ALFALFA BERMUDAGRASS MANAGEMENT GUIDE

PREFACE

The incorporation of alfalfa into any grass pastures improves forage production and nutritive quality and decreases the reliance on commercial nitrogen fertilizer. Bermudagrass is no exception. This guide provides information on establishment, management and use, integrated pest management (weeds, insects, and plant diseases), and economics of alfalfa-bermudagrass systems across the "Bermudagrass Belt", a region that spans from coast to coast, encompassing the entire southern portion of the United States and much of the transition zone. 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 or suggestions included in this guide.

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INTRODUCTION

Bermudagrass [*Cynodon dactylon* (L.) Pers.] is a warm season forage widely grown throughout the southern USA. It forms an adaptation area, the “Bermudagrass Belt”, that encompasses the entire southern portion of the United States and much of the transition zone with an estimated 28 million acres in use for both hay and pasture. Bermudagrass achieved its high rank as a forage crop for some very simple reasons; it is persistent, dependable, widely adapted, and high yielding. Though bermudagrass is becoming increasingly vulnerable to fluctuations in costs associated with commercial synthetic fertilizer inputs and changing environmental and economic conditions in the region.

Alfalfa (*Medicago sativa* L.) was once a dominant perennial legume species in the south, introduced into Savannah, GA in the 1700`s. However, the harsh environment, elevated insect pressure, and availability of cheap nitrogen sources soon eliminated many productive alfalfa stands by the 1950’s in the region (Lacefield et al., 2009). In the North and Midwest, alfalfa is highly utilized and well-adopted, largely due to improved variety (AKA cultivars or cultivated varieties) development focusing on these geographies, providing higher forage yields, multiple pest resistance traits, targeted fall dormancy, better winter survival, and improved quality potential. However, newer alfalfa varieties have been developed with improved adaptation to hot humid growing conditions and with dual use (hay and grazing) that better fit the management strategies for forage-livestock farmers in the southern region. Alfalfa is now considered a low acreage forage crop in the South, however the potential for integration into existing bermudagrass systems is high.

Historically, incorporating legumes into perennial warm-season grasses can increase economic and environmental benefits to southern livestock and forage systems. Perennial legume-grass mixtures help by spreading out the forage growth across the season, extending production and use of an area, and decreasing reliability on synthetic fertilizer inputs. Benefits of alfalfa-bermudagrass (ABG) forage systems include improved seasonal forage production potential, nutritive value, nutrient cycling, increased species diversity, and ecosystem services. This publication provides an overview of establishment and management considerations for ABG mixtures across the “Bermudagrass Belt”.

ESTABLISHMENT OF ALFALFA-BERMUDAGRASS MIXTURES

Soil and Fertility Recommendations

Alfalfa requires well-drained, fertile soils. During the winter-spring before the recommended fall planting period, soil sampling should be conducted at both the topsoil (0 to 6 inches) and subsoil (6 to 12 inches) depth to determine baseline fertility and pH correction needs. The topsoil pH in the 6.5 to 7.0 range and subsoil pH at 5.5 or greater are preferred. While lime applications improve topsoil pH within the planting year (6+ months after application), it is a challenge to change subsoil pH levels with lime incorporation without soil disturbance and a deep tillage. Therefore, this practice for subsoil pH correction is not considered when integrating alfalfa into existing bermudagrass sods. Other soil fertility factors to consider are soil phosphorous (P) and potassium (K) levels in the medium range for the site and adequate molybdenum (Mo) and boron (B) as they play a significant role in alfalfa success. Adequate B and Mo are crucial for nodulation and nitrogen fixation on alfalfa plants, therefore, adequate levels in soil can influence the formation of nodules.

When selecting a bermudagrass field for alfalfa incorporation, it is ideal to select a well-managed field within the proper soil fertility and pH. When comparing the general fertility recommendations for either bermudagrass or alfalfa monocultures, the main difference is the lack of nitrogen (N) fertilizer requirement for alfalfa production. The other nutrient recommendations, including soil P and K, are nearly identical for management of bermudagrass or alfalfa monocultures. Neither bermudagrass nor alfalfa tolerate excessively wet areas and will not persist in poorly drained soils. A rule of thumb is "if bermudagrass won't grow there, neither will alfalfa". Alfalfa incorporation should be reserved for the best bermudagrass fields, not the challenging ones.

Other bermudagrass field selection considerations are 1) previous field history, soil depth and drainage, 2) reoccurrence of hard to control weeds and 3) herbicide applications in recent years. If a residual herbicide was used for broadleaf weed control, be sure to know the timeline, rate of application, the active ingredient, and the required planting interval between application and planting of alfalfa or another legume. For example, a short-term residual chemistry (i.e., dicamba) applied in the spring prior to planting alfalfa in the fall is considered safe, but longer-term residual chemistries (i.e., sulfonylureas) require delayed planting from 4 to 12 months post-application. In areas where aminopyralid or picloram was used in recent years, a bioassay is recommended for best certainty before planting at minimum of 12 months after use. A bioassay is easily done by taking soil cores from the site and planting alfalfa into them in a controlled environment to assess germination and seedling establishment.

Planting and Stand Establishment

Successful establishment is the most critical aspect of alfalfa incorporation into bermudagrass, and bermudagrass suppression during that time is crucial. Thus, planting is best in the fall when bermudagrass is going dormant. Planting should occur under ample soil moisture and when soil temperature is ranging from 65 to 80° F. Note that alfalfa grows slow when soils are cold, thus new seedlings need 6 to 8 weeks of growth before the first hard freeze occurs. However, the further south the location, the hard freeze date tends to be pushed back allowing for later planting than the more northern locations of the Bermudagrass Belt (Figure 1). For example, in Florida, successful stands have been established in late December to early January.

Table 1. Recommended alfalfa planting dates for selected regions within the Bermudagrass Belt.

REGION BY SOIL TYPE	PLANTING DATE
Coastal Plains	Oct. 15 - Nov. 30
Limestone Valleys	Sep. 1 - Nov. 1
Piedmont	Sep. 15 - Oct. 15

** Alfalfa in bermudagrass planting recommendations are based on research conducted in these regions but are dependent on the timeframe for onset of dormancy for bermudagrass.*

Figure 1. Representation of Bermudagrass Belt (in blue).

