

Forage Species for Texas

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Forage and forage-based livestock production enterprises are big business in the US. Latest available USDA statistics (2013) indicate hay harvested in the US was worth approximately \$20,211,663,000 (Table 1). This makes hay third in overall value among agricultural crops grown in the US, only corn and soybeans exceeded the value of hay. The value of all cows and calves in 2012 was estimated at approximately 48.2 billion dollars with the gross income from beef cattle estimated at \$85 billion the same year.

A large majority of cattle and hay produced in the US is contained in 14 southern states. It should be obvious then, forages play a major role in the economics of these states, including Texas. While warm-season perennial grasses provide the base of most operations, cool-season forages also play a significant role in both cow-calf and stocker calf production systems. The main species adapted for use as grazeable forages or hay crops in the South, with special emphasis on Texas, will be discussed in the following sections.

Warm-Season Grasses

Bahiagrass

Bahiagrass (*Paspalum notatum* Flugge) is a warm-season perennial grass native to South America. The first introduction to the U.S. occurred in 1913 with common bahiagrass by the Florida Agricultural Experiment Station. In 1935, Escambia County Extension Agent Ed Finlayson found a more productive bahiagrass growing along the docks and railroad tracks at Pensacola, FL. This variety became known as ‘Pensacola’ and has been the most widely used of all the varieties to date. A 1989 release from the USDA-ARS station at Tifton, GA, ‘Tifton 9’ has exhibited increased seedling vigor and greater yield compared with Pensacola. Nutritive value of Tifton 9 is comparable to Pensacola. The USDA and the University of Georgia recently released ‘TifQuik’. It has fewer hard seeds and results in a more rapid or “quick” stand

establishment. In the spring, it grows faster than Tifton 9 or Pensacola because of faster seedling emergence.

Bahiagrass has several characteristics making it valuable as a pasture grass. Bahiagrass grows on a wider range of soils than bermudagrass or dallisgrass. Compared with hybrid bermudagrass, bahiagrass tends to green up earlier in the spring and remain green longer in the fall, but lacks the drought tolerance of bermudagrass on deep sandy soils. Bahiagrass is resistant to weed encroachment due to extremely thick sod and tolerates close, continuous grazing better than most other grasses. Bahiagrass also produces moderate levels of dry matter on soils of very low fertility and, finally, is established from seed. Pensacola seedlings, however, may exhibit poor vigor and establishment can be slow. Bahiagrass is only recommended in higher rainfall zones (e.g. east of IH35 in Texas).

Suitable soil types range from upland sandy sites (on which bahiagrass may suffer during summer drought) to more poorly drained sandy areas. When establishing bahiagrass, seed should be broadcast onto a well-prepared seedbed at 12 to 15 lbs of pure live seed (PLS) per acre, covered with no more than one-half inch of soil, and rolled to ensure good seed-soil contact. Pure live seed is the product of the percentage of live, viable seed and the percentage of the target species seed in the bag. If the PLS is not 100%, adjustments should be made to ensure planting the appropriate amount of seed. For example, if the recommended seeding rate is 10 lbs of PLS/acre, but the PLS percentage is only 80%, divide the recommended seeding rate by the PLS percentage to obtain the appropriate seeding rate. In this example $10/0.80 = 12.5$. Higher seeding rates can help to speed establishment. Establishment usually takes place in the spring after the last chance of a killing frost has occurred. Although the optimum temperature range for bahiagrass seed germination is 85 to 95°F, weed pressure is greater with later plantings and the relatively weak bahiagrass seedlings are at a competitive disadvantage. Based on a soil test, apply any needed P (phosphorous) and K (potassium) and 30 to 40 lbs/acre of N (nitrogen) at planting. Additional nitrogen will only serve to encourage weed competition. After the grass begins to cover, 40 to 60 lbs/ac of additional N may be applied. The herbicide, 2,4-D may be used only after the grass reaches five to six inches in height; use of phenoxy herbicides prior to this stage may kill or injure the grass seedling. Once bahiagrass achieves a thick, solid stand, weeds are seldom a problem. Ideally, bahiagrass should

be fertilized annually according to soil test recommendations, although even minimal amounts of N, P and K will serve to increase dry matter production and crude protein content.

Bahiagrass should be primarily used for pasture, although some is harvested and conserved as hay. Bahiagrass should be cut when it is eight to 10 inches tall if greater levels of hay nutritive value are desired. If bahiagrass is cut for hay, it is critical to apply appropriate N, P, and K based on soil test recommendations due to the removal of nutrients from the site. Given similar levels of fertility, hybrid bermudagrass will usually provide more dry matter production and greater levels of crude protein and digestibility (Table 3). However, under low levels of fertility bahiagrass can persist for many years in relatively pure stands. Forage nutritive value is usually adequate for mature beef animals, but performance of weaned, growing animals may suffer if an appropriate supplement is not provided.

To maximize use of the pasture and to help reduce winter-feeding costs, overseeding bahiagrass with a legume, small grain or annual ryegrass may be beneficial. Bahiagrass has a thick layer of rhizomes (underground stems), so the pasture should be grazed close and lightly disked prior to overseeding. Clover or annual ryegrass seed should be broadcast approximately 6-8 weeks prior to the historic first frost date. For overseeding cereal grains, a drill should be used to place the seed deeper. Note that although bahiagrass can perform under low fertility programs, winter pasture species will not. Fertilizer should be applied at the recommended rate based on soil test.

Although bahiagrass has many positive characteristics as a pasture grass, it has its share of problems. Because the species can persist under lower fertility environments, many producers have witnessed an invasion of bahiagrass into their bermudagrass fields. This is usually because fertility is less than optimum for the bermudagrass to prevent establishment of bahiagrass. Once present, bahiagrass tends to remain and even become dominant in bermudagrass fields. Generally, 0.3 oz/acre of the herbicide Cimarron is required to eliminate mature plants. Without a change in fertility or grazing management, bahiagrass often will re-establish from seed the following year.

Bahiagrass establishment is slow and the species responds poorly to N fertilizer rates above 100 lbs/acre. Lower dry matter production compared with hybrid bermudagrass can create a need to decrease stocking rate. Likewise, lower forage nutritive value decreases animal performance. These situations reduce the potential for profit for those attempting to maximize

production per unit area of land. However, lower input costs associated with bahiagrass may actually increase the profit potential depending on the price of fertilizer and cattle.

To summarize, bahiagrass has a bad reputation, but only when compared with well-managed bermudagrass. Under more realistic circumstances of lower fertility inputs, bahiagrass may be a good option for grazing pastures. Depending on the goals and objectives for the particular property, bahiagrass may deserve more respect than it has received in the past.

Bermudagrass

Bermudagrass (*Cynodon dactylon* (L.) Pers.) is native to Africa. The earliest mention of bermudagrass comes from the diary of Thomas Spalding, owner of Sapeloe Island, Georgia, and a prominent antebellum agriculturalist. Found in his diary was the following entry:

“Bermudagrass was brought to Savannah in 1751 by Governor Henry Ellis.” He went on to say, “If ever this becomes a grazing country it must be through the instrumentality of this grass.”

Writers as early as 1807 referred to bermudagrass as one of the most important grasses in the South at the time. Thus, bermudagrass has been a part of southern agriculture for at least 250 years. Hybrid bermudagrass with improved productive capability and nutritive value has played an important role in livestock production across the southern U.S. for over 70 years with the introduction of ‘Coastal’ in 1943.

Bermudagrass is a warm-season perennial grass spreading mainly by rhizomes (horizontal belowground stems) and stolons (horizontal aboveground stems). The grass tolerates a wide range of soil types and soil pH values, thus making it adapted to most of the southern U.S. Limited cold tolerance in early common and hybrid cultivars of bermudagrass led to the release of several cold-tolerant varieties, thus providing useful warm-season perennial grasses for the warm-season, cool-season transition areas of the U.S., including Oklahoma, Arkansas, Missouri, and Tennessee.

