FORAGE LEGUMES

in the Southeast

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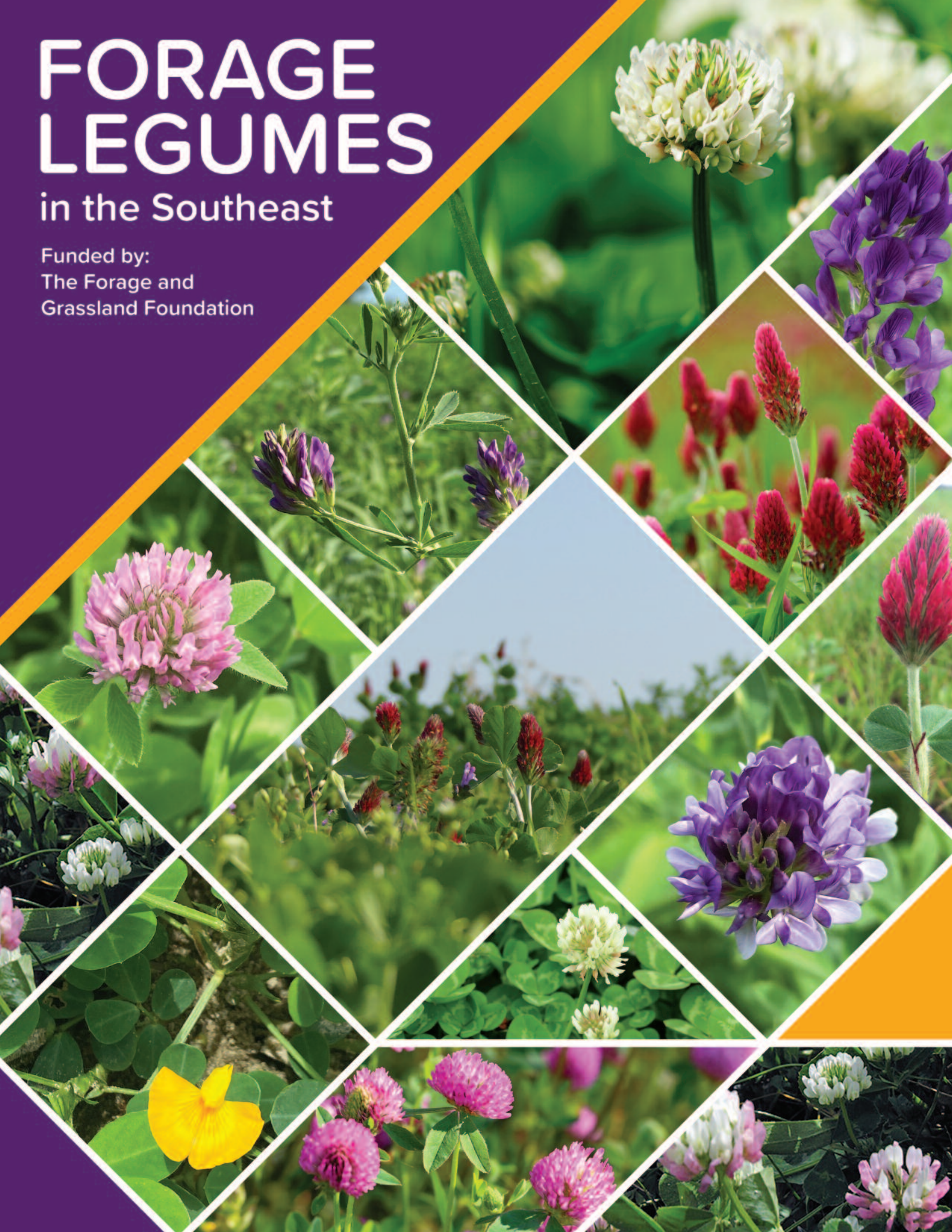

Preface

This guide provides information on incorporating legumes into the Southeast United States management systems. The authors do not assume any responsibility, make any guarantees, or offer any warranties regarding the results obtained from the use of any management strategies included in this guide.

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Forage Legumes in the Southeast

Introduction

Enhancing sustainability of on-farm forage production is an important goal for forage-livestock operations. Depending on location, soil types, and site characteristics, producers may have a number of forages to consider for use in their forage program. Forage legumes are an excellent addition to consider incorporating into a forage-livestock systems where appropriate and offer many potential benefits which support production and resilience of forage stands in the region.

The incorporation of forage legumes into pastures and hayfields can provide:

- ✓ **Biological nitrogen fixation that results in reduction of nitrogen fertilization**
- ✓ **Improved forage quality**
- ✓ **Enhanced seasonal distribution of forage growth**
- ✓ **Greater forage yield potential**
- ✓ **Ecosystem services and provisions**

Forage crops generally provide less expensive nutrition for livestock than other feeds. As a result, livestock production systems in the Southeast United States rely on forages to supply the majority of nutritional needs during the year. Most operations rely heavily on perennial grasses such as tall fescue, bermudagrass, or bahiagrass as the base forage within the production system. Legumes are often incorporated into these systems to help improve forage production, increase nutritive value, and reduce nitrogen fertilizer inputs. Legumes can either be planted in mixtures with other forages or alone.

This handbook provides a general overview of legume species commonly used in the Southeast United States region, management recommendations, applications for on-farm use, ecosystem provisions provided, and economics of use in forage systems.

Major Adapted Forage Legume Species

Introduction

Forage legumes are important components of livestock production systems. There are annual and perennial legumes that can be used in the Southeast U.S., both for the warm and cool seasons, and in monoculture or mixtures. Before planting legumes, it is important to make sure there is no herbicide residue in the soil because that can lead to stand failure. This chapter will describe some of the most used forage legumes in this region.

Cool-Season Annual Legumes

Arrowleaf Clover

Arrowleaf clover (***Trifolium vesiculosum***) is characterized by non-hairy, arrow-shaped leaves with a “V” white water mark. Its flower becomes tinged with pink or purple colors as it matures. It requires a soil pH ranging from 5.8 to 6.5. It requires well-drained soils and does not tolerate calcareous soils, such as those found in the Black Belt region of Alabama and Mississippi. The planting window is late September through early November. Recommended seeding rate is 5 to 10 lb/acre of inoculated pure live seed (PLS)†, and seeding depth is ¼ to ½ inch. Depending on the percentage of the inert material in pre-inoculated seeds, the seeding rate may need to be increased. If the information on the seed bag indicates that the inoculation date has expired, the seed should be reinoculated before planting. It can be planted with other cool-season forages. The peak of production occurs in early April through May, and crude protein (CP) ranges from 16 to 20%. Recommended stubble height is 4 inches, and when harvesting for hay, it should be cut at bloom stage.

Balansa Clover

Balansa clover (***Trifolium michelianum* Savi**) has an upright growth habit with large, non-hairy leaflets and white flowers. It is adapted to relatively poor soil drainage and drought conditions, and tolerates a wider range of pH than some legumes (4.5 to 8). Recommended seeding rate is 5 to 7 lb/acre at a seeding depth of ¼ inch. Due to seed size, balansa may have better establishment when broadcast rather than drilled. Balansa clover grows relatively slowly in the winter, but produces a rapid flush of growth in the spring. It has an upright growth habit, which allows it to potentially suppress weeds when used as a cover crop. Balansa clover has more traditionally been grown in Australia, but popularity is increasing in the US.

Ball Clover

Ball clover (***Trifolium nigrescens***) has non-hairy leaflets and white flowers. It is widely adapted in the Deep South and can tolerate poorly drained soils. Seeding rate recommended is 2 to 3 lb/acre, and seeding depth should be from ¼ to ½ inch. Peak of production ranges from late March through May and it can be managed for reseeding under grazing. Crude protein ranges from 16 to 20%.

Crimson Clover

Crimson clover (***Trifolium incarnatum***) has pubescent leaves and stems and crimson flowers. It requires well-drained soils and does not tolerate calcareous soils, such as those found in the Black Belt region of Alabama and Mississippi. The recommended seeding rate is 20 to 30 lb. PLS/acre and seeding depth should be from ¼ to ½ inch. It is the

earliest producing of the clovers. The peak of production occurs from March through April. It can be used for grazing or hay production with a stubble height of 4 inches. Crude protein typically ranges from 16 to 20% and digestibility can be up to 80%.

Vetches

Hairy vetch (***Vicia villosa***) is winter hardy and requires well-drained fertile soils with optimal pH ranging from 6 to 7. Recommended seeding rate is 15 to 20 lb PLS/acre and the seeding depth of ½ to 1 inch. Planting window is late Aug through October, and it can be planted in a mixture with other cool-season forages. It can be managed under grazing or single-cut hay production. The peak of production of hairy vetch occurs in late March through late April/May.

Berseem Clover

Berseem clover (***Trifolium alexandrinum***) has oblong leaflets and yellowish-white flowers. The optimal soil pH is 7 or higher, and it is adapted to loam soils. For this reason, it grows particularly well in the Black Belt region of Alabama and Mississippi. Recommended seeding rate ranges from 12 to 18 and 2 to 2.5 lb/acre for broadcast and drilling, respectively. Seeding depth should be from ¼ to ½ inch. Recommended stubble height is 4 inches, and it can be used in a mixture with other cool-season forages.

Winter Pea

Winter pea (***Pisum sativum***) requires a well-drained loam to sandy loam soil. The planting window is September through October. The recommended seeding rate and planting depths are 30 to 40 lbs. PLS/acre and ¼ inch. It can be used for a single cut of silage in April or managed under grazing. Winter peas work well in a mixture with other cool-season annual grasses (e.g., annual ryegrass, small grains).

Cool-Season Perennial Legumes

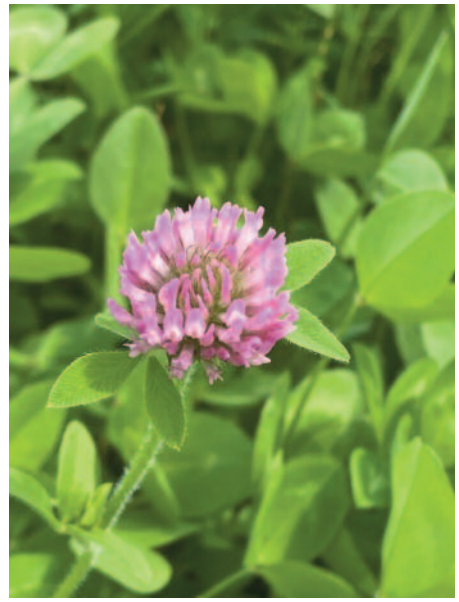
Alfalfa

Alfalfa (***Medicago sativa***) is a high-yielding, species well-suited for hay, silage, baleage, and grazing. Alfalfa requires well-drained, high fertility soils and has limited tolerance to pests and disease pressure. Prior to planting alfalfa, soil pH and fertility testing must be conducted. It is recommended to collect soil samples to a 15-inch depth, by dividing the soil profile into two layers, surface (0 to 8-inches) and subsoil (8 to 15-inches). Soil pH should range from 6.5 to 7.0 in the topsoil surface and be approximately 5.5 on subsoil. Lime application should be completed at least six months prior to planting to allow for soil incorporation. If the subsoil pH remains acidic, application of gypsum ($CaSO_4$) can be used to reduce aluminum toxicity in deeper soil layers because it incorporates calcium. Adequate levels of boron (B) and molybdenum (Mo) are essential for nodule formation on roots for biological nitrogen (N) fixation, and some varieties include base levels of these in the seed coat. Most alfalfa seed is pre-inoculated and requires proper storage and handling to guarantee seed quality. If seeds purchased are not inoculated or inoculum viability is unknown, inoculant (Type A, *Rhizobium meliloti*) should be purchased and applied according to label instructions. Alfalfa seeding rate is 20 to 25 lb /acre, and seeds should be planted to about ¼ inch deep during the fall establishment window. After establishment, a general recommendation is to apply 12 lb of phosphorus (P_2O_5) and 50 lb of potash (K_2O) per acre for every ton of alfalfa harvested. Supplemental Mo and B are recommended yearly or every other year during the life of the stand.

