Texas Cooperative EXTENSION
The Texas A&M University System

Forages

Forages for Texas

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Forage and forage-based livestock production enterprises are big business in the US. Latest available USDA statistics (2001) indicate hay harvested in the US was worth approximately $12.6 billion. This made hay second in overall value among agricultural crops grown in the U.S. Only corn ($19.2 billion) exceeded the value of hay (Table 1). The value of all cows and calves in 2000 was estimated at approximately $72 billion with the gross income from beef cattle estimated at $36 billion that same year.

Table 1. Value of commondities produced in the U.S.

Commodity	Value[1] ($)
Barley	535,472,000
Corn	19,209,312,000
Cotton	3,383,732,000
Cows and calves	41,128,150,000
Hay	12,611,560,000
Rice	895,757,000
Rye	20,243,000
Soybeans	12,439,597,000
Sugarbeets/sugarcane	2,054,821,000
Tobacco	1,916,234,000
Wheat	5,553,815,000

[1] All values are based on 2001 statistics except for cows and calves and sugarbeets/sugarcane (2000)
Source: USDA National Agricultural Statistic Service.

Approximately 40% of the total cowherd is contained in 14 southern states (Table 2). Likewise, much of the hay produced also comes from these same states. It should be obvious, then, that forages play a major role in the economies of these states. While warm-season perennial grasses provide the base on which most operations are based, 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*) 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 more recent release from the USDA-ARS station at Tifton,

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

State	Number of head	Value ($)
Alabama	1,360,000	788,800,000
Arkansas	1,810,000	1,140,300,000
Florida	1,800,000	1,134,000,000
Georgia	1,270,000	800,100,000
Kentucky	2,260,000	1,469,000,000
Louisiana	860,000	533,200,000
Mississippi	1,070,000	631,300,000
Missouri	4,250,000	2,890,000,000
North Carolina	950,000	570,400,000
Oklahoma	5,050,000	3,232,000,000
South Carolina	445,000	280,350,000
Tennessee	2,170,000	1,302,000,000
Texas	13,700,000	8,357,000,000
Virginia	1,650,000	1,105,500,000
U.S. Total	**97,308,500**	**70,552,530,000**

Source: USDA National Agricultural Statistic Service, 2001.

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Georgia, 'Tifton 9' has exhibited increased seedling vigor and higher dry matter production compared with Pensacola. Nutritive value of Tifton 9 has been comparable with Pensacola.

Bahiagrass has several characteristics that make it valuable as a pasture grass. Bahiagrass grows on a wider range of soils than does bermudagrass or dallisgrass. Compared with hybrid bermudagrass, bahiagrass tends to green up earlier and remain green longer in the fall, but lacks the drought tolerance of the bermudagrass on deep sandy soils. Bahiagrass is resistant to weed encroachment due to an extremely thick sod formed and tolerates close, continuous grazing better than most other grasses. The species 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.

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 per acre, covered with no more than one-half inch of soil, and rolled to ensure good seed-soil contact. Higher seeding rates can help to quicken 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. Apply any needed P and K and 30 to 40 lbs./ac. of N at planting. Additional nitrogen (N) will only serve to encourage weed competition. After the grass begins to cover, 40 to 60 lbs./ac. of additional N may be used. Early weed management involves mowing or limited mob grazing. 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 reaches a thick, solid stand, weeds are seldom a problem. Ideally, bahiagrass should be fertilized 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 primarily be used for pasture, although some is harvested and conserved as hay. Producers used to harvesting bermudagrass hay should realize bahiagrass should be cut at a much lower plant height (eight to ten inches) if high levels of forage 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 higher levels of crude protein and digestibility (Table 3). Under low levels of fertility, bahiagrass, however, can persist for many years in relatively pure stands. Forage nutritive value is usually adequate for mature beef animals, but weaned growing animal performance 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 ryegrass may be advisable. In the past, producers have perceived it difficult to establish cool-season pasture in bahiagrass. This is generally due to the thick layer of rhizomes produced by bahiagrass. In order to reduce bahiagrass competition, the pasture should be grazed close and lightly disked. Clover or ryegrass seed should be broadcast sometime in mid-October. If using a cereal grain, 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 the bahiagrass. Once present, bahiagrass tends to remain and even become dominant in bermudagrass fields. Generally, 0.3 oz./ac. of the herbicide Cimarron (formally Ally) is required to eliminate mature plants. Without a change in fertility or grazing management, bahiagrass generally will re-establish from seed the following year.

