based on estimates of mineralization rate and nutrient loss considering the application method. Remarks indicate if heavy metals are high enough to warrant special consideration in monitoring sites where the waste is routinely applied.

For most reliable results, representative samples of waste should be taken after mixing and just before application. Details of sampling procedures are contained on the information sheet which must accompany each sample. One quart of liquid or solid waste is required for analysis. Samples should always be placed in plastic bags or containers to avoid contamination and/or loss of sample.

Additional information on waste analysis can be obtained from your local agricultural advisor or by contacting the Waste Advisory Section, Agronomic Division, NCDA, 2109 Blue Ridge Road, Raleigh, NC 27607; 919-733-2655.

Solution Analysis

Solution analysis provides an assessment of water quality. Results can be used by livestock producers to help determine causes of poor animal performance. Irrigation water can be evaluated for suitability in irrigating forages and other crops. Evaluations of ground and surface water also provide a means for monitoring nutrient movement in the environment.

The Solution Advisory Section of the Agronomic Division provides solution analysis for a fee of $4.00 per sample. Concentrations of elements considered essential for plant growth (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, B, Cl) are determined. Additionally, conductivity (soluble salts), pH, total carbonates, and Na are determined. A sodium absorption ratio is calculated. All of these factors contribute to the evaluation of water quality and usability in livestock and crop production.

One quart of water is needed for evaluation. The sample should be placed in a clean plastic container and shipped to the laboratory for evaluation as soon as possible. If the water is stored for any length of time before analysis, it should be refrigerated. Care should be taken to fill containers completely at sampling. Additional instructions and sampling procedures are provided on the information sheet that must accompany each sample.

For more assistance on solution analysis, contact your local agricultural advisor or the Solution Advisory Section, Agronomic Division, NCDA, 2109 Blue Ridge Road, Raleigh, NC 27607; 919 733-2655.

NEMATODE ASSAY

Jack L. Imbriani

Nematodes are microscopic roundworms found in all soils. Some species of nematodes are parasitic on forage plants and cause varying degrees of loss depending on the plant species–nematode species combination. Control using chemicals is usually not advisable or economical. Management consists of selecting nematode-resistant varieties or minimizing other stresses. Nematode assays are used to predict the likelihood of nematode damage in a field before planting and to determine whether nematodes are part of a growth problem in an established field.

Predictive Assays

Sample fields before planting or renovation. Late summer to early fall is the best time to sample. The sample should be taken with a soil probe to a depth of 4 to 6 inches and should consist of about 20 cores taken in a zig-zag pattern across the field. Place the cores in a plastic bucket, mix, then seal one quart of sample in a plastic bag and send it to the laboratory.

Diagnostic Assays

If a problem exists in an established field, assays are used to determine if nematodes are involved. Samples can be taken any time of year provided the soil is not too wet, too dry, or frozen. The samples should be taken from the margin of delining areas, not from dead plants. Roots, adjacent soil, and leaf tissue must be included. It is useful to take comparative samples from good and poor areas.

Detailed instructions for sampling are found on the back of the assay information sheets. Both predictive and diagnostic nematode assay samples must be kept cool, placed in a plastic bag to prevent drying, and sent to the laboratory as quickly as possible. There is a $2.00 fee per sample.

Send samples to:

Agronomic Division
Nematode Advisory Section
North Carolina Department of Agriculture
PO Box 27647
Raleigh, NC 27611-7647

For additional information, contact your local agricultural advisor or Dr. Jack Imbriani at 919 733-2655.

SEED ANALYSIS

James M. Warren and Jewell G. Stallings

The North Carolina Department of Agriculture has a mandate under the North Carolina Seed Law to establish minimum quality standards and labeling requirements for seed offered for sale in the state. The regulatory seed specialists inspect seeds at licensed retail and wholesale dealers to ensure that seeds are legal for sale, meet minimum quality standards, and are properly labeled. These specialists collect seed samples which are tested by seed analysts in the Department's Seed Testing Laboratory.

Seed lots that fail to meet quality and labeling standards are ordered removed from sale. These Stop Sale Orders remain in place until acceptable labeling has been provided or proper final disposition of the seed has been determined. Following such corrective action, a release from stop sale is granted.

The Seed Testing Laboratory performs two major functions for the seed industry. First it supports the regulatory arm of the Department by analyzing official samples. This analysis provides information and support for regulatory action taken by the seed specialists and Seed Program Administrator.

The second primary function is to provide a testing service for seed producers, seed dealers, farmers, and other seed consumers. The two services most often requested are purity analysis and germination. These tests are provided at no charge. Seed in channels of trade must be retested for germination every nine months. Other testing services offered include cold tests of corn, cool tests of cotton, accelerated aging tests of soybeans, and tetrazolium (TZ) tests. The TZ test requires a fee of $5.00 per sample and gives an indication of germination potential of the seed tested.

Minimum weights of samples submitted for purity, germination, and noxious weed seed examination are as follows:

- Two ounces of grass seed (for grasses not listed below), alsike, white clover, or seeds of similar size.
- Five ounces of alfalfa, crimson or red clover, foxtail millet, rape, ryegrasses, fescues, or seeds of similar size.
- One pound of millet (proso and pearl), sudangrass, or seeds of similar size.
- Two pounds of cereal grains, vetches, sorghums, or seeds of similar or larger size.

Submit samples to the following address:

Seed Testing Laboratory
North Carolina Department of Agriculture
Plant Industry Division
PO Box 27647
Raleigh, NC 27611-7647

Street Address:
216 West Jones Street

Telephone: 919 733-3930

TALL FESCUE ENDOPHYTE ANALYSIS

Betsy Randall-Schadel

The tall fescue endophyte is an organism best known for its adverse effects on cattle and broodmares. The endophyte ("endo" = inside + "phyte" = plant) is a fungus that grows between the tall fescue cells. Although harmful to animals, it is beneficial to tall fescue, providing resistance against insects, disease, and mammals. The endophyte can make the tall fescue much hardier and make the grass better for conservation and turf uses.

One of the ways this endophyte provides resistance is by making toxins, some of which are harmful to livestock, particularly cattle and broodmares. In cattle, major symptoms of fescue toxicosis, the disease associated with the endophyte, include reduced grazing, poor weight gain, increased body temperature and respiration rate, and shaggy, dull hair in the summer. The symptoms in broodmares include thickened and/or retained placentas, prolonged gestation, abortions, and stillbirths.

The Tall Fescue Endophyte Testing Service is provided by the Seed Pathology Laboratory in the NCDA Seed Section. Analyses can be performed on pasture samples, new crop seed, and carryover seed. Plant and seed samples can be tested for both low and high levels of the endophyte. High levels of endophyte may be used to conserve tall fescue where animals will not be grazing. Low levels or endophyte-free fescue may be preferred on certain soils where animals will graze.

Pasture Samples

One tiller or stem should be collected per plant. At least 50 tillers should be collected in a random pattern for every 10 acres of pasture. Avoid fence rows and ditches and separate large pastures into subpastures for testing. The quality of the sample directly affects the value of the test report. A nonrandom sample with lots of tillers from the same plant will not adequately reflect the level of endophyte in the pasture. The number of tillers taken per acre is also important. A minimum of five tillers per acre is recommended. The fee is $15.00 per sample of up to 50 tillers.

New Crop Seed

Submit 1 pint of fescue seed. Make sure the seed represents all the seed you need tested. If you have several bags of seed, get several portions of seed from each bag and mix them together well. Then take the amount needed to send to the laboratory. The fee is $15.00 per sample. One hundred seed are tested per sample.

Carryover Seed

Submit 1 pint of fescue seed. Make sure the seed represents all the seed you need tested. If you have several bags of seed, get several portions of seed from each bag and mix them together well. Then take the amount needed to send to the laboratory. The fee is $25.00 for in-state residents. Carryover seed are planted in the greenhouse, and the resulting plants are allowed to grow for six to eight weeks before they are harvested and tested to ensure the endophyte inside the seed is still alive. The seed stain test cannot distinguish between living and dead endophyte tissue.

For more information or a brochure on these services contact your local Extension Center or

Betsy Randall-Schadel
Seed Section, NCDA,
PO Box 27647, Raleigh, NC 27611-7647
Telephone: 919 733-3930
Fax: 919 733-1041.

FORAGE TESTING

Jack M. VanStavern

The Farm Feed Testing Service, a cooperative project of the North Carolina Department of Agriculture (NCDA) and the North Carolina Cooperative Extension Service, analyzes forage samples submitted by North Carolina producers. For a $10 per sample fee, the NCDA provides compositional information and the Extension Service gives nutritional recommendations.

The testing service analyzes samples for the nutrients listed in Figure 1. Upon request, forage samples may also be analyzed for nitrates, and mixed feeds or grains for aflatoxin. Copies of the results are mailed to the producer, the producer's county Extension Center, and the North Carolina Cooperative Extension Service at North Carolina State University.

Figure 1. Sample reporting form from the forage testing service.