White Clover

White clover (***Trifolium repens***) has a creeping growth habit and high grazing tolerance. It is often planted in a mixture with other cool-season perennial forages to extend the grazing season. The optimum pH is from 5.5 to 6.0, and proper soil fertility is necessary for establishment, persistence, and productivity. The recommended seeding rate is 2 to 3 lb/acre, and the planting window ranges from late August to early Nov. Seeding depth should not exceed ¼ to ½ inches. In a clover-containing system, improved forage yield and quality increases animal performance. Crude protein ranges from 15 to 25% with high digestibility. Rotational grazing is recommended with a stubble height of two to four inches.

Red Clover



Red clover (***Trifolium pratense***) is a biennial or short-lived perennial. It grows best on well-drained loamy soils with a pH of 6 or higher, but can tolerate less well-drained and moderately acid soils. Red clover performs as a winter annual in the southernmost portion of the United States. For example, it is productive for one year in central and southern Alabama and Georgia but may remain productive for longer in the other northern regions, such as Tennessee and Kentucky. The recommended seeding rate is 4 to 9 lb/acre, and seeding depth should be from ¼ to ½ inch. Red clover is low-yielding in February through March compared with other legumes, but has the potential to provide a substantial amount of good-quality forage in late spring and into the summer. It is quick growing, easily established, and provides a source of nitrogen and high-yielding forage rich in protein. It is often planted into cool-season perennial grasses, especially tall fescue. White clover can also be planted in mixture with other forages, such as small grains, and overseeded into warm season perennial grass sods.

Warm-Season Annual Legumes

Aeschynomene

Aeschynomene (***Aeschynomene americana***) grows well in moist flatwood soils, and it is commonly found in the Florida peninsula, but grows well under similar conditions along the U.S. Gulf Coast. Aeschynomene typically produces flowers and seeds in early fall, with plants dying after seeds are mature. Grazing management must be targeted to optimize seed production during this period to maximize reseeding in the following year. This forage legume is more tolerant of wet conditions than drought conditions, although if young plants are completely submerged for prolonged periods, they will not survive. Seeding rate is 25 lb/acre, and the best timing to plant is typically in late spring to early summer when soil moisture should be more favorable. Seeding depth should range from ½ to ¾ inch depth, and grazing should start after plants reach 12-18 inches. Aeschynomene has good nutritive value and potential to add biologically fixed N to the system. Overseeding bahiagrass or limpograss with aeschynomene is a common practice in South Florida, and cattle performance on grass-aeschynomene mixtures is often higher as compared with grass monoculture.

Cowpea

Cowpea (***Vigna unguiculata***) is well adapted to grow under relatively dry conditions. Planting dates vary from mid-March to late August. Growers should wait until soil temperatures reach 60°F to plant. The recommended seeding rate is 30 to 40 lb/acre, and seeding depth should be from ¾ to 1¼ inches. Recommended row spacing is 30 or 36 inches. Cowpea can be grown on relatively poor soils. However, it does not tolerate grazing well, therefore, it should be used in mixtures with warm-season annual grasses that are intermittently grazed (e.g., pearl millet, sorghum × sudangrass).

Forage Soybeans

Forage soybeans (*Glycine max*) are a bushy legume with three hairy leaflets and white or pink flowers. Soybeans are drought tolerant and work well in mixtures with other warm-season annual grasses (e.g., sorghum, pearl millet). Forage soybean varieties produce more vegetative biomass than oilseed soybean varieties, but any variety of soybean can be grazed or used for hay. Soybean forage is difficult to cut and cure, so conditioning is required. Forage should be harvested at 75% pod fill. Only one to two grazing events per year can be expected, as regrowth of soybeans is limited. Soybean should be planted at 60-100 lb/acre at 1-inch depth.

Striate Lespedeza and Korean Lespedeza

Both striate lespedeza (***Lespedeza striata***) and Korean lespedeza (***Lespedeza stipulacea***) have shallow taproots and pink flowers. Optimal soil pH ranges from 5.5 to 6. Recommended seeding rate ranges from 20 to 30 lb/acre, and either species should be planted from March to May. Crude protein normally ranges from 12 to 15%, with TDN ranging from 50 to 55%. Striate lespedeza exhibits narrower leaflets, and its flowers and seeds are borne in leaf axils, whereas Korean lespedeza flowers and seeds are found at the ends of stems. The prostrate growth pattern of Striate lespedeza makes it better suited for grazing than hay production. Korean lespedeza is more drought tolerant but is susceptible to bacterial wilt and tar spot which can result in summer leaf loss and thinned stands. Korean lespedeza is less competitive with companion grasses than striate lespedeza. These species are more commonly planted in tall fescue, especially on soils and sites where clovers are not well suited.

Sunn Hemp

Sunn hemp (***Crotalaria juncea***) can grow up to six feet tall. It tolerates drought and soils with relatively low fertility. The optimal soil pH ranges from 5 and 8.4. Sunn hemp grows best in sandy, well-drained soils and should be planted into a prepared seedbed when soil temperature has reached 65°F. The recommended seeding rate is 25 to 30 lb. of PLS per acre. Seeding depth should be ¼ to one inch. A substantial quantity of biomass accumulates within 30 to 60 days after planting, by which time plants may have reached a height of six feet. Grazing should start around 45 days after planting, when plants are around one and one-half to three feet tall. The recommended stubble height left after grazing is 12 to 18 inches. Sunn hemp works well in mixtures with warm-season annual grasses such as pearl millet and sorghum × sudangrass, and can work relatively well with tall fescue.

Warm-Season Perennial Legumes

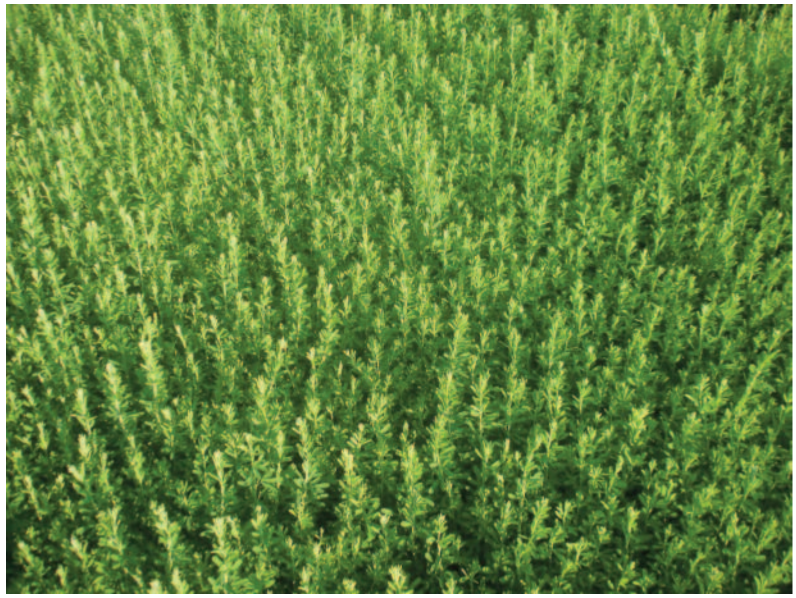
Kudzu

Kudzu (***Pueraria lobata***) is a drought-tolerant non-native species with large, trifoliate leaves on long, twining vines. It should not be planted due to its invasive nature, but grazing of existing kudzu stands can provide high CP quality. Continuous grazing can weaken plants and reduce productivity, so rotational grazing should be used if stand persistence is of interest. Forage production occurs from May through October.

Rhizoma Perennial Peanut

Rhizoma perennial peanut (***Arachis glabrata*** **Benth.**) is adapted to Florida Peninsula, Gulf Coast regions, and Southern areas of GA, AL, and other sites with similar conditions. It is well adapted to sandy soils with good drainage, and produces best under improved soil fertility and pH ranging from 6 to 6.5. Although it grows well also in more acidic conditions (pH 5.5 to 6). Rhizoma perennial peanut has bright yellow to orange flowers, but seed production is almost nonexistent. It has a large rhizome mass, and this is the propagative material used to establish new areas. The recommended rate is 80-100 bu/acre, and the rule of thumb is that 1 acre of a well-managed nursery produces enough planting material to establish 15-20 acres. Strip-planting is one option to reduce establishment costs. The strip width should match equipment size to facilitate planting. In Florida, the width used has been 9-ft, and the alternating grass and legume strips have the same width. Planting period is typically in early Spring (March) or Summer (June/July). Rhizoma perennial peanut has improved nutritive value (70% digestibility and 18% CP), has potential to add N via biological N fixation, and is tolerant to grazing. Research data has demonstrated improved cattle gains on mixed pastures of bahiagrass-rhizoma peanut compared with bahiagrass-only pastures.

Sericea Lespedeza



Sericea lespedeza (***Lespedeza cuneata***) is deep-rooted and grows well on medium- to well-drained clay-to-loamy soils. It can be used for hay production or managed under grazing conditions. Generally, it grows from April through October, and its forage production peaks from June through August. Sericea lespedeza can be grown in combination with tall fescue, but due to poor seedling vigor, sericea needs to be established first. Once sericea plants have lived through a summer, they can persist for many years if not overgrazed, thus making it one of our most sustainable forages. The seeding rate is 20 to 30 lb PLS/acre, and the planting window runs from March 15 to May 1st. A naturally occurring compound in sericea is condensed tannin which is linked to reduced intake and digestibility of the forage. Condensed tannins increase the amount of protein bypassing the livestock rumen, contributing to more efficient feed use. However, the amount of condensed tannins in the animal diet need to be balanced; otherwise, it can have a negative impact on nutrient use and absorption by animals. Sericea lespedeza also helps reduce internal parasite loads in small ruminants, including *Haemonchus contortus* (barber pole worm).

A Note on Range of Adaptation of Forage Legumes in the Southeast US

Producers should review the Extension planting recommendations for various legume species within their state to identify adapted legumes, varieties for use, and relative fit for the desired management applications on farm.

