Bermudagrass Production in North Carolina

Photo courtesy of Lynn Stillwell

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Introduction to Bermudagrass Production

Bermudagrass (*Cynodon dactylon*) is a warm-season perennial grass that was first introduced in the United States in the early 1700s. Over the years, the acreage of bermudagrass has increased in North Carolina. Unlike fescue, bermudagrass grows well in sandier soil types and can tolerate high temperatures. It is popular because of its ability to take up large amounts of nitrogen applied in the form of animal or municipal waste, high nitrogen use efficiency, and high summer yields.

Bermudagrass is grown for both hay and pasture farming systems. In North Carolina, swine producers typically allocate 75 to 100 percent of their sprayfields for bermudagrass production for use as hay or pasture. For a 10- to 12-month grazing program, annual ryegrass or winter annuals such as rye, oats, wheat, or triticale can be incorporated as a winter overseed. Using a winter overseed reduces forage shortage and allows animal or municipal waste to be applied during the fall and winter months. The seasonal production of cool- and warm-season plants is shown in Figure 1; their growth characteristics can be used to determine a year-round grazing program.

Grass Selection and Characteristics

Varieties of bermudagrass can be classified into three categories: common seeded, improved seeded, or sprigged hybrids. Although there are many varieties of bermudagrass suitable for the southern United States, sprigged hybrid varieties including Coastal, Tifton 44, Tifton 85, Midland 99, and Ozark are of major importance to North Carolina forage growers. Figure 2 shows the areas where different hybrid varieties are recommended. Improved seeded varieties have become important in recent years in North Carolina as well. Some of these include Cheyenne, Cheyenne II, Wrangler, CD90160, Mohawk, Ranchero Frio, and Laredo. Some varieties are blended to provide many characteristics. Common bermudagrass, or "wiregrass," is the old standard that is still used in situations but is low yielding and usually of lower quality compared to the improved seeded or hybrid varieties.

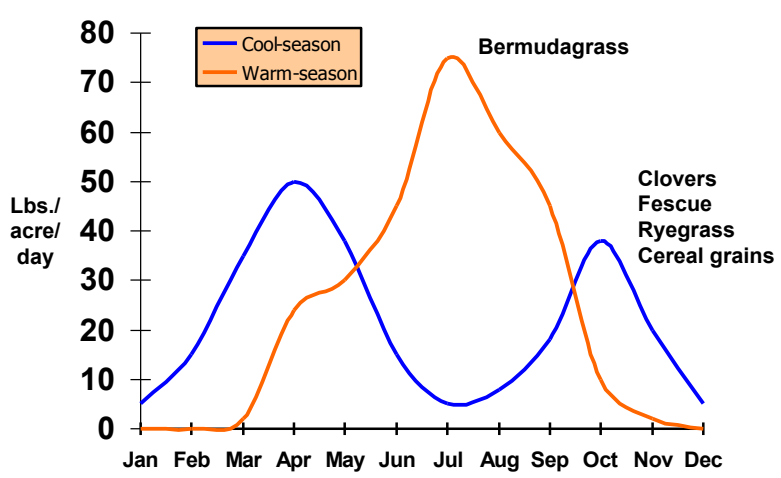

Figure 1. Seasonal Distribution of Growth for Cool- and Warm-Season Plants.

Hybrid Sprigged Varieties

Coastal bermudagrass is a hybrid between an old "cotton patch" common strain found near Tifton, Georgia, and a variety introduced from South Africa. Its stems, stolons, and rhizomes are larger and its internodes are longer than those of common bermudagrass. In addition, the light-green Coastal bermudagrass leaves are more sharply angled to the stem. Coastal bermudagrass produces fewer seed heads than common bermudagrass, and the seeds are sterile. In sandy soils, Coastal bermudagrass roots extend as deep as eight feet. When well fertilized, Coastal has nearly three times as many roots below the four-foot level as common bermudagrass, making it more productive and drought tolerant. Coastal bermudagrass is resistant to the root-knot nematode, which will die if it penetrates Coastal roots.

Tifton 44 is a hybrid between Coastal bermudagrass and a winter-hardy bermudagrass from Berlin, Germany. Compared to Coastal, Tifton 44 has finer stems, is darker green, and has a more vigorous rhizome and root system, thereby forming a denser sod. On heavy clay soils, Tifton 44 does not spread as rapidly as Coastal or the other hybrids. Even though it produces fewer seed heads, Tifton 44 is often confused with common bermudagrass because of its fine stems and leaves. During short dry periods, Tifton 44 rapidly produces seed heads. It also recovers from drought much more slowly than Coastal. Tifton 44 usually begins growing 7 to 14 days earlier than Coastal. Research from the University of Georgia indicated that Tifton 44 is about 5 percent more digestible than Coastal and averages about 19 percent better daily beef gains.

Tifton 85 was released to certified growers in 1992. Tifton 85 is a cross between PI 290884 from South Africa and Tifton 68. Compared to Coastal and Tifton 44 varieties, Tifton 85 is taller, has larger stems and wider leaves, and is darker green. It is of better quality than Coastal but has a lower tolerance to cold than Coastal and Tifton 44. Tifton 85 has large rhizomes and can be established from sprigs or from top growth. Research from Oklahoma State University shows Tifton 85 tolerates temperatures as low as 22° F, whereas Coastal tolerated temperatures as low as 19° F in the same study.

Midland 99 was released by the Oklahoma, Kansas, Arkansas, and Missouri Agricultural Experiment Stations, the Samuel Roberts Noble Foundation, and the USDA-ARS in 1999. It is tolerant of heavy grazing, low pH soils, and winter stress. Midland is a hybrid cross between Coastal and a winter-hardy variety. Yields are similar to or greater than Tifton 44. Crude protein content is comparable to Coastal and Tifton 44. Midland 99 produces seed heads later than most bermudagrass varieties. Midland 99 is tall and leafy and is slightly more winter-hardy than Tifton 44.

Ozark was released in 2002 and is best adapted to sandy loam soils. Adapted well to cold, it is often recommended for the northern half of the bermudagrass belt, but it can be grown anywhere in N.C. Yields for Ozark are similar to those of Tifton 44. The forage quality of Ozark is similar to or better than other high-yielding bermudagrass varieties. Relatively tall with an upright growth pattern, Ozark has longer leaves compared to Tifton 44.

Improved Seeded Varieties

Cheyenne has a forage quality similar to Coastal, has exceptionally good persistence, is winter-hardy, and is quick to establish. Cheyenne has not been a good seed producer and availability has been limited. Cheyenne II was released from improved selections of Cheyenne. It has been shown to match the yield and persistence of Cheyenne in initial evaluations. Cheyenne II is now being sold and used in seed blends such as Ranchero Frio.