Bermudagrass is generally planted on a well-prepared seedbed with sprigs (stolons and rhizomes) of hybrid varieties at 25 to 40 bushels per acre. Seeded varieties are generally planted at 8 to 10 lbs of unhulled (does not have the outer seed brackets removed) seed per acre for rapid establishment. An initial soil test will indicate whether P, K or limestone is required. If so, these nutrients should be incorporated into the seedbed prior to planting.

Sprigs should be fresh and planted the same day they are dug. Sprigs should be planted two to three inches deep, while seed should be planted no more than ¼ inch deep. Rolling helps to ensure good sprig- or seed-soil contact and good establishment. One quart of labeled 2,4-D low volatile ester or one to two quarts of Weedmaster should be applied per acre the day of planting to minimize broadleaf weed problems and to suppress small-seeded annual grasses. A new label for Grazon P+D indicates up to 1½ pints/acre may be used on newly established bermudagrass if there is at least six inches of stolon development and growing conditions are good. When new growth is noticed, 40 to 50 lbs N/acre should be applied along with the recommended K. When stolons begin to develop, another 40 to 50 lbs N/acre should be applied.

Although capable of high yields, bermudagrass must be well fertilized to optimize production (Table 4). Given adequate moisture, N is usually the most limiting factor to forage production, but appropriate levels of P and K are critical to yield and persistence. Inadequate levels of N not only limit bermudagrass dry matter production, but also reduce crude protein levels. Adequate soil pH (>6.0) is also important in maintaining a vigorous stand of bermudagrass. Less than optimum bermudagrass growth can invite weed infestation, thus reducing carrying capacity and increasing input costs. Careful attention to soil fertility, beginning with an annual soil test of hay fields to determine the soil nutrient status is necessary to ensure good bermudagrass growth, disease resistance, and cold tolerance.

Besides providing good nutrition for cows during the growing season, bermudagrass is harvested and conserved extensively as hay for livestock winter-feeding programs. However, the use of hay is generally an expensive way to winter cattle. In fact, the average 1000-lb round bale of bermudagrass costs the producer more than \$60.00 to 70.00 to harvest, bale, haul, store and haul again to the feeding area. Nevertheless, bermudagrass hay production is a popular practice across most of the South. See more under the Hay Production section.

Non-traditional methods of bermudagrass use may also help reduce winter feeding costs. These include the use of standing or “stockpiled” bermudagrass for fall and early winter grazing and overseeding bermudagrass swards with cool season annual forages such as small grains, ryegrass and clover to provide later winter and spring grazing. The combined use of stockpiled bermudagrass and overseeded ryegrass, when possible, can reduce winter feeding costs.

Warm-season perennial grasses, including bermudagrass, generally have lower nutritive value compared to warm-season annuals or cool-season forages. However, with a sound fertility

practices (Table 5), and careful attention to stage of maturity at harvest (Table 6), bermudagrass can provide forage of good to excellent nutritive value. Bermudagrass is the most important warm-season grass forage in the South and will likely continue to be throughout this century. Below is a short description of several popular bermudagrass cultivars currently used in the South.

Coastal

A hybrid between 'Tift' bermudagrass, a vigorous growing bermudagrass found in an old field near Tifton, Georgia, and an introduction from South Africa. Coastal is a result of an extensive breeding program by Glenn Burton, USDA-ARS, Georgia Coastal Plains Experiment Station at Tifton, GA, and was released as a variety by that station in 1943. Coastal is a highly productive bermudagrass with both rhizomes and stolons and is adapted to a wide range of climatic conditions. It has exceptional longevity, readily responds to fertility and irrigation, and possesses better drought tolerance than common. Coastal is also tolerant of heavy grazing pressure or frequent and close defoliation. Coastal is the most widely planted bermudagrass in Texas.

Tifton 85

Dr. Glenn Burton (USDA-ARS) in cooperation with the University of Georgia Coastal Plain Experiment Station, Tifton, Georgia, developed Tifton 85 in 1991. Tifton 85 is a hybrid between a plant introduction from South Africa and 'Tifton 68'. Tifton 85 has large stems, long stolons and a reduced number of rhizomes compared with Coastal. Tifton 85 can be established either by planting sprigs or vegetative tops (aboveground material). In a three-year trial in Georgia, Tifton 85 produced 26% more dry matter and was 11% more digestible than Coastal (Mandevu et al., 1999). Animal gains are approximately 25% better than Coastal due to the higher digestibility (Mandevu et al., 1999). At Overton, Tifton 85 has remained green longer into the season than Coastal.

Tifton 44

Dr. Glenn Burton developed Tifton 44 at the Georgia Coastal Plains Experiment Station as a cross between Coastal and a cold-hardy plant surviving in Berlin, Germany, for 15 years.

Tifton 44 dry matter yield and disease resistance are similar to Coastal, but Tifton 44 has a slightly greater forage nutritive value and cold tolerance than Coastal. Tifton 44 generally greens up a week to ten days earlier in the spring and remains green a week to ten days longer in the fall than Coastal. Tifton 44, like Coastal, is relatively slow to establish. Because of this slow development, it needs to be planted in soils relatively free of common bermudagrass, which can become a serious weed problem. Tifton 44 is used more in North and Northeast Texas because of its cold tolerance.

Jiggs

Jiggs is a private release of a bermudagrass found growing along the Texas Gulf Coast. Jiggs establishes rapidly and is generally planted using tops. The naturalized ecotype is productive, and anecdotal evidence suggests Jiggs may perform better on poorly drained, tighter soils than other bermudagrass varieties. There is no difference in nutritive value between Jiggs and Coastal. In 2014, Jiggs received an official PI number from the USDA – Griffin, GA and is now included in the USDA bermudagrass data bank as PI 671960.

Alicia

Cecil Greer of Edna, Texas, selected Alicia reportedly from bermudagrass collected in Africa in 1955. Franchise growers sold cuttings of tops for the establishment of Alicia. Alicia spreads primarily by stolons, has fewer rhizomes than Coastal, and is usually not as productive as Coastal. Alicia is usually propagated using tops rather than by sprigs. Under moderate to heavy grazing and fairly severe winters its recovery in the spring is slow. Alicia forage has lower nutritive value and is not as winter hardy as Coastal, and is susceptible to rust.

Callie

Callie was selected as an aberrant plant in an old plot of bermudagrass plant introductions at Mississippi State University in 1966 from a plant introduced from Africa. Callie is a robust grass with large stolons, wide leaves and a tall growth habit that establishes rapidly the first year. It produces dry matter yields about equal to Coastal and gives good animal gains when free of rust. Callie produces a ground cover consisting of an open-type sod. Because of the open sod,

spring recovery may be slower than Coastal. Callie is not as cold tolerant as Coastal and is susceptible to rust, which reduces forage yield and nutritive value.

Coastcross-1

Coastcross-1 was developed by crossing Coastal and a plant introduction from Kenya, Africa, and released by the Georgia Coastal Plains Station in 1967 from the breeding program of Dr. Glenn Burton. Coastcross-1 grows taller and has broader, softer leaves than Coastal. It is highly resistant to foliage diseases. Coastcross-1 spreads rapidly from stolons, but produces few rhizomes. Coastcross-1 produces about the same dry matter yield as Coastal, but is greater in crude protein and digestibility. Although Coastcross-1 produces more fall growth, it does not have the winter tolerance of Coastal and is limited to regions with less severe winters, such as in South Texas or along the Gulf Coast.