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

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

[1]Louisiana State University

Bahiagrass establishment is slow and the species responds poorly to N fertilizer rates above 100 lbs./ac. 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.

To summarize, bahiagrass has a bad reputation, but only when compared with *well-managed* bermudagrass. Under more realistic circumstances of lower fertility and continuously stocked pastures, bahiagrass may not be so bad as a pasture grass. 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*) probably originated in southeast 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 that "*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 nearly 60 years with the introduction of 'Coastal' in 1943.

Bermudagrass is a warm-season perennial grass that spreads mainly by rhizomes (underground 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 of sprigs per acre. Seeded varieties are generally seeded at 8 to 10 lbs. of unhulled seed per acre for the quickest establishment. An initial soil test will indicate whether P 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. 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 many small-seeded annual grasses. A new label for

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

Application Rate (lb.s/ac.)	DM 1992 (lbs./ac.)	DM 1993 (lbs./ac.)
N-P_2O_5-K_2O (lbs./ac.)		
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]	7580	6930
4 SPR	8320	7450
4 SPR + 4 SUM	8850	7840
8 SPR	9810	9270

[1]Evers, 1998
[2]SPR is late spring and SUM is mid-summer

Grazon P+D indicates that 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/ac. should be applied along with the recommended K. When stolons begin to develop, another 40 to 50 lbs. N/ac. should be applied.

Although capable of high production, bermudagrass must be well fertilized to reach its production capability (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. Adequate pH is also important in maintaining a vigorous stand of bermudagrass. Inadequate levels of N not only limit bermudagrass dry matter production, but also reduces crude protein levels. Less than optimum bermudagrass growth can also invite weed infestation, thus reducing carrying capacity and increasing input costs. Careful attention to soil fertility, beginning with an **annual soil test** 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. 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 approximately $35.00 to harvest, bale, haul, store, and haul again to the feeding area. Regardless of the cost involved, however, bermudagrass hay production is a popular practice across most of the South. See more under the Hay Production section.

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

	Crude Protein (% DM)									
	1992					1993				
Application Rate (lbs/ac)	June 11	July 9	Aug 6	Sept 8	Oct 7	May 7	June 17	July 19	Aug 23	Sept 22
N-P_2O_5-K_2O (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/ac)										
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

[1]Evers, 1998.
[2]SPR is late spring and SUM is mid-summer.

Warm-season perennial grasses such as bermudagrass generally have lower nutritive value compared to warm-season annuals or cool-season forages. With a sound fertility practice (Table 5), however, 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 varieties 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 producing 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

Tifton 85 was developed by Dr. Glenn Burton of the USDA-ARS in cooperation with the University of Georgia Coastal Plain Experiment Station, Tifton, Georgia 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. In a three-year trial in Georgia, Tifton 85 produced 26% more dry matter and was 11% more digestible than Coastal. Animal gains are approximately 25% better than Coastal due to the higher digestibility. At Overton, Tifton 85 has remained green longer into the season than Coastal.

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

[1]Burton and Hanna, 1995.

Tifton 44

Dr. Glenn Burton developed Tifton 44 at the Georgia Coastal Plains Experiment Station as a cross between of Coastal and a cold-hardy plant surviving in Berlin, Germany for 15 years. Tifton 44 dry matter yield and disease resistance is similar to Coastal, but Tifton 44 has a slightly higher forage nutritive value and a greater 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. Tifton 44, like Coastal, is relatively slow to establish. Because of this slow development, it needs to be planted in soils that are 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 that Jiggs may perform better on tighter soils that are poorly drained than other bermudagrass varieties. There is no difference in nutritive value between Jiggs and Coastal. Little information is available regarding Jiggs, but the variety has generated a good following where it is used.

Common

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 throughout 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 with the forage nutritive value being about the same or slightly higher is crude protein in some instances.