Wrangler was developed from a germplasm at Oklahoma State. Wrangler has good cold hardiness and has good cover during the establishment year. Based on Georgia and North Carolina trials, Wrangler is not recommended in sandy sites of the coastal plains. CD90160 is used in seed blends due to its yield potential, winter hardiness, and persistence. Mohawk was developed from a turfgrass variety to provide high-quality bermudagrass with cold tolerance. Mohawk shows cold tolerance in trials in Virginia. There are also many blends available - Ranchero Frio and Laredo are two blends available in our area. Evaluate the blend to make sure it is recommended for your area. Recommendations are to purchase a blend that contains no more than 25 percent Giant and no common bermudagrass. Ranchero Frio is a blend of different varieties that may include Cheyenne, Cheyenne II, Mohawk, and Giant. Laredo is a blend of different varieties.

Common

Common or "wiregrass" bermudagrass is related to the hybrid varieties and they share the same scientific name [*Cynodon dactylon* (L) Pers. Var. dactylon]. However, common bermudagrass produces many viable seeds, whereas hybrids, even though they make seed heads, are sterile and must be established vegetatively from rhizomes, stolons, or mature stems. In North Carolina, there are many ecotypes of common bermudagrass, often called "wiregrass." Common bermudagrass grows low, forming a dense sod with very short internodes; it spreads profusely by rhizomes, stolons, and seeds. During late summer, it often suffers from severe leaf disease. During drought stress, it produces many short seed heads.

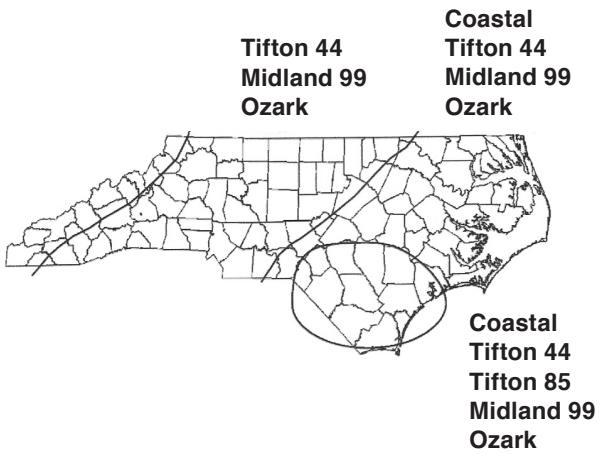

Figure 2. Adaptation of bermudagrass cultivars and types to North Carolina.

Giant

Giant bermudagrass is technically different from common and hybrid varieties because it has a different chromosome number and name (*Cynodon dacty lon* var. *Aridus* Harlan et de Wet). Practically speaking, however, Giant is similar to common bermudagrass because it produces viable seeds from which it can be established. It is often sold in mixtures with common bermudagrass or with improved varieties. Giant bermudagrass is not as winter hardy as common bermudagrass and Tifton 44 but probably offers the same feed quality as common bermudagrass. The first three years after planting, yields of mixtures containing Giant may be similar to some of the hybrids, but because Giant bermudagrass frequently declines over winter, yields may eventually resemble those of common bermudagrass.

Adaptation

As long as internal soil drainage is good, bermudagrasses will grow well in a variety of soil types, including sands, loams, silts, and clays. Bermudagrass is adapted to a wide range of soil conditions but is best suited to a well-drained site. Plants may survive in poorly drained soils, but production potential is limited. It is not adapted to wet areas. Bermudagrass grows best at high temperatures (85°F to 95°F) and grows very little when the night temperature falls below 60°F. Therefore, bermudagrass

varieties are most practical in the piedmont and coastal plain regions of North Carolina. Bermudagrass is not tolerant to shading but is drought tolerant, although production and yield decreases during drought conditions. Bermudagrass grows best when soil pH is 5.5 and higher, the ideal range from 5.8 to 6.0. The hybrid varieties, which vary in their winter-hardiness, are often recommended for soils too sandy to realistically produce high yields of row crops or to be productive with clover-fescue mixtures. Figure 2 illustrates the general area of adaptation in North Carolina. Site selection is important to optimize production potential and stand life.

Uses

Bermudagrass can be used for grazing, hay, silage, and baleage/haylage. It also can be used as a receiver crop for wastes from confinement animal operations, processing plants, and municipalities because the extensive root system takes up large amounts of nutrients.

Grazing

Bermudagrass is well adapted to close, frequent defoliation because of its low-growing, creeping growth pattern. During the active growing season, pastures often regrow rapidly enough to regraze at 10- to 21-day intervals. For good animal performance, bermudagrass must be kept short (2-4 inches) and leafy. Because bermudagrass tolerates a wide range of conditions and management, it is often planted in small pastures used by free-roaming grazing animals, such as pleasure horses. Bermudagrass, especially the common types, can withstand severe grazing pressure and trampling. However, many of the common types will become very low growing due to the grazing pressure and may become difficult for livestock to utilize. Under more controlled management, hybrid varieties will likely give the highest production.

Hay

Hybrid bermudagrasses can produce high yields in response to high fertilizer or manure application rates. Bermudagrass hay cures quickly and, with proper fertilization and harvesting schedules, can produce satisfactory feed quality for many classes of animals. It is critical to control the maturity of hay. Research has determined that bermudagrass should be harvested at intervals of four to five weeks for the best compromise between yield and quality. As the plant matures, the crude protein and total digestible nutrients decrease in the hay and may need supplementation.

Silage

For good silage, manage bermudagrass as you would hay and cut at four to six weeks of growth. Chop as short as possible and pack the forage tightly in the silo. Aim for a target dry matter of 35 percent. You may or may not need to let the bermudagrass wilt. Fresh Coastal bermudagrass usually contains 65 to 75 percent moisture when cut at four to six weeks of age. For low-moisture silage, wilt the bermudagrass to 50 percent moisture and store it in a reasonably airtight structure (for example, a tightly packed trench silo sealed with plastic, a sealed plastic bag, capable of storing 100 tons or more of silage or a covered, sealed tower silo).

Baleage/Haylage

Baleage, also referred to as haylage, is baled forage that is baled at a higher moisture content than traditional hay and wrapped in an airtight cover. Baleage is similar to silage. To make baleage, follow the same harvesting window as you would for hay, every four to six weeks. The bermudagrass should be baled between 40 and 60 percent moisture, with the target being 50 percent. Baling at the proper moisture is key to good baleage. Too much moisture results in low forage quality. Too little moisture will reduce fermentation and increase mold production.

The bales are then wrapped in plastic. Bales can be wrapped individually, in a row, or placed in specially designed plastic tubes. Whichever method is chosen, the key is to provide an airtight environment. Any punctures or tears in the plastic should be repaired as soon as possible as the exposure to air will cause mold growth and forage loss. Store bales in a shady location to reduce temperature fluctuations that can degrade the plastic wrap. Maintain adequate weed control around the bale storage to control any animals that might chew into the bales.