Laboratory results	As sampled basis	Dry matter basis
Dry Matter, %		
Crude Protein, and Acid Detergent Fiber, %		
TDN, %		
NE (Lactation) Mcal/lb		
Calcium, %		
Phosphorus, %		
Sodium, %		
Magnesium, %		
Sulfur, %		
Potassium, %		
Copper, ppm		
Iron, ppm		
Manganese, ppm		
Zinc, ppm		
Nitrate, Ion, %		

Many factors affect forage's quality, including type of species, stage of maturity, soil condition, climate, storage, and handling. Laboratory analysis is the best way to determine a forage's nutrient content, knowledge of which is necessary for producers to develop optimum feeding practices and balanced rations.

Mailing kits for samples are available from the North Carolina Department of Agriculture and from county Extension Centers. Complete the form clearly and accurately and enclose a check for $10 per sample. Deliver samples to the Constable Laboratory, 4000 Reedy Creek Road, Raleigh, or mail them to the Forage Testing Facility, Constable Laboratory, NCDA, P.O. Box 30600, Raleigh, NC 27622.

For more information, contact

Dr. Jack W. VanStavern
Food & Drug Protection Division
North Carolina Department of Agriculture
PO Box 27647
Raleigh, NC 27611-7647
Telephone: 919 733-7366
Fax: 919 733-6801

or

Dr. Lon W. Whitlow
Extension Dairy Husbandry
Department of Animal Science
Box 7621
North Carolina State University
Raleigh, NC 27695-7621
Telephone: 919 515-2771

FORAGE TESTING POLICY AND CAPABILITIES: *Rollins Animal Disease Diagnostic Laboratory*

Robin B. Smith, Jr.

The mission of Rollins Animal Disease Diagnostic Laboratory is to diagnose animal health problems as quickly as possible to prevent further loss. The laboratory does not conduct quality control work. Forage testing is done only after consultation with a veterinarian or one of the laboratory's personnel to determine if forage contamination may be causing an animal health problem. This determination is made by evaluating the animals' symptoms, lesions, and/or necropsy findings. Laboratory personnel then analyze the forage for contaminants that might have caused the set of symptoms seen in the animals. The laboratory analyzes for most mycotoxins of economic significance, various minerals, nitrate/nitrite, Vitamin A, arsenic, pesticides, lead, and other possible contaminants. It is best to consult your veterinarian or one of the personnel at the Rollins laboratory before sending samples.

The contact person for forage testing at this laboratory is Robin Smith, at 919-733-3986.

PLANT DISEASE AND INSECT CLINIC

Ronald K. Jones

North Carolina State University's Plant Disease and Insect Clinic provides free diagnostic services for diseased and injured plants submitted through the Cooperative Extension Service or NCSU personnel. For samples submitted directly to the clinic there is a fee of $5 per sample (in state) or $25 per sample (out of state). The ability of the clinic's staff, and that of the specialists in the Entomology and Plant Pathology departments, to make a correct diagnosis is directly related to the quality of the sample submitted. Different types of material need to be submitted in different ways. No one way of preparing plants and insects for shipping will assure their satisfactory arrival in the laboratory.

For Plant Disease Diagnosis:

- Contact your local county Extension Center for information, assistance, and clinic forms.
- Always give complete information requested on the clinic form. Be sure to include information on symptoms and distribution (check appropriate box).
- Send specimens immediately after collection and mail them early in the week to avoid weekend delays. If the specimen cannot be mailed the same day it is collected, keep it cold until shipment. Dead plants, or material that is dry or decomposed on arrival, cannot be diagnosed. Place specimens in plastic bags at time of collection, not hours or days later, making sure there is no water on plant surfaces and that the bags are not overstuffed.
- When submitting specimens from counties under state and federal regulations for witchweed control, be absolutely certain there is no loose soil in the package. All soil must be sealed in plastic bags.
- Send to

  Plant Disease and Insect Clinic
  Box 7211
  North Carolina State University
  Raleigh, NC 27695-7211

- The diagnostic report will be returned to you through your local county Extension Center.

For Insect Identification:

- **Most insects** — Roaches, termites, bugs, beetles, flies, wasps, ants, maggots, spiders, etc. should be sent in 70% alcohol. This can be purchased locally; it will be labeled as 70% isopropyl rubbing alcohol.
- **Mites, scales, aphids, and thrips** — Send them in alive on some of the affected foliage/stems, collected as you would a plant specimen. Place in a plastic bag when collected.
- **Butterflies and moths** — Kill them with rubbing alcohol and send the specimens packaged lightly in tissue paper in a crushproof box.
- **Caterpillars** — Send them in alive on some of the host plant in a plastic bag.
- **Grubs** — Send them in alive in a pint or two of soil enclosed in a plastic bag.
- When in doubt, put specimens in 70% alcohol.
- Collect five or more specimens if possible.

Four pieces of information are very important for proper diagnosis of insects and must be included with the sample.

1. Date specimen collected. List the date the specimen was actually found.

2. Town and county where specimen was collected. List the town and county where the insect was actually found. If not found within a town, list the nearest town and the distance and direction of the location from that town.

3. Name of collector. Name the person who actually captured or collected the insect.

4. Where were the specimens and on what were they feeding when collected. If the insects were feeding on a plant, list the plant name. Otherwise, list the type of location (window sill, carport, closet, bag or box of dog food, etc.) where you found the insect.

Take care in preparing insect samples. DO NOT wrap insects in tissue or cellophane and then put in an envelope. DO NOT place them in an empty vial or overcrowd them because they will decay or get broken, or both. NEVER leave any sample in the sun or in a closed car for even a few minutes; "cooked" samples may be impossible to diagnose.

Send insect specimens to

Plant Disease and Insect Clinic
Box 7211
North Carolina State University
Raleigh, NC 27695-7211

For more information on either plant disease or insect samples contact your local Extension Center or call the Plant Disease and Insect Clinic at 919 515-3619 or 919 515-3825.

Contacts:

Disease samples — Dr. Tom Creswell

Insect samples — David Stephan

SAFETY REGULATIONS AND PESTICIDE LICENSES

John H. Wilson

Farmers who buy or apply any restricted-use pesticides on their own or rented lands must be certified as private pesticide applicators. An initial four-hour certification program is offered by the North Carolina Cooperative Extension Service. A two-hour recertification program offered by Extension is required every three years to maintain the certification.

Commercial pesticide applicators and public operators (town, city, county, state, and federal workers) who apply any pesticide in North Carolina must be licensed in the appropriate specialty. Specialty areas include ornamentals-turf, structural, aquatic, regulatory, seed, wood treatment, tributyltin paints (TBT), rights of way, public health, forestry, agricultural pest-plant, agricultural pest-animals, aerial and demonstration-research. These applicators can be licensed by passing the appropriate tests. Manuals can be obtained from John Wilson, North Carolina State University, Box 7609, Raleigh, NC 27695, 919 515-3113. The Extension service offers two-day classes for people wishing to obtain a license. These applicators must be recertified every five years by attending recertification classes sometime during the five-year period. Annual license fees are $30 for commercial applicators. There is no annual fee for public operators. Dealers who sell restricted-use pesticides and consultants who give advice/recommendations for a fee on any pesticides must also be licensed.

Private and commercial applicators must abide by the laws and regulations of the United States Environmental Protection Agency (EPA) and in North Carolina by the North Carolina Pesticide Board. The North Carolina Pesticide Law of 1971 is administered and enforced by the NCDA, 919 733-3556. Questions concerning the application of pesticides inside structures should be addressed to the Structural Pest Control Division, NCDA, PO Box 27647, Raleigh, NC 27611 or call 919 733-6100.

During the certification/licensing process, pesticide applicators learn to apply pesticides safely and properly. They also learn about regulations governing the following areas: pesticide registrations, licensing procedures, bulk distribution, availability, storage, disposal of pesticides and containers, public safety, inspection, and chemigation, as well as other areas. Fines are issued to anyone who violates federal and state pesticide laws and regulations.

Training in the safe and proper use of pesticides includes pest identification, pest control methods, labels, human safety, environmental safety, equipment, calibration, and laws and regulations. Training also covers specific areas such as endangered species protection, worker protection standards and ground and surface water protection.

Questions about pest control and pesticides can be addressed to your local Extension Center or the appropriate subject matter Specialist at North Carolina State University.

- **Study manuals for pesticide tests:**

  John Wilson
  North Carolina State University
  Box 7609
  Raleigh, NC 27695-7609
  919 515-3113

- **Questions about pest control inside structures:**

  Structural Pest Control Division
  NCDA
  PO Box 27647
  Raleigh, NC 27611
  919 733-6100

- **Other pesticide questions:**

  North Carolina Department of Agriculture
  PO Box 27647
  Raleigh, NC 27611
  919 733-3556

Chapter 25

CURRENT TRENDS: *Farm Bill and Associated Requirements*

Dana L. Hoag and Bobby G. Brock

Most farmers have heard about the Conservation Reserve Program (CRP), Conservation Compliance (CC), and Sodbuster. These programs were the first in a wave of new legislation aimed at reducing environmental problems that occur on some farms. The 1985 Food Security Act opened the door for such legislation by linking government payments and other farm benefits to soil conservation. The Food, Agriculture, Conservation and Trade Act of 1990 expanded the environmental legislation to include global warming, water quality, pesticide use, food safety, and sustainable agriculture. It also strengthened the soil conservation and wetland programs put in place in 1985.

