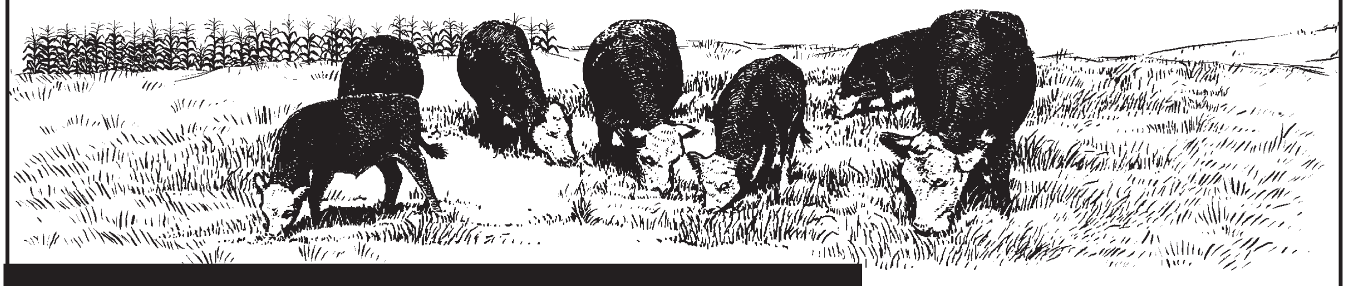

FORAGE FACTS

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Kansas State University Agricultural Experiment Station and Cooperative Extension Service
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Kansas State University
Research and Extension

FORAGE FACTS

Publication Series

SMOOTH BROME

INTRODUCTION

Smooth bromegrass is a long-lived perennial, sod-forming grass that grows best during months with cool weather, primarily March through June and September through November. It becomes semidormant during the hot, dry summer months. Most production occurs during the spring growth period, generally peaking in May through early June. The amount of fall growth depends on available moisture. Mature plants are 18 to 48 inches tall with erect leafy stems.

Smooth brome is one of the more important cool-season grasses in the eastern half of Kansas and in favorable dryland locations in central and western Kansas. It provides excellent pasture with a high carrying capacity and excellent hay when properly managed and harvested. Forage yields can be exceptional—3 to 4 tons per acre or more—with good management when rainfall is adequate. Smooth brome also provides excellent permanent cover for sites such as waterways, eroded areas, rocky areas and farm lanes.

VARIETIES

Because of their superior drought and heat tolerance, only Southern varieties should be grown in Kansas. The following varieties are recommended for use in Kansas:

- Achenbach, named by the Kansas State University Agricultural Experiment Station, is a heavy producer of both seed and forage, and much of the 'common' is from this source. No certified seed is available.
- Southland, developed at the Oklahoma Agricultural Experiment Station, has greater resistance to leaf diseases than most strains, but its chief advantages are superior yield capacity and seedling vigor. Certified seed is available.
- Lincoln, developed at the Nebraska Agricultural Experiment Station, is well adapted for conservation purposes because of good seedling vigor and ease of establishment. Certified seed is available.
- Other varieties available as certified seed or commercial seed include Baylor, Blair and Fischer.

ESTABLISHING SMOOTH BROME

Time of Seeding. Smooth brome has been established on sites such as eroded and rocky areas, unproductive weed patches, bluegrass pastures, brush infested areas and marginal cropland. Cool-season grasses are established most successfully with late summer or fall plantings, but smooth brome can also be planted in winter or early spring (Figure 1). Winter and spring plantings are not recommended on droughty claypan soils because bromegrass will not survive if a hot, dry summer follows planting.

Germinating weeds encouraged by summer tillage can be destroyed by light discing or other tillage operations in mid-August for a late August or early September planting. No-till seeding of brome has emerged as a viable planting method.

Seedbed Preparation. The ideal smooth brome seedbed is firm, moist, free of weeds, and adequately fertilized and limed. For best results, minimize weed competition, obtain uniform seed distribution, plant shallow and evenly cover seed with soil. Many smooth brome pastures have been successfully established on sites that cannot be adequately tilled because soil is too shallow and/or slopes are too steep.

Smooth brome will grow on moderately acid soils, but does best on near neutral pH soils. Because smooth brome stands can remain productive for 20 years or longer, correcting soil pH prior to seeding is essential. Applying 30 to 40 puounds of nitrogen before seeding will help ensure vigorous establishment of brome. Soils in Kansas vary in levels of phosphorus and potassium, therefore, a soil test is essential to determine requirements for these nutrients. Broadcasting and incorporating recommended rates of phosphorus and potassium during seedbed preparation is the most desirable practice.

Seed Source and Rate. Seeding rate depends on seed quality and method of seeding. When planting in a well-prepared seedbed, 10 to 15 pounds of pure live seed (PLS) is adequate. PLS refers to the amount of live seed of the desired species in a bulk lot. As an example, 100 pounds of bulk smooth brome seed that has a germination of 90 percent and a purity of 95 percent contains 85.5 pounds of pure live seed ($100 \times .90 \times .95 = 85.5$). If a poor seedbed exists, seeding rates as high as 20 pounds. PLS per acre may be required to obtain satisfactory stands. Higher seeding rates should be used when brome is broadcast on the surface and covered.

Method of Seeding. Drilling smooth brome at ½ to ¼ inch deep is the preferred method of seeding because drilling ensures accurate seeding rates, uniform seed distribution, and uniform depth of coverage. Broadcasting brome seed on the surface with shallow incorporation can result in good stands. An additional method of seeding is to use a cover crop such as wheat. Twenty pounds of brome seed can be broadcast on the surface prior to wheat seeding. As the wheat is drilled, the brome seed is covered. This is a slow establishment method, but it is desirable on soils subject to erosion or to obtain a return from the field the first year.

MANAGING SMOOTH BROME

New Stands. New stands of brome should be protected from grazing until the grass is well established. With proper management, fall seeded smooth brome usually can be grazed the next year with light grazing and haying at the bloom stage. Spring seedings should not be grazed until the following spring.

Established Stands. Because brome requires annual fertilization for optimum production, pastures and meadows should be soil tested during July. Phosphate and/or potassium should be applied by broadcasting in the fall or before spring growth begins.

Nitrogen management is critical for optimum smooth brome production. Several nitrogen sources are available—liquid nitrogen solutions, urea, ammonium nitrate, and anhydrous ammonia. Nitrogen source research generally has shown little difference among sources under most conditions.

When brome is grazed in the fall, the yearly nitrogen application should be split. If adequate soil moisture is available for good growth in late August and early September, apply all phosphorus and potassium indicated by a soil test plus 30 to 40 pounds of nitrogen per acre. Before the soil freezes in November or December, apply the remainder of the nitrogen recommended for haying or grazing. Split or late fall applications generally initiate earlier green up in the spring.

If soil moisture is limited, apply all nitrogen, phosphorus and potassium before the soil freezes in November or December. Do not apply fertilizer to frozen soil. Spring applications as soon as the soil thaws are acceptable for spring-only grazing.

Weed Control. When smooth bromegrass plants lose their ability to compete, weedy plants invade. This can result from a fertility imbalance, low fertility—particularly nitrogen and/or phosphorus—unfavorable weather, repeated heavy summer grazing, and numerous other factors. Adequate fertility and proper grazing management will minimize most weedy plant invasions. For the latest chemical control recommendations, see your county Extension Agent and ask for *Chemical Weed Control for Field Crops, Pastures, Rangeland & Noncropland*, a publication issued annually.

SMOOTH BROME UTILIZATION

Grazing Management. If smooth brome is to be grazed the entire season, stocking rates must be adjusted so that enough forage remains for grazing during summer months when production is low. It should not be grazed below a stubble height of 4 inches. If warm-season native grass, bermudagrass or a summer annual pasture is available, an alternative is to heavily stock brome pastures during the spring, utilize the warm-season grass in summer, and then move back to the brome with moderate stocking in the fall.

If brome is to be grazed during the dry summer months, it is necessary to stock moderately during the early part of the grazing season so more forage will be available during summer months. Mineral supplementation to meet local deficiencies should be provided with any grazing management program.

Rotational grazing can increase the carrying capacity and/or better utilize brome pastures, but it does not increase the forage production. Concentrating animals from several pastures into a single pasture for a shorter grazing period ensures that more forage is harvested, and once livestock are moved, regrowth is quicker and more uniform.

Hay Production. The production of high-quality brome hay requires adequate fertility and timely cutting. Brome hay should be cut between early heading and full bloom—usually mid-May to June 1—to optimize quantity and quality. It should never be cut before the early heading stage or below a stubble height of 4 inches as stand reduction or loss can occur, particularly during dry soil conditions.

Hay Quality. Crude protein levels in well fertilized hay harvested at early heading range from 10 to 18 percent, but drop rapidly after heading. Decreases in crude protein levels by as much as one-half percent per day after heading have been recorded. Two of the most important factors affecting nutritive value of forage are its digestibility and dry matter intake, which both decrease with maturity.

Seed Production. Seed is harvested when the stem just below the head has matured. Brome seed should be harvested on days when the relative humidity is below 50 percent, and harvested seed should be turned and stirred daily to ensure that heating does not occur. Nitrogen rates for seed production in eastern Kansas are 80 to 100 pounds per acre applied in November or early December. Excessive nitrogen can cause lodging. Apply needed phosphorous and potassium at the same time. Seed yields of well managed brome range from 300 to 1,000 pounds per acre.

OTHER PUBLICATIONS

Seed Production and Management for Bromegrass and Tall Fescue (MF-394).

Chemical Weed Control for Field crops, Pastures, Rangeland & Noncropland (Report of Progress issued annually).

Smooth Brome Production and Utilization (C-402).

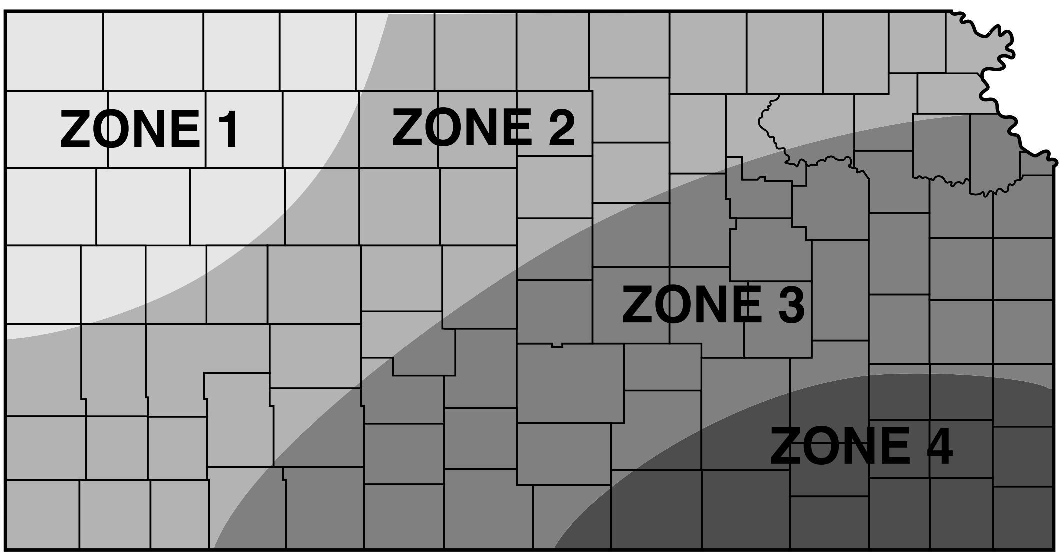

Figure 1. Optimum seeding dates for smooth brome.

	Zone 1	Zone 2	Zone 3	Zone 4
Fall	Aug 10–Sep 15	Aug 15–Sep 20	Aug 15–Sep 20	Aug 15–Oct 1
Winter	Nov 1–Mar 1	Nov 15–Feb 15	Dec 1–Feb 15	*
Spring	Mar 1–Apr 1	Feb 15–Apr 1	Feb 15–Apr 1	*

* Not recommended

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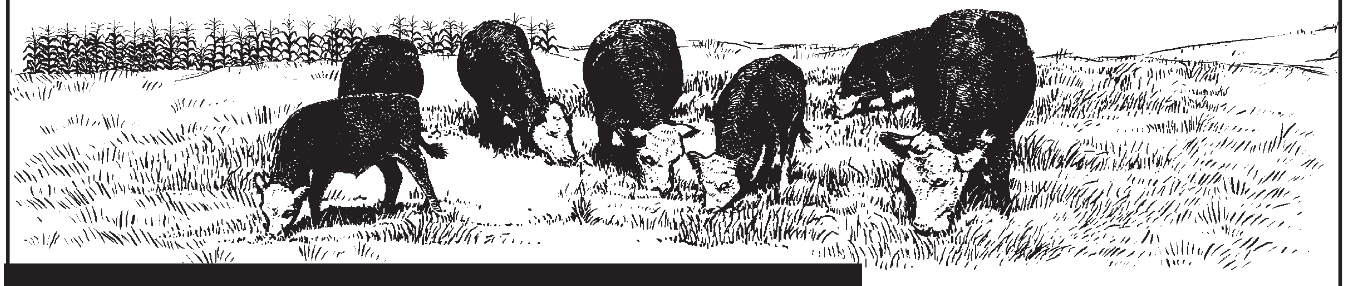

FORAGE FACTS

Publication Series

TALL FESCUE

INTRODUCTION

Tall fescue is a cool-season perennial grass species adapted to the climate and soils of the eastern one-third of Kansas. Tall fescue can persist under limited fertility conditions and, when compared with smooth brome, better tolerates wet soils, grazing abuse, claypan soils and summer drought.

Fescue can be used not only for forage but also for waterways, pond dams, farm lanes and lawns. Fescue will grow when average temperatures are as low as 34°F but does better with temperatures above 45°F. Summer growth is retarded by high temperatures and low moisture, with little growth occurring above 85°F.

Animals readily graze fescue during April, May, and June and again in the fall. With consideration for both the grass and animals, grazing should be avoided during late June, July and August. Tall fescue grazed during the summer results in low animal performance and possible damage to the grass. It should be "rested" during summer months to allow the plants to increase vigor.

Tall fescue is the best adapted cool-season grass in Kansas for winter use. Thus, fescue can provide most of the spring, fall, and winter feed for a beef-cow herd. Tall fescue should be used in conjunction with warm-season forage crops such as native grasses, bermudagrass, or summer annuals to provide summer forage.

TALL FESCUE TOXICITY

The terms fescue fungus, endophyte, fungal endophyte, and fescue endophyte have been used to denote the toxicity associated with tall fescue. "Endo" (within) plus "phyte" (plant) means a plant that lives within another plant. The fungus lives its entire life cycle within the fescue plant.

Two characteristics of the endophyte are significant: the organism does not affect either the growth or appearance of the grass and requires microscopic examination to detect, and it is seed transmitted only. The alkaloid, ergovaline, is thought to produce the animal symptoms observed in livestock feeding on infected tall fescue. Fungus-free plants remain fungus free, and infected pastures come from infected seed. The only way a fungus-free pasture becomes infected is when fungus-infected seed is brought into the pasture and the plants establish from that seed.

Over 500 pastures in Kansas have been tested for the endophyte, and approximately 95 percent were found to have infection. The average infection rate was 64 percent, with a range from 0 to 100 percent. Only about 20 pastures have been found free of endophyte. The specific instructions on sampling pastures and testing seed for endophyte can be found in K-State Research and Extension publication AF-139, *Sampling and Testing Procedures for Fungal Endophyte of Tall Fescue.*

ANIMAL RESPONSE TO TALL FESCUE TOXICITY

Cattle that consume infected fescue plants react to toxins that are produced either by the fungus or by the plant in reaction to the fungus. These toxic compounds are also present in stored hay or seed and can affect the animals that eat it. Data from several states, including Kansas, suggest that for each 10 percent increase in endophyte level, there is a reduction of approximately 0.10 pound in average daily gain (ADG) of growing beef animals. This can be much lower when tall fescue is only grazed March through May and September through November. Grazing infected pastures during July and August is especially deleterious to animal performance.

A steer grazing study at Auburn University showed an 82 percent increase in average daily gain (ADG), and a 42 percent increase in gain per acre with endophyte-free fescue compared with endophyte-infected fescue. Research in Kentucky showed a 34 percent reduction in pregnancy in spring-calving cows grazing high-endophyte fescue pastures compared with grazing low-endophyte pastures.

Given a choice, grazing animals will spend much more time grazing endophyte-free pastures, with greater forage intake, thus requiring a lower stocking rate. Fungus-free pastures are much more subject to damage by overgrazing. Fungus-free pastures require lower stocking rates but produce higher average daily gain and more beef per acre on grazing yearling cattle compared with pastures infected with the endophyte.

ESTABLISHMENT AND MAINTENANCE

Several new certified varieties free of the endophyte fungus are suitable for Kansas. Pastures planted to fungus-free seed will have a 20 to 30 percent lower carrying capacity because the grazing animal eats more endophyte-free grass. Tall fescue will grow on almost any soil but produces best on fertile, moist soils. The ability of fescue to withstand low fertility and wet soil, as well as submersion for a few days, is excellent. It will produce on soils with a pH of 5.2 to 8.0, but optimum growth occurs in the 5.8 to 7.0 pH range.

Fescue establishes best in a well-limed and fertilized seedbed that has been tilled 4 to 6 inches deep, leveled, and firmed before seeding. When planting in a well-prepared seedbed, 15 pounds per acre of clean, high germinating seed is adequate. When seed germination is not known or the seedbed is less than desirable, a rate of 20 to 25 pounds per acre may be required for a satisfactory stand. For best results, the seed should be covered with ¼ to ¾ inch of soil.

Seeding fescue with winter wheat is often desirable because the cover crop can protect the soil from erosion and furnish additional grazing or grain production income in the seeding year. If wheat is grazed, avoid grazing during wet weather when new grass seedlings could be injured by trampling.

A soil test should be taken well ahead of planting to determine lime and fertilizer needs. Local agricultural Extension agents can provide fertilizer recommendations based on soil test results. Once established, fescue production will depend on the amount and time of fertilizer application. Adequate combinations of phosphate, potassium, and nitrogen can make the difference between good and poor yields. Research shows that 100 pounds of actual nitrogen produced only 1.6 tons of dry matter per acre; however, when adequate phosphate and potassium were applied with the nitrogen, yields increased to 3.7 tons. Phosphorus and potassium need only be applied once per year. For improved plant health, improved stand and good yields, a fall (September) application is recommended.

If fescue is grazed in the spring and fall, nitrogen should be applied in the winter and late summer because research indicates that spring-applied nitrogen does not carry over for fall growth; likewise, fall applications of nitrogen do not increase spring performance. Apply two-thirds nitrogen in spring and one-third nitrogen in fall.

HAY PRODUCTION

The key to quality fescue hay production is adequate fertilization and early cutting. Fescue crude protein drops 0.5 percent per day from the boot stage to the mature seed stage, therefore, fescue hay should be cut no later than mid-May in southeast Kansas. Cutting the forage for hay when it starts to show a few heads also results in lower levels of the endophyte in the hay. Nitrogen rates should be approximately 100 pounds of actual nitrogen. Phosphate and potassium should be applied according to soil test.

UTILIZATION BY CATTLE

High endophyte fescue pastures should be grazed only in the spring and fall to reduce the endophyte effect. Grazing when the grass has a high percentage of leaves can result in less toxicity occurrence compared with grazing mature grass. If pastures are to be grazed in the summer, legumes may be planted in high-endophyte fungus pastures to dilute the amount of fescue consumed. Legume interseeding has improved average daily gain of stocker cattle and conception rates in spring-calving cows.

A good mineral program is needed on high-endophyte fungus pastures because there appears to be some absorption problems with phosphorus even though the level in the plant is high. Grass tetany may occur in early spring when tall fescue starts growing. To prevent it, a mineral mixture containing 8 percent magnesium or 12 to 15 percent magnesium oxide is needed during March and April. Magnesium oxide is not palatable, so adding 10 percent soybean meal or dried molasses may be required to ensure proper intake by grazing cattle.

Brahman and Brahman-cross cattle may be more tolerant of the endophyte fungus and heat stress than other breeds of cattle grazing high-endophyte fungus pastures.

Performance of the grazing fescue pasture can be improved by energy supplementation. Dry matter intake is lower on high-endophyte fungus pasture compared with fungus-free pasture, which would make energy even more limited. Supplementation with 4 to 5 pounds of grain may be necessary to dilute the intake of the endophyte and to help compensate for the energy lost through lower dry matter intake.

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FORAGE FACTS

Publication Series

EASTERN GAMAGRASS

INTRODUCTION

Eastern gamagrass is a native, warm-season bunch grass adapted to deep soils with good moisture relationships. The tall, clump type grass has thick, knotty rhizomes that can form plants 2 to 4 feet in diameter. Eastern gamagrass is rarely found in native rangeland grazed season long, but can be found on sub-irrigated sites throughout Kansas. It is highly palatable and forage production and quality are higher than other native species.

Eastern gamagrass is currently being promoted for tame pasture, hay meadow or seed production. Under irrigation and high fertility, forage production has reached as high as 10 tons per acre. Production on non-irrigated situations varies.

Only one named cultivar, “Pete,” has been officially released to commercial seed companies. All seed released is from this source which was released in 1988. Historically, eastern gamagrass has been considered difficult to establish. Seed dormancy, seeding date, stand establishment, and grazing management are the major barriers.

ESTABLISHING NEW STANDS

Dormant seed should be planted ½ to 1 inch deep between December 1 and March 1 at a rate of 6 to 8 pounds per acre of pure live seed (PLS). Within the first year after harvest, seed dormancy can greatly limit seedling emergence. The process of stratification, which is chilling, soaking, and treating with a fungicide, can improve the problem. Stratified seed cannot be allowed to dry before planting and must be kept chilled if not planted immediately after purchase. Since it is moist, it may heat and destroy the germination. Stratified seed should be planted ½ to 1 inch deep between March 15 and May 30 at a rate of 6 to 8 pounds per acre of PLS.

The ideal row spacing for Eastern gamagrass is 10 inches wide or less. Traditionally, stands have been planted 30 to 60 inches apart, which results in large clumps up to 3 feet across with large bare spaces between plants. The rough fields are difficult to harvest and hard on harvest equipment.

There currently aren’t any herbicides labeled for eastern gamagrass weed control, but frequent clipping and flash grazing can control weed growth. Once established, a prescribed burn will enhance grass production and weed management. The burn should occur when new spring growth is about 1 inch tall, which is prior to the usual time to burn native rangeland.

MANAGEMENT

Fertilizer should be applied in late April according to soil test results. Eastern gamagrass can be cut for hay or grazed. When cut for hay, the first harvest should occur about June 15 to 20 and the second cutting six weeks later. A 6- to 8-inch stubble should be left at both cuttings.

About 50 pounds of actual nitrogen can be applied in mid-April and again after the first cutting. This will produce 3 to 4 tons of hay with 12 percent crude protein.

Eastern gamagrass should not be grazed continuously or grazed shorter than 8 to 10 inches. Successful grazing should include a seven- to nine-paddock pasture system with each paddock grazed two to five days. The paddocks should be allowed at least a 30-day rest period before restocking. A five-year research project in Oklahoma produced an average daily gain of 2.03 pounds in cattle grazing a paddock system between May 9 and August 25.

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Publication Series

BERMUDAGRASS

INTRODUCTION

Bermudagrass is a warm-season, deep-rooted perennial pasture grass that can be used for grazing or hay in Southeast Kansas. Bermudagrass requires a high degree of management for favorable production results. Yields and subsequent profit from bermudagrass will vary according to the amount of management the grass receives.

SEEDBED PREPARATION AND SPRIGGING RATE

The major requirement in planting bermudagrass sprigs is a well-prepared, firm seedbed similar to that for corn or soybeans. All lime and fertilizer requirements should be incorporated during seedbed preparation, especially phosphorus and potassium.

A minimum sprigging rate of 15 bushels per acre is necessary in loose, dry soil, but a sprigging rate of 20 bushels per acre is preferred. Drying of the sprigs before or after planting will cause decay and molding which will prevent growth of the young buds.

Producers should use only freshly dug sprigs or those that have been properly stored, and the sprigs should have a minimum amount of top growth and old dead crowns included. Good sprigs are dug from fields that were well fertilized and managed the year before digging. If sprigs are to be transported or stored for any period of time, they should be covered and protected from wind. Moisture may need to be added, but producers should take care to avoid over-watering.

TIME OF PLANTING

Bermudagrass should be planted as early in the spring as the sprigs can be dug. Planting sprigs too late is much more of a concern than planting too early. If plantings are delayed until early June, most stands fail to establish. It is important to get the sprigs into the ground before they are subjected to hot, dry soil conditions.

DEPTH OF PLANTING

The sprigging machine should be set to plant the sprigs about 2 inches deep. If the roots are in a large clump, the machine may be set a little deeper. The soil should be firmed around the sprigs at planting time with press wheels or the wheels of a tractor. If soil moisture is adequate at planting time, some of the sprigs may have their tips slightly exposed. During warm weather and under good moisture conditions, sprigs will start emerging within two weeks after planting and continue for three to four weeks if moisture conditions allow. The depth of planting and plant food content of the roots affect the rate of emergence of the bermudagrass sprigs.

WEED CONTROL

The control of weeds and weedy grasses is very important in establishing bermudagrass because young emerging plants are susceptible to shading. It is also difficult to get a good establishment when undesirable weeds and grasses compete for water and nutrients. There are several methods to control weed growth in bermudagrass pastures, but the use of herbicides such as 2,4-D and Karmex are probably the most important.

2,4-D should be applied at a rate of about ½ to 1 pound of active ingredient per acre. It should be applied after the bermudagrass is sprigged and when broadleaf weeds are young and actively growing. In fields where crabgrass and other foxtail grasses are not a problem, 2,4-D can be used very economically to control broadleaf weeds in the establishment of a bermudagrass pasture.

Karmex should be applied at a rate of 1 to 2.4 pounds of active ingredients per acre to control unwanted grass species of weeds. It should be broadcast after sprigging and before weeds emerge. A post-emergence treatment of .8 pounds per acre can be applied after sprigging and when the weeds have germinated and are not more than 4 inches tall. Karmex requires a 70-day grazing restriction after application.

Be sure that applicators read the labels of pesticides and apply accordingly.

FERTILIZATION

Fertilization is the key to economical production of bermudagrass forage because the greatest return per dollar invested comes from the proper application of fertilizer. It takes much less water to produce a pound of dry matter on well-fertilized soils than on soils of low fertility. Since bermudagrass is a high user of plant nutrients, a balance must be maintained in the soil for continued high production. It is important to apply nitrogen, phosphorus and potassium according to soil test recommendations. It has been shown that the winter-hardiness of bermudagrass may be greatly reduced by low potassium, especially under high nitrogen fertilization.

FERTILIZER FOR NEW STANDS

At planting time, the application of nitrogen should be limited to 20 pounds per acre. This small application results in feeding only the new seedlings of bermudagrass that will be emerging. Stimulation of weed growth occurs with higher rates of nitrogen. After the new bermudagrass is about 6 to 8 weeks of age, apply up to 50 pounds of nitrogen per acre if the new bermudagrass has started to run. This will supply additional amounts of nitrogen for the new plants to continue to grow during the seedling year.

FERTILIZER FOR ESTABLISHED STANDS

Fertilizer use, particularly nitrogen, increases yield and protein content of bermudagrass forage and increases the carrying capacity of the pastures, but will have little effect on daily gain of the livestock. The timely application of proper amounts of nitrogen is one of the best management tools to increase livestock production and profits from bermudagrass.

A fertilizer application of 150 to 200 pounds of actual nitrogen during the growing season is considered a profitable amount. Nitrogen should be split into two or three applications during the summer. The first application should be made on May 1 with additional applications at six-week intervals. Application of phosphorous and potassium should be based on soil test recommendations and applied with the first application of nitrogen each year. Bermudagrass is the most efficient user of nitrogen fertilizer of any crop in Kansas.

HAY PRODUCTION

The production of high quality hay is important in a profitable bermudagrass program. Excess forage produced in the spring should be harvested as hay. Likewise, excess fall forage may be cut for hay if done by September 15. Proper fertilization and timely cutting are the main factors in increasing the protein and energy content of bermudagrass hay. Generally, fertilized bermudagrass cut every 25 to 30 days contains 12 percent protein.