Tifton 78

The Georgia Agricultural Experiment Station and USDA-ARS released Tifton 78 in 1984. Tifton 78 is a hybrid between Tifton 44 and Callie bermudagrass. Compared to Coastal, Tifton 78 is taller, spreads faster, establishes easier, is greater yielding, and more digestible. The greater digestibility allows for improved animal gains. Tifton 78 is also immune to rust. Tifton 78 has rhizomes but less cold tolerance than Coastal. Tifton 78 appears to be adapted only to the most southern areas of the state.

World Feeder

Louis Gordon, president of Bethany-based Agricultural Enterprises Corporation at Bethany, Oklahoma, offered this bermudagrass for sale in 1991. World Feeder bermudagrass has rhizomes and stolons and makes rapid growth. Data from both Oklahoma State University and Texas A&M University indicate World Feeder is less productive than most of the commonly used hybrid bermudagrasses, similar in forage nutritive value, and expensive to establish.

Common

Common bermudagrass is a highly variable cultivar in appearance that responds favorably to good management in East Texas. Common may be found growing under almost

every conceivable condition through the bermudagrass-growing region. It can be considered a forage grass, a turf grass or a noxious weed. Because of the long experience with common, it is often used as a standard for evaluating new material. Common dry matter yields are generally about one-third lower than Coastal and forage nutritive value is about the same, or slightly greater in crude protein in some instances. Common and other seeded varieties should be planted when soil temperature is at least 60° F and warming.

Giant (NK-37)

Giant is a strain of common bermudagrass with a more upright growth habit. It is less likely to form a sod, has longer leaves, finer stems, fewer rhizomes and stolons, and no pubescence (soft, fine hairs). Giant begins growing later in the spring than Common bermudagrass and is not as cold tolerant. In severe winters, damage can be high. However, the loss appears to be associated with disease damage and low fertility rather than as a direct result of low temperatures.

Giant does well in lower humidity climates. It is susceptible to leaf spot disease, and dry matter yield declines in 2 to 3 years due to cold weather and diseases. Plantings will typically become a Common bermudagrass stand.

Texas Tough Plus

Texas Tough Plus is a mixture of seeded bermudagrass blended and sold by East Texas Seed Company of Tyler, TX. The blend consists of one-third hulled common bermudagrass; one-third unhulled Majestic and one-third hulled Giant bermudagrass. Many blends of bermudagrass are available from other sources.

Cheyenne

Cheyenne is a cross between a bermudagrass from an old turf site in the Pacific Northwest and another plant from Yugoslavia. Jacklin Seed Company and Pennington Seed developed and released this cultivar in 1989. Like common bermudagrass, Cheyenne is established using seed. Cheyenne, although apparently slow to become established, produced well the last two years of a five-year evaluation trial at Overton, TX.

Tierra Verde

Tierra Verde, like Texas Tough, is a mixture of Giant and common bermudagrass. The Tierra Verde blend is 50% hulled and unhulled Giant and 50% hulled and unhulled common. In a five-year variety evaluation trial at Overton, TX, Tierra Verde averaged 6,967 lbs DM/acre, placing third among seeded varieties (Table 7).

Other Bermudagrass Varieties

There are several other varieties of bermudagrass grown in Texas, including both public and private releases. Varieties include ‘Russell’, ‘Sheffield’, ‘Zimmerly Select’, ‘Wrangler’, ‘Ozarka’, and ‘Midland 99’. Most of these varieties, however, offer no advantages over the more popular hybrids (Coastal, Tifton 44, Tifton 85) used in Texas. Exceptions could be Midland and Ozarka, which have good yield potential and exceptional cold tolerance. These varieties could prove useful north of a Texarkana-Dallas-Abilene line in Texas. For more information on bermudagrass varieties see E-320, *Bermudagrass Varieties, Hybrids, and Blends for Texas*.

Dallisgrass

Dallisgrass (*Paspalum dilatatum* Poir.) is native to South America, and the first noted specimen was collected in Louisiana in 1842. The grass is a tufted, leafy, deep-rooted perennial. It is palatable and produces forage greater in nutritive value and palatability than bahiagrass and some bermudagrasses. It initiates growth earlier in the spring and grows later into the fall than most warm-season grasses. Dallisgrass can be an important pasture grass for the following reasons:

1. It produces forage of good nutritive value and can retain this nutritive value late into the summer.
2. It grows well with bermudagrass, white clover, and annual ryegrass.
3. The forage is palatable to cattle.
4. It persists under heavy grazing.
5. It is adapted to poorly drained loam and clay soils common in parts of the South.

The disadvantages of dallisgrass are lower dry matter production compared to some bermudagrass varieties, difficulty with establishment, and susceptibility to ergot (*Calviceps* spp.)

infection which can be toxic to cattle when infected seedheads are consumed. Seed availability also may be a problem for those wishing to establish this species.

Dallisgrass responds to fertilization up to approximately 150 to 200 lbs N/acre. Phosphorus and potassium should be applied based on soil test recommendations. No nitrogen should be used if white clover is grown as a companion crop, which is a common practice since both dallisgrass and white clover tend to favor similar sites.

Pearl Millet and the Sorghums

These warm-season annual grasses are popular both as grazing and hay forages. Pearl millet (*Pennisetum glaucum* (L.)) and the various *Sorghum* spp. (sudangrass, forage sorghum, sorghum-sudan hybrids) have good heat and drought tolerance. Both types of grass, however, tend to accumulate nitrates to toxic levels when drought affects plant growth, especially in the presence of N fertilizer. Because the sorghum types can also produce toxic levels of prussic acid, their best use may be as hay crop since the prussic acid volatilizes out of the forage during the field curing process. Pearl millet, which does not produce prussic acid, may be the better choice as grazing forage though nitrate toxicity can still be a problem.

Both pearl millet and sorghum are generally planted at approximately 18 to 25 lbs/acre. Increased seeding rate (up to 45 lbs/acre) may decrease stem diameter and improve curing time of sorghums planted for hay harvest. Smaller stem diameter also promotes quicker recovery from cutting or grazing.

There have been positive responses for both the sorghum-sudan hybrids and pearl millet to N fertilizer up to 400 lbs N/acre. However, most production systems will use approximately 200 lbs/acre for hay production. Grazing systems may only use 50 to 75 lbs N/acre. Application rates greater than 100 lbs N/acre should be split-applied to minimize loss due to leaching on sandy soils and reduce nitrate accumulation potential. Phosphorus and potassium should be applied based on soil test recommendation and pH should be maintained between 6 and 7. Dry matter production of these forages can exceed 10 tons/acre if adequate moisture is received and the appropriate level of fertility is used. Forage nutritive value can be good if the grasses are harvested at the right stage of maturity. To maximize regrowth, either for a hay crop or in a grazing pasture, plants should not be harvested lower than six inches. This helps to stimulate regrowth from the terminal buds. Plants harvested below six inches may experience reduced re-

growth or even plant death. To maximize production for hay with high nutritive value, plants should be harvested as they attain heights of 32 to 48 inches. Most uniform grazing and the least amount of waste occur if grazing is initiated when plants are 20 to 28 inches tall.

Although these warm-season annual grasses can be productive, producers who use them should be aware of the situations that can produce toxic levels of nitrate accumulation or prussic acid poisoning. For more information see AgriLife Extension publication, *Nitrates and Prussic Acid in Forages: Sampling, Testing and Management Strategies*.

Teff

Teff (*Eragrostis tef*) is a warm-season annual grass from Ethiopia that is finding acceptance in the US for those wanting a quick growing annual that reportedly has no nitrate accumulation or prussic acid issues. Producers in the Dakotas like the fact they are able to obtain multiple hay harvest under good growing conditions during their relatively short growing season. Teff is also gaining favor as a horse hay. Seeding rate is 5 lbs PLS/acre. Fertility requirements and yield have not yet been documented in Texas.