National farm bills have a profound impact on American farmers. They influence the types of crops produced, the technology used to produce them, and the income that farmers make. The last two farm bills, legislation passed in 1985 and 1990, attempted to reduce the impact that agriculture has on soil erosion, water quality, wildlife, and wetlands. Many of these environmental goals can be achieved through the increased use of grasslands. Economic uses of grassland (such as for hay, forage, and hunting) are allowed at varying levels under all of the grassland establishment provisions.

Important Farm Bill Programs

Three government programs will have a major impact on grasslands: Conservation Reserve Program (CRP), Conservation Compliance (CC), and Flex Cropping. Several other programs have a minor impact on use of grasses, such as requirements for more grassed waterways and conservation cover requirements on land idled in the Acreage Reduction Program.

The CRP pays farmers an annual rental payment and pays half the costs to establish a conservation cover on highly erodible land idled from production for 10 years. Currently there are 151,401 acres of CRP land in North Carolina. This land cannot be cropped or grazed, but hunting is allowed.

The Conservation Compliance Program requires that farmers with highly erodible land prepare and follow a soil conservation plan to qualify to receive price and income supports and other USDA benefits. Over 60,000 plans have been prepared in North Carolina. Most of these plans use residue management to decrease soil erosion to permitable levels, but many also incorporate grass in rotation. Tobacco farmers have few alternatives but to rotate grass with tobacco, usually following two years of tobacco with two years of grass. Plans require full implementation before 1995, but only a small fraction of required grassland has already been planted.

Finally, it is hoped that new flexibility in the crop price and income support programs for corn, sorghum, and small grains will promote rotations. These programs have worked against rotations that might include grasses because they rewarded the production of the supported crops. A mandatory 15% flexibility requirement and an optional 10% additional flexibility program give farmers the opportunity to rotate up to 25% of a nonprogram crop into their farm without loss of farm program benefits.

What These Programs Will Mean

It is difficult to say exactly what CC, CRP, and flexibility will mean for North Carolina farmers because the plans have not been fully implemented. However, some general observations can be made: most notably, the amount of grasslands will increase.

The CRP has already increased the use of grasses to cover highly erodible acreage placed in the program. The major impacts of this program have been a slight reduction in the supply of retired crops, because yields on these lands were low, and an increased demand for grass seed.

Conservation Compliance and flexibility will certainly increase the amount of grassland. This offers opportunities to increase cattle production. Under program rules, the forage must be produced. Therefore, farmers practicing proper conservation management will benefit if they increase the value of this forage by feeding it to cattle or selling hay. Consult the Soil Conservation Service, because cattle grazing is not always allowed.

Appendix A

SEED SIZE AND WEIGHT AND CALIBRATING EQUIPMENT

Seed Size and Weight

Table 1. Approximations of seeds per pound or pounds per bushel.[1]

Legumes			Grasses		
	No. of seeds/lb	lb/bu		No. of seeds/lb	lb/bu
Alfalfa	220,000	60	Bahiagrass	153,000	—
Crimson clover	140,000	60	Bermudagrass	1,787,000	**
Ladino clover	800,000	60	Bluegrass (Ky)	2,177,000	—
Lespedeza			Dallisgrass	220,000	20
Kobe	185,000	25*	Fescue (Tall)	227,000	24
Korean	240,000	45*	Flaccidgrass	515,000	—
Sericea	335,000	60**	Millet		
Red clover	275,000	60	Pearl	88,000	50
Subclover	65,000	—	Foxtail	220,000	—
Sweetclover	260,000	60	Orchardgrass	600,000	14
Vetch			Redtop	5,000,000	35
Hairy	20,000	60	Rye	18,000	56
Crown	110,000	—	Ryegrass		
Trefoil	—	—	Annual	227,000	24
Birdsfoot	375,000	60	Sudangrass	50,000	—
			Sorghum-sudan	35,000	—
			Switchgrass	390,000	—

*Unhulled **Hulled

[1]The number of seeds per pound can vary widely depending on growing season and cultivars.

Calibrating Equipment

Calibrating Drills

Planting small-seeded forages often requires precision planting equipment and seeding rates because depth of planting is critical and seed costs are usually high. Calibrations charts are usually found on the equipment, and they are useful as a guideline for making an initial setting. However, because of variations in seed size, purity, moisture, equipment performance, and other factors, it is wise to calibrate equipment periodically. Chart settings frequently are in error by as much as 50%.

There are three calibrating methods for determining rate of seed being applied per acre. Method 1 entails collecting and weighing the seed delivered from each seed box opening while pulling the drill a determined distance. Necessary information for this method includes drill width, distance traveled, and weight of seeds collected. Method 2 is similar to Method 1, except that it is carried out by turning the

drive wheel. Method 3 entails counting the seeds dropped per foot of row. Necessary information includes the number of seeds/pound or the number of seeds required per acre. Step-by-step instructions for each of these methods are provided in the following boxed paragraphs.

METHOD 1. (Drive and Collect Seeds — For Drills)

Step 1. Fasten a container or a plastic bag to each seed box opening and collect seeds during a measured travel distance. Pull drill at field speed.

Step 2. Weigh the seeds. (454 grams = 1 pound)

Step 3. Measure width of drill.

Step 4. To calculate seeding rate/acre:

a) determine soil area covered during the collection "run" (distance traveled × drill width)

b) seeding rate can then be determined by lb/acre = (43,560/area of collection run) × pounds of seed collected.

EXAMPLE: If 0.5 pound of seed is collected from an 8-foot drill pulled 100 feet, the seeding rate would be:

lbs/a = [(43,560/(8' x 100')] × 0.5 = 27.22

METHOD 2. (Wheel Turn and Catch)

This method can be used to calibrate equipment in the shop before going to the field.

Step 1. Measure the circumference of the drive wheel or the distance it travels during one revolution. Circumference = diameter of a circle × 3.1416. (Or you can measure circumference directly with a tape.)

Step 2. Determine the number of revolutions to turn the wheel if you wanted to collect seed from 0.1 acre.

(43,560/drill width) ÷ 10 ÷ (wheel circumference)

EXAMPLE: 8-foot drill width and a wheel circumference of 7 feet would require 77.8 revolutions to = 0.1 acre.

43,560 ÷ 8 = 5,445

5,445 ÷ 10 = 544.5

544.5 ÷ 7 = 77.8

Step 3. Put seed in drill and elevate the drive wheel so it can be turned by hand when the drill is engaged.

Step 4. Collect seeds from each opening while turning the wheel the required number of revolutions (77.8 in this example).

Step 5. Calculations: seed weight (lb) × 10 = lb/acre

METHOD 3. (Count Seeds in Foot Row)

For this method, you must know the number of seeds per pound and rate per acre in pounds desired. Use Table 2 to estimate seed density at various row widths and seeding flow rate. The values are not adjusted for purity or viability (pure live seeds).

Step 1. Lay a canvas on level ground or drop seeds onto pavement, clean driveway, or other surface where seeds can be seen easily for counting.

Step 2. Pull the drill over the sample area at field speed with seed dropping so that each row can be distinguished.

Step 3. Record the number of seeds per foot in each row. If the number varies more than 25%, consider adjusting delivery for that row.

Step 4. Determine seeding density (seed/ft^2) with this equation: (seeds/ft of row × 12) ÷ row width (inches) (Using Table 2). Then check seed charts showing number of seeds per pound.

For example, assume you are seeding ladino clover that has 800,000 seeds per pound, that your drill row width is 7 inches (See Table 2), and that you counted an average of 23.3 seeds/ft of row (count several rows).

23.3 × 12 = 279.6 ÷ 7 = 40 = seed density (seed/ft^2) (Table 2).

40 × 43,560 (square feet in one acre) = 1,742,400 = total seed seeded per acre.

1,742,400 ÷ 800,000 = 2.18 = pounds of ladino seeded per acre.

Table 2. Seeds per foot of row needed to achieve certain seed densities (15 to 60 seeds/ft^2) from drills with various row widths.[1]

Drill row width (in.)	Seed density (seeds/ft^2)					
	15	20	30	40	50	60
	Seeds/running foot of row					
6	7.5	10.0	15.0	20.0	25.5	30.0
7	8.8	11.7	17.5	23.3	29.2	35.0
8	10.0	13.3	20.0	26.6	33.3	40.0
9	11.2	15.0	22.5	30.0	37.5	45.0
10	12.5	16.7	25.0	33.3	41.7	50.0

[1]Seed density = (Seeds/ft of row × 12) ÷ row width (inches). After calculating density, you must know the number of seed per pound to calculate the rate.

INOCULANT GROUPS

There are many different kinds of legume bacteria. Rhizobia are very specific for certain legumes. For example, the bacteria that work on alfalfa and sweet clover *will not* be effective on clover or soybeans.

Group Designations

Because legume bacteria are definitely selective, cross-inoculation groups were developed to categorize the many legumes. Any plant within a group can usually be inoculated with a culture of the right kind of bacteria. Such inoculant is usually prepared from several strains of bacteria known to effectively inoculate all of the legumes in that particular group. However, recent research indicates that there may be some merit in finding very specific strains of bacteria for each cultivar within a species.

The main cross-inoculation culture groups are given below with an abbreviated list of the most important legumes in each.