BERMUDAGRASS AND COMPANION CROPS

Planting winter cereals into bermudagrass is best accomplished by the use of a grassland and/or hoe-type drill. The bermudagrass should be either grazed or clipped short and the winter cereal seed planted during late September. This provides some winter cereal pasture during late winter and particularly early spring.

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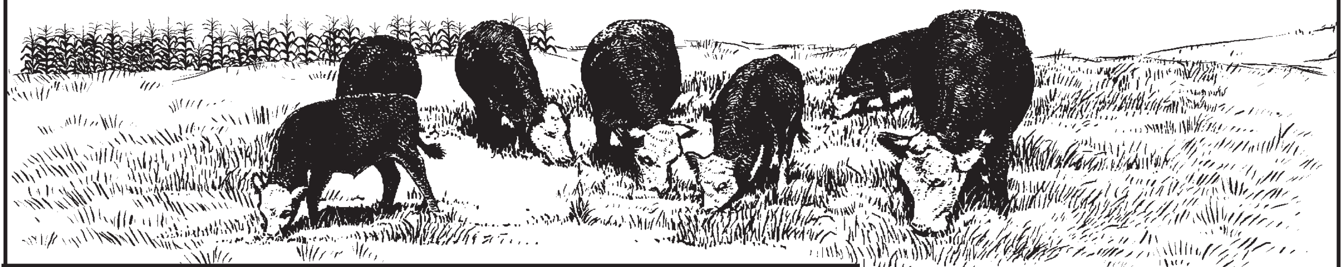

FORAGE FACTS

Publication Series

OLD WORLD BLUESTEM

INTRODUCTION

Old world bluestems are a group of grasses from the southeast Soviet Union, Turkey and surrounding areas that were introduced in the 1930s as 'improved' grasses. They are called bluestems, but they are not closely related to big bluestem and little bluestem. Silver bluestem, an undesirable native species, is the closest native relative.

ADAPTATION

The old world bluestems are the survivors of centuries of overgrazing. They are drought tolerant, aggressive, prolific seed producers and unpalatable in comparison to desirable species. Old world bluestems are adapted to high calcareous and high pH soils, and do well on any well drained soil.

On calcareous and high pH soils, old world bluestems invade neighboring pastures 10 or more years after establishment. In south-central Kansas, invasion into native rangeland has been common. The old world bluestems can invade any time another species or mixture is overgrazed, stressed by drought or wildfire, or otherwise suppressed. Once old world bluestems begin invading other pastures, there is no known way to stop the invasion.

The current varieties adapted in Kansas are Caucasian, Plains (southern Kansas only), WW Spar, and Ironmaster. Plains and WW Spar appear to be the least aggressive.

MANAGEMENT

Production management requires burning as the grass emerges from winter dormancy. Unfertilized old world bluestem pastures generally have similar production as native range, therefore, nitrogen and phosphorus applications are required for economical production.

Forage production normally occurs in May and June, but the leaf to stem ratio drops below one in as little as 45 days and the forage becomes mostly stems. Intensive rotational grazing can limit the stem problem, but the best animal performance has been observed in the early part of the growing season. Forage quality is similar to prairie hay, but the digestibility and palatability are lower than prairie hay.

Current recommendations from Kansas State University and the National Resource Conservation Service-USDA are for limited use of the old world bluestems with first consideration for currently recommended native and introduced species.

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LEGUMES FOR PASTURE

INTRODUCTION

Many legumes may be successfully established into grass pastures. One strategy is to no-till cool-season annual legumes into bermudagrass pastures. The bermudagrass must be carefully managed to ensure that a minimum amount of residue remains at the time of establishment. If the bermudagrass canopy is not removed, emerging legume seedlings will not be able to compete for sunlight and become established. Forage canopies may be removed by grazing or mowing.

Another popular strategy for utilizing legumes in a grass pasture is to mix a legume with tall fescue or other cool-season grass pastures. The tall fescue has a negative effect on the bloating potential of legumes, and the legumes may play a role in reducing the effects of fescue toxicity.

The following is a short description of the legumes that may be used for pasture.

Alfalfa is a perennial legume that is difficult to establish in existing pasture, but will persist for three to four years under grazing conditions. The seeding rate for alfalfa is 10 to 15 pounds per acre. Rotational grazing will increase production and life of the stand. It has a high bloat potential and a bloat preventative must be used. Alfalfa offers high forage production and high animal performance.

Red clover is an easy legume to establish in new pastures or existing pastures that are closely grazed. It performs best on well-drained soils of high moisture content with a pH above 6.2. It can be seeded in the fall or spring at a seeding rate of 6 to 8 pounds per acre. Red clover will persist with good forage yield potential for two to three years without reseeding, and if it is moderately grazed, enough seed will be produced for reseeding. Some bloat potential exists with red clover, but it is not as serious a problem as it is with alfalfa and ladino clover.

Sweetclover is a biennial legume that has a high forage yield potential in the second year of growth. Utilization should occur during early and mid-summer because the growth rate slows after mid-summer. A heavy stocking rate is desirable to prevent the forage from becoming coarse and unpalatable which would counteract the benefit of using sweetclover. High coumarin levels affect palatability and can cause health problems with livestock. Sweetclover is generally less desirable than other legumes for grass-legume combinations. The seeding rate for sweetclover is 6 to 8 pounds per acre.

Ladino clover is a short-lived perennial white clover that persists longer than most legumes under heavy grazing conditions. Bloat can be a problem when a high percentage of the pasture is ladino. The legume does not produce as much forage as red clover in southeast Kansas, but does persist longer in poorly-drained soils. The seeding rate for ladino clover is 1.5 to 3 pounds per acre.

Birdsfoot trefoil is most productive on fertile, well-drained soils, but does grow on poorly drained, dry, infertile and acidic soils. The legume is prone to establishment problems, but once a good stand is attained, natural reseeding does occur. It is subject to root diseases in southern Kansas and bloat is not a problem with the legume. The seeding rate for birdsfoot trefoil is 6 to 8 pounds per acre.

Lespedeza grows in Kansas as an annual and a perennial. The annual types reseed each year and are easily established and maintained in pastures. They grow on acidic, eroded, and low fertility soils where production is low. On good soils annual lespedeza can compete with unfertilized grass. The seeding rate for annual lespedeza is 20 to 25 pounds per acre. Perennial lespedeza (Sericea) becomes woody in most pastures and contributes very little to livestock feed during the summer months. Perennial lespedeza is considered noxious in some Kansas counties and must be controlled in rangeland and pastures.

Arrowleaf clover is a winter annual legume that is adapted to well-drained soils and tolerates acidity and low fertility less than red clover. It should be planted in early fall (August 15 to September 15) at a seeding rate of 8 to 10 pounds per acre. Arrowleaf clover is primarily adapted for overseeding in bermudagrass, but grows slowly in the fall and can be prone to winterkill if not properly rooted. The legume will start spring growth in early April and flower during June and July. Reseeding will occur naturally under grazing conditions, but will require annual seeding under haying conditions. Arrowleaf clover has a high forage production and needs grazing to prevent a reduction in an accompanying grass stand.

Berseem clover is an annual legume that resembles alfalfa in its appearance, but does not cause bloat. When planted in the fall at a seeding rate of 10 to 15 pounds per acre, some forage can be utilized, but most forage production occurs between April and July.

Hairy vetch is a cool-season winter annual legume that has vine-like growth. The seeding rate is 20 to 25 pounds in early September. A companion crop such as wheat or rye is needed for attachment by the vines of hairy vetch. The high production months are April through June with maturing occurring in June. Hairy vetch can contaminate wheat fields and when grazed in a pure stand, cattle can develop dermatitis.

Austrian winter peas is an annual legume planted with a companion crop such as a winter cereal in late August or September. They grow best on well-drained loam or sandy soil, and they are intolerant of low pH soils. The seeding rate is 15 to 25 pounds per acre.

Cowpeas is an annual warm-season, vine-like plant with large leaves which will tolerate dry and low fertility soil conditions. The plant should be seeded in May or June at a seeding rate of 40 to 70 pounds per acre. Cowpeas do not cause bloat and can be used as hay, creep grazing, or limit grazing when low quality forages are used.

OTHER PUBLICATIONS

Kansas Crop Planting Guide (L-818)

Establishing Legumes into Cool-Season Grasses (Forage Fact Sheet Series)

Fertilizing Cool- and Warm-Season Grasses (Forage Fact Sheet Series)

Grass-Legume Mixtures (Forage Fact Sheet Series)

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FORAGE FACTS

Publication Series

IRRIGATED PASTURE

INTRODUCTION

Irrigated pasture can be a high producing, high quality forage alternative to traditional grazing options and assist feedlots with organized cattle placement. Irrigated pastures have been primarily used for stocker cattle, but the use of irrigated pasture for cow/calf operations has increased. Irrigated pasture is a high-investment, high-management grazing system that requires the efficient conversion of forage to pounds of beef throughout the grazing season.

MANAGEMENT CONSIDERATIONS

Producers using irrigated pasture in southwest and south central Kansas have reported high performance for forage and livestock. Management requirements are 20 to 24 inches of irrigation above normal precipitation, 200 to 300 pounds of nitrogen applied in split applications, and 20 to 40 pounds of phosphorus annually. Production costs are about the same as a well-managed corn crop on the same field.

Species used successfully are primarily smooth bromegrass, cool-season mixes and Matua prairie bromegrass. Warm-season pastures have not been economically practical due to the limited use season, normally May through mid-September.

Very few species or mixtures have been used for long periods of time on irrigated pastures. Sharp's #6 (from Sharp Brothers Seed; Healy, Kansas) is a mixture of smooth brome, meadow brome, orchard grass and creeping foxtail. After two to four years, the bromes will provide the bulk of the forage and creeping foxtail will dominate around wet areas or standing water. Matua prairie bromegrass, a cool-season perennial from New Zealand, has been in use for a few years on irrigated pastures. However, several stands have been recently reduced by winterkill.

Two management considerations must be evaluated when using mixtures. First, the species must be of equal palatability or have growth patterns that allow grazing to move from one species as it reaches maturity to the next species as it begins vegetative growth. Mixtures that have palatability differences and grow with the same growth patterns have not been practical. Secondly, most mixtures of warm-season and cool-season species have not worked well because one will dominate the other. The exception is the use of rye, triticale, annual ryegrass or similar annuals interseeded into a warm-season perennial in late August or early September. This system works best when the cool-season is grazed-out by the start of the warm-season's spring growth.

LIVESTOCK PERFORMANCE

Stocker gains have exceeded 2 pounds per head per day in May and June, but generally drop to 1¼ to 1½ pounds per day in July and August. From late August to mid-November, gains usually attain 2 pounds per day. Utilizing two to three groups of animals each year is common practice on irrigated pastures.

Carrying capacities have been in the 8 to 12 AUM per acre range. Typical stocking rates for stockers and cow/calf pairs are shown in Table 1.

Table 1. The following stocking rates are typical on irrigated land capable of 150 bushels of corn per acre.

Season of year	Stockers	Cow/calf
	----pounds of live animal per acre----	
Late April through June	2,500	2,500
July through mid-September	1,000	900
Mid-September through November	1,500	1,350

GRAZING SYSTEMS

Rotational grazing is highly recommended for irrigated pastures. Eight paddocks appears to be ideal, but six can be effective especially when two circles are used. Destruction of the plants in the narrow points at the pivot can reduce the total acres available for grazing. The rotation system should be based on using 40 to 50 percent of available forage each time through to obtain best animal and forage performance.

Cool-season forage production is similar to brome or fescue with 40 to 50 percent of the dry matter produced from May to early June. Twenty to 40 percent of the dry matter will be produced from late June through August (depending on water application and temperature), and 20 to 30 percent will be produced in the fall.

Livestock water can be located at several places in the circle. If nitrogen fertilizer is injected through the pivot system, DO NOT USE the pivot for livestock water. Water sources can be located on the perimeter of the circle and serve several paddocks by using a pen and rotating the animals through the pen.

OTHER PUBLICATIONS

Stocking Rate and Grazing Management (MF-1118)

Stocking Distribution (MF-515)

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MATUA GRASS

INTRODUCTION

Matua prairie bromegrass, introduced from New Zealand in the 1980s, is a cool-season perennial bunch grass that has not been tested in long-term research projects in the United States. The closest related species to Matua are Rescuegrass, Cheat grass, Downy brome and Japanese brome.

TRAITS

Matua is a high-producing, high quality grass that appears to be extremely palatable. When given a choice, cattle have preferred Matua to ryegrass, and the cattle have consumed the Matua stems. Researchers in New Zealand reported that horses spent twice as much time on Matua as on ryegrass, timothy, orchard grass or tall fescue.

Work at the Noble Foundation in Oklahoma indicated that the perennial nature of Matua does not extend to the Central Great Plains region. Survival of perennial plants at several locations in Oklahoma has been rated at 10 to 70 percent when it has been managed as a winter annual. Pennsylvania researchers call Matua a perennial but add that each plant is short lived in that state. Matua must be managed as a winter annual in Kansas and allowed to produce seed or be overseeded every other year to perpetuate the stand.

MANAGEMENT CONSIDERATIONS

Producers using Matua on irrigated pasture in southwest Kansas have reported high performance for forage and livestock. Management requirements are 20 to 24 inches of irrigation above normal precipitation, 200 to 300 pounds of nitrogen applied in split applications, and 20 to 40 pounds of phosphorus annually. Production costs are about the same as a well managed corn crop on the same field.

Seeding rate recommendations are between 20 to 40 pounds per acre, which results in a high seeding cost per acre of $30 to $50. Livestock can be removed from matua pastures five weeks prior to seed maturity to allow for a seed crop.

Forage production is similar to brome or fescue with 40 to 50 percent of the dry matter produced from May to early June. Twenty to 40 percent of the dry matter will be produced from late June through August (depending on water application and air temperature), and 20 to 30 percent will be produced in the fall. Oklahoma researchers reported hay yields of 2.5 tons per acre on one cutting which tested between 10 to 15 percent protein content. Researchers compared that to a fescue grass yield of 3.5 tons per acre.

Carrying capacities on irrigated pasture have been in the 9 to 12 AUM per acre range with stocker gains exceeding 2 pounds per day in May and June. Rotational grazing is highly recommended for Matua-irrigated pastures. Eight paddocks appears to be ideal, but six can be effective especially when two circles are used. The rotation system should be based on using 40 to 50 percent of available forage each time through to obtain best animal and forage performance.

OTHER PUBLICATIONS

Irrigated Pastures (Forage Fact Sheet Series)

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Kansas State University Agricultural Experiment Station and Cooperative Extension Service

FORAGE FACTS

Publication Series

GRAZING WHEAT PASTURE

INTRODUCTION

Wheat pasture is a valuable source of high-quality forage, typically available in late fall, winter, and early spring, when other forage sources are low in quality and quantity. The crude protein content of wheat pasture commonly ranges from 20 to 30 percent. The stocking rate during fall and winter ranges from 250 to 500 pounds of live animal per acre, depending on growing conditions. During the spring, stocking rates usually can be increased to 500 to 1,000 pounds of animal per acre to utilize the lush growth. Average stocker gains commonly range from 1.5 to 2.5 pounds per day.

CULTURAL PRACTICES

Planting Date. Early planted wheat has the potential to produce excellent fall growth if adequate soil moisture and temperature allow rapid germination and emergence. Producers generally plant wheat two to three weeks earlier than usual if it is to be grazed. Grazing can begin four to eight weeks after planting when there is 6 to 12 inches of growth.

Disadvantages do exist if wheat is planted for pasture too early. The incidence of diseases such as wheat streak and barley yellow dwarf mosaics may increase, which would reduce forage production. Early planted wheat serves as a host, especially for wheat streak, allowing the disease to spread to later planted fields. Early planting also encourages heavy Hessian fly infestations.

Planting Rate. Producers interested in early fall grazing generally increase planting rates by 50 to 100 percent, depending on the planting date and soil moisture.

In irrigated fields and in eastern Kansas where rainfall is higher, seeding rates commonly are 90 to 120 pounds per acre. In dryland areas of western Kansas, seeding rates should be no more than 50 percent above those of wheat planted for grain. In central Kansas, recommended seeding rates for wheat pasture are 75 to 120 pounds per acre.

Fertility. Adequate amounts of all essential plant nutrients especially nitrogen, phosphorus and potassium, are necessary for maximum forage production. Wheat used for grazing will remove more soil nutrients than the wheat grain crop. Nitrogen is usually the most limiting nutrient associated with wheat forage production.

Wheat forage containing 25 percent crude protein will have 80 pounds of nitrogen in each ton of dry matter. A general recommendation is to increase nitrogen rates by 30 to 50 pounds per acre for wheat as forage.

A band of starter fertilizer, near or in the seed forrow, containing no more than 20 pounds per acre nitrogen and from 30 to 60 pounds per acre phosphorus, has significantly increased forage production in Oklahoma studies and is recommended in Kansas. If soil pH is 5.1 or less, use of starter fertilizer is highly recommended. Selection of an aluminum tolerant wheat variety is also advised on low pH soils.

NUTRITIVE VALUE OF WHEAT PASTURE

Wheat forage provides succulent and highly nutritious feed for cattle and sheep. The forage is palatable; high in protein, energy, and minerals, and low in fiber. The high moisture content of wheat forage sometimes makes meeting the daily dry matter needs of grazing livestock difficult. To improve animal performance, producers should offer dry, high quality forage or grain in addition to the wheat pasture.

The crude protein content is particularly high, usually between 20 and 30 percent, and sometimes above 30 percent. Properly managed wheat can be an effective protein supplement for livestock simultaneously grazing or consuming other lower quality feedstuffs.

Stage of maturity influences chemical composition of wheat. In vitro dry matter digestibility decreases from 80 percent or more during the vegetative stages of fall and early spring to less than 60 percent by the soft dough stage. The major decline occurs by the heading stage. Crude protein also declines rapidly, dropping from 25 to 30 percent for vegetative wheat forage to 12 to 15 percent by heading and 9 to 10 percent by the soft dough stage.

GRAZING MANAGEMENT

In Kansas, most grazing occurs during late fall and early winter and again in spring, with animals removed early enough (before jointing) to allow good grain production. Depending on rainfall and stored soil moisture, wheat pasture is generally available for 120 to 150 days. Grazing cannot begin until the plants have adequate root development to prevent damage by grazing animals. Ordinarily, wheat is available for grazing between October 15 and November 15.

Studies in Kansas indicate that grazing appears to have little effect on grain yields when fertility is adequate, grazing is not too heavy, and livestock are removed before the first hollow stem.

LIVESTOCK MANAGEMENT

Both stocker cattle and mature animals can effectively utilize wheat pasture. Because of its high nutritive value, stockers and fall-calving cows can utilize the forage most profitably. Both continuous and rotational grazing systems are acceptable for stocker cattle. The primary advantage of rotational grazing is better utilization of available forage. It reduces spot grazing and may result in 10 to 15 percent increased animal gain per acre.

Optimum stocking rates vary considerably from year to year, depending on many climatic and management factors that influence wheat forage yields. Recommended fall and winter stocking rates often range from 250 to 500 pounds of animal per acre (1 to 2 acres per stocker, depending on weight). Spring stocking rates usually are 1.5 to 2.0 times greater than for fall (0.75 to 1.3 acres per stocker, depending on weight), although rates as high as 1,400 pounds of animal per acre (2.5 stockers/acre) have been noted in some research trials during late spring graze out.

Providing some drier feed may offset possible animal digestive problems—including bloat—that result from the succulent, laxative wheat forage. High quality hay, silage or grain is helpful. To avoid overgrazing and damage from trampling, it is best to provide an area (preferably grass) near the wheat pasture for water, salt-mineral, supplemental feeding, and animal loafing. Remove animals from the pasture during extremely wet weather, particularly on fine-textured soils. During periods of extreme cold—about 15°F or less—remove animals to prevent injury to plants.

GRAZING PROBLEMS

Two potential problems when grazing wheat pasture are bloat and grass tetany. To aid in preventing bloat, do not put hungry cattle on lush pasture. Bloat potential is greatest during the three- to four-week periods of lush growth in the fall and early spring. Feeding Bloat-Guard (poloxalene) in a dry or liquid energy supplement, molasses block, or mineral supplement is the most effective procedure to prevent bloat. Feeding high-quality grass hay, silage and/or grain with Rumensin or Bovatec also will minimize the bloat potential.

Tetany is characterized by a low blood magnesium level in livestock. It occurs more often in older cows nursing young calves, but may affect stockers as well. The easiest prevention is to provide 6 to 8 percent magnesium in a palatable, free-choice mineral supplement.

OTHER PUBLICATIONS

Wheat Pasture in Kansas (C-713)

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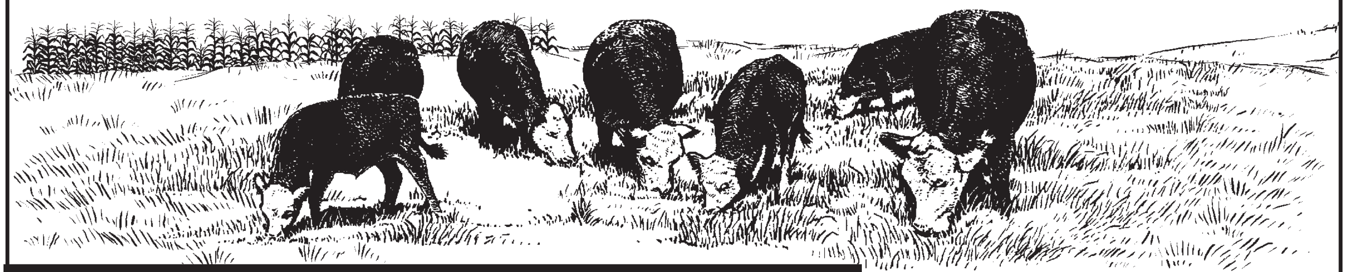

FORAGE FACTS *Publication Series*

SMALL GRAIN CEREALS AS FORAGE: CROP SELECTION

INTRODUCTION

Small grain cereals can be a valuable forage to complement summer annuals and native grass pastures, and a good primary forage when backgrounding beef cattle. For fall and spring pasture, producers can use winter wheat, rye, barley and triticale. These crops, as well as spring oats, can produce an early summer supply of hay or silage. Animal health concerns, such as nitrate poisoning, are less likely to occur with hay and silage from small grains than with summer annual forages.

WHEAT

Wheat has good potential for pasture, silage or hay production. It is usually higher in quality than oats, rye and triticale, and can produce more forage dry matter per acre than barley. Wheat should be planted earlier and at a higher seeding rate when grown for forage instead of grain alone. Wheat streak mosaic, barley yellow dwarf mosaic and hessian fly infestations can be greater concerns for early planted wheat.

Plant height may become a more important consideration than grain yield when growing wheat for grazing, haying, or silage production. However, if wheat is to be grazed and then used for grain production, grain yield potential should be an important factor in variety selection. Select a variety with rapid emergence, good tillering and upright growth characteristics.

WINTER BARLEY

Winter barley is generally more susceptible to winterkill than wheat, especially when it has been overgrazed. Therefore, winter barley should not be grazed as short or as late into the fall as wheat. Some varieties have barbed awns which can affect palatability of hay or silage and cause mouth problems if cut after heading.

Barley grows best on fertile, well-drained soils, but is also well adapted to sandy soils. Barley yellow dwarf, leaf rust and smut can be serious problems, especially when planted early in the season.

TRITICALE

Triticale is a cross between wheat and rye and has a higher forage yield, but lower quality than wheat. For forage purposes, triticale is best suited as pasture. Triticale has large stems which make field wilting for hay or packing for silage difficult.

Although pure triticale will not contaminate adjacent wheat fields with rye, triticale seed is sometimes contaminated with rye seed. At present, little or no cash market exists for the grain, though feed value is excellent in poultry and swine diets.

RYE

Rye is the most cold tolerant and least exacting in its soil and moisture requirements of the small grain cereals. Quick fall and spring growth make rye the most productive of the small grains for pasture. Rye consistently produces more spring pasture than wheat, although it quickly becomes stemmy and unpalatable in late spring.

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If rye is not allowed to head and produce seed, contamination of adjacent fields can be eliminated. After pasturing, rye should be harvested at the late boot stage for hay or silage, or destroyed with tillage or herbicides before seed production.

SPRING OATS

Spring oats must be planted in early spring, generally by April 10, when grown for hay or silage. The forage type varieties are those with high forage and grain yield potential as well as resistance to barley yellow dwarf, crown rust and stem rust. Forage type oats are generally later maturing varieties than grain type oats and are likely to fill only small, shriveled grain. In Kansas trials, forage type oats have rarely out yielded grain types in forage production.

OTHER PUBLICATIONS

Kansas Crop Planting Guide (L-818)

Small Grain Cereals for Forage (MF-1072)

Wheat Pasture in Kansas (C-713)

Wheat Pasture Grazing (Forage Fact Sheet Series)

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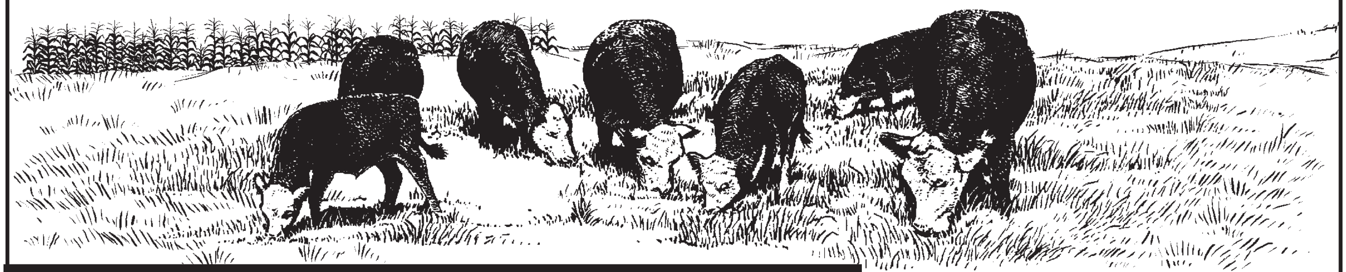

FORAGE FACTS

Publication Series

BRASSICAS AND CHICORY FOR FORAGE

INTRODUCTION

Brassica forages are high quality, high yielding, fast growing crops that are suitable for livestock grazing. Brassicas have been used sparingly in Kansas, therefore, most of the information about brassicas is based on work done in other parts of the United States. Both tops (stems plus leaves) and roots (bulbs) can be grazed and are very nutritious. Members of the brassica family include kale, forage rape, turnips and swedes. Brassicas are very high in crude protein and energy, but extremely low in fiber. Weight gains by feeder lambs have been 0.2 to 0.4 pounds per day and 1.5 to 2.0 pounds per day for stocker cattle. Brassicas may best fit an early to late fall grazing program in Kansas. Chicory is a perennial cool-season herb in the sunflower family. In New Zealand, it produces in excess of 10 tons of forage with 18 to 22 percent protein and 62 to 77 percent in vitro dry matter digestibility.

TYPES OF BRASSICAS

Kale has the greatest cold tolerance of the brassicas and can survive temperatures down to 10°F. Varieties vary greatly in the rate of establishment, stem development, days to maturity and winter hardiness. Stemless (marrow stem) varieties reach crop heights of 25 inches and mature in 90 days. Varieties with stems can grow to 60 inches in height with 2-inch stems and require 150 to 180 days to attain maximum production.

Forage rape, which should not be confused with oil seed rape, is a short-season leafy brassica whose stems and leaves are ready to graze 60 days after establishment. It is a prime forage for fattening lambs or flushing ewes. Forage rape is usually categorized as a giant or dwarf. Giant varieties are mainly utilized for cattle or sheep grazing, whereas the dwarf varieties are best suited for finishing lambs. Generally, a 60-day growth period is required prior to the first grazing or harvest and a 30-day regeneration period is required prior to the second harvest, however, harvest management can vary with variety.

Turnips, an excellent late-fall forage, are short-season, fast growing brassicas that reach maximum production in 80 to 90 days after establishment. The tops have 15 to 22 percent protein while roots contain 8 to 10 percent protein. Turnip varieties can range from 90 percent top/10 percent root to 15 percent top/85 percent root.