Crabgrass

Crabgrass (*Digitaria* spp.) is a warm-season annual grass well adapted to much of the US including Texas. It is a reliable producer of forage high in nutritive value when moisture is available. Crabgrass responds to good management just as other forages. For grazing, up to 100 lbs of N/acre is adequate; up to 200 lbs of N/acre per harvest can be applied for hay production if moisture is adequate. Phosphorus and K should be applied based on soil test recommendations and soil pH, ideally, should be 6.0 or higher. One disadvantage of crabgrass is it must be managed for re-seeding if the species is to persist.

Native Grasses

Input costs associated with owning grazing livestock, whether cattle, sheep, goats, or horses have increased significantly over the past several years, so much so many livestock producers are considering forage varieties not requiring as much fertilizer as bermudagrass. At the same time, many landowners have expressed interest in restoring native prairies for wildlife habitat enhancement. Native grasses are well-adapted and quite persistent with good grazing management, but typically are not used for hay production. Native grasses may require longer

time to establish and are less tolerant of overstocking. If interested, check with your local county extension agent, NRCS personnel, or Texas Parks and Wildlife Department biologist to determine which species are best adapted to your property.

Other Warm-Season Grasses

There are other varieties of warm-season grasses suited for more arid environments such as South Texas, the Edwards Plateau, and North Texas. These varieties include the various Old World bluestems, buffelgrass, kleingrass, and weeping or Wilman lovegrass. Before attempting to establish any forage in an arid environment, check with local professionals to determine the viability of such an undertaking.

Warm-Season Legumes

Cowpeas

Cowpeas (*Vigna unguiculata*) are annual, viney plants with large leaves. The species is fairly tolerant of drought, low fertility, and a wide range of soil pH including moderate soil acidity or alkalinity. Cowpeas, however, do require adequate levels of P and K to be productive. Forage nutritive value is generally high and plants are easily established during May through June. Many times cowpeas are used as a warm-season planting for white-tailed deer to offset the negative effects of summer stress. Allowing growing beef animals to have creep access to cowpeas provides for enhanced animal performance during summer when forage nutritive value of other species is typically reduced. Cowpeas do not cause bloat in ruminants, but depending on previous exposure to legume forage by cattle, may not be found immediately palatable by cattle and are generally planted for white-tailed deer. Forage cultivars include 'Iron & Clay' and 'Red Ripper.'

Annual Lespedezas

The annual lespedezas [Common (*Kummerrowia striata*) and Korean (*Kummerrowia stipulacea*)] are tolerant of acidity and low P soils; thus, these species are well adapted to infertile sites and offer forage of moderately high nutritive value during late summer under low-input production systems. Seed should be planted at 25 to 35 lbs/acre during March or April. Light grazing pressure will generally still allow the plants to re-seed. Yield is less (1-2 tons/acre)

than other warm-season forages such as bermudagrass or the sorghum annual grasses. As with cowpeas, growing animals perform well when allowed creep access to lespedeza pastures.

Lablab

Lablab (*Lablab purpureus*) is a vining, herbaceous tropical legume with high nutritive value as a forage or browse for ruminant animals. Useful qualities of this tropical forage include drought tolerance, high palatability and nutritive value, excellent forage yields and adaptation to diverse environmental conditions.

Currently, seed of the Australian lablab cultivar 'Rongai' is imported into the US primarily for supplemental forage plantings for white-tailed deer. Rongai was released by the New South Wales Department of Agriculture in 1962. Rongai is very late maturing and generally does not flower in northeast Texas before frost. 'Rio Verde' lablab was developed through selection for tolerance to defoliation, forage production potential and Texas seed production. 'Rio Verde' was developed at the Texas A&M AgriLife Research and Extension Center at Overton, Texas, and released by Texas A&M AgriLife Research in 2006. 'Rio Verde' is the first lablab cultivar developed in the US and also has the value-added trait of Texas seed production. 'Rio Verde' was evaluated at four Texas locations in 2004 and two Texas locations in 2005. Forage production of 'Rio Verde' lablab was not different from Rongai in five of the six location-years and ranged from slightly more than 1.4 to 2.5 T/acre of dry forage at Dallas and Overton in 2004, respectively.

Soybeans

Although there is not a large selection of other warm-season legumes, soybeans (*Glycine max*) are adapted to many regions of Texas. Most are planted for white-tailed deer, although deer appear to prefer cowpeas or lablab to soybeans.

Cool-Season Grasses

Limited forage growth during fall, winter, and early spring causes many livestock producers to feed hay, silage, or concentrates. This winter-feeding program is generally expensive and can reduce profitability. More cost effective winter feeding programs generally

utilize some form of cool-season pasture. Note a higher level of risk is associated with winter forage programs due to the inconsistency of fall precipitation.

Although adapted cool-season perennial forage grasses could provide the least costly means of wintering livestock with the exception of tall fescue, suitable cool-season perennial forage grasses have not been identified for most portions of the South. Thus, cool-season annual forage grasses are the most commonly used forms of winter pasture. The following is a brief discussion of cool-season annual forage grasses used for winter pasture programs in the South.

Annual Ryegrass

Annual ryegrass (*Lolium multiflorum*) is indigenous to southern Europe and is a popular forage choice for late winter/early spring feeding of livestock. It grows on a wide range of soil types and grows better on wet soils than any other cool-season annual grass. Annual ryegrass is generally later in maturity, thus extending the grazing season well into spring. It establishes readily without any seedbed preparation and tolerates a high level of grazing pressure. With adequate moisture, annual ryegrass can produce large quantities of forage (mostly during the spring production phase) and is generally the most productive of all the cool-season annual grasses if appropriate levels of fertility and an adequate soil pH are provided. At Overton, several varieties such as TAMTBO, TAM90, Nelson, and Jumbo have demonstrated good dry matter yield over the past several years. For more variety information visit <http://overton.tamu.edu> and <http://varietytesting.tamu.edu>.

Rye

Rye (*Secale cereal* L.) also originated in Europe and is the most winter-hardy of the cool season annual grasses. Rye is also the most productive cool-season annual grass on soils low in fertility, well drained, acidic, and sandy in texture. It is not adapted to heavy soils that are poorly drained or stand water, but is more tolerant to acid soils relative to other small grain species. Rye generally produces more fall forage than spring forage and matures earlier in the spring than most wheat varieties. Because of this aspect, a mixed-planting of rye and annual ryegrass provides good seasonal distribution of forage production since ryegrass makes most of its growth during spring. The most popular rye varieties used in Texas have been developed by the NOBLE Foundation at Ardmore, Oklahoma. They are 'Elbon', 'Maton', and 'Maton II'.

Wheat

Wheat (*Triticum aestivum* L.) is grown on several million acres of land in the U.S., in many cases as a dual-purpose (grain + forage) crop. Most of the wheat acres in the Southern Plains are planted to hard red winter wheat, but in the south most wheat planted is soft red winter wheat. Although wheat is an excellent forage crop, rye usually produces more total forage, more forage in the fall, has greater cold tolerance, and is better suited to the acid, sandy soils encountered across much of the southern U.S. However, soft red winter wheat is more tolerant to wet growing conditions than rye. Generally, wheat is also better adapted to heavier-textured soils.

Oat

Oat (*Avena sativa* L.) originated as a domesticated crop in Europe and has been used as both food for humans and feed for livestock. Oat also provides excellent cool-season pasture for livestock and is a popular planting for white-tailed deer and turkey. Oat has the least cold tolerance of the cereal grains and this limits its use to generally the southern half of Texas. Oat and soft red winter wheat grow better on wet soils than the other cereal grains. Oat is planted both during late summer/early fall and in late winter/early spring for either pasture or hay. If planted in late summer/early fall, oat is more susceptible to winterkill than with later plantings. Popular varieties include 'Dallas', 'Harrison', and 'Heavy Grazer' and 'Bob'.