- **ALFALFA GROUP**
  - (a) alfalfa
  - (b) sweet clover
- **CLOVER GROUP**
  - (a) alsike clover
  - (b) red clover
  - (c) white clover (ladino and intermediate)
- **OTHER CLOVERS (SPECIFIC)**
  - (a) sub clover
  - (b) crimson clover
- **PEA AND VETCH GROUP**
  - (a) field pea
  - (b) garden pea
  - (c) Austrian winter pea
  - (d) common vetch
  - (e) hairy vetch
- **COWPEA GROUP**
  - (a) cowpea
  - (b) annual lespedeza
  - (c) sericea lespedeza
  - (d) kudzu
- **BEAN GROUP**
  - (a) garden bean
  - (b) navy bean
  - (c) kidney bean
  - (d) pinto bean
- **LUPINE GROUP**
  - (a) blue lupine
  - (b) white lupine
- **SOYBEAN GROUP**
  - (a) all cultivars

Recognize Effective Nodules

Well-nodulated plants will display characteristic types of nodules. Effective nodules are usually large and pink to beefsteak red on the inside. The red color is due to the leghemoglobin, an iron-containing pigment associated with active nitrogen fixation.

Ineffective bacteria often produce nodules, but these nodules are small and white, gray, or green on the inside. Plants that exhibit symptoms of nitrogen deficiency (yellowing of leaves and unthrifty growth) and that have white, gray, green, or brown decayed nodules are probably not fixing nitrogen and should be reinoculated.

Preinoculated Seeds

Preinoculated and/or lime-coated seeds are now on the market in North Carolina. Preinoculation is the process of sticking large amounts of inoculant to the seed at the processing plant before bagging. Often the preinoculated seeds are coated with finely ground limestone, thus providing what is called lime-coated, preinoculated seeds which are ready to plant. However, under most warehouse storage conditions many of the nodule bacteria will not remain viable for more than two to three months. This is especially true for seeds stored through the summer for fall plantings. *Always* reinoculate if there is any doubt. Since water or sticking solutions will cause the lime coating to "gum up," use mineral or vegetable oil (0.5 to 1.0 ounce/pound of seed) to stick new inoculant to the lime-coated seeds just

before planting. Some companies provide reinoculation kits for lime-coated preinoculated seed.

Inoculation Recipe *(for 25 pounds of seed)*

1. Use a commercial sticking agent or make one by mixing 2 ounces of syrup or molasses with 8 ounces of water. Shake well.
2. Add about one-third of the inoculum (2 ounces) to about 7 ounces of the sticking agent to form a black slurry.
3. Place 25 pounds of seed in a tub.
4. Add the slurry (7 ounces) to 25 pounds of seed in a tub and mix thoroughly, coating every seed with inoculant.
5. Add remainder of the inoculant (about 4 ounces) to coat and dry the seeds. This is four times the manufacturer's recommended rate, but is usually necessary in North Carolina.
6. Let the seeds air dry by spreading them in the shade. To speed the drying process, add more peat-based inoculant or a small amount of finely ground limestone.
7. Plant the inoculant seed as quickly as possible or keep in *cool conditions* for no more than one to three days. Avoid leaving inoculated seeds in direct sunlight. The bacteria will be affected most favorably if planted into slightly moist soil.

   Never mix inoculated seed with fertilizer.

Emergency Inoculation Methods

If nodulation is not satisfactory for plant growth, one of the following methods may be used under favorable moisture and temperature conditions. The rates of inoculant should be increased by 50% if environmental conditions are not favorable.

- Thoroughly mix 1.5 pounds of the black peat inoculant with 50 to 100 pounds of sand, cottonseed meal, wheat middlings, or limestone. Uniformly broadcast this mixture over one acre. Unless applied between rain showers, there would be an advantage in using a grain drill or other method of putting the inoculant *into the soil.*

- Mix a fine slurry of 1.5 pounds of peat inoculant with 20 gallons water and apply a broadcast spray at the rate of 20 gallons per acre. Some inoculant preparations may clog spray nozzles and valves. In limited tests in North Carolina, inoculant sold under the trade name Pelinoc appears to have been more finely screened, thereby causing fewer problems. Even with Pelinoc, there is an advantage in additional screening for some equipment. Large spray tips without screens and with vigorous agitation will be necessary.

Apply these treatments immediately before or after a rain. If the sun is shining, apply treatments late in the afternoon because direct sunlight or high temperatures (85°F or warmer) are detrimental to the survival of nodule bacteria. Getting the inoculant into the soil with rain or irrigation is essential.

Summary *(See Figure 1.)*

- Always inoculate legumes before planting.
- Always read label (for date and crop).
- Store inoculants in cool conditions.
- Know the definitions of inoculation terms.

Figure 1. Left: Inoculum applied to alfalfa with a wet sticking agent. Right: Inoculum applied to seed dry.

FORAGE MOISTURE TESTING

Methods to Estimate Forage Moisture

There are several methods and pieces of equipment available to estimate forage moisture. The electronic methods are quick but give more variable results than a microwave or forced-air heating unit such as the Koster Tester.

Electronic Testers

The most common problems with the electronic probes are related to

- the need for several probings per bale in order to get an average reading
- unreliable results because of varying density of the bale, small sample area, varying texture of the forage, and differences among species
- erroneous readings when power gets low on battery-operated testers
- undependable results when estimating moisture in windrow

To improve the reliability, make four to six readings per bale and insert probes into the uncut side of the bale at a 45° angle to horizontal.

Microwave

Procedure:

1. Obtain representative sample (whole plants) from swath, silo, or sward.

2. Cut into 1-inch pieces, keeping leaves and stems uniformly mixed.

3. Weigh a plate plus 100 grams of plant sample. It is best to spread sample as uniformly thin as possible. Put a paper towel between the sample and plate to minimize "sweat" from forming on the plate.

4. Put a 10- to 16-ounce covered glass of water in the corner of oven to capture unabsorbed microwaves as the plant tissue dries.

5. Set oven to HIGH for 5 minutes.

6. After 5 minutes weigh sample and plate and record weight of sample.

7. Change the water and put sample into oven for 2 more minutes. Weigh and record sample weight.

8. Repeat steps 6 and 7 until sample weight does not change more than 1 gram (this means sample is dry).

9. Percent moisture = 100 grams – dry weight grams.

10. Percent dry matter = the last dry weight of sample (assuming 100 grams starting wet).

11. With experience you can adjust the time periods and decide whether or not it is necessary to use the glass of water. Usually, the above method will give moisture content that is about 2% more than true sample moisture content.

12. For hay, this procedure takes 10 to 20 minutes, depending on initial moisture content of sample.

13. Silage samples take 15 to 25 minutes because of coarser particle sizes and grain content, which dry slower.

14. Practice this procedure several times before the day you really need it because it takes some experience to get the procedure fine-tuned.

The Grab Test *(Squeeze Test)*

The test may be used to show the moisture condition of crops standing in the field, lying in the swath or windrow, or chopped in the wagon. Pick up a handful of finely chopped crop and squeeze tightly (with all your strength) for 90 seconds. Release your grip and note the condition of the ball of crop in your hand. The condition of this ball and the dampness of your hand provide an estimate of the moisture content. Refer to the figures on page 144.

Determining Dry Matter Content of Forage

- **Definition**

The dry matter of a forage is what is left after all moisture has been lost. Dry matter is often referred to as DM.

$$\text{DM percentage} = \frac{\text{final dry weight (out of oven)}}{\text{initial fresh weight at cutting or sampling}} \times 100$$

■ Methods to Determine Dry Matter Content

Oven Drying

The only way to determine actual dry matter content is to weigh a sample and dry it in an oven (microwave or forced air) until it no longer contains any moisture. See procedure for microwave on the previous page. It is very important that accurate weights be taken before and after drying.

Natural Air Drying

This natural drying procedure will take several days depending on temperature and humidity of the drying location. Normally, the sample will reach about 84 to 88% dry when spread on a table or wagon in direct sunlight for two to four days. Hay, ready to bale, is about 80% dry.

Estimating by Looking and Feeling

This is a poor alternative to oven drying, but a good guess is often better than having no idea at all. Assume that no dew or raindrops are on the forage. Table 1 provides some estimates of dry matter percentage in forages at different growth stages.

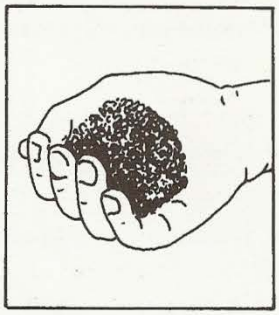
Table 1. Estimate of dry matter percentage in forages at different stages of growth.[1]

Dry matter range %	Description of forage
8 to 15	young, green, succulent (i.e., turnips tops, small grains, fescue, ryegrass, especially in seedling stages)
15 to 20	young, green leafy grasses in spring or when growth is rapid and succulent; ladino clover in mature stages; alfalfa in prebud
20 to 30	older, slightly brown, or slow-growing plants; headed cool-season grasses; bermudagrass actively growing; alfalfa in 10% bloom
40 to 50	growth that is more than 40% brown; stockpiled growth in winter and dormant grasses; may be stored in airtight silo.
70 to 80	plants that have been cut for storage; feels slightly damp or pliable, but too wet to bale
80 to 85	hay freshly baled; mold forms if stored below 80% DM
85 to 92	hay stored inside after several months; in samples that are air dried in cloth bags the leaves will break easily when crumbled or twisted

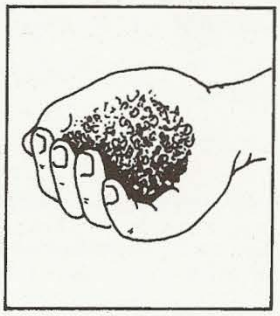
[1] This assumes that no dew or raindrops are on the forage.