Turnip hybrids are a cross between Chinese cabbage, rape, turnip and swede. Some hybrids have a fibrous root only and do not work well in a grazing situation.

Swede is a long-season plant with a large edible root. It requires 150 to 180 days to reach maximum production. Swede is recommended for late-fall grazing and is higher yielding than turnips.

CROP ESTABLISHMENT AND HARVEST MANAGEMENT

Brassicas require good soil drainage with a soil pH between 5.3 and 6.8. Seeds should be planted ½ inch deep in a firm, moist, seedbed with 6- to 8-inch rows. Fertility requirements are similar to wheat for pasture and should be based on soil test results.

To provide grazing in November and December, rape, turnips, and turnip hybrids should be planted in July or early August and swede and kale (with stems) should be planted in May or early June. Rape, turnips and stemless kale should be planted in May or June for August and September grazing.

Strip grazing and rotational grazing provide the most efficient utilization of these crops. Approximately 6 to 8 inches of stubble should remain following the grazing period to allow adequate regrowth during a four-week rest period. Consumption and damage to the root of turnips and swede during grazing can prevent regrowth and limit additional grazing.

Brassica yields in Pennsylvania have averaged 3.1 tons per acre of dry matter at 90 days after planting. Longer maturing swede and kale have averaged over 4 tons per acre at 120 days after planting. The average carrying capacity of a good brassica stand in Pennsylvania is approximately 1,550 ewe or 160 cow grazing days per acre. This is moisture driven and would be much lower in Kansas because of the dry falls. Dry matter digestibility is between 85 to 95 percent and generally does not decrease markedly with increasing plant maturity. The low fiber content of brassicas can cause health disorders in grazing animals if they exceed 75 percent of the diet. Introducing animals to brassicas slowly and avoiding abrupt changes from dry pasture to lush brassica can reduce the problems.

CHICORY

Puna chicory, a member of the sunflower family, is a perennial cool-season herb which originated in Central Europe but was developed for forage production in New Zealand. Puna chicory has larger and denser leaves, much like dandelion in winter, than the native wild chicory of North America. Pure stands in New Zealand pastures yielded up to 22,300 pounds of dry matter per acre with crude protein content between 18 and 22 percent. In Pennsylvania, from April through October, chicory produced 50 pounds of forage per acre per day. At peak growth periods, chicory produced 73 pounds of forage per acre per day.

Chicory is suited to well or moderately drained soils with a soil pH of 5.5 or greater, and moderate to optimum soil phosphorus and potassium levels. Drilling 3 to 4 pounds of seed per acre ¼ to ½ inch deep should produce optimum stands. Frost seeding is also an option for establishment of chicory. If chicory is grown without a legume partner, 100 to 150 pounds nitrogen (N) per acre should be applied in split applications: one-third at green up in early spring, one-third in early summer and one-third in early fall. Since N will enhance stem growth, the forage yield increase must be weighed against the ability to keep chicory grazed so that stems do not bolt.

Maximum life of chicory stands with good quality will be about five to seven years. Chicory will disappear from pure and mixed-grass pastures when grazed full season, whereas rotational grazing allows chicory to persist in the stand. Chicory should be grazed heavily, leaving a stubble height of 1½ to 2 inches, for short periods of time. This intense grazing should prevent plants from bolting, which will extend the vegetative state and forage productivity. A rest period of at least 25 to 30 days between grazings will allow chicory stand persistence and optimum performance. Research at USDA-ARS in El Reno, Oklahoma, indicated that chicory has the potential as a high-quality and highly productive cool-season forage crop.

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FORAGE FACTS

Publication Series

UTILIZING CRABGRASS AS A FORAGE

INTRODUCTION

Crabgrass is a summer annual forage that has the potential to produce a large quantity of high-quality forage during the summer months. It is a highly palatable forage that provides excellent grazing and makes top-quality hay when properly managed. The area of adaptation for crabgrass is primarily in the southern and southeastern states where sufficient rainfall, moderate temperatures, and long growing seasons permit optimum production. The growing season and area of adaptation for crabgrass are similar to those for Bermudagrass. Crabgrass makes maximum growth during warm summer months when there is sufficient rainfall. Crabgrass is especially useful for grazing during July and August when cool-season perennial grasses such as tall fescue are semi-dormant and produce suboptimal animal gains.

The Noble Foundation at Ardmore, Oklahoma, developed and released the variety Red River through a selection process of the naturalized crabgrasses. Red River, the only known developed variety of crabgrass, will generally produce more forage than common crabgrass and will likely be the only crabgrass seed that is commercially available.

Crabgrass should be planted on a firm, well-prepared seedbed during early spring to midsummer. Planting should occur when the bare soil temperature in the upper 2 to 4 inches is consistently above 70°F at midday. Good agronomic practices are especially critical for initial establishment of crabgrass since successive crops are dependent upon volunteer reseeding from the previous year. Recommended seeding rate is 3 pounds of pure live seed per acre for most situations. Seed should not be planted more than $\frac{1}{2}$ inch deep. Crabgrass seed does not flow well due to its small size and rough-textured husk. Planting is often done by mixing the seed with fertilizer or some other material, such as dry sand, to provide bulk and improve flow characteristics. When seeding crabgrass with a rotary fertilizer spreader, keep in mind that most of these spreaders will only throw crabgrass seed about 25 feet. Therefore, spread width and spreader calibration rate must be adjusted accordingly. Grass seed planters with a good agitator in the bottom of the hopper can plant the pure seed.

It is necessary to remove grazing livestock from crabgrass pastures at least two to three weeks in advance of the first frost in order to allow sufficient seed production for next year's crop. Shallow annual tillage is necessary to incorporate the seed into the soil so that it will voluntarily emerge in succeeding years. This operation needs to be done early in the winter or early in the spring before the last frost in order to not interfere with crabgrass emergence.

Phosphorus and potassium should be applied according to a soil test along with 75 to 100 pounds of actual nitrogen per acre. A general rule is to apply 1 to 2 pounds of nitrogen per acre for each day of expected acceptable growing conditions. Lower rates are used on sandy soils and in low rainfall situations. Crabgrass does best on soils that are moderately acidic to slightly basic.

Grazing can begin when crabgrass is 4 to 6 inches tall. Grazing and haying management should minimize the appearance of seed heads. Hay should be harvested before the plant reaches maturity. Plants should not be mowed or grazed closer than 3 inches above the soil surface to allow opportunity for maximum regrowth. Timely mowing may be necessary to control weeds, keep the crabgrass from becoming mature, and minimize spot grazing. Stocking rates can be as high as 800 to 1,200 pounds of liveweight per acre depending upon levels of fertility and rainfall. Gains of stocker cattle have averaged approximately 1.50 pounds per day when adequate conditions for plant growth existed.

Crabgrass can be grown in a double-crop program with a winter annual cereal such as wheat or rye. In this system, the crabgrass is completely grazed out by September 1, the ground is fertilized, lightly disked, and wheat or rye is planted. The cereal is grazed out in late spring just prior to crabgrass emergence. Lightly disking or dragging the soil prior to crabgrass emergence in the spring will likely improve crabgrass stands. While the double-crop system allows for more total forage production per acre, crabgrass will typically produce more forage over a longer period of time when grown as a single crop.

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FORAGE FACTS

Publication Series

STOCKPILING TALL FESCUE FOR WINTER USE

INTRODUCTION

Stockpiling tall fescue grass for use during the late fall and winter is a practice that is much lower in cost than feeding hay, has higher nutrition for the grazing animal and greatly improves the grass state of health. If properly planned, this practice is nothing short of outstanding in the fescue growing region of Kansas.

The basic practice is to remove animals from a particular pasture or hay production field in late summer and allow the growth to accumulate until after the cool-season has ended.

Overgrazing often occurs during the summer on fescue as heat and lack of moisture make it impossible for the grass to keep ahead of grazing animals. As carbohydrates are removed from roots to support leaf regrowth, the roots die. Once leaves have grown sufficiently to again trap sunlight, the plant begins to also regrow roots. Going into the winter dormant period with a strong root system results in early, productive growth the next spring. Stockpiling fescue forage starting in early September and continuing through mid-November results in greatly improved plants and high-quality forage for winter utilization. In response to short days and cool night temperatures, tall fescue accumulates a high level of soluble carbohydrates in both leaves and stems. With up to 20 percent of the dry weight of the plant as free sugars, the nutritive quality of fall-grown fescue is quite high. In addition, the heavy, waxy cuticle on the leaves makes the plant more resistant to frost damage than most other cool-season grasses.

To produce a high-yielding stockpile, the pasture should be hayed or grazed or clipped fairly short prior to September 1. At that time, 40 to 60 pounds of actual nitrogen should be applied along with P_2O_5 and K_2O as indicated by soil test. P_2O_5 and K_2O only need be applied once per year—fall is the best time for application. Delaying initiation of stockpiling will result in a higher-quality forage but significantly lower yield due to fewer days of growth. Stockpiled fescue can be grazed throughout the winter months. Fall-fertilized fescue will carry protein levels of 12 percent even into February.

Utilization of stockpiled fescues is important. Once cattle are turned into a pasture, considerable waste can occur. In fact, as much as 50 to 60 percent of produced forage can be wasted.

Producers should strongly consider controlled grazing through strip grazing. Start with the first strip closest to the water point, place a single portable electric wire across the area to give a one- or two-day feed supply. The next morning, move the wire forward to the required distance for the next day's feeding. By doing this, the producer can get up to 70 percent utilization of stockpiled forage. Without restricted grazing, producer's can expect only 30 to 40 percent utilization.

Depending upon when stockpiling is initiated, fertilizer rate and fall rains, it is possible in Kansas for 1 acre of fall-grown fescue to meet the needs of a dry 1,000-pound cow or two 500-pound yearlings for 50 to 60 days. Cows will graze through considerable snow as long as ice is not present. Yearlings may need some hay, protein and energy during times of very cold and snowy weather.

Due to the fact that fescue holds its quality, producers should graze crop residues first in the fall and use fescue later in the winter.

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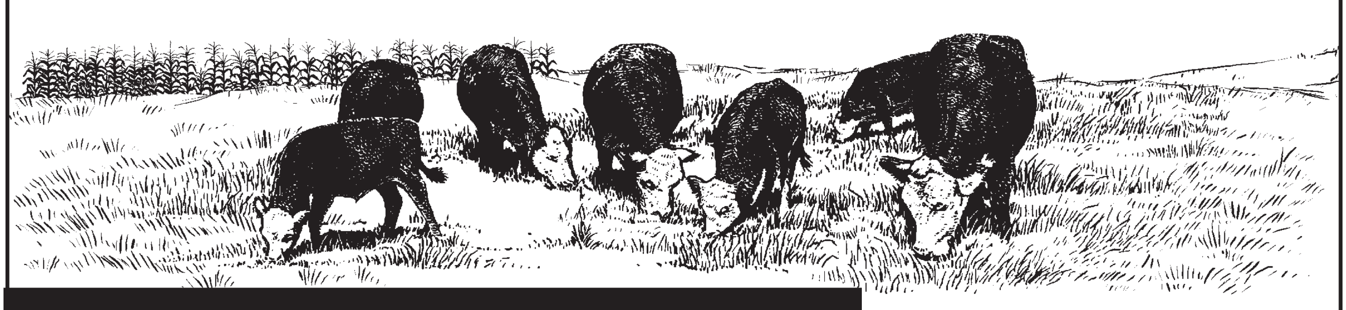

FORAGE FACTS

Publication Series

Research and Extension

INTERSEEDING WINTER CEREAL CROPS IN BERMUDAGRASS

INTRODUCTION

Bermudagrass is a warm-season perennial forage that can be very productive in southern Kansas when intensively managed. However, it has a relatively long period of winter dormancy and is often invaded by annual, weedy species during this time. While these weedy species produce some forage, their production is sporadic and their quality short-lived.

Winter cereal crops such as wheat, rye, and triticale produce high-quality forage during the time period that Bermudagrass is dormant. Fall-established cereals grown in the dormant Bermudagrass sod can be used to lengthen the grazing season of the pasture. Cattle gains from rye interseeded into Bermudagrass sod compared favorably with gains from rye grown in clean-tilled conditions, despite less forage being produced, due to better utilization. Efficiency of land use nearly doubled when rye was no-till seeded into Bermudagrass sod compared to growing each crop on separate acres.

SPECIES

Any fall-seeded winter-hardy forage species adapted to the area could be suitable for seeding in Bermudagrass sod. However, the earliest, most productive species would likely produce the most desirable results. Rye, wheat, and winter barley had similar forage yields when interseeded into Bermudagrass sod, but growth was retarded when compared to winter cereals grown alone in clean-tilled conditions. Rye will generally produce the most early growth. Rye, wheat, and triticale have each resulted in satisfactory pasture gains.

SEEDING

The cereal crop must be seeded early enough in the fall to enable establishment and provide growth for early grazing, but late enough that the Bermudagrass will not compete with cereal crop seedlings for moisture and nutrients. Mid-September is an optimum time for cereal seeding in southern Kansas. By mid-September, shorter day length and cooler nights have typically slowed Bermudagrass growth, and the likelihood of fall showers usually enables seedings of cereals to become established. Prior to seeding, the Bermudagrass cover needs to have been reduced to no more than a few inches in height.

For consistency in interseeding, a drill that is suitable for no-till conditions is required. Broadcasting seed on the surface of the sod will rarely produce an acceptable stand. A grain drill designed for tilled seedbeds may produce good stands when soil conditions, particularly moisture, are nearly optimum. However, since Bermudagrass is efficient at extracting the limited amount of soil moisture that is typically available in late summer, Bermudagrass sods are usually dry. Therefore, a heavy no-till drill may be needed to place the seed at the optimal 1-inch depth.

Seeding rates vary by species because of differences in seed size and establishment rate. Stands optimal for forage production of cereals require, as a rule, 1.5 to 2 times the seeding rate for optimal grain production. When seeded in early September, adequate stands have been obtained by seeding 90 pounds/acre of wheat and 100 pounds/acre of rye or triticale. Later seedings or less favorable conditions may require higher seeding rates.

FERTILIZATION

Bermudagrass is efficient at extracting and immobilizing soil nitrogen (N) as well as soil moisture. Satisfactory production of cereal grains in Bermudagrass sod will, thus, usually require added N. However, timing of the application is critical so that N is available when the cereal crop needs it. Nitrogen that is applied in the fall when soil temperatures exceed 50°F may be immobilized in Bermudagrass sod. Cereal seedlings will likely suffer some N deficiency in early fall, but N application prior to late fall will likely not benefit them much.

Application of 45 pounds/acre of N in January produced almost as much animal gain as 135 pounds N/acre. Thus, the application of N in excess of what the cereal crop can use, or an amount that produces more forage than the animals can utilize, will not benefit animal gain and may not carry over to be used by the Bermudagrass.

Annual phosphorus and potassium applications should be made to meet Kansas soil test recommendations for Bermudagrass pastures.

FORAGE USE

Forage produced by a cereal crop in Bermudagrass typically will be primarily for pasture, with the possibility of harvesting forage that cannot be grazed out. The retarded development of interseeded cereals makes them unattractive for use as harvested forage and particularly for grain. Grazing should begin when adequate forage is available to carry the animals for a period of time.

A benefit of grazing interseeding cereals is that there is less limitation caused by wet soils because of the ability of the Bermudagrass sod to carry hoof traffic. This is especially helpful in areas where high rainfall may limit the opportunities to graze conventional wheat fields.

Weed control is another benefit to grazing winter cereals interseeded in Bermudagrass. Many cool-season species that invade Bermudagrass are suppressed by winter cereals, and their production can be utilized by cattle in early spring.

Fall grazing will likely be limited due to competition from the Bermudagrass for moisture and nutrients which inhibits fall cereal production. Most grazing will occur during a 60-day period beginning in mid-March. During that time, cereals will support a stocking rate similar to the summer carrying capacity of the Bermudagrass and provide a high level of animal performance. This would be especially true if the same cattle were grazed on the Bermudagrass, since they would be smaller at placement on the cereal than when Bermudagrass growth begins. This further simplifies management and allows placement when stocker prices may be lower.

OTHER PUBLICATIONS

Forage Production of Small Grains Interseeded Into Bermudagrass Sod or Grown in Monoculture. pp. 10-12. IN: Kansas Agricultural Experiment Station Report of Progress 786 (Title of SRP 786--1997 Agricultural Research. Southeast Agricultural Research Center).

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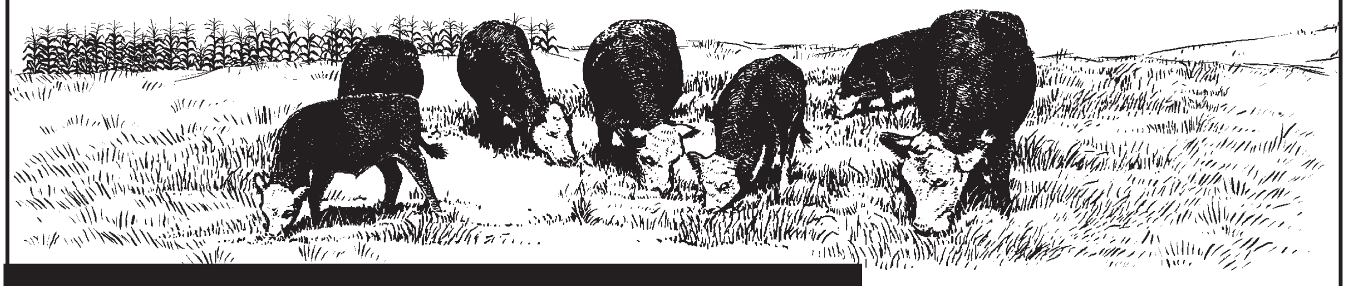

FORAGE FACTS

Publication Series

FORAGE SORGHUM SILAGE

INTRODUCTION

Forage sorghum is an important silage crop for beef and dairy producers in Kansas. Sorghum is well adapted to environments with limited rainfall, high temperatures, and low soil fertility, and producers usually will harvest greater quantities of forage dry matter (DM) than from other crops, such as corn or grain sorghum. The general constraints to forage sorghum silage production and utilization have included a generally lower nutritive value than corn or grain sorghum silage, an accumulation of a high level of nitrate under certain environmental stress conditions, and prussic acid poisoning in early primary growth or regrowth situations.

PLANTING

Sorghums should be planted when the soil temperature reaches 70 to 75°F. Planting in a cooler soil reduces seed germination and delays emergence, which could subject the seed to attack by soil microorganisms. Planting in late April and early May could result in shorter plants than an early to mid-June planting. However, delaying the planting date could decrease total dry matter production by reducing the amount of grain produced. Late planting might not allow the crop to reach the optimum cutting stage before frost. Because sorghums have a wide range of growth characteristics, adjusting the planting date to a sorghum hybrid or variety season-length is essential.

Optimum planting depth of sorghums varies with soil type and moisture conditions, but 1½ inches generally is recommended. Germination is enhanced by covering the seed with moist soil to provide firm seed-to-soil contact. Sorghums usually are planted in 30-inch rows, but that might vary according to the harvesting equipment available to the farmer. Seeding rates for forage sorghums are similar to those recommended for grain sorghum and are relatively high because only 65 to 70 percent of the seeds normally emerge. Rates vary across the state depending on cultivar, rainfall, growing conditions, and intended use of the forage.

FERTILIZATION

Fertilizer and lime needs are best determined by soil tests because sorghums are grown in all areas of Kansas under a wide range of climatic and cultural conditions. Nitrogen is the nutrient most frequently lacking for optimum production. On nitrogen deficient soils, apply 30 to 40 pounds of nitrogen per acre for each expected ton of DM production. Split applications provide better nutrient distribution and reduce the potential for nitrate or prussic acid accumulation. A high nitrate concentration is likely if excessive nitrogen is applied or if production is limited by drought. To minimize nitrate accumulation, application rates should be based on a soil test and previous crop and manure credits. Phosphorus, potassium, and other nutrient applications should be based on soil test recommendations.

CULTIVAR SELECTION AND NUTRITIVE VALUE

Cultivar selection should be based on the nutrient requirements of the livestock, because large differences exist in agronomic and nutritional quality traits among species, hybrids and varieties. The sorghum types available for silage production include: forage sorghum hybrids, grain sorghums, the older forage sorghum varieties, sudangrass hybrids, and sorghum-sudangrass hybrids. Those best suited for silage are the forage and grain sorghums. Sudangrass and sorghum-sudangrass hybrids usually are better suited for hay production or grazing than for silage.

Forage sorghums generally are categorized into three groups according to season length: early-, middle-, and late-season. Early- and middle-season cultivars tend to be shorter and produce more grain than the late-season cultivars. Because forage sorghums of different season lengths can mature during varying environmental conditions, a tremendous variability exists among cultivars for both agronomic and nutritional quality traits. Early-season cultivars can have drastically low silage DM yields, if summer growing conditions are dry, and late-season cultivars can be adversely affected by early frost or wet fall weather. Most forage sorghum silages have lower nutritive values compared to corn or grain sorghum silages.

Grain sorghum compares favorably to corn as a whole-plant silage when harvested at the mid- to late-dough stage of kernel maturity. Grain sorghum silage usually has a higher crude protein content than corn silage, but slightly lower net energy values for beef and dairy cattle.

Important characteristics to consider when choosing a sorghum cultivar for silage include: high whole-plant DM and grain yield potential; season-length; adequate whole-plant DM content for ensiling; high nutritive value; low lodging potential; and insect and disease resistance.

STAGE OF MATURITY

Research at Kansas State University has established that harvesting sorghums in the mid- to late-dough stage of kernel development optimized both silage yield and nutritive value. Harvesting sorghum at an earlier stage of maturity (lower DM content) could result in excessive effluent, a silage with a higher acid content, and the chance of a greater dry matter loss in the silo. Harvesting the crop at a later stage of maturity (higher DM content) could make the forage more difficult to chop and pack, and the drier silage could be more aerobically unstable during the feedout phase.

LIVESTOCK POISONING POTENTIAL

Sorghums can accumulate potentially toxic nitrate levels when stressed by drought, shade, frost, or temperature extremes. Nitrates normally are highest in young plant growth; however, concentrations can remain high in mature sorghum. Raising the cutter bar 6 to 12 inches to exclude basal part of the stalk can reduce nitrate levels. Environmental conditions in Kansas create high nitrate concentrations in some forages virtually every year; therefore, feed analysis is necessary to determine management options. Generally, forages that contain more than 6,000 ppm nitrate (DM Basis) should be considered potentially toxic. The fermentation phase in the ensiling process converts about 50 percent of the nitrates to a nontoxic form. Toxicity is related to the total amount of silage consumed and how quickly it is eaten. High nitrate silages can be fed if proper precautions are taken. These include diluting the forage with other feeds; supplementing grain; gradually adapting livestock to increasing nitrate amounts; and not feeding to hungry, sick, pregnant, or stressed animals.

Prussic acid, or hydrogen cyanide (HCN) poisoning, is caused by cyanide production in sorghums that grow rapidly following a stress situation. Cyanide is concentrated in young, actively growing leaves and is commonly associated with new shoot growth at the end of a summer drought or after the first autumn frost. The ensiling process does not decrease the prussic acid concentration in the silage; however, field wilting prior to ensiling might decrease the level of prussic acid by percent.

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Publication Series

GRAZING CORN RESIDUE

INTRODUCTION

Kansas has an abundance of crop residue available for grazing in late fall and winter. However, the location of fields in relation to cattle, the lack of shelter or appropriate fencing, and water availability often prevent grazing of many fields. Despite these limitations, residue grazing has become an integral part of many cattle operations, primarily as a feed resource for maintaining the breeding herd during winter or putting weight on cull cows. Calves destined to grass the following summer can also be wintered on cornstalks if appropriate supplementation is used and adequate shelter is available.

GRAZING CHARACTERISTICS

Weather can be the most important factor in successfully grazing crop residue. Snow cover can reduce or eliminate access to crop residue. Mud may make grazing difficult and may result in decreased performance and greater waste of forage due to trampling. Cornstalk fields grazed shortly after harvest are higher in nutrient content than fields grazed 60 days after harvest. This indicates that there is some weathering loss of nutrients. The greatest nutrient loss appears in the husk and leaf and the loss is primarily a loss in energy content.

One Animal Unit Month (AUM) is the amount of forage required to sustain a 1,000-pound cow or equivalent for one month. One acre of corn stalks will provide approximately 1.5 to 2 AUM of grazing. For example, excellent harvest conditions would mean less grain is left in the field, so there would be a lower total nutrient value and fewer grazing days before cattle would need to be moved to fresh stalks.

Cows grazing cornstalks will consume 25 to 30 percent of the available residue in 30 to 100 days, depending on stocking rate. This can leave enough material to prevent soil erosion. Cattle will select and eat the grain first, followed by the husk and leaf, and finally the cob and stalk. Therefore, over the grazing period, the cornstalk residue being consumed could be very high in energy content (70 percent TDN) to very low (40 percent TDN). Also, as the stocking rate (number of cows per acre) is increased, the nutrient content of the remaining residue declines much quicker because the grain and husk are being removed at a much faster rate.

MEETING NUTRITIONAL NEEDS

Salt, phosphorus, calcium, and vitamin A supplements are recommended for all cattle grazing dormant winter range and crop residues. These supplements can be supplied free-choice to the cattle. When protein supplementation is required, natural protein sources provide a better response than protein sources with nonprotein nitrogen such as urea. Three-year-old cows grazing cornstalks from mid-November to February 1 supplemented with .4 pound of crude protein equivalent per head per day in the form of either soybean meal or 7.2 percent urea supplement gained .99 and .76 pound per day, respectively, indicating that if cows have only husk and leaves to consume in a cornstalk field, an all natural protein source is recommended. This could be in the form of a good quality alfalfa or a concentrated natural protein supplement that contains soybean or cottonseed meal.

COWS AND FIRST-CALF-HEIFERS

As long as cattle have grain to select in a cornstalk field, they will consume a diet that is probably above 7 percent crude protein and as high as 70 percent TDN. This will exceed the protein and energy needs of an 1100-pound cow in mid-gestation. Spring calving cows are at mid- to late gestation during fall and early winter; therefore, their nutrient requirements match well with a crop residue grazing program. Producers need to periodically monitor what is available in the residue field. For gestating cows grazing corn residue, if corn is visible in the manure, supplementation with other than vitamins and minerals is probably unnecessary. However, when most of the grain has been consumed, protein supplementation is needed. A mature 1100-pound cow in mid- to late gestation consuming husks and leaves will need about 5 pounds per day of average quality alfalfa hay to help meet her protein requirement. Cows in mid- to late gestation or after calving forced to eat the cob and stalk will lose weight and body condition. Protein and energy will need to be fed or cow and calf performance will be reduced.

Heifers in late gestation should not be allowed to graze cornstalk fields long after the grain has been consumed. Heifers have a high protein and energy requirement and the remaining residue does not have a high enough nutrient content to meet their requirements.

Lactating cows, such as fall calving cows grazing crop residue, need to be managed carefully. As long as lactating cows have grain to select in the field, their energy needs should be met. If the breed type has a high milk potential, protein supplementation is necessary even if the cattle have grain to eat. Crop residue should not be grazed in the spring with lactating cows because of the lower nutritional value of the residue.

Protein supplementation appears necessary for calves grazing cornstalks. Bulkiness of the forage may cause lower performance for young cattle because rumen capacity per unit of body weight is less than with mature cows. There is some indication that a protein supplement with at least .36 pound of escape protein per head per day is appropriate. An escape protein is a protein source that is not digested in the rumen but is broken down in the small intestine. Total protein supplementation may need to be as high as 0.9 pound per head per day. Even then, average daily gain for calves grazing crop residue should not be expected to exceed 1 pound per day. This may be adequate if a producer is wintering calves for low rates of gain and plans to summer these calves on grass.

This factsheet is based on a University of Nebraska publication authored by Rick Rasby, extension beef specialist, and Roger Selley, extension agriculture economist.