Texas Tough

Texas Tough is a mixture of seeded bermudagrass blended and sold by East Texas Seed Company of Tyler, TX. The blend consists of one-third Giant and two-thirds common bermudagrass, one-half of which is hulled and the other one-half unhulled. At Overton, a five-year variety evaluation trial has indicated Texas Tough to be the most productive of-the seeded varieties in the trial, averaging 7,496 lbs DM/ac. over the five-year period (Table 10).

Alicia

Cecil Greer of Edna, Texas selected Alicia. Alicia was reportedly selected from bermudagrass collected in Africa in 1955. Franchise growers sold cuttings of aboveground material (tops) for the establishment of Alicia. Alicia spreads primarily by stolons and has fewer rhizomes than Coastal and is usually not as productive as Coastal (Table 7). Alicia is usually propagated by cuttings rather than by sprigs. Under moderate to heavy grazing and fairly severe winters it's recovery in the spring has been slow. The forage nutritive value of Alicia is lower than Coastal. Alicia is not as winter-hardy as Coastal and is susceptible to rust.

Table 7. Annual and average yield (lbs. DM/ac) of selected bermudagrasses.[1]

	Variety			
Year	**Coastal**	**Coastcross-1**	**Alicia**	**Common**
1971	5985	8443	6309	2751
1972	16459	18808	19033	14015
1973	15121	18806	13290	11816
1974	12849	13805	12711	9316
1975	19320	15761	15540	13443
1976	15773	14809	12960	11591
1977	14839	9583	11317	9977
Avg.	**14335**	**14288**	**13023**	**10416**

[1]Eichhorn et. al., Homer, LA. Annual fertilization = 500 lbs. N, 150 lbs. P_2O_5, 300 lbs. K_2O.

Table 8. Annual average crude protein content (% DM) of selected bermudagrasses.[1]

	Variety			
Year	**Coastal**	**Coastcross-1**	**Alicia**	**Common**
1971	14.6	14.8	15.4	15.2
1972	13.3	13.0	12.8	13.4
1973	12.6	10.8	12.5	13.9
1974	13.2	13.5	12.9	14.3
1975	12.0	12.5	12.1	14.0
1976	13.8	16.2	14.4	15.4
1977	15.1	19.9	15.5	16.8
Avg.	**13.5**	**14.4**	**13.6**	**14.7**

[1]Eichhorn et. al., Homer, LA. Annual fertilization = 500 lbs. N, 150 lbs. P_2O_5, 300 lbs. K_2O.

Table 9. Annual average in vitro digestible dry matter (IVDDM) of selected bermudagrasses.[1]

	Variety			
Year	**Coastal**	**Coastcross-1**	**Alicia**	**Common**
1971	56.4	60.6	55.0	58.7
1972	56.8	61.1	54.4	56.1
1973	53.3	55.1	50.4	53.1
1974	50.6	56.9	47.3	49.9
1975	52.4	56.2	48.2	51.2
1976	57.7	59.9	56.2	58.4
1977	55.9	58.2	54.3	56.7
Avg.	**54.7**	**58.3**	**52.2**	**54.8**

[1]Eichhorn et. al., Homer, LA. Annual fertilization = 500 lbs. N, 150 lbs. P_2O_5, 300 lbs. K_2O.

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.

Cheyenne

Cheyenne is a cross between a bermudagrass from an old turf site in the Pacific Northwest and another plant from former 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 to years of a five-year evaluation trial at Overton.

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 (Table 7), but is higher in crude protein and digestibility (Tables 8 and 9). Although Coastcross-1 produces more fall growth, it does not have the winter tolerance of Coastal. Its lack of cold tolerance limits it to the lower bermudagrass growing region.

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. Data obtained from a five-year variety evaluation trial at Overton indicates Tierra Verde has averaged 6,967 lbs DM/ac., which places it third among seeded varieties that have been evaluated for five years (Table 10).

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 higher yielding, and more digestible. The higher 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.

Other Bermudagrass Varieties

There are several other varieties of bermudagrass grown in Texas. These varieties are both public and private releases.

Table 10. Comparison of seeded bermudagrass varieties at TAMU-Overton Center.[1]

Variety	1997		1998	1999	2000	2001	AVG
	Grass	Weeds	DM (lbs./ac.)				
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	2408	268	3430	6640	8159	13431	6814
Common					6666	11352	9009
Wrangler					6239	7550	6895
Giant					6591	6443	6617

[1]Evers, 2001.