Legume Establishment and Management

Establishment Methods

Legumes can be established in either monocultures or mixed stands. As a result, there are a variety of different methods that can be used successfully. For monoculture stands (e.g., alfalfa), a prepared seedbed is the preferred method. Tillage should only be used if it is possible without negative environmental consequences such as soil erosion. The seedbed should be firm (this is important) and weed free. A good rule of thumb is that the soil should be firm enough that when a person walks over a field, shoe prints should not be much deeper than the sole of a shoe. Plowing and discing should be done as needed, and pre-plant applications of lime and fertilizer can be distributed and incorporated at this time. A systemic herbicide (e.g., glyphosate) should be used to remove any newly emerged weed seedlings after soil preparation. A cultipacker or heavy roller should be used as the final step to firm the seeded and improve stand establishment.

No-tillage methods are useful for legume establishment when planting into an existing grass sod or when tillage is not an option. In this method, removal of above ground plant material is necessary to minimize shading during legume seedling emergence and establishment. This can be achieved through mowing or close grazing prior to seeding. Chemical suppression of the existing sod may be necessary, but care should be taken to prevent permanent damage to the existing forage stand. When using a no-till planter or grain drill, care should be taken to ensure proper seeding depth. Many no-till drills are equipped with a small seed box that allows simultaneous planting of large and small seeds at different seeding rates. However, the coulter depth should be set to the shallowest seed being planted as legume seeds are very small. Typically, legume seeds should not be planted deeper than ¼ inch.

Broadcasting seed is also a common method of establishment. Existing plant residue should be reduced through mowing or grazing prior to seeding to increase seed to soil contact. Cultipacking or grazing immediately following seed broadcasting can increase seed to soil contact. Seeding rates for broadcasting should be greater than those for drilling. If no broadcast rate is available, increase the given seeding rate by 15% to account for reduced establishment.

For producers north of latitude 34˚, frost seeding can be used to interseed clover seed into an existing grass sod. This method requires the top layer of the soil to freeze, as the freezing and thawing action of the soil works the seed into the soil where it can germinate. Frost seeding should take place during mid to late February. When using this method, proper seeding rates should still be used and seed should be broadcast during the February frost seeding window. Seed should fall directly on the soil surface, so plant residue should be removed prior to seeding. Frost seeding offers a low-input and simple method to establish clover into a grass stand for producers in this region.

Each forage species has a specific seeding rate that should be used to ensure a productive and healthy stand. If a mixture is being planted, a lower seeding rate can be used. Typically, seeding rate of each component species is reduced by 50% when planting as a mixture with other forages vs. a monoculture. Seeding rates are given as rate of pure live seed. Each certified seed bag tag will include a germinate rate and a pure seed rate. The PLS% can be determined by Pure Seed% × Germination%. The seeding rate should then be increased by this percentage to get the desired forage establishment rate. Non-certified seed should not be used for forage establishment, as there is no guarantee as to the amount of pure seed fraction.

Seed Inoculation

When establishing legumes, using inoculated seed is important to promote N-fixation and forage productivity, as well as to reduce N fertility needs. Today, seeds of many legume species come with an inoculant coating already applied. If your legume seeds are not coated, it is important to select the correct inoculant. Table 1 lists the inoculant group and species for common forage legume groups. In order to apply the inoculant, a carrier must be used to adhere the inoculant to the seed. Commercial products are available, or a carrier product can be made by using a 1:10 dilution of syrup, molasses, milk or soda to water. Use of a rotating tub mixer (e.g., concrete mixing stand) ensures uniform distribution of the coating on the seed. Seed should be planted within 24 hours of inoculation to ensure the bacteria remain viable. Coated seed and inoculant should be stored in a dry, cool location to avoid killing the *Rhizobia* species. Follow any inoculant or seed bag instructions for application rates, storage methods, and expiration dates.

Table 1. Inoculant group and species for common forage legumes.

Legume Group	Inoculant Group	Rhizobia species
Alfalfa, Sweetclover	A	*R. meliloti*
True clovers	B	*R. trifolii*
True peas and vetches	C	*R. leguminosarum*
Soybean	S	*R. japonicum*
Birdsfoot trefoil	K	*R. loti*
Crownvetch	M	*R. spp.*

Soil Fertility

Soil fertility is a critical consideration when preparing to establish legumes. Legumes have little soil acidity tolerance. Maintaining a soil pH of at least 6.0 (or higher for some legumes) is required for stand establishment and persistence. Soil testing should be done at least 6 months before the desired planting date to ensure enough time for soil pH to increase if lime needs to be applied when preparing a seedbed, lime can be incorporated into the soil, otherwise it can be broadcast. For some legume species, it may take 1-2 or more years to raise the subsoil pH to appropriate levels. Soil testing should be repeated every 2 years in pastures and annually in hayfields to prescribe needed lime and fertilizer amendments needed to maintain soil pH to ensure legume productivity and persistence.

Legumes fix nitrogen (N). Legumes have a mutually beneficial relationship with the bacteria *Rhizobium*. These bacteria infect legume root hairs forming small nodules near the point of root elongation, or root nodes. These bacteria help remove N gas from the atmosphere and convert it to a plant usable form. This process is referred to as biological nitrogen fixation. The legume plant receives nitrogen in exchange for sugars and other compounds the bacteria need to survive.

Biologically fixed N is available first to the legume once the roots have been infected and nodulated. As legume plants age, the number and size of nodules on the roots can be used as an indicator of relative nitrogen fixation. A good way to see if fixation is occurring is to dig mature legume plants and look at nodule formation on the roots. Cut open a nodule. If the color inside of the nodule is pink-to-red in color, this is a sign of active N fixation.

The range of N fixation potential for legume species commonly used in the Southeast is wide and is partially related to legume plant presence in the stand and growing conditions. It is generally recommended that legumes make up at least 30% of the pasture if no N fertilizer is applied. This proportion (30%) results in less nitrogen fixed compared with legumes in pure stands under nearly ideal growing conditions. It is important that legume plants are well distributed across the forage system to see a more uniform response. During legume establishment, the addition of a small amount of N fertilizer (no more than 50 lb N/acre) can hasten establishment but is not required for long-term maintenance of the stand. A range of N fixation potential for various major legumes adapted to the Southeast US are listed in the table below.

Table 2. Nitrogen fixation potential of various legumes adapted to the Southeast US.

Species	Range of Nitrogen Fixed, lb/acre/year
Aeschynomene	30-75
Alfalfa	50-250
Arrowleaf clover	50-150
Ball clover	50-125
Balansa clover	50-75
Berseem clover	50-200
Cowpea	50-100
Crimson clover	50-150

Forage soybeans	20-60
Kudzu	100-250
Lespedezas	30-120
Red clover	75-200
Rhizoma perennial peanut	50-250
Sunn hemp	100-200
Vetches	50 - 150
Winter peas	30-100
White clover	50-250

†Adapted from the IPNI Forage Crop Pocket Guide, 2012, Ball et al., 2015, Dabney et al., ND; Nitrogen fixation is dependent on site-specific soil, environmental and management conditions.

Phosphorus (P) is essential for root development, energy transfer and other important plant processes, and potassium (K) is important for disease resistance, persistent stands, and high yields. Soil test results will provide the appropriate P and K fertility rates for each legume species based on the current soil nutrient status. Like lime, P and K can be incorporated into the soil if using a prepared seedbed. Otherwise, they can be broadcast prior to or at the time of planting. Serious deficiencies should be amended well in advance of planting.

For some legumes, micronutrients may be recommended. For example, establishment of alfalfa may require additional sulfur (S), boron (B), or molybdenum (Mo). Contact your local Extension office for assistance with questions on fertilization needs that may be required for establishing a legume stand.

Weed Management

Weed management in legume systems, particularly grass-legume mixed forage stands, can be challenging. An integrated weed management program is the most successful way to deal with weeds. Prevention, cultural management, mechanical removal, and chemical methods should all be part of a good integrated weed management program. Preventing weeds is the first and easiest step to ensure a relatively weed-free field. A healthy, actively growing stand of forage will outcompete most weeds. A forage stand that is under fertilized, overgrazed, or otherwise mismanaged, will allow introduction, establishment, and expansion of weedy plants Transportation of weed seeds into a field occurs through weedy hay, non-certified seed, livestock manure, mowing equipment, and the surrounding environment (wind, water, and wildlife). While not all of these can be controlled, it is important to manage the things that can be controlled such as soil fertility, grazing management, and feed sources.

Figure 3. Application of liquid herbicide on a pasture using a boom sprayer. Photo Credit: David Russell

At some point, weeds will germinate and grow in a field even when best management practices are used. When this occurs, mechanical or chemical removal methods are required. If the weed problem is limited to a small area, plants can be completely removed by digging. Mowing can be used to reduce the height of weeds that are too large for chemical spraying. This also reduces shading of the desirable forage stand and allows it to be more productive and compete with weeds. Careful herbicide control should be considered when managing weeds. This requires proper weed identification, proper herbicide selection, and equipment calibration.

Many commonly used forage herbicides are designed for grass-only pastures and will not only kill legumes (broadleaf plants), but often have a soil residual effect that can last for a year or more. When establishing a new legume stand, it is important to know the herbicide history of the field to prevent loss of stand due to herbicide residue. In grass-legume pastures, there are limited herbicide options that will not harm either the grass or the legume component. In these systems, prevention and cultural management are key to a productive forage stand. All herbicide labels contain information regarding target weed species, application rate, forage species that tolerate the chemical, soil residual timeline, animal use protocols, as well as other vital information on the storage and application of the herbicide. The entire herbicide label should be read before applying herbicides to a field. Your local Extension office has more information on specific herbicides and their uses in legume and grass-legume mixtures, as well as information on herbicide application methods.

Lessons with Legumes – Establishment Summary:

After planting, germination, growth and nitrogen fixation are ways producers can gauge success in establishment of productive legumes. Good site conditions help foster legume growth, and allow legumes to begin to produce measurable dry matter production. Planning, site preparation, and timeliness are keys in the successful establishment of forage legumes.

Forage Production, Nutritive Value, and Animal Performance of Legumes

Monocultures:

Legume monocultures are most often used for harvested feed production. Through hay or baleage technology, producers have the ability to harvest a high quality, high protein feed source that can serve as a supplement later in the season when needed. Although acreage is limited, alfalfa is the predominant legume species grown in monoculture in the Southeast region for hay or baleage production.

Alfalfa has one of the highest feeding values of forages. It is generally known as a good source of protein in livestock diets, but energy value is also typically high. Multi-year results from the Sunbelt Ag Expo Southeast Hay Contest in Moultrie, GA have reported an average relative forage quality of 234, 25% crude protein (CP), and 72% total digestible nutrients (TDN) of samples of alfalfa hay grown in the region and submitted in the contest, which demonstrates high quality potential.

Use of alfalfa in livestock diets should be tailored to match the type and stage of production of the animals being fed. Alfalfa can be used as a supplement in livestock diets or as a sole-source diet resource. The risk of bloat is typically only an issue in grazed settings, and even then, only in relatively rare occurrences. Feeding alfalfa hay or baleage has a very low bloat risk. If producers have concerns about bloat, risk can be decreased through various management strategies. Ensure hungry animals are not solely provided alfalfa with no acclimation period. Alfalfa can be fed in combination with other higher fiber forages, such as grass hay, to decrease bloat potential. Finally, bloat risk can be reduced by providing an ionophore or poloxalene in the diet for beef cattle.