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FORAGE FACTS

Publication Series

ECONOMICS OF SEALING HORIZONTAL SILOS

INTRODUCTION

An economically attractive method in Kansas for storing large amounts of ensiled forage is the horizontal silo (i.e., bunker, trench, or pile), but because so much of the surface of the ensiled material is exposed, dry matter (DM) and nutrient losses can be extensive. If left unprotected, losses in the top 2 to 4 feet can exceed 50 percent. This is particularly disturbing when one considers that in the typical horizontal silo, over 20 percent of the silage might be within the top 4 feet.

These losses can be minimized by sealing (covering) the ensiled mass with polyethylene sheets, which usually are weighted with tires or soil. Although this method minimizes losses, it is so cumbersome and labor intensive that many producers feel the silage saved is not worth their time and effort.

Top spoilage research has been conducted at Kansas State University since 1989, and the results document the magnitude of the DM and nutrient losses in the original top 3 feet of the ensiled crop. However, these losses cannot be seen until the silo is opened. Even then, the spoilage might appear to be only the top 6 to 12 inches of silage, obscuring the fact that this area of spoiled silage represents substantially more silage as originally stored.

A few simple calculations allow producers to estimate the value of silage saved by sealing, based on their crop value, silo dimensions, and cost of the sealing material and labor to cover their silage.

CALCULATIONS AND EXAMPLES

Calculating the value of silage saved by sealing is based on four economic inputs and two silo/silage inputs. The four economic inputs are:

(1) Value of the silage ($/ton)
(2) Cost of the polyethylene sheet (cents/ft^2 × number of ft^2)
(3) Cost of the weighting material (zero was used in the examples)
(4) labor cost ($/hr × number of hrs).

Ten hours per 4,000 ft^2 of polyethylene sheet were used to calculate the labor cost. In order to account for overlapping from sheet to sheet and along the side walls or base, we assumed a covering efficiency of 80 percent.

The first of the two silo/silage inputs determines the amount of silage within the original top 3 feet of the silo after filling is complete. It is determined by multiplying the silo width(ft) × length(ft) × depth of interest (3 ft) × the silage density (lb/ft^3) and dividing the product by 2,000 (lb/ton). The second silo/silage input estimates the amount of silage within the original top 3 feet of the silo that is lost as spoilage.

The following example estimates the net return from sealing a horizontal silo with a 40 feet width × 12 feet depth × 100 feet length and an exposed surface of 4,000 ft^2.

Economic assumptions:
(1) Corn silage price: $25/ton
(2) Polyethylene film: $.055 per ft^2 of surface covered.
$.055 × 4,000 ft^2 = $220
(3) Weighting material: zero cost assumed
(4) Labor cost: 10 hr/4,000 ft^2 sheet × $20/hr = $200
Sealing cost = $220 + $200 = $420

Silo/silage assumptions:

(1) Assuming a silage density of 45 lb/ft^3 (4000 ft^2 surface × 3 ft deep × 45 lb/ft^3)/2000
= 270 tons of silage within the original top 3 feet (total capacity of the silo is about 1,080 tons)

(2) Assume 20% loss in the top 3 feet if sealed, 50% loss if unsealed.

Loss, unsealed:
270 tons × $25/ton × 50% = $3,375

Loss, sealed:

270 tons × $25/ton × 20%	= $1,350
Cost of sealing	= $ 420
Net, sealed	= $1,770

Net return to sealing:
$3,375 – $1,770 = $1,605

The concepts shown above are presented in a user-friendly spreadsheet format in Table 1. The first nine lines are economic inputs determined by the producer, and the next six lines are results that are based on formulas utilizing the producer's inputs. They can be programmed easily into the spreadsheet using the row letters as guides.

The most important single factor influencing preservation efficiency of ensiled forages is the degree of anaerobic fermentation achieved during ensiling process. When silage is not sealed or when the seal is inadequate, air and moisture enter the mass and affect both the ensiling process and silage quality during the storage and feedout phases. Based on the examples in Table 1, sealing a 40 × 100-foot silo could save approximately $1,600 worth of silage. Using the same concept, covering a 100 × 400-foot silo could save the producer over $16,000.

Although future technology might introduce a more environmentally and user-friendly product, polyethylene (6 mm) is the most effective sealing material available today. The most common sealing method is to place the polyethylene sheet over the ensiled forage and weight it down with rubber tires (20 to 25 tires per 100 square feet).

Research-based calculations confirm that the financial loss incurred by not sealing silage is substantial and reinforces the recommendation that sealing the exposed surface of a horizontal silo is one of the most important management decisions in any silage program.

Table 1. Value of Silage Saved by Sealing Three Horizontal Silos Differing in Size

Economic inputs				Spreadsheet	
Silage crop	Corn	Corn	Corn	Formulas	
Silage value, $/ton	25	25	25	A	
Silage density, lb/ft^3	45	45	45	B	
Silo width, ft	40	100	100	C	
Silo length, ft	100	250	400	D	
Cost of 40 ft x 100 ft poly sheet, $	175	175	175	E	
Efficiency of sheet, %	80	80	80	F	
Silage lost if unsealed, %	50	50	50	G	
Silage lost if sealed, %	20	20	20	H	
Labor cost, $/hr	20	20	20	I	
Results					
Silage in the top 3 ft, tons	270	1,688	2,700	J	(C×D×3×B)/2000
Silage value lost if unsealed, $	3,375	21,094	33,750	K	J×(G/100)×A
Silage value lost if sealed, $	1,350	8,438	13,500	L	J×(H/100)×A
Cost per ft^2 of poly sheet, ¢	5.5	5.5	5.5	M	([E/(F/100)]/4000)×100
Sealing cost, $	419	2,617	4,188	N	[(C×D×M)/100)]+[(I×C×D×10)/4000]
Value of silage saved, $	**1,606**	**10,039**	**16,063**	**P**	**K–(L+N)**

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FORAGE FACTS

Publication Series

IMPROVING SILAGE QUALITY

INTRODUCTION

Advances in silage technology, which include high-capacity precision chop harvesters, improved silos, polyethylene sheeting, shear-cutting silage unloaders, and total mixed rations, have made silage an important method of forage preservation for beef and dairy cattle producers. Silage quality and nutritional value are influenced by numerous biological and technological factors, including: the crop species, stage of maturity and dry matter (DM) content at harvest, chop length, type of silo, rate of filling, forage density after packing, sealing technique, feedout rate, weather conditions at harvest and feedout, additive use, timeliness of the silage-making activities, and the training of personnel. Because many of these are interrelated, it is difficult to discuss their significance individually. However, there are two dominant features of every silage: (1) the crop, including its stage of maturity and its "ensileability" and (2) the management and know-how imposed by the silage maker.

In "perfect" silage, available carbohydrates are converted by anaerobic bacteria (mainly "homofermentative" lactic acid bacteria) to lactic acid. That lowers the pH rapidly and preserves the silage. In even the best of circumstances, some DM is lost during lactic acid production. But the ensiling process is seldom perfect. Whenever oxygen is present, carbohydrates are converted to carbon dioxide and water, accompanied by the generation of considerable heat. The results are serious DM losses.

SILAGE ADDITIVES

Additives can be divided into three general categories: (1) fermentation stimulants, such as bacterial inoculants and enzymes; (2) fermentation inhibitors, such as propionic, formic and sulfuric acids; and (3) substrate or nutrient sources, such as molasses, urea and anhydrous ammonia.

Perhaps no other area of silage management has received as much attention among both researchers and livestock producers in recent years as bacterial inoculants. Effective bacterial inoculants promote a faster and more efficient fermentation of the ensiled crop, which increases both the quantity and quality of the silage. The bacteria in commercial products include one or more of the following species: *Lactobacillus plantarum* or other *Lactobacillus* species, various *Pediococcus* species and *Enterococcus faecium.* These strains of LAB have been isolated from silage crops or silages and were selected because: (1) they are homofermentative (i.e., ferment sugars predominantly to lactic acid); and (2) they rapidly grow under a wide range of temperature and moisture conditions. Bacterial inoculants have inherent advantages over other additives, including low cost, safety in handling, a low application rate per ton of chopped forage, and no residues or environmental problems.

Enzymes are capable of degrading plant cell walls and starch, which could provide additional sugars for fermentation to lactic acid and increase the nutritive value of the ensiled material. Although enzymes offer potential to improve silage quality, considerable work needs to be done before they will become commonly used additives.

The justifications for using nonprotein nitrogen (NPN) have been prolonged aerobic stability during the feedout phase and the addition of an economical nitrogen source to low-protein crops, such as corn and sorghum. However, major drawbacks to ammoniation are the potentially dangerous volatile and caustic properties of anhydrous ammonia plus the need for specialized application and safety equipment. NPN always acts as a buffer during fermentation, requiring extra lactic acid to be produced to lower the pH enough for preservation. Thus, NPN addition always increases DM loss.

20 YEARS OF SILAGE ADDITIVE RESEARCH AT K-STATE

Results from over 200 laboratory-scale studies, which involved over 1,500 silages and 25,000 silos, indicate that bacterial inoculants are beneficial in over 90 percent of the comparisons. Inoculated silages have faster and more efficient fermentations—pH is lower, particularly during the first two to four days of the ensiling process, and lactic acid content and the lactic to acetic acid ratio are higher than in control silages. Inoculated silages also have lower ethanol and ammonia-nitrogen values compared to untreated silages.

Results from over 30 farm-scale trials, which evaluated 71 silages, show that bacterial inoculants consistently improve fermentation efficiency, DM recovery, feed to gain ratio, and gain per ton of crop ensiled in corn, forage sorghum and alfalfa silages. Applying urea or anhydrous ammonia adversely affects fermentation efficiency, DM recovery, average daily gain, feed to gain ratio, and gain per ton of crop ensiled, particularly for the higher moisture forage sorghums. An additive with a urea-molasses blend had less negative influence on silage preservation and cattle performance than urea or anhydrous ammonia.

Economics of Bacterial Inoculants and NPN Silage Additives. Based upon the results at Kansas State University, a 2- to 4-pound increase in gain per ton of crop ensiled produces $2 to $4 increases in net return per ton of crop ensiled. If producers use NPN, they actually lose $4 to $6 per ton of corn or sorghum ensiled because of the decreased DM recovery, increased feed to gain ratio, and added cost of replacing the loss of volatile nitrogen. These results apply to beef producers who background cattle or grow replacement heifers and to dairy producers who raise heifers.

Selecting a Bacterial Inoculant. The inoculant should provide at least 100,000 colony-forming units of viable LAB per gram of forage. These LAB should dominate the fermentation; produce lactic acid as the sole end product; be able to grow over a wide range of pH, temperature and moisture conditions; and ferment a wide range of plant sugars. Purchase an inoculant from a reputable company that can provide quality control assurances along with independent research supporting the product's effectiveness.

PROTECTING SILAGE FROM AIR AND WATER

Everyone in the silage business acknowledges that sealing (covering) a horizontal silo (i.e., bunker, trench, pile, or stack) ranks high on the troublesome list. Because so much of the surface of the ensiled material is exposed to air, great potential exists for excessive DM and nutrient losses. The extent of these losses in the top 2 to 4 feet, if there is no protection, is far greater than most people realize. A barrier must be built against air and water after the silo filling operation is completed.

Although future technology might bring a more environmentally and user-friendly product, polyethylene is the most effective sealing (covering) material today. After it is put over ensiled forage, the sheet must be weighted down. Tires are the most commonly used weights, and they should be placed close enough together that they touch (about 20 to 25 tires per 100 square feet). In a 1,000-ton bunker silo, an effective seal to protect the top 3 feet of silage can prevent the loss of $500 to $2,500 worth of silage, depending on the value of the crop. The bottom line is that sealing the exposed surface might be the most important management decision in many silage programs.

QUESTIONS AND ANSWERS ABOUT SILAGE

What are the characteristics of a good corn hybrid for silage? A corn hybrid must be capable of producing a high whole-plant dry matter (DM) yield and a high grain to forage ratio in the silage. It also should have a whole-plant DM content of 30 to 36 percent when the kernel is in the 60 to 80 percent milk-line stage of maturity.

How do sorghums compare to corn as silage crops? Grain sorghum compares very favorably to corn as a whole-plant silage. Grain sorghum should be harvested at the mid- to late-dough stage of kernel maturity. It usually has a higher crude protein (CP) content than corn silage, but slightly lower net energy values for beef and dairy cattle.

The agronomic and nutritional quality traits of forage sorghum silages are far more variable than those of whole-plant corn or grain sorghum silages. Therefore, hybrid or variety selection is critical for forage sorghum, and a good rule-of-thumb is to avoid the phenotypic extremes.

Is it better to harvest (ensile) the silage crop too early or too late? For corn, sorghum, and small grain cereals, it is probably better to harvest too early rather than too late, but excessive effluent must be avoided (i.e., do not harvest above 70 to 72 percent moisture). The earlier-harvested silage will have a lower pH, a higher acid content, and the chance of a greater DM loss in the silo than later-harvested silage. The later-harvested crop will be more difficult to chop and pack, and the drier silage will be more aerobically unstable during the feedout phase than earlier-harvested silage.

For field-wilted forages that are more difficult to ensile, it is probably better to harvest too late (i.e., at a lower moisture) rather than too early (i.e., at a higher moisture). When these forages are ensiled too wet, chances are greater for a clostridial fermentation and high butyric acid and ammonia-nitrogen levels in the silage. When wilted forages are ensiled at a lower moisture, they are more difficult to pack and present risks of heat damage (i.e., a decrease in nutrient availability) and a high mold content. Regardless of the length of the field-wilting period, these forages must be cut at the correct stage of maturity.

What is the proper size for a bunker, trench, or pile silo? The tons of crop to be ensiled and the projected tons of silage to be fed daily determine the proper size for a bunker, trench, or pile. The height, width, and depth dimensions should be small enough to allow a rapid progression through the silage mass during the feedout phase. Most silos are too large—they take too long to fill, and the feedout rate is too slow.

How long after filling can the silo be opened for feeding? The fermentation phase should be completed before the silo is opened for feeding. This normally takes two to three weeks after filling. If silage is fed after only a few days in the silo, DM intake is likely to be affected adversely. Inoculants should reduce the time required for the fermentation phase to be completed. Because grasses and legumes usually ferment slower than corn (or sorghum), grass or legume silages should not be fed until at least three weeks after filling.

What are the losses in a very good silage? The losses in a very good silage will range from 5 to 15 percent, whereas the losses in a very bad silage will range from 25 to 50 percent. Loss is defined as the amount of forage DM that is put in a silo minus the amount of silage DM that is removed from the silo and fed. These losses are the result of effluent, respiration, primary and secondary fermentation, and aerobic activity during the storage and feedout phases.

How does the type of silo affect "losses" and "silage quality?" The type of silo does affect "losses" and "silage quality;" however, minimum losses and high quality silage can be achieved in any type of silo—if it is well managed. In general, vertical silos (towers) are more efficient than horizontal silos (bunkers, trenches, piles and bags), and smaller-capacity silos are less efficient than larger-capacity silos (if filling is not delayed and the silage removal rate is not too slow). "Forage in" versus "silage out" losses range from as low as 5 percent to more than 40 percent.

How do I manage the silage "face" during the feedout phase? The silage "face" should be maintained as a smooth surface that is perpendicular to the floor and side walls (in bunker and trench silos). This will minimize the square meters of surface that are exposed to air. The rate of progression through the silage mass must be sufficient to prevent the exposed silage from heating and spoiling. An average removal rate of 8 to 12 inches from the face per day is a common recommendation.

What problems are associated with silage effluent? Silage effluent has a very high biological oxygen demand, and, thus, is an environmental hazard, particularly if it is allowed to enter a watercourse. Most forages that are ensiled below 26 to 28 percent DM can produce effluent during the first few days postfilling. Effluent is very nutrient-rich and contains soluble sugars, nitrogen and minerals.

What is the real cost of silage? A common method of calculating the real cost of silage is to divide the actual cost per ton of forage after the silo is filled by the percent of the silage that is actually removed and fed when the silo is empty. For example, if 1,000 tons of whole-plant corn are ensiled in a bunker silo at a cost of $25 per ton and 900 tons of corn silage are removed and fed, the real cost is $25 divided by 90 percent (.9), which equals $27.78. If only 750 tons of corn silage are removed and fed, the real cost is $25 divided by 75 percent (.75), which equals $33.33.

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FORAGE FACTS

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ESTABLISHING ALFALFA INTO COOL-SEASON GRASS PASTURES

INTRODUCTION

Successfully establishing alfalfa into existing cool-season grass pastures requires intensive management practices by producers. The three most important practices are: (1) soil testing the existing pasture; (2) reducing the competition of the existing grass; and (3) controlling the weed competition during establishment. Other important considerations include date of seeding, insect control, planting method, and management after alfalfa establishment. Increased performance is the result of grazing livestock on legume and cool-season grass mixtures, but it will require more management in the areas of fertilizer application and grazing strategies.

ESTABLISHING ALFALFA INTO COOL-SEASON GRASS PASTURES

Step 1. Alfalfa can be successfully planted in Kansas in the spring (March to April) or fall (August to September). Generally, local recommendations should be followed, but a dry May/June or September can greatly reduce the success rates.

Step 2. Soil testing should be done at least six months prior to the intended seeding date. Legumes require a much higher soil pH and fertility level than most grasses, and most existing grass pastures have low pH and phosphorus levels. Lime should be applied a minimum of six months prior to seeding and rates should be based on local recommendations. Generally, in Kansas, 2 tons per acre of agricultural lime is enough to establish legumes.

Phosphorus and potassium fertilizer applications should occur at or just ahead of planting. Phosphorus can be placed in direct contact with the seed, whereas potassium and nitrogen should not be in direct contact with the seed. Nitrogen application at planting should be limited to 20 pounds or less.

Step 3. The existing grass must be reduced by 50 to 75 percent by heavy grazing, tillage or chemical applications to allow the alfalfa to establish. Tillage with a disc and field cultivator on the grass prior to alfalfa seeding provides adequate reduction of the grass stand. Chemical application of Gramoxone or Roundup can also result in adequate grass reduction. Producers should consult the local extension agent on proper chemical rates and timing of application. Most interseeding failures occur because the existing grass stand was not reduced enough for the alfalfa to establish.

Step 4. After the ground has been fertilized and the existing grass has been reduced, planting can occur. A seeding rate of 12 to 15 pounds of red clover or alfalfa is suggested , and seed should be inoculated with alfalfa rhizobia (at recommended rate). Producers may consider applying fresh inoculant to pre-inoculated seed. A sticking agent that ensures the inoculant sticks to the seed may also be used. Seeds should be planted ¼ to ¾ inches deep.

Step 5. Many attempts at establishing alfalfa have failed because grass and weeds were allowed to grow and reduce the light and water available to the young alfalfa plants. Mowing or grazing can reduce the competition. Generally, about four to six weeks are needed to establish alfalfa.

Step 6. Annual fertility programs should be followed based on soil test recommendations.

Step 7. Intensive management practices must be followed to favor the growth of the alfalfa once it has been established. Some practices to follow include mowing pastures to remove seed heads, controlling weeds and woody vegetation, and harvesting hay or managing grazing to favor the legume. Rotational grazing favors alfalfa growth and should begin at or just prior to the bud stage. Pastures should be grazed "quickly" to 3 to 4 inches in three to four days, then the pasture should be rested for 20 to 30 days before repeating the cycle. Actual systems should depend on pasture productivity and local recommendations.

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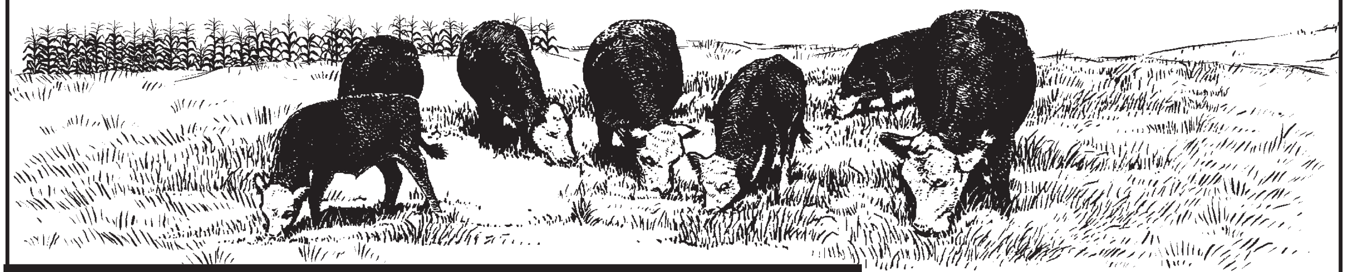


FORAGE FACTS
Publication Series

NATIVE HAY MEADOW MANAGEMENT

INTRODUCTION

Prairie hay provides relatively inexpensive supplemental forage for livestock and is a valuable asset to Kansas producers. Native hay meadows, however, require careful management for sustained high quality and forage yield.

TIME OF CUTTING

Harvest date is the most important factor in hay meadow management. It affects forage quality, yield, stand composition and regrowth. Maximum quality and yield cannot be achieved in the same harvest. Hay quality peaks early in the growing season and progressively declines during summer (see figure). Highest herbage yield occurs late in the growing season, but 75 percent of hay has been produced by mid-July. Cutting in early July in southern Kansas or mid-July in northern Kansas is the best compromise between yield and quality.

High quality is as important as high yield. Crude protein and available energy levels decline with increasing maturity, and after early July the nutritional value of prairie hay drops rapidly. Total pounds of crude protein removed from a meadow are higher in July than in August or September.

Delaying harvest to obtain higher yield affects more than hay quality. Cutting native hay in August or September does not give the warm-season perennial grasses sufficient time to rebuild carbohydrate root reserves before frost. Low root reserves weaken plants, and grass production is reduced the following year. Repeated late-season harvesting diminishes the vigor of perennial grasses, and undesirable weeds and annual grasses invade. Total hay yield and production of desirable species decline over time. If a meadow cannot be harvested by August, it is best not to cut at all, and graze the area after frost.

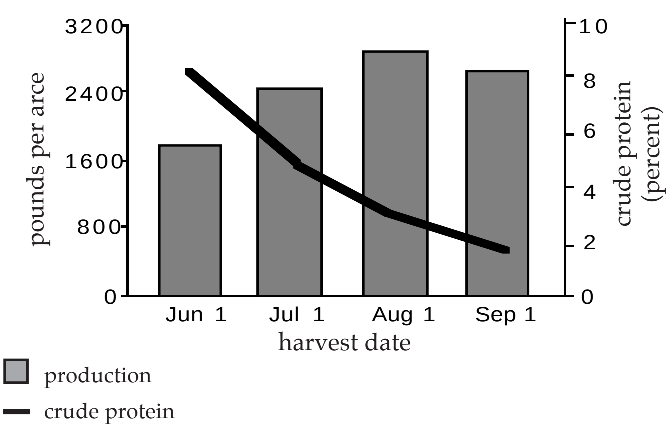
CUTTING HEIGHT

Residue and litter left on the ground in the fall protect against erosion and conserve soil moisture, improving hay yield the following year. Harvesting at a 3- to 4-inch height normally leaves sufficient stubble for regrowth and soil cover. In drought years, raise the cutting height.

GRAZING

Following harvest, perennial grasses need the rest of the growing season to replenish their root reserves. After frost, the meadow can be grazed without adversely affecting next year's production. Heavy grazing during winter, however, may increase runoff and reduce soil moisture. Grazing should be as uniform as possible, leaving at least 3 to 4 inches of growth so the meadow can be cleanly burned in the spring.

Time of harvest determines the yield and quality of prairie hay.



A **FORAGE FACTS** Publication of the **KANSAS FORAGE TASK FORCE**
Kansas State University Agricultural Experiment Station and Cooperative Extension Service

PRESCRIBED BURNING

Prescribed burning improves both forage quality and yield. Burning removes mulch and old growth that reduces hay quality. The best time to burn native hay meadows is mid- to late April when big bluestem and Indiangrass are 1 to 2 inches tall. To increase desirable warm-season grass production, hay meadows should be burned at least every two or three years. If the hay meadow is fertilized, annual burning is usually required to prevent vegetative shifts to cool-season grasses and annual forbs.

Prescribed burning in late spring is an important tool for controlling weeds, brush and undesirable cool-season grasses. One exception is prairie threeawn, an unpalatable annual grass that must be burned in November to be controlled. Because winter burning can reduce forage production, a hay meadow should not be burned in November unless it is heavily infested with threeawn.

FERTILIZATION

Nitrogen fertilizer, along with adequate rainfall, increases hay growth, but its effect on native warm-season grass production is limited. If annual grasses or forbs are present in the hay meadow, nitrogen fertilization increases their production. Do not apply more than 30 to 40 pounds of nitrogen per acre. Even then, nitrogen fertilization may not be economically feasible.

Native hay meadow soils frequently are deficient in phosphorus, and in some areas of the state, applying 10 pounds of phosphorus per acre can increase hay production. Phosphorus fertilization often benefits broadleaf forbs more than it does native warm-season grasses.

If a hay meadow is fertilized, nitrogen and phosphorus should be applied when warm-season grasses are growing and have reached 3 to 5 inches. Earlier fertilization favors production of annual forbs and undesirable cool-season grasses such as Kentucky bluegrass and annual bromes. If plant composition begins to shift, burn fertilized hay meadows annually.

WEED AND BRUSH CONTROL

Many perennial forbs improve hay quality and do not compete with grasses for moisture or nutrients. Harvesting by mid-July controls most undesirable annual weeds. Leaving hay bales in the meadow kills underlying vegetation and provides spots for annual weed invasion.

Prescribed burning controls most weed and brush species. Smooth sumac is resistant to fire, however, and may require spot herbicide applications. Herbicides may kill both desirable and undesirable shrubs and forbs, but may not increase forage production enough to be economically justified. Apply only herbicides labeled for target weed species and registered for use in hay meadows. Pay particular attention to the waiting period between herbicide application and harvest. Consult your county Extension office for the latest recommended chemicals.

DROUGHT

Under drought conditions, harvest date and cutting height are critical in maintaining a productive meadow. Cut no later than mid-July and leave at least 3 to 6 inches of stubble. If the forage is not tall enough by mid-July to justify harvesting, the area can be grazed after the first killing frost.

SUMMARY

- Harvest date is the most important factor in managing native hay meadows. Cutting by early July in southern Kansas and by mid-July in northern Kansas is best for obtaining both high forage quality and yield. Cutting later in the growing season reduces hay quality and shifts the plant population to undesirable weedy species.
- Prescribed burning controls weeds, brush and cool-season grasses, and increases production and quality of desirable warm-season grasses.
- Nitrogen and phosphorus fertilization increases hay yields, but usually favors forb and cool-season grass production unless applied in conjunction with annual prescribed burning.

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FORAGE FACTS

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AMMONIA TREATMENT OF LOW QUALITY FORAGES

INTRODUCTION

Millions of tons of crop residue and other poor quality forages are produced every year in the United States. However, because of their bulkiness, relatively low energy and protein contents and overall feeding value, relatively little of this abundant feed source is utilized for livestock. Ammoniation is a procedure designed to increase the energy availability of low quality forages such as wheat, barley and oat straw, corn or grain sorghum stover, and very mature warm-season grasses. Research over the last few decades has clearly demonstrated that ammonia treatment of low quality roughages will substantially improve digestibility, voluntary intake and cattle performance. Most forages less than 5 percent crude protein and 45 percent TDN on a dry matter basis are candidates for ammonia treatment.

HOW DOES AMMONIATION IMPROVE FORAGE FEEDING VALUE?

Ammoniation increases the digestibility of crop residues and grass hays by breaking lignin-cellulose bonds in plant fiber, thereby swelling the plant tissue to allow greater microbial activity, and improving dry matter digestion (TDN) 8 to 15 percentage units.

Ammoniation boosts feed intake 15 to 20 percent or more because of improved forage digestibility and increased rate of passage through the digestive tract.

Ammoniation usually doubles crude protein content by being a non-toxic source of non-protein nitrogen (NPN) and it is well utilized by calves and cows.

Ammoniation preserves forage that contains up to 25 to 30 percent moisture because it kills molds and fungi and prevents heating which reduces feed losses.