Soil Sampling

Taking soil samples is the only way to make sure the correct amount of fertilizer is being applied to pastures and hayfields. Benefits of soil testing include: taking advantage of nutrients already in the soil, identifying nutrients that are lacking in the soil, providing a proper balance of plant nutrients, obtaining proper soil pH for optimum plant performance, saving money by applying only the nutrients and lime needed, and reducing chances of excess nutrients getting into water sources.

Bermudagrass needs 16 essential nutrients to grow and requires favorable chemical conditions indicated by the soil pH. Soil pH affects the availability of nutrients in the soil as well as those applied as fertilizer. Maintaining the proper soil pH in bermudagrass hay or pastureland will help the nutrients applied in fertilizer work for you. Results of maintaining a proper pH are: nutrient solubility improves so plants have a better

nutrient supply, plants develop healthier roots because they are exposed to less toxic aluminum, and there is enhanced nodulation of companion legumes. Lime will also provide calcium and magnesium (in the case of dolomitic limestone).

When soil sampling, it is important to use a well-developed sampling protocol. Poor sampling gives misleading test results, leading to under or over application of nutrients. Soil testing can be divided into three major steps: 1) collecting the sample, 2) analyzing the sample, and 3) interpreting the results. Collecting the sample is the step most likely to cause inaccurate results.

Collect your samples with stainless steel or chrome-plated sampling tools and plastic buckets to avoid contaminating the samples with traces of chemical elements (micronutrients) from the sampling tools. Avoid brass, bronze, or galvanized tools. Make sure the buckets and sampling tools are clean and free of lime, fertilizer, or feed residues. When sampling an established pasture or hayfield, or when establishing using no-till methods, sample to a depth of 4 inches. If sampling a new establishment site where tillage will be utilized, sample to 6 inches and then incorporate lime and nutrients before planting or sprigging.

Each sample area should consist of only one general soil type or condition. If the area being sampled contains sections that are different in slope, color, drainage, and texture, those areas can be fertilized separately and should have a sample taken and submitted for each area. Areas within a field where different crops have been grown in the past should be sampled separately. On sprayfields, the acreage receiving effluent should be sampled separately from areas that don't receive effluent (such as corners). Assign a permanent sampling identification name of five characters or less to each area and maintain a soil sampling map for future reference.

Collect soil cores with a probe at 15 to 20 random locations across your sample area in a zigzag pattern. Samples must be submitted in the standard soil boxes and accompanied by a completed "Soil Sample Information" form, which can be picked up at your local Extension office. It is critical that the correct crop code (such as bermudagrass maintenance or bermudagrass establishment) is listed on the form. Submit samples two to four months before planting or making fertilizer applications. Any lime needed should be applied in the fall to allow time for lime to neutralize soil acidity and raise the pH to optimum levels. Once optimum pH levels are achieved, sampling every two years is adequate. Intensively managed crops or fields receiving animal or municipal waste should be sampled yearly.

Soil samples can be dropped off at your local Extension office or samples can be mailed to NCDA&CS Agronomic Services Division, 1040 Mail Service Center, Raleigh NC 27699-1040, or to 4300 Reedy Creek Road, Raleigh NC, 27607-6465

Establishment

There are three ways to start new bermudagrass fields: 1) by seeding either common bermudagrass or the newer improved bermudagrass varieties, 2) by sprigging hybrid bermudagrass, or 3) by using cuttings. Common bermudagrass and the newer varieties produce viable seeds. The improved seeded type bermudagrasses are more productive than common. Hybrid varieties do not produce fertile seeds and must be established from sprigs or top-growth cuttings. Freshly dug sprigs are the best source of planting stock for hybrid bermudagrasses. Mature top-growth cuttings can be used to establish some varieties, but growing conditions, especially moisture, must be favorable to succeed.

When establishing bermudagrass, the grower has the option of using a seeded variety (common or improved) or using sprigs. Although sprigging is more expensive than establishing bermudagrass from seed, it offers some advantages. First, herbicides are available for weed control during early vegetative establishment. The lack of effective weed control is a serious issue when establishing seed-type varieties, as stands can be lost to weed competition during the first year. Second, many available sprig-planted bermudagrass hybrids were developed in the South and may be better adapted to our environment. The advantages to seeding are that it is usually less expensive and it may be easier to find a source of seeds.

Fields should be fertile, free of weeds, firm, moist, and the soil pH should be above 5.5. If soil pH is below 5.5, lime is best applied and incorporated six months prior to planting to allow time for the soil pH to adjust to the desired level. Fertilizer should be applied according to soil test recommendations. For all plantings, proper soil preparation and moisture are the keys to success.

Planting Methods

Seeding common bermudagrass. Plant common bermudagrass seeds in April or May at a rate of 5 to 10 pounds of seed per acre. The field should be disked and cultipacked firmly prior to planting. Plant the seeds 1/4 inch deep, then cultipack/firm the soil. If moisture conditions are good or if the area is irrigated, it is possible to produce stands from seeds planted as late as June. Because bermudagrass seedlings are weak competitors, weeds should be controlled with recommended tillage and herbicide applications for several years before establishment is planned.

Seeding improved bermudagrass. Choosing a well-adapted variety is important when establishing an improved seeded bermudagrass field. Newer varieties are often blended and sold under different names, so evaluate the mixture before planting. It is recommended to seed when the soil temperature is 65°F or higher at a 4-inch depth (usually around the first of May in North Carolina). Improved seeded bermudagrass is available in hulled, unhulled or hulled and clay coated. The coating increases the size and weight of the seed to make broadcasting easier. If using a no-till drill or Brillion type cultipacker-seeder, uncoated seed may be preferred. Waiting for soil to be warm should improve bermudagrass seedling vigor and disease resistance.

Seeded bermudagrass should be established into a well-packed, clean-tilled seedbed. Prepare the ground as soon as possible in the spring to allow the soil to settle. Weeds can be sprayed with glyphosate (Roundup) or paraquat (Gramoxone Max) to create a weed-free seedbed. Do not disturb the soil after spraying weeds. Seed can be broadcast and cultipacked into a firm seedbed. A way to determine if the seedbed is firm enough is to walk across the field and observe footprint depth. If your boot sinks deeper than 1/8 inch, the soil is not firm enough. Plantings can also be done using a no-till drill. Seeding depth must be controlled to make sure seed is not deeper than 1/4 inch.

Sprigging. Hybrid bermudagrass does not produce viable seed, so it is established by sprigging. Sprigs are vegetative plant parts containing stolons, crown buds, and rhizomes/runners dug from an established field. Each sprig contains roots and is capable of producing a new plant when it is transplanted. Dormant sprigs (no green leaves) are more desirable than non-dormant sprigs (with green leaves).