Legumes in Warm-Season Perennial Forage System Mixtures: Overview

Recently, there has been growing interest in interseeding high-quality legumes into existing warm-season perennial grass stands as a step toward improving forage, animal, and ecosystem sustainability in the Southeast U.S. Integrating legumes into existing warm season perennial grass systems has been widely successful because the legumes can complement the seasonal growth, production characteristics, and management requirements of bermudagrass and bahiagrass. Integrated grass-legume systems have wide potential application as they do not require 1) complete pasture/field renovation, 2) expensive infrastructure such as irrigation, and 3) as much establishment cost when compared with pure stand legume production. Further, the addition of legumes into bermudagrass or bahiagrass systems decreases the need for nitrogen fertilizer, increases forage nutritive value, and extends the forage production season. When evaluating profit potential, both sides of the profitability equation (cost and revenue) can improve through incorporating legumes into grass dominant perennial pasture systems. On the cost side of the equation, improvements occur from a reduction in input costs. Specifically, reductions in fertilizer and application costs, need for hay production, supplemental feeds, and associated storage and feeding costs usually occur if grazing can be extended in the fall and begin earlier in the spring. On the revenue side of the equation, improvements may occur from improved animal performance or from potential income from high-quality seasonal hay harvests.

Bermudagrass-Based Systems

Bermudagrass is one of the most abundant perennial warm-season grasses grown for pasture and hay in the Southeast (~20 million acres). Bermudagrass-dominant systems have become increasingly vulnerable to changing ecological and economic conditions. The limitations of moderate forage quality, increased insect pressure, and high nitrogen fertility requirements leave farmers seeking alternative management options for predominately forage-based livestock production systems.

Bermudagrass + Alfalfa

Alfalfa can be interseeded into bermudagrass to provide extended use and improved quality and can be utilized within the first growing season. Adding legumes to grass mixtures for grazing can help reduce the need for synthetic nitrogen fertilization with very little impact on pasture carrying capacity and can improve animal performance and production per unit area. Mid-to-late season grazing of alfalfa-bermudagrass mixtures offers improved forage quality compared to bermudagrass alone, which begins to decline rapidly late in the growing season. Average daily gain of stocker cattle grazing either ‘Russell’ or ‘Tifton-85’ bermudagrass and alfalfa was 1.5 – 2.4 pounds per day with a total seasonal gain of 622 – 822 pounds dependent on grazing management strategy in Georgia. Researchers in Mississippi reported greater animal performance (average daily gain and total gain) for steers grazing alfalfa-bermudagrass (1.8 pounds per day and 278 pounds per acre) compared to ‘Midland’ bermudagrass alone (1.2 pounds per day and 212 pounds per acre). The addition of alfalfa to bermudagrass also extends the grazing season by two to three months per year, and accomplishes this during a time of year when availability of grazeable forage is typically low. Alfalfa forage quality often meets or exceeds the nutritional requirement of most livestock, with an average of 16% CP and TDN of 60% or higher. The improvement in forage quality leads to potential for supporting increased weaning weights, body condition scores, reproductive rates. The high CP of interseeded alfalfa from biological N fixation also increases the return of nutrients to the grazed ecosystem. With proper grazing management, these nutrients in the forage can be better distributed across the pasture in the form of dung and urine, which may influence fertility requirements in this production system.

Bermudagrass + Rhizoma Perennial Peanut

In Florida, and the southern parts of a few other states, one possible option is to integrate rhizome perennial peanut into bermudagrass stands. Mixed stands of Tifton-85 bermudagrass and ‘Ecoturf’ rhizoma perennial peanut resulted in forage with better nutritive value and some N being contributed to the grass. Rhizoma perennial peanut was better than ‘Pintoi’ peanut and annual peanut, thus showing it has greater potential for biological nitrogen fixation. Although these systems do not replace high levels of N fertilizer input, they can contribute to improvements in productivity and nutritive value. Studies in the Florida panhandle showed greater nitrogen agronomic efficiency for mixtures of bermudagrass and legumes (alfalfa or rhizoma perennial peanut) compared with N fertilized Tifton-85 bermudagrass. Among the warm-season perennial legumes, rhizoma perennial peanut grows well in Florida sandy soils. Because of its large rhizome mass, rhizoma perennial peanut is tolerant to grazing and can persist well for years. It has good nutritive value compared with warm-season grasses, with typical digestibility around 70% and 18% CP. A 4-year study indicated that integrating “Ecoturf” rhizoma perennial peanut in “Argentine” bahiagrass resulted in 85% reduction in nitrogen fertilizer input, decreasing from 200 to 30 lb nitrogen per acre per year. In this study, pastures were overseeded in the fall with a blend of grass only or grass-clovers, depending on the experimental treatment. Including rhizoma perennial peanut improved average daily gain by 74% during summer (from 0.77 to 1.34 pounds per head per day). Integration of rhizoma perennial peanut also reduced the water footprint of the system, resulting in less water needed to produce the same body weight gain.

Bahiagrass and Limpograss Systems

Overview

Bahiagrass is the dominant forage on four million acres in Southeast U.S. It is well adapted to low soil fertility, is grazing tolerant, and persists well under the levels of cold temperatures typically observed in the Coastal Plain region of the Southeast. However, bahiagrass nutritive value is limited. Forage digestibility often ranges from 40 to 55%, and CP from 6 to 14%, resulting in average daily gains of only around 0.7 pounds per head per day in beef stocker calves. Also, bahiagrass requires inputs of nitrogen fertilizer to increase its forage production potential to an acceptable level. Forage accumulation rate doubled when nitrogen fertilizer inputs increased from 35 to 105 pounds of nitrogen per acre per year in a Florida study, however, under no nitrogen fertilizer input, bahiagrass productivity is limited. Another important perennial warm-season grass in the same region is limpograss. It is well adapted to flatwood soils and has been planted extensively in South Florida and it is becoming increasingly popular in North Florida. Limpograss often has better digestibility than bahiagrass, but during rapid growth or when stockpiled, its nutritive value limits animal production. Like bahiagrass, it also requires application of nitrogen to enhance forage yield.

Bahiagrass and Limpograss + Warm-Season Annual Legumes

Legume integration into warm-climate grass pastures with improved performance is another option of potential significant benefit. This strategy has been successful in research studies in numerous instances. In Florida, overseeding aeschynomene into limpograss pastures for three years increased ADG of yearling steers from 0.8 pounds per head per day for limpograss-only to 1.5 pounds per head per day in limpograss-aeschynomene pastures. This resulted in greater gain per area for the mixed pasture (335 pounds per acre per year) compared to limpograss in monoculture with 237 pounds per acre per year. Other annual legumes have also been tried including sunn hemp. However, most of the data available related to sunn hemp was when it was grown in monoculture, and there is limited information with overseeding on perennial grass pastures. Cowpea has been tested by overseeding it on bahiagrass pastures in South Florida. When cowpea was overseeded, there was low herbage mass and accumulation, with limited persistence for the summer season. The researchers concluded that further research is necessary to exploit the superior nutritive value of cowpea in grazing systems in the Southeast U.S.

Overseeding Warm-Season Perennial Grasses with Cool-Season Legumes

Annual Clovers

A more common practice is the overseeding of cool-season annual clovers into dormant bermudagrass or bahiagrass to increase land use into the late winter and early spring months before greenup. Use of annual clovers provides a short-term high quality harvestable (hay/baleage/grazing) forage and a time-released nitrogen contribution to the perennial grass base. Crimson, arrowleaf, and ball clovers are most commonly used in overseeded cool-season mixtures. These species are often overseeded along with cool-season annual grasses such as small grains or ryegrass to provide forage dry matter production during the winter months. A 3-year grazing study with beef cow-calf pairs in Southeast Alabama demonstrated that the inclusion of annual clovers with small grains resulted in nearly double the calf gain per acre compared to overseeding with only annual ryegrass. Overseeding cool-season grass-annual legume mixtures into bermudagrass stands supported an average of 90 days of grazing in this study. A summary of grazing research trials from the mid-1970s through mid-2010s noted that adding annual clovers to cool-season pastures had a low cost of production compared to grass-alone due to reduced or elimination of N fertilizer in these systems.

Biennial and Perennial Clovers

Red clover and white clover can be overseeded into dormant warm-season perennial grasses such as bermudagrass and bahiagrass. As stated earlier, red clover is a biennial (or short-lived perennial) clover that is treated much like an annual the farther South in the region it is grown. A noteworthy difference in red clover and more commonly used annual clovers is the significant potential for prolonged forage production and multiple harvests. Red clover and white clover have greater carryover potential into the early summer months than most cool-season annual clovers. Several studies in south Alabama and Georgia have demonstrated up to 15% of the harvested dry matter of mixed grass-legume stands being comprised of red clover or white clover into early July in overseeded warm-season perennial grasses.

White clover is best-adapted to bottomland soils-sites and has some tolerance to wet soil conditions. It is quite tolerant to grazing it has a creeping growth pattern that allows it to spread with stolons (or "runners") it produces near the soil surface. Because of its growth habit, it can help fill gaps in the forage canopy. White clover supports complementary growth in bermudagrass or bahiagrass systems, and lengthens the production season and forage nutritive value of stands. A summary of multi-year grazing trials in Mississippi and Louisiana reported similar or greater milk production per cow for dairy cattle grazing white clover-bermudagrass pastures compared to nitrogen-fertilized systems. The authors reported that in the same study the cost of beef production per acre was less on bermudagrass systems overseeded with white clover than those fertilized with nitrogen. A mixture of white clover and red clover can also be a potential option for overseeding in warm-season perennial grass systems, especially in sites that are not excessively drought prone.

Legumes in Cool-Season Perennial Forage Systems

Overview

The utility of annual and perennial legumes is a key practice that eliminates or greatly reduces nitrogen fertilizer needs, while also improving the quality of cool-season forage systems.

Tall Fescue

Tall fescue is the predominant cool-season perennial grass adapted to the Southeast region. Most of this tall fescue is infected with the endophyte *Neotyphodium coenophialum*, which causes problems with animal production and health. The addition of cool-season perennial or biennial legumes (white and red clover, respectively) to toxic tall fescue can be of much value. This is primarily because the fungus-produced ergot alkaloids that cause fescue toxicosis are diluted by ingestion of clover forage. When legumes are included in grass-based systems, research has demonstrated that forage intake is generally increased. In addition to greater forage intake potential, forage quality is increased through the addition of clovers to tall fescue systems. White clover and red clover have proven to be quite effective at increasing gains in livestock grazing tall fescue and reducing the severity of tall fescue toxicosis. The most commonly grazed grass-legume mixture in the Southeast is tall fescue and white (including ladino) clover. Over the last half century, there are numerous studies showing an increase in cow-calf and yearling cattle gains when grazing a mixture of endophyte-infected tall fescue and white clover compared with toxic tall fescue alone. Average daily gain of steers grazing infected and non-infected fescue increased when white clover was interseeded in the stand (1.9 vs. 2.2 pounds per day) over the course of a 3-year study in the Midwest. However, each year the benefit of the white clover diminished as the percent clover in the pasture decreased, ultimately being 11% of the stand in the last year. Previous research in North Alabama has shown 0.5 pound per day greater average daily gain for steers grazing an infected tall fescue-ladino clover mixture compared to infected tall fescue alone. This resulted in 208 pounds per acre greater gain across the grazing season in interseeded toxic tall fescue compared to toxic tall fescue monoculture.