TECHNIQUES OF AMMONIA APPLICATION

The most common and consistently successful means of treating dry forages with ammonia has been to cover the material with 6 mil black plastic sheeting, sealing the plastic against the ground with dirt, crushed rock or other material. Enough fill should be placed to keep the plastic from being pulled loose by winds and when the ammonia gas fills the stack cover like a balloon. Apply the ammonia slowly (for three to five hours) into the center of the stack at the rate of 3 percent (60 pounds of anhydrous ammonia per ton of dry forage). Producers should weigh a few bales to estimate gross weight of the stack. If the moisture content is 15 percent, dry matter weight will be 85 percent of the gross weight. A slow application of ammonia is best as it permits the liquid to fully volatilize, reducing the amount lost in the soil.

Producers should build the stack and estimate the total dry forage for treatment. The exact amount of anhydrous ammonia can be ordered, and the ammonia can be applied until the tank is empty. After starting the application, producers should check the cover for leaks and apply duct tape to any holes in the plastic.

For best results, crop residues and other forages should be covered and ammoniated as soon after harvesting as possible to minimize weathering and dry matter losses and to maximize feed value. The time needed for maximum treatment effect may range from only a few days in 90°F plus weather to 30 to 45 days during cold winter temperatures. Anhydrous ammonia will seek the moisture in the stacked forage which aids in the uniform spread of the ammonia. Eight to 10 percent is an adequate forage moisture content, but 15 to 25 percent is preferred. The ammoniated stack should remain covered until two weeks prior to feeding when the cover is opened to allow bales to air out to reduce the concentration of residual ammonia.

SAFETY CONSIDERATIONS

Anhydrous ammonia is maintained under pressure and can be dangerous. If misused, it can burn skin, eyes or throat and can explode and burn. Follow these precautions:

- Wear goggles, rubber gloves and protective clothing.
- Work upwind when releasing anhydrous ammonia.
- Have fresh water available to wash off any anhydrous ammonia that comes in contact with the skin.
- Check all valves, hoses and tanks for leaks.
- Check the plastic cover on the stack for leaks and seal any holes with duct tape.
- Do not smoke near anhydrous ammonia.
- Keep children away from the treatment area.

The possibility of ammonia toxicity with cattle fed ammonia-treated forages appears remote. Studies have been conducted with application rates of over 6 percent ammonia to dry forages without illness or harmful side effects to ruminants. The ammonia odor of freshly uncovered treated forages also acts as a safety factor. Research has shown that animals will not eat ammonia-treated crop residues unless they are aerated or mixed with a fermented feed so that the silage acids neutralize the ammonia. Ammoniated forages should have the end of the plastic cover removed and allowed to aerate for two weeks prior to feeding.

SUMMARY

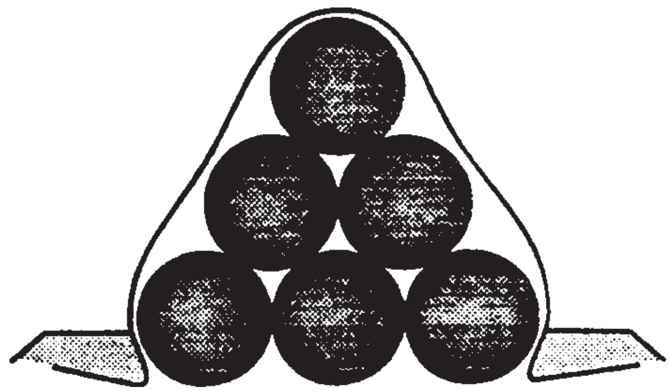
Ammonia treatment is a very effective means of markedly increasing the feeding value of poor quality forages. Large crop acreages offer an almost unlimited supply of crop residues which can be transformed into relatively nutritious forages with the potential of improving the economy of cattle production.

OTHER PUBLICATIONS:

Ammoniated Straw as an Emergency Feed (Available by calling 785-532-1267)

Ammoniation of Dry Forages for Beef Cattle (Available by calling 785-532-1267)

Emergency and Supplemental Forages (MF-1073)



When treating big round straw bales, backfill over at least 12 inches of plastic cover.

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FORAGE FACTS

Publication Series

FERTILIZING GRASSES

INTRODUCTION

Fertilizer can be an expensive input into forage grass management, a balance must be met between soil test results, fertilizer application rates, and potential forage production and utilization by grazing or haying. Producers cannot afford to over-fertilize if the extra forage produced in response to fertilizer is not utilized by animals.

COOL-SEASON GRASSES

Research has shown that bromegrass, fescue and other grasses respond to fertilizer if proper management guidelines are followed for rate and timing of application and appropriate choice of fertilizer.

Before applying any fertilizer, producers should review soil test results and intended use of the grass (spring grazing, fall grazing, or haying), and assess the presence of legumes.

Lime, phosphorus and potassium applications should be based on soil test results. Lime only needs to be applied on established pastures when the pH is 6.0 or less and the rate of application should not exceed 2 tons of agricultural lime. When preparing soil for a new establishment, lime should be applied when the pH is 6.4 or less.

Yearly phosphorus and potassium applications can be applied in the fall or winter. However, research has shown that a fall (September to October) application results in a healthier plant that is better able to tolerate drought and overgrazing. Fall fertilized plants develop healthy root systems in the fall which results in a stronger plant the following year.

Nitrogen should be split into fall and winter applications if fall and spring grazing are utilized. Fescue responds more to this practice than bromegrass because fescue grows and stays green longer into the winter than bromegrass. A fall application of 40 pounds of actual nitrogen is usually sufficient for an increase in forage yield and protein content. During the winter, an additional 60 pounds of actual nitrogen should be applied to the pasture when spring grazed and 100 pounds of actual nitrogen for hay production.

When legumes are present in grass pastures, winter nitrogen applications should be eliminated or applied at very low rates. However, 40 pounds of nitrogen can be applied in the fall without reducing the legume stand. Legumes are sensitive to adequate lime, phosphorus and potassium fertilization.

WARM-SEASON GRASSES

Native hay meadows respond well to an early May application of 30 pounds of nitrogen, 10 pounds of phosphorus and 0 to 30 pounds of potassium.

An established stand of Indiangrass and big bluestem grown for hay responds to a nitrogen application of up to 60 pounds, and a phosphorus and potassium application at one-half of the soil test recommendation for grain sorghum.

Eastern gamagrass responds to 90 to 100 pounds of actual nitrogen and a phosphorus and potassium application at the same level of the soil test recommendation for grain sorghum. The nitrogen application should be split between a mid-April application and after the first hay cutting in early-June.

Timely nitrogen application on bermudagrass pastures is critical because bermudagrass is the most efficient user of nitrogen. When bermudagrass is grazed, 75 pounds of actual nitrogen should be applied in mid-April and an additional 75 pounds in mid-June. For hay utilization, 100 pounds of nitrogen should be applied in mid-April, an another 50 pounds should be applied after the first cutting in early-June, and an additional 50 pounds after the second cutting in mid- to late July.

Phorphorus and potassium should be applied to soil test with the first nitrogen application.

OTHER PUBLICATIONS

The Effects of Nitrogen Fertilizer on Soil (C-625)

Smooth Brome Production and Utilization (C-402)

Tall Fescue Production and Utilization (C-729)

Native Hay Meadow Management (MF-1042)

Brome Utilization and Production (Forage Fact Sheet Series)

Tall Fescue (Forage Fact Sheet Series)

Bermudagrass Establishment and Management (Forage Fact Sheet Series)

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FORAGE FACTS

Publication Series

RANGELAND BRUSH AND WEED CONTROL

INTRODUCTION

The main objective of brush control is to minimize the population of woody plants on rangeland to increase or maintain an optimum amount of area available for livestock grazing. Other potential benefits of brush control include: (1) increased forage quality; (2) increased animal production; (3) easier handling and care of animals; and (4) reduction of potential fire hazard if volatile fuels like cedars are removed. Total removal of all woody plants is not necessary or recommended. Brush and trees around watering areas, in ravines, and other areas where they are difficult and expensive to control can provide shade and winter protection for livestock and wildlife. Complete removal of these plants would have little effect on livestock carrying capacity. The key to brush management is recognizing potential problems and controlling them before they become severe.

PRESCRIBED BURNING

Prescribed burning can keep rangeland almost free of unwanted brush, and it can also be a low-cost way to control many woody species after establishment. It is most effective in late spring, when brush and trees are small, and adequate fuel (old grass) is available to generate a hot fire.

Seedlings and sprouts can be controlled by fire, whereas, large, mature trees can't be as effectively controlled. Burning in late spring for three or more consecutive years is required to control species that resprout. Redcedar, buckbrush, elm, oak, and hedge can be controlled effectively by burning, however, sumac can be enhanced by a late spring burn because the plant may be dormant when the prescribed burn occurs.

CHEMICAL CONTROL

Most woody plants are susceptible to herbicides when applied properly. All chemicals must be applied according to the label directions. Be sure to read all label information. The application of herbicides can be done by one of several methods.

Aerial or Ground Application. Chemicals may be applied by air or ground sprayers when heavy stands or large areas are to be controlled, but proper herbicide selection, timing of application for the optimal growth stage and proper application rate are important factors to consider. Most foliar-applied herbicides should be applied at full leaf stage when plants are actively growing.

Basal Bark. Some species can be controlled by applying a mixture of diesel and herbicide to the lower 18 to 24 inches of the trunk. The mixture should be applied all the way around the trunk and allowed to drain at the soil line to reduce root collar sprouts.

Cut Stumps. Many species, except redcedar, resprout after cutting near ground level. Treating the exposed surface with a herbicide shortly after cutting will usually prevent regrowth.

Pellets or Granules. Spot treatments applied by hand or aerial application of pelleted or granular herbicides are effective when used properly. The herbicide is leached into the soil by rainfall and then absorbed by the plants. Pellets or granules should not be applied on frozen or water saturated soils, and their effectiveness can be reduced on soils that contain high amounts of clay.

Soil Applied Liquids. The application and action of liquids are similar to pellets and granules except they are more effective on heavier clay soils.

TIMING OF HERBICIDE APPLICATION

Generally, brush is most susceptible to foliar applied herbicides immediately after the full leaf stage in the spring because herbicides are absorbed and translocated to the site of action. Since the growth and development of plant species differ, the application date needs to correspond with the target species. For example, buckbrush is in full leaf by late April or early May, whereas hedge trees are not in full leaf until early June. Blackberries are most susceptible to herbicide control when treated in early to mid-June, which is well after the full leaf stage. Only an actively growing or flowering sericea lespedeza is susceptible to a treatment between June and September.

WEED CONTROL

Many plants regarded as weeds by producers can be a forage source for livestock or an important component of the grassland ecosystem. These plants should be controlled if they result in an increase in forage utilization by grazing livestock or if they are considered noxious weeds by individual counties. A prescribed burn can greatly reduce annual weeds if conducted after the initial emergence of seedlings. Producers who choose to control weeds with chemicals should contact the local county Extension office for recomendations in the annual issue of *Chemical Weed Control for Field Crops, Pastures, Rangeland and Non-Cropland* from Kansas State University.

OTHER PUBLICATIONS

Rangeland Weed Management (MF-1020)

Rangeland Brush Management (MF-1021)

Prescribed Burning Safety (L-565)

Prescribed Burning: A Management Tool (L-815)

Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland (Report of Progress issued annually)

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Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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FORAGE FACTS

Publication Series

NONTRADITIONAL FORAGES AS EMERGENCY OR SUPPLEMENTAL FEEDSTUFFS

INTRODUCTION

Despite the best plans, shortages of forage commonly occur some time during the year in Kansas. Drought, hail, early freeze, crop failure, harvest delays and unusually cold and wet winters can cause forage shortages. In response, producers may choose to buy the extra forage needed or sell livestock. But in many cases, it may be more economical to utilize nontraditional forages.

SOYBEANS

Soybeans can be grazed hayed or ensiled, and livestock performance can be adequate. Pasturing can begin as soon as the plants are 12 to 18 inches tall, and if livestock is removed once most of the leaves have been eaten, there can be enough regrowth in about a month. Soybean hay is a satisfactory substitute for alfalfa or clover hay if it is cut before the pods are 1 inch long. A mixture of chopped soybeans with corn or sorghum forage at the rate of 1 ton of soybean silage with 2 to 4 tons of other forage produces good silage.

KOCHIA

Kochia can be used in central and western Kansas as an emergency forage source for livestock, but it does not grow well in the eastern third of the state. This hardy weed can be used as hay, silage, or grazing. During its early stages of growth, it is a low-fiber, high protein forage with protein levels comparable to alfalfa.

Even under extreme conditions, kochia should not comprise a major portion of the diet. Weight loss and oxalate toxicity symptoms have been reported in cattle grazing older, mature stands of kochia. Steers that graze kochia gain less than those grazing native grass pasture, but they do perform well when placed in the feedlot.

AMARANTH

Although normally considered an alternative grain crop, amaranth (red pigweed) can be cut for hay or silage. It is generally comparable to soybean or oat forage, but inferior to sudangrass or sorghum-sudangrass hybrids in forage yield and protein content. Mature drought-stressed amaranth forage can produce nitrate and oxalate toxicity, and the risk is higher when it is the sole source of feed.

BRASSICAS (KALE, RAPE, TURNIPS)

Forage brassicas are high-quality, fast growing cool-season crops that can offer good grazing potential throughout the state. They can be seeded from mid-March through May for summer grazing, or June through August for fall and winter grazing. Grazing usually begins about 45 to 60 days after seeding. Brassica forage has exceptionally high digestibility, protein and energy content. However, the fiber content is low so roughage must be provided. When planted immediately after wheat harvest on irrigated ground, brassicas can make an excellent forage for livestock during the summer.

CRABGRASS

Crabgrass can make an excellent forage for grazing or haying because the palatability of immature crabgrass is comparable to native grasses. Crabgrass can be grazed or hayed to about 3 inches and then allowed to regrow. It should be cut prior to maturity for optimum quality and to avoid spreading the seeds in the hay.

JOHNSONGRASS

Johnsongrass is a noxious weed in Kansas that can be used as a grazing crop or harvested at the boot stage to provide an emergency hay crop. Prussic acid poisoning can be a problem with grazing weather-stressed Johnsongrass, but it is generally not a problem with hay or silage. Because Johnsongrass is a noxious weed, it should not be allowed to produce seed.

OTHER PUBLICATIONS

Emergency and Supplemental Forages (MF-1073)

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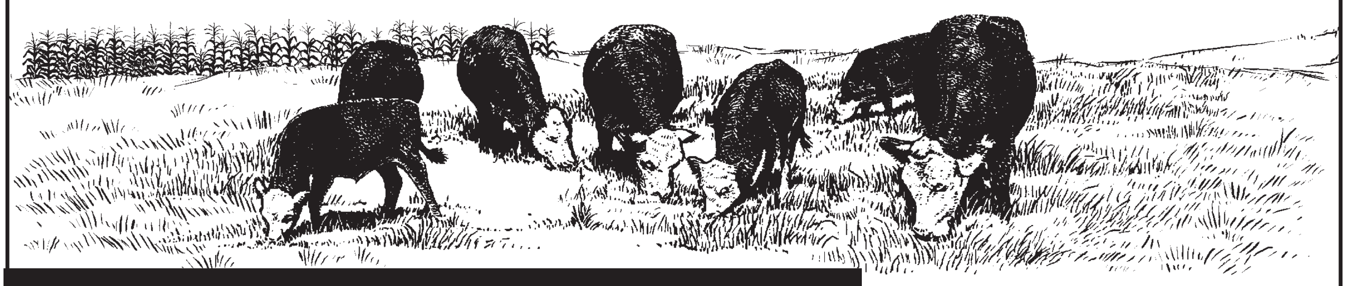

FORAGE FACTS

Publication Series

SUMMER ANNUAL FORAGES: SELECTION AND PRODUCTION CHARACTERISTICS

INTRODUCTION

Summer annual forages are warm-season grasses that tolerate hot, dry weather and are adapted to most areas of Kansas. They include forage sorghums, sudangrass, sorghum-sudangrass hybrids, hybrid pearl millet, and foxtail millet. Selecting a type or variety of summer annual should be based on the needs and location of the individual livestock program because they have different growth characteristics which influence how they are used.

TYPES OF SUMMER ANNUALS

Sorghum-sudangrass hybrids, the most common annual grass in Kansas, can produce high forage yields, but over 50 percent of the yield production is stem. Consequently, the plants are better suited for silage, haying, or grazing.

Forage sorghums mature late in the growing season and produce high yields with limited regrowth ability, which makes them best suited for one-cut silage operations.

Sudangrass produces less forage than most other summer annuals, but their small stems, extensive tillering, and rapid regrowth potential are ideal for grazing and haying operations.

Hybrid pearl millet has high forage quality and regrows rapidly which makes it ideally suited for haying and grazing operations. However, it is sensitive to overgrazing, and at least 8 inches of stubble is necessary for regrowth.

Foxtail millet has low quality and palatability, and forage yields are relatively poor. It is shallow-rooted and easily pulled out of the ground when grazed.

PRODUCTION CHARACTERISTICS

Summer annuals should be planted when the soil temperature reaches 70° to 75°F. Hybrid pearl millet and foxtail millet seeds are particularly intolerant of cold, wet soils and should not be planted until late May or early June. It usually takes four to six weeks after planting before summer annuals can be used.

Optimum planting depth of summer annual grasses varies with soil type and moisture, but generally is 1 to 1½ inches. Hybrid pearl millet and foxtail millet have small seeds and should be planted ¾ to 1 inch deep. Germination is enhanced by covering the seed with moist soil to provide firm seed-to-soil contact.

Seeding rates for summer annuals are relatively high because only 65 to 70 percent of the seeds normally emerge. When drilling in narrow rows, hybrid pearl millet and forage sorghums should be planted at 10 to 20 pounds per acre; foxtail millet planted at 15 to 30 pounds per acre; and sudangrasses and sorghum-sudangrass hybrids planted at 20 to 25 pounds per acre. Seeding rate of forage sorghums planted in wide rows is 4 to 6 pounds per acre. Producers should use lower seeding rates in dry areas and higher rates in irrigated areas.

A **FORAGE FACTS** Publication of the **KANSAS FORAGE TASK FORCE**
Kansas State University Agricultural Experiment Station and Cooperative Extension Service

Summer annual forages have nutrient requirements similar to grain sorghum and must be fertilized according to soil test recommendations to be productive. Nitrogen is the nutrient most lacking for optimum production. On nitrogen deficient soils, 30 to 40 pounds of nitrogen per acre should be applied for each expected ton of dry matter production. Split applications provide better nutrient distribution and reduce the potential for nitrate or prussic acid toxicity. To minimize nitrate accumulation potential, application rates should be based on a profile nitrogen soil test and previous crop and manure credits.

Phosphorus, potassium and other nutrient applications should be based on soil test recommendations. Because phosphorus does not appreciably move in the soil, it should be applied either preplant or banded at seeding. Lime is recommended if the soil pH is 6.0 or less in the eastern third of the state, or less than 5.5 in other areas.

Rapidly growing summer annual grasses are competitive with weeds that emerge after seeding. Cultivation can control weeds if row spacing is adequate. Herbicides are an alternative for problem weed species, although there are few herbicides labeled for weed control in most summer annual forages. Atrazine may be either soil-applied or foliar-applied on forage sorghum and sorghum-sudan hybrid. Other herbicides are brand specific and should not be applied unless specifically approved on the label.

Insect infestation problems vary throughout the state and from season to season. Greenbugs can cause statewide damage to sorghums and sudangrasses, but hybrid pearl millet is highly resistant to greenbug damage. Chinch bugs are often a problem in central and eastern Kansas, particularly during dry seasons or if the summer annual is planted into wheat stubble. Heavy infestations or destructive insects may necessitate spraying with an approved insecticide. Follow label directions carefully when applying insecticides.

OTHER PUBLICATIONS

Producers should refer to the annual K-State Research and Extension publication, *Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland*, for recent information on herbicides for summer annual forages.

Nitrate and Prussic Acid Toxicity in Forage (MF-1018)

Prussic Acid Poisoning (Forage Fact Sheet Series)

Nitrate Toxicity (Forage Fact Sheet Series)

Summer Annual Forages (MF-1036)

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FORAGE FACTS

Publication Series

SUMMER ANNUAL FORAGES: UTILIZATION

INTRODUCTION

Summer annual forages are warm-season grasses that tolerate hot, dry weather and are adapted to most areas of Kansas. Harvesting and utilizing summer annuals depends on the livestock operation, weather, available equipment, storage facilities, and the needs, abilities and preferences of the producer.

GRAZING

Sudangrasses and hybrid pearl millets can provide high-quality forage in a grazing system. Sorghum-sudangrass hybrids can be grazed, but are less palatable than sudans or hybrid pearl millet, and livestock performance is lower. Because forage sorghums have thick stems, limited regrowth ability, and are notorious prussic acid producers, they are desirable for silage production only.

The objective of a summer annual grazing system is to keep the plants in a vegetative stage and prevent them from seeding. Sudangrasses should not be grazed until 18 inches tall and sorghum-sudangrass hybrids should not be grazed until 24 to 30 inches tall. Ideally, the pasture should be rapidly grazed to a 6- to 8-inch stubble, rested until regrowth reaches the appropriate height, and then regrazed. Overstocking removes too much stubble and severely reduces regrowth production, whereas understocking allows the plants to mature and become stemmy. Livestock will selectively graze the leaves and avoid the stems. The forage would be better utilized as hay or silage if the summer annual is more than 36 inches high.

Summer annual grazing programs may either supplement or complement native grass. A supplementary forage system allows livestock to graze summer annual pasture simultaneously with native range at an approximate ratio of one acre cropland to three acres rangeland. Once the summer annual is ready to graze, the cattle are allowed free access between native and planted forages. Native and summer annual pastures are grazed as separate entities in a complementary program. Livestock are moved from native grass to summer annual pasture around mid-July and remain until the end of the growing season. The livestock receive a higher quality forage, and the late-season rest increases the vigor of the perennial grasses.

Continuously grazed complementary pastures are generally underused or overused because stocking rates do not correspond with the fluctuations of moisture, temperature, and regrowth throughout the growing season.

The highest stocking rates and most efficient use of summer annual pastures are obtained with a rotational grazing system. This involves subdividing a pasture and stocking one section with enough livestock to graze the plants to a 6- to 8-inch stubble in 10 to 14 days and then moving the livestock to the next field. The planting dates can be staggered so the cattle are sequentially rotated to a field that is ready to graze.

With a rotational grazing system, summer annuals can provide nearly 90 days of high-quality forage which can handle two to six yearling steers per acre. Actual stocking rates are difficult to predict because they depend on plant species, livestock size, soil type, fertilization, moisture, and other managerial and environmental factors.

HAY UTILIZATION

Sudangrass and hybrid pearl millets are best adapted for hay operations. Sorghum-sudangrass hybrids can be cut for hay, but their thick stems are difficult to cure, and crushing, crimping, or a hay conditioner is required to speed drying.

For high quality hay, plants should be cut before the heads emerge. Harvesting after heading substantially reduces forage quality. Summer annuals can produce two or three hay crops if 6 to 8 inches of stubble is left for regrowth. Applying 30 pounds of nitrogen after the first harvest can hasten regrowth and increase protein content.

SILAGE UTILIZATION

Forage sorghums and sorghum-sudangrass hybrids are best suited for silage because they have a high yield, quality and grain potential. The highest quality silage is from forages that have at least 20 percent of the dry matter from grain. The tall, late-maturing hybrids may produce high forage yields, but they produce minimal grain yield. The late-season cultivars are prone to lodging and a high moisture content, which can produce excessive effluent at ensiling.

Harvesting the forage at the proper stage of maturity is a critical factor affecting silage quality. Sorghums should be harvested for silage at the mid- to late-dough stage of kernel maturity to optimize forage quality and yield. The moisture content at the mid- to late-dough stage of kernel maturity is approximately 60 to 70 percent. Summer annuals that are cut at a higher moisture content must be wilted until the moisture content reaches an acceptable level.

GREEN CHOP

Sorghum-sudangrass hybrids are best suited for a green chop program. Once the crop reaches 30 inches it can be cut and fed daily as needed. With a cutting height of 6 to 8 inches and adequate moisture and fertility, the regrowth can be harvested within 30 days.

Green chop is generally a high-protein forage and commonly fed to dairy cattle or other high-producing livestock. The harvested forage should be fed immediately after cutting and not allowed to wilt and heat in the wagon or feed bunk.

LIVESTOCK POISONING POTENTIAL

Summer annual forages may be potentially dangerous to livestock. Under certain environmental and managerial conditions, summer annuals can be prone to nitrate toxicity and prussic acid poisoning, however, those problems can be minimized with careful management. For more detailed information, see K-State Research and Extension publication MF-1018, *Nitrate and Prussic Acid Toxicity in Forage.*

Horses should not consume high amounts of sorghums, sudangrasses, or foxtail millet because they occasionally may develop kidney and bladder problems from the forages if they are a major component of the diet.

OTHER PUBLICATIONS

Nitrate and Prussic Acid Toxicity in Forage (MF-1018)

Prussic Acid Poisoning (Forage Fact Sheet Series)

Nitrate Toxicity (Forage Fact Sheet Series)

Summer Annual Forages (MF-1036)

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FORAGE FACTS *Publication Series*

METHODS OF LEASING CROP RESIDUE FOR GRAZING

INTRODUCTION

Grazing crop residue is the key to year-round grazing for many cow-calf and stocker operators throughout Kansas. As is the case with most types of rental arrangements, leasing rates for grazing crop residue are dominated by tradition. “Rules of thumb” rates are commonplace, but generally are poor fits for any given year in the cattle cycle.

Typically, pasture is rented on a per weight per period basis, for a flat rate per acre, or on a gain basis. Depending on the level of involvement by each party in the grazing venture, the most desirable arrangement will vary. Land owners with a track record of above-average animal performance on their ground, whether from providing additional service or not, will be more likely to rent pasture on a gain basis. Landowners who desire a hands-off approach probably will use another method that is less closely tied to animal performance. Regardless, it should be remembered that there is no “one-size-fits-all” pasture lease for crop residue.

MANAGEMENT CONSIDERATIONS

Determining grazing rates for crop residue is a multi-step process. First, the cattle owner must decide which grazing scenario best fits his or her situation. Amount of residue present in any given field, degree of grain drop, location of the field, and cattle market projections are a few of the factors that play a role in selecting stocking rates and grazing scenarios.

Next, the cattle owner must make projections for animal performance, death loss, and the price of feeder cattle at the end of the grazing period. This is essential to project the value of cattle gain leaving a field. The expected off-value less the actual in-price yields the value of gain from which variable and fixed costs, operator labor, and profit are taken. Operator experience and cattle quality dictate projected animal performance.

It is important to be conservative in developing bids in a manner that is dependent upon projected animal performance. If ADG is overestimated, value of gain is overestimated, and the cattle owner could offer a grazing fee that is too high. Likewise, the cattle owner should carefully estimate the costs of keeping cattle on residue. Supplemental feed, veterinary, transportation, fencing, water, and interest expenses all impact the final bid.

METHODS OF LEASING CROP RESIDUE

The per hundred weight per month method is used widely for winter wheat and annual pasture grazing. Producers use the beginning weight of cattle onto pasture rather than an average weight during the season. If the beginning weight is used and weight gains are poor, the cattle owner suffers. Since cattle performance has no bearing on total rent paid, the residue owner has less incentive to provide service for which he or she is not compensated. Conversely, if rent is paid on the average weight during the grazing season, a gain component is embedded in the agreement for the pasture owner. This situation makes it advantageous for the pasture owner to do a good job of managing the livestock for optimum performance.

The flat rate is an appealing method for many landowners who prefer to have no participation in the grazing enterprise and is better suited for residue grazing than for wheat or permanent pasture. Provided minimum cover remains to satisfy conservation plan requirements, the danger of overgrazing is far less worrisome in a residue situation than a wheat pasture situation.

Renting pasture "on the gain" shifts a large portion of the economic incentive for increased animal performance to the landowner. The agreement is negotiated, cattle are weighed going onto pasture, and then weighed at the end of the grazing period. Total gain is multiplied by the negotiated rate per pound to arrive at the total rental fee. Under this arrangement, the pasture owner clearly has an incentive to manage for the greatest possible total gain. Both sides are likely to benefit if the residue owner checks for sick cattle in a timely manner and makes sure water and mineral supplies are current. Rule-of-thumb rates for "on the gain" crop residue rentals should be viewed critically. Again, they are generally poor fits with time as market conditions vary.