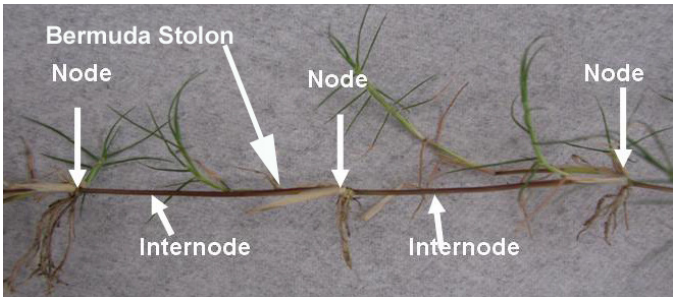

Figure 3. Bermudagrass stolon, which grows on soil surface, showing the location of new growth initiation in March.

It is recommended to plant certified sprigs to avoid planting common bermudagrass, other unwanted grass species, or noxious broadleaf weeds along with the desired hybrid variety. Certified sprig fields are inspected annually by the North Carolina Crop Improvement Association to verify both variety and minimal weed content. The certified sprig sources are listed on the NCCIA website at www.nccrop.com. There may be well-known, very reputable spriggers who are not certified in your area, but know what you are getting before you plant. Sprigs are measured and sold by the bushel or cubic foot. One bushel equals about 1.25 cubic feet and contains about 1,000 sprigs. Certified sprigs of Coastal, Tifton 44, Tifton 85, Midland 99, and Ozark are varieties available in NC.

There are two methods for sprigging bermudagrass: dormant and spring sprigging. Dormant sprigging occurs in the winter (February to early March) when the plants have not yet begun to grow. This method generally allows for quicker coverage in the establishment year. Sprigging in mid- to late-spring (April to June) can be successful if moisture is adequate. Sprigging can be successful even as late as mid summer. However, plantings after late June are more likely to encounter moisture deficit, heat stress, weed competition, and freezing of poorly developed root systems the first winter.

Sprigs may be planted in a number of ways. Plant hybrid bermudagrass sprigs into a moist, clean-tilled, firm seedbed at a rate of 40 to 60 bushels of sprigs per acre. Regardless of establishment method, it is very important to firm the soil around the sprig to maintain sprig-soil contact, retain soil moisture, and improve sprig survival.

Commercial sprigging machines generally offer the best results (see Figure 4). The sprigger machine cuts a shallow furrow, drops the sprigs 2 to 3 inches deep, and firms the soil over the sprigs with press wheels. Sprigs can be broadcast onto the soil surface with a manure spreader or by hand. Press the sprigs into the soil using a disk with its blades set to cover lightly. Following the disk, firm the soil around the sprigs with a cultipacker. Cultipacking after sprigs are planted helps root-soil contact and leaves a smooth surface that is less prone to erosion in the event of heavy rains after planting. The sprigs should not be covered with more than about 1 to 3 inches of soil. Sprigs that are covered too deeply may not survive. Sprigs should be planted as soon as possible after digging to maintain quality. If this is not possible, they can be stored in a cool, moist place for no more than 24 hours. Sprigs quickly lose their viability as a result of high temperature and low moisture. Sprigs allowed to dry or stored in sunshine for several hours will have decreased viability. Avoid harvesting sprigs two days after a sharp late freeze because of decreased viability.

Figure 4. Commercial no-till sprigger.

Sometimes farmers purchase certified sprigs to establish a 1- to 2- acre nursery. The following spring, the sprigs are harvested and used to plant larger acreage. Nurseries should be established in fields that are free of common bermudagrass and weeds. Digging machines are available to harvest sprigs. An alternative is to cross-disk to break into small sprigs and then cultivate with a spring tooth harrow to bring sprigs to the surface. A hay rake can be used to shake the soil from the roots and make it easier to pick the sprigs up.

Top growth/cuttings. Fresh cuttings or clippings can be planted to establish some varieties such as Tifton 85 and Coastal. Establishment from cuttings refers to green top growth that is cut like hay, gathered, and quickly spread over the seedbed and lightly incorporated in the soil. Fresh cuttings should be planted the same day they are cut to achieve the best results. Bermudagrass intended for cuttings should be six to eight weeks old and have several nodes on each stem. Cuttings can be spread in rows or broadcast with a manure spreader. The cuttings should be incorporated with a disk to cover nodes on the stems. The soil should be firmed with a cultipacker or field roller after disking to improve soil contact. This technique is inexpensive but more risky than sprigging. Irrigation when conditions turn dry is strongly recommended for establishment using top growth.

Weed Control during Establishment

Good weed control during the establishment phase is essential. Try to plant in fields that are relatively free of weeds. Newly established bermudagrass cannot compete with rapidly growing annual grasses and broadleaf weeds. A thick cover of weeds slows stand establishment by shading the emerging bermudagrass and prevents the stolons from pegging down. Mowing or grazing may be an option to control grassy weeds, but must be done in a cautious manner to prevent pulling up sprigs. Selective grazing and clipping will encourage the plants to spread across the soil surface rather than to grow erect. Animals can graze any time, as long as they do not pull the runners or plants out of the soil and the herbicide application waiting period is observed. If mowing or grazing is not an option, then an herbicide application may be needed.

Diuron (Direx), a pre-emergence herbicide, can be used on sprigged bermudagrass (do not use on seeded) only to help reduce weed competition. Diuron applications provide fair to good control of crabgrass, crowfootgrass, and goosegrass and provide residual control of certain annual broadleaf weeds. Diuron should be applied immediately after sprigging before weeds emerge. Bermudagrass sprigs should be planted 2 inches deep to lessen chance of injury. Do not graze or feed treated foliage for 70 days after diuron application. After emergence, most broadleaf weeds can be controlled with 2,4-D, but read the label so you do not use it too soon. Check with your local Cooperative Extension agent for additional information and current recommendations.

Test the soil to determine how much lime and fertilizer must be added to the soil to establish and grow bermudagrass successfully. After the plants begin to make runners (six to eight weeks after growth begins), apply another 45 to 60 pounds of nitrogen per acre. If moisture and nitrogen are readily available and weeds are controlled, the soil may be covered in one season.

Hay Management

Fertilization

Once bermudagrass is well established, continue to use soil test results as a guide for applying phosphorus, potassium, and lime. Because each ton of dry bermudagrass forage contains about 40 to 50 pounds of nitrogen and potassium and 12 pounds of phosphorus, you will need a lot of fertilizer to achieve a good bermudagrass yield (5 to 8 tons per acre). Hybrid bermudagrass responds well to heavy fertilization.