More recent research has reported that other mechanisms of legumes may help reduce tall fescue toxicosis. Some legumes contain what are known as secondary metabolites. These are naturally occurring compounds within these plants that have antimicrobial, antioxidant, or phytoestrogen properties. Specifically, red clover contains secondary metabolites which may help mitigate some of the issues observed with tall fescue toxicosis. It is worth noting that the addition of these legumes in <u>non-toxic</u> cool season perennial pastures (i.e. novel-endophyte tall fescue, orchardgrass, etc.) have also demonstrated significant improvements in animal average daily gain and gain per acre when compared to cool-season perennial monoculture pastures, and to toxic tall fescue pasture interseeded with legumes.

Cool-Season Annuals in a Prepared Seedbed

Cool-season annual mixtures result in contributions from a more diverse combination of forages, and can lengthen the growing season. Annual legumes are often grown in combination with small grains or annual ryegrass during the winter months. Small grains, annual ryegrass, and clovers may be successfully established on prepared seedbed or overseeded to extend the active grazing period of warm-season perennial grass pastures in the Southeast US. Management strategies for selecting one such species or a mixture of cool-season annual forages may be based on seasonal and total dry matter potential; class and type of livestock nutritive requirements, animal performance goals, and costs of using winter annual forages compared to hay and supplement.

Unlike stocking strategies used for small grain-ryegrass mixtures that often involve stocker cattle, warm-season pastures overseeded with ryegrass and clover have been used primarily for cows and calves due to timing and growth of forage in late-winter into the summer months. The predominant cool-season annual clovers used in these mixtures are: arrowleaf, ball, berseem, and crimson. Crimson clover is the most widely used by producers due primarily to establishment ease, seed availability, and producer familiarity. Multi-year trials involving cow-calf grazing of ryegrass and/or clover showed that adding clovers had a lower cost of production due to reduction or elimination of nitrogen fertilization. In addition, average daily gain of suckling calves has generally been greater on cool-season annual pastures including clovers vs. ryegrass monocultures. Appropriate stocking strategies using cool-season annual forages in warm-season perennial grass pastures provide excellent examples and illustrations of extending the grazing season for sustainable livestock production in the Southeast U.S.

Lessons with Legumes – Forage production, Nutritive Value and Animal Performance Summary:

A forage-livestock producer should evaluate if legumes may be a fit for his or her forage system as monocultures, mixtures, or both management scenarios. In most systems, legumes complement the common grass-based production systems present in the Southeast U.S. The integration of legumes into perennial or annual grass-based systems can increase growing season length, increase forage quality, decrease nitrogen fertilizer inputs, and enhance livestock production via grazing or stored forage.

Legume Management Systems

There are three types of forage management systems commonly used with legumes grown as monocultures or in grass-based mixtures. These include harvested or conserved forage, grazing, and dual-purpose production systems. These management systems are often discussed individually; however, they often exist concurrently on many forage operations in the Southeast. Fluctuations in the frequency of rainfall events and in temperature (high daily and relatively low night temperatures) require forage-livestock producers to be flexible in terms of harvest management decisions.

Figure 1. Legume-grass mixtures can be harvested as hay or baleage (left) or rotationally grazed (right).

Table 1. General overview of production characteristics and harvest/grazing management requirements of common legume species in the Southeast.

Item†	**Alfalfa**	**Rhizoma Perennial Peanut**	**Perennial Clovers**	**Annual Clovers**
Anticipated average yield (lbs dry matter/year)	10,000	8,000	4,000	2,000
Average crude protein, % dry matter basis	20-25	15-20	20-25	20-25
Average total digestible nutrients (energy), % dry matter basis	60-80	65-75	70-80	70-80
Target stubble height (inches)	4”	4”	3”	3”
Target height to start grazing (inches)	10-16”	6 to 12”; varietal dependent	6-8”	8-10”
Target height to end grazing (inches)	4”	4”; varietal dependent	3”	3”
Recommended minimum rest period	30 d	42 d	15 d	20 d

†Rest periods are dependent on environmental and management conditions for regrowth.

Harvested or conserved forage management

Conserved forages can be an important tool in grazing systems as surplus forage can be harvested following periods of excess forage growth when forage availability exceeds forage demand. Storing forage for later use allows producers to better protect the quality of the forage product and minimize waste in their production system. Furthermore, regularly harvesting forage with machines or animals will promote good forage growth and productivity. The biggest limitations to hay or baleage production is often the cost of the equipment and time/labor required for its operation.

Legume monocultures are more generally harvested as small square bales because they are considered a premium product and are consistently sold at a higher price per ton compared to large round bales. Furthermore, legumes grown alone tend to wilt down to smaller windrows than grasses. Older hay equipment may be unable to efficiently accumulate this material into a bale. Legume-grass mixtures are an excellent solution to this problem.

Legumes and legume-grass mixtures can be harvested or conserved as either hay or baleage. Hay is defined as harvested forage preserved by drying generally to a moisture content of less than 20%, and they are stored in square or round bales. Baleage (or baled silage) is defined as forage stored in a round bale between 40 and 60% moisture and wrapped in plastic. The process for harvesting these products is similar. The main difference between harvesting hay and baleage is the *speed* at which the above activities occur. Hay production can take 3-5 days depending on drying conditions, forage stand density, equipment use, etc. Baleage production generally occurs within 24 hours from start to finish.

1. Ideally, a hay mower with a roller or crimper conditioner will be used to cut the forage to the recommended stubble height. Most legumes should be harvested to ~ 3 inches (Table 1). A mower without a conditioner can also be used, but drying time will be slower. Mowers with flail, impeller, or tine type conditioners are generally not recommended for use in legume monocultures because the conditioner may increase leaf shatter. These types of conditioners are commonly used for harvesting grass monocultures and may be used for harvesting legume-grass mixtures if the implement can be adjusted so that the impact of the conditioner is less abrasive on the cut forage.
2. If the forage is being harvested as dry hay, a tedder may be used to speed the drying process. While tedding grass hay is common, it is less often used on premium legume hay. Tedding this material may cause significant leaf loss if the implement is not properly adjusted or it is used on forage below 50% moisture or without a dew. Forage is rarely tedded for baleage production. Windrow inverters can also speed drying, but these tools are more common in the western US.
3. Regardless of the harvested product, a hay rake must be used to merge the swath rows into windrows after the forage is allowed to wilt to the desired moisture (usually 10-15% above the baling moisture). There are several types of hay rakes available on the market. Rotary rakes are preferred for legumes because they are less abrasive or destructive than V or speed rakes and parallel bar rakes. Rotary rakes are powered by the tractor’s PTO, not ground driven in the case of the other two types of rakes. This allows the forage to be more gently swept into a windrow with

the rotors, rather than being pushed across the ground. This prevents leaf loss and lowers ash content of the harvested material. Rotary rakes also create a taller, “fluffier” (more porous) windrow, which allows for better air flow and improved drying rates within the windrow. This allows the producer to rake the forage at a higher level of moisture, which will further improve leaf retention. If speed or parallel bar rakes must be used, the tines should be adjusted such that they minimize contact with the ground.

4. Hay can be baled with a square or round baler, whereas baleage production is nearly always completed with a round baler. Balers are used to accumulate the forage to be stored in its final product. There are many types of balers available on the market, each with their own pro’s and con’s. The biggest consideration that should be discussed here is the need for balers built with additional features for “silage” or “baleage” production. Baleage or silage balers (name depends on company) are built with heavier bearings to accommodate the increased bale weight, and scrapers on belts or rollers to prevent buildup of the wet forage material. They may also offer additional features such as knives to pre-cut the forage as it enters the bale chamber to increase bale density and reduce oxygen in the bale. A baleage baler can also be used for dry hay, however a regular hay baler cannot be safely used for baleage.
5. Baleage should be wrapped in plastic within 12 hours after baling, but the sooner the better! There are three types of wrappers available on the market: individual, in-line, and integrated. Individual bale wrappers are used to wrap each bale individually. This decreases the speed in which bales can be wrapped, but is preferred among small or medium scale producers who do not feed stored forage on a regular basis. Conversely, bales are continuously placed into in-line bale wrappers to create long lines of baleage. This greatly increase the speed in which bales can be wrapped, and reduces the need for a second tractor operator to run the wrapper. Unfortunately, once the line of baleage is opened, the bales must be fed at a rate of roughly 1-2 bales every 2-3 days to prevent spoilage.

Figure 2. Baleage production on alfalfa-bermudagrass grown in Tifton, GA.

Grazed forage management

Grazing refers to the removal of the plant tissues by an animal. Legumes provide a high-quality source of nutrients for grazing livestock. Additionally, grazing animals recycle nutrients back to the pasture system. Managing forages under grazing can be more challenging than managing them for mechanical harvest as the livestock do not graze as uniformly or efficiently as a hay mower can cut. The impacts of grazing must be considered on both above- and below-ground plant parts. When livestock graze the forage, they are removing the parts of the plant that are critical for photosynthesis. Therefore, the plant will need to rely on carbohydrate reserves from the roots to supplement the reduced photosynthesis of the remaining plant's stubble.

One of the biggest concerns that producers have before planting a legume is regarding the stand's persistence and longevity, especially under grazing management. There are several principals to sound grazing management that are important regardless of the species of legume or legume-grass mixture being grown. First, residual forage is critical for both resiliency of the forage and regrowth following the defoliation event. Low-growing species that form dense sods can be grazed to 2-3" whereas upright-growing species that form crowns should not be grazed below 4” on average (Table 1). Likewise, forages require time to rest and recover between grazing events. This period is critical for the plant to replenish root carbohydrate levels via photosynthesis. Most forages grown in the Southeast require 28 to 42 days between grazing events, but this number can vary based on temperature, rainfall, fertility status, and stocking density (Table 1). The easiest way to control residual forage heights and ensure proper rest is to practice some form of rotational stocking (rotational grazing). There are several strategies for rotational stocking that are discussed below. Forage producers should monitor forage availability and adjust the stocking rate and/or density as appropriate. High stocking rates lead to shorter rest periods and often to overgrazed forage while increasing the need for supplementation. Low stocking rates often result in overmature forage with declining quality and gain per area.

There are several strategies for implementing rotational stocking. These strategies are illustrated in the book Southern Forages (see reference at end of the text). While continuous stocking is fairly common across the Southeast, rotational stocking is critical to ensure longevity of legume stands. Continuous stocking only results in ~40% utilization of the forage resources on average.

- Rotational stocking simply refers to the practice of moving livestock between two or more pastures. The number of paddocks in the rotation and frequency at which livestock are moved can be simple or complex depending on the goals of the operation. Utilization of forage typically exceeds 60% when managed under rotational stocking. Across the Southeast, research shows that properly implementing rotational stocking can increase gain/acre by 30-60%.
- Strip grazing is a type of rotational stocking in which an electric fence is used to restrict the forward and sometimes backward movement of the livestock in the field to “ration” the available forage for the animals. This method can further improve utilization beyond basic rotational stocking (~80% utilization).
- Limit grazing can also be used as a type of rotational stocking. Here livestock are maintained on lower quality pastures and only allowed access to the high-quality

forage for a certain time period each day or week depending on the goals of the system and forages available.