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FORAGE FACTS

Publication Series

ESTIMATING CROP RESIDUE AVAILABLE FOR GRAZING

INTRODUCTION

Utilizing livestock to consume excessive residue is an efficient way to manage crop aftermath. Knowing the quantity of residue initially available and how much residue should remain to provide adequate protection of the soil allow the producer to determine how much residue is available to be consumed by livestock.

DETERMINING THE AMOUNT OF CROP RESIDUE

There are several ways to determine the amount of residue on a particular field. The methods can range from scientifically measuring the amount of residue on a field to simply calculating the quantity of residue produced based on harvested grain yield. The initial evaluation of residue quantity is important to estimate the quantity of feed available to livestock.

When measuring the quantity of residue, several samples should be collected from a quadrant or a known area and weighed. Having a weight from a known area will allow a conversion to pounds per acre. Residue does contain moisture and should be dried before weighing to determine pounds of dry matter per acre.

An easy way to estimate pounds of residue is to make a template from pliable rod or material that is 132 inches long and can be bent to form a circle. The circular template will have a diameter of 42 inches. The area within the circle is a unique size because the weight of the dry matter residue within this circle, weighed in grams and multiplied by 10, will equal pounds per acre. For example, if 800 grams of residue dry matter are collected from within the circle, there are approximately 8,000 pounds of residue dry matter per acre available for grazing.

A second method to estimate the quantity of residue present is based on calculations with residue index factors relating to grain yields. These values are found in Table 1. Residue indices are simply prediction numbers and measuring the residue is more accurate. Residue produced per bushel of grain harvested varies because of environmental conditions, therefore, the calculation method is an estimate of the residue produced and available in a field.

The following is an example of calculating the quantity of residue based on the residue indices:

70 bushel grain sorghum crop
grain sorghum has a residue index of 60
$70 \times 60 = 4200$ pounds of residue per acre
approximately 50 percent of the residue is removed
2,100 pounds of residue per acre are available for livestock removal

Table 1. List of crop residue index values. Multiply index by bushels of grain produced per acre for an estimate of available residue.

Crop	**Residue Index***
Wheat	100
Corn	60
Grain Sorghum	60
Oats	55
Soybeans	45
Sunflower	1.5

* Residue index = pounds of residue produced/bushel of grain produced

DETERMINING PERCENT COVER

Residue is essential because it reduces soil erosion from wind and water, therefore, it is important to keep some residue in the field. The amount of residue required to minimize erosion varies with the type of residue present, type of soil, the slope of the land, and the presence of barriers (terraces, windbreaks, etc.) which affect the potential for wind and water erosion.

An accurate method of determining percent cover is the transect method, which involves stretching a 100-foot tape across the field at a diagonal to the run of the row. The number of foot marks that are directly over a piece of residue should be counted. If it is slightly off to the side of a piece of residue, it should not be counted. Beginning at the 1-foot mark and ending at the 100-foot mark, 100 sites should be examined on the tape. For every mark that is over a piece of residue, a 1 percent cover is estimated. Therefore, if 30 marks lie directly over residue, a 30 percent cover would be estimated. This should be done at several locations in the field to accurately estimate percent cover. A second method is visual evaluation. Publications by Kansas State University and the National Resource Conservation Service (NRCS) are available with photographs representing various levels of residue cover.

EFFECT OF GRAZING ON SOIL COMPACTION.

Grazing livestock can cause soil compaction, but generally the compaction is shallow and temporary. Soil moisture and soil type are the two main factors which affect the severity of the compaction. Moist soils with significant clay content are most prone to compaction and are often referred to as "tight" soils. Completely saturated soils or dry soils do not compact. The winter freeze/thaw and spring tillage will eliminate most compaction created by livestock.

OTHER PUBLICATIONS

Soil & Water Conservation Software RES-N-TILL USER MANUAL, V 2.2. Department of Agronomy, Kansas State University

Wheat Stubble: What is its value? (MF-2240)

A guide for planning and analyzing a year-around forage program. University of Nebraska Cooperative Extension (EC 86-113)

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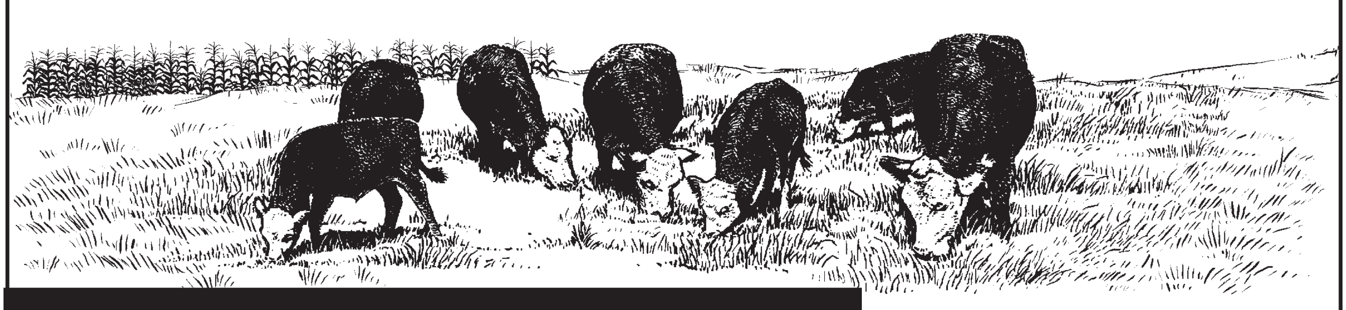

FORAGE FACTS *Publication Series*

SMALL GRAIN CEREALS FOR SILAGE AND HAY

INTRODUCTION

Although winter cereals generally are planted for grain, they are also used as forage crops by many livestock producers. Depending on grain and cattle prices, producers sometimes realize a higher net income by harvesting small grain cereals as forage rather than as grain.

Winter cereal forages can be used with fall-harvested crops in a year-round forage program by double cropping the land after harvesting the small grain cereal as silage or hay. The risk of crop loss from rain, wind, or hail is decreased by harvesting a winter cereal as silage or hay compared to waiting to harvest the grain. Finally, circumstances sometimes make it desirable, even necessary to use winter cereals as forage even though they were planted for another purpose, i.e., weather stressed wheat with a low level of grain production might be more profitable if harvested as silage or hay.

PRODUCTION FACTORS

Maximizing the silage or hay potential of any of these cereal crops depends on several basic production factors. It is important to follow the recommended planting dates for each crop. For best forage production, the planting of small grain cereals should begin about two to four weeks before the free date for Hessian fly infestations. Seeding rates for small grain cereals grown for silage or hay should be 25 to 50 percent higher than normal. Thicker seeding rates will reduce stem size and make wilting easier. With small grain cereals grown specifically for silage or hay, use the same nitrogen rates recommended for grain production.

SILAGE PRODUCTION AND ANIMAL PERFORMANCE

Forage yield and feeding value are affected by the stage of maturity of the small grain at ensiling time. Small grains should be ensiled at 62 to 68 percent moisture. Because cereals advance from the boot- to dough-stage rapidly, producing a high-quality cereal silage is often more difficult than producing high-quality corn or sorghum silages. Harvesting at the dough stage, a critical 10- to 14-day period, requires good management. It may be wise to start early, when the grain is in the milk stage and when the moisture is 65 to 70 percent so harvest will not extend beyond the dough stage of maturity. Barley usually matures a week earlier than wheat; and wheat matures one to three weeks before spring oats, depending on the late-spring and early summer weather conditions.

When fed to finishing cattle in high-grain rations, wheat, barley and corn silages support similar feedlot performance. Growing beef cattle should gain 1.5 to 2.25 pounds per day when fed rations containing 85 to 90 percent good-quality wheat or barley silages. Feeding cereal silages can produce up to 50 percent more beef per acre than feeding the grain alone. Silage palatability generally is not affected by the presence of awns, although awns in hay can be a concern.

The feeding value of small grain silage for growing/backgrounding cattle can be compared to whole-plant corn silage as follows:

Barley 90 to 100 percent of corn silage

Wheat 70 to 90 percent of corn silage

Oats 60 to 80 percent of corn silage

Triticale 50 to 70 percent of corn silage

Rye 50 to 65 percent of corn

HAY PRODUCTION

Small grain cereals can be used as a hay crop, either as an emergency feed or as part of a planned early summer forage program. Yields often average about two to four tons of dry matter per acre. Small grain hays have the highest quality when harvested at the late-boot stage of maturity. However, harvesting at the early milk stage offers the best compromise between high dry matter yields and maximum hay quality. If protein content is a high priority for the small grain hay, the crop should be harvested at the late-boot stage of maturity. Dry matter yields are about 20 to 40 percent lower at this stage compared with the dough stage of maturity.

Rough awns in small grain hay can cause livestock considerable soreness and irritation to the eyes, mouth, lips, gums, and lower surface of the tongue. A crop with rough awns should be ensiled rather than baled to minimize this occurrence. Harvesting at the late-boot stage rather than the dough stage reduces palatability problems caused by rough awns.

Occasionally, nitrates accumulate in small grains cereals because of drought, hailstorms, or late frosts. Oat hay is more likely to have a high nitrate level than any other small grain cereal hay.

Additionally, small grain cereal hay tends to be more slippery than alfalfa or native grass hays, and the bales can be more difficult to stack.

OTHER PUBLICATIONS

Kansas Crop Planting Guide (L-818)

Small Grain Cereals for Forage (MF-1072)

Wheat Pasture in Kansas (C-713)

Wheat Pasture Grazing (Forage Fact Sheet Series)

Small Grain Cereals as Forage: Crop Selection (Forage Fact Sheet Series)

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FORAGE FACTS

Publication Series

PASTURE RENOVATION PRACTICES FOR EASTERN KANSAS

INTRODUCTION

Kansas has two broad types of pastures: warm-season and cool-season grass pastures. The warm-season pastures are generally native rangeland that varies from the tallgrass rangeland of the Flinthills to the short grass prairie of western Kansas. Cool-season pastures are the result of grasses that are planted on cropland acres in the eastern one-third of the state. Generally, the 1.5 million acres of tame pasture in Kansas are either smooth bromegrass or tall fescue.

Stocking rates, grazing systems, prescribed burning and brush control can be effective pasture renovation practices for native rangeland. Cool-season pasture improvements can be as simple as applying fertilizer according to soil test recommendations or as complex as destroying the existing forage and reseeding grass.

WARM-SEASON NATIVE GRASS PASTURES

The best grazing system to improve and/or maintain rangeland is the intensive early stocking (IES) grazing system. Intensive early stocking is defined as stocking twice as many cattle per acre between May 1 and July 15 as normal season-long stocking rates. When compared to season-long grazing, the IES system results in: (1) higher grass yields and lower brush production; (2) improved grass quality; and (3) a more uniform grazing distribution. Pastures grazed season-long have resulted in considerable spot grazing and nonuniform burns the following spring.

Stocking rates should be based on three factors: (1) desired animal performance; (2) forage available for livestock utilization; and (3) adequate forage remaining at the end of the grazing season to support a prescribed burn the next spring.

An overgrowth of brush is generally the result of overgrazing and a lack of prescribed burning. Infrequent burning results in a reduction of warm-season grasses and forb species and an increase in woody vegetation. When prescribed burning is postponed, trees and shrubs can become established in a few years. Timely burning can result in a dominance of warm-season grasses and reduced cool-season grasses and forbs. Producers should burn three consecutive years and then may skip three to five years before repeating the burn cycle.

Kansas State University research between 1950 and 1989 showed an average increase of 14 percent in total gain for steers grazing burned pasture compared to pasture that was not burned. In addition, late spring (May 1) burning consistently produced a more desirable plant composition than did earlier burning (March 20) or not burning at all.

COOL-SEASON GRASS PASTURES

Most cool-season pastures suffer from overgrazing and low fertility. Overgrazing results in plants that usually don't respond well to fertilization because of shallow root systems and low vigor.

Low vigor pastures generally turn green after fertilization, but don't respond with much actual growth. A spring or fall fertilization and a 50 percent reduction in stocking rates during the prime growing season can improve vigor. An additional method to improve a cool-season pasture is to apply recommended fertilizer in late August and avoid any grazing until November 1.

A nitrogen application should be applied prior to each grazing season because it does not carry over from one season to the next. If a phosphorus and potassium application is required it only needs to be applied once per year, preferably in the fall.

Adding legumes to cool-season grass pastures can increase animal performance, especially if the pasture is grazed during June, July and August. Tall fescue is an ideal grass for grass-legume pastures because the bunch grass has open spaces in the sod for legumes to establish. Legumes to consider for use in grass-legume mixtures are red clover, ladino clover, alsike clover, annual lespedeza and alfalfa. With the exception of annual lespedeza, the legumes grow from May through mid-summer and produce high quality forage for grazing. Annual lespedeza needs adequate spring moisture to establish each year, but it does provide good late-summer growth.

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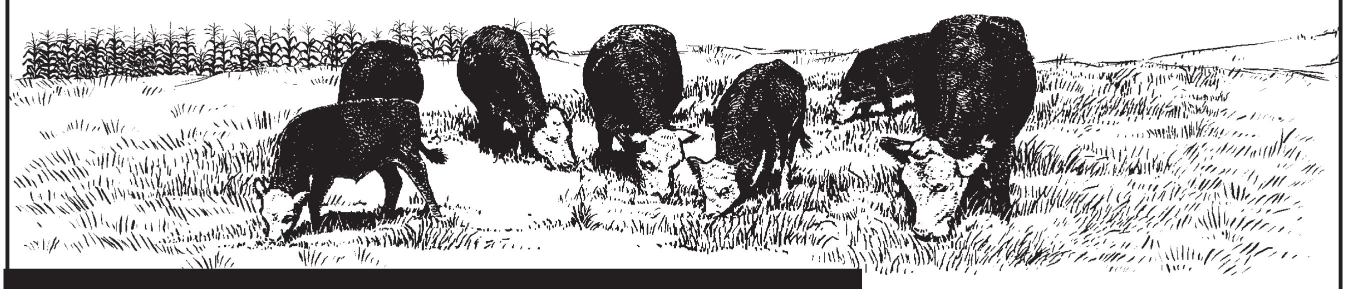

FORAGE FACTS

Publication Series

SUNFLOWER SILAGE

INTRODUCTION

Although sunflowers are generally planted for seed production, they can be used as a forage source by livestock producers. Seeds represent about one-third of the sunflower plant's dry matter, therefore, large amounts of potential livestock forage is not utilized when only the seed is harvested. Stressed sunflowers with a low level of production can be profitable if utilized as a forage source for livestock. When sunflowers are grown as a second crop following small grains, sunflower silage or grazing may be the only alternative when seeds do not have sufficient time to mature.

SUNFLOWER TYPES

Two primary kinds of sunflowers are grown in Kansas—oil and confectionery (non-oil or edible). Oil sunflowers have a shiny black color and are more common in Kansas than confectionery sunflowers. The small oil sunflower seeds are used to produce a high-quality cooking oil and sunflower meal for livestock feed. Confectionery sunflowers have larger seeds than oil sunflowers and are black with white stripes. They are grown to produce food products for baking, direct seed eating and birdseed.

NUTRITIONAL VALUE

Research conducted prior to 1930 indicated a feeding value for sunflower silage of 80 percent of corn silage, but today's improved varieties have improved that to 90 to 95 percent of corn silage.

Whole-plant sunflower silage usually contains slightly more crude protein and considerably more fat on a dry matter basis than corn silage. Sunflower silage contains 10 to 12 percent crude protein compared to 8 to 9 percent commonly found in corn silage. In addition to a higher crude protein content, sunflower silage made from oil seed varieties contains 10 to 12 percent fat compared to 2 to 3 percent fat in corn silage. Silage made from non-oil seed sunflowers or low yielding crops usually contain only slightly more fat than corn silage.

The disadvantage of sunflower silage is the fibrous stalk that causes a high fiber content which can be two to three times as much as corn silage. The increased fiber content of sunflowers is caused by high levels of lignin, which is the undigestible portion of the plant. Because the increased fiber content of sunflower silage is offset somewhat by the higher oil content, the total digestible nutrients (TDN) of sunflower silage is only slightly lower than corn silage.

Intake of sunflower silage may be a problem when it is the only forage fed because the high fat content can reduce consumption. The high rate of fiber content in sunflower silage may also reduce intake by slowing down the rate of passage. These problems can be managed by limiting sunflower silage to one-half or less of the total forage in the ration.

ENSILABILITY OF SUNFLOWERS

One of the main limitations of sunflowers for silage is the low dry matter content at the time of harvest. Sunflower stalks hold high amounts of water which makes it difficult to achieve the proper dry matter content for ensiling. The ideal dry matter content for ensiling sunflowers is between 30 and 40 percent. The brown, dried appearance of the leaves can mislead producers about the dry matter content of the whole plant. Even when the seed is mature, the whole-plant dry matter content of the sunflower can still be 20 percent, which is too wet for ensiling. South Dakota researchers reported a 30 percent dry matter content in mature sunflowers two weeks after a killing frost. Low dry matter silages (less than 30 percent dry matter) can cause an undesirable fermentation and excessive effluent seepage from the silo.

OTHER PUBLICATIONS

Improving Silage Quality (Forage Fact Sheet Series)

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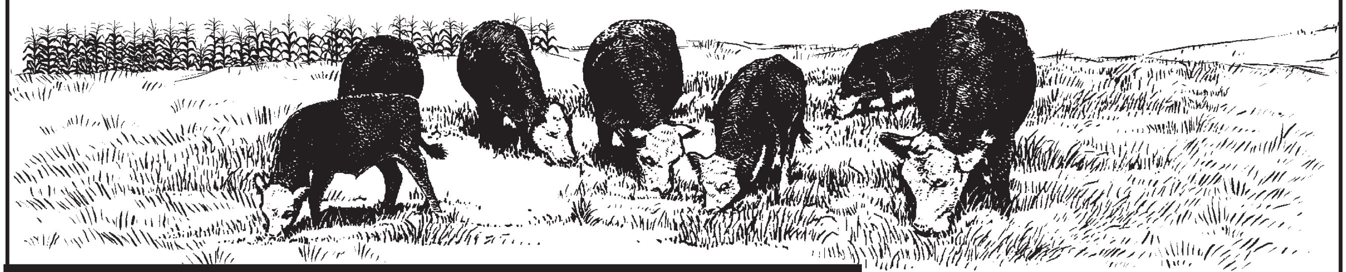

FORAGE FACTS

Publication Series

BLISTER BEETLES

INTRODUCTION

Blister beetles are elongated, narrow, cylindrical, generally soft-bodied insects that may measure up to 1½ inches in length. A constriction in the area between the back of the head and the rest of their leg-bearing thoracic body region makes it appear as if they have a well-defined neck. Color and size vary among the nearly 60 species known to occur in Kansas. Only about half a dozen of these species were found to infest alfalfa in a recent series of studies.

Although small areas within soybean and alfalfa fields may sometimes experience noticeable leaf-feeding damage from dense congregations of adults, these insects most often are a concern to livestock producers when their bodies become trapped within stored forage, particularly alfalfa, during harvesting. Defoliation or flower feeding by adults rarely causes economic damage outside of vegetable gardens. Immatures generally are considered beneficial in that the larvae of many species feed on grasshopper eggs.

THREAT TO LIVESTOCK

The bodies of blister beetles contain a toxic substance called cantharidin. Horses are particularly sensitive to this material, but cattle also are affected. Death of an affected animal can occur if the problem is severe and not adequately diagnosed, and prompt treatment is not administered. Spiking cattle rumen fluid with cantharidin in one K-State Research and Extension study resulted in reduced digestion of forage substrates. Ruminants eating cantharidin-contaminated hay might exhibit lessened rates of gain, even if they suffer no long-term health risks.

Cantharidin is an irritating compound which can cause blistering of external and internal body surfaces. In horses, colic, diarrhea, blood in the stool and urine, and sloughed intestinal mucosal linings may be observed following ingestion of contaminated hay. Animals may experience pain while urinating, passing frequent and small quantities of blood-tinged urine with each effort. Affected horses place their muzzles in water without drinking, exhibit elevated temperatures, and have increased pulse rates, dehydration, depression and shock. Body tremors, congested mucosal membranes, odd breathing patterns, including a fluttering of the diaphragm that is synchronized with the heartbeat, may develop. Blood chemistry analysis may show that a lowered blood calcium level has developed. If poisoning is suspected, examine recent feed sources, looking for beetle bodies, wing covers and other body fragments. Consult a veterinarian immediately for advice on treating your animal.

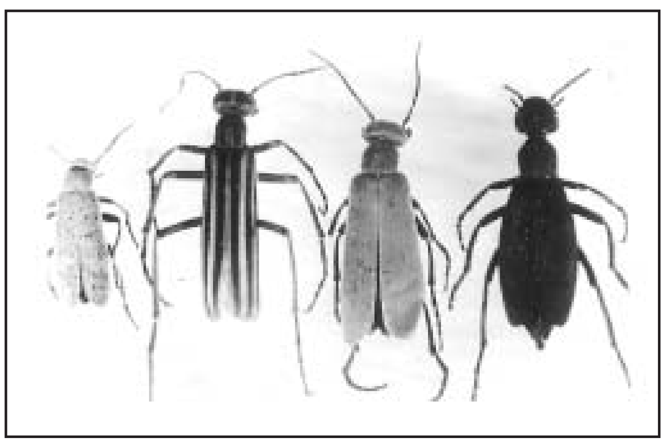

Figure 1. Common species of blister beetles found in Kansas.

Figure 2. Part of a swarm or aggregation of three-striped blister beetles within standing alfalfa

HOW DO THE INSECTS GET INTO THE HAY?

Blister beetles of several species regularly inhabit alfalfa across Kansas. Because each insect contains only a small quantity of toxin, the risk of livestock poisoning is largely confined to one species, the three-striped blister beetle, which tends to congregate and form large aggregations or swarms. Aggregations of 60,000 or more individuals have been observed in Kansas alfalfa.

During the harvesting process, blister beetles can be crushed and killed as hay is swathed. Side-mounted, pull-type, or self-propelled mowers or swathers with conditioning rollers are frequently blamed for causing virtually all of the blister beetle contamination in processed hay. However, research at Kansas State University showed that wheel traffic drive over from tractors employing sicklebar mowers can kill about the same percentage of blister beetles as hay conditioners.

Although raking and pickup tines on a baler may cause many dead insects to drop to the ground, significant quantities of cantharidin may remain in the hay if body fluids were transferred from smashed beetles to the forage.

Since the area occupied by a single swarm of striped blister beetles is frequently wider than the width of the haying equipment, harvesting machinery frequently moves into and out of each aggregation several times as the hay is swathed. The process of loading and stacking the hay on trucks or trailers and restacking it in piles adds to the redistribution process, serving to scatter infested bales rather than keeping the risk clustered in well-defined areas.

HOW MANY INSECTS DOES IT TAKE TO CAUSE ANIMAL HEALTH RISK?

Virtually all the available data relate only to horses. Size and health of the animal combine with amount of toxin ingested as major components in predicting risk. Beetle species vary in terms of amount of cantharidin contained. Reliable reports indicate that somewhere between 25 and 300 or more beetles may result in horse mortality following a single feeding. One 5-pound flake of hay collected from the site of a massive swarm contained 145 grams of dead blister beetles. This quantity of blister beetles, if distributed evenly, would be enough to kill more than 25 horses. In reality, a single animal probably would have consumed the entire flake of hay.

WHAT CAN BE DONE TO MINIMIZE THE RISK?

Scouting for the insects within a field of standing hay is not likely to be reliable. The largest swarm of blister beetles we have ever discovered was encountered in a field that had been intensively scouted by trained individuals earlier that same day. When the scouts initially left the field they were confident there were no swarms of beetles present. A few hours later, as we were releasing small groups of color-marked beetles in preparation for a series of equipment evaluation experiments, we encountered tens of thousands of beetles in a large aggregation which was dense enough to bend over the standing hay. The beetles infesting this 500- to 600-square foot area must have flown into the field during the short time the scouts were out of the field—illustrating the dynamic and unpredictable nature of this pest problem.

The least lethal harvesting equipment we studied was a self-propelled swather with conditioning rollers fully open or, better yet, completely removed from the machine. This relatively low-risk machine also was equipped with a windrowing attachment so wheel traffic run over did not occur while the equipment was moving up and down the field cutting the alfalfa. With one important exception, relatively few blister beetles were killed with this machine during our studies. Hay in turn areas at the ends of the field should be segregated and fed to non-cantharidin-sensitive animals because aggregations of beetles in these areas might be crushed beneath the wheels of the swather, trapping them in the hay, as it was turned around for another pass down the field. Some beetles were killed using this device, so completely blister beetle-free hay could not be guaranteed.

Experiments involving many brands and types of chemical desiccants failed to identify a nontoxic substitute which could speed drying and replace mechanical conditioning. Many of these products killed blister beetles quite rapidly, thereby possessing the same disadvantages associated with the use of insecticides.

WHAT ABOUT INSECTICIDES?

Insecticides are not recommended as a means of eliminating blister beetles from infested fields. Killing the insects only serves to trap the poison within the field. Living beetles are not highly attracted to fallen hay and soon take flight, leaving mown areas of the field generally within 24 hours. If the field is cut in sections, expect that many of the blister beetles that were in the first areas to be cut will simply move to the standing hay—thereby increasing the cantharidin contamination risk, particularly in the outer sections of the standing forage.

ARE SOME CUTTINGS AT GREATER RISK THAN OTHERS?

Yes, although generally the most weed-infested alfalfa, the first cutting is the least likely to possess blister beetles which form aggregations. However, even the first cutting is not blister beetle-free since some non-aggregating species can be found in some areas. Cuttings two, three, and four have shown the greatest likelihood to contain striped blister beetles. Populations of striped blister beetles generally peaked from late June through the month of July, with risks still evident into August and even September.

RISK OF POISONING FROM DEHYDRATED, PELLETED, OR LONG-TERM STORED HAY

We have been unable to find alfalfa processors willing to let us run blister beetles and alfalfa through their mill and dehydration equipment to determine whether high temperatures and the mixing/chopping process would dilute the risk represented by a trapped swarm of beetles. However, laboratory studies indicate that cantharidin is a relatively stable compound, retaining its identity and toxicity in the presence of significant heat. Studies of air-dried cantharidin contaminated hay indicate that the toxin can still be identified at threatening levels for nearly one year after the harvest process occurred.

IS PRAIRIE HAY FREE OF BLISTER BEETLES?

Many horse owners rely exclusively on prairie hay as their forage source, believing that blister beetle contamination is unknown in these forage species. We do not have data to support or deny this supposition; however, most horse poisoning reports have been associated with the feeding of contaminated alfalfa hay.

DO HIGH GRASSHOPPER POPULATIONS FORETELL LARGE BLISTER BEETLE RISKS?

Because many blister beetle species rely on grasshopper eggs as a food source for their immatures, it seems likely that the risk of blister beetle contamination will be greater the year after significant grasshopper populations are present.

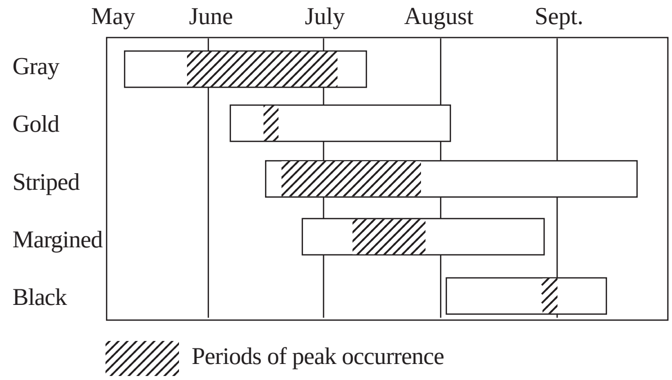

Figure 3. Seasonal and peak occurrence of blister beetles in Kansas alfalfa.

HOW EASILY ARE BLISTER BEETLES OBSERVED IN CONTAMINATED BALED HAY?