Table 1 reports a study that showed that an application of 200 pounds of nitrogen per acre per year (divided into three applications) on the deep sandy soils of the sandhills of North Carolina resulted in a yield of 4.3 tons per acre, compared to 0.6 ton per acre when no nitrogen was used (Table 1). On deep sand and in the piedmont, the maximum practical nitrogen application rate for hay production is probably around 200 pounds per acre annually. When using this quantity of nitrogen under average conditions, phosphorus and potassium requirements can be met by one application of 500 to 800 pounds of a 0-10-20 fertilizer per acre. On the better soils of the coastal plains, which have a long

Table 1. Yield, Percentage of Crude Protein, and Percentage of Apparent Nitrogen Recovery as Influenced by Rate of Nitrogen Application at Two Locations in North Carolina

	Sandhills, 10-Year Average			Upper Coastal Plain, 6-Year Average		
Annual Nitrogen Application (lb/acre)	Yield (tons/acre)	Crude Protein (%)	Apparent N Recovery (%)	Yield (tons/acre)	Crude Protein (%)	Apparent N Recovery (%)
0	0.6	8.0	--	0.5	8.8	--
100	2.9	8.9	86	2.6	10.6	85
200	4.3	10.8	84	5.0	12.5	100
400	5.4	14.0	70	6.7	16.3	97

Source: W. W. Woodhouse, Jr., North Carolina State University.
Note: Nitrogen was applied in three equal measures. Cutting frequency was every four to six weeks.

growing season, the nitrogen rate may be increased to 300 pounds per acre with a one-time application of 800 to 1,000 pounds of a 0-10-20 fertilizer (or equivalent) per acre. Of course, the price of fertilizer, environmental considerations, alternative feeds, and farm goals will influence the level of fertilizer application.

Bermudagrass requires substantial amounts of phosphorus (P_2O_5 or P) and potassium (K_2O or K), in addition to nitrogen (N). Many Coastal bermudagrass producers supply adequate nitrogen fertilization but not adequate phosphorus and potassium. In particular, potassium deficiency seems to intensify problems such as winter kill, low yields, and increased incidence of leaf spot disease.

When using more than 200 pounds of nitrogen per acre, it is best to split the potassium applications. If nitrogen is applied alone (either as a solution or as a granular), apply an additional 500 to 800 pounds of phosphorus (if indicated by soil test report) and potassium in April or May using a 0-1-2 fertilizer. Then, a second application of potassium (using muriate of potash) can be made in mid-July. Nitrogen, phosphorus, and potassium can be applied at the same time using a 4-1-2 fertilizer. For example, if you use a 20-5-10 fertilizer, apply 200 to 400 pounds per acre in April, June, and in mid-July. Much of the land in the coastal plain has high P levels already and there may be no yield response from a P application. Apply phosphorus only if indicated by a soil test. On coarse sands, nitrogen and potassium are lost through leaching and crop uptake. On deep sand, it is recommend splitting nitrogen and potassium applications after each hay harvest on dedicated hayfields or twice during the growing season on pastures. One recommendation is to use a 4-0-5 ratio fertilizer to supply 40 to 50 lb/A N and 50 lb/A K2O. If the sulfur (S) index is 25 or lower, apply 25 lb/A sulfur in the spring. Beware of overuse of ammonium sulfate (21-0-0) fertilizer as it may significantly depress soil pH. Potassium sulfate (0-0-50) or sulfate of potash-magnesia (0-0-22) may be better S sources. Hayfields can be soil sampled in late summer to determine if K is needed for the fall. If K is needed, then half can be applied then and the rest in the following year.

If using poultry litter, it is recommended to split applications with one in March and the other in July, to avoid nitrate accumulation and reduce potential nutrient runoff. Always sample litter before applying to know its exact nutrient level. Nitrogen availability in the litter is difficult to predict especially when applied on the soil surface, so applying lower rates in late winter to early spring and again in July (after the second hay harvest) will ensure nitrogen is there when the crop needs it. Higher application rates can cause excess phosphorus accumulation in the soil, so monitor your soil samples.

Soil test reports for maintenance call for a pH of 6.0, but bermudagrass will tolerate more acidic soils. In fact, if the soil pH is between 5.5 and 5.8, there is usually little response to lime applications. Nevertheless, there are good reasons to apply lime well before pH drops below 5.0. For example, if legumes are grown with bermudagrass, the pH should be maintained above 6.0 and ideally closer to 6.5. Liming also helps maintain adequate calcium and magnesium on sandy soils, and it can improve winter survival of Coastal bermudagrass. Also, lime is needed to neutralize the acidity caused by applications of ammonium forms of nitrogen. Lime moves very slowly through the soil profile, and all the lime is being concentrated on the soil surface in established stands. If a lime recommendation is greater than 1 ton/acre, apply 1 ton/acre immediately and the balance of the recommended lime in the next six to twelve months. It is good practice to have your soil tested every two years. A soil test may recommend adding sulfur to increase plant yield and vigor. This is probably not needed in fields receiving animal waste.

Harvesting

Much research has been conducted to determine when bermudagrass should be harvested for the best compromise between yield and quality. Plant maturity (clipping

interval) and seasonal rainfall can influence yield and protein content (Table 2). As a rule of thumb, cut bermudagrass at four- to five-week intervals or when it is 12 to 15 inches tall, whichever comes first (Figure 5). When the forage is 12 to 15 inches tall, a delay of two weeks or more can result in the loss of regrowth and quality.

Figure 5. For the best compromise between quality and yield, hybrid bermudagrass should be harvested at four- to five-week intervals or when the grass is 12 to 15 inches tall, whichever comes first. Photo courtesy of Colby Lambert.

Fall Management

Fall management is important in maintaining vigorous stands and preventing winter injury, particularly in the piedmont. At the start of winter, bermudagrass should have 3 to 4 inches of growth that will serve as insulation against winter damage. This growth should not be grazed or otherwise removed before February 15. Burning in winter to early spring has several benefits. Burning will encourage early spring growth by removing dead material from the previous year, which allows the soil to warm up quicker in the spring and reduces competition for sunlight as the new bermudagrass struggles to break dormancy. Another advantage to spring burning is that it helps with weed management. Sandspur-infested fields, for example, benefit greatly by having the previous year's spur seeds burned before they can germinate in the summer. The primary issue to consider before burning is safety. If you do not have the necessary equipment or experience to safely burn a field, then err on the side of caution. Also, you should always check local burning laws and consult the NC Forestry Service to make sure no burning bans are in effect before burning.

Summary of Hay Production Practices

- Have your soil tested and apply the amount of lime needed to maintain a pH of 6.0 or higher (even though bermudagrass will tolerate more acidic soil).
- Apply nitrogen when growth begins in the spring (normally April) and after each harvest, except the last. Refer to Table 3 as a guide for the amount of nitrogen needed to obtain yield goals.
- All the phosphorus and potassium may be applied in the spring. On sandy soils, however, you should split the potassium, applying half in the spring and half after the second cutting, especially if the yield goal is more than 5 tons per acre.
- Consider burning old residue two to three weeks before the bermudagrass breaks dormancy in spring to ensure rapid growth.
- Make the first cutting when plants are 12 to 15 inches tall and every four to six weeks thereafter, depending on the quality of feed needed.
- Make tight, round hay bales and store them inside or on a well-drained site.