Triticale

Triticale (*Triticum secale*) is a unique species resulting from a cross between wheat and rye. Grain from triticale is used as a feed grain for the livestock industry. In Kansas, triticale has been shown to produce more forage than wheat or rye, be better adapted for early planting for fall forage production, provide a longer grazing period than wheat or rye, and has superior tolerance to drought, pests, and low pH when compared with wheat.

Barley

Barley (*Hordeum vulgare* L.), along with wheat, is thought to have originated in the Near East. This species is probably the least utilized of the cereal grains for pasture use since barley is

generally grown for grain used in the brewing industry. Barley is less winter-hardy than wheat and rye and winterkilling could be a problem during especially severe winters. Barley can provide good winter pasture, although other cereal grains typically provide better alternatives. Of the cereal grains, barley is the most tolerant of saline and alkaline soils, and thus, may provide pasture on soils less productive when other cereal grains are used. Barley does not grow well on very sandy soils and is generally used primarily on soils with high pH. Currently, there is renewed interest in barley as a forage crop in Texas.

Tall Fescue

Tall fescue (*Festuca arundinacea*) is a cool-season, perennial bunchgrass arriving in North America from Europe in the late 1800's. Since the discovery of a field of tall fescue in eastern Kentucky in 1931 and the subsequent release of the 'Kentucky 31' variety in 1943, tall fescue has become the dominant cool-season perennial grass in the southeastern United States. Most commonly referred to as a "fescue," tall fescue is used for forage and erosion control.

The species is best adapted in Arkansas, Missouri, Tennessee, and Kentucky. Tall fescue, however, is also found in abundance west into eastern Oklahoma and northeast Texas.

Tall fescue grows on a wide variety of soil types, but it performs best when grown on loam or clay soils with some water-holding capacity. Tall fescue will also grow well on soils typically too wet for most other forage grasses, but will not tolerate flooded conditions. Conversely, tall fescue should not be planted on extremely droughty sites or on deep sands.

The Endophyte Challenge

The term "endophyte" refers to a fungus, *Neotyphodium coenophialum* hidden within a plant and may be either parasitic or symbiotic in its relationship with the host plant. The endophyte lives within the fescue plant itself and grows between the cell walls. The fungus obtains its nutrition from plant materials and since plant cells are not destroyed it is impossible for a producer to determine infection simply by looking at the fescue plant.

Both endophyte and fescue plant benefit from their relationship. The fescue plant provides the endophyte a source of nutrition, protection from the environmental elements, and a means of reproduction. The endophyte either produces a number of other alkaloids or is responsible for plant production of the alkaloids providing the plant with resistance to insects,

nematodes, and certain environmental stresses such as drought. The endophyte also enables the fescue plant to tolerate close, continuous grazing.

However, the alkaloid compounds produced as a result of the fescue-endophyte infection create a number of adverse effects in grazing livestock. The beef cattle industry alone experiences an estimated \$600 million dollar annual loss due to endophyte-induced alkaloids. Bred mares grazing endophyte infected tall fescue during the last trimester of pregnancy may experience several negative effects including abortion, stillborn foals, agalactia (reduced milk production), prolonged gestation and thickened placentas.

Removal of the endophyte from the fescue plant and the resulting removal of the alkaloids cause the fescue plant to be more susceptible to insects, certain plant diseases, drought, and close grazing. Some recent research has suggested a “novel” or friendly endophyte-infected tall fescue variety can provide the positive benefits of the endophyte, but none of the negative.

There are two basic approaches to minimizing the negative effects of endophyte-infected tall fescue: learn to manage the grass properly, or renovate the existing fescue. When renovating, the choice may be to re-establish the field to a warm season perennial grass, or to re-establish to the novel endophyte-infected tall fescue varieties. Many producers have found tall fescue to be a valuable component of their pasture systems, if not the primary forage base of their livestock operations. Those who successfully utilize tall fescue have learned to dilute and minimize the toxic effects for cattle by overseeding clovers or by providing other forages such as a dry hay. These management strategies do not work in the case of horses. Producers should not allow cattle to graze endophyte-infected tall fescue after about May 1. Alkaloid compounds in the plant are higher during this time of year, while fall forage and early spring forage are relatively low in alkaloid compounds.

Establishment of Cool-Season Grasses

Cool-season annual forage grasses are well adapted to most regions of Texas with soil texture generally the most important factor in adaptability of each species. The choice of species, therefore, is largely dependent on the producer’s management philosophy and livestock production needs. Be aware cool-season annual grasses can produce different levels of forage (Figure 1). Regardless of species, it is important cool-season annual forage grasses be established under a fairly narrow set of conditions to ensure maximum success potential.

Maximum fall forage production is generally a function of moisture, planting date, planting method, and fertility. Adequate stored soil moisture can be critical to maximizing forage production; thus, many producers choose to leave cool-season annual pastures fallow during the warm months of the year to conserve soil moisture.

Where moisture is generally not limited, such as in East Texas, cool-season annual forages may be successfully sod-seeded into warm season perennial grass swards. This practice is used to increase forage nutritive value, extend the grazing season, and reduce winter feeding costs. The warm season grass, however, should be grazed or mowed short prior to establishment of cool season annual grasses. When sod-seeding cool season forages into warm season pastures, a light disking operation can improve establishment and early forage yield.

A soil sample should be obtained well before the time to establish the cool season pasture. Adequate P and K should be present and soil pH should be 5.5 or higher. If planting into a clean-tilled seedbed, necessary P, K, and especially limestone should be incorporated into the soil ahead of planting. Phosphorous can also be applied at planting in the seed furrow as 18-46-0. If overseeding into a warm-season grass sod, P, K, and limestone can be surface-applied with good results.

Nitrogen is generally second only to moisture as a limiting factor to plant production. On heavy-textured soils and where available, N fertilizer may be applied as anhydrous ammonia pre-plant in clean-tilled seedbeds. Typically, however, N is applied as a dry form of inorganic N fertilizer, such as ammonium nitrate or urea and either incorporated into the seedbed during preparation, or as a top-dress at various times during the forage growth cycles. Liquid formulations of N, such as 32-0-0, may also be used to top-dress forages.

Nitrogen application rates will vary with region of the state. In East Texas, 100 to 200 lbs of actual N per acre may be required for small grain-ryegrass combinations. As fields are planted further west in the state, less N is applied due to reduced moisture availability.

Planting for fall pasture should be made as early as possible to allow maximum forage production prior to winter dormancy, but this is a region specific. In Central and Northeast Texas, for example, late-summer plantings on prepared seedbed (i.e., late August, early September) can capitalize on the bimodal precipitation pattern to provide pasture for grazing by late October or early November. If sod-seeding, then a mid-October time frame would be more

desirable to capitalize on the somewhat reduced growth rate of the warm-season perennial grass. If planting in South Texas, the timing could very well be later in the year.

Seeding rate and planting depth can be critical elements in stand establishment. Small grains are generally seeded at 90 to 100 lbs PLS/acre. Tall varieties of wheat can be planted as deep as two to three inches in late August and produce good stands. This aspect can be important for later summer plantings when producers attempt to plant to soil moisture. Semi-dwarf wheat, on the other hand, suffers from poor emergence if planted greater than one inch due to a much shorter coleoptile (a protective sheath covering the emerging shoot) length. Rye should not be planted any deeper than three-fourths inch. Ryegrass is generally not drilled, as are the small grains, but simply broadcast at a rate of 30 lbs PLS/acre over a field generally as part of a fertilizer application. For more information, see *Forage Establishment Fundamentals*, SCSC-2015-05 and *Annual Winter Pastures for East Texas*, SCSC-2006-05.