Immediately prior to interseeding alfalfa, it is recommended to closely mow or heavily graze the bermudagrass sod to 1 to 2 inches to open the canopy and remove the residual material in preparation for planting to improve seed to soil contact. After removing plant residue, spray a suppression rate of glyphosate (9 oz./ac if 5.5 lb. a.i. formulation or at 12 oz./ac if 4 lb. a.i. formulation) to induce bermudagrass dormancy. Then, wait one week to ensure grass dormancy before seeding alfalfa to reduce grass competition for resources.

Choose an alfalfa variety that is recommended for your region and consider using dual-purpose varieties (hay and grazing). Not all alfalfa varieties are suitable for use in mixture with grasses. Prior to planting, make sure to use inoculated seed that contains the appropriate *Rhizobium* strain. Note that newer alfalfa varieties come pre-coated with an inert material that contains the necessary inoculant and starter micronutrients (Mo and B) for alfalfa establishment. For the most up to date varietal recommendations contact your local Extension agent.

Due to the small size of alfalfa seeds, ideal planting depth is ¼ to ½ inch. Planting too deep accounts for more than half of alfalfa stand establishment failures. For best results use a no-till drill equipped with a box foe small seed, plugging every other hose on the box to maintain a 14-15" row spacing between planted alfalfa rows.

A good rule of thumb is there should be a few seeds visible on top of the drill row; if no seed are visible, then depth is too deep. Recommended seeding rate is 12 to 15 lbs pure live seed (PLS)/acre. In terms of row spacing, planting closer on a ~7.5" row spacing results in the shading of bermudagrass by alfalfa; while, planting wider at ~24" row spacing favors the bermudagrass growth and shades out the alfalfa component. The ~15" row spacing is considered the ideal complementary mix and creates the ebb and flow relationship for greatest benefit of this mixture.

Soon after planting (7 to 14 days), begin scouting fields for seedling emergence. It is also important to scout for insect. After alfalfa emergence, spray the field with an insecticide to control insect pests during the establishment phase. Continue scouting fields regularly during establishment and throughout the stand life for insect and weed pests, diseases, signs of fertility issues, and flowering stage. Irrigation is not required but is recommended if possible as it will help both during stand establishment and throughout the stand life when rainfall is limited.

Soil Fertility Recommendations After the Establishment Year

Soil sample annually, usually during the winter months to ensure fertility needs are met and mitigate potential stand issues related to soil fertility. Soil fertility is crucial to meet yield potential and assure persistence of the ABG system. Phosphorous (P) is essential for root development and energy transfer and is applied once per year, usually in the late winter to early spring, along with additional nutrients based on soil analysis recommendations. While boron (B) deficiency is usually visible via the plant throughout the growing season and can cause significant yield loss, it is recommended to conduct plant tissue analyses to determine nutrient levels in the plant. Applying boron with other fertilizer in the late winter annually should help mitigate boron deficiencies. When using foliar fertilizer, rates over 0.5 lb B/acre can induce toxicity in ABG mixtures; therefore, split application is recommended throughout the season. Molybdenum (Mo) can be applied every two years in the late winter or early spring before new shoots reach 2 to 3 inches in height. Tank mixing Mo and B with spring insecticides to control alfalfa weevil is also an option.

Potassium (K) is key to alfalfa and bermudagrass stand resistance and persistence. Many stand losses in both alfalfa and bermudagrass are attributed to K deficiency. Plants are luxury consumers of potassium thus split applications are recommended for best efficiency. A minimum of three split applications per year is recommended in the spring, summer, and fall. In some instances, like the very sandy soils of the Coastal Plains, four applications provide better results. Follow soil test recommendations and contact your local Extension agent for assistance with analysis and interpretation of results if needed.

WE DO NOT RECOMMEND:

(1) establishing alfalfa and bermudagrass at the same time
(2) establishing alfalfa into bermudagrass via broadcast planting
(3) establishing alfalfa into bermudagrass during springtime.

COMMON NUTRIENT DEFICIENCIES

Fertilization of ABG mixtures take in consideration requirements for both species, as well as goals for forage production and stand persistence. In this context, regular soil testing is essential to determine amendments needed. Often, early management practices greatly impact alfalfa establishment and persistence. On table 2, deficiency symptoms of selected nutrient are briefly described to facilitate diagnosis. On ABG mixtures, synthetic nitrogen (N) fertilizer application is not required once alfalfa, a forage legume, is able to fix N biologically from atmosphere because it is a legume. However, it is crucial to provide best conditions for alfalfa to form healthy nodules by using good quality inoculated seeds and adequate soil fertility, and pH. The level of phosphorus (P) available may be impacted by dry soil conditions, cold temperatures, soil compaction, herbicide injury, insect pressure, and poor overall soil health limiting its absorption and root growth. In terms of micronutrients, boron (B) and molybdenum (Mo) are crucial for nodule formation and health and will impact stand persistence.

Table 2. Symptom of selected nutrient deficiencies in alfalfa.

NUTRIENT	MOBILITY IN THE PLANT	DEFICIENCY SYMPTOMS
Boron (B)	Immobile	discolored terminal buds, shorter internodes, and stunt upper plant parts (youngest leaves). In extreme conditions, growing points and leaves may die.
Nitrogen (N)	Mobile	stunted growth and light green or yellow alfalfa plants.
Phosphorus (P)	Somewhat Mobile	reddish to purple color on the edge of older plant leaves.
Potassium (K)	Mobile	stunted plant growth, poor root system development and yellow or white spots forming on the margins of leaflets of older leaves, and they start to senesce.
Sulfur (S)	Immobile	stunted plant growth and yellowing plants.

Visual observation commonly diagnoses nutrient deficiencies in the field since plant symptoms, such as yellowing and stunted growth, are associated with specific nutrients. Care should always be taken when diagnosing in-field issues, as some problems may have similar symptoms. For trained observers, this approach is efficient; however, more than one nutrient can is associated with a visual symptom. For example, stunted growth. Therefore, a plant tissue sample analysis is highly recommended where this is the case. The plant tissue report provides a detailed description of the main macro and micronutrients available thereby allowing for the best fertilizer nutrient recommendations to improve yield and stand persistence. Soil tests are helpful, but do not provide as accurate of information for specific nutrients such as sulfur, boron and molybdenum that are highly important for alfalfa. Also, some symptoms may be similar to damage caused by insects as well. For example, damage caused by three cornered alfalfa hopper is similar to boron deficiency (Figure 2). For tissue analysis, it is recommended to take plant tissue samples in the middle of the season or whenever nutrient deficiency symptoms are observed. Samples should be collected when stands are at 10% bloom, with timing being critical for appropriate analysis interpretation. It is important to get a representative sample of the entire field by collecting several stems randomly throughout the area. Prior to sampling, check with the laboratory about sample size needed and appropriate packing and shipping protocols to avoid loss, spoilage, and/or contamination.

Figure 2. Boron deficiency (left) and three-cornered alfalfa hopper (middle) damage in alfalfa. On the right, there is a diagram to differentiate potato leafhopper and potassium defficiency (Coutesy of Dr. Dennis Hancock).

HARVEST MANAGEMENT OF ALFALFA-BERMUDAGRASS MIXTURES

Hay and Baleage Production

Harvest management of alfalfa-bermudagrass forage systems require a proper balance of production, nutritive value, and alfalfa persistence. In the establishment year, the first harvest should occur at the mid to late (25% or greater) alfalfa bloom stage. Although there are minimal nutrient quality losses in hay compared to harvesting in early bloom, delaying the initial harvest is beneficial to allow the alfalfa to be more competitive with the bermudagrass early in the season and for the root system to develop and store carbohydrates reserves crucial for longer term stand persistence. Subsequent harvests normally occur on a 28-to-35-day interval during active alfalfa growth at or near a 10% bloom stage. After the establishment year, initial harvests occur once the alfalfa stand is in bud to early bloom (10%) stage of growth. Seasonal alfalfa growth distribution and harvest expectations are dependent on the location and dormancy rating of the variety planted. Fall dormancy refers to the ability of the variety to continue to grow during winter which could compromise the plant`s ability to recovery from winter injuries. A non-dormant alfalfa variety [8+ fall dormancy (FD)] provides active growth and harvestable forage earlier in the Spring and later in the Fall than a semi-dormant (4-5 FD) variety. A semi-dormant alfalfa variety is generally more cold tolerant and less sensitive to winter injury. Be sure to match the chosen alfalfa variety with winter historical temperature lows and production expectations.

When harvesting ABG mixtures, the recommended stubble height is 4 inches above the soil surface. This allows proper residual leaf area for fast regrowth.

Regrowth of alfalfa plants occurs through initiation of crown buds and axillary buds forming new shoots; therefore, the cutting height should be greater than 2 inches to avoid removing axillary buds and delaying potential regrowth.

In addition, it is important to minimize loss of alfalfa leaves during harvesting by decreasing the field dry down time. Using a mower-conditioner

Figure 3. Harvested forage being baled for baleage (top); inline baleage wrapped (middle) and dry hay (bottom).

and tedder decrease drying time especially during the rainy season. Both, tedding and raking operations cause excessive leaf losses if performed when alfalfa is below 40% moisture. After raking, the curing process continues in the windrow. Proper moisture for baling is ≤ 20%for hay production and, ranges from 40 to 60%for baleage production (Fig. 3). Several factors, including environmental moisture and temperature, affect drying time; therefore, drying time may vary within the time of the growing season. Commercial preservatives assist in preventing molding when baling hay in high rainfall and humid areas. For baleage, applying a forage inoculant helps with fermentation and conserves the forage nutritive value while decreasing spoilage.

The last harvest of the season occurs in the fall, prior to the first hard frost. Throughout the colder months, bermudagrass remains dormant in the region, and starts to green up in late spring (April-May). During this period, alfalfa growth also slows down, but in the Deep South seasonal growth can start as early as February/March. Thus, it is recommended that ABG stands remain uncut during the winter months to rest, recover, and tolerate significant drops in temperature including freezing temperatures or ice deposition. Generally, the number of harvests per season may range from six to eight harvests depending on management practices and location.

Forage Nutritive Value Characteristics and Livestock Use of Alfalfa-Bermudagrass Hay and Baleage

When harvested at an interval of 28 to 35 days, overall nutritive value of the mixed grass-legume system ranges from 60 to 65% total digestible nutrients (TDN) and 12 to 22% crude protein (CP) per harvest, with greater nutritive value associated with increasing proportion of alfalfa in the mixture. In general, alfalfa addition to bermudagrass stands increase relative forage quality (RFQ) values by more than 25 points. For best livestock nutritional management, conduct a forage analysis to determine nutritive value of ABG and compare these results to the requirements of the class of livestock being fed and stage of production. Alfalfa-bermudagrass hay or baleage provides high-quality roughage in livestock diets, and often meets most nutritional needs with little to no supplementation.

Table 3. Monthly herbage accumulation of Tifton 85 bermudagrass interseeded with Bulldog 805 alfalfa harvested every 28 to 35-d in Tifton, GA.

Year	Herbage accumulation (lbs/acre)								
	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Annual†
2016	--	--	2841	1570	2726	2569	1970	--	1471	13147
2017	4374	2585	1503	2805	2194	2580	1801	2917	--	20759
2018	4055	--	3703	2241	2655	2173	1553	1426	--	17806
2019	1624	2455	1264	2051	729	2232	--	--	--	10355
2020	3257	--	2204	1459	2147	2098	--	--	1797	12962

† Correspond to the sum of monthly harvests per row/year.

Table 4. Crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), total digestible nutrients (TDN) and in vitro digestible dry matter (IVDMD) of Tifton 85 bermudagrass-Bulldog 805 alfalfa mixtures harvested every 28 to 35-d in Tifton, GA.

Year	CP	NDF	ADF	TDN	IVDMD
	Percentage (%)				
2016	13.9	52.0	31.5	65.6	78.6
2017	22.1	39.9	26.8	70.6	82.2
2018	20.7	41.0	29.2	68.0	79.7
2019	18.8	47.4	32.0	63.6	76.2
2020	17.8	52.3	32.2	62.5	76.0
Average†	**18.6**	**46.5**	**30.3**	**66.1**	**78.5**

† Value corresponds to the average by columns.