Blister beetle body parts are difficult to locate within contaminated hay. All flakes within all bales would need inspection, which is impractical. Furthermore, most of the bodies may have been knocked free during the harvest process, leaving only body-fluid contaminated hay. In the future, devices which detect blister beetle bodies or cantharidin may be developed. It also might be possible to train dogs to detect blister beetles through volatile odors given off from the beetles' bodies. These latter two detection methods, while conceivable, have unproven value at this time.

SUMMARY

Alfalfa producers selling hay as horse feed and horse owners buying alfalfa hay for their animals probably have the most need to become familiar with blister beetles.

Signs of poisoning are varied. Consult a veterinarian promptly if blister beetle poisoning is suspected.

The greatest risk is posed by blister beetle species that form dense aggregations, thereby concentrating the amount of cantharidin. In Kansas, the most common aggregating species is the three-striped blister beetle. Second through fourth cuttings are the most likely to have infestations of this blister beetle present.

Harvesting equipment and the way it is employed can greatly influence the likelihood that blister beetles present in the field will be killed.

Actively try to reduce the chances of killing blister beetles in forage fields. Beetles tend to rapidly leave mown hay if they have not been injured or crushed, thereby taking the cantharidin out of the field before the forage is baled.

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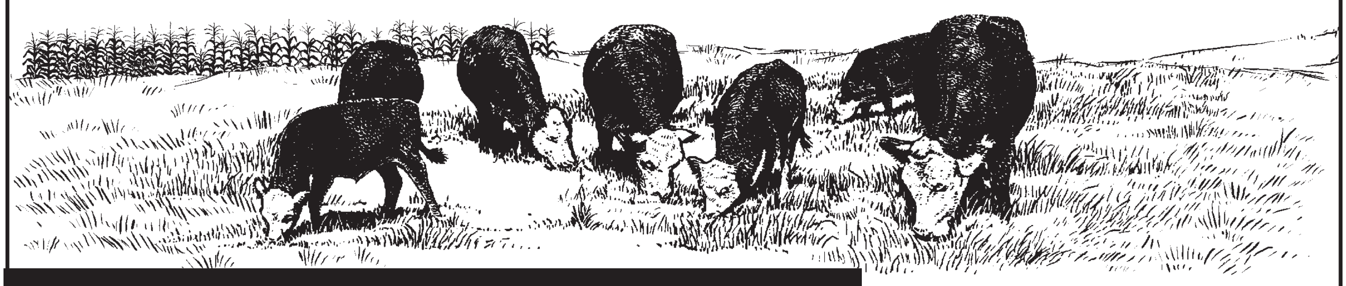

FORAGE FACTS

Publication Series

NUTRITIONAL REQUIREMENTS FOR BEEF COWS

INTRODUCTION

Cow nutrition is dynamic. Factors that affect cow nutritional requirements are cow size, stage of production, "work load," and environment (weather, ambient temperature, humidity). Because these factors can change daily, a beef cow's nutrient requirements are constantly in flux. Fortunately, most changes in nutrient requirements are subtle in nature and long-term nutritional programs can be planned. Requirement levels for energy are the most variable, followed by the protein, minerals and vitamins. Keep in mind, each cow has her own required amount of a particular nutrient to perform at a specified level; however, with tabular values, producers can still have confidence in their management programs. It has been and will continue to be common to report requirements as a percentage of the diet. In doing so, practitioners must know the nutrient requirement of the animal and the daily dry matter intake.

Energy drives every biological system in nature. Beef cows use energy to maintain body weight, gain weight, reproduce and to produce milk. Biological units of energy are measured in terms of calories making it unique to other nutrients. To convert calories, to pounds or a percentage of the diet, TDN (total digestible nutrients) was conceived. The drawback from using TDN in energy calculations is that TDN overestimates the energy value of forages and underestimates the energy value of grains. The energy requirement necessary to maintain body weight is closely related to the surface area of the animal. Body weight raised to the .75 power is a good estimate of surface area. Therefore, if the weight of the animal is known, the amount of energy that is required for maintenance can be calculated. The formula for maintenance is equal to 0.77 Mcal per kilogram of body weight raised to the .75 power. The environment, breed and body condition can affect the energy requirement to maintain body weight. Energy is also needed for animals to grow, produce edible products and to exercise or work. This energy is often called net energy for gain (or performance). Net energy for gain (NEg) is only available for the animal after the energy demands for maintenance are met. Net energy for gain requirements are not a function of body weight or surface area but are dictated by the nature of the work or the composition of the growth. Therefore, the animal's total energy demand is additive between maintenance and gain. And to complicate management decisions, producers should also remember that both dry matter intake and energy density of the diet affect animal performance simultaneously.

Proteins play many important roles in the ruminant body. Functions include enzyme systems, muscles, nerves and soft tissues. What makes ruminants unique is that dietary proteins (and other nitrogen sources) are first made available to microflora inhabiting the rumen. Those nitrogen sources used by rumen microorganisms have been called DIP (Degradable Intake Protein) and are used by the "bugs" to reproduce and to digest carbohydrates (cellulose, starch and sugar). Rumen microflora not only supply energy to the animal by breaking down cellulose and starches, but they are also one of the most balanced protein sources available to the animal. Dietary protein that is not utilized by the microflora is not necessarily wasted. Dietary protein that enters the small intestine unaltered is called UIP (Undegradable Intake Protein) and can play an important role in meeting the requirements of the host animal. Like energy, as cow weight increases, the requirement for protein increases. Forages are richest in protein when they are vigorously growing, and often meet or exceed the ruminant's protein requirement. As forages mature, quite often the protein content decreases to the point that cattle cannot consume sufficient DIP to maintain desired performance levels. Limiting protein adversely affects dry matter intake to the point that energy intake is compromised. Supplemental DIP has been shown to greatly stimulate low-quality forage intake and enhance animal performance more than starchy (high energy) supplementation. This is true only when dietary protein is the first limiting nutrient.

Major and trace minerals have important functions in the body. Bones are composed mostly of calcium and phosphorus. Many of the enzyme systems utilize minerals—enzyme systems that control such economic traits as immunity, reproduction, digestion and milk production. Dietary requirements for minerals make up a small percentage of the diet. Major minerals (calcium, phosphorus, salt) are commonly reported in grams per day or percentages, while trace minerals (copper, manganese, zinc) are usually reported in parts per million. Forages are good suppliers of most minerals, and their mineral content is a reflection of the native soil and weather. Many interactions exist between minerals and other nutrients making mineral nutrition fairly complicated. Subtle changes in mineral proportions can cause deficiencies. Producers sometimes look to supplementation of minerals as a cure all, however, quite often more fundamental concerns to energy and protein deserve greater scrutiny.

The two major classifications of vitamins are fat-soluble and water-soluble. Water-soluble vitamins, commonly called the B vitamins, are produced in sufficient quantities within healthy rumens so that dietary fortification is unnecessary. On the other hand, fat-soluble vitamins (Vitamins A, D, E) must be a part of the cattle diets. Fortunately, most green forages are high in these vitamins and only when they have been improperly harvested or stored will supplemental vitamins be advantageous. Vitamin A is commonly supplemented to cows during the winter months, particularly during the last trimester of pregnancy.

BEEF COWS' NUTRIENT REQUIREMENTS

A few of the basic nutrient requirements are listed in the following table. These values may be used as a baseline and adjustments for variations in animal and environmental factors may be used to calculate a specific animal's requirements.

Several assumptions have been made to determine the tabular values that are listed below. The table is based on cows weighing 1,100 pounds (in moderate body condition), who is average in milk production (15 pounds per day), and will be grazing within her thermal neutral zone. The following sections have been included to adjust tabular values to more correctly predict cow requirements.

ANIMAL ADJUSTMENTS

As a general rule, each 100-pound change in body weight directly changes the requirement for TDN by about .65 pound, NEm .57 Mcal, and crude protein about .1 pound daily. Milk production has a major affect on nutrient demand. Every 5-pound variation in milk production per day requires 1.2 pounds of TDN or 1.7 Mcal of NEm, .3 pounds of crude protein, 5.5 grams of calcium an 2.75 grams of phosphorus. Since energy used for exercise must be included in the animal's daily requirement, it has been determined that cows in grazing situations expand about .9 Mcal per day more than when kept in drylots.

Table 1. *NRC Requirements for an 1,100 pound beef cow producing 15 pounds of milk.*

	Nutritional Periods			
Lactation	Yes	Yes	No	No
Days post calving	82	123	70	90
	post-calving	pregnant & lactating	mid-gestation	pre-calving
TDN (lb/day)	14.5	11.5	9.5	11.2
NEm (Mcal/day)	14.9	12.2	9.2	10.3
Protein (lb/day)	2.3	1.9	1.4	1.6
Calcium (grams/day)	33	27	17	20
Phosphorus (gram/day)	25	22	17	20
Vitamin A (IU/day)	39,000	36,000	25,000	27,000

Nutrient Requirements of Beef Cows, NRC, 1984.

ENVIRONMENTAL ADJUSTMENTS

Energy is the only nutrient that is influenced by changes in the ambient temperature. Ambient temperature is defined as the temperature that is experienced by the animal. Wind speed and moisture are two factors that affect ambient temperature besides the temperature measured by a common thermometer. Haircoat condition is the major factor in determining lower critical temperature. Table 2 lists the lower critical (ambient) temperature of different haircoats. For each degree (F) below the lower critical temperature, energy consumption must increase 1 percent to prevent weight loss.

Table 2. *Estimated lower critical temperature for beef cattle.*

Coat Description	Critical temperature (°F)
Wet or summer coat	59
Dry fall coat	43
Dry winter coat	32
Dry heavy winter coat	19

SUMMARY

Advancements in beef cow nutrition have progressed to where tabular nutrient requirements can be insufficient in predicting animal performance. However, tabular data along with “cow sense” can be used to make good management decisions. Readers should remember that intake (nutrient concentration equals the amount of nutrient consumed, which is the true measure of nutrient requirements. When cattle are grazing, their daily dry matter intakes are difficult to measure. Also, the nutrient levels of forages (plant parts) that are actually consumed are difficult to obtain. Samples of harvested forages can be sent to commercial testing laboratories to approximate their nutritive values. Visual observation of animals allows for body condition scoring to accurately assess most nutritional programs for energy and protein. Finally, cattle producers should keep cowherd production records documenting individual reproductive and growth performance and use those records to assess past and predict future nutritional programs.

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FORAGE FACTS

Publication Series

FOAMY PASTURE BLOAT

INTRODUCTION

An important factor affecting animal performance of cattle grazing high-quality legume and cereal grain pastures is frothy bloat. Bloat can have potentially devastating effects on animal health, if cattle are not monitored closely, especially when cattle are first introduced to bloat-susceptible pastures and/or during certain climatic conditions and plant growth stages when the nutrient composition of the grazed forage changes rapidly. For example, average death losses attributed to wheat pasture bloat have been estimated at 2 to 3 percent, but can occasionally reach 20 percent. In addition to increased death loss, other consequences of bloat that reduce profitability of grazing enterprises include reduced weight gains, lower milk production, reduced feed efficiency, increased labor costs and added treatment costs. Understanding the causes of bloat and using practices that reduce and/or prevent pasture bloat will help to reduce losses and improve performance of cattle grazing lush forages.

DEFINITION

Foamy bloat occurs when cattle consume feeds that are readily digestible, such as finely ground grains and high-quality alfalfas, clovers and cereal grain forages. Once consumed, these feeds provide readily available nutrients that are immediately utilized by ruminal microbes, leading to a very rapid production of gas in the rumen. In the case of foamy, or frothy bloat, these gasses are then “trapped” in a thick, proteinaceous foam. The presence of the thick foam prevents the animal from expelling the gas, leading to excessive pressure and creating the characteristic distended abdomen. If severe cases are left untreated, pressure can continue to build, resulting in severe discomfort and eventual death.

CAUSES OF BLOAT

Bloat is thought to occur when highly digestible feeds are degraded and fermented rapidly. Rapid fermentation can occur when rapidly growing, succulent forages are consumed. This includes alfalfas and clovers grazed during the pre-bloom and early-bloom stages and cool-season annual and perennial forages during periods of rapid growth. Factors influencing the incidence of frothy bloat in grazing animals can be categorized into three areas: animal, plant and ruminal factors.

Animal Factors. Variation in incidence and severity of bloat between animals grazing the same pasture may be partially related to animal factors such as differences in diet selection, forage intake and saliva production. Increased saliva production may reduce formation and stability of frothy bloat through its potential anti-foaming characteristics, buffering capabilities and effects on rate of passage. Animals highly susceptible to bloat may secrete less saliva and/or have unique ruminal populations of bacteria and protozoa compared with less susceptible animals. Although forage intake would appear to affect an animal’s susceptibility to wheat pasture bloat, research remains unclear on the role of forage intake patterns on occurrence of bloat.

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Plant factors. In general, bloat provocative forages are actively growing, highly digestible species with high protein and low fiber contents. These include temperate legumes such as red clover, white clover, Persian clover and alfalfa, as well as small grains and annual and perennial grasses such as winter wheat. Foamy bloat has been associated with increases in soluble proteins and/or carbohydrates associated with the rapidly growing forage, as well as a more rapid release of plant cell contents in the rumen that leads to a high rate of ruminal gas production. In addition to soluble proteins, mineral content of the grazed forage also has been related to metabolic disorders of animals grazing winter wheat. Research indicates that increased occurrence of bloat is associated with increases in calcium (Ca) and magnesium (Mg) concentrations of legumes, as well as increased potassium (K) and/or potassium:sodium ratios of winter wheat.

Ruminal factors. Perhaps even more important than the mineral composition of the grazed forage are the relative ratios of cations ingested by the animal and present in the rumen. While ruminal concentrations of soluble proteins and minerals may not initiate bloat, they are believed to increase the stability of foam in the rumen, potentially increasing the incidence and severity of bloat. Attraction between soluble proteins, which are negatively charged, and positively-charged mineral ions present in rumen fluid can increase the stability and strength of foams. Similar to colloidal suspensions of soils, divalent (Ca and Mg) and trivalent ions can form bonds with two or three negatively charged protein particles, thereby creating a more stable foam compared with sodium, a monovalent ion. Several trials evaluating legume bloat indicated that ruminal Ca, Mg and K concentrations were significantly higher and Na levels significantly lower in bloating animals, suggesting Na supplementation may reduce the incidence of bloat. Additional wheat pasture bloat research also indicates an increase in occurrence of bloat concurrent with increases in forage potassium levels.

PREVENTION OF BLOAT

Cattle and pasture management, as well as the use of surfactants and additives will help to reduce the incidence of pasture bloat. Occurrence of bloat is affected by a combination of climatic conditions, soil fertility, forage maturity and grazing management factors. Reducing the incidence of bloat may require changes in several management practices, as well as close management of grazing animals.

Grazing Management. Possible pasture management techniques include managing interseeded, or "mixed" pastures to maintain no more than 50 percent alfalfa or clover, and selecting alfalfa and clover varieties with less potential for causing bloat.

Cattle Management. Fill cattle on dry roughage before introducing them to bloat-susceptible pastures. If possible, delay initial turnout until midday, when pastures are dry. Where facilities and labor management permit, identify animals with greater susceptibility to bloat and manage them separately.

Use of Surfactants. Surfactants, or anti-foaming agents, have been used successfully in some grazing situations. Spraying surfactants on bloat-provoking pastures when conditions are conducive to bloating works well, especially in highly controlled grazing systems with small paddocks. An alternative to pasture spraying is to add the agent to drinking water; however, addition to drinking water may be less effective because of variation in water consumption.

Poloxalene. Several studies indicate that feeding poloxalene (Bloat Guard) at levels of 1 to 2 grams/100 pounds of body weight per day dramatically reduces bloat. Poloxalene is a mild detergent that reduces the surface tension of the foam, resulting in decreased formation of foam and release of gasses entrapped in the foam. There are several products available for use in grazing programs, including mineral supplements, blocks, liquid feeds and top dresses. It is important to remember that in order to be effective, adequate amounts of poloxalene must be consumed on a regular basis. Guaranteed consumption of a sufficient amount of poloxalene may mean hand-feeding 1 to 2 pounds of a highly palatable supplement containing poloxalene each day.

Ionophores. Although not as effective as poloxalene, Rumensin and Bovatec have been shown to reduce the incidence and severity of frothy bloat while also improving animal performance. Research with winter wheat pasture indicates that ionophores may reduce the incidence of bloat by reducing the amount of gas produced by microbes in the rumen. Ionophores work well when included in supplementation programs, providing a level of bloat protection while improving daily gains throughout the grazing season.

SUMMARY

The occurrence of frothy bloat in grazing livestock is initiated primarily by a rapid release of plant cell contents that are quickly degraded and fermented in the rumen. The gasses produced in the rumen are then trapped in a thick foam that prevents the animal from expelling the produced gasses. While actual death loss due to bloat may be small, subclinical bloat can reduce animal performance and increase labor and medical costs. Evaluating your pasture management techniques, watching cattle closely, and providing bloat-reducing products can reduce the occurrence of bloat and improve animal performance when grazing lush, high-quality forages.

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FORAGE FACTS

Publication Series

HOW TO ASSEMBLE AND EVALUATE A FORAGE GRAZING SYSTEM

INTRODUCTION

Within a particular county, or even community, the basic forage resource may be quite different. Soil, kind of grass, dryland or irrigated forages, cool-season or warm-season and even annual or perennial plants make up part of that diversity. There is no one plan or program that fits all. Consequently, there is no "right or wrong" forage program. There are numerous options, and each producer must make careful selections. Any forage program must result in the most economical method that results in good livestock performance and is environmentally sound.

Which came first, the chicken or the egg? Each producer should match the forage program to the cattle needs or base the cattle to the forages that are available. Without question, a producer's overall forage production philosophy has an important influence on the type of forage program developed. For example: if the producer doesn't want to graze grain sorghum after harvest residue, that forage won't be part of this program.

There is a basic difference in producer philosophy in different parts of the United States. Some see themselves basically as *livestock managers* who run their animals on pasture. In other parts of the country, producers see themselves as *grass farmers* who are using livestock to harvest their grass.

ASSEMBLE THE SYSTEM

Producers should start with the inventory of the forages that they already have and develop the livestock program around the resource. Generally, the animal portion is either already on hand or we want to have a particular animal program, and then try to make an existing forage situation fit the needs of the livestock.

It would be ideal for producers to have the nutrient requirements of the grazing animals met by an existing forage mix.

Producers should inventory their forage source. Write down acreage and kind of forage. Note when it is high quality and when quality is low. Make an estimate of yields. Consult K-State Research and Extension agents or NRCS staff who have knowledge of production in your area. Work on averages. It is better to have more forage than expected instead of the reverse.

Next, inventory your animal requirements—cow/calf or yearlings, fall-calving or spring-calving. Does the forage that you currently have "line up" with the high nutrient requirements of the yearlings or cows during the first three months after calving?

Grass farmers will establish forages as needed to fit the animals' nutritional needs.

FORAGE PLANT SELECTION

There are no all season forage plants available, although native rangeland can be close. Producers should recognize the limitations of plant seasonality as well as take advantage of its benefits. Complementary forage systems that incorporate both cool- and warm-season plants (in separate pastures) provide nearly yearlong grazing.

COOL-SEASON FORAGE

Cool-season forage plants operate on the C_3 photosynthetic process. Optimum growth occurs around 65 to 75°. Cool-season forages start growth early in the spring, go dormant in the summer as it gets hot and dry, then resume growth in the fall and early winter. As a general rule, they both respond to applied fertilizer and require more moisture than warm-season plants. We have both perennial and annual cool-season forages. They all reproduce in May or June. The perennials regrow after seed maturity, whereas annual plants do not. Being cool-season, we call cool-season annuals "winter annuals."

Bromegrass. A native of Europe and introduced in the United States in the early 1880s. Can be used for grazing or hay. It is best adapted to well-drained soils in the 28- to 35-inch rainfall belt in Kansas. Will respond to nitrogen as well as P_2O_5 and K_2O if a soil test so indicates. Makes most of its yearly growth in the spring; limited growth in the fall. When cut for hay, leave a 4-inch stubble. Never graze below 3 inches. When grazed close, allow 30 days before grazing again.

Tall Fescue. A native of Europe and introduced in the United States in 1886. It is best adapted to claypan soils where excessive moisture is a problem some parts of the year. It is tolerant of more abuse than bromegrass, but really responds to good grazing management including fertilization. Producers should always plant a variety that is fungus free (no endophyte) to avoid animal performance problems. Legumes perform better in fescue than bromegrass because it is a "bunch" grass. The quality of tall fescue is best in the spring and fall. Stockpiled growth can be grazed in the winter. When fall nitrogen is applied, protein stays at about 10 to 12 percent. Without it, protein drops to 6 percent.

Winter Cereals. Winter annuals, such as wheat, rye or triticale, can be planted in early September and grazed when plants are established well enough that they are not pulled up by the grazing animal. In the case of wheat, it can be grazed and harvested for grain. Of course, the option to "graze-out" is always there. For graze-out situations, consider a mixture of wheat and rye; about one-third rye and two-thirds wheat. If you do not let the rye seed mature, there is no volunteer. Winter cereals respond well to nitrogen. Apply one-half of the total needed at planting and topdress the remainder during the winter. Total nitrogen should be 120 pounds. P_2O_5 and K_20 should be applied to the soil test. If wheat is grazed and cut for grain, too, do not graze later than about April 1 or jointing, whichever comes first. Other cool-season grasses include: orchardgrass, reedcanary grass, Kentucky bluegrass and Matua. These are limited in use—know the limitations of each before using them.

WARM-SEASON FORAGE

Native Rangeland. This is a true native mix of forage species which has been in existence since time began. Developed under the climate that exists, it has experienced drought, floods, fire, periods of destructive grazing and long rest periods. Today's native rangeland, from the Flint Hills east, is a diversity of plants—warm- and cool-season, grass and broadleaf, some annual and perennial. We usually say that big bluestem, little bluestem, indiangrass, switchgrass and sideoats grama are the grasses, when in reality the system may contain over 200 plant species. Fire is an important management tool today. Brush control and reduction of spot grazing are important reasons for its employment. In the case of yearling cattle, annual burns are important for animal performance. For cows, three consecutive years of fire are necessary for good brush control. The best way to improve rangeland is intensive early stocking or to double-stock until July 15, and then remove all cattle. Winter grazing does not hurt native rangeland, but may reduce fuel supply for spring burn.

Summer Annual Forages. Sudangrass, Sudansorghum hybrids, hybrid Sudangrass and hybrid pearl millet are summer annual forages. They all produce a lot of forage in a short period of time in late spring and summer. Of the summer annuals, hybrid pearl millet is the best to graze. When drilled at 10 pounds of seed per acre, it is ready to graze when it is 16 to 18 inches tall. It is very leafy and animals perform well. It does not contain prussic acid, but can accumulate nitrates under drought conditions. The Sudangrass annuals produce more forage than pearl millet, but two-thirds of the weight is in the stalk of the plant. Those forages are best used for hay (when cut early) or greenchop. All summer annuals respond to nitrogen. Apply 50 pounds of nitrogen at planting, and another 50 pounds six weeks later.

Crabgrass. This can be a valuable summer forage, too. Crabgrass is not native to the United States, but probably came in with European immigrants as a contaminant in seed for feedstuffs. Today, there is even a registered variety named Red River. Common or unnamed crabgrass is not as productive as Red River. Crabgrass is used for the forage production during the summer months. If planned, crabgrass will produce year after year by volunteering. It works very well in a winter cereal crabgrass rotation. Please discuss production details with your county agricultural agent.

Bermudagrass. A highly productive warm-season perennial, limited to about 12 counties in south central and southeast Kansas. A native of Africa, the plant lacks winter hardiness in most of Kansas. However, variety development continues to add to the production area. Stands are generally established by sprigging roots. Only one variety, Guyman, can be seeded and survival expected. Once established, nitrogen should be split into three applications: first in late April (75 pounds N); second, early June (50 pounds N); and third, mid-July (50 pounds N). Can be cut for hay two or three times or grazed with high stocking rates. Probably best for cows because individual animal performance on stockers can be less than 1.5 pounds per day; but that is not to say that it cannot be improved with management.

Other Warm-Season Forages. Eastern gama grass, alfalfa and other legumes offer a wide selection of forage crops to choose from. Please visit with your county agents and let them help you plan your forage program.

EVALUATION OF FORAGE PROGRAM

One would like to say if you made money, you must have a good program. But with depressed cattle prices, the one that loses the least may be a better evaluation tool.

In reality, forage programs must be evaluated on such things as:

- Weaning weight and cow conception rates
- Stocker gains: spring, summer, fall and winter
- Condition of perennial forage pastures
- Amount of hay purchased
- Animal health problems
- Was the producer happy with the results?

Now it is your turn to develop a forage program and evaluate it.

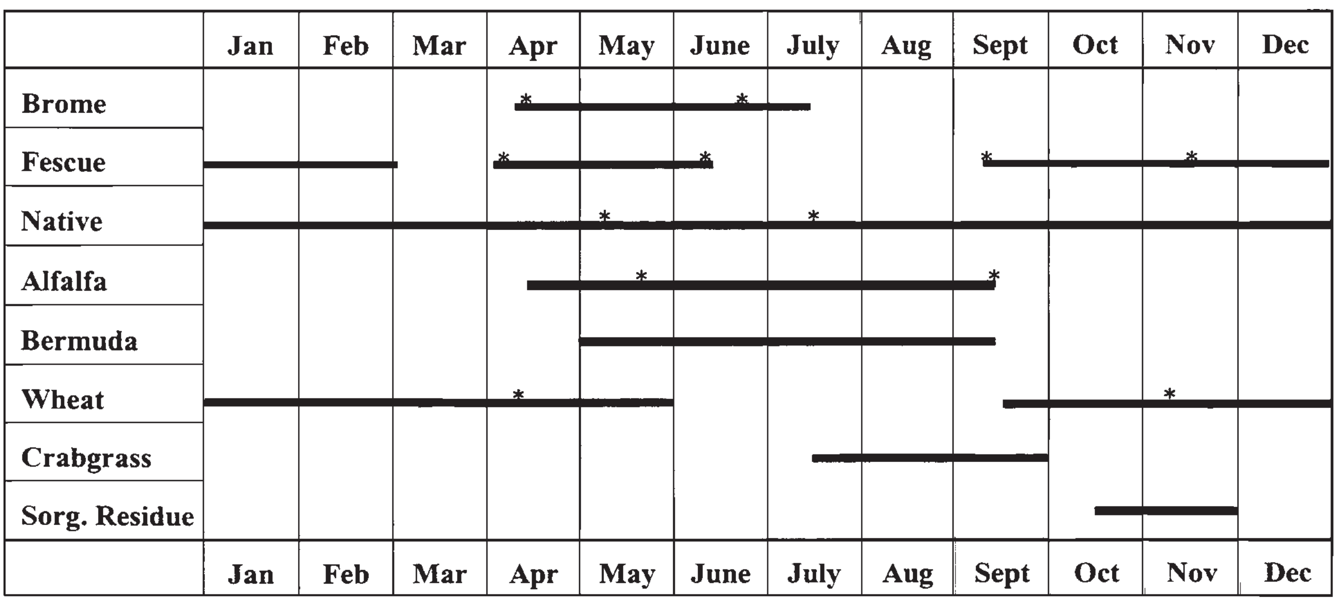
Situation 1. Cow/calf, calve in February to March, sell calves in the fall.

When are nutrient requirements the highest? What will you feed these cows year round?

Situation 2. Yearlings purchased in the fall, wintered and summer grazed. To keep average daily gain at least 1.5 pounds, what will you do?

Evaluation: How will you measure success?

Table 1. *Forages and Their Grazing Times*



* Indicates “best” grazing time.