Varieties include 'Russell', 'Sheffield', 'Zimmerly Select', 'Wrangler', 'Ozarka', and 'Midland 99'. Most of the varieties, however, offer no advantages over the most popular hybrids (Coastal, Tifton 44, Tifton 85) used in Texas. Exceptions could be Midland 99 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.

Dallisgrass

Dallisgrass is native to South America, and the first noted specimen was apparently collected in Louisiana in 1842. The grass is a tufted, leafy, deep-rooted perennial. It is palatable and produces forage that is higher 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 disadvantage to dallisgrass is its lower dry matter production compared to some bermudagrass varieties, it is difficult to establish, and is subject to ergot (*Claviceps* spp.) infection, which can be toxic to cattle when the infected seedheads are consumed.

Dallisgrass responds to fertilization up to approximately 150 to 200 lbs. N/ac. Phosphorus and K should be applied based on soil test recommendation. No N should be used if white clover is grown as a companion crop. This is a common practice with dallisgrass since both it and white clover tend to favor similar sites.

Pearlmillet and the Sorghums

These warm-season annual grasses are popular both as grazing and hay forages. Pearlmillet (*Pennisetum americanum*) 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. Pearlmillet, which does not produce prussic acid, may be the better choice as a grazing forage though nitrate toxicity can still be a problem.

Either pearlmillet or one of the sorghums is generally planted at approximately 18 to 25 lbs./ac. Increased seeding rate (up to 45 lbs./ac.) 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/ac. Most production systems, however, will use approximately 200 lbs./ac. for hay production. Grazing systems may only use 50 to 75 lbs. N/ac. Application rates greater than 100 lbs. should be split-applied to minimize loss due to leaching on sandy soils and to reduce nitrate accumulation potential. Phosphorus and K 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/ac. 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 increased re-growth from the terminal buds. Plants harvested below six inches may experience reduced re-growth or even plant death. To maximize production for hay high in 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. Either malady can and does kill cattle with certainty.

Crabgrass

Crabgrass (*Digitaria* spp.) is a warm-season annual grass that is well adapted to much of the US including Texas. Crabgrass is a reliable producer of forage, when moisture is available, that is high in nutritive value. Crabgrass responds to good management just as other forages. For grazing, up to 100 lbs. of N/ac. is adequate; up to 200 lbs. N/ac. 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 that it must be managed for re-seeding if the species is to persist on location.

Others

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 selections of native bluestem and switchgrass. Before attempting to establish **any** forage in an arid environment, check with local professionals to determine the viability of such an exercise.

Warm-Season Legumes

Cowpeas

Cowpeas (*Vigna unguiculata*) are annual viney plants with large leaves. The species is fairly tolerant of drought, low fertility, and moderate soil acidity. 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 are not found immediately palatable by cattle, and are generally planted for white-tailed deer.

Annual Lespedezas

The annual lespedezas [Common (*Kummerrowia striata*) and Korean (*Kummerrowia stipulacea*)] are tolerant of acidity and low P soils; thus, the 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./ac. during March or April. Light grazing pressure will generally allow the plants to re-seed. Yield is lower 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.

Others

Although there is not a large selection of other warm-season legumes, soybeans and lablab are adapted to many regions of Texas. Most are planted for white-tailed deer. See SCS-2000-24, *Wildlife Forage Areas for White-tailed Deer* for additional information on using these species.

Cool-Season Grasses

Small Grains and Annual Ryegrass

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 that 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.

This following is a brief discussion of those cool-season annual forage grasses that may be used for winter pasture programs in the South.

Ryegrass

Ryegrass (*Lolium multiflorum*) is indigenous to southern Europe and is a popular forage choice for late winter/early spring feeding of livestock. Ryegrass grows on a wide range of soil types and grows better on wet soils than any cool-season annual grass. Ryegrass is generally later in maturity, thus extending the grazing season well into spring. Ryegrass establishes readily without any seedbed preparation and tolerates a high level of grazing pressure. With adequate moisture, 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 is provided. At Overton, several varieties such as 'Big Daddy', 'Abundant', 'Marshall', and 'TAM 90' have demonstrated good dry matter yields over the past several years.