Pasture Management

Fertilization

Since bermudagrass uses the nutrients in manure and urine, an estimated amount of 25 percent less fertilizer can be utilized for pastures than for hay fields. Test the soil regularly (2-3 years) as part of your pasture-management program. Apply phosphorus only if recommended on a soil report. Nutrient suggestions for sustained production on soils testing medium in phosphorus are as follows:

- On sandy or low-potassium soils, apply 400 to 500 pounds of 0-10-20 fertilizer per acre in April or May or split potash and apply half in May and half in July. Add 50 to 70 pounds of nitrogen in April, June, and July. Pastures can be soil sampled in late summer to

Table 2. Influence of Clipping Frequency and Season on Dry Matter Yield and Crude Protein Content of Coastal Bermudagrass Grown at Tifton, Georgia

	Dry Yield (tons/acre)		Crude Protein (%)	
Clipping Interval (weeks)	Wet Year	Dry Year	Wet Year	Dry Year
2	2.2	1.0	13.6	16.2
3	3.3	1.4	12.9	12.8
4	3.7	1.7	11.2	11.0
6	4.8	2.3	7.8	9.3
8	5.1	2.4	8.4	9.7

Source: G. M. Prine and G. W. Burton, Agron. J. 48:296-301.
Note: Phosphorus, potassium, and other elements were adequately supplied. Nitrogen was applied at 100 lb per acre.

Table 3. Estimated Yield Response of Bermudagrass to Nitrogen Levels in Three Geographical Regions

	Nitrogen (lb/acre)					
Region	**0**	**50**	**100**	**150**	**200**	**300**
	Dry Yield (tons/acre)					
Sandhills	0.6	1.8	3.1	4.0	4.7	5.3
Upper coastal plain	0.8	2.0	3.3	4.5	5.5	6.4
Piedmont	0.8	1.9	3.2	4.4	5.3	6.1
	Pounds of Dry Matter per Pound of Nitrogen Applied					
Sandhills	--	50	51	46	42	32
Upper coastal plain	--	50	51	50	48	38
Piedmont	--	44	48	48	45	35

Note: These estimates are based on summaries from many experiments on many soils over several years.

determine if K is needed for the fall. If K is needed, half can be applied then and the rest in the following year.

• On red clay soils, apply 300 to 400 pounds of 0-10-20 fertilizer per acre in April or May, and add 40 to 60 pounds of nitrogen in April, June, and July.

• On stands containing more than 50 percent winter annual legumes, use 400 to 500 pounds of 0-10-20 fertilizer in the fall and omit the April application of nitrogen, but topdress with 40 to 60 pounds of nitrogen per acre in June and July.

• On soils testing high in phosphorus, no yield benefit will be obtained from additional phosphorus fertilization.

Grazing

Maintain bermudagrass in a young, leafy condition. Note the high protein content of frequently cut plots (Table 2). Continuous grazing to sustain a stubble height of 1½ to 2 inches gives better animal gains than a stubble height of 3 or more inches. It is recommended that pastures be subdivided into several paddocks, then grazed close and periodically clipped or mowed. Measuring stop/start grazing heights with a tool, such as a grazing stick, will give an idea of when to begin grazing a paddock and when to remove animals. For bermudagrass, the recommended start grazing height is 6 inches and the stop grazing height is 2 inches.

Bermudagrass is not usually the best choice for grazing dairy animals but well-managed, higher-quality bermudgrass may be very useful in some situations. In older studies by NC State researchers, when animals receive 20 to 25 pounds of concentrate feed per head per day, milk yields are similar to yields from cows grazing pearl millet. In a four-year study conducted at the Piedmont Research Station, daily animal production of fat-corrected milk from Coastal bermudagrass and pearl millet was 45.3 and 45.8 pounds, respectively. The carrying capacity per acre on Coastal bermudagrass was 2.2 cows per acre compared to less than one cow per acre for pearl millet.

In general, the average daily gain of yearling cattle that graze on Coastal bermudagrass is not as high as those grazing ladino clover-fescue, but the number of animal days per acre is considerably higher (Table 4). The relatively high carrying capacity and satisfactory animal gain make a small acreage in the forage program beneficial. Research shows a very good response to low-level supplementation with corn (3 lbs/day) on stocker cattle grazing bermudagrass. In cow-calf operations, tall fescue-clover and bermudagrass in grazing pastures can result in more than 500 pounds of calf gain per acre, with average daily calf gains in excess of 1.5 pounds.

To control grazing pressure and animal performance, divide pastures into several fields. Also keep in mind that grass grows at different rates depending on conditions such as moisture, temperature, and other factors. Mow when the growth rate exceeds what the livestock can use during a three- to four-week period.

Stockpiling

In recent years more producers have become interested in stockpiling forage for late fall or winter grazing. This practice eliminates the cost of mechanical harvesting, storage, and feeding. Much work has been done on stockpiling fescue in N.C., but more is being done to investigate the use of stockpiled bermudagrass. The

Table 4. Beef Cattle on Coastal Bermudagrass and Clover-Fescue Systems

	Ladino Clover Grass	Coastal Bermudagrass Plus Fescue
Days in season	117	178
Cow days per acre	185	389
ADG (lb)	1.95	1.11
Beef per acre (lb)	344	432

Note: Data represent a four year average of tests conducted in Rowan County

quality of stockpiled bermudagrass is not as high as fescue, but still can reach levels sufficient for dry cows in good body condition. In an on-farm trial in Johnston County, stockpiled bermudagrass fertilized with swine waste contained 11.14 percent crude protein and 57 percent TDN on October 7, but by October 28 quality had declined to 10.14 percent crude protein and 55 percent TDN. Quality of bermudagrass will more rapidly decline after frost, so stockpiled bermudagrass should generally be grazed starting in October.

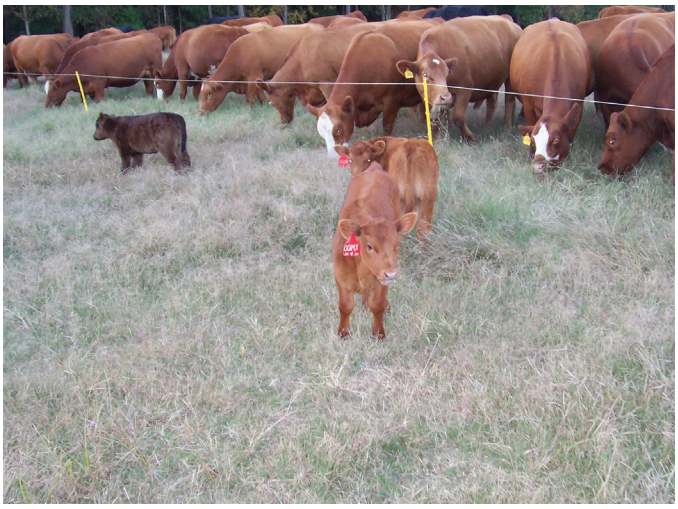

Figure 6. Cattle grazing stockpiled bermudagrass. Photo courtesy of Dan Wells.