- Creep grazing is often used in conjunction with strip grazing or intensive rotational stocking. When a field is creep-grazed, animals with higher nutritional requirements are given access to the field before animals with lower requirements. This type of grazing is based on the principal that the first bite of the forage is the most nutritious, so the animals with greater requirements should take that bite before the next group moves in to graze the residual forage.

The biggest limitation for implementing any type of rotational stocking system is the availability of fence and water resources. Such systems typically require a combination of permanent, semi-permanent, and temporary fence and water resources. The requirements of a system will depend on the level of grazing intensity desired.

Figure 3. Beef steers grazing an alfalfa-bermudagrass mixture in Tifton, GA.

Dual-purpose forage management

USDA NASS data reports land used for both hay and pasture separately, but many producers in the Southeast use a given unit of land for both purposes (hay and grazing). A dual-purpose system can help producers strategically allocate or distribute their high-quality forage resources throughout the entire year. For example, spring and early summer harvests of alfalfa-bermudagrass for conserved forage allows producers to capture higher-quality feed resources and preserve this product for a time of later use. This typically occurs in the fall and mid-winter months when high-quality forages are not actively growing, and grazing is limited across much of the Southeast.

There is a clear need for more research to better understand the economic and agronomic implications of dual-use production systems. There are continued evaluations of legumes-grass systems managed under both hay and grazing management occurring in multiple states in the region. These evaluations are critical for fine-tuning management recommendations for these systems while promoting their application throughout the region.

Figure 4. Dual-purpose systems optimize production by integrating grazing and mechanical harvesting (i.e., baleage).

Factors affecting forage quality

Several factors can affect forage quality regardless of the management system and product being produced. These are only briefly discussed here as more thorough information is available through state Extension services.

1. Harvesting on time is the #1 way to improve forage quality. Actively growing forages should be harvested every 28-35 days to optimize forage mass and quality. This timing may vary based on age of stand, fertilization, temperature, and precipitation.
2. Proper bale storage is critical for protecting the nutrients conserved in hay or baleage. It is not uncommon for storage losses to exceed 20%! Hay should be stored in a well-ventilated barn to minimize storage losses. Baleage should be stored in an area free of debris and away from trees or fence lines. Excessive vegetation needs to be managed to prevent damage to the plastic from weeds or rodents. The plastic should be routinely inspected for damage and any holes covered with baleage or silage tape.
3. Balanced fertilization plays a relatively minor role in forage legume quality; however, it is critical for stand persistence or longevity.
4. Forage species plays a minor role in forage quality when legumes are directly compared to each other. Bigger differences are likely to be found when comparing the grass components of the legume-grass mixtures. Cool season grasses are generally higher quality than warm season grasses. Annual grasses typically have higher nutrients concentrations than perennial grasses.
5. Insect damage can substantially decrease the quality of the forages, especially chewing or leaf-sucking insects that remove valuable nutrients from the vegetative leaf tissue. It is important to scout for forage insects and consult the pest management handbook for the state in which you live.

Preventing/Managing Bloat

Many livestock producers fear their livestock will bloat while grazing legumes, although the incidence of bloat is rarely an issue. The risk of bloat is greatly reduced if the legume makes up less than 50% of the stand. For producers with potential concerns regarding bloat, consider the following management strategies:

1. Avoid turning hungry animals out onto lush pastures, especially early in the morning. Rapid consumption of the legume forage will prevent adequate saliva from being produced.
2. Do not turn animals out onto legume pastures when there is a heavy dew or immediately after a rainfall event. The excessive moisture can affect the rate of digestion.
3. Offer dry hay to animals grazing lush and leguminous pastures to slow consumption and digestion.
4. Feed poloxalene or an ionophore (monesin) to further reduce the risk of bloat.

Lessons with Legumes: Management Systems Summary

When evaluating the use of legumes for a given farm, desired management uses and potential applications should be considered.

Ecosystem Services of Legumes

Overview

Ecosystems services (ES) are “the benefits people obtain from ecosystems”. Forage legumes provide numerous ecosystem services in grasslands including biological N fixation, enhancing cattle productivity, increased efficiency of nutrient cycling, habitat for pollinators and wildlife, carbon sequestration, and reduced need for N fertilizer, resulting in less N leaching and reduced carbon footprint of livestock systems. Legumes increase diversity of grass-dominated grasslands resulting in greater primary productivity because of more efficient resource utilization. Grazing systems can integrate legumes both in time and space. In the Southeast U.S., integration of legumes into perennial forage systems is an option to extend the grazing season and develop sustainable livestock systems.

The proportion of legumes in pasture mixtures typically influences the benefits obtained. Usually, a range of 20 to 40% legume plants in the pasture botanical composition is recommended, but the proportion of legume required to optimize ecosystem services is yet to be defined, and it might vary with ecological and economic aspects. It is also likely that different ecosystem services would require different proportions of legumes to reach the optimum level. For example, the best proportion of legumes to reach maximum biological nitrogen fixation might be different than the proportion to reach maximum animal performance. Therefore, it is important to evaluate the entire suite of desired ecosystem services and the importance of each when determining the average proportion of legume required to optimize delivery of ecosystem services from grassland systems.

Adoption of forage legumes is lagging behind the potential benefits they can provide. Reasons for limited adoption might include access to N fertilizer, low seed or planting material availability and thus high price, poor legume persistence, or lack of valuation of the benefits legumes can provide. Delivery of a broad range of ecosystem services could enhance adoption of legumes. Potential uses include traditional grazing systems, as cover crops in crop-livestock integrated systems, for wildlife habitat and feed, supporting hunting leases, and as ornamentals in landscapes. This chapter will focus on major ecosystem services delivered by forage legumes in the Southeast U.S., emphasizing success stories and ways to enhance their adoption.

Cattle productivity on grass-legume mixtures

Grass-legume mixtures are an important tool for livestock producers in the Southeast. While grasses typically provide superior yield, the forage produced is often only of moderate forage quality. On the other hand, legumes typically provide a high-quality feedstuff, but they may be lacking in forage productivity and persistence. In many cases, in terms of animal performance, there is an additive effect of cattle grazing grass-legume mixtures compared to grass-only systems. Animal performance responses of cattle grazing grass-legume mixtures is described by forage system in **Chapter 4 – Forage production, nutritive value, and animal performance**.

Biological nitrogen fixation and nutrient cycling

Forage legumes provide ecosystem benefits through biological nitrogen fixation and nutrient cycling in grassland systems. In times of increased or fluctuating N fertilizer input costs, forage legumes are generally revisited as an option to help provide N in forage systems.

Legumes can help provide a source of nitrogen for grasses in the system through a "give and take" relationship. As legumes are defoliated, either by grazing or clipping, this causes the roots to die back, releasing some nitrogen for surrounding plants. Aboveground legume leaf litter, or leaves that have fallen from plants over time, will degrade and go back to the soil, serving as a slow-release source of nitrogen. In ungrazed systems, N returns to the soil via above and belowground plant litter decomposition, as plants or plant components naturally die back and regrow over time. Grazing animals also recycle nutrients back to the soil through excreta in pastures, which represents a significant source of nutrient return. When animals are present in a grassland, they will alter the nutrient cycling in the system, decreasing the proportion of nutrients returned via plant litter, as the rate of nutrient return via animal excreta increases.

Figure 1. Excreta distribution in a pasture following winter feeding on a beef cow-calf operation in North Alabama.

It is estimated that 70 to 90% of the nitrogen, phosphorus, and potassium consumed by grazing cattle is returned to the pasture through the manure or urine. Areas where manure or urine are distributed can be a significant source of nitrogen return in pasture systems. Grazing management that promotes more uniform nutrient distribution can potentially reduce fertilizer inputs. However, because nutrients in dung must be broken down into a plant available form, nitrogen takes some time to become available to surrounding grass plants in a mixed stand. As for many biochemical processes, there is a feedback mechanism controlling biological nitrogen fixation, which naturally responds with increased or decreased nitrogen fixation depending on the amount of soil N present. This controlled mechanism represents an increase in N efficiency at the system level and reduces nitrogen losses into the environment. Therefore, losses from grass-legume mixtures tend to result in lesser N leaching than N-fertilized grass only.

Greenhouse gas emission and carbon sequestration

Worldwide, forages are the primary feed source for livestock production due to the low production costs and wide range of adapted species. With the ongoing human population growth, agricultural systems have been challenged to increase food and fiber production while minimizing negative environmental impacts. Forage systems play an essential role in delivering ecosystem services. Management practices directly impact forage production and quality, animal performance, and the environmental footprint of forage systems; therefore, they also affect the delivery of ecosystem services. In the Southeast, most livestock production systems are based on perennial grasses, which require adequate nutrient management (i.e., fertilizer) to support an acceptable level of forage production and animal performance. Fluctuations in input prices often compromise nutrient replenishment, which can lead to land degradation when combined with inadequate management practices, such as overgrazing. Over the past decades, there has been increasing interest in improving management strategies to optimize carbon storage and reduce greenhouse gases in livestock-forage systems. Incorporating legumes can be a sustainable alternative to N fertilization of grasses to enhance forage quality and nutrient cycling.

Figure 2. Dung beetles in a manure pat.

In recent decades, the animal production industry has significantly focused on improving sustainability and reducing greenhouse gas emissions. Greenhouse gases are carbon dioxide, nitrous oxide, and methane. Of these three, nitrous oxide has a global warming potential 300 times greater than carbon dioxide. Livestock activities emit around 18% of global non-carbon dioxide emissions. Generally, agricultural nitrous oxide emissions originate from using inorganic N fertilizer and animal excretion. Sources of greenhouse gases include methane from the digestive fermentation process by ruminant animals and excreta. Nitrous oxide is emitted from excreta, decomposition, and use of inorganic N fertilizer. Incorporating legumes into forage systems reduces the use of N fertilizer while improving plant litter quality, forage system biodiversity, and nutrient cycling. This leads to decreased nitrous oxide and methane emissions from grazing livestock compared with N-fertilized grass-based systems. However, incorporating legumes requires management adjustments to support continued production and persistence in forage systems, especially under grazing management.

Using legumes helps improve overall forage quality, while adjustments to management practices, such as enhanced excreta distribution and proper plant maturity at harvest, help mitigate emissions. There is also ongoing research on using plants with high condensed tannin concentrations to reduce methane production. Tannins act as a natural mediator of rumen fermentation and are found in higher concentrations in certain legumes.

Figure 3. Soil structure under a 6-yr old bermudagrass stand during early February in Florida.