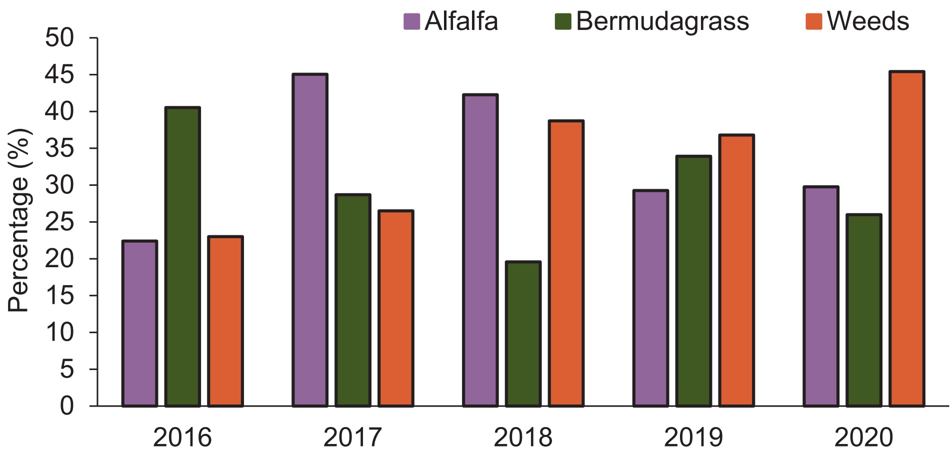
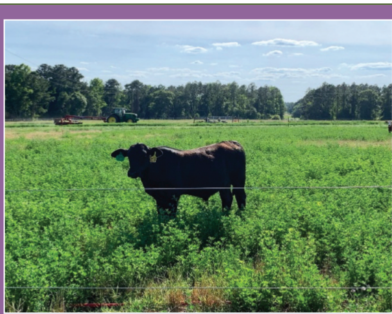


Figure 4. Average annual botanical composition percentage in Tifton 85 bermudagrass-Bulldog 805 alfalfa mixtures harvested every 28 to 35-d in Tifton, GA.

Harvested forage baled for hay or baleage. When feeding baleage, it is important to adequately estimate daily feed intake based on its moisture. Before feeding a new bale, check for mold and signs of trash and manure contamination as this compromise nutritive quality as well as animal health. Traditionally, animals need a few days to adapt to consuming baleage.

Grazing Management

Continuous stocking is not recommended for an alfalfa-bermudagrass pastures. Using rotational stocking allows for a rest period for plants to restore root carbohydrate reserves thereby enhancing future persistence. Just as with mechanical harvesting, in the first year of establishment, do not graze until alfalfa has reached 25% or greater bloom stage. As nutritive value decreases with stand maturity, a good management practice is to take the first harvest in the establishment year as a cutting for hay or baleage production followed by the initiation of rotational stocking at bud to



early (10%) alfalfa bloom stage. Managing stands for alfalfa persistence in grazing systems is crucial. Grazing no lower than 4 inches stubble and no longer than 7 days (3 to 4 days is a better target), followed by a 28-day rest period, is best. Use of temporary electric fence is often recommended to subdivide the field to manage grazing pressure to achieve these grazing height targets. The recommended stubble height and rest (4 inches, 4 weeks) allows proper residual leaf area to remain in field which is crucial for quick regrowth and production of forage until the next grazing cycle. Estimate available forage mass and adjust stocking density or allocations of land area accordingly throughout grazing to aid alfalfa persistence. During the mid-summer months, adjustments in stocking density are required to decrease grazing pressure and allow longer rest periods for plant recovery, especially during droughts.

Timing of the last grazing event at the end of the season is also an important step to protect root reserves and ensure adequate storage carbohydrate reserves prior to winter dormancy. End grazing about 30 to 45 days prior to an anticipated frost event. Post-frost, removal of residual standing material can be done through grazing or mowing. Stockpiling ABG is an option to extend the grazing season in the region. The current recommendation is to harvest the pasture in late August and allow 6 to 8 weeks for regrowth prior to grazing initiation. Ongoing research efforts are focused on better understanding the appropriate harvest date and regrowth period to optimize forage quality.

Forage Nutritive Value and Livestock Use Under Grazing

Because of the high nutritive value of alfalfa-bermudagrass mixtures, it is important to match quality with livestock nutritional needs. Growing animals or those in peak lactation benefit the most from the high-quality aspects of the system. During the spring and early summer, alfalfa generally is the predominant component in the stand. By mid-summer, a shift in the plant species proportion occurs, with bermudagrass becoming more dominant. If properly managed through the summer, especially areas with mild winters, alfalfa re-emerges as the dominant species in the fall months. Management which focuses on keeping alfalfa in the stand helps improve forage nutritive value relative to bermudagrass alone and provides a high-quality source of nutrition for grazing livestock. Rotational stocking is required to help balance stand diversity. Grazing animals have the tendency to select for legumes in the stand, therefore alfalfa rest and recovery during the growing season is important for plant persistence. An alternative to rotational stocking is creep grazing. Creep grazing allows smaller animals (i.e., calves) with the greatest nutrient demands access to ABG pastures while excluding animals with lower nutrient needs. This provides supplemental nutrition to growing animals. Limit-grazing, which controls the amount of time livestock have access to mixed alfalfa-bermudagrass pastures, is another management strategy. Animals may be allowed to graze for a certain number of hours per day or a limited number of days per week. This strategy can be used as a way to provide high-quality supplemental forage for livestock and improve forage use efficiency.

Monitor livestock during the first few days of turnout onto pasture, as animals often undergo an acclimation period when placed on high-quality pasture. While bloat is a risk sometimes associated with grazing legumes, there are several risk management strategies that can be used by a producer to reduce the incidence of this occurrence. One of those strategies is a "built in" component of this system, which is to grow alfalfa with grass. Digestion of alfalfa-grass mixtures by grazing livestock is slower compared to alfalfa alone. Hungry livestock should not be turned out onto mixed alfalfa-bermudagrass pastures. Fill animals with dry hay or grass pasture prior to turnout onto the mixtures. Provide a mineral supplement containing an ionophore, which can help improve digestion and reduce the occurrence of bloat on pastures.

INSECT PESTS, DISEASES AND WEED CONTROL

Insect Pest Management

Although most insects found in ABG systems are beneficial or incidental, there are a few insect pests that substantially reduce yield and increase economic losses. Therefore, it is important to know what insects are in your field and how to properly identify them.