To stockpile bermudagrass, begin six to seven weeks before the average first frost by clipping or grazing the field, then apply 60 pounds of nitrogen. Keep animals off the field and allow the pasture to grow until October. Strip grazing (also known as frontal grazing) is the best way to utilize stockpiled forage (Figure 6). This can be accomplished by using temporary fencing to give livestock daily strips of forage, forcing them to eat a higher percentage of the grass. A network of electrified perimeter fencing can supply power to a reel of polywire or polytape supported on step-in posts to fence off temporary paddocks. The most common method is to start at the end of the field where the water is and move the fence ahead every one to three days. A back fence to keep animals off of previously grazed portions is not necessary with stockpiled forages, since the grass is not trying to regrow.

Overseeding

To lengthen the grazing season, overseed bermudagrass with rye, ryegrass, or annual legumes. Where adapted, the perennial legumes ladino or red clover can be grazed with bermudagrass during the late spring or summer. During the summer, a bermudagrass-clover mixture will require much less nitrogen than just bermudagrass. Overseed in October using a no-till drill, or lightly disk, then drill or broadcast the seed. It is generally not recommended to overseed a bermudagrass field in the establishment year. This can significantly stress the grass, especially if the sprigs were planted late (May, June).

In recent studies, overseeding with winter rye or annual ryegrass produced dry matter yields of 2,500 to 5,000 pounds per acre during the cool season. The higher yields were obtained when the winter annuals were cut for hay. When Coastal bermudagrass was overseeded, the yield ranged from 1,200 to 2,500 pounds per acre. The higher yields were obtained when rye, rather than ryegrass, was used. In areas where bermudagrass is the only pasture species available, 50 to 100 percent of the acreage may be overseeded with winter annuals to provide supplemental grazing during winter and early spring (Figure 7).

Figure 7. Winter annuals such as rye (shown here) can extend the grazing season in areas where bermudagrass is the only perennial pasture species available. Photo courtesy of Sharon Freeman

When overseeding bermudagrass hay fields in the fall with winter annuals, clip the bermudagrass to a stubble height of 3 inches or less. For pastures, establish a grazing height of 1 to 2 inches before overseeding because bermudagrass pasture sod is thicker than hay field sod.

Timely removal of a winter annual that is overseeded in bermudagrass is essential for its survival. An overseed crop left on bermudagrass too long shades the bermudagrass when it is trying to re-emerge from winter dormancy. Over time, this can cause a significant decline in bermudagrass, especially if the field is overseeded every year. An overseeded winter annual grass (rye, ryegrass, oats) should be harvested at the "boot" stage of growth—prior to emergence of seed heads from the

sheath. For rye this is usually late March or early April. In most years a follow-up harvest of the winter annual may be needed, but the first harvest is most critical for survival of bermudagrass. Regrowth following an early April harvest will be stronger with ryegrass or oats than cereal rye. Consider removing winter overseed as silage or haylage/baleage because of probable poor drying conditions in early spring.

Decline and loss of hybrid bermudagrass stands on swine farm wastewater sprayfields is an increasing concern on sites that are overseeded with ryegrass and managed for hay. Ryegrass overseeded on hayfields adds competitive stress and can significantly reduce bermudagrass stands if not managed. Many swine operations must overseed their sprayfields due to limited wettable acreage. Use an early maturing small grain, such as rye or oats, to overseed sprayfields. Do not use annual ryegrass on sprayfields except when overseeding pastures. Oats have intermediate maturity but tend to produce leafier and more competitive regrowth than rye or triticale. Wheat matures late and is not well adapted as an overseeded crop.

A winter annual legume can lengthen the spring grazing season by four to eight weeks and also add a considerable amount of nitrogen to the grass. Legumes can add 90 to 120 lbs N per acre to the pasture system and yield 3,000 to 4,400 lb DM per acre at peak growth. Legumes also can capture 12 to 14 lb P per acre, making them a tool for maintaining proper soil mineral balance. Use 15 to 20 pounds of a reseeding variety of clover, such as crimson or arrowleaf, or use 25 to 30 pounds per acre of hairy vetch or winter peas. Ladino clover can be planted at four to five pounds per acre, red clover at eight to ten pounds per acre, rye at two bushels per acre, and annual ryegrass at 20 to 30 pounds per acre. In addition to providing high-quality forage, the legumes resulted in higher crude protein and TDN contents in the hay harvested from the pastures, particularly in the earlier cuttings. Winter annual growth should be managed carefully, however, to avoid damaging established bermudagrass pastures. Decreased stand vigor has been observed in pastures were the legumes were allowed to shade the grass for extended periods. Additionally, vetch may form dense mats that can kill areas of bermudagrass.

Spring and fall are critical periods for allowing crimson clover to re-establish from natural reseeding. In the spring, crimson clover seed must be allowed to mature, which will cause severe shading and delay spring growth of the bermudagrass; therefore, do not overseed all the bermudagrass acres. In the fall, maintain the bermudagrass at a height of 2 inches to allow the clover seed to germinate and develop. A light disking is often helpful.

Weed Management

A healthy and properly managed stand of bermudagrass will not require much weed management during the growing season. Early spring is the main time of year when many weeds (both broadleaf and grassy) will be able to out-compete bermudagrass. One critical component in weed control and management is proper weed identification. Your local Cooperative Extension agent can help you identify problem weeds. You can also consult the W*eed Identification in Pastures and Hayfields* manual available at your local Cooperative Extension office.

Broadleaf weeds

Broadleaf weeds are for the most part readily controlled by the numerous forage herbicides on the market. Most of these products are a blend of two or more chemicals and usually offer a significant amount of residual control. A single spring application of most broadleaf forage herbicides will give sufficient control for the growing season. For heavy weed infestations or for some particularly troublesome weeds, a second application may be necessary later in the summer.

Grassy weeds

Grassy weeds (nut sedge, bahiagrass, sandspurs, and such) are significantly more difficult to control. Effective herbicide selection is much more limited than the products that are available in the broadleaf market. Proper herbicide selection, as well as timing of application, is more critical when trying to control grassy weeds. Also, for heavy infestations, it may take two to three years of spraying to effectively control most grassy weed problems.

For specific control measures in forage herbicides, contact your local Cooperative Extension Agent or consult the NC Ag Chemicals Manual.

Disease and Pests

Disease

Several environmental and biotic factors can reduce yield and quality of forage crops. Bermudagrass leaf spot is a disease that decreases yields, nutritive value, and palatability. It is caused by a fungus from the genus *Helminthosporium* and has been informally called Helminthosporium leaf spot, Helminthosporium leaf blotch, or leaf blight. Leaf rust or Puccinia disease caused by *Puccinia cynodontis* has similar impacts. Both diseases typically appear in late summer when weather is warm, usually between 75°F and 90°F, with high relative humidity. Heavy infestations can decrease both hay yields and hay quality.

The most effective way to treat bermudagrass leaf spot or rust is avoidance. There are five management practices that are effective in decreasing risk of disease

infection including: 1) selecting a resistant bermudagrass variety, 2) maintaining soil fertility, 3) managing irrigation, 4) removing thatch, and 5) harvesting forage in a timely manner. Other bermudagrass diseases are minor or sporadic.

Pests

Check forages regularly to detect insect infestations. Check frequently during the active growing season, particularly during periods of drought. Monitor three to four locations in each 10-acre section. Symptoms of insect infestation may be early visible chewing. Symptoms also may be less obvious. Insects may be on the foliage, hide in the crowns of the plants, or feed on the plant roots. Look for yellowing plants and spots where the grass may be dead or thinning. Pay special attention to fields treated with organic fertilizers and to bermudagrass hayfields. The five insect/pests in North Carolina bermudagrass fields are fall armyworms, green June beetles, fire ants, two-lined spittlebugs, and sting nematodes.

Fall armyworm moths migrate north from the Caribbean islands, extreme southern Florida and Texas, and from Central America each year. By early summer, they are laying eggs in pastures and hayfields in North Carolina. Reports of damaging populations usually come in late July and early August when later generations of the pest are present. However, damaging populations can occur as early as June. Hot, dry weather is favorable for fall armyworm outbreaks. Fall armyworms need to be treated when they are still small, no more than ½- to 1-inch long. Detecting infestations when the caterpillars are small gives more time to implement control measures. When armyworms are fully grown, they are less susceptible to insecticides and harder to kill. In addition, if most of the caterpillars are nearly grown, most of the feeding damage may already have been done.

The green June beetle is an increasing problem. The grubs of this beetle, commonly called grubworms, rarely feed on grass roots, but their extensive burrowing activities disrupt the root-soil contact. Once the soil around the roots is loosened, grazing cattle can easily uproot the plants. When green June beetle grubs are present, the pasture will seem to have thinned out. There will be areas where the soil is pulverized, and you may see ½ inch diameter tunnels that the grubs have made.

It is estimated that fire ants cost cattlemen millions of dollars each year. The impact of fire ants in pastures is hard to document because they affect different areas of the livestock operation. They injure both cattle and humans, and they also damage haying equipment, electrical equipment, and livestock feed. Controlling fire ants in livestock pastures is more difficult because of the extensive land area involved, the high cost of insecticides, and livestock safety considerations. Broadcast applications of baits are better than individual mound treatments for pastures because the visible mounds are only the tip of the iceberg. There are other colonies that have not yet built mounds. Mound treatments may be useful follow-ups a few weeks after the bait has been applied.

Two-lined spittlebugs can damage bermudagrass pastures. They have two generations per year. Two-lined spittlebugs overwinter as eggs in sheltered places, such as in plant debris on soil, in hollow stems, and behind leaf sheaths. Humid conditions are required for eggs to hatch and for development of young spittlebugs. Young spittlebugs hide inside foamy masses of saliva-like material. Nymphs and adults feed by sucking juices from the roots, stems, and leaves of bermudagrass. In heavy infestations, injured grasses tend to yellow and dry out. Damage occurs most frequently in dense, overgrown stands of bermudagrass. No chemical control strategies are recommended. Control measures are to burn the affected areas to destroy the spittlebugs and the accumulated thatch. If burning is not possible, mow the pastures and then rake to reduce the amount of accumulated thatch.

Sting nematode (Belonolaimus spp.) is occasionally a pest to bermudagrass where soil texture is coarse sand (~85 percent sand by volume). If sting nematodes are present and the soil is sandy enough for it to be active and reproduce, the nematodes will devastate stands. They can be easily transferred in sprigs. There is no labeled chemical treatment. The only options are to manage with irrigation and high fertility to make the grass grow vigorously and stimulate root growth. The root impairment usually happens in the early spring, and as soils warm and dry, this large-bodied nematode retreats to deeper in the profile. Bermudagrass with nematode injury is especially susceptible to other competitive stress.

For specific control measures in forage pesticides, contact your local Cooperative Extension Agent or consult the NC Ag Chemicals Manual.

Nitrates

In recent years, the North Carolina forage lab has seen an increase in samples with dangerously high levels of accumulated nitrates due to over application of animal wastes and commercial fertilizers to pasture and hay ground. In the past, most concern for nitrate poisoning was focused on known nitrate-accumulating plants.

Nitrate poisoning in livestock is caused by the consumption of feed or water containing high levels of nitrate nitrogen. Normally forages do not contain levels of nitrates high enough to be toxic. But when certain circumstances occur—such as during periods of low soil moisture, low temperature, low humidity, cloudy weather, or drought— poisoning and death can occur.

Table 5. Management considerations for use in feeding forages with various levels of nitrate.

Nitrate Ion % in Forage	Unadapted Animals	Adapted Animals
0.0 - 0.25	Safe: Generally considered safe for all animals.	Safe
0.25 - 0.50	Slight Risk: Should not make up more than 50% of total intake for pregnant animals.	Safe
0.50 - 1.00	Moderate Risk: Do not feed to pregnant animals. Limit to less than 50% total intake for all other animals.	Slight Risk
1.00 - 1.50	High Risk: Exercise extreme caution when feeding. Limit to 33% of the ration.	Moderate Risk
1.50 - 2.00	Severe Risk: Do not feed to any animals free choice. If using in a mixed ration, limit to 25% of the ration.	High Risk
2.00 - 2.50	Extreme Risk: Do not feed at all.	Severe Risk
2.50 and up	Extreme Risk: Do not feed at all.	Extreme Risk

Source: Nitrate Management in Beef Cattle. Poore et al.

Anything that slows down the rate of plant growth can lead to increased nitrate levels in well-fertilized plants. Nitrate can increase to toxic levels in forages any time the nitrogen supply in the soil exceeds the nitrogen needs of the plant. The most common situation where significant animal deaths occur is when a producer places hungry animals that are not adapted to nitrate on high-nitrate forages. It is also important to know that nitrates degrade little with drying, so hay should be analyzed not only for nutrient value, but to also check nitrate levels

Most state labs and commercial labs will analyze forages for nitrate. In North Carolina, the NCDA&CS forage testing lab will, upon request, analyze a forage for nitrate, or add nitrate to standard forage quality analysis at no extra charge. The N.C. lab will notify producers immediately when they find high nitrate levels. Commercial labs usually add a small charge when nitrate is requested. Table 5 lists feeding precautions based on nitrate ion percentage reported from the lab.

Symptoms of nitrate poisoning include labored breathing, muscle tremors, frothing at the mouth, frequent urination, diarrhea, and a staggering gait, after which the animal falls down, gasps for breath, and dies quickly. The membranes of the eyes and mouth are bluish, indicating a lack of oxygen. If a venous puncture is made, the blood is reddish-brown in color but turns a brighter red when exposed to air.

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