Soils under perennial grasslands are major nutrient sinks, especially for carbon dioxide, due to the limited soil disturbance and constant deposition and decomposition of above- and belowground plant material. Management strategies directly impact nutrient accumulation rates and their stability in the soil. Generally, grassland management practices focus on increasing aboveground production to increase animal performance. In recent years, there has been growing interested in supporting improved management strategies also to promote belowground production and species diversity. This helps incorporate organic matter into the soil, which improves soil fertility and health. In grass-legume mixtures, decomposition of legumes releases significant quantities of N to the ecosystem, increasing nutrient recycling and nutrient accumulation in the soil. In a review of 126 studies, observed rates of soil organic carbon accumulation from 480 to 730 lb/acre/yr were observed in grass-based ecosystems under inorganic and organic fertilizer application, respectively. The role that soil organic matter and soil nutrients play in sustainability of grasslands must be well understood, since they are key to support agricultural production. Proper management practices on forage systems directly contribute to promote soil health parameters, since soil health determination often includes organic matter, soil fertility and pH, and biodiversity.

Benefits of grass-legume mixtures in pollination services

Enhancing the pollinator's habitat contributes to the yield and economic revenue of crop commodities that are entirely dependent on pollinators. Due to warm temperatures and adequate rainfall, the U.S. fruit and vegetable industry is clustered in the Sunbelt states (Alabama, Arkansas, Arizona, California, Colorado, Florida, Georgia, Kansas, Louisiana, Mississippi, North Carolina, New Mexico, Nevada, Oklahoma, South Carolina, Tennessee, Texas, and Utah), producing around 70% of the total fruits and vegetables of the country. For example, in Florida, pollinator contribution has been shown to support yield increases of 43% in crop commodities, including watermelon, pumpkins, squash, passion fruit, papaya, and cucumbers.

An improved grassland that contains added legumes offers a suitable habitat for bees and other flower-visiting insects at a potentially low cost. Legume mixtures have prolonged flowering periods, and support richer pollinator communities compared to monoculture grasslands. Also, some species, like white clover and red clover, produce pollen high in protein and amino acids. Using forage mixtures, especially perennial grasses with legumes, increases pollen and nectar availability in the landscape, and when species have different phenology or seasonality, they provide resources for pollinators over a longer period while improving forage quality for livestock. Therefore, management practices that aim at improving grazing cattle performance such as including clover or other legumes in mixtures often also allow for flower resources for various pollinators, including native bees and other beneficial insects, at a potentially low to zero added cost to the livestock operation.

Managed grasslands are important ecosystems in the Southeast U.S. These ecosystems provide habitats for pollinators, which in turn help support grassland production and food webs. Grazing is a common practice in grasslands and can be used to maintain structural diversity, encourage the growth of plants rich in nectar, and create potential wildlife nesting habitats. When comparing grazing systems, those that included a mixture of legumes attracted more native bees than monocultures of grasses. Similar trends were observed with old-world bluestems, a perennial grass in the semiarid Southern Great Plains of the U.S. This grass, well-adapted to dryland conditions, attracted a greater number of pollinators (e.g., native bees, honeybees, and hoverflies) when alfalfa and native grasses were mixed with it. However, legume abundance and persistence are more sensitive to inadequate management practices. Overgrazing may occur when stocking rates are too high, or when trampling, long grazing periods, and short resting periods occur in forage systems. Benefits to pollinators will only be tangible when maintaining legume proportion in pastures is an overarching goal in a production system.

Multifunctional legume cropping systems optimize forage availability for a diversity of wild pollinators. They also deliver various agronomic and environmental benefits. Farmers in the Southeast U.S. commonly use grass-legume mixtures, such as cereal rye and hairy vetch, oats and red clover, or field peas and small grains in cover crop systems. Other mixtures might include a legume or a small grain with oilseed radishes or a combination of small grains. In addition to other ecosystem services previously described, mixed grass-legume stands usually are more effective in suppressing weeds and controlling pests than a single species, which may reduce the use of pesticides that may negatively affect native bees. Conversely, in other mass flowering crops such as cotton and soybean, the risk for insecticide exposure is higher. Use of neonicotinoids (a water-soluble insecticide particularly effective against sap-feeding insects) in the environment may cause impairment of foraging, reduce population densities, reduce reproduction success, and increase the susceptibility to disease and parasites in native bees.

Future research in legume-pollinator interaction in grasslands and cropping systems in the Southeast U.S. should address pasture management, grazing intensity, and other pollinator-friendly practices. The season effect should be considered, as well as the difference in forage species combined with the grazing effect between cool to warm seasons.

Reducing Runoff and Water Quality

In grazed systems, there is an increased risk of nitrate leaching from urine patches, especially under high soil moisture conditions. Nutrient runoff from forage systems is also possible. However, in comparison to systems based on grass or cereals fertilized with N, grazing systems containing forage legumes may result in reduced N losses to water. This occurs because one of the primary factors driving N losses in agriculture systems is the amount of N inputs, which is typically significant when nitrogen is applied through chemical fertilizers. The combined effect of N fertilization and grazing may further increase runoff potential and N-leaching to groundwater, even in grass-legume mixtures. If the amount of N exceeds the uptake capacity of plants at time of application, N will often accumulate in the soil profile and become prone to leaching. Because forage legumes often have greater N concentration than grasses, depending on their proportion in the pasture, grazing animals might produce urine with high N concentration resulting in further environmental losses. However, it is important to highlight that regardless of the N source (chemical or organic fertilizer, animal urine and dung, or decomposition of plant litter), the more N in the system, the more N that is prone to leaching or runoff.

Synchronizing N supply to plant N demand is one of the strategies to mitigate N losses via nitrate leaching, and may reduce runoff through optimizing above ground forage growth with nutrient availability. Research has revealed that legumes are likely to release N at rates that match potential rates of N uptake of a growing pasture. Thus, given good growing conditions which favor ground cover, N losses via leaching are less likely to occur in grass-legume mixtures. In long-term clover-grass pastures, it is unlikely that N inputs will surpass 180 lb/acre/year, reducing the chance of mixed legume-grass pastures to negatively affect water quality compared to grass pastures receiving large quantities of N chemical fertilizer.

Aesthetic and cultural value

Legumes can provide aesthetic and cultural value that improve human wellbeing. Besides urban landscaping, legumes in rural areas often provide a scenic view that enhances the aesthetic value of rural landscapes (Figure x). Forage legumes have been used in the Southeast U.S. to improve habitat for wildlife in hunting leases. In Jackson County, FL, a farming operation based on hunting leases utilizes rhizoma perennial peanut in the warm season and annually overseed fields with cool-season clovers to enhance habitat for white tail deer. Seed mixtures for cool-season forages including legumes are commonly found in the regional market and indicate the value of forage legumes for this ES. The University of Florida, for example, recommends forage varieties for wildlife including several legume options.

Figure 4. Rhizoma perennial peanut (*Arachis glabrata* Benth) can provide aesthetic value for rural and urban landscapes.

Lessons with Legumes – Ecosystem Services Summary

Legumes offer many benefits outside of traditional agricultural production. These ES have the potential not only to enhance livestock productivity, but also to reduce environmental problems, improve economic return, and enhance human wellbeing. It is worthwhile to consider what ecosystem provisions may be of benefit to an operation and how legumes may add this element to the farm. Programs incentivizing the use of legumes to enhance delivery of ES need to be be put in place, and will benefit livestock producers, the environment, and society at large.

Opportunities and Challenges of Legumes in the Southeast – Producer Experiences and Testimonials

Producer experiences with legumes in the Southeast provide insight into how legumes fit in various operations and showcase successes and failures in differing production environments. The following chapter shares several testimonials of farmers in the region.

Alabama

Mr. Tim Tucker has been in the cattle business for 45 years near Uriah. He is the fourth-generation family member in forage-livestock production. The predominant forages used on his operation include bahiagrass, bermudagrass, ryegrass, and clovers (ball, crimson, and white). His major focus is to manage the pastures under grazing. Hay is produced when there is a surplus of forages. Legumes have been part of their operation as long as Mr. Tucker can remember. He considers ball and crimson clovers as successes. These clovers are managed for reseeding and are an important resource to reduce N fertilizer use. For Mr. Tucker, weed control is the major drawback for the inclusion of legumes, but given the options of available herbicides and management practices, not as bad as in the past.

For those interested in incorporating legumes, these are the steps he recommends. First, conduct a soil test to adjust your pH as needed. Then adjust the seed depth at planting and use mixtures of grasses and legumes when possible. When overseeding perennial grasses, it is important to make sure the grass is no longer actively growing. Mr. Tucker says, “Do not plant the whole farm in one thing. Also, I’d prefer to be a little late when overseeding than early because early planting can result in issues with drought and competition.”

Mr. Jaffe Paysinger has been farming since 2011 near Elkmont. His grandfather farmed, but after skipping a generation, family interest was renewed with Mr. Paysinger. The predominant forages are tall fescue, orchardgrass, clovers, and crabgrass. He grows alfalfa that he uses to produce baleage and pre-condition his animals. This cuts his bought feed costs. He relies on fields for grazing, hay, and baleage production and started using legumes to improve forage quality and soil fertility. For Mr. Paysinger, his alfalfa field is one of his biggest successes, and he attributes this to help from the Alabama Cooperative Extension System. He uses rotational stocking to manage his pastures successfully. Among his failures are planting clover seeds too deep and not correcting the soil pH to the appropriate levels beforehand.

Therefore, for someone wanting to start using legumes, he suggests “doing homework” before planting. This includes soil testing and getting professional help through the Extension system. Then, it is essential to have a plan and understand what conditions you have in terms of soil type, management, etc. Being on top of soil fertility and weed control management is also crucial. About his alfalfa field Mr. Paysinger says, “Extension people made that a success.”

Florida

Mr. Glenn Emerson started farming in 2007 near Tampa and is a first-generation farmer. The predominant perennial forages used are rhizoma perennial peanut, bahiagrass, and bermudagrass. He has fields under grazing, hay, and baleage production and produces vegetative rhizoma perennial peanut sprigs in nursery fields. He grows Florigraze, Peace, and Tito rhizome perennial peanut varieties. He states that rhizoma perennial peanut provides the persistence, resilience, high forage quality, and ability to share N when grown with grasses. On the other hand, he mentions that weed control is key to success and that it is crucial to be timely with any herbicide application. The steps he recommends for someone interested in using legumes are first to go see what someone is already successfully doing to learn from them, including for hay production. Then, once you have decided to start your business, rely on working with a producer with excellent background and experience, that person will be able to share relevant experience. Mr. Emerson says that working with rhizoma perennial peanut is rewarding and that “It is a great product.”

Mr. Mack Glass has been a farm manager for over 50 years. His family started farming in 1916, and it carried over a multi-generational operation near Marianna. The predominant perennial forages used are bahiagrass and bermudagrass, but they also plant pearl millet and cool-season species (rye, triticale, ryegrass, and ball and crimson clovers). Over the past five years, the pastures were grazed exclusively, and hay was purchased only as needed. Mr. Glass says they started using clovers in the 1980s to reduce N fertilizer use and improve forage quality to support better conception rates. He lists those as the major benefits they achieved after incorporating legumes but mentions that controlling weeds was difficult. He recommends that producers consider using mixtures of legumes and grasses to improve the nutrients available for plants and animals. He also says, “I hope to continue to see research being done on the use of legumes aiming to decrease the use of N fertilizer.”