Integrated Pest Management

Integrated pest management (IPM) is a strategy that uses multiple tools to combat pests and minimize economic and environmental risks. Biological, chemical, cultural, and physical controls are all techniques that can work together to manage insect pests effectively. Examples of these techniques include resistant or tolerant varieties specifically adapted to your area, planting within the recommended planting date, and insecticides applied at the economic threshold. A vital component of an IPM strategy is to regularly scout fields. Once or twice a week, the field is inspected to assess crop growth as well as pest and beneficial insect populations. The easiest way to assess insect levels is with a sweep net. A bucket is used in alfalfa by beating stems inside the bucket to dislodge any insects. Check several areas of the field and note the number and life stage of pests and check for the presence of any beneficials present. This information impacts future management decisions.

Chemical control is a useful in ABG systems to quickly reduce a pest population. Insecticides are used when plant damage or pest population approaches levels that lead to yield loss greater than the treatment cost. Pests possess unique thresholds based on their biology, ability to damage the crop, and the cost to treat. Preventative pesticide applications are not advisable as they decrease beneficial insect populations and promote resistance in pest populations. Always read and follow label directions. Generally, insecticides with different modes of action are rotated. Use chemicals that target pests in a variety of ways so as not to increase the proportion of resistant individuals. If insecticides with the same mode of action are used repeatedly, selection for resistant insects occurs more quickly.

Major Insect Pests

When insect pests reach high enough levels and are uncontrolled in ABG mixtures, they cause significant yield loss. The following are major pests that pose a consistent threat to these crops.

Alfalfa Weevil

Alfalfa weevil adults are brown in appearance with a long snout. Both adult and immature weevils (larvae) cause damage, but larvae are most damaging. The larvae are light green with a black head and a long white stripe running down the length of their body. The smaller larvae will chew holes in the leaf terminals and buds. As larva mature, feeding progresses to the outer leaflets where they "skeletonize" the leaf tissue with only the netted leaf veins remaining. Damage takes on a frosted appearance and can look almost white from a distance. Adult insects defoliate alfalfa and will feed on developing crown buds and leaves preventing fields from greening up after the first harvest. The first harvest (early spring) is at the greatest risk for damage by alfalfa weevils. In heavy outbreak years, both larvae and adults threaten the second harvest. In the south, it is important to begin scouting fields in late February for the young larvae. A sweep net is used to sample for numbers of larvae and thresholds numbers vary based on how tall the crop is. If the field is over the threshold (normally 1.5 larvae per stem) and within 10 days of harvest, harvesting best; otherwise, a chemical application is necessary.

Figure 5. Alfalfa weevil larvae are light green with a white stripe along the side of the doby. Photo: Pat Porter, TAMU.

Blister Beetles

Blister beetles are distinct looking with a narrow neck and a broad head. They have long skinny legs, and their bodies are from 0.5 to 1 inch long. Their shorter antennae distinguish them from another group, the long-horned beetles, that have much longer antennae. Blister beetles come in various colors but gray, black, yellow, or orange are common with various patterns. Growers using ABG systems are concerned with blister beetles not because of yield loss but rather because of the threat they post to livestock.

Figure 6. Blister beetles come in various sizes. Note the narrow neck and broad head. Credits: Pat Porter, TAMU.

Blister beetles get their name because they cause skin blistering on humans and animals. Beetles possess a chemical, antharidin, which they can squeeze from their leg joints when threatened. This serves as a defense mechanism from potential predators. Blister beetles in hay pose a threat; they are eaten whole, crushed, or otherwise exude cantharidin. This leads to internal blistering and inflammation in animals feeding on the hay. While all species of blister beetles produce cantharidin, the content varies among species, individuals, and regions in the country. Therefore, it is difficult to estimate the number of beetles that are toxic to livestock. Research demonstrates that horses are more susceptible while sheep and cattle are more tolerant. The age, size, breed, and overall health of animal play a role in blister beetle toxicity. Proper identification and field scouting of blister beetles is key. Otherwise, know the hay suppliers and their management practices. Another point is to control weeds in and around alfalfa fields so there are no alternative hosts for the beetles. An insecticide treatment is normally necessary prior to harvest; recheck field prior to application.

Grasshoppers

Grasshoppers are a sporadic pest, but capable of causing damage during outbreak years. Grasshoppers overwinter as eggs then hatch into nymphs with increasing soil temperatures and spring rains. Nymphs cannot fly and are less mobile than adults. They are usually found in the field margins next to grassy edges or a tree line. If grasshopper populations are found early, a border spray is effective rather than treating the entire field. However, if the grasshoppers are mature, they are more mobile and easily move through the entire field. Treatment is warranted when populations are heavy, and defoliation is noticeable. If an entire field is infested, one option is to harvest the field early then apply an insecticide to protect the regrowth. Smaller grasshoppers are easier to kill with insecticides than larger grasshoppers. To reduce the cost and amount of insecticide used when treating an entire alfalfa field, harvest the field but leave several small, uncut strips across the field. The remaining grasshoppers quickly congregate in these strips, enabling spraying only these smaller areas.

Bermudagrass Stem Maggot

Bermudagrass stem maggots (BSM) are the larval form of an invasive fly pest that is relatively new to the southeast. Bermudagrass and stargrass *(Cynodon nlemfuensis)* are the only hosts of this pest. The adult fly is 1/8 inch long with big dark eyes and several dark spots on their yellow abdomen. The larvae are most damaging as they begin feeding inside the plant stem. The adults are very active in the field and easier to identify than the larvae. The whole life cycle of BSM (egg to adult) lasts about three weeks with multiple generations per year. After feeding on the plant, larvae drop into the soil to pupate before emerging as an adult (Fig. 7).

Figure 7. Bermudagrass stem maggot adults (left & middle; note the dark spots on the abdomen) and damage on bermudagrass stem.

Bermudagrass stem maggots feed inside of plant shoots resulting in death of the top two or three leaves (Fig. 7). These dead leaves give the field a frosted appearance and are easily pulled from the sheath. The shoot stops elongating, and the plant sometimes initiates secondary shoots; these newer shoots are likewise vulnerable to attack by the next generation of BSM. Grazed pastures are less affected by BSM because livestock disrupt their habitat and even consume larvae as they consume the grass. Bermudagrass varieties with finer stems appear more susceptible. Harvesting, especially if near ideal time, with hay removal as soon as possible is best. However, surviving larvae burrow into the soil to pupate and complete their life cycle. Therefore, an insecticide application 7 to 10 days after harvest is an option. Pyrethroids are currently the best chemical control option for BSM. They are a contact insecticide so spraying when adults are present is necessary.