The Grab Test

Liquid runs freely or shows between the fingers. The crop contains 75 to 85% moisture.



The ball holds its shape and the hand is moist. The crop contains 70 to 75% moisture.



The ball expands slowly and no dampness appears on the hand. The crop contains 60 to 70% moisture.

The ball springs out in the opening hand. The crop contains less than 60% moisture.

Appendix D

A CALENDAR OF TIMELY FORAGE MANAGEMENT PRACTICES

James T. Green, Jr. and J. Paul Mueller

JANUARY

- To get maximum use of stockpiled fescue, restrict the grazing area (electric cross fencing) so that four to six cows are grazing on an acre.
- If winter pasture is limited, feed hay in the pasture or allow cows to graze every other day. The priority for limited pasture is for (1) calves by creep grazing, (2) stockers, (3) nursing cows, and (4) dry cows.
- Winter annual pastures that were planted on a prepared seedbed may be severely damaged if animals trample on them during wet periods. Allow calves first priority to these high-quality annual pastures.
- Sample hay bales which are stored outside that will be fed during the next four to eight weeks.
- Decide which fields will be re-seeded or overseeded during late winter and early spring; obtain soil test and supplies for planting.
- Lime may be applied on sod during this "off season."
- Keep a record of winter weed problems (especially in alfalfa) so that control measures can be taken next fall. This is the latest month that some herbicides may be used on legumes.
- Determine animal feed requirements for the year (about 6 tons hay equivalent/cow-calf pair) and outline a 12-month forage production and use plan to meet the needs.

FEBRUARY

- Apply nitrogen to cool-season grasses to stimulate early spring growth.
- Overseed legumes (ladino, red, alfalfa) into well-grazed (2 inches or less), well-limed grass pastures.
- Remember to inoculate legume seeds.
- Lime fields that will be prepared for spring plantings.
- Divide pastures to improve the quality and persistence of pasture plants.
- Locate sources of hybrid bermudagrass sprigs for planting next month.
- Burn warm-season grass residues in late February or early March.
- Get herbicide sprayers ready to control weeds in dormant bermudagrass fields. It is also the last chance to control winter annuals in dormant alfalfa fields.

MARCH

- Apply nitrogen, phosphorus, and potassium to the cool-season grasses to increase spring production.
- Begin grazing of fall-planted fescue, orchardgrass, and clovers when growth reaches about 6 inches.
- Overseeding clovers (ladino, red, and alfalfa) into grass pastures should be completed early.
- Scatter manure droppings in pastures where hay was fed or where cattle congregated during the winter.
- Dig weed-free bermudagrass sprigs and plant them before growth begins. Consider using a herbicide.
- If pure stands of alfalfa are to be planted on prepared seedbeds during the spring, use a preemergence herbicide because weeds will be more troublesome than they are for autumn plantings.
- Control winter annual weeds in dormant bermudagrass with herbicides or by burning.
- Grass tetany may be a problem as rapid grass growth and cool, wet weather prevails.
- Check alfalfa plantings made last fall for nodules. If there are no nodules or they appear ineffective, consider "emergency" application of inoculant.

APRIL

- Fertilize cool-season grasses if you have not already done so.
- Watch for symptoms of grass tetany.
- Spray for alfalfa weevil according to recommendations.
- Winter annual pastures should be completely used before grazing begins on other pastures which may be harvested as hay.
- Harvest fescue and orchardgrass pastures or hay fields as soon as the seed heads begin to flower.
- Harvest alfalfa (second year stands or older) in the bud stage (before flowering begins).
- To maintain clover in grass pastures and maintain quality, develop a rotational grazing system in which cattle can graze forage to a 2-inch height before moving them to another pasture.
- Fertilize warm-season grasses (bermuda, bahia, dallis, switchgrass, flaccidgrass) as soon as dormancy breaks.
- Get all hybrid bermudagrass established this month unless irrigation is available. Seed bahia grass or switchgrass during mid-April or May in the piedmont.

MAY

- Plant warm-season perennial grasses such as switchgrass, flaccidgrass, common bermudagrass, gamagrass, and bluestem.
- Plant summer annuals at two-week intervals to stagger the forage availability.
- Fertilize warm-season grasses with nitrogen after each cutting or every four to six weeks on pastures.
- If irrigation is available, hybrid bermudagrass sprigs may be planted, but weed control will be essential.
- Spray pasture weeds while they are small (3 inches) for most effective control.
- Do not apply nitrogen to fescue or orchardgrass pastures after April until August.

JUNE

- Take soil samples from fields which will be overseeded or planted during the autumn. Apply limestone as far in advance of planting as possible.
- A late planting of summer annuals may be made to extend forage supply.
- To stimulate warm-season grass yields, apply nitrogen after each cutting or every four to six weeks.
- Graze bermudagrass close (1- to 2-inch stubble), and, every four to six weeks, harvest any growth that has not been grazed. Cross fencing is a practical tool to help manage feed quality.
- Control summer pasture weeds before they get too tall and mature.

JULY

- Stick to a four- to six-week schedule of nitrogen applications on summer grasses. Do not delay application because of dry weather unless it has not rained at all since the previous application.
- Maintain harvesting frequency for quality hay.
- Hot, dry weather can result in nitrate and prussic acid poisoning of animals grazing stunted, highly fertilized summer annuals.
- Sample soils and apply lime on fields to be planted in the autumn.
- If cool-season forages are to be planted in the fall on a prepared seedbed of old sods, it is time to get the land prepared so clods and root mass have time to settle before planting.
- Get silage harvesting equipment ready (sharpen knives, purchase plastic for covering silo) so there will be no delays when the crop is ready.
- Decide which fescue pastures will be stockpiled for winter grazing. Nitrogen (60 to 80 pounds/acre) should be applied August 1 in the mountains and between August 7 and September 1 elsewhere.

AUGUST

- Prepare good seedbeds and plant on time—especially alfalfa and other legumes.
- If legumes are to be sod-seeded into grass pastures in the autumn, plan the grazing program so those pastures can be grazed close (1 to 2 inches) by planting time.
- Use good-quality inoculant and good methods to obtain the best legume seedling development.
- Apply limestone to pastures with pH below 5.8 to be overseeded next spring.
- Start harvesting corn silage in the hard dent stage and when the dry matter is in the range of 35 to 40%.
- Fertilize warm-season grasses.
- Fertilize fescue and keep cattle off of the pastures to be stockpiled for winter grazing.

SEPTEMBER

- Fertilize and lime cool-season grasses.
- Plant cool-season legumes such as ladino, sod clover, and alfalfa into tall fescue sods. Use insecticide.
- Keep the grazing pressure on the summer grasses and completely use them before grazing cool-season forages.
- Watch for fall insects (armyworms, grasshoppers, crickets) on established and seedling stands of forages.
- Plant winter annuals on prepared seedbed for earliest fall grazing. No-till planting can be successful, but will not usually be ready to graze as soon after planting as on prepared seedbed.
- Overseed or no-till winter annual legumes or grasses onto summer perennial grass after they have been closely grazed. Planting early may require that herbicides be used to suppress the existing grass growth.
- Make a winter feed supply inventory so deficiencies can be avoided now (by purchasing hay or planting more winter pasture).

OCTOBER

- Finish using summer grasses before grazing the cool-season ones.
- Plant cool-season legumes such as ladino clover and alfalfa into tall fescue sods by October 20 (piedmont, coastal plains).
- Overseed warm-season grasses with winter annuals.
- Be wary of prussic acid poisoning in animals grazing sudan and sorghum-sudans after the first few frosts.
- Check alfalfa plantings made earlier this fall for proper nodule formation. If nodules have not developed on seedlings, an "emergency" application of inoculant can be successfully made in October, March, or April.
- Kill tall fescue or orchardgrass this month with herbicide on fields to be planted to alfalfa in the winter or switchgrass in April or May.
- Sample soils to be overseeded or planted next spring so the limestone can be applied early enough to react.

NOVEMBER

- To improve feeding efficiency, test forages before winter feeding begins.
- As winter feeding begins, separate the herd into lactating and dry cows so the best-quality pastures and hay can be fed to the cows with nursing calves.
- Do not graze fall-planted perennial pastures until growth reaches 6 to 8 inches.
- Winter annual pastures that were planted early (September) may be responsive to an additional application of nitrogen (30 to 50 pounds/acre).
- Weed control in fall plantings of alfalfa and other legumes should be completed between now and December or January depending on herbicide selection.

DECEMBER

- Limit the grazing of winter pastures by feeding hay on pasture or restricting acres available to animals.
- Feed hay stored outside before using hay that is stored inside.
- Map a monthly forage demand for specific classes of livestock. Total annual needs can be estimated if you remember that each cow requires 25 to 30 pounds of hay equivalent per day.
- Weed control should be completed on seedling legumes, especially for certain herbicides.
- If you plan to seed switchgrass in April or May, buy your seed this month and store at room temperature or slightly higher to break seed dormancy.