Georgia

Mr. Ernie Ford is a fifth-generation farmer and has been farming since 1970 near Calhoun county. The predominant forages used are bahiagrass, bermudagrass,

and clovers. He relies on grazing and harvesting hay for managing his commercial cattle operation. Legumes were introduced into the farm around 40 years ago aiming to reduce N fertilizer input and costs. In addition to these reasons, he also wanted to increase protein in the animal diet. The major success is the results obtained with crimson clover establishment and management to reseed. With the extent of presence of clovers in his pastures, he is able to harvest bahiagrass-clover mixtures for hay which improves the forage quality for animals. In terms of difficulties, weed control is more challenging when using legumes so this has required some adjustments to be able to decrease weed populations, but also keeping a clover-friendly environment. Herecommends for someone wanting to adopt legumes into their forage systems to first correct soil pH as needed. Then, Mr. Ford says, “(One) needs to be content with the weed control attained (when using legumes)”. He has tried alfalfa before in mixture with bermudagrass but, he says that it had high maintenance requirements and high costs and was not a good fit for his operation.

Mr. Phil Moshell is a fifth-generation farmer and has been farming since 1969 near Morris. The predominant forages used are bermudagrass, ryegrass, clovers, and alfalfa. He relies on grazing and producing baleage for backgrounding his beef cattle.

Legumes were introduced into the farm aiming to reduce N fertilizer use and increase forage quality. In addition to these reasons, he makes more cuttings per season with his alfalfa-bermudagrass fields compared to bermudagrass alone. This helps with additional forage for animals to graze longer in the season. The major success is better animal gain, especially in late winter, when feeding mixed grass-alfalfa forage. In terms of difficulties, correcting soil pH was a difficult step, but he has not had major issues with insects. Being able to make baleage helped with reducing drying time, especially during summer. In terms of steps, he would recommend for someone adopting legumes to rely on the recommendations of the Extension personnel and, when possible, use a Roundup Ready alfalfa variety. Mr. Moshell says, “I am happy with it and plan to expand the use of legumes.”

South Carolina

Mr. Bobby Padgett and his wife started their farm in 2012 near Cameron. The predominant forages used are bermudagrass and bahiagrass. They also plant sunn hemp and cool-season mixtures containing legumes (winter peas, clovers, ryegrass, rye). They have fields for hay production and manage additional acreage under grazing. They started using legumes eight years ago to improve soil health, increase weight gain and milk production, and reduce N fertilizer use. The major successes with using legumes were improved animal performance and health. Difficulties were deer pressure at establishment and growth, requiring a higher management level. For anyone wanting to incorporate legumes, Mr. Padgett recommends starting with small acreage to be able to adjust management. He also emphasizes the importance of not being afraid to try something new and to network and ask other producers about what worked or not for them. Mr. Padgett says, “My wife is a huge part of the farm; without her, it would not be possible to farm.”

Mr. Kevin Yon and Mrs. Lydia Yon started farming in 1989 near Ridge Springs, SC. It is now a multi-generational operation. The predominant forages are bermudagrass, bahiagrass, tall fescue, crabgrass, and annuals (sorghum, oat, wheat, rye, clovers, etc.). Fields are dedicated to grazing and hay and baleage production. They initially incorporated clovers to improve forage quality and reduce N fertilizer input. It successfully allowed them to reduce N fertilizer and improve soil health. Bloat was never an issue. Mr. Yon also has experience growing alfalfa. The major challenges were weed pressure in legume-containing areas, including roundup-resistant pigweed in alfalfa fields. For those wanting to start using legumes, Mr. Yon says that relying on fundamental agronomic principles such as using high-quality seeds and properly calibrating the drill before planting is essential. Using proper grazing management will ensure persistence. Mr. Yon says, “Managing a forage system is key since it takes all the little things to do a good job.”

Mr. Reed Edwards started farming in 2007 near Laurens, SC. He had horses and bermudagrass but decided to try sericea lespedeza. Currently, the predominant forages on his farm are sericea lespedeza, alfalfa, tall fescue, and mixtures of annual forage species for both the summer and the cool season. He produces hay to sell but relies mostly on grazing fields for nutrition for cattle and horses. The decision to start using legumes was based on trying to identify drought-tolerant forage species. Major successes with legumes were drought tolerance with sericea, overall improved forage quality and sales prices for hay, and reduced use of N fertilizer. He also mentioned that the improved forage quality helped balance the horse's diet, that in turn supported his emphasis on diversifying the pastures. In terms of challenges faced, weed control is a major one given pasture diversity. For the alfalfa areas, deer pressure and insect damage were major difficulties since he dislikes spraying insecticides. Initially, the lack of information on sericea lespedeza was challenging. Regarding steps, he would recommend that someone adopting legumes to first soil test. Weed control is essential before establishment. Leaf retention is also critical, so bale during times when retention is maximized. Lastly, mixtures with grasses can reduce the risk of bloat and should be used. Mr. Edwards says, "I do not want a field that doesn`t have legumes on it."

Lessons with Legumes – Producer Experiences Summary

Producer experiences illustrate that there is no "one size fits all" approach to forage management, and the inclusion of legumes on farm. Across these producer testimonials, having well-defined production goals, learning from trusted resources, and getting the basics of soil fertility and weed control right for legume establishment success are emphasized as being critical.

Economic Considerations of Incorporating Legumes into Forage Systems

Forage legumes play a vital role in agricultural systems in the Southeast U.S. as they provide high-quality feed for livestock, improve soil health, and reduce greenhouse gas emissions.

There are several economic factors that are important to consider when determining whether establishment is right for a particular operation. In this section, we will discuss the economic costs, economic benefits, and other related considerations when incorporating forage legumes.

Economic Cost of Forage Legumes

The cost to establish forage legumes varies widely depending on several factors, such as location, species, variety, and management practices implemented. Some of the factors that can affect the cost of establishing forage legumes are as follows:

- **Land preparation:** The land where forage legumes will be established should be prepared to ensure good establishment and growth. The cost of land preparation can vary depending on the level of soil preparation required, the type of equipment used, and the labor costs.
- **Equipment Costs:** Specialized equipment such as a grain drill, no-till drill, cyclone or pendulum spreader may be needed to plant forage legumes.
- **Seed Cost:** The cost of forage legume seeds varies depending on species, variety, quality, and the amount of seed needed. Some forage legumes will be more expensive than others due to their availability and demand. While seed cost varies, it almost always represents a small part of the overall cost of stand establishment. Purchasing good quality seed of a variety or type known to be capable of providing dependable performance is prudent.
- **Lime and Fertilizer and Lime:** Lime is often required to raise the soil pH to an acceptable level. Fertilizers will likely be required to improve plant growth and establishment. The cost will vary depending on the type and the amount needed.

- **Inoculant:** Inoculant containing the specific rhizobia bacteria that will form nodules on the roots of legumes are necessary to ensure effective nitrogen fixation in forage legumes.
- **Disease and pest management:** Forage legumes can be susceptible to certain diseases and pests, which can reduce yield and quality. The cost of disease and pest management must be factored into the economic analysis of forage legumes.

Overall, the cost to establish forage legumes can vary significantly. For example, this could range from a few dollars per acre for white clover to a few hundred dollars per acre for alfalfa. The cost of establishing forage legumes must be weighed against the potential benefits they that can provide.

Economic Benefits of Forage Legumes

When managed properly, forage legumes can provide numerous economic benefits for producers, livestock, and the environment. The economic benefits of incorporating forage legumes into agricultural production systems varies widely depending on several factors, such as location, species of forage legume, and management practices implemented. The following are some of the factors that can affect the economic benefits of incorporating forage legumes are:

- **Increased animal productivity:** Forage legumes provide high-quality protein, energy, and other nutrients, which makes them an excellent source of nutrition for livestock. Research has shown that livestock grazing forage legumes usually gain weight more quickly and produce high-quality meat and milk than animals grazing traditional grass pastures. This helps promote increased weight gain, body condition, and muscle growth. The higher quality protein and nutrients of forage legumes also help support nutritional needs associated with reproduction and lactation, as well as animal performance and health in livestock systems.
- **Reducing feed costs:** Forage legumes with higher yields and of better quality will provide greater economic benefits to livestock producers by

reducing the need for supplemental feed and improving animal performance through improved forage quality.

- **Nitrogen Fixation**: Forage legumes do not fix atmospheric nitrogen, bacteria do. The symbiotic relationship of forage legumes with nitrogen fixing bacteria allows for potential reduction or elimination of N fertilizers in forage systems. In order for these benefits to be realized, legumes must be successfully established and productive components of the forage system. Additionally, the extent of nitrogen fixation can vary widely depending on the species, management practices, and environmental conditions.

These economic benefits result in both a cost savings for producers as well as improvements in productivity of livestock and soil.

Other Economic Considerations

There are several other management considerations that producers should assess as they evaluate forage legumes for their operation.

- The yield and nutritive quality of forage legumes will vary depending on the species, variety, climate, soil type, and management practices. Consideration of these criteria is critical in producing a productive stand of forage legumes.
- Forage legumes can be used as a multi-purpose crop, such as for grazing, hay production, and seed production, providing producers a diversified income stream and potential increase profitability.
- The market demand for forage legumes as a hay, haylage, baleage, or silage crop will influence the economic viability of the crop. Producers should consider the local demand and prices of forage legumes before deciding to incorporate them. In some regions, there may be a high demand for a forage legume product resulting in a premium price. In other regions, the demand may be low, which reduces the economic incentive for producers to grow forage legumes.

- Forage legumes have been found to provide several environmental benefits such as reducing greenhouse gas emissions and improving soil fertility. The environmental benefit of reducing greenhouse gas emissions could lead to additional revenue streams through carbon credits, whereas the improvement in soil fertility leads to cost savings from a reduction in nitrogen fertilizer costs.
- It's also important to note that grazing management is critical to realizing the full benefits of forage legumes. Proper grazing management practices, such as avoiding overgrazing, ensuring adequate rest periods, and using rotational grazing can help maximize animal gains and overall productivity. Additionally, appropriate stocking rates, stocking density, and forage legume species selection should be considered to achieve optimal forage and animal performance.

Lessons with Legumes – Economics Summary

Overall, the economic considerations of forage legumes depend on several factors, including cost of production, forage yield and quality, animal productivity, nitrogen fixation, management, and market demand. Forage legumes can provide significant economic benefits to livestock producers and agricultural systems, but these benefits do come at a cost. Producers should carefully evaluate whether the short-term and long-term benefits of incorporating forage systems into their production system can outweigh those costs and result in increased profitability and sustainability.

Supplemental Reading

Ball, D.M., C.S. Hoveland, and G.D. Lacefield. 2015. Southern Forages, 5th edition. International Plant Nutrition Institute, Peachtree Corners, GA.

Tucker, J., K. Mullenix, L. Silva, C. Prevatt, D. Samac, K. Kesheimer, M. Tomaso-Peterson. 2021. Alfalfa bermudagrass management guide. National Alfafla and Forage Alliance, St. Paul, MN. https://www.alfalfa.org/pdf/AlfalfaBermudagrass-LowRes.pdf.

Planting Guides

Consult your local Extension office for resources on planting legumes as forage crops in your respective county in the Southeast US.

Extension Publications

For more information on legumes, visit your state's respective Extension website for resources on forage management.