Rye

Rye (*Secale cereale*) also originated in Europe. Rye is the most winter-hardy of the cool-season annual grasses. Rye is also the most productive cool-season annual grass on soils that are low in fertility, well-drained, and sandy in texture. Rye is not adapted to heavy soils that are poorly drained or that stand in water. 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', 'Bonel', 'Oklon', 'Maton', and 'Bates'. Several new releases from other sources show good potential.

Wheat

Wheat (*Triticum aestivum*) 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 acres in the Southern Plains planted

to wheat are planted to hard red winter wheat, but in the south most wheat planted is soft red 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. Soft, red winter wheat, however, is more tolerant to wet growing conditions than rye. Generally, wheat is also better adapted to heavier-textured soils.

Oat

Oat (*Avena sativa*) 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', 'Heavy Grazer', and 'TAMO 397'.

Triticale

Triticale (*Triticum secale*) is a unique species that resulted from a cross of 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. Trials at the TAMU-Vernon Center have also identified triticale varieties superior in forage production compared with wheat. Production and distribution of forage is similar to most wheat varieties. Although often overlooked, triticale could be a good choice for annual winter pasture.

Barley

Barley (*Hordeum vulgare*), 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, however, 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 certain soils that are 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. Barley is seldom used as forage in Texas.

Tall Fescue

Tall fescue (*Festuca arundinacea*) is a cool-season, perennial bunchgrass that came to 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 "fescue", tall fescue is used for forage and erosion control.

The species is bested 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 that have some water-holding capacity. Tall fescue will also grow well on soils that are 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* that is 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 that provide 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.

The 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 that a "novel" or friendly endophyte-infected tall fescue variety can provide the positive benefits of the endophyte, but none of the negative.

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 endo-

phyte-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.

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, 'MaxQ'. Many producers have found tall fescue to be a valuable component of their pasture systems, if not the primary forage base for their livestock operations. Those who successfully utilize tall fescue have learned to dilute the toxic effects for cattle by overseeding clovers or by providing other forages such as dry hay to minimize negative effects. 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 greatest limiting factor. The choice of species, therefore, is largely dependent on the producer based on their particular management philosophy and livestock production needs. Be aware that cool-season annual grasses can produce different levels of forage (Figure 1). Regardless of species, it is important that 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 limestone may be incorporated into the soil ahead of planting. Phosphorus 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 tighter-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 topdress at various times during the forage growth cycles. Liquid formulations of N, such as 32-0-0, may also be used to topdress forages.

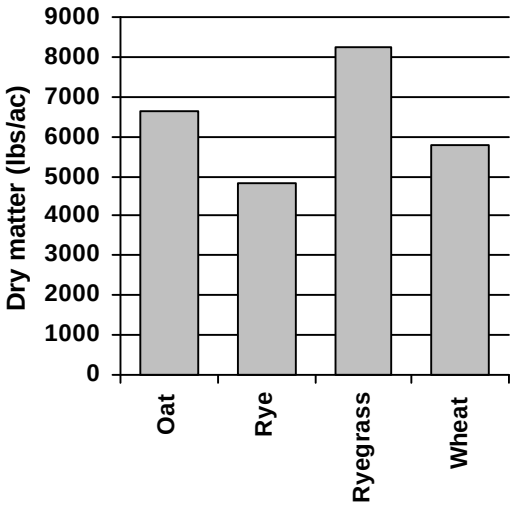

Figure 1. Dry matter production of various cool-season annual grasses at Overton, TX 2001-2002. Nelson, 2002.

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 farther 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 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 capi-

talize on the somewhat reduced growth rate of the warm-season perennial grass. If planting in South Texas, however, 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./ac. 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 during late summer plantings where 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 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 20 to 30 lbs./ac. over a field, generally as part of a fertilizer application.

Cool-Season Legumes

Legumes may be used in much of the eastern one-third of the state as a means of extending the length of grazing season, 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 silage and are relished by both cattle and white-tailed deer. Some of the important forage legumes are listed below.

Alfalfa

Alfalfa (*Medicago sativa*) 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 that alfalfa stand life may be reduced under most grazing scenarios, but has good sustainability under as a hay crop.