Cool-Season Legumes

Legumes may be used in much of the eastern one-third of the state where moisture is not limiting as a means of extending grazing season length, increasing the nutritional plane of grazing livestock, and/or reducing the amount of N fertilizer required in a pasture program. Several forage legumes are widely adapted to and used in Texas. Most species make good hay and are relished by both cattle and white tailed deer. However, baling legume hay requires much experience. If baled too dry, there is much leaf shatter loss and baled too moist results in fungal growth and additional potential problems. Some of the important forage legumes are listed below.

Alfalfa

Alfalfa (*Medicago sativa* L.) is the most important perennial forage legume for hay production and is sometimes used for grazing. Proper soil fertility and pH along with well-drained soils are critical for high forage yields and long-lived stands.

Alfalfa is normally sown between mid-September and mid-October without a companion crop. Companion crops may be useful to help control wind erosion on sandy sites, but generally use much of the required moisture as well as compete for light and nutrients. This competition reduces the potential for a successful stand of alfalfa.

Alfalfa growth begins in March and continues until the onset of short days and cold temperatures or until drought-induced dormancy. Harvesting for hay at 28- to 35-day intervals followed by a four-week recovery period will generally maintain good stand life and high production. Work at the TAMU-Overton Center indicated alfalfa stand life may be reduced under grazing, but has good sustainability as a hay crop.

Arrowleaf Clover

Arrowleaf clover (*Trifolium vesiculosum* Savi.) is a relatively late-producing cool season annual clover with most of its growth during April and May. Arrowleaf clover typically matures during late May through June. If conditions are favorable during early fall (short grass sod, good moisture, adequate temperature) some growth may be available for grazing in later fall or early winter.

Arrowleaf clover is not adapted to highly calcareous or wet soils and has some degree of drought tolerance. Bloat potential with arrowleaf clover is low and which is a good choice for pasture mixes where adapted. When arrowleaf clover is kept grazed to a height of three to four inches during spring, livestock may continue to graze until early June or later. If a hay crop is desired, grazing should be terminated in early to mid-May. This allows the clover a chance to regrow before cutting and may reduce some of the problems associated with making hay during the typically rainy May weather in Texas. Because of its late maturity, arrowleaf clover can pose a problem with early season growth of warm-season grasses; thus, special consideration should be given to management of this species to minimize negative effects on warm-season grass pastures.

Due to virus and fungal problems, 'Yuchi' arrowleaf clover has not been a reliable forage producer in East Texas for the past several years. Another variety, 'Apache' developed at the Texas A&M AgriLife Research Center, Overton, TX, is virus tolerant and provides good forage production later into the season compared with virus-infected Yuchi. A new variety (2012), 'Blackhawk' also developed at the Texas A&M AgriLife Research Center, Overton, TX, has multiple disease tolerance (both bean yellow mosaic virus and *Pythium ultimum*). Blackhawk seed are 95% black with only slight variation in degree of dark color. Blackhawk is slightly earlier in maturity than Apache arrowleaf and is in full-bloom around May 10 at Overton, TX.

With proper grazing management, arrowleaf clover is an excellent reseeding annual due to the high percentage (70 to 90%) of hard seed produced. If managed for reseeding, the arrowleaf clover stand may remain viable for many years.

Austrian Winter Peas

Austrian winter peas (*Pisum sativum*) may produce a moderate amount of dry matter used for grazing, as a hay crop, or as a green manure. Winter peas are often used as companion crops with cereal grains and are high in nutritive value.

Winter peas are easily established on well-drained loam or sandy loam soils and should be planted during September or October at 20 to 30 lbs of PLS/acre in pure stands. Austrian winter peas are intolerant of low pH soils.

Ball Clover

Ball clover (*Trifolium nigrescens* Viv.) is a low-growing annual clover similar in appearance to white clover. It tolerates a wider range of soil pH than white clover, but does not do as well on the wet sites. Ball clover is intermediate in maturity to crimson and arrowleaf clover, has good dry matter production, and reliably re-seeds. Commercial seed availability is low and restricted mainly to clover grown for seed by a few producers in Central Texas and the southeast US.

Berseem Clover

Berseem clover (*Trifolium alexandrinum* L.) grows to a height of two feet or more. This annual clover is adapted to wet, alkaline sites. Berseem clover can provide fall forage but produces peak forage during March through June. Grazing should keep plants between three and four inches in height to encourage new leaf production. Berseem clover is not a particularly good reseeding species but does not cause bloat problems. Similar to arrowleaf clover, special management is required when overseeding this species into warm-season grass pastures due to its maturity. Berseem may best be used in pure stands rather than as a sod-seeded species.

Common Vetch

Common vetch (*Vicia sativa* L.) is less cold tolerant than hairy vetch and not as tolerant of poorly drained soils. Common vetch, along with hairy vetch, is generally more tolerant of acid soils than most other forage legumes. Like other legumes, common vetch can provide N to the pasture system and improve the nutritive value of early spring forage.

Crimson Clover

Crimson clover (*Trifolium incarnatum* L.) is well adapted to the Gulf Coast regions and is an early clover with peak production occurring in March through April. Crimson clover is similar to arrowleaf clover in areas of adaptation. It will not tolerate calcareous or poorly drained soils but is better suited to acidic soils than arrowleaf clover. Crimson clover may be successfully established into bermudagrass by drilling the seed into a pasture that has been grazed or mowed short. Crimson clover is easy to establish and provides excellent forage. Crimson clover is a relatively poor reseeder due to lack of hard seed. The tendency is for the soft seed to germinate with late spring/early summer rains, but the plants die due to the heat and drought of summer.

Hairy Vetch

Hairy vetch (*Vicia villosa*) is a dependable, widely adapted cool-season annual legume used throughout the South. The plant has a large seed allowing seedlings to emerge through a thatch of three to four inches to reach sunlight. Hairy vetch is tolerant of acid soils.

Hairy vetch has a vine-like growth habit with peak production during March and April. Plants bloom in early May and will have mature seed by late May. If allowed to mature, hairy vetch has good reseeding capability.

Dry matter production is normally less than other cool-season annual legumes, but the plant is a dependable forage producer. Hairy vetch can be grazed or harvested as a hay crop. Cattle grazing pure stands of vetch have developed dermatitis (inflammation of the skin) similar to photosensitization. This has not been a problem when adequate grass was available. Cattle may develop muscular problems when grazing vetch, especially when the seeds are forming. Moving cattle to a pasture without vetch is the only practical way to control this problem.

Annual Medics

This group of cool-season annuals consists of several different species. In general, they resemble clovers but are actually closely related to alfalfa. Medics are best adapted to alkaline soils. Some examples of annual medics found in Texas that can make a significant contribution to forage production programs include: burr medic (*Medicago polymorpha*), button medic (*M. orbicularis*), little burr medic (*M. minima*), barrel medic (*M. truncatula*), spotted burr medic (*M. arabica*), and black medic (*M. lupulina*).

Little research has been conducted on the medics in the US. They originated from the Mediterranean area and are used as short-lived annuals. Medics germinate in the fall or early spring and terminate growth in May and June after flowering.

Except for burr and little burr medics, commercial seed for the annual medic species is normally difficult to find and the plant is seldom intentionally sown. Due to a large percentage of hard-seed coat, the seed may lie dormant in the soil for many years; but, when the medics do appear, they produce excellent forage for grazing and may produce an abundant seed crop. Producers should take advantage of these species and encourage their production. Two released varieties from Texas A&M AgriLife Research Beeville include 'Armadillo' burr medic and 'Devine' little burr medic. Armadillo has shown great potential where cold weather is not a concern. Devine is best adapted in the I-35 corridor from south of San Antonio to nearly the Oklahoma border. Recommended seeding rates are 3 to 5 lbs PLS/acre. Devine grows well with most perennial grasses provided the grasses are managed to be grazed short in the fall to allow for establishment.

Red Clover

Red clover (*Trifolium pratense* L.) is a short-lived perennial with an upright growth habit that may be used as pasture or as a hay crop. Due to a long growing season, red clover typically is the greatest yielding clover in areas of adaptation. In Texas, however, red clover is an annual and has limited use in commercial pastures. Red clover is typically planted during September through early October or February through March, at 6 to 8 lbs of PLS/acre in drill rows or 12 to 15 lbs/acre broadcast. Soil pH should be above 5.5 for maximum production.

Red clover is not as long-lived as alfalfa; however, stands of red clover may be maintained for many years by reseeding with 2 lbs of PLS/acre every two to four years. Due to

its late maturity date, when red clover is overseeded into warm-season grass pastures it requires special consideration so grass production is not adversely affected.

Rose Clover

Rose clover (*Trifolium hirtum* All.) is a cool-season annual somewhat new to the South. Most varieties of rose clover available in the past were earlier in maturity than either crimson and arrowleaf clover. Drought tolerance of rose clover, however, is typically greater than crimson or arrowleaf clover. Rose clover will not tolerate wet or poorly drained soils but is fairly tolerant of alkaline soils and soils of low fertility. If rose clover is allowed to produce seed the first year, a lower initial seeding rate may be used with a good stand becoming established in the second year.

Subterranean Clover

Subterranean (sub) clover (*Trifolium subterraneum* L.) is a dense, low-growing, annual legume of medium maturity that withstands close grazing and continues to produce seed. Following pollination of the small white flowers, the flowers “peg down” and the seeds develop on or just under the soil surface. Sub clover develops very little hard seed under East Texas growing conditions; therefore natural re-seeding of this species is often unreliable.

Sub clover normally reaches no more than six or eight inches in height and is not as productive as arrowleaf or crimson clover. Sub clover is not well suited for hay production.

Sub clover is more tolerant of acid soils than most clovers, but with the exception of a few varieties, generally does not tolerate a pH above 7.0. Sub clover is tolerant of close continuous grazing and is more tolerant of shade than other legumes, but does not do as well as other clovers in grass sods.

Sweetclover

White (*Melilotus albus* Medik.) and yellow sweetclover (*Melilotus officinalis*) can be either annual or biennial and can produce 2 or more tons of forage/acre. Sweetclover is very similar to alfalfa and has great value as a soil improving crop when and plowed and incorporated into the soil as a green manure crop. It is best adapted to clay or loam soils at near-neutral or higher soil pH.

Sweetclover is relatively drought tolerant and winter hardy and either of the species may be planted in spring or autumn at 10 to 15 lbs of PLS/acre. Coumarin, an aromatic compound found in sweetclover forage, reduces the palatability to livestock until they become accustomed to the bitter taste. Dicoumarol, a toxic substance developing from coumarin during heating and spoiling of wet sweetclover hay, reduces the blood-clotting ability of animals and may result in their death. This problem has been overcome by the development of low-coumarin sweetclover varieties, such as Denta, Polara and Norgold.

White Clover

White clover (*Trifolium repens* L.) is a perennial legume common across most of the southern US. While perennial in nature, in Texas white clover generally persists as a re-seeding annual. Common white clovers are of shorter stature and do not exhibit the larger leaf of the taller ladino varieties. White clover requires good soil moisture, is usually found on clayey, bottomland soils, and is not productive under droughty, upland conditions.

White clover is often planted at 3 to 4 lbs of PLS/acre into existing tall fescue or bermudagrass stands. Best production will be obtained on fertile, well-drained soils if rainfall is favorable. White clover will tolerate wet soil conditions better than most legumes. Because it is often found on wetter sites, white clover may survive a drought during the summer months better than other forage legumes.

White clover does not exhibit the same erect growth habit as red clover and mixed grass-clover stands should be grazed fairly close to prevent competition for sunlight. While cattle are grazing pure stands of white clover, bloat potential may be reduced with free-choice access to grass hay or if grown as a companion crop with a grass species. As with red clover, broadcasting 1 or 2 lbs of PLS/acre in the fall or winter may be necessary to maintain a stand for several years.

‘Neches’ white clover is a recent release from Texas A&M AgriLife Research, Overton, TX. Neches flowers early compared to ‘La S-1’ and slightly earlier than ‘Durana’, being in full bloom by mid-April at Overton, TX. Leaf size of this new cultivar is 20% larger than Durana. Forage yield is generally equal to La S-1 and other check white clover cultivars.

Legume Fertility Requirements

In general, legumes are typically more sensitive to soil nutrient deficiencies than are forage grasses. However, because of the symbiotic relationship with *Rhizobia* bacteria, N fertilizer is generally not required. An annual soil test should be used to determine the need for P, K, micronutrients (such as boron), and limestone. Phosphorus and K are particularly critical to maintain a productive stand of legumes. Legumes are more sensitive to low soil pH than most forage grasses and, recommended limestone should be applied when soil pH values fall below 6.0.

Legumes in Grass Pastures

Many legumes may be successfully established into grass pastures. One popular strategy is to sod-seed (no-till) cool-season annual legumes into bermudagrass pastures. The bermudagrass must be carefully managed to ensure a minimum amount of residue remains at the time of establishment. If the bermudagrass canopy is not removed, emerging legume seedling will not be able to compete for sunlight and become established. Forage canopies may be removed by grazing (recommended) or by mowing. Proper use of a cool-season annual legume in bermudagrass will provide forage of high nutritive value during the late winter and early spring, and the legume will serve as a source of N for early bermudagrass growth. This may help reduce the requirement and expense of N fertilizer. It can also be important to choose a legume with a relatively early to moderate maturity date producing a high percentage of hard seed.

Another popular strategy for utilizing legumes in a grass pasture is to mix red or white clover into a tall fescue or other cool season grass pasture. The tall fescue has a negating effect on the bloating potential of legumes, and legumes may play a role in reducing the effects of fescue toxicity. A higher level of management is required for this type of program, but the effort may result in improved animal performance and reduce the need for N application.

Inoculation

When properly inoculated, legumes generally do not require N fertilizer and can produce a significant amount of N because of a symbiotic relationship with *Rhizobia* bacteria. In the symbiotic relationship, bacteria extract atmospheric N and convert it to a plant-available form within root systems of legumes. The amount of N produced will vary between species, sites, and years but can range from as little as 30 up to 150 lbs/acre. While it is possible to establish

legumes without the N-fixing bacteria, N fertilizer must be applied and the economic advantage is lost.

In pastures where legumes have been used in the past, the *Rhizobia* bacteria may persist for several years. However, when initially establishing legumes, the proper type of bacteria (inoculant) must be introduced into the forage system. This is known as inoculation. Inoculation of seed occurs before planting and is accomplished by applying a sticking agent to the seed and then adding inoculant. The inoculation should be applied immediately prior to planting the seed.

Inoculated seed should be planted the same day, and not stored in a location where the seed will be subjected to high temperatures for a lengthy period of time nor should the seed be mixed with fertilizer. Both practices can be lethal to the bacteria.

The most reliable method is to inoculate legume seed with the proper *Rhizobia* each time the seed is planted regardless of the pasture history. *Rhizobia* bacteria are host specific and the appropriate strain of bacteria should match the legume being established. Commercial packages of inoculant list the legume species for which the *Rhizobia* are effective.