ESTIMATING PASTURE QUALITY AND EFFECT OF PLANT MATURITY ON QUALITY

Purpose

Producers should periodically monitor the quality of their pastures to make sure animals' nutrient requirements are being met and that fertilization practices are appropriate.

Visual Features to Characterize Quality

The characteristics listed below may be used by graziers to make decisions on changes in pasture quality. Combining the estimates based on these characteristics with data on yields, plant height, animal use, and forage testing will provide opportunity for making sound decisions on pasture use and animal performance. Keeping written records for each pasture can be useful in marketing and operation planning.

Species Composition

Legumes usually result in better animal performance than do grasses because of improved intake, digestibility, and crude protein. Estimates of botanical composition should be based on the amount of the mixture on a dry weight basis. Clovers usually "look more evident" than they actually appear on a dry weight basis.

Percent Leaves

Digestibility of leaves is much higher than flowering stems of most plants; however, there is little difference between petioles and leaves of ladino clover.

Age of Plants

Young leaves are more digestible than old ones, and animals eat more of them. Leaves more than three weeks old begin to deteriorate. (See Tables 1-7.)

Color of Plants

The growth rate and quality of pasture is closely related to the amount of green leaves present. The percent green estimate can be used to help predict availability and quality of forage. Bare ground and dead or brown plant tissue indicate low yields, poor growth rates, poor quality, and low intake.

It is often difficult to know exactly what green color is desired. Three broad categories may be useful:

- Emerald green indicates **high quality.**
- Yellowing indicates **declining quality.**
- Brown indicates **very low quality.**

How to Sample Pastures for Feed Testing

1. Use a clean plastic bag or brown grocery bag to hold the collected tissue. Be sure there are no contaminants in the bag, on your hands, or on the collected tissue.

2. Walk the pasture much the same way you would for soil sampling or scouting for insects. Take a sample of grazeable vegetation by plucking or grabbing a few leaves between the thumb and index and middle finger. Snap the leaves at the same height as the animals are grazing, especially if you want to know what is being consumed at the time.

3. Collect at least a pound of wet plant tissue; with slight packing this will fill a 1-gallon plastic bag. Press the air out of the bag and send to a testing laboratory by **overnight mail.** The sample will spoil if it remains in the mail more than one to two days. Air drying the sample will reduce damage caused by extended mail delivery.

Table 1. Effect of stage of harvest of tall fescue hay on quality, daily dry matter intake per animal, and daily animal gain.[1]

Stage and date of harvest	Protein (%)	Daily dry matter intake per animal (lb)	Digestibility (%)	Hay per acre, 1st cutting (lb)	Average daily gain per animal (lb)
Late boot to head, May 3	13.8	13.0	68	1,334	1.39
Early bloom stage, 10% shedding pollen, May 14	10.2	11.7	66	1,838	0.97
Early milk stage, seed forming, May 25	7.6	8.6	56	2,823	0.42

[1]Fescue hay area was grazed until March 22 when 50 pounds of nitrogen were applied. Holstein heifers weighing 500 pounds were used in the experiment and were fed salt and water plus hay. Source: Personal correspondence with Monty Montgomery. Research conducted by Monty Montgomery, Bob Bearden, and Karl Barth, University of Tennessee. From Southern Regional Beef Cow-Calf Handbook.

Table 2. Effect of stage of harvest of orchardgrass on protein and average daily gain of dairy heifers.

Stage of harvest	Protein (%)	Average daily gain per animal (lb)
Boot	18	2.0
Full head	12	1.4
Milk	9	0.4

Fed to 500-lb dairy (Holstein) heifers.
Source: Monty Montgomery, University of Tennessee, Animal Science Department (Dairy). Data presented by Joe Burns, University of Tennessee at American Forage and Grassland Council annual meeting.

Table 3. The effect of cutting intervals on the daily dry matter intake per animal, digestibility, and daily gain per animal on Coastal bermuda hay.

Cutting Interval	Daily dry matter intake per animal (lb)	Percent digestibility (%)	Average daily gain per animal (lb)
4 weeks	11.8	55	1.2
8 weeks	9.3	53	0.9
13 weeks	9.5	45	0.0

Source: M. E. McCullough and Glenn W. Burton, Georgia Ag. Research, Volume 4.

Table 4. Average protein content of sorghum-sudangrass hybrid with age and stage of maturity.

Stage and date of growth	Age (days)	Height (inches)	Crude protein (%)
Pre-boot — June 24	40	27	20
Early-boot — July 3	50	53	12
Medium-head —July 13	60	70	8
Full head — July 18	65	73	7

Source: Tennessee Farm and Home Science, "Summer Annuals for Hay and Silage," by Monty Montgomery, Bob Bearden, and Jack Plummer. Data presented by Joe Burns, University of Tennessee, at American Forage and Grassland Council annual meeting.

Table 5. Influence of stage of growth of alfalfa on daily dry matter intake per animal, percent digestibility, and animal performance.

Stage of growth	Daily dry matter intake per animal (lb)	Digestibility (%)	Daily milk per animal (lb)
Early bloom	28	67	43
Late bloom	22	51	31

Source: Certified Alfalfa: the Profit Factor in Livestock Farming, University of Minnesota Extension Pamphlet 203 (revised).

Table 6. Influence of stage of growth of alfalfa on intake, percent digestibility, and animal performance.

Quality of hay	Daily dry matter intake per animal (lb)	Digestibility (%)	Crude protein (%)	Average daily gain per animal (lb)
Poor	11.6	44.9	13.7	– 0.06
Fair to good	17.1	56.5	18.7	1.85

Source: Personal communication with Joe C. Burns, University of Tennessee.

Table 7. Estimates of quality.

	IVDMD[1]	Crude Protein (%)	Dry Matter
Alfalfa			
Vegetative (early spring)	75-80	25-30	15-20
Early bud (top 1/2 of canopy)	70-75	20-25	20-25
Early bud (bottom 1/2 of canopy)	60-65	16-20	25-30
10% bloom (top 1/2 of canopy)	68-72	18-22	25-30
10% bloom (bottom 1/2 of canopy)	55-60	14-18	30-35
Bermudagrass			
Vegetative (<4" tall and 14 days of age)	56-60	15-18	15-20
Vegetative (6-10" and 14-21 days of age)	52-58	12-16	20-25
Vegetative (10-15" and 21-28 days of age)	50-54	11-14	25-30
Mature (4-6 weeks)	46-50	8-10	30-35
Mature (8-12 weeks)	40-45	5-7	30-35
Caucasian bluestem			
Vegetative (6-8")	76+	15-17	18-22
Vegetative (8-12")	70-74	12-14	23-25
Heading	65-69	10-12	29-33

[1]These values are estimates of forage quality at stage of growth indicated if machine harvested. Under grazing conditions, animals will selectively graze more leaves, and forage eaten will be somewhat higher in In Vitro Dry Matter Digestibility (IVDMD) than shown.

Table 7. Estimates of quality *(continued).*

	IVDMD[1]	Crude Protein (%)	Dry Matter
Fescue/orchardgrass/ryegrass			
Vegetative stage (10-21 days of age)	70+	17-22	15-20
Vegetative (21-35 days of age)	60-70	13-18	20-25
Vegetative (fall stockpiled)	65-70	12-15	20-25
Boot	60-65	13-15	20-25
Heading	55-60	10-12	20-25
Flowering	50-55	8-10	25-30
Seeds Forming	45-50	6-8	25-30
Flaccidgrass			
Vegetative (12-18")	76+	16-18	16-20
Vegetative (25-35")	69-73	14-16	22-25
Boot stage	59-63	12-14	26-30
Heading	52-56	9-12	32-38
Gamagrass			
Vegetative (12-18")	72+	16-18	18-22
Vegetative (25-35")	65-70	12-15	25-28
Heading	52-56	8-12	30-35
Small grain			
Vegetative (4-8" tall)	75+	18-25	10-15
Vegetative regrowth (4-8" tall)	70-75	16-22	10-15
Stem elongation (8-12")	68-72	14-20	12-18
Boot stage	63-68	12-18	20-26
Switchgrass			
Vegetative (12-20")	74+	15-17	18-22
Vegetative (25-35")	62-68	10-13	24-27
Boot stage	56-60	6-8	28-32
Heading	43-49	3-5	34-40
Flowering	39-42	3-4	42-45
Seed set	32-37	3-4	45-48

[1]These values are estimates of forage quality at stage of growth indicated if machine harvested. Under grazing conditions, animals will selectively graze more leaves, and forage eaten will be somewhat higher in In Vitro Dry Matter Digestibility (IVDMD) than shown.

"RAGDOLL" TEST FOR SEED GERMINATION

It is often important to determine the potential germination of seeds that have been held over from previous years. In the case of switchgrass, one needs to get an idea about how many seeds may be dormant. It is always best to send a sample of seed to the NCDA Seed Testing Lab; however, a fairly simple procedure can be conducted at home to get some indication of germination. Seeds that will not germinate in an ideal environment like that of a "ragdoll" most likely will not germinate in a field situation.

Properly used, the ragdoll test is very valuable. Following are some suggestions to help you obtain the most reliable results.

- Use a firm paper towel such as a brown hand towel or equivalent. The soft, very absorbent paper towels often used in a kitchen make poor ragdolls because they allow roots and shoots to penetrate into the fiber, making seedlings difficult to remove during counting. If no other type of towel is available, the soft towels can be used, but it is best to use two layers. These towels often hold too much water which drowns the seeds.

- Wet the towel and allow free water to drip off for a minute. Lay the wet towel flat and add seeds.

- Count out 100 seeds (50 for larger seeds like corn, peanuts, and soybeans) and place them on one half the towel. Fold the towel in half and roll it into a moderately tight tube. Rolling it around a pencil works well. Place the tube in a jar or sealable plastic bag.

- Position the ragdoll so the tube is upright. Doing this causes roots to grow down and shoots to grow up so that seedlings are more easily removed during counting. The ragdoll should be kept in a warm place (between 75 and 85°F). A little water in the bottom of the jar or plastic bag will insure adequate moisture.

- Make the first germination count for most crops in about three days. Open the towel and count the seedlings as you remove them. After another three to four days make another count. If you had 100 seeds, the number of seedlings removed equals the percentage germination.

- You can distinguish hard or firm (dormant) seeds from dead seeds by pushing down on each nongerminated seed with the flat part of a pencil eraser. If the seed does not flatten with gentle pressure, it is considered hard. Dead seed will usually be moldy at the end of the test.

- You can test your procedures using viable alfalfa or clover seed that you know has good germination. Those seedlings should look normal in a ragdoll test if the ragdoll procedures are favorable.

Source: Dale Wolf and Dave Parrish, Research Agronomists, Virginia Polytechnic Institute and State University, Blacksburg.

DETERMINING THE AMOUNT OF GRAZEABLE FEED AVAILABLE IN A PASTURE

Livestock and dairy farmers can easily determine how much hay or silage is on hand at any time; however, determining the amount of feed that can be grazed from a pasture is not as simple. It is just as important to know how much feed is available in a pasture as it is to know how much is stored.

Meeting the daily feed requirements of animals depends upon knowing how the availability, dry matter content, and quality of forage influence animal consumption and performance. Regardless of the method used, it is necessary for a manager to be able to visually relate availability and quality of the growing forage to animal performance. See Appendix E for instructions on how to estimate quality and dry matter content. Experience and "eyeball assessment" will be satisfactory for making most decisions. For more exact estimates of seasonal production see Tables 1 and 2.

There are four basic ways to estimate the amount of feed in a pasture:

1. Cut, weigh, and dry (Cut-Weigh-Dry)
2. Eye estimates based on height and density of canopy (Eyeball)
3. Rising plate (Plate)
4. Electronic probe (Probe)

The Cut-Weigh-Dry method is the best way to determine exactly how much forage is in an area, but it requires a lot of samples and many hours of work. The other methods are calibrated based on cutting, weighing, and drying of samples from a known land area. For these reasons, the other methods are often the most practical.

The following are assumptions understood about pasture availability estimates:

- Refer to all the above-ground plant tissue growing in a pasture.
- Usually expressed on a dry weight basis per acre.
- Include both dead (brown) and live (green) plant tissue (except the Probe Method, which estimates green tissue only).
- Brown plant tissue is very poor in quality compared to green forage.
- Available forage is often referred to as yield, farm cover, or herbage mass.

Methods to Estimate Available Forage

Cut-Weigh-Dry Method

- Drop a square frame (18 inches x 18 inches, which is 2.25 square feet) onto an area of ground that is representative of the average forage supply.
- Clip all of the forage inside the frame to ground level. An alternative is to clip to the same stubble height to which the animals will graze.
- Exclude roots, litter, and debris from the sample. Collect only forage.
- Repeat this process several times throughout the pasture.
- Weigh the paper or cloth bag in which you place the forage samples. This way the weight of the bag can be subtracted to determine the weight of only the forage.
- Place the forage in the bag in preparation for drying.
- Dry the sample in an oven or dryer to obtain the sample's dry weight. If it is impossible to dry the sample, use the estimates for dry matter presented in the table at the end of Appendix C.
- Pounds of available forage per acre to the height of cut = Dry sample weight x (43,560 square feet/2.25 square feet).

Eyeball Method

- The height of a pasture is easy to measure. When the pasture is relatively dense (greater than 95% soil coverage), an estimate of available forage can be made by measuring or estimating height of the

canopy. Because of differences in plant characteristics, available forage per inch of height is not the same for all crops or for all stages of growth within a crop type.

■ Both height and density of pasture are important when assessing pasture yields. Some very rough rules of thumb relating yield to height of canopy (assuming a reasonable degree of density) are provided in Table 1.

Table 1. Yield estimates for three pasture types of various heights.

Species	Pasture canopy height (inches)			
	2	4	6	8
	DM yield lb/a			
Fescue-clover	700	1,500	2,000	2,400
Hybrid Bermuda	1,000	2,000	2,500	3,000
Rye (small grain)	300	700	1,300	1,700

Rising Plate

This is a simple round or square plate that covers approximately 2.4 square feet and weighs about 2.5 pounds. The plate is dropped or placed onto the canopy, and the distance between the ground and the height at which the plate settles is recorded. This is called bulk height, which is a measure of height and density of the vegetation. This bulk height can be related to yield of total dry matter per acre by comparing it to Cut-Weigh-Dry samples. It is necessary to take several readings (40 to 50) per paddock in order to get an average bulk height. This height is then related to calibrated dry matter per inch of bulk height.

Example: Walk over a paddock taking 50 plate readings of bulk height. The average is 6 inches. Then select approximately three sites in the paddock that resemble the average height and density of the paddock. Place a frame on the areas, take bulk height readings and clip the forage inside the frame to the grazing height or to ground level. Weigh the clippings and dry them if possible to get dry weight. Compute the yield from the frame in pounds per acre. Use the following formula to estimate the forage.

Formula: Avg plate reading in paddock / Avg plate reading in frame x yield within frame = estimated yield for the paddock.

Pasture Probe

There are electronic instruments that can predict the amount of green tissue dry matter in a pasture canopy. Some probes can be programmed to keep records of available forage in several pastures over several measuring dates. Accuracy depends on the number of samples taken, the kind of forage, percentage of dead tissue, the ground cover, and dry matter percentage.

Advantages of such probes include instantaneous estimates of dry weight, estimates of green tissue on offer, multiple paddock record keeping, growth in a particular paddock since the last measurements were made, and the ability to dump the data to a computer for quick summarization. The probe is used to make many (50 to 100) readings within the paddock, providing a "running" average for the paddock.

Frames to Aid in Making Pasture Estimates

A frame with a known area (such as 18 inches x 18 inches square) is necessary to make Cut-Weigh-Dry estimates of the amount of forage per acre, but it can be helpful in making eyeball estimates also. The frame gives a consistent area from which to make estimates of such things as height, density of vegetation, and percent green tissue. The frame can be made from any material that is easy to handle; wood (¾ inch x 2 inches), metal rods ($^3/_{16}$ inch in diameter) or ½-inch PVC pipe will work well.

Table 2. Daily dry matter growth rate.[1]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual (total)
	lbs/acre/day												
Alfalfa	0	0	27	40	53	40	27	40	27	8	5	0	8,000
Bahiagrass 200N	0	0	0	4	7	39	46	39	29	17	4	0	5,500
Bermuda–Hyb 100N	0	0	0	16	20	30	50	40	30	10	4	0	6,000
Bermuda–Hyb 200N	0	0	0	24	30	45	75	60	45	15	6	0	9,000
Bermuda–Com 200N	0	0	0	19	29	36	60	48	29	19	0	0	7,200
Bermuda + Rye 250N	7	18	37	51	22	29	62	55	33	18	22	11	11,000
Bermuda + Ryegrass 250N	4	8	35	38	54	46	65	58	31	19	19	8	11,500
Bermuda+Rye and Ryegrass 250N	8	16	32	48	44	40	68	60	32	20	20	12	12,000
Bluegrass + White clover	0	1	13	20	33	27	13	5	8	9	3	0	4,000
Dallis/Lespedeza	0	0	0	0	12	30	45	38	23	3	0	0	4,500
Fescue 100N	3	10	24	35	26	10	3	5	12	26	14	3	5,200
Fescue 200N	5	15	35	50	38	15	5	8	18	38	20	5	7,500
Fescue–Stockpiled 200N	5	12	35	47	35	14	5	7	19	37	14	5	7,000
Kudzu	0	0	0	4	18	29	29	18	12	8	0	0	3,500
Ladino/Fescue	4	7	22	54	43	17	9	9	17	22	9	4	6,500
Ladino/Orchardgrass	2	4	24	50	40	20	12	12	14	16	4	2	6,000
Lespedeza, Annual	0	0	0	0	4	14	41	35	21	2	0	0	3,500
Orchardgrass 200N	4	10	28	40	38	16	8	10	14	20	8	4	6,000
Pearlmillet 150N	0	0	0	0	18	50	75	63	38	8	0	0	7,500
Red clover/Grass	2	5	23	58	47	28	14	14	16	19	5	2	7,000
Ryegrass, Ann. 150N	7	16	30	42	56	47	12	0	0	7	9	7	7,000
Smallgrain 100N	6	15	23	34	29	5	0	0	5	12	17	8	4,600
Sorghum-Sudan 150N	0	0	0	0	19	53	80	67	40	8	0	0	8,000
Sericea	0	0	0	8	23	45	38	23	15	0	0	0	4,500
Switchgrass 140N	0	0	5	14	35	47	55	46	24	7	0	0	7,125

[1] Estimates made by J. T. Green, J. P. Mueller, and D. S. Chamblee. Use these very carefully in planning forage supply.