Bloat may be a problem when grazing alfalfa. Carefully read the section on managing bloat in this publication.

Arrowleaf Clover

Arrowleaf clover (*Trifolium vesiculosum*) is a relatively late-production cool-season annual clover that produces most of its growth during April and May. Arrowleaf clover plants typically mature 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 late 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 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 warm-season grass emergence; thus, special consideration should be given to management of this species to minimize negative effects to 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. A new variety, 'Apache' developed at the TAMU-Overton Center is virus tolerant and provides good forage production later into the season compared with virus-infected Yuchi.

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 seed/ac. in mixed stands with cereal grains or ryegrass and 30 to 40 lbs./ac. in pure stands. Austrian winter peas are intolerant of low pH soils.

Ball Clover

Ball clover is a low-growing annual clover that is similar in appearance to white clover, but tolerates a wider range of soil pH than white clover and does not do as well on the wet

sites that white clover is best adapted to. Ball clover is intermediate in maturity to crimson and arrowleaf clover, has good dry matter production, and is a reliable re-seeding species. Commercial seed availability is low and restricted mainly to clover grown for seed by a few producers in Central Texas and the southeast U.S.

Berseem Clover

Berseem clover (*Trifolium alexandrinum*) 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 levels 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 late maturity. Berseem may best be used in pure stands rather than as a sod-seeded species.

Common Vetch

Common vetch (*Vicia sativa*) 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*) 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 a 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 that allows 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 a peak production period 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 that of 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. Medica 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 clover (*M. orbicularis*), black medic (*M. lupulina*), and spotted or southern burclover (*M. arabica*).

Little research has been conducted on the medics in the U.S. 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.

Commercial seed for the annual medic species is normally difficult to find and the plant is seldom intentionally sown. 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. One released variety from TAMU-Beeville is 'Armadillo' burr medic that has shown great potential where cold weather is not a concern.

Red Clover

Red clover (*Trifolium pratense*) is a short-lived perennial where well-adapted 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 highest 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 six to eight lbs./ac. in drill rows or 12 to 15 lbs./ac. broadcast. Soil pH should be above 5.5 for maximum production.

Red clover is not as long-lived as is alfalfa; however, stands of red clover may be maintained for many years by reseeding with two lbs. of seed/ac. every two to four years. Due to its late maturity date, red clover that is overseeded into warm-season grass pastures requires special consideration so that grass production is not adversely affected.

Rose Clover

Rose clover (*Trifolium hirtum*) is a cool-season annual that is somewhat new to the South. Most varieties of rose clover that have been 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.

Most rose clover varieties from California have relatively low dry matter yield. A relatively new release from TAMU-Overton, 'Overton R-18', has a yield potential equal to crimson clover and is intermediate in maturity to crimson and arrowleaf clovers.

Subterranean Clover

Subterranean (sub) clover (*Trifolium subterraneum*) is a dense, low-growing, annual legume of medium maturity that will withstand close grazing and continue 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 alba*) and yellow sweetclover (*Melilotus officinalis*) can be either annual or biennial and can produce two or more tons of forage/acre. Sweetclover is very similar to alfalfa and has great value as a soil-improving and pasture crop if plowed down 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 seed/ac.

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 that develops 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. Researchers at the TAMU-Overton are working to develop low-coumarin varieties for Texas.

White Clover

White clover (*Trifolium repens*) 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 three to four lbs./ac. 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 from becoming a limiting factor in white clover production. 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 one or two lbs. of seed/ac. in the fall or winter may be necessary to maintain a stand for several years.

Legume Fertility Requirements

In general, legumes are typically more sensitive to soil nutrient deficiencies than are forage grasses. Because of the symbiotic relationship with *Rhizobia* bacteria, however N fertilizer is generally not required (See *Biological Nitrogen Fixation,* SCS-2001-13 for additional information). Phosphorus and K, however, are critical to maintaining a productive stand of legumes. An annual soil test should be used to determine the need for P and K. The soil test would also indicate if there were deficiencies in micronutrients, such as boron. Legumes

are more sensitive to low soil pH than most forage grasses and, based on soil test recommendations, soil test-recommended levels of 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 that a minimum amount of residue remains at the time of establishment. If the bermudagrass canopy is not removed, emerging legume seedlings 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 that produces 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 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. Legumes, when properly inoculated, can fix significant amounts of N. The amount will vary between species, sites, and years but can range from as little as 30 up to 150 lbs./ac. While it is possible to establish without the N-fixing bacteria, N fertilizer must be applied and the economic advantage of using legumes is lost.

In pastures where legumes have been used in the past, the *Rhizobia* 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** (See *Biological Nitrogen Fixation,* SCS-2001-13). Inoculation of seed occurs before planting and is accomplished by applying a sticking agent to the seed and then adding inoculant to the seed. The inoculant should be applied immediately prior to planting the seed.

Inoculated seed should not be 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.

Once a field has a successful stand of a legume species, bacteria may remain viable in the soil for several years. If present in sufficient quantities, a subsequent planting of the same legume may not require that seed be inoculated at planting. Due to high *Rhizobia* populations in areas where a particular legume is grown, however, it is often difficult to establish another legumes that requires a different inoculant strain, due to competition and ineffective nodulation.

The most consistent method, however, 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 that the inoculant will adhere, but these are **not** as effective as the commercial sticking agents are.

Bloat

Certain forages can create serious bloat problems in ruminants. Certain legumes and wheat generally cause the most bloat, but other small grains and ryegrass can also cause bloat. Bloat is caused by the formation of stable foam in the rumen. If not relieved, the pressure created by the entrapment of rumen fermentation gases in the foam can lead to death by suffocation in as little as one hour or less.

Environmental aspects may also play a contributing role in bloat. Cattle have been observed to stop foraging prior to passage of a weather front and gorge themselves following the inclement weather. Cattle may need to be moved or a bloat preventative may be required during such times. Frost can also increase the incidence of bloat by disrupting plant cell walls thus enhancing protein degradation in the rumen. Delay grazing those legumes and grasses that are known to cause bloat for a few days following a hard frost.

Legume bloat usually occurs during the lush growth period associated with spring. When using a legume known to cause bloat, problems can be minimized with proper management (Table 11).

Poloxalene, a bloat preventative, must be consumed by cattle daily, both prior to turning cattle onto legumes and thereafter, to be effective. Feed poloxalene at 1 to 2g/100 lbs. of body weight per day. Cattle should be accustomed to consuming a mineral mixture, and a feeding strategy that results in cattle getting an effective amount of poloxalene should be used. This may mean hand feeding cattle one to two pounds of highly palatable supplement containing the desired amount of poloxalene.

There are reports that feeding either oat hay or sudangrass hay "effectively controlled" bloat of steers grazing young, lush regrowth of alfalfa. The amount of hay that cattle must consume to decrease bloat is large and in the range of four to six lbs/head/day for 400 to 600-lb. cattle depending on how much of the bloat-causing forage they consume.

Table 11. Management strategies to minimize bloat potential in livestock.

- ✓ Never turn hungry cattle into a lush legume pasture. Allow cattle to fill on grass hay first.
- ✓ Provide a bloat preventative to livestock several days prior to and while grazing legumes of known bloat potential.
- ✓ When first turned into lush legume pastures, watch cattle closely for several days for distended rumens indicating bloat.
- ✓ If possible, fill cattle with hay or other roughage immediately before or after the passage of a weather front.
- ✓ Delays grazing bloat-causing plants for a few days following freeze damage.
- ✓ Allow lviestock to have free-choice access to grass hay while grazing lush legumes.

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 generally N only is applied under the false impression that it is the only nutrient bermudagrass requires. Nothing could be further from the truth! It takes all of the nutrients in appropriate amounts for bermudagrass to produce the high yields it is known for.

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 that is already low in phosphorus (P) and/or potassium (K). A typical 2-ton hay harvest from bermudagrass removes approximately 100 lbs N, 30 lbs P_2O_5, and 90-100 lbs K_2O. 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.

Non-traditional methods of bermudagrass use may also help reduce winter feeding costs. These uses 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 late winter and spring grazing. The combined use of stockpiled bermudagrass and overseeded ryegrass, when possible, could reduce winter feeding costs by up to $100 per cow per winter.

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 that you desire.

Produced by Soil and Crop Sciences Communications, The Texas A&M University System
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