Commercial sticking agents are available from those who provide the inoculant and generally these provide the most appropriate method for inoculating legume seed. A 10 to 50% solution of sugar/water or syrup/water may also be used to moisten the seed so the inoculant will adhere, but these are not as effective as the commercial sticking agents. Pre-inoculated or coated seed is available for many, if not most, legume varieties and reduces the labor requirements for establishment considerably. For additional information regarding forage legumes, see *Biological Nitrogen Fixation*, SCSC-2001-13 and *Planting Winter Annual Legumes*, SCS-2001-16

Hay Production

Hay production can result in degradation of the soil nutrient status if a sound soil fertility strategy is not used. This is due to soil nutrients being continually mined from the soil, and if they are not replaced in an appropriate manner, soil productivity is reduced. Many soils test low and very low in P and/or K. Typical fertilizer strategies may involve limited application of these nutrients, but often only N is applied under the false impression it is the only nutrient bermudagrass requires. Nothing could be further from the truth. It takes all of the essential plant nutrients in appropriate amounts for bermudagrass to produce the high yields for which it is known.

Think of the hay harvest as a checkbook with a low account balance. If a check is written, but no deposit made to cover the check, the account will be overdrawn in short order. If however, a deposit is made to cover each check written, the account balance will not decrease. In the same manner, each hay harvest represents a check written on an account already low in phosphorus and/or potassium. A typical 2-ton hay harvest from bermudagrass removes approximately 100 lbs N, 30 lbs P₂O₅, and 90-100 lbs K₂O. If the soil test for P and/or K is low or very low, consider returning this level of nutrients back to the hay field after each harvest. This helps to minimize continued mining of the soil at the site. Another option would be to rotate hay fields in and out of production and allow certain fields to be grazed for a few years before harvesting hay again. This practice would allow grazing animals to return P and K to the soil via urine and feces. For more information, see *Hay Production in Texas*, E-273, available through the AgriLife Extension Bookstore.

Summary

Forages in Texas form the basis for several important grazing livestock agricultural enterprises. Texas, however, is a diverse state with regard to climate and soil types. Not all forage species are well adapted or suited to all regions of the state. Not all forages are managed the same, although many fundamentals will apply regarding adequate fertility and proper grazing management. Prior to selecting any forage for establishment, determine the potential for successful use of each species based on comparative research data from professionals in your part of the state. Finally, by paying close attention to management details, forages in Texas can play a vital role in helping your forage-based operation achieve the success you desire.

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Table 1. Value of commodities produced in the United States.

Commodity	Value¹ (\$)
Barley	1,271,986,000
Corn	62,716,048,000
Cotton	5,198,750,000
Cows and calves	48,200,000,000
Hay	20,211,663,000
Rice	3,025,992,000
Rye	60,307,000
Soybeans	41,837,286,000
Sugar beets	2,338,789,000
Sugarcane	1,348,361,000
Tobacco	1,574,982,000
Wheat	14,404,734,000

¹All values are based on 2013 statistics except sugar beets and sugar cane (2012).

Source: USDA National Agricultural Statistic Service.

Table 2. States comprising the US southern region, estimated number of cows and calves, and their estimated value.

State	Number of head¹	Value (\$)
Alabama	1,240,000	429,349,000
Arkansas	1,660,000	766,476,000
Florida	1,620,000	531,869,000
Georgia	1,000,000	403,172,000
Kentucky	2,090,000	1,033,722,000
Louisiana	790,000	249,963,000
Mississippi	930,000	332,491,000
Missouri	3,800,000	1,968,617,000
North Carolina	810,000	332,733,000
Oklahoma	4,300,000	3,402,919,000
South Carolina	360,000	92,352,000
Tennessee	1,760,000	735,511,000
Texas	10,900,000	13,013,127,000
Virginia	1,530,000	707,976,000

¹Cattle including calves inventory (First of January 2014)

Table 3. Forage nutritive value of bahiagrass, bermudagrass, and mixed warm-season grass hay.¹

Hay Type	Crude Protein	Total Digestible Nutrients % DM	Acid Detergent Fiber
Bahiagrass	8.3	50.0	44.2
Bermudagrass	10.7	54.4	40.4
Mixed Grass	9.3	50.7	43.1

¹Twidwell, E.K. 1992.

Table 4. Coastal bermudagrass dry matter (DM) yield as affected by fertilizer and broiler litter application. ¹

Application rate (lbs /ac.)	DM yield 1992 (lbs/ac.)	DM yield 1993 (lbs/ac.)
N-P₂O₅-K₂O		
0-0-0	4780	4050
100-33-67	7140	6450
200-67-134	8680	8290
400-134-268	9640	10460
Poultry Litter (tons/ac.)		
2 SPR + 2 SUM ²	7480	6930
4 SPR	8320	7450
4 SPR + 4 SM	8850	7840
8 SPR	9810	9270

¹Evers, 1998

²SPR is late spring and SUM is mid-summer.

Table 5. Coastal bermudagrass crude protein (CP) content as affected by fertilizer and broiler litter application rate.¹

Crude Protein (% DM)										
Application rate (lbs/ac)	1992					1993				
	June 11	July 9	Aug 6	Sept 8	Oct 7	May 7	June 17	July 19	Aug 23	Sept 22
N-P20-K20 (lbs/ac)										
0-0-0	11.2	9.4	9.8	10.0	8.9	11.5	9.4	6.6	8.9	8.1
100-33-67	13.2	10.1	13.1	11.8	9.0	19.8	8.5	9.3	9.5	9.3
200-67-134	14.2	11.2	15.0	14.6	11.5	20.3	9.8	11.7	10.0	10.3
400-134-268	16.8	13.1	16.9	16.4	14.3	21.8	14.3	12.8	11.1	12.9
Poultry Litter (tons/acre)										
2 SPR + 2 SUM ²	13.0	10.4	13.0	11.9	9.4	13.7	10.4	7.8	10.1	10.0
4 SPR	13.4	10.5	10.2	10.7	8.8	18.1	10.0	7.0	9.8	10.3
4 SPR + 4 SUM	13.8	11.3	15.5	14.2	9.6	17.0	11.7	10.1	10.9	11.8
8 SPR	15.9	13.8	13.1	12.5	10.1	22.3	14.3	9.5	9.5	10.6

¹Evers, 1998.

²SPR is late spring and SUM is mid-summer.

Table 6. Effect of clipping frequency on yield and nutritive value of 'Coastal' bermudagrass hay.¹

Clipping Interval (wk)	DM Yield (tons/ac)	Leaf (%)	Crude Protein (%)	Lignin (%)
1	6.3	--	21.4	--
2	7.8	87.6	20.8	9.4
3	8.6	81.3	18.8	9.6
4	9.7	74.8	17.0	10.3
6	12.6	57.7	13.8	11.2
8	12.5	51.4	12.2	12.0

¹Burton and Hanna, 1995.

Table 7. Comparison of seeded bermudagrass varieties at Texas A&M AgriLife Research Center, Overton, TX.¹

Variety	1997		1998	1999	2000	2001	AVG
	Grass	Weeds					
	DM (lbs/acre)						
Texas Tough	2480	523	5262	11749	6997	10993	7496
Ranchero Frio	1943	291	2912	8984	9116	12428	7077
Tierra Verde	2085	159	4885	9054	7065	11748	6967
Cheyenne Common	2408	268	3430	6640	8159	13431	6814
Wrangler					6666	11352	9009
Giant					6239	7550	6895
					6591	6443	6617

¹Evers, 2002.

Figure 1. Dry matter production (lbs/acre) of various cool-season annual grasses at Overton, TX 2001-2002. Nelson, 2002.