Summary Rules of Thumb

■ Cows generally eat 1.5 to 3.3% of their body weight in forage per day, depending on the digestibility and availability of forage.

Stocker animals should be encouraged to consume > 3% of body weight per day to maximize gain; this is about 15 pounds dry matter (DM) for a 500-pound animal.

■ On a year-round basis it takes about 4.5 tons DM to feed a cow-calf pair.

■ The average yield per acre for pasture or hay is about 2.5 to 4 tons DM; therefore, it takes 1.25 to 2 acres to produce the annual feed requirements for a cow-calf pair for 12 months.

- When determining the stocking rate for the farm always include hay being brought onto the farm from other acres. In other words, consider all acres being used to produce the hay or grazing for the herd. Many people only count the pasture being grazed when determining stocking rate, but they have to consider the other land producing hay or silage.

- Use of what is grown may range from 40 to 85% depending on the grazing and harvesting management. Many farms waste 30% of what is grown in spring and overuse plants during stress, which reduces potential production.

- On most farms consider growing 20 to 35% of the forage acreage in warm-season grasses as a way to even out the monthly production of feed.

- Some common conversions:
  a. To convert TDN to DM, divide by %TDN
  b. To convert DM to hay equivalent, divide by 0.85 (Assumes hay is 85% DM)
  c. To convert DM to pasture equivalent, divide by 0.22 (Assumes pasture is 22% DM)
  d. To convert DM to silage, divide by 0.34 (Assumes silage is 34% DM)

Example: Assuming that forage is 65% TDN then
  a. 16 pounds TDN = 24.6 pounds DM
  b. or 28.9 pounds hay equivalent
  c. or 112 pounds pasture equivalent
  d. or 72 pounds silage equivalent

- Remember: All of the planning and calculating in the world will not mean a thing if managers cannot control the animals or if they do not exercise good judgment in matching changing forage quality to changing animal needs.

MISCELLANEOUS UNITS OF MEASURE AND CONVERSION FACTORS

Weight/Volume Equivalents of Water

1 gallon = 8.34 pounds

1 cubic foot = 7.48 gallons = 62.4 pounds

1 acre inch = 1 inch of water on 1 acre of land = 27,154 gallons

1 cubic centimeter (cc) = 1 gram (g)

1 fluid ounce = 29.57 cubic centimeters (cc)

Area

Diameter of a circle x 3.1416 = circumference

Square of the radius of a circle by 3.1416 = area

Base of triangle x half the altitude = area

1 acre = 43,560 square feet

Liquid Measure

3 teaspoons = 1 tablespoon = 14.8 cc

2 tablespoons = 1 fluid ounce

8 fluid ounces = 1 cup

2 cups = 1 pint

2 pints = 1 quart

4 quarts = 1 gallon

1 liter = 1000 cubic centimeters (cc)

Dry Measure

1 ounce = 28.35 grams

16 ounces = 1 pound

1 pound = 453.6 grams

27 cubic feet = 1 cubic yard

1 bushel = 1.2445 cubic feet

Going Metric

1 square meter = 10.76 square feet

1 hectare = 2.47 acres

1000 grams = 1 kilogram = 2.2 pounds

Temperature Conversion

$°F = (^9/_5\ °C) + 32$

$°C = {}^5/_9 \times (°F - 32)$

To convert column 1 into column 2, multiply by:	Column 1	Column 2	To convert column 2 into column 1, multiply by:
	Length		
1.094	meter	yard	0.914
0.394	centimeter	inch	2.54
	Area		
2.471	hectare	acre	0.405
	Volume		
1.057	liter	quart (liquid)	0.946
	Mass		
2.205	kilogram	pound	0.454
	Yield or rate		
0.892	kg/hectare	pounds/acre	1.121

Appendix I

STANDARD LIVESTOCK UNIT

An animal unit (AU) is considered one mature nonlactating cow weighing 1,100 pounds and fed at maintenance level. An animal unit consumes approximately 17.6 pounds of dry matter per day. For consumption of 17.6 pounds of dry matter to result only in maintenance, the feed consumed would have a digestibility of about 57% (10.0 pounds of total digestible nutrients).

Assuming that one AU has a dry matter intake rate of 17.6 pounds per day, any animal may be represented as a certain fraction or multiple of the AU, based solely on its rate of forage intake per day. An animal that has a forage intake rate different from the 17.6 pounds per day will have an AU equivalent that is proportional to one AU.

To determine how many animals can be compared to one AU, review the table below.

Animal weight (pounds)	Animal unit	Number of animals per AU
Sheep and Goats		
22	.038	26.3
44	.063	15.9
66	.086	11.6
88	.106	9.4
110	.126	7.9
132	.145	6.9
154	.163	6.1
Cattle and Horses		
220	.3	3.3
440	.5	2
660	.68	1.5
880	.84	1.2
1,100	**1**	**1**
1,320	1.15	.9
1,540	1.29	.8

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[1] This is an annual publicaton, therefore the publication date and number change each year.

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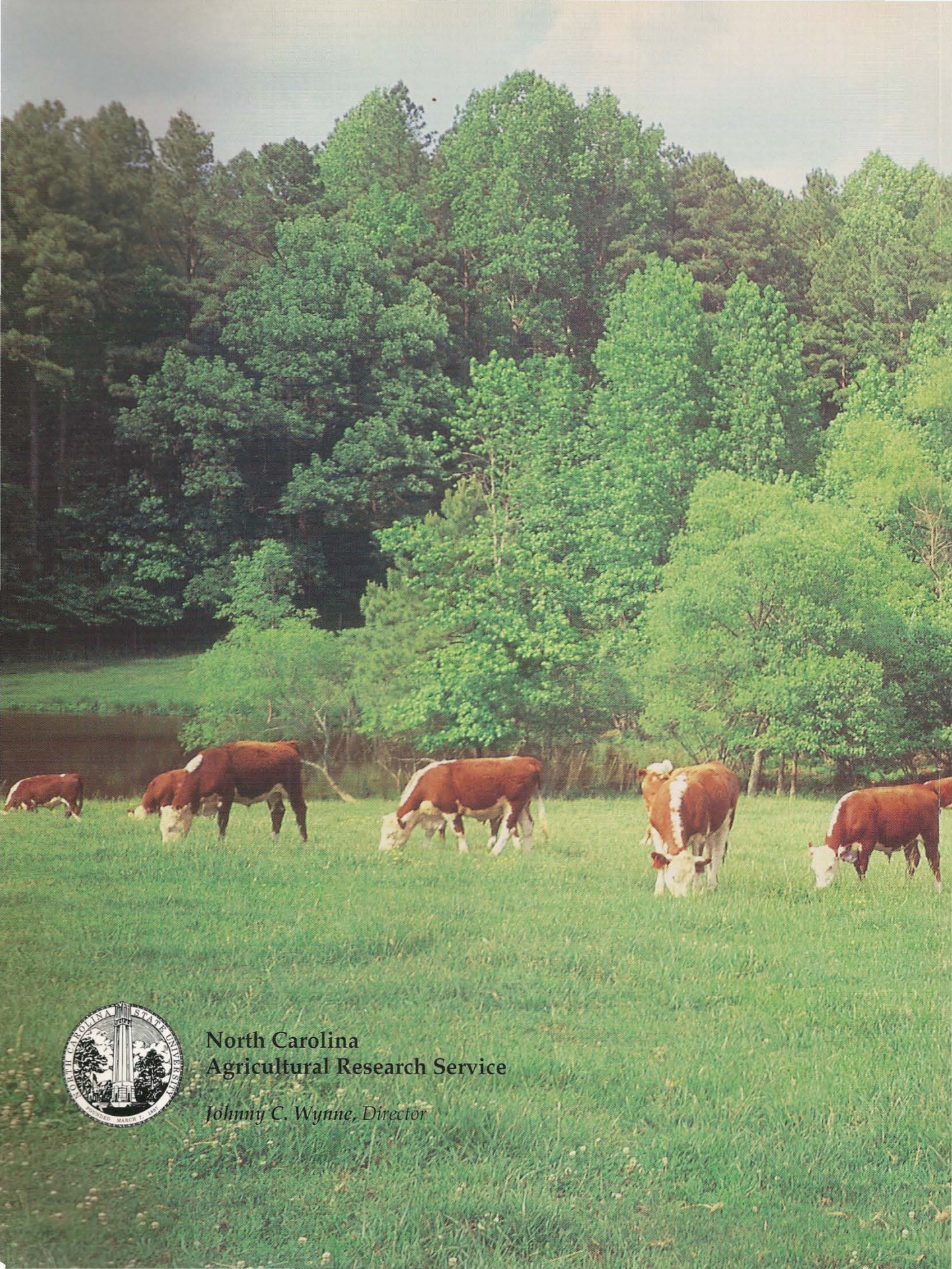

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