Fall Armyworm

Fall armyworm is a consistent and problematic pest every year. The adult moths are migratory and travel north annually. The timing and severity of outbreaks depend on a variety of environmental factors. Hot, dry weather followed by a rain typically lead to outbreaks. Fall armyworms show a broad host range but well-maintained bermudagrass is preferred. There are several caterpillar species that resemble fall armyworms. Fall armyworms are identified by the inverted “Y” on their head and four raised bumps that form a square on their posterior end. Use a sweep net to scout for worms but avoid scouting in the heat of the day as the worms can hide in the soil or be found on the soil surface or in leaf litter deposited. Sample several parts of the field when scouting to obtain an accurate representation. Increased bird activity in the field is also a sign that you have armyworms.

Figure 8. Fall armyworm. Credits: Pat Porter, TAMU.

The majority of fall armyworm damage is caused by the biggest caterpillars as they get ready to prepare to pupate. An insecticide application is normally made after considering the size of the worms and the growth stage of the hay. If the field is ready for harvest cut and bail as soon as possible rather than applying an insecticide. Larger worms are harder to control than smaller worms. Pyrethroid insecticides provide immediate knockdown and work well on small or medium worms. Insect growth regulators work best on small worms but show no effect on larger worms that are ready to pupate. Pyrethroids show shorter residual control than insect growth regulators. Follow the label for grazing or harvest restrictions and choose a control agent that possesses the best residual for your infestation. In grass forages, treat if you find 2 to 3 larvae/square foot.

Disease Control in Alfalfa

Alfalfa diseases reduce forage yield and quality, decrease stand persistence, and increase susceptibility to environmental stresses. Selection and planting of adapted disease resistant alfalfa varieties is an important tool in managing alfalfa. Utilization of seed treatments reduces seedling diseases and increase plant establishment. In-season fungicides are available for controlling foliar diseases; however, they require proper timing of application before symptoms are apparent and are often not cost-effective in Southern forage systems. In most cases, harvesting forage early helps reduce yield losses due to foliar diseases and remove future pathogen inoculum. The most common alfalfa diseases are presented below.

Bacterial Wilt

Bacterial wilt is caused by *Clavibacter insidiosus*. Symptoms include mild cupping, curling, and mottling of leaves. Severely infected plants appear yellow-green and stunted; and show spindly stems and small, deformed leaflets. This pathogen survives in soil plant residue, infecting plants through wounds in the roots and crown or through the cut ends of newly mowed stems. Generally, symptoms first appear after 2 to 3 years of growth. Disease incidence and severity is increased by interaction with the root-knot nematode (*Meloidogyne hapla*; *M. incognita*) and stem nematode (*Ditylenchus dipsaci*). Resistant varieties are the primary method used to manage bacterial wilt, while avoid mowing plants when leaves and stems are wet reduces transmission.

Figure 9. Bacterial wilt symptoms on root (right) and leaves (left).

Bacterial Stem Blight

Bacterial stem blight is caused by *Pseudomonas syringae* pv. *syringae* and *Pseudomonas viridiflava*. Cold, wet conditions in the spring are necessary for disease development and the pathogen penetration primarily occurs at frost injury sites. Common symptoms are curled or twisted stem tip ("shepherd's crook") and yellow to white tip and veins of upper leaves (Fig. 10). Lesions on lower leaves become water-soaked, necrotic, and leaves die, often remaining attached to

Figure 10. Bacterial stem blight symptoms.

the stem. Diseased stems become stunted, spindly, and break easily. Generally, management is done through removal of infected plant material from the field.

Common Leaf Spot

Common leaf spot is caused by *Pseudopeziza medicaginis*. Typical symptoms of common leaf spot are small brown spots that typically remain as separate lesions and lower leaves are generally affected first. This disease causes leaves to drop, resulting in mild or severe defoliation and reduced yield and forage quality. It is favored by prolonged periods of cool and wet weather and yield losses can be up to 40%. Most alfalfa varieties have low levels of resistance, although some varieties are highly resistant to this and other leaf diseases. Management is associated with early harvest to reduce leaf drop and source of inoculum for future infection.

Figure 11. Common leaf spot.

Crown Rot

Crown rot is caused by a complex of species including *Fusarium*, *Phoma*, and *Rhizoctonia*, bacteria and nematodes. Brown to black areas develop in the crown tissue and are visible when the crown is split. The central core of the crown and root also appears rotted or hollow. As crown rot becomes more severe, plants become stunted and wilted leading to stand thinning. Conditions that favor crown rot include poor fertility (low potassium in particular), low soil pH, and insect damage. Crown rot increases due damage to crowns from machinery and grazing animals, and plant stress due to improper harvest management. Best control options include the use of resistant varieties, allied to decreased stress, and stand damage.

Figure 12. Crown rot infection.

Downy Mildew

Downy mildew is caused by *Peronospora trifoliorum*. Downy mildew is widespread and develops on leaves and stems of alfalfa under wet and cool conditions. Infected areas on leaves are chlorotic and whole leaves become twisted and curled. White fuzzy mycelial growth is often visible on the underside of infected leaves. Stems become systemically infected, developing leaf bunches at their terminal ends. Seed treatment, early harvest of infected stands, and planting in the spring reduce losses.

Figure 13. Mildew systemic (left), spores (middle) and chlorosis (right).

Leptosphaerulina Leaf Spot

Figure 14. Leptosphaerulina leaf spot symptoms in alfalfa leaves.

This is a common leaf disease of alfalfa also called pepper leaf spot and is caused by *Leptosphaerulina briosiana*. It is problematic during wet and cool weather, primarily affecting younger leaves. Lesions begin as small brown spots that develop into larger (1 to 3 mm) spots with a dark brown margin surrounded by a bright yellow halo. Lesions enlarge to kill patches on the leaves, and leaflets die and drop after clinging to the stems for some time. Management is associated with early harvest to reduce source of inoculum for infection.

Phytophthora Root Rot

Figure 15. Phytophthora root rot symptoms.

Phytophthora root rot is caused by *Phytophthora medicaginis.* Infected seedlings wilt and collapse and show rotted tan-colored roots; while, established plants wilt, become stunted, and often develop a yellow-reddish brown color on their leaves. Plants are infected during periods of high soil moisture and infection occurs anytime during the growing season. Infected taproots develop a reddish-brown to black rot on the surface, and lesions enlarge until the root is mostly rotted or girdled. Plants pull easily from the ground due to a short taproot and few lateral roots. Maintenance of adequate soil fertility to promote lateral root growth and harvesting to minimize plant stress also reduce disease incidence.

Disease Control in Bermudagrass

Leaf Spot

Leaf spot is often caused by a fungal complex and *Bipolaris*, *Curvularia*, and *Exserohilum* spp. are often found in the complex. The symptoms include crown and root rot of bermudagrass plants, and small spots and lesions on older leaves that rapidly progress to stems and younger leaves. Initially, the leaf lesions appear as reddish-brown small, pin-point spots that rapidly enlarge to irregularly shaped, brownish green to black necrotic lesions that advance to the leaf sheath and stems (Fig. 16, left). Blighted leaves appear brown and dried out and fall off the stems in the advanced stage of melting-out that results in a loss of stand density. Fields infected by leaf spot appear drought-stressed with irregular patches of blighted grass ranging in size from 4 inches to several feet in diameter (Fig. 16). Usually, *Bipolaris* and *Exserohilum* spp. infect bermudagrass during periods of cool, wet weather on fall and spring and the pathogens can on infected plant parts deposited on the soil surface. Crown and roots are susceptible to infection under warm, dry conditions during summer. Leaf spot is active when temperatures range from 68 to 86°F, while leaf blight and plant death (melting-out) are accelerated during the hot summer months when temperatures exceed 95°F and humidity is high. Use of a bermudagrass variety tolerant to leaf spot is recommended, while the recommended control measures are mowing and bailing affected areas to reduce available substrate for the pathogens and fungal inoculum to proliferate and persist. Often chemical control is not an option due to costs and currently there are no fungicides labeled for leaf spot in bermudagrass fields.

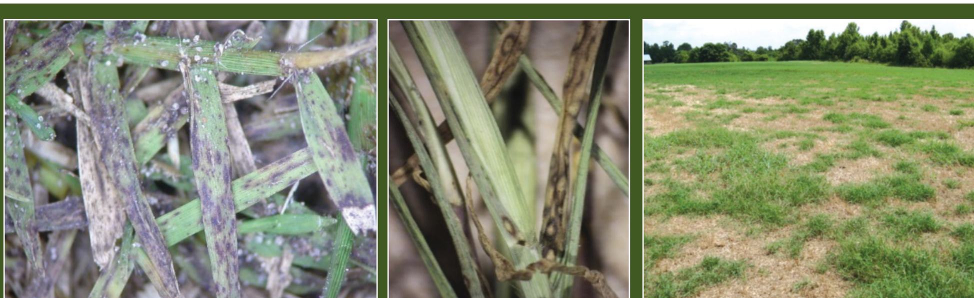


Figure 16. Leaf spot necrotic lesions (left), concentric bands on tissue (middle) and field damage on bermudagrass stands (right).

Leaf Rust

Leaf rust is caused by *Puccinia cynodontis,* a host-specific pathogen. The optimal temperature range for growth and sporulation of *P. cynodonitis* is from 68 to 85°F. Moisture on leaf surfaces is required for infection, but symptoms are more severe under dry conditions when bermudagrass is experiencing drought stress or nutrient deficiencies. Under high disease severity, dark orange to rust-colored dust appears when walking through an infected field. Generally, grazing animals avoid areas where leaf rust is active as infected plants are not palatable. The initial symptoms are small, yellow flecks on the leaf surface of bermudagrass plants then, they expand within the leaf veins covering much of the surface. As lesions mature, areas can present irregular patches of yellow to brown grass (Fig. 17). Similar management practices as described above for leaf spot are recommended where mowing and baling to remove infected leaf material is often helpful. It is also important to remember that drought-stressed and nutrient deficient bermudagrass is most susceptible to leaf rust. In irrigated fields, soil moisture is maintained for adequate growth and soil fertility closely managed to reduce disease severity. Nutrient deficiencies of N and K predispose bermudagrass to leaf rust. Soil and plant tissue analyses performed annually with fertilization to their recommendations will maintain proper N and K fertility levels.

Figure 17. Detail of pustules (left), and spores on leaves (middle) and occurrence of patches on fields (right).

Weed Control

Before interseeding alfalfa into bermudagrass a historic inventory of herbicide application on the bermudagrass stand is important. Bermudagrass fields sprayed in past 12-18 months with aminopyralid, or equivalent herbicides are not recommended for planting alfalfa. Both Roundup-Ready® and non-Roundup-Ready® alfalfa varieties can be used in ABG mixtures. Limited herbicide products are recommended for non-Roundup-Ready® varieties without affecting them or bermudagrass. Therefore, pre-emergent technologies recommended and applied timely for best results.

Prowl® H_2O is used at specific times throughout the season before weed seed germination. The rate depends on production goals, weed pressure and time of application. Always read labels to ensure appropriate application. After the establishment year, applications usually occur three to four times across the season as follows: 1) immediately following first harvest in early Spring before bermudagrass green up, 2) midway throughout the growing season, and 3) in late summer. Under rotational grazing management, if pastures are physically distanced then it may be an option to use Prowl just after animal removal and allow the adequate rest period until animals are turned in again. In this scenario, it is crucial to closely read the label for grazing.

Other chemistries as 2,4-D B can be used for broadleaf control; however, care needs to be taken so as not to damage the alfalfa. The same herbicides recommended for non-Roundup-Ready® varieties are recommended for Roundup-Ready® varieties. An ability to use Roundup or glyphosate herbicides simply add an important management tool that favors the alfalfa component of the ABG mixture. Roundup is used throughout the year for Roundup-Ready® varieties but is especially useful for winter weed control when bermudagrass is dormant. For further questions, please consult your Extension agent. Contact your local Extension Agent for further recommendations for weed control in ABG mixtures.

ECONOMICS

The primary economic objective for any livestock producer is increased profitability. Profit is simply a function of total revenue (sales) minus total costs (expenses). Many management decisions and production practices (site selection, field preparation, variety selection, soil fertility program, insect and weed control, harvest frequency, harvest height, etc.) that producers implement affect cost of production. Due to changes in these input levels and their prices along with revenues based on the quantity and quality of the product (forage or animal products) produced determines specific ABG profitability. Alfalfa establishment costs are incurred in the seeding year. However, since alfalfa is a perennial crop, its establishment costs are prorated over the expected useful life of the stand that for the southeast region ranges between 3 and 5 years. Once prorated, they are then added to the annual operating costs for each production year. Therefore, alfalfa persistence and longevity in an ABG stand is critical to insure profitability.