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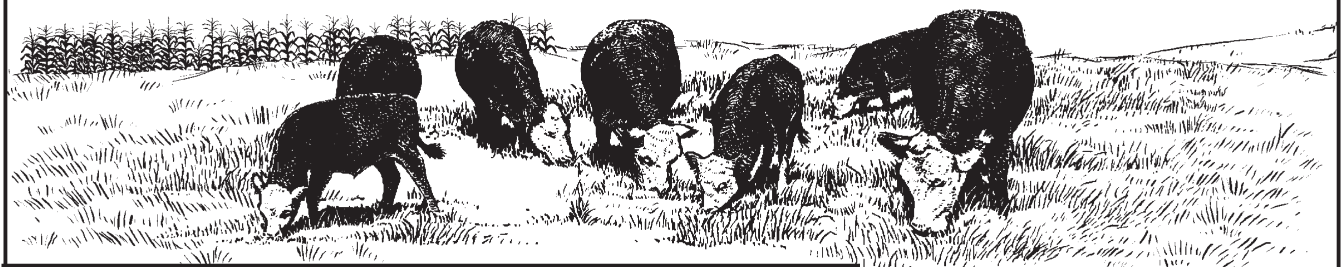

FORAGE FACTS

Publication Series

SERICEA LESPEDEZA

HISTORY

Sericea lespedeza (*Lespedeza cuneata*) is an introduced perennial legume that was first recognized as a potential weed problem in southeast Kansas in the early 1980s. Since that time, sericea has spread profusely throughout southeast Kansas and beyond. Southeast Kansas counties began declaring it a “county option” noxious weed in the late 1980s; and by July 1, 2000, it will be a statewide noxious weed in Kansas. This is the first time that a federally listed crop has been declared noxious.

Sericea lespedeza was introduced into the United States by the USDA in 1900 for erosion control. In the 1930s it was planted on strip-mined areas in southeast Kansas, and in the 1940s and ‘50s was planted around state and federal reservoirs for wildlife habitat. It is recognized for its tolerance of drought, acidity and shallow soils of low fertility. It will tolerate soils ranging from very acidic to slightly alkaline, but prefers a Ph of 6.0 to 6.5. It does best on clay and loamy soils that are deep, fertile and well drained, but will also grow on poor sites. Sericea uses water less efficiently than many other warm-season plants and does best when annual precipitation is 30 inches or more.

Most recent large-scale introductions of the plant occurred with establishing native grass on Conservation Reserve Program (CRP) acres, a provision of the 1985 Farm Bill. Numerous CRP fields throughout the eastern part of Kansas have been found infested with sericea lespedeza. The native grass seed used in these plantings was contaminated with sericea lespedeza seed—not recognized as a noxious or invasive weed at that time.

FORAGE QUALITY

Sericea lespedeza as a legume is recognized for its high levels of crude protein, but this is offset by high concentrations of chemical compounds called tannins. Tannins bind with proteins, leaving them unavailable for digestion. They also reduce the palatability and digestibility of forages. The level of tannins in sericea appears to increase with maturity of the plant, high air temperatures and low rainfall. The tannins also reduce insect feeding.

WILDLIFE CONSERVATION

Sericea lespedeza has been considered valuable for wildlife benefits, both as food and cover. However, this is not supported by research or practical experience. Deer will not utilize sericea unless it is kept short by mowing or grazing. Quail will consume the seeds in fall and early winter, but the seeds do not contain enough energy to sustain quail through adverse weather conditions. Sericea probably holds its greatest wildlife benefit as a source for cover, but when dormant, cover will be lacking because other plants are excluded by the sericea.

COMPETITIVE CHARACTERISTICS

Sericea lespedeza, once established, will reduce or eliminate competing vegetation. However, it is relatively slow to establish, having a rather weak and vulnerable seedling stage. On the other hand, it is opportunistic, and will establish itself in full sun or partial shade. While it tolerates shading quite well, it doesn't seem to establish in dense shade where direct sunlight does not reach during any part of the day.

Sericea perhaps establishes best where competing vegetation is very short, and light is allowed to reach the germinating seedlings. Many legumes need good exposure to sunlight during the seedling stage, which is the situation of a burned pasture. Fire is also assumed to scarify sericea seed, enhancing germination. However, the fire may result in more sunlight hitting the seed and seedlings, resulting in better germination. Seedlings will also germinate and survive where ground cover and other plant competition is quite dense but at a much lower population. It has established in fence rows, brushy and grassy areas, where fire and grazing have been excluded for years.

Once established, sericea restricts the amount of light reaching other plants because it is tall with multiple branches and dense foliage. It requires more water to produce foliage than other warm season plants, creating a “drought” for competing vegetation. It also produces allelopathic chemicals that inhibit seed germination and growth of other plants. Some of these chemicals are produced by the roots, while others come from plant residue, chiefly leaves.

Although sericea is a legume, it furnishes very little nitrogen to surrounding plants, and that amount is negated by the effects of the allelopathic toxins it produces. Rather than providing nitrogen for other plants, it actually makes it necessary to add nitrogen to maintain production of introduced forages. The shoots of grass exposed to the toxins of sericea residue have lower nitrogen content, consequently, overcoming the loss of production caused by the toxins requires nitrogen fertilization.

CONTROL

As with any weed problem, early detection and treatment is paramount to gaining control of this weed. Investing the time to control scattered plants and isolated patches must be done. Remedy and Escort are the two chemicals of choice at the present time for controlling sericea lespedeza. Once it becomes established over a wide area, an integrated approach to control will be necessary. Conventional management practices such as prescribed grazing and fire have been less than effective in preventing the spread of sericea in rangelands.

Chemical control includes Escort or Ally at .5 ounces per acre applied after bud stage until early October. Remedy is also effective at 1.5 pint per acre applied to actively growing plants in the vegetative stage (June) or in flower (late July to August). If applying from the ground, use a minimum of 20 gallons spray per acre. If sericea plants are not growing or flowering because of heat or drought conditions, herbicide effectiveness is greatly reduced. When Escort or Ally is applied in mid-September or later, seedling control has been observed the following spring because of herbicide carryover in the soil. Earlier applications do not result in this condition.

Some suppression of sericea has been observed after mowing or burning followed by intensive early stocking with stocker cattle. Livestock will consume the seeds and deposit them elsewhere in manure, so it is advisable to not graze sericea-infested range in fall and winter when the plants have produced seeds. Intensive early stocking provides this option. Goats will provide some control as they do eat sericea much more readily than cattle. However, any grazing control program must be closely monitored and continued once begun. Grazing will increase the number of tillers of each individual plant. This means that if grazing is ceased, then a larger, more robust, multi-tillered plant is left than if it had never been grazed, and will result in increased seed production. Current research with goats indicated that they will eat sericea and reduce seed production, but have not reduced plant population.

Mowing will reduce the vigor of sericea plants if it is cut closely multiple times each year. Plants should be mowed each time they reach a height of 12 to 18 inches. The most damaging time to cut sericea is late in the growing season when the plants are trying to build root reserves. However, mowing will not kill sericea, and may damage desirable grasses.

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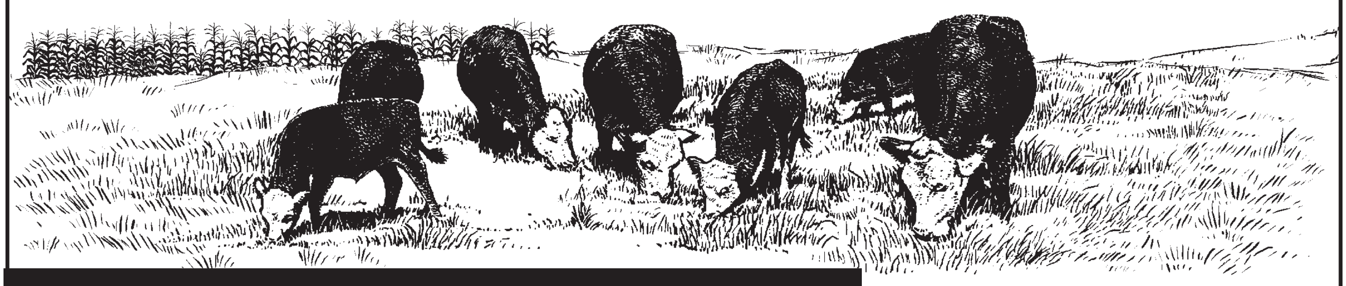

FORAGE FACTS

Publication Series

RELATIVE FEED VALUE MEASURES FORAGE QUALITY

INTRODUCTION

The most widely accepted measure of the quality of alfalfa is Relative Feed Value (RFV). RFV is an index used to compare the quality of forages relative to the feed value of full bloom alfalfa. RFV is used to compare similar forages for two important qualities—how well it will be consumed and how well it will be digested.

Alfalfa RFV is determined by its content of Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF). ADF evaluates the content on cellulose and lignin in a forage and is closely related to digestibility. ADF is also used to calculate the energy (NEM, NEL and NEG) content of a forage. NDF is an evaluation of the total fiber content which includes hemicellulose in addition to the cellulose and lignin content. The NDF content is related to intake because it evaluates the bulkiness of a forage.

RFV is calculated from the estimates of Digestible Dry Matter (DDM) and Dry Matter Intake (DMI) as follows:

$\%DDM = 88.9 - (0.779 \times \%ADF)$

Example:

If $\%ADF = 30\%$: $\%DDM = 88.9 - (0.779 \times 30) = 65.5\%$

$DMI = 120 \div \%NDF$

Example:

If $\%NDF = 40\%$: $DMI/\text{body cwt.} = 120 \div 40 = 3.0\%$

$RFV = (\%DDM \times \%DMI) \div 1.29$

$RFV = (65.5 \times 3.0) \div 1.29 = 152$

RFV has no units, instead, it is to be used to rank similar forages for potential dry matter intake. The RFV of alfalfa will be higher than other high-quality forages since the ratio of NDF to ADF is lowest in alfalfa. Therefore, RFV should be used to compare forages within the same species. The RFV of excellent-quality corn silage will not be as high as excellent-quality alfalfa, but that does not mean that corn silage is an excellent form of energy. Table 1 shows the RFV of various forages.

RFV of alfalfa can be too high when it is a major component of the forage program. Some extremely high quality alfalfa may test in excess of 200 RFV. Usually, an all alfalfa forage program with 180 or higher RFV will result in too rapid of a rate of passage of forage. Lower RFV forage should be included with unusually high RFV hay to slow the rate of passage.

Table 1. *Relative Feed Value of various forages.*

Forage	ADF (%)	NDF (%)	RFV (%)
Alfalfa, pre-bud	28	38	164
Alfalfa, bud	30	40	152
Alfalfa, early bloom	32	43	138
Alfalfa, grassy	39	54	101
Brome, late vegetative	35	63	91
Brome, late bloom	49	81	58
Corn silage, well eared	28	48	133
Corn silage, few ears	30	53	115
Sorghum silage	32	52	114

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When RFV is calculated, the protein content of the forage is not included in the calculation. Since protein is an expensive nutrient, the protein content of alfalfa should be considered along with RFV when evaluating its quality.

The best use of RFV is for selecting forages to be used in rations which require high nutrient density such as high producing dairy cows. Alfalfa with a RFV less than 140 should not be considered good enough for early lactation cows. However, alfalfa with a RFV of 125 to 140 could be fed to dairy cows in late lactation. Lower RFV alfalfa would be adequate for growing heifers.

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FORAGE FACTS

Publication Series

CATTLE GRAZING AND SOIL COMPACTION

INTRODUCTION

Soil compaction can be a problem on most Kansas soils. Compaction can reduce plant growth, inhibit root penetration, restrict water and air movement in the soil and, ultimately, reduce yields. Soil compaction is influenced by soil structure and texture, organic matter content, and soil water content. Figure 1 demonstrates the relationship between soil water content and susceptibility to compaction.

The structure of a soil (how well the soil breaks up into small, cohesive clumps when crumbled) also plays a role in the potential for compaction. A soil with higher levels of organic matter generally has better structure and resists compaction. Organic matter helps create large, strong soil aggregates. Hard, dense low organic matter soils suffer more from compaction than loose, friable, high organic matter soils.

What about cattle grazing and compaction? Grazing can result in compaction, yet compaction is rarely an issue in pastures grazed in conventional systems at normal stocking rates. Even in rotational grazing systems which concentrate large numbers of animals on smaller areas, there have not been concerns with compaction.

There are two primary reasons why compaction is not a major concern in grazing systems. First, established pastures generally have high organic matter levels, particularly in the surface 2 to 3 inches. High organic matter levels help resist compaction. In addition, pasture forages tend to have dense root systems which resist compaction. The second major reason compaction rarely becomes an issue in pastures is that the compaction caused by cattle grazing tends to be very shallow. This shallow compaction is easily eliminated by normal wetting/drying or freezing/thawing cycles in the soil.

What about equipment to address compaction in pastures? Machinery has been designed to help alleviate compaction; terminology like "pasture saver" or "pasture renovator" is used. Limited research in Kansas with equipment like this has not shown any consistent positive effects.

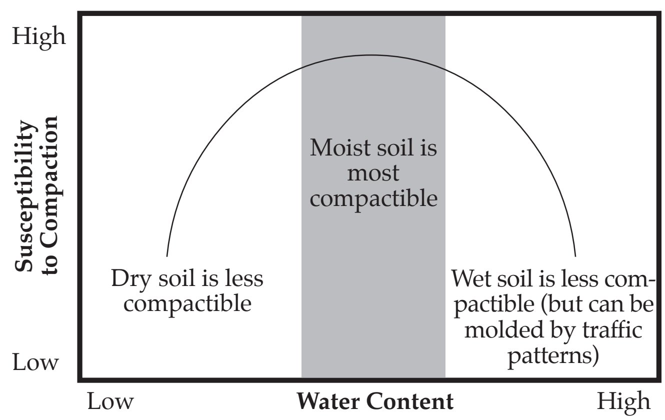

Figure 1

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FORAGE FACTS

Publication Series

SOIL TYPE AND FORAGE PRODUCTION

INTRODUCTION

The soils of Kansas are very diverse. Soils range from the weathered, shallow claypan soils of southeast Kansas to the relatively young, deep silt loam soils common in the western part of the state. In between, significant acreages of sandy soils exist, generally along and south of the Arkansas River. These soils vary in many properties including water holding capacity, acidity, depth and nutrient status. All of these properties can influence the suitability of a given soils potential for successful forage production. Fortunately, a wide array of forages are adapted to Kansas growing conditions. To address the issue of soil type and forage production, forages will be grouped into warm-season perennials, cool-season perennials, summer annuals, and legumes or grass legume mixtures.

WARM-SEASON PERENNIALS

Many of these species are native to Kansas and can do well on most soils in the state. They can be found on many acres deemed unsuitable for production of cash grain crops (shallow, rocky or eroded soils).

These species have good productive potential without supplemental fertilization, even when nutrient levels in the soil are often low. Because these forage species are so well adapted to the diverse Kansas soils, they were widely planted on the state's large CRP acreage.

COOL-SEASON GRASSES

The cool-season grasses grown in Kansas are introduced forages. They can be very productive but require a higher level of management than the grass forages. These grasses are best adapted to the soils of eastern Kansas and in favorable locations in central western Kansas—deep, well-drained soils. Many of these species are well adapted for irrigated pasture on a variety of soil types. These species can be productive on poor soils (shallow, rocky, eroded soils) but often require lime, nitrogen and other nutrients for optimum production. Even on deeper, highly productive soils, these forages require fertilization with nitrogen and sometimes phosphorus and/or potassium and may require liming.

SUMMER ANNUALS

These forages include Sudangrass, sorghum-Sudangrass hybrids, and millets. They can grow on most Kansas soils, with productive potential based primarily on moisture. Thus, in the drier areas of the state, they do best on deep soils with more water holding capacity.

LEGUME/LEGUME MIXTURES

Legume or grass-legume mixtures can be successfully grown on most soil types with moisture being a major limitation. Legumes may require supplemental fertilization (phosphorus and/or potassium) and liming (on acid soils). Legumes do not fare well on very shallow or rocky soils.

SUMMARY

Most of the forage species grown in Kansas can be productive on most Kansas soils. The level of production is usually a function of water, so deep soils with more water-holding capacity have more productive potential.

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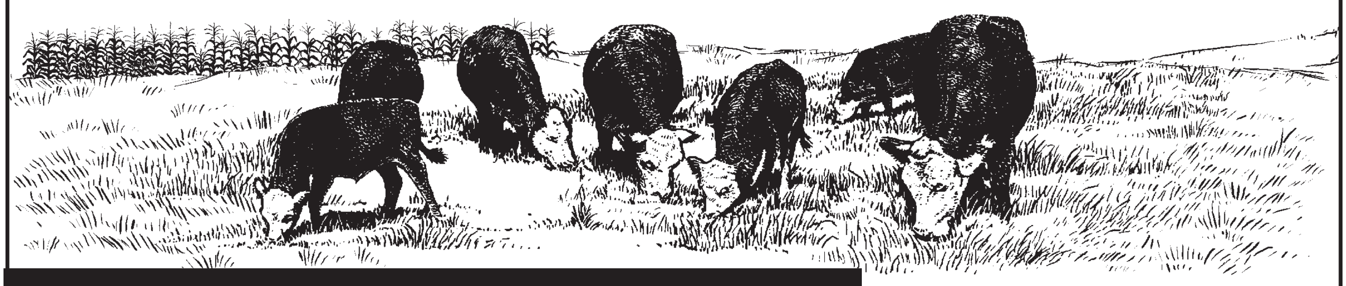

FORAGE FACTS

Publication Series

MUSK THISTLE CONTROL

INTRODUCTION

Musk thistle is an introduced invasive broadleaf weed native to Europe, Siberia, Asia Minor and North Africa. It was first introduced into the United States in 1852 in Pennsylvania. Musk thistle now occurs throughout most of the United States and is found in nearly all 105 Kansas counties. Musk thistle was first reported in Kansas in 1932 and was declared a noxious weed in 1963. It can be found growing on roadsides, railroad right-of-ways, building sites, vacant lots, range and pastureland, alfalfa fields and in wheat fallow.

Musk thistle is primarily a biennial or winter annual, relying on seed to reproduce. Seedlings may emerge any time during the growing season with optimum germination occurring in moist soils with temperatures between 59 to 86°F. The plant spends about 90 percent of its lifecycle as a rosette. The rosettes can be identified by the distinct light green midrib. Leaves are coarsely lobed, spiny, hairless and often have a silver-gray leaf margin. The stem elongates (bolts) in late April and May and the plants can exceed 6 feet in height. Flowering generally starts in May and may last several weeks. Musk thistle flower heads are large and have a "powder puff" shape in comparison to the "shaving brush" heads of many other thistles. Musk thistle flowers generally are rose-purple in color. Seed dispersal occurs 7 to 10 days after blooming. A single plant is capable of producing in excess of 10,000 seeds. Seeds can remain viable in the soil for a decade or longer.

CONTROL OPTIONS

The goal of any control practice should be to prevent seed production. The first line of defense against musk thistle invasion on range and pasture is good grazing management. Use stocking rates designed to avoid overgrazing, that maintain a competitive cover and prevent bare ground. Prescribed burning in the late spring just as the grasses are starting growth will not directly kill musk thistle, but does stimulate the warm season grasses that help prevent musk thistle from becoming established. Cool-season pastures should also be managed to maintain vigorous competitive stands. Proper stocking rates, proper season of use for grazing or haying, and maintenance of soil fertility will generally reduce the likelihood of musk thistle invasion in cool-season grass stands.

MECHANICAL

Scattered plants of musk thistle can be effectively controlled by hand cutting and digging. Cut through the taproot at least 2 inches below the crown to prevent resprouting. Individual flowering heads can be removed but new heads will develop in the leaf axils unless the entire plant is dug and allowed to dry out. Flowering heads that are removed should be placed in a tight container and either buried or allowed to rot to prevent possible seed germination.

Mowing can be an effective control of musk thistle if done when the plants are in the late-bloom stage. Repeated mowing is generally necessary to eliminate seed production and control musk thistle. Research at Kansas State University has shown that a single mowing at the late bud stage only killed 11 percent of the musk thistle plants. A second mowing, 4 weeks later, increased control to 79 percent.

CHEMICAL

A number of herbicides are labeled and effective for control of musk thistle. These include 2,4-D, dicamba, picloram and metsulfuron methyl. All chemicals must be applied according to label directions. Specific recommendations can be found in the annual issue of *Chemical Weed Control for Field Crops, Pastures, Rangeland and Noncropland* available from Kansas State University.

Chemical control of musk thistle declines after the plant bolts and begins to flower. Treatment of musk thistle rosettes in the fall or spring with recommended herbicides typically results in 90 to 100 percent control. Herbicide treatment after musk thistle bolts and begins to flower may control some plants but will probably not completely eliminate seed production.

Musk thistle control with herbicides is more effective when the plant is actively growing under conditions of good soil moisture and favorable air temperatures (70 to 90°F). Air temperatures should exceed 50°F when herbicides are applied in the fall. A 6-hour rain-free period after application is sufficient to ensure adequate absorption of the herbicide.

BIOLOGICAL

The head weevil, *Rhinocyllus conicus*, can provide biological control of musk thistle. The head weevil was first released in Kansas in 1973 in Riley County with widespread release of the organism by 1982. The head weevil is now commonly found in musk thistle stands throughout most of northeast and north central Kansas. The adult weevil lays its eggs on the bracts of the flower buds. The eggs hatch in 6 to 9 days and the larvae feed on the seed-producing tissue. Adults emerge starting in mid-July. The head weevil overwinters as an adult seeking protection under litter, at the base of plants and in wooded areas.

The rosette weevil, *Trichosirocalus horridus*, was first imported and released in Kansas in 1978. The adults begin laying eggs in the fall within the midrib on the undersides of the leaves on musk thistle rosettes. As larvae hatch, they begin feeding within the midrib and migrate toward the center of the rosette. Continual feeding by the larvae causes a blackened necrotic center on the thistle plant. This feeding may eventually kill the plant but often results in shorter, multistemmed plants the next spring.

Biological control is a long-term approach to musk thistle control. Typically, it takes 6 to 10 years after weevil release to see a significant impact on the thistle population. Any plan relying on the use of the musk thistle head or rosette weevil needs to be approved by the Kansas Department of Agriculture. Contact your local county weed director for assistance in developing a plan for biological control of musk thistle.

INTEGRATED PEST MANAGEMENT

Mechanical, chemical and biological options exist for control of musk thistle. The approach to use depends on the severity and location of the infestation. A single approach will work in many cases but long-term control may be enhanced by integration of methods. Control options can be integrated in time or space. Stands with head weevils can be sprayed in the fall or early spring when thistles are in the rosette stage. Mowing can be used after the primary heads have started to die and the adult weevils are emerging. Biological control might be used exclusively in remote or environmentally sensitive areas with large thistle populations. Herbicides or mechanical methods could be used in adjacent areas to prevent the spread of musk thistle, allowing time for the weevils to establish and for suppression to occur.

OTHER PUBLICATIONS

Chemical Weed Control for Field Crops, Pastures, Rangeland and Noncropland (Report of Progress issued annually)

Musk Thistle Identification and Control (L-231 revised)

Biological Control of Musk Thistle in Kansas (L-873)

Kansas Department of Agriculture. Musk Thistle Official Control Program (http://www.ink.org/public/kda/phealth/phprot/mthistle.html)

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FORAGE FACTS

Publication Series

FORAGE SAMPLING AND ANALYSIS

INTRODUCTION

Feed costs represent the lion's share of a cow/calf and stocker operator's expenses and are an ideal starting place to implement and maintain hard-nosed cost-control measures. Forage grazing systems utilized by beef producers throughout the United States are all vulnerable to unpredictable precipitation patterns as well as the seasonality of pasture and range forage quality. Simply put, forage is harvested to hedge against periods of time when the base forage supply is low or when animal nutrient requirements are elevated relative to what is available. However, forages are grown, harvested and stored under a variety of conditions that can dramatically affect feeding value. A nutrient analysis is the only means by which to properly establish the feeding value and determine if additional nutrient supplemental programs are necessary.

PROPER FORAGE SAMPLING IS ESSENTIAL

The indispensable prerequisite to feed cost control are the results of a forage analysis collected from a representative sample of the forage lot being analyzed. A forage lot consists of forage harvested from one field at the same cutting and maturity within a 48-hour period and usually contains fewer than 100 tons of hay. A forage lot should be similar for forage type, field (soil type), cutting date, maturity, variety, weed infestation, type of harvest equipment, weather during growth and harvest and storage conditions.

In the case of crude protein, improper forage sampling techniques can affect profitability and productivity from two different perspectives (1) a false high analysis of crude protein which actually is low, will result in a potential crude protein deficiency and (2) a false low analysis of crude protein, which actually is high, can result in excessive supplementation expenses. Based on a recent study conducted by Kansas State University to determine the extent of nutrient variation that can exist in a forage lot, sample sizes were determined for large round bales of various forage types to achieve various degrees of precision and confidence intervals. Table 1 contains the recommendations for the number of bales by forage lot that constitute a well-defined forage lot to be subsampled and composited into one sample for submission to a commercial analytical laboratory. The precision estimates were computed as percentage units not as fractions of the mean. For example, a forage lot of third cutting alfalfa estimated to average 20 percent crude protein would range from 19 to 21 percent with 1 percent precision and 19.5 to 20.5 percent with .5 percent precision. Users of the table on page 2 may discover that the recommended sample sizes exceed, or constitute a large proportion of the number of bales in the forage lot being sampled. Producers should subsample the recommended number of bales stated in the table as long as that number is less than 20 percent of the forage lot. If the recommended number of bales is greater than 20 percent of the forage lot, producers are advised to subsample 20 percent of the forage lot.

If sampling standing forage, it is recommended to select at least eight representative locations and clip the forage at grazing or harvest height from a 1 square foot area at each location.

SUBMITTING FEEDSTUFFS FOR NUTRIENT ANALYSIS

Many commercial hay probes are available on the market and range considerably in price. If the purchase of one is not an option, many county extension offices have forage probes available for use. Forage should be sampled as near to the time of feeding or sale as possible.

Be sure to allow time for test results to be returned for formulation of a ration or determination of supplement needs. As a general rule, allow 2 to 3 weeks for results of the analysis. Information turnaround will be affected by the particular analysis requested, methods employed and the overall number of samples received.

It is recommended to submit forage samples to an accredited laboratory of the National Forage Testing Association (NFTA). Accreditation is gained through participation in a check-sample program. Involvement in these programs indicates that the laboratory monitors its performance against that of other labs. Depending upon the nutrients being tested, a forage analysis will cost from $12 and higher. The report from the laboratory should clearly indicate the moisture (as-received) basis and dry matter basis.

When coupled with environmental variability, feed cost control represents a moving target that can only be bulls-eyed with appropriate planning and evaluation of existing options. The first step towards efficient feed cost control is knowing the quality of the forage. The key to getting that information is submitting a forage sample that is representative of the forage used in the feeding program.

Table 1. *Recommended number of large round bales to subsample and composite based upon desired degree of precision and confidence interval for crude protein content.*

Forage Type	Precision of Average Crude Protein Estimate, %	Confidence Interval 99%	95%	80%
1st Cutting Alfalfa	±1	19	11	5
	±.5	76	44	19
3rd Cutting Alfalfa	±1	12	7	3
	±.5	47	27	12
Prairie Hay	±1	4	2	1
	±.5	15	9	4
Sorghum-Sudan Hay	±1	7	4	2
	±.5	28	16	7

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FORAGE FACTS

Publication Series

GRAZING AND HAYING CONSERVATION RESERVE PROGRAM LAND

INTRODUCTION

Conservation Reserve Program (CRP) Land contracts began expiring October 1, 1997, and interest in managing these lands for grazing and haying has increased. Based on research in Kansas and surrounding states, converting CRP land to cropland can be expensive. The potential to graze or hay the land can be an alternative when managed properly.

BACKGROUND

CRP grass stands, both native and cool-season, were established and allowed to grow for 8 to 10 years, often without any management (mowing or burning). As a result, the stands have limited ground cover, large amounts of standing dead material and possibly litter layers. Large spacing between grass plants is common, resulting in poor plant vigor and low forage production. These characteristics prevent the grass plants from growing and developing normally. Research and experience have shown the need to develop the production potential while utilizing the plants. The primary needs of the stand are to remove standing dead growth, recycle the plant nutrients in the material and increase plant density. Initial stocking rates must be low in order to develop the grass plant's ability to produce forage and be grazed.

RESEARCH RESULTS

When CRP stands of mixed native species come out of the contract period, they are not in condition for full grazing pressure. Based on Kansas research and demonