NOBLE RESEARCH INSTITUTE

BERMUDAGRASS

AS A FORAGE AND HAY CROP IN THE SOUTHERN GREAT PLAINS

by Eddie Funderburg, Ed.D.

RESOURCES

More News, Books Online

Keep up with the latest news and information from Noble Research Institute consultants at www.noble.org

You can also purchase more books about wildlife, plants and more at www.noble.org/store

noble.org

twitter.com/nobleresinst

facebook.com/nobleresearchinstitute

linkedin.com/company/nobleresearchinstitute

youtube.com/nobleresearchinstitute

pinterest.com/nobleresearchinstitute

instagram.com/nobleresearchinstitute

A Noble Research Institute Publication
First Edition 2017
Publication ID: NR-SO-17-01

Noble Research Institute, Ardmore, Okla. 73401

CHAPTER ONE
General Information

Bermudagrass (*Cynodon dactylon*) is an important forage and hay crop that is grown primarily in the southeastern and southern Great Plains regions of the United States, although it occurs in other areas of the United States and the world. It is generally adapted to areas between 45 degrees S and 45 degrees N latitude.

Bermudagrass is a warm-season perennial grass that was introduced from Africa into the United States in 1751. In addition to agricultural production, it is an important species in erosion control and turfgrass applications because it is fairly easy to establish, covers rapidly and tolerates traffic well.

Bermudagrass can be a major weed problem when it occurs in areas where it is unwanted, such as crop fields and gardens. The same characteristics that make it a good forage species can make it a troublesome weed. It is fast-growing, hardy, and tolerant of high levels of salt,

Bermudagrass spreading by stolon.

a wide variety of soil and environmental conditions, heavy grazing, and many herbicides. It will withstand several weeks of flooding, especially if the water is moving. However, bermudagrass does not tolerate cold winters or shade of more than 30 percent during the growing season.

Bermudagrass requires hot weather and abundant soil moisture for best growth. Average daily temperatures above 75 degrees F are required for substantial growth, and temperatures of 100 degrees F result in maximum growth rates if soil moisture is not limiting. Bermudagrass enters dormancy when temperatures are less than 32 degrees F.

Bermudagrass has two types of shoots. The above-ground shoots are known as stolons, and the below-ground shoots are known as rhizomes. Bermudagrass can root at, and form new plants from, each node of the stolons and rhizomes; it can spread by the creeping nature of the stolons and rhizomes. Bermudagrass leaves are usually smooth and pointed in shape, with a ring of white hairs at the junction of the sheath and blade. Stems usually have a paper-like sheath at each node. Flowering stems are upright and have a terminal group of three to seven branches that resemble spikes. Seeds are very small, with about 2,000,000 seeds in 1 pound.

CHAPTER TWO
Bermudagrass Establishment

Preparing field for bermudagrass establishment.

Many varieties of bermudagrass have been developed in recent years. They fall into two main groups: selections of common bermudagrass that can be planted from seed and hybrid bermudagrass that must be propagated by vegetative means. The most common method of vegetative propagation in the Southern Great Plains is planting roots, commonly referred to as "sprigging." A method that is used in higher rainfall environments is establishing bermudagrass with topgrowth cut in midsummer.

FERTILIZATION AND LIMING FOR ESTABLISHMENT

Collecting good soil samples is a must for determining lime and fertilizer rates during establishment. At a minimum, the soil samples should be analyzed for soil pH and lime requirement, extractable phosphorus, and exchangeable potassium.

Bermudagrass is more tolerant of acidic soils than most forage plants. How-

Left: *Seedbed too fluffy for proper bermudagrass planting.*

Right: *Firm seedbed is shown by a shallow footprint.*

ever, lime is recommended if the soil pH is highly acidic. Noble Research Institute recommends liming established bermudagrass when the soil pH falls below 5.0; however, it may be beneficial to lime in the establishment year if the soil pH is below 5.5. This is because lime can be incorporated during the establishment year, which will not be practical after the stand is established. Lime may also be recommended when the soil pH falls below 5.5 if bermudagrass is interseeded with winter annual grasses or legumes.

Phosphorus and potassium are essential for good grass growth and stand health. They should be applied according to soil test results. If these nutrients are deficient, not applying them will cause the grass to establish very slowly, if at all. This will limit yield and extend the time it takes the stand to cover, which complicates weed control and delays grazing initiation.

Nitrogen (N) fertilizer should be applied in the establishment year to increase the growth of the plants and help the stand completely cover as soon as possible. Noble Research Institute generally recommends 50 pounds of actual N per acre during the establishment year. We recommend waiting until the plants are actively growing and rooting on the first node of the runners before applying N. If N is applied before this time, weed competition will be increased since weeds can establish more quickly than bermudagrass.

WEED CONTROL FOR ESTABLISHMENT

Excessive weed competition during the establishment year is probably responsible for more stand failures than any other factor, although severe drought and poor seedbed preparation are also often the cause. If the stand is sprigged, Diuron can be used as a pre-emergent herbicide (check the label to make sure it is legal in your state). Diuron controls many annual grasses (such as crabgrass, sandbur and ryegrass) and broadleaf weeds. It should be applied after the bermudagrass is sprigged but before it emerges. Noble Research Institute highly recommends Diuron when bermudagrass is sprigged. This is the only way to control most annual grass weeds when establishing bermudagrass from sprigs. Diuron cannot be used when bermudagrass is seeded. It will kill grass that emerges from seed. Always read and follow label directions before using pesticides.

Broadleaf weed control during the

establishment year can be achieved with many commonly used pasture herbicides; but apply only after the stand has become established with a good root system. Read individual herbicide labels to see when they can be used, but most recommend not applying the herbicide until a certain amount of time has elapsed since planting or until the plants reach a certain growth stage.

If herbicides cannot be used and weed competition is severe, there are two possible options. You can mow the area to remove the top growth of weeds, which may allow the bermudagrass to release and grow. However, there is a possible disadvantage to mowing. If the weeds are very large and thick, the mown residue can form a mulch on the ground that may suppress bermudagrass growth as much as the standing weeds did.

Flash grazing can sometimes be used for weed control if the weeds are palatable to cattle (such as crabgrass). Watch carefully to make sure cattle are not uprooting or trampling the young bermudagrass plants.

ESTABLISHING BERMUDAGRASS FROM SEED

A well-prepared seedbed is critical to successfully establish bermudagrass from seed. A good seedbed should be uniformly firm, smooth, weed-free, and free of clods, holes and ridges. A firm seedbed is essential with seeded bermudagrass varieties because the seed are very small and seeding depth is critical. If the seedbed is too fluffy, it is easy to plant seeded varieties too deep. A good way to determine if the soil is too fluffy for planting is to walk on the field that has been prepared for planting. If footprints are more than ¼ inch deep, the soil is too fluffy.

A cultipacker or drag harrow is very helpful in establishing bermudagrass from seed. An excellent way to plant seeded bermudagrass varieties is to:

1. Disk and harrow the field until the seedbed is prepared.
2. Cultipack the field to firm the seedbed.
3. Broadcast the seed.
4. Cultipack again to press seed into the ground.

Above: *A cultipacker is an excellent implement for preparing the seebed.*

Left: *Chain harrow is often used for firming the seedbed.*

Some seeders, such as a Brillion, combine steps 2-4 and save two trips across the field. A drag harrow can be used in place of the cultipacker, but it generally does not work as well at firming the soil.

Bermudagrass seed may be coated or uncoated. The coatings usually contain a combination of fertilizers and fungicides. Unfortunately, the coatings usually double the weight of the seed, so the seeding rate must be doubled when using coated seeds to get the same amount of pure live seed as with uncoated seed.

Bermudagrass seed may also be sold as hulled or unhulled. Hulled seed have part of the seed coat removed so that

germination is speeded up. Most bermudagrass seed are hulled. Unhulled seed have the seed coats attached and some of the seed will not germinate quickly, but will lie dormant until conditions are more favorable. In general, if you have a good seedbed prepared and you are planting at the correct time, hulled seed are preferred. If you are planting into less than ideal conditions, unhulled seed, or a combination of hulled and unhulled seed, is probably better.

The seeding rate for hulled bermudagrass is usually 5-10 pounds of pure live seed (PLS) per acre; for unhulled seed, it is 15-20 pounds of PLS per acre. Remember that the seeding rate must be increased proportionally if the seed are coated due to the weight of the coating. Seeds usually germinate when temperatures are above 68 degrees F and begin to grow within three weeks if temperature and soil moisture are sufficient. Growth can be very rapid if conditions are optimum, and one plant has been observed to cover an area of 3 square yards within 150 days after germinating.

ESTABLISHING BERMUDAGRASS FROM SPRIGS

A well-prepared seedbed is usually helpful for sprigging bermudagrass, but no-till can be used successfully if a no-till sprigger is available. Good contact between the sprigs and the soil is essential to keep the sprigs from drying out and dying.

Some varieties of bermudagrass should be sprigged after they break dormancy in the spring (Tifton 85, for example). Many varieties can be sprigged either in the dormant season or after they break dormancy. Planting in the dormant season is usually preferred with these varieties due to better sprig survival and the fact that they are more likely to receive rainfall during early establishment if planted in the dormant season.

Sprigs should be planted as soon as possible after digging. They should be kept moist and cool before planting. If more than 24 hours elapses between digging and planting, sprigs should be soaked in water for 12-15 hours before planting. The usual sprigging rate is 20-40 bushels per acre. Using the higher sprigging rate is more expensive, but decreases the amount of time it takes for the stand to cover the soil.

ESTABLISHING BERMUDAGRASS FROM TOPGROWTH

Bermudagrass can be established from topgrowth if rainfall is abundant and sufficient growing season remains after planting. This involves cutting the grass as if for hay, baling or otherwise transporting the grass while it is green to a prepared seedbed, and broadcasting it onto the field. After the grass is applied to the field, lightly disk it into the soil. For best results, run a cultipacker over it after disking to firm the soil. New plants will emerge from nodes on the grass that was applied to the field. Since this method is usually done in mid to late summer, it requires either an irrigated environment or an environment where rainfall is likely at this time.

One hundred pounds of green, uncured clippings will plant about 2,500 square feet. This means it will require about 1,750 pounds of green clippings to plant 1 acre.

ADVANTAGES AND DISADVANTAGES OF SPRIGGING, SEEDING AND TOPGROWTH PLANTING

Advantages of Sprigging

1. Hybrid varieties are generally higher yielding than seeded varieties. If high yield is a major reason for planting bermudagrass, a sprigged variety is probably the way to attain your goal.
2. Sprigged bermudagrass can be treated with Diuron (if labeled for your area). This product is very good at controlling many annual grasses that compete strongly with bermudagrass in the establishment year. If your field has heavy infestations of crabgrass, annual ryegrass or sandbur, sprigging may be the best option since there is a pre-emergent herbicide option. There are no herbicides available to control grassy weeds in seeded bermudagrass during the establishment stage.
3. Sprigged varieties usually have a more

upright growth habit that is an advantage if the grass is to be harvested for hay.

Disadvantages of Sprigging
1. It is usually more expensive to establish a stand from sprigs.
2. Specialized equipment is needed.
3. Sometimes coverage is slower since there are initially fewer plants per square foot.

Advantages of Seeding
1. It is usually cheaper to establish seeded bermudagrass than sprigged bermudagrass.
2. If high yield is not a large factor (erosion control or turf establishment are more important), seeding is a good method.
3. Stand establishment may be faster.

Disadvantages of Seeding
1. Seeded varieties are usually lower yielding than hybrid varieties.
2. Seedling bermudagrass is more negatively affected by dry conditions soon after emergence because of a lesser developed root system.
3. Control of grassy weeds in the establishment year is difficult since Diuron cannot be used.

Advantages of Topgrowth Planting
1. Does not require digging roots and can be done with conventional hay equipment.
2. Stand establishment can be very rapid if sufficient soil moisture is available.

Disadvantages of Topgrowth Planting
1. Probably requires manually broadcasting grass onto the field.
2. Requires good soil moisture in midsummer.

CHAPTER THREE
Fertilization of Established Bermudagrass

There are many factors to consider in fertilizing bermudagrass. The goal of the producer is paramount. If the goal is to run the maximum number of cattle on an operation, an aggressive and targeted fertilization program should be used. If the goal is to produce fewer cattle with limited inputs, fertilizer rates can be manipulated to meet this goal. Bermudagrass is an excellent species to use to manage cattle numbers by varying fertilizer rates.

SOIL TESTING

A fertilization program begins with the use of soil testing. Results of a good soil test can be used to determine whether or not to lime, and how much, if any, phosphorus and/or potassium is needed. Soil testing can also determine if enough residual N is in the soil to reduce N fertilizer recommendations. Soil testing can further determine if toxic levels of some substances, such as salt, are present in the soil.

A good soil testing program is dependent upon taking a good sample. Most experts recommend testing every field of introduced forages that will be fertilized at least once every three years. A sampling depth of 0 to 6 inches is recommended. Cores should be collected at random from 10 to 15 places within the field and thoroughly mixed to make one sample. An additional 6- to 12-inch sampling depth is recommended if there is interest in determining the amount of residual soil N. Problem areas should be sampled separately. If a problem area is included in a sample made up primarily of good areas, the cause of the problem cannot be identified and the sample may appear a bit worse than it actually is.

There are many videos on the internet showing the proper method of soil sample collection. One can be found at this address bit.ly/soil-sample

LIMING

The Noble Research Institute recommends liming at the following target pH levels: (1) forage legumes and alfalfa when the soil pH drops below 6.0; (2) bermudagrass when the soil pH drops below 5.0; and (3) most other species when the soil pH drops below 5.5.

The target pH for liming bermudagrass at the Institute is lower than that recommended at some other institutions. However, research (Table 1) in both Texas and Louisiana (Hillard, et al., Haby, and Eichhorn, et al.) shows that bermudagrass is very acid tolerant and that resources are better used on fertilizer than lime until the soil pH drops below 5.0 on fields grown exclusively in bermudagrass.

Much of the bermudagrass acreage in the Southern Great Plains is also managed for winter annual grasses and legumes, such as ryegrass and clover, and lime is recommended in this production system when the pH drops below 5.5 for optimum production of the winter annual grasses or 6.0 for legumes.

Soil testing is an essential component of proper fertizilation.

TABLE 1. A brief summary of research on response of bermudagrass to lime.

LOCATION	RESEARCHER	FINDING
Arkansas	Phillips, et al.	No response to lime on bermudagrass at pH 5.9
Texas	Hillard, et al.	No response to lime on bermudagrass at pH 4.7
Texas	Haby	No response to lime on bermudagrass at pH 4.3, but ryegrass responded to lime at pH 5.3
Louisiana	Eichhorn	No response to lime on bermudagrass at pH 4.9

NITROGEN RATE

The most limiting nutrient in bermudagrass production is usually N. Nitrogen is vital to plants for optimum growth. Deficiencies of N appear as pale green color in the plants, poor growth and yield, and low crude protein.

The optimum N rate for a particular situation is dependent upon a producer's goals. Cattle carrying capacity can be manipulated by varying the amount of N used on bermudagrass. See Chapter 6, Grazing Management, for examples of how N rates affect stocking rate numbers.

Bermudagrass yield response to N rate varies by variety (Figures 1 and 2). In general, hybrid varieties are higher yielding than seeded varieties. They are also able to convert higher N rates to forage than seeded varieties. In general, seeded varieties of bermudagrass should be fertilized with less N than hybrid varieties since they are less efficient at converting higher N rates to forage.

Research studies have been conducted to determine N use efficiency in bermudagrass at varying rates of N. Nitrogen use efficiency is defined as the pounds of dry matter forage produced by an additional pound of N input over that which was achieved with no N fertilizer. Most of this research shows ranges in bermudagrass N use efficiency from 20-40 pounds of dry matter production per pound of N above that produced with no N. An average figure of 30 pounds of bermudagrass dry matter produced per pound of N above the amount of grass produced with no N is often used when determining stocking rates.

As can be seen in the following tables (Tables 2-4), N use efficiency of bermudagrass declines as the amount of N used increases. Also note that N use efficiency increases relative to the amount of rainfall received. Evidence of this is that Overton, Texas, and Homer, Louisiana, are both in

SOIL SAMPLE

Go online to see how to take a correct soil sample with Noble Research Institute's Eddie Funderburg, Ed.D., at bit.ly/soil-sample

FIGURE 1. Yield of seeded bermudagrass varieties in south-central Oklahoma in 2008-10. From Funderburg, et al., Forage and Grazinglands 2011. doi:10.1094/FG-2011-1223-01-RS

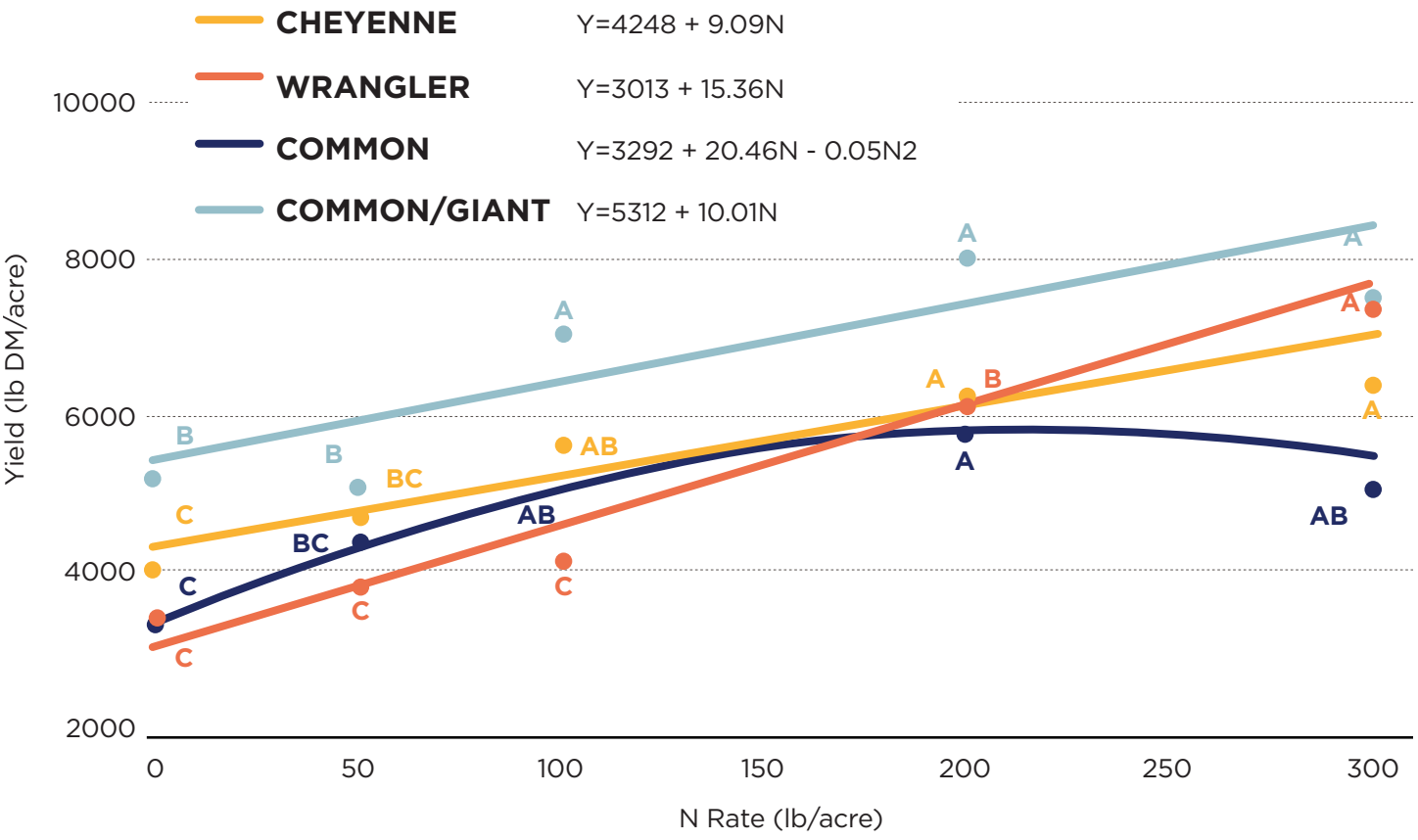


FIGURE 2. Yield of hybrid bermudagrass varieties in south-central Oklahoma in 2008-10. From Funderburg, et al., Forage and Grazinglands 2011. doi:10.1094/FG-2011-1223-01-RS

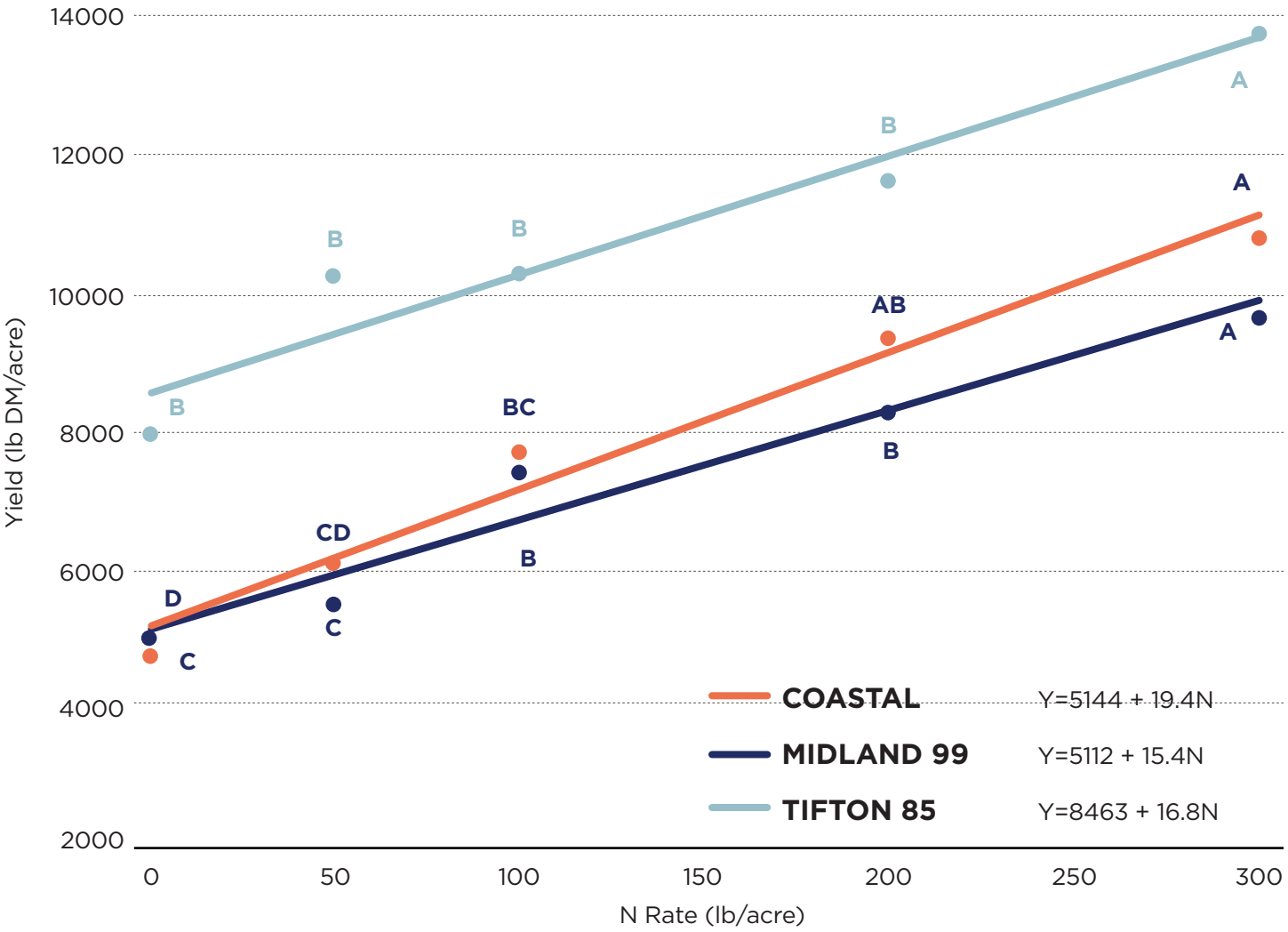


TABLE 2. Bermudagrass response to N rate in Oklahoma. Osborne, et al, OSU, Ardmore, Oklahoma (1993-95)

N RATE (LB/A)	YIELD (LB/A)	POUNDS DM PRODUCED ABOVE CHECK PER POUND APPLIED N
0	3015	---
200	6351	17
400	9384	16
600	10479	12
1200	10632	6

TABLE 3. Bermudagrass response to N rate in Texas. Haby, et al., Texas A&M, Overton, Texas (1984-86)

N RATE (LB/A)	YIELD (LB/A)	POUNDS DM PRODUCED ABOVE CHECK PER POUND APPLIED N
0	5200	---
160	12200	44
320	15200	31
320	15200	31
480	16000	23

TABLE 4. Effect of N rate on bermudagrass yield and crude protein content in north central Louisiana. Eichhorn, et al, LSU, Homer, Louisiana (1972-82)

N RATE (LB/A)	FORAGE YIELD (LB/A)	CRUDE PROTEIN (%)	POUNDS DM PRODUCED ABOVE CHECK PER POUND APPLIED N
0	2,077	8.6	---
100	5,807	9.9	37
200	9,244	10.8	36
300	11,319	11.5	31
400	13,562	12.7	29

higher rainfall areas than Ardmore, Oklahoma, and both have better N use efficiencies.

Noble Research Institute recommendations for N rate on bermudagrass vary according to the productivity of the soil, variety and the producer's goals. In the Southern Great Plains, a flat, deep soil with good water-holding capability can efficiently use a higher rate of N than a thin soil or one with steep slopes. For grazing only, N recommendations in the Southern Great Plains will usually range from 0-150 pounds of actual N per acre, with a rate of 50 pounds N per acre commonly recommended. For hay production on very productive sites, recommended rates may increase to as much as 200-400 pounds of N per acre.

The bermudagrass variety used enters into the decision on how much to fertilize. Figures 1-2 show that hybrid varieties can convert more N fertilizer into forage than seeded varieties. Therefore, it is seldom recommended to fertilize a seeded variety with more than 100 pounds of N per acre, while hybrid varieties can be fertilized at a higher rate, if needed.

NITROGEN SOURCE

The best N source for fertilizing summer pastures is often debated. Urea can suffer volatilization losses if applied to the soil surface in hot weather when no rain occurs within three days. Losses can be as high as 40 percent of the total N applied. Urea-Ammonium Nitrate (UAN) solutions contain about one-half urea, and the urea portion is subject to volatilization loss. Most of the research conducted around the Southern Great Plains region shows little urea volatilization loss when urea is applied in April, or earlier in the spring. Losses increase as urea is applied later in the summer. When losses occurred in these research tests, they were seldom more than 15-20 percent. Tables 6 and 7 show N source comparisons from research in Oklahoma.

TABLE 5. Nitrogen use efficiency among seven different bermudagrass varieties with a N rate of 100 pounds per acre in south-central Oklahoma. 2008-2010. From Funderburg, et al., Forage and Grazinglands 2011. doi:10.1094/FG-2011-1223-01-RS

VARIETY	POUNDS DM FORAGE PER POUND OF N
Cheyenne	16
Wrangler	8
Common	18
Common/Giant	19
Coastal	29
Midland 99	24
Tifton 85	23

In general, urea can be used with little or no loss if the ground will be tilled within two to three days after application, if a rainfall event of more than 0.25 inches occurs within two to three days, or if the temperature is below 75 degrees. Ammonium nitrate is usually a better choice for summer fertilization when N is applied to the soil surface and not incorporated.

NITROGEN TIMING

Research on the optimum time to apply N on bermudagrass has been conducted in

several locations, with particular attention paid to whether it is better to apply all N in the spring or whether to split the amount into two or more applications. Most of the research (Tables 8-9) suggests that split applications are preferable when the total N rate exceeds 100 pounds per acre.

If the total N rate is more than 100 pounds N per acre, the Institute usually recommends that 100 pounds N per acre be applied in late April or early May to take advantage of the more predictable spring rains. The balance can be applied during the summer when a good forecast of rain exists. Even considering the additional application expense, the advantages of splitting applications of more than 100 pounds actual N usually outweigh the cost.

Noble Research Institute sometimes recommends applying 40-50 pounds N per acre in late August to grow fall bermudagrass. The purpose of this is to stockpile the forage for the fall-early winter season and decrease the amount of hay that needs to be fed. If this technique is used, the grass should be cut or grazed short before fertilization so that the regrowth will be high quality. Defer grazing on this area until dormancy occurs. The grass can then be used as standing hay, as needed, until early January. Quality in dormant bermudagrass in the Southern Great Plains usually begins to decline in January, and the forage should be used before that time.

PHOSPHORUS AND POTASSIUM FERTILIZATION

Noble Research Institute recommends fertilizing with phosphorus (P) and potassium (K) based on soil test results. These recommendations are based on field research studies for a particular location and are superior to general fertilizer recommendations. Using soil testing as a basis for determining the need for these nutrients is cost-effective and prudent.

Bermudagrass removes relatively large amounts of phosphate (P_2O_5) and potash (K_2O) when harvested for hay. Research at the Noble Research Institute shows that bermudagrass hay removes about 12 pounds of P_2O_5 and 50 pounds of K_2O per ton of hay. Grazing animals remove very little P and K since most of it is deposited onto the land in the form of manure and urine.

TABLE 6. Effect of N source on bermudagrass yield. Westerman et al., OSU, Haskell, Oklahoma, 1978-80

N SOURCE	YIELD (TONS/ ACRE)
Anhydrous Ammonia	4.07
UAN Solution	4.56
Urea	4.25
Ammonium Nitrate	4.61

TABLE 7. Effect of N source and timing, Altom, et al., Noble Research Institute, Burneyville, Oklahoma, 1985-89

N SOURCE	150 LBS N/A ALL APRIL	150 LBS N/A SPLIT APRIL/JUNE
Urea	6,618	7,143
Ammonium Nitrate	6,579	7,622

TABLE 8. Effect of N timing on bermudagrass yield. Eichhorn, et al., LSU, Homer, Louisiana, 1972-74

N RATE (LBS/A)	SINGLE APPLICATION	4-WAY SPLIT
180	6,140	8,344
360	10,052	12,800
540	16,152	16,152

TABLE 9. Effect of N timing on bermudagrass yield. Altom, et al, Noble Research Institute, Burneyville, Oklahoma (1985-89)

N RATE (LBS/A)	SINGLE APPLICATION	1/2 APRIL, 1/2 JUNE
150	6,579	7,622

PHOSPHORUS FERTILIZATION

Many soils in the Southern Great Plains are deficient in P. Phosphorus is vital for developing a healthy root system in plants and achieving optimum yield. Nitrogen fertilizer is not used efficiently in plants that are deficient in P.

TABLE 10. Effect of P on bermudagrass yield. Funderburg and Thomason, Noble Research Institute. Various on-farm Oklahoma locations, 2002

P_2O_5 RATE (LBS/A)	LOW P SOIL 1 (LBS/A)	LOW P SOIL 2 (LBS/A)	LOW P SOIL 3 (LBS/A)	HIGH P SOIL 1 (LBS/A)	HIGH P SOIL 2 (LBS/A)
0	2,980	6,380	5,812	4,840	7,259
25	3,452	8,281	7,332	4,885	8,881
50	4,270	8,156	6,464	5,189	7,329
75	4,557	9,589	6,061	4,471	7,849
100	4,077	9,771	7,860	5,555	8,929
200	4,925	10,735	6,962	5,275	8,703

All plots received 200-0-120

Data on P fertilization of bermudagrass are limited. The existing data show that when soil test P is low or very low, a good response to P fertilizer is obtained. Most data show a yield increase of about 1 ton of forage per acre when P is applied at the recommended rate according to soil test results. Most sites show little to no increase to P fertilizer when soil test P levels are medium or higher, although some sites show inconsistent increases even when soil test P is high.

TABLE 11. Effect of K_2O on bermudagrass yield and stand on a very low soil test K site. Eichhorn, et al., LSU. Homer, Louisiana, 1974-80

K_2O RATE (LBS/A)	YIELD (LBS/A)	BG STAND YR 1 (%)	BG STAND YR 6(%)
0	8,919	57	29
100	12,399	47	84
200	13,583	45	89
400	14,341	41	88

POTASSIUM FERTILIZATION

Potassium aids plants in their ability to resist diseases. It also aids in water translocation in plants and makes bermudagrass less susceptible to winter kill. Deficiencies of K can cause both yield losses and stand losses. Research has shown that stands of bermudagrass were about half as good where K is deficient compared to where K was sufficient. There was also an increase of about 2 tons in forage yield per acre where K was applied at recommended levels on a soil testing very low in K (Table 11).

If high rates of K (more than 120 pounds K_2O per acre) are recommended by soil test results, it is better to split the application than to apply it all at once. To reduce leaching in sandy soils (CEC <4), it is suggested to apply no more than 120 pounds of K_2O per acre at one time. In very sandy soils (CEC <2), it is suggested to apply no more than 60 pounds of K_2O per acre at one time. It can be beneficial to split applications of potassium even in soils where potassium leaching is not expected. This is because bermudagrass will take in more K than it needs if an abundant supply is present, in a process called luxury consumption. It is not harmful to the grass, but it is a costly and inefficient way to use K.

SECONDARY AND MICRONUTRIENTS

In most circumstances, bermudagrass grown for pasture or hay does not respond to secondary (calcium and magnesium) or micronutrients (boron, zinc, manganese, iron, molybdenum and copper). There may be instances where sulfur becomes deficient in bermudagrass grown in very sandy soils where high N rates are used. Tissue analysis is a better indicator of sulfur deficiency than soil tests. If a sulfur, or other secondary or micronutrient deficiency is suspected, confirm the deficiency through tissue testing before adding these elements.

CHAPTER FOUR
Weed Control

Western Ragweed at a growth stage that is easy to control.

Good weed control can be achieved in pastures and hay fields if planning and attention to detail are followed. It is a matter of targeting the correctly identified weed at the proper growth stage with a labeled herbicide effective against that weed, applied under the right environmental conditions with a well-calibrated sprayer. If these things are done, weed control should be excellent.

First, correctly identify the weed. If you don't know what the target species is, it is hard to develop measures to control it. Ask for help, or refer to online images to make sure you know what the problem plant is. Incorrect identification can lead to the use of a product that is ineffective. If you email images to someone to assist in identification, keep these things in mind. Take an overall shot of the area of the field infested with the weed. Then take a closer shot of the entire plant. Take another close-up photo of a

leaf. If seedheads or flowers are present, take a separate shot of these. Send images at the highest resolution possible. This will aid the person trying to identify the plants from a computer screen.

There will probably be several species of weeds in the field. Determine the ones that are most abundant and prioritize their importance. One herbicide applied at a particular time may not control all the weeds in a field, so it is critical to choose the product that will either control the most weeds or the ones causing the most damage. Table 12, adapted from Oklahoma Cooperative Extension Publication E-832, shows the estimated level of control you can expect if you use the listed herbicide according to the labeled rate, weeds are at the proper growth stage for optimum control, environmental conditions are correct for spraying, and the sprayer is well-calibrated.

Choose a herbicide that is labeled for the crop and is labeled to kill the target weeds. You may need to consider other factors beyond whether a particular herbicide will kill the weeds in question. The label will tell you if the product is particularly damaging to legumes, how long to wait to plant certain crops after using the herbicide, and how long to wait before harvesting a treated field for hay or grazing cattle, as well as other precautions.

Read the herbicide label to determine when to spray. Most herbicides should be sprayed when the weeds are at a certain growth stage. Usually this is when the weeds are small and actively growing. However, a few weeds, such as blackberries, sericea lespedeza and horsenettle, should be sprayed when they are larger. Pesticide companies invest a great deal of money to create the label. Read and follow the label instructions, and your success in controlling weeds will increase dramatically.

Herbicides must be sprayed under certain environmental conditions for best results. Spraying under the wrong conditions can cause at least two problems. One is poor weed control. The most common environmental situations that cause poor weed control are hot and dry conditions that result in the weeds becoming drought stressed. If the weeds are not actively growing, they will be much harder to kill. Another problem that can occur when spraying under adverse conditions is off-target spray drift. Killing the weeds in your fields is a good idea. Killing or damaging the neighbor's crops, gardens or ornamental plants is not. Make sure the wind speed is within the labeled recommendation, and make sure the wind direction is blowing away from non-target, sensitive plants. Keep a log of the weather conditions when you started and finished spraying (wind speed, direction, temperature, etc.). Make sure the log is detailed – not just approximate wind speed and direction. Refer to your state regulatory agency to find out what information is required to be entered and kept.

Calibrate your sprayer. You cannot know how much product to add to the sprayer if you do not know how much volume the sprayer is applying. Proper sprayer calibration takes a little time but is essential for executing a good weed control program. How-to videos about sprayer calibration are available from the Noble Research Institute at bit.ly/boom-calibration-vid (calibrating a boom sprayer using the 1/128 of an acre method) and bit.ly/boomless-calibration-vid (calibrating a boomless spraying using the 1/8 of an acre method).

It is easier to prevent weed infestations than to control them after they are established. One way to prevent weeds is to practice good grazing management and not overgraze. Most weeds need bare spots in the pasture to emerge through. Maintaining a good cover throughout the year will prevent many weeds from emerging. Mowing can reduce the height of weeds and make them less competitive, but mowing is not generally recommended for weed control. One reason is the expense. Mowing costs more than most herbicide treatments. Another reason is that the desirable forage is mowed down along with the weeds. A third reason is that many pasture weeds are perennials and will regrow after mowing. While they will be less competitive, they will generally still make seed after mowing unless it is done late in the season.

SPRAYER CALIBRATION

Proper sprayer calibration takes a little time but is essential for executing a good weed control program. How-to videos about sprayer calibration are available from the Noble Research Institute at bit.ly/boomless-calibration-vid and bit.ly/boom-calibration-vid

TABLE 12. Estimated levels of weed control normally expected with pasture and range herbicides when used according to label directions. Adapted from 2015 Extension Agent's Handbook of Insects, Plant Disease, and Weed Control. E-832. Oklahoma Cooperative Extension Service, Oklahoma State University.

TRADE NAME	BITTER SNEEZEWEED	BROOMWEED	BUFFALOBUR	COCKLEBUR	CROTONS	MARESTAIL	LANCELEAF RAGWEED	SUMPWEED	PIGWEED	SANDBUR	JOHNSONGRASS	FOXTAILS	SERICEA LESPEDEZA	HORSENETTLE	SILVERLEAF NIGHTSHADE	NUTSEDGE	WESTERN IRONWEED	WESTERN RAGWEED	WESTERN YARROW	MUSK/SCOTCH THISTLES	WAVYLEAF THISTLES	COMMON NAME
Weedar 64*	7	8	7	9	7	5	9	5	8	0	0	0	3	3	-	0	5	8	9	8	6	2,4,D amine
Weedone LV6	8	9	8	9	7	5	9	6	8	0	0	0	3	3	-	0	5	9	9	8	7	2,4-D LV ester
Amber Custom Pack	7	9	7	8	6	7	9	7	7	0	0	0	4	-	-	0	1	9	4	5	4	Triasulfuron
Banvel	7	9	8	9	7	7	9	3	8	0	0	0	5	-	-	0	7	8	6	8	7	Dicamba
Cimarron Plus	9	9	7	9	9	9	4	7	9	0	0	0	9	4	4	0	1	0	9	9	9	Metsulfuron; chlorsulfuron
Cimarron Max	9	9	9	9	9	9	9	9	9	0	0	0	9	7	7	0	5	9	9	9	9	2,4-D; Metsulfuron; Dicamba
Crossbow	9	9	8	9	8	7	8	-	8	0	0	0	6	3	-	0	7	9	5	9	9	2,4-D; Triclopyr
Grazon P+D	9	9	9	9	9	7	9	6	9	0	0	0	5	7	9	0	4	9	7	9	9	2,4-D; picloram
GrazonNext HL	9	9	9	9	9	8	9	7	9	0	0	0	5	8	9	0	-	9	-	9	9	2,4-D; aminopyralid
Milestone	9	9	9	9	9	8	9	7	9	0	0	0	5	8	9	0	-	9	-	9	9	Aminopyralid
PastureGard	-	8	-	-	-	-	8	-	-	0	0	0	9	-	-	0	7	7	-	7	7	Triclopyr; fluroxypyr
Pastora	8	8	6	8	8	8	3	6	8	9	8	8	7	3	3	0	1	0	8	-	-	Metsulfuron; nicosulfuron
Rave	8	9	8	9	7	8	9	7	8	0	0	0	5	3	-	0	7	9	6	-	-	Dicamba; triasulfuron
Remedy	9	8	-	-	-	-	8	-	-	0	0	0	9	-	-	0	7	7	6	-	-	Triclopyr
Weedmaster	9	9	8	9	9	8	9	6	9	0	0	0	4	6	9	0	7	9	6	9	9	2,4-D; dicamba
Outrider	0	0	0	8	0	0	0	0	0	0	9	0	0	0	0	8	0	0	0	0	0	Sulfosulfuron

Rating Scale – 0=No Control 10=100 percent control. Dash means insufficient data to generate a rating. Use of product and trade names does not constitute a guarantee or warranty of any of the products listed and is not an endorsement of one product over another. Grazing restrictions are listed on the label and must be followed. Refer to the label for recommended rates and target species. Read and follow all labeled directions. The label is the law!

CHAPTER FIVE
Insect Control

Many species of insects inhabit bermudagrass, but only three general groups are usually considered major pests in the Southern Great Plains. These are armyworms (two species), grasshoppers (multiple species) and the red imported fire ant. A relatively new insect, the bermudagrass stem maggot, is a problem in the southeastern U.S. and may become a major pest in the Southern Great Plains in the future.

GRASSHOPPERS

Grasshopper species number more than 70 in the Southern Great Plains. Most produce one generation per year and overwinter as eggs, which are deposited in the soil in pods of eight to 30 eggs. Eggs begin to hatch in the spring when soil temperatures reach 60-70 degrees F and the ground is moist. Grasshopper nymphs grow through five instar stages. They become adults within 40-55 days after hatching. Grasshopper nymphs

are wingless, and the adult stage will have wings. Since there are many species of grasshoppers and they all develop at different times, there can be a constant supply of grasshoppers throughout the spring and summer if weather conditions are favorable for their growth.

Grasshoppers eat up to 50 percent of their body weight in forage per day. This means that 60 pounds of grasshoppers will eat as much as a 1,200-pound cow. If grasshoppers are present and treatment is being considered, scout the fields to determine the numbers of grasshoppers per square yard. Count grasshoppers in a 1-square-yard area in at least 30 places in a field, and average the counts to determine the average grasshopper density per square yard. The economic threshold varies from three to 40 per square yard. For example, the threshold will be lower if conditions are dry and grasshopper development is optimum, and higher if conditions are warm and humid, which favor development of a disease that aids in controlling grasshoppers.

Chemical control of adult grasshoppers is often ineffective since they are mobile and can easily re-infest from untreated areas. Spot treatments can be effective if grasshoppers are localized in certain areas. If insecticides are needed, be sure the insecticide chosen is labeled for the pest and crop, and that all label directions are followed. Table 13, adapted from Oklahoma Extension Service fact sheet CR-7193, gives suggestions on chemical options for grasshopper control.

TRUE ARMYWORMS

The armyworm (*Mythimna unipuncta*), sometimes called the "true armyworm," can sometimes damage bermudagrass pastures in the Southern Great Plains. True armyworms do not prefer bermudagrass as a food source but will eat it when more preferred food sources have been consumed. Damage from true armyworms (mostly to winter annual pastures) occurs very quickly due to their large numbers and voracious appetites.

True armyworms (*Mythimna unipuncta*) overwinter in the area where the damage occurs. They are usually a spring pest and are usually associated with cool, wet springs that produce a lush, heavy growth of winter annual pastures. Their life cycle takes 40-60 days to complete and usually produces only one generation per year.

Fall armyworms can be very damaging in bermudagrass.

True armyworms are less likely than fall armyworms to need control measures in bermudagrass pastures. They do not prefer bermudagrass as a food source, and the winter annuals are near the end of their life cycle when true armyworms are present. Table 14, adapted from Oklahoma Extension Service fact sheet CR-7193, gives suggestions on chemical options for true and fall armyworm control.

FALL ARMYWORMS

Fall armyworms (*Spodoptera frugiperda*) can be a major pest of bermudagrass pastures in the Southern Great Plains. They overwinter in south Texas and Central America, and migrate northward each year. They produce multiple generations and can cause damage until freezing conditions occur. Each generation takes about 30 days to complete, so there is the potential to have damage occurring from a new crop of fall armyworms every 30 days.

Fall armyworm damage can sometimes occur as a brown patch, resembling drought damage, in bermudagrass. This occurs from dehydration of the plant after the armyworms have chewed the tender growth. Bermudagrass is seldom killed from fall armyworm damage, but yields can be reduced.

True armyworms feed mostly at night, while fall armyworms are most active early in the morning and late in the afternoon.

TABLE 13. Management of grasshoppers in pasture. Adapted from "Management of insect pests in rangeland and pasture." Oklahoma Cooperative Extension Service, Oklahoma State University CR-7193 revised 0615.

PEST, DAMAGE AND TREATMENT THRESHOLD	INSECTICIDE FORMULATION	RATE OF PRODUCT/ ACRE	COMMENTS
GRASSHOPPERS **DAMAGE:** Feed on foliage. Can damage from spring through fall, but more of a problem in late summer. Small grasshoppers less than 0.5 inches are more easily controlled and can be spot treated with foliar spray if nesting sites are mapped out in spring. **THRESHOLD:** Small: 24-100 per square yard less than 0.5 inches. Large: 8-40 per square yard greater than 0.5 inches.	Baythroid XL (beta cyfluthrin)	2.6-2.9 fl oz per acre (0.02-0.022 lb ai)	No grazing or hay restriction.
	Besiege (lambda cyhalothrin + chlorantraniliprole)	6.0-9.0 fl oz per acre	No grazing restriction, 7-day hay restriction.
	Declare (gamma cyhalothrin)	1.02-1.54 fl oz per acre (0.01-0.0154 lb ai)	No grazing restriction, 7-day hay restriction.
	Dimilin 2L	2 fl oz per acre	Apply when a majority of grasshoppers are in the 2-3 instar stage (<0.5 inch).
	Karate w Zeon (lambda cyhalothrin)	1.28-1.92 fl oz per acre (0.02-0.03 lb ai)	No grazing restriction, 7-day hay restriction.
	Mustang Max (zeta cypermethrin)	2.8-4.0 fl oz per acre (0.0175-0.025 lb ai)	No grazing or hay restriction.
	Prevathon (chlorantraniliprole)	8-16 fl oz per acre 0.027-0.054 lb ai)	No grazing or hay restriction.
	Sevin 80S Sevin 80 SP	1.25-1.875 lb per acre 1.25-1.875 lb per acre	14-day grazing and hay restriction.
	Sevin 4F Sevin XLR Plus	2-3 pints per acre 2-3 pints per acre	14-day grazing and hay restriction.

To scout for armyworms outside these time frames requires digging in the thatch and looking closely near the base of the plants. Economic thresholds can be found in Table 14. For pastures, an easy way to scout is to take a wire hanger and open it up into a square. This represents about 1 square foot. Place it on the ground and count the armyworms in the square.

One-square-foot method of scouting for armyworms.

BERMUDAGRASS STEM MAGGOT

The bermudagrass stem maggot is a native of southern Asia and was first found in the U.S. in Georgia in 2010. It has since spread westward into other states, including Oklahoma.

The maggot is the larval stage of a fly (*Atherigona reversura*) that is about the size of a horn fly. Bermudagrass hay fields seem to suffer more damage than fields that are grazed. Most estimates of yield loss to the maggot are 10 percent or less for well-managed bermudagrass stands, although damage can reach 50 percent in some locations.

Since the insect has only been in the country for a short time, there are no economic thresholds established and no

TABLE 14. Management of armyworms in pasture. Adapted from "Management of insect pests in rangeland and pasture." Oklahoma Cooperative Extension Service, Oklahoma State University CR-7193 revised 0615.

PEST, DAMAGE AND TREATMENT THRESHOLD	INSECTICIDE FORMULATION	RATE OF PRODUCT/ ACRE	COMMENTS
TRUE ARMYWORM Caterpillar can reach slightly more than 1 inch. Dark green or brown with five stripes along body. **DAMAGE:** Feed on foliage, usually a problem in the spring. **THRESHOLD:** Three to four per square foot. **FALL ARMYWORM** Large striped caterpillar that reaches 1.5 inches when mature. Has an inverted "Y" in the front of its head. **DAMAGE:** Feed on foliage. Typically a problem in the fall. **THRESHOLD:** Three to four per square foot.	Bacillus thuringiensis Biobit XL, Javelin WG, Xen Tari	See label for rates.	All Bt products work best applied to small catepillars. No grazing or hay restriction.
	Baythroid XL (beta cyfluthrin)	1.6-1.9 fl oz per acre (0.013-0.015 lb ai)	No grazing or hay restriction.
	Besiege (lambda cyhalothrin + chlorantraniliprole)	6.0-9.0 fl oz per acre	No grazing restriction. 7-day hay restriction.
	Declare (gamma chhalothrin)	1.02-1.54 fl oz per acre (0.01-0.015 lb ai)	No grazing restriction. 7-day hay restriction.
	Entrust (spinosad)	0.63-1.25 oz per acre	No grazing restriction. 3-day hay restriction.
	Karate w Zeon (lambda cyhalothrin)	1.28-1.92 fl oz per acre (0.02-0.03 lb ai)	No grazing restriction. 7-day hay restriction.
	Malathion	2 pts per acre	No grazing or hay restriction.
	Mustang Max (zeta cypermethrin)	2.8-4.0 fl oz per acre (0.0175-0.025 lb ai)	No grazing or hay restriction.
	Prevathon (chlorantraniliprole)	14-20 fl oz per acre	No grazing or hay restriction.
	Sevin 80S Sevin 80 WSP Sevin 4F Sevin XLR Plus	1.25-1.875 lb per acre 1.25-1.875 lb per acre 2-3 pts per acre 2-3 pts per acre	14-day grazing and hay restriction.
	Tracer (spinosad)	1-2 fl oz per acre	No grazing restriction. 3-day hay restriction.

insecticides labeled for the larval stage of the pest. Adults can be controlled with pyrethroid insecticides, but multiple applications must be made. One control method is to cut the affected field for hay since this procedure removes egg laying sites.

RED IMPORTED FIRE ANT

Fire ants (*Solenopsis invicta*) are native to South America and entered the U.S. at Mobile, Alabama, in the 1930s. They now infest more than 320 million acres in 13 states. Fire ants are not heavy feeders of bermudagrass and generally do not reduce forage yields In fact, they prey on forage feeding insects. However, the damage they can inflict on humans and livestock places them into the pest category.

Insecticides for fire ants fit into two categories. First is the mound treatment insecticides, which are usually contact agents. Each mound is treated individually. These work well for lawns and small acreages, but are often impractical where heavy infestations on large acreages occur. The other category is bait. Baits treated with insecticide are broadcast into the field. Worker ants take the bait back to the mound and feed the queen. If the queen ant dies, the mound will die. A combination treatment of using a bait first, then treating individual mounds a few days later has been more effective than either treatment alone.

CHAPTER SIX
Grazing Management

Good grazing management is essential to ensure optimal growth and quality of bermudagrass. Two of the most essential components of good grazing management, which have not been previously covered, are setting a proper stocking rate and resting pastures through timely rotation of fields.

For bermudagrass to thrive, sufficient leaf area must remain after grazing for plants to recover. If too much leaf area is removed, the plants cannot produce enough photosynthates to maintain good root growth. If a producer is overstocked, which causes the cattle to remove too much leaf area, plants begin a downward spiral that cannot be reversed without rest of the pasture. A study by Dr. Crider in 1955 showed root growth was unaffected when less than half the leaf area was removed by grazing. However, removal of 80 percent of the leaf area completely stopped root growth for a period of time, and removing more than 50 percent, but less than 80 percent, of the leaf area se-

Overgrazed pasture on right with properly grazed pasture on left.

verely slowed root growth for that same time period. Without good root growth, plants cannot take in enough water and nutrients to thrive. Overgrazing is the number one culprit in pasture decline.

When overgrazing causes a loss of above-ground growth, other bad things can happen. The soil is more subject to erosion when it is not completely covered. Soil compaction is increased because there is no cushion effect of the grass against hoof traffic. In addition, the resultant bare areas give weeds an opportunity to gain a foothold.

CARRYING CAPACITY AND STOCKING RATE

Determining the carrying capacity of the land is critical to prevent overgrazing. A proper stocking rate can be determined once the carrying capacity is known. Stocking rate is defined as the number and class of animals that will be grazing a specific area for a specific amount of time. It is expressed in animal units per acre for a given time. Proper stocking rate will vary depending on precipitation, soil productivity, condition of the forage base, forage species, forage variety, size of animals, whether hay is cut from the land or purchased off-site, and fertilizer rate, among other factors.

In the Southern Great Plains, unfertilized bermudagrass will usually yield 2,000-3,500 pounds of dry matter per acre above a 3- to 4-inch base, depending on precipitation, soil productivity and condition of the forage base. Research shows that about 1,000 pounds of dry matter per acre will not be utilized due to various factors. This means that 1,000-2,500 pounds of dry matter forage are useable by the grazing animals. A cow will consume about 2.5 percent of its body weight in dry matter forage. This means a 1,200-pound cow will eat about 30 pounds of dry matter forage per day (1,200 X 0.025). Over the course of 365 days, this cow needs 10,950 pounds of dry matter forage to thrive (30 X 365). If the field grows 1,000-2,500 pounds of useable dry matter forage per acre with

no fertilizer, this means the field can run one cow on 11 acres on the low productivity soil (10,950/1,000) and one cow per 4.4 acres on the high productivity soil (10,950/2,500) with no fertilizer, if the field has to provide all the forage for the cattle (Table 15).

The above examples assume that hay will be produced and fed on the farm. The carrying capacity can be increased if hay is purchased from off-site because the fields do not have to produce all the forage the animals eat in the year. Assume that a three-month supply of hay is purchased from off-site and fed on the operation. This is about three large round bales of hay weighing 1,000-1,200 pounds each per cow. This represents 25 percent of the total amount of forage needed by the animals for the year, so the fields on the farm only need to provide 75 percent of the forage needed. In the example where a low productivity soil has a stocking rate of one cow per 11 acres on unfertilized bermudagrass with hay made on-site, this same field will run one cow per 8.25 acres (11 X 0.75) if a three-month supply of hay is brought in from off-site. Likewise, the high productivity field that would run one cow per 4.4 acres if hay is made on the operation will run one cow per 3.3 acres if hay is brought in from off the operation (Table 15).

There are advantages other than increasing carrying capacity of buying hay from off-site instead of producing it on the operation. The major advantage involves the nutrient content of the hay. A ton of good bermudagrass hay will contain about 40 pounds of N, 12 pounds of phosphate (P_2O_5) and 50 pounds of potash (K_2O). At current fertilizer prices, these nutrients are worth about $46 per ton of hay. The vast majority of N, phosphorus and potassium in the hay do not remain in the animal and are returned to the land in the forms of manure and urine. In essence, when you purchase hay and bring it in, you not only get the feed value of the hay, you also get "free" fertilizer nutrients. Another advantage of purchasing rather than producing hay is that the rancher is not committed to the cost and labor of producing hay and can spend time doing other things.

Another way to increase carrying capacity on bermudagrass pastures is through fertilization. Bermudagrass responds well to fertilization if the forage base is in good shape, weeds are controlled and precipitation is adequate. In the above examples of setting stocking rates on unfertilized bermudagrass, the range of useable dry matter forage was set at 1,000-2,500 pounds per acre. In the Southern Great Plains, 1 pound of actual N will produce about 30 pounds of dry matter bermudagrass forage above that produced with no fertilizer (Chapter 3, Tables 2-5). A common N application to bermudagrass pastures in the Southern Great Plains is 50 pounds per acre. If the field would make 1,000 pounds of dry matter forage with no N, and each pound of N applied makes 30 pounds of dry matter forage per acre, how would fertilizing affect the stocking rate? The formula is 1,000 pounds forage made with no N + (50 pounds N X 30 pounds dry matter forage per pound of N). Mathematically, this is 1,000 + (50 X 30) = 2,500. The field that would run one cow per 11 acres with no fertilization will run one cow per 4.4 acres with an application of 50 pounds of N per acre (10,950/2,500), assuming soil needs for lime, phosphorus and potassium are met and rainfall is adequate (Table 15).

Let's look at the high productivity soil example where the field made 2,500 pounds of dry matter forage with no fertilizer and ran one cow per 4.4 acres. If 50 pounds of N per acre are applied, the field will make 2,500 + (50 X 30) = 4,000 pounds dry matter forage per acre. This means the field will now run one cow per 2.75 acres (10,950/4,000) with an application of 50 pounds of N per acre, assuming soil needs for lime, phosphorus and potassium are met and rainfall is adequate (Table 15).

Fertilizing bermudagrass is an excellent way of increasing carrying capacity. It is important to note that these N use efficiencies will only be realized if soil pH, P and K levels are adequate. If soil tests show they are not adequate, and the producer is not willing to apply nutrients to correct these deficiencies, do not apply

TABLE 15. Stocking rate estimates for bermudagrass pastures in south-central Oklahoma grown on soils of different inherent productivity, fertilized with different amounts of N, with and without purchased hay.

INHERENT SOIL PRODUCTIVITY	N RATE (POUNDS PER ACRE)					
	0		50		100	
	Produce own hay[2]	Buy hay[3]	Produce own hay[2]	Buy hay[3]	Produce own hay[2]	Buy hay[3]
	Stocking Rate (acres/cow)[4]					
FAIR	11	8.3	4.4	3.3	---	---
AVERAGE	7.3	5.5	3.7	2.8	---	---
HIGH	4.4	3.3	2.8	2.1	2	1.5

[1]N rate of 100 pounds per acre is only recommended on highly productive soils.
[2]Hay will be produced and fed on the property where the cattle are located.
[3]Three-month supply of hay (about three large round bales per cow) will be purchased from off-site and fed to cattle.
[4]Assumes that phosphorus and potassium are not limiting and area receives average or above average rainfall for the growing season.

N since it will not be efficiently utilized by the plants and will not generate an economic return. Table 15 shows approximate stocking rates that can be achieved in south-central Oklahoma on soils of different inherent productivity at three N rates, based on whether hay is produced on the operation or is purchased from off-site. Keep in mind that these are approximate and depend heavily on precipitation, soil productivity and bermudagrass variety, among other factors.

ROTATIONAL GRAZING

Some research shows that rotational grazing will increase grazing efficiency by 20-25 percent over continuous grazing if the stocking rate is correct. Rotational grazing helps improve the forage base by allowing plants in a field to rest while cattle graze other pastures. The optimum number of pastures varies, but it is essential to have at least two pastures, and more are usually desirable. Generally speaking, bermudagrass grazing should begin when the forage is 6-8 inches tall, and grazing of that field should terminate when the plants have been grazed to a height of about 4 inches. In general, do not graze more than one-half the growth to ensure that root production does not suffer. When grass is actively growing, cattle should be moved more quickly so they can gain the benefit of grazing the higher quality upper growth of the plants.

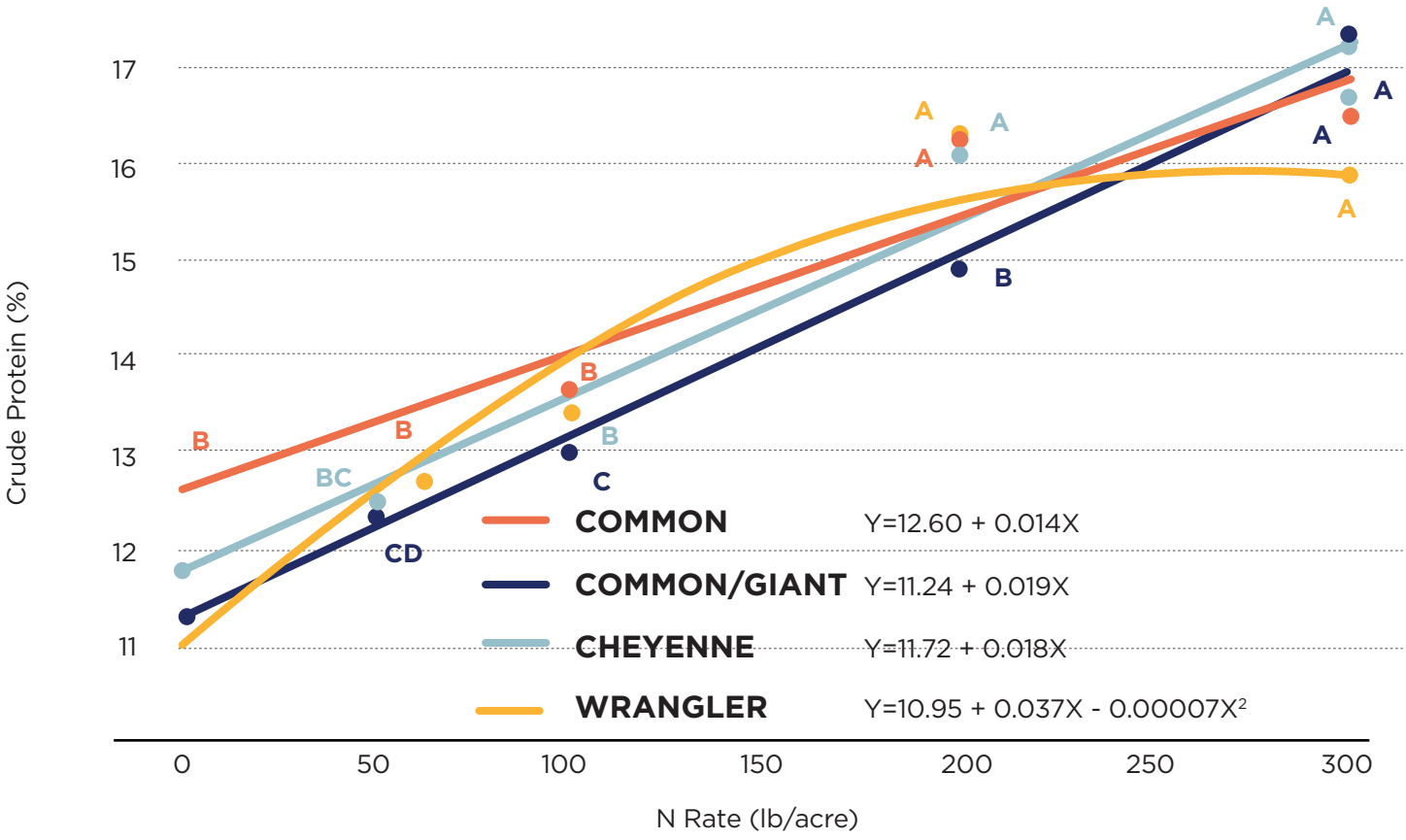
Rotational grazing also has the benefit of reducing the selective grazing tendencies of cattle. If cattle are allowed to graze continuously in one pasture, they will selectively graze their favorite species and areas within the field. This causes overgrazing in some areas and not enough grazing in others, which results in forage that becomes rank and unpalatable. If more cattle are concentrated into smaller areas, they will more uniformly graze the field.

CHAPTER SEVEN
Bermudagrass Forage Quality

For this publication, forage quality is defined as crude protein and total digestible nutrients (energy). The main factors contributing to bermudagrass forage quality are growth stage (maturity) and N fertilization. Of the two, growth stage is more important. Protein and energy are highest in young plants. As plants mature, lignin, which is mostly indigestible, is deposited into the cell walls. The higher the lignin content, the lower the digestibility of the plant. The decline in digestible nutrients is most pronounced in tissue of warm-season perennials, such as bermudagrass, that is older than 35-40 days. Research at LSU shows the decline in crude protein as bermudagrass plants mature (Table 16). Crude protein content declined rapidly until growth reached 56 days, but stabilized after that point.

Nitrogen fertilizer influences crude protein and total digestible nutrient content of bermudagrass, but to a lesser degree than plant maturity. Research by Funderburg, et al., showed that crude

FIGURE 3. Crude protein content of seeded bermudagrass varieties at five N rates in south-central Oklahoma in 2008-10. From Funderburg, et al., Forage and Grazinglands 2012. doi:10.1094/FG-2012-0517-01-RS.



protein increased 1-2 percent and total digestible nutrients increased 0.5-0.9 percent per 100 pounds N applied, depending on variety. This research consisted of plots cut every 30 days, so overmaturity of the grass was not a problem. In general, there was little difference in crude protein or total digestible nutrients between seeded and hybrid varieties where no N was used. Seeded varieties had higher crude protein and total digestible nutrients where higher N rates were used. This was probably due to the fact that seeded varieties yielded less than hybrid varieties, and the applied fertilizer N was used by plants to increase protein rather than yield in seeded varieties (Figures 3-6).

TABLE 16. Average crude protein content of three varieties of bermudagrass at five different growth periods. From Dore, MS thesis, LSU. 2006.

DAYS OF GROWTH	CRUDE PROTEIN CONTENT (%)
14	20.6
28	11.3
42	8.6
56	6.5
70	6.5

Average crude protein content of Jiggs, Common and Russell varieties.

FIGURE 4. Crude protein content of hybrid bermudagrass varieties at five N rates in south-central Oklahoma in 2008-10. From Funderburg, et al., Forage and Grazinglands 2012. doi:10.1094/FG-2012-0517-01-RS.

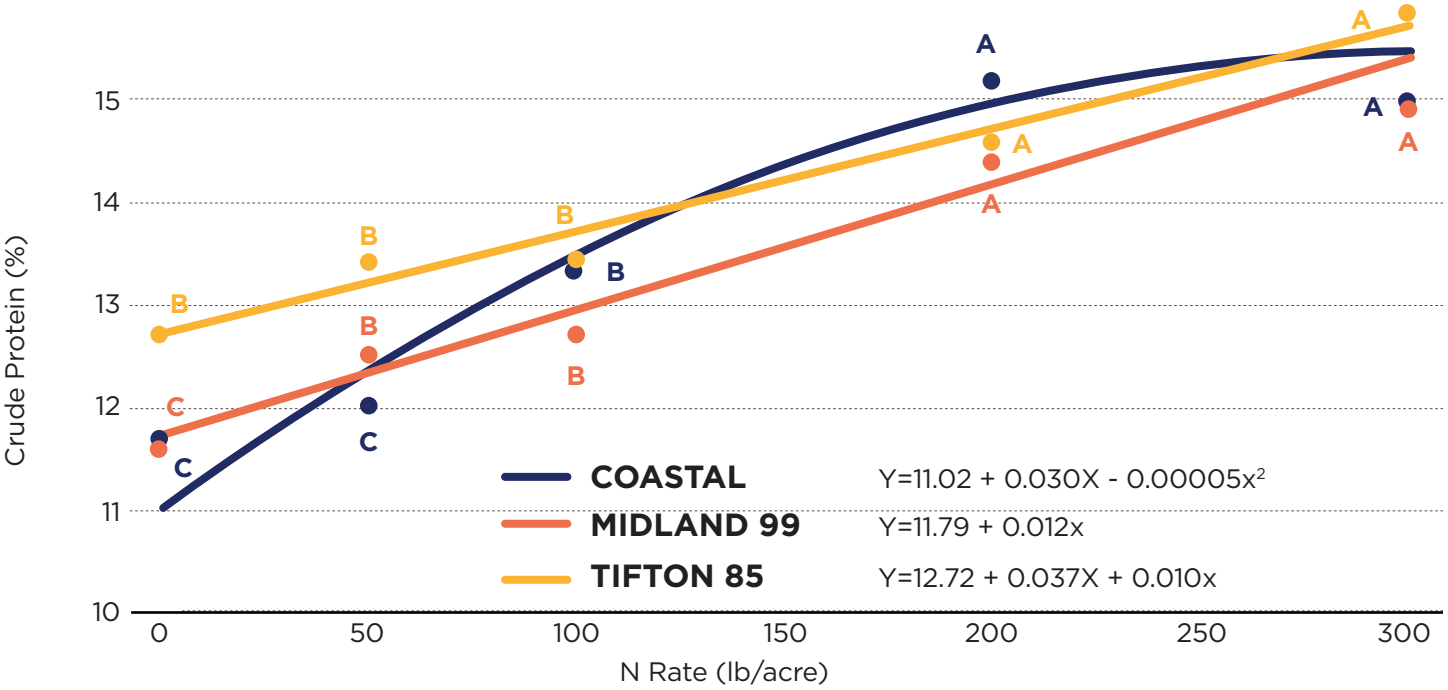


FIGURE 5. Total digestible nutrient content of seeded bermudagrass varieties at five N rates in south-central Oklahoma in 2008-10. From Funderburg, et al., Forage and Grazinglands 2012. doi:10.1094/FG-2012-0517-01-RS.

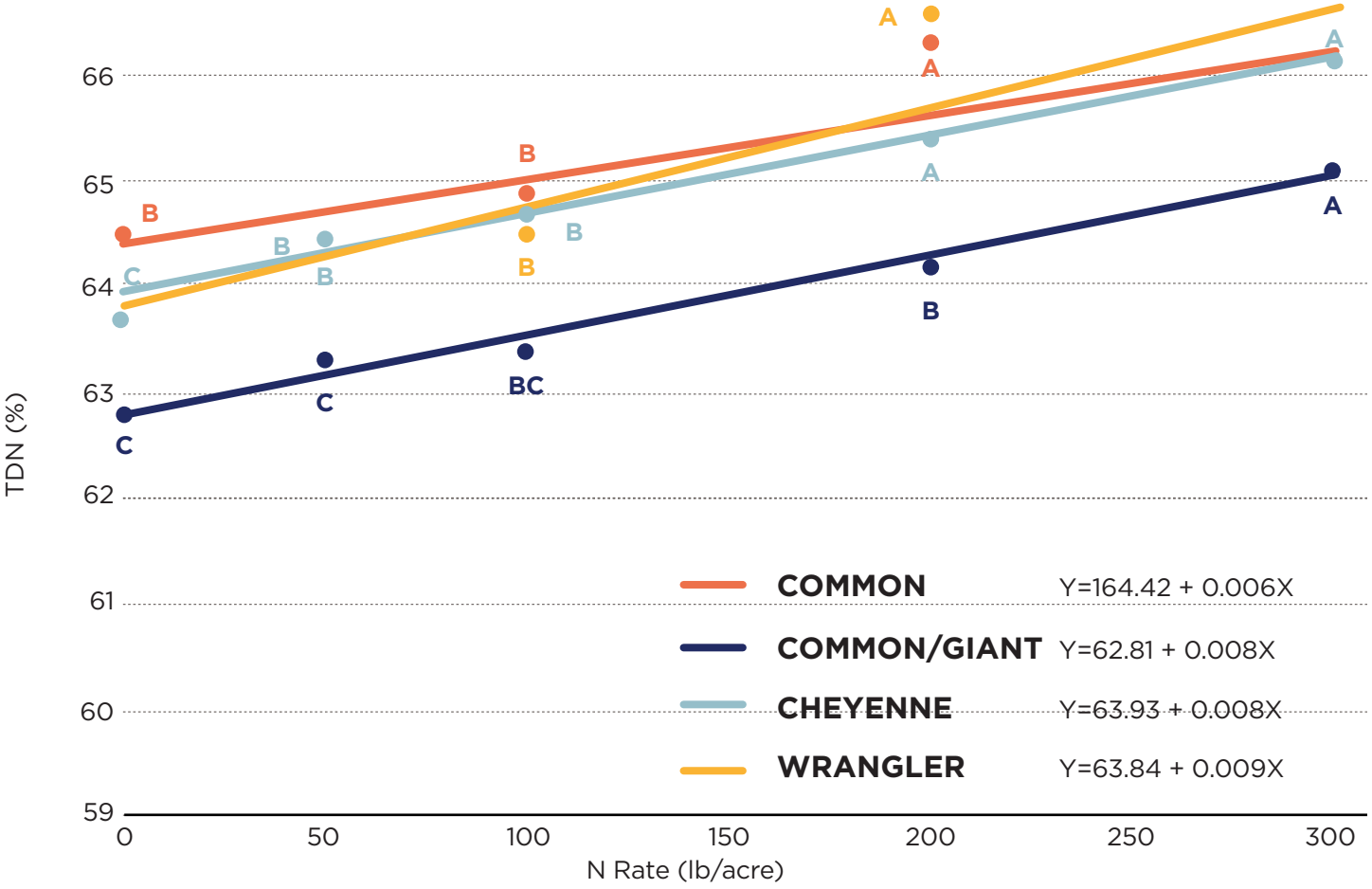
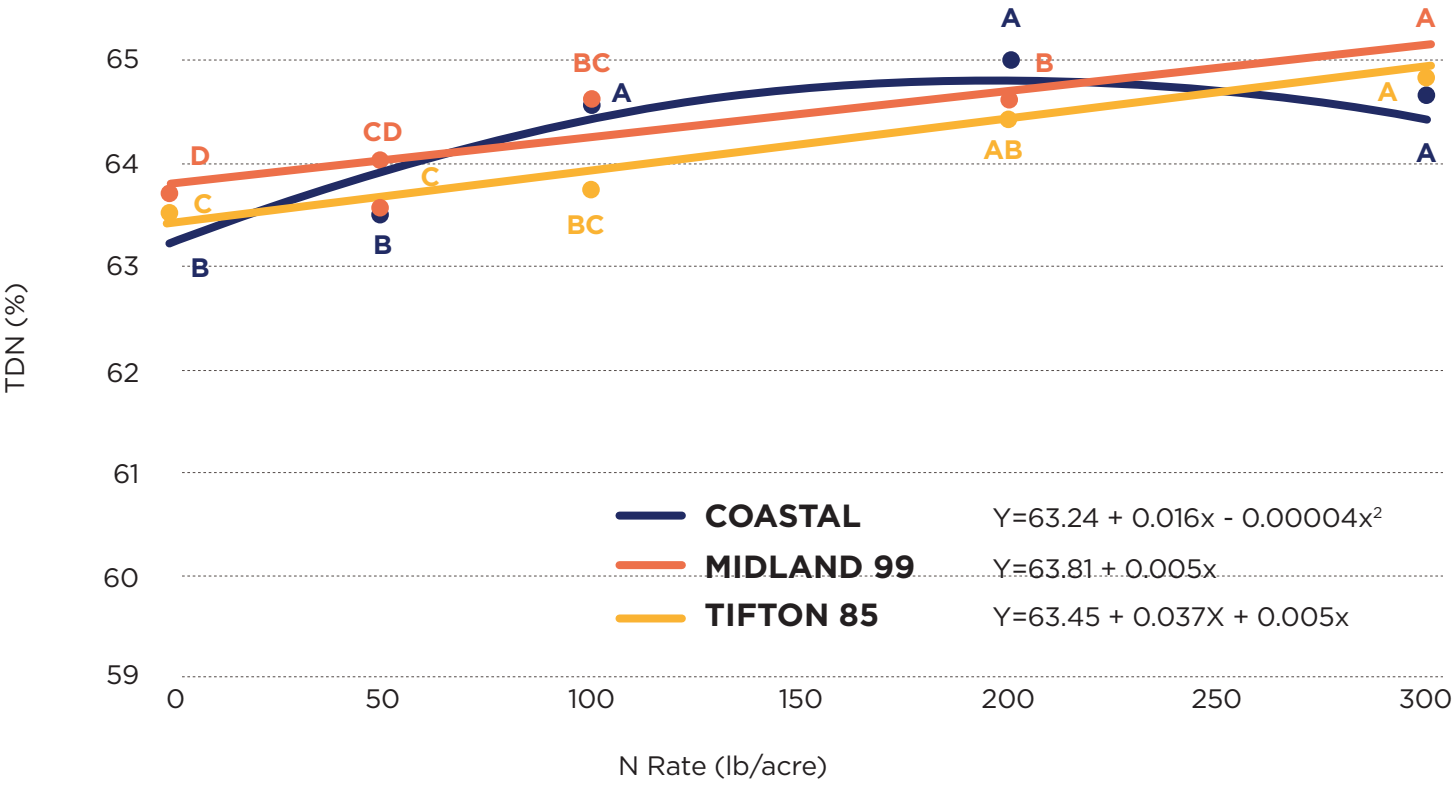


FIGURE 6. Total digestible nutrient content of hybrid bermudagrass varieties at five N rates in south-central Oklahoma in 2008-10. From Funderburg, et al., Forage and Grazinglands 2012. doi:10.1094/FG-2012-0517-01-RS.



ACKNOWLEDGEMENTS

Thanks to Dr. Tom Royer, Professor and IPM Coordinator at Oklahoma State University, for his review and critique of the "Insect Control" chapter that greatly improved the publication.

REFERENCES

Aljoe, H. 1998. Why rotationally graze? Noble Research Institute (formally The Samuel Roberts Noble Foundation) Ag News and Views April 1998.

Annis, D., and Funderburg, E. 2011. Pasture and hay field weed control for Oklahoma. Noble Research Institute (formally The Samuel Roberts Noble Foundation) fact sheet NF-SO-11-11.

Anonymous. 2015. OSU extension agent's handbook of insect, plant disease and weed control. Oklahoma Cooperative Extension Service Publication E-832.

Crider, F. J., 1955. Root-growth stoppage resulting from defoliation of grass. Technical Bulletin 1102. USDA, February 1955.

Dore, R. T. 2006. Comparing bermudagrass and bahiagrass cultivars at different stages of harvest for dry matter yield and nutrient content. MS Thesis Louisiana State University. May 2006.

Duble, R. L., Bermudagrass, "The sports turf of the south." Texas A&M AgriLife Extension fact sheet.

Flanders, K. L. 2015. Pastures and forage crops – insect and weed control recommendations for 2015. Alabama A&M and Auburn Universities Extension Fact Sheet IPM-0028

Funderburg, E. 2005. Fire ants: the invasion continues. Noble Research Institute (formally The Samuel Roberts Noble Foundation) Ag News and Views April 2005.

Funderburg, E. 2009. Nitrogen losses from urea. Noble Research Institute (formally The Samuel Roberts Noble Foundation) Ag News and Views May 2009.

Funderburg, E. 2011. Establishing bermudagrass for pastures and hay fields. Noble Research Institute (formally The Samuel Roberts Noble Foundation) fact sheet NF-SO-11-04

Funderburg, E., Ball, J., Johnson, J., Thomason, W., and Annis, D. 2002. Fertilizing bermudagrass. Noble Research Institute (formally The Samuel Roberts Noble Foundation) publication NF-SO-03-02

Funderburg, E.R., Biermacher, J.T., Moffet, C.A., Alkire, D. and Mosali, J. 2012. Effects of applying five nitrogen rates on quality of nine varieties of introduced perennial forages. Online. Forage and Grazinglands doi:10.1094/FG-2012-0517-01-RS.

Funderburg, E. R., Biermacher, J. T., Moffet, C. A., Haque, M., and Mosali, J. 2011. Effects of applying nitrogen on yield of introduced perennial summer grass cultivars in Oklahoma. Online. Forage and Grazinglands doi:10.1094/FG-2011-1223-01-RS.

Funderburg, E., Biermacher, J., Moffet, C., Haque, M., and Mosali, J. 2012. Effect of nitrogen rate on yield of nine warm-season introduced perennial forage varieties.

Johnson, J. 2015. Grazing affects plant root growth. Noble Research Institute (formally The Samuel Roberts Noble Foundation) Ag News and Views January 2015.

Locke, J. 2005. Grasshoppers: will this be a big year? Noble Research Institute Ag News and Views July 2015.

Loftin, K., Lorenz, G., and Corder R. Managing armyworms in pastures and hayfields. University of Arkansas Extension Fact Sheet FSA7083.

Newman, Y. C., Adesogan, A. T., Vendramini, J., and Sollenberger, L. 2009. Defining forage quality. University of Florida/ IFAS Extension SS-AGR-322.

Robinson, J. Pests of permanent and improvement pastures. Texas Cooperative Extension Service Fact Sheet

Rogers, J. 2014. Bermudagrass stem maggot invades Southern states. Noble Research Institute (formally The Samuel Roberts Noble Foundation) Ag News and Views July 2014.

Royer, T. A. and Mulder, P. G. Grasshopper management in rangelands, pastures, and crops. Oklahoma State University Extension Service Fact Sheet EPP-7196

Royer, T. A. and Talley, J. L. 2015. Management of insect pests in rangeland and pasture. Oklahoma Cooperative Extension Service CR-7193, revised 0615.

Stichler, C. and Bade, D. Forage bermudagrass: selection, establishment, and management. Texas AgriLife Extension. Online http://aggie-horticulture.tamu.edu/archives/parsons/turf/publications/foragebermuda/bermuda.html

Twidwell, E. K., 2010. Bermuda grass varieties for hay and pasture in Louisiana. LSU Ag Center Extension Publication 2315.

NOBLE RESEARCH INSTITUTE