Given the high costs involved in the establishment and annual production of alfalfa, a producer needs to utilize available economic tools to make management decisions. One key tool is an enterprise budget as it allows an evaluation of the economic viability and potential profitability. It also provides producers with the opportunity to learn the value of basic production inputs necessary to produce and grow the crop as well as to identify the variable and fixed costs associated with producing and marketing the final product.

The "Alfalfa in the Deep South" Microsoft Excel spreadsheet is an inter-active production budget that is available for producers. It provides a format for producers to evaluate their current and future costs for their alfalfa operation. Users input their own information based on their expectations or farm records to build a budget that evaluates important management decisions of their farm. This budget is available online as a Microsoft Excel spreadsheet at the following address:
http://www.secattleadvisor.com/2019/05/23/alfalfa-bermudagrass-budget/

While attempts are to make these budgets as realistic as possible, modifying an enterprise budget based on their own situation such as soil conditions, fertility costs, weather, availability of machinery and equipment, and many other factors vary greatly across operations in the southeastern US is recommended. While it is important to use an enterprise budget to evaluate management changes, reducing inputs or not following the recommended production practices to cut costs must be carefully evaluated. These decisions could result in higher expenses in the long-run or a reduction in revenue from lower yields, lower quality, or a reduction in stand life. Producers need to work through an Alfalfa Budget for their own operation. The more effort made by producers to input their numbers, the better estimates one makes on profitability and understanding the impact changes as they occur throughout the growing season.

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National Alfalfa & Forage Alliance

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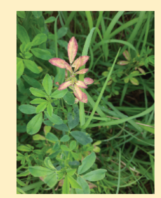
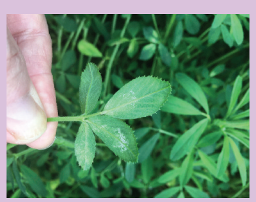
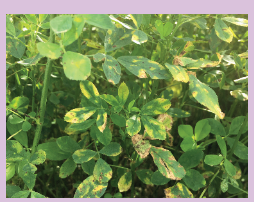
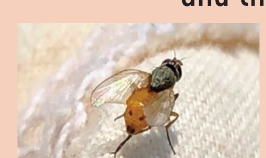
MANAGEMENT CALENDAR

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
HARVEST MANAGEMENT			Subsequent years 1st harvest at 10% bloom Clean up cut 	First year of establishment 1st harvest at 25% bloom 				Late August Consider initiation of stockpiling	Stockpile initiation/ growing period 	Final harvest prior to first hard frost 		
FERTILIZATION		Take Soil Samples 					Apply Split K Rate			Apply Split K Rate		
					Scout for nutrient deficiencies and collect plant tissue sample if needed 							
			Apply B and MO (every 2 years)	Apply Split K Rate								
DISEASE MANAGEMENT	Scout for diseases: lepto; leaf spot; downy mildew   				Scout for diseases							
INSECT PEST MANAGEMENT		Scout for potato leafhopper and alfalfa weevils  					Scout for bermudagrass stem maggot,fall armyworms (R) and three-cornered leafhopper   					
WEED CONTROL			Spray pre-emergent weed control immediately after harvest			Spray pre-emergent weed control immediately after harvest				Spray pre-emergent weed control immediately after harvest		

Alfalfa Bermudagrass Mixture MANAGEMENT CALENDAR

Jennifer Tucker
Animal & Dairy Science
University of Georgia

Kim Mullenix
Animal Sciences
Auburn University

Liliane Silva
Animal & Veterinary Sciences
Clemson University

SELECTING THE AREA

SOIL TEST: Target pH is 6.5 or greater for soil surface and 5.5 or greater for subsoil (~1 ft below soil surface). Levels of P and K are at least the medium range, and micronutrients such as Mo and B are essential.

SOIL TYPE: Select an area with a well-drained, deep, and fertile soil. Poor drainage is detrimental to persistence.

PRIOR WEED CONTROL: Avoid areas where GrazonNext, Pastora or similar herbicides with long-term residual activity were applied within the last year.

PRIOR TO PLANTING

APPLY FERTILIZER AND LIME: Based on soil test results, apply necessary amendments. Do not expect lime to increase soil pH in less than 6-months.

SECURE SEED: Consult your local Extension agent to select a variety suitable for growth in your area. Not all alfalfas are created equal – selecting the right variety for your location is imperative! Purchase seed well in advance of the planting period.

Suppress Bermudagrass Sod: Prior to interseeding alfalfa, graze or mow bermudagrass to 1 to 2 inches. Then, spray the stand with a light rate of a non-selective herbicide (glyphosate) to induce bermudagrass dormancy ("put it to sleep").

PLANTING

PLANT: Using a **calibrated**, no-till drill, sow alfalfa directly into the bermudagrass sod. Plant no deeper than ½ inch (some seeds need to be visible on top of the drill row)! Recommended seeding rate of alfalfa is 12 to 15 lbs pure live seed (PLS)/acre with row spacing of 14-15 inches.

****NOTE:** Most alfalfa seed come pre-inoculated, however it is always good to check to make sure prior to planting and apply Rhizobium inoculum if not pre-inoculated! Inoculum also adds about 30% by weight to seed so this is important to consider when calculating PLS.

AFTER EMERGENCE

INSECT PEST MANAGEMENT: Immediately after alfalfa emergence, spray with insecticide (i.e., Mustang® Maxx, Karate® or similar) to control insect pests that damage young alfalfa plants and hinder successful stand establishment. Subsequent applications should occur as needed.

WEED PEST MANAGEMENT: If using an alfalfa with Roundup Ready® technology, use glyphosate as necessary to control winter weeds and re-induce dormancy of bermudagrass in unusually warm winters. Once alfalfa is established, pre-emergent technologies are recommended to help combat common volunteer annual weeds (i.e., annual ryegrass, crabgrass). Read the label and follow grazing restrictions guidelines.

REFERENCE CALENDAR

Alfalfa-bermudagrass mixtures can be used for stored forage production, grazing, or dual-purpose use. This guide contains a calendar which outlines general time periods for management decisions during the year.
NOTE: the timeline for various management decisions may vary by region based on weather conditions, etc. and are meant to provide a reminder for growers throughout the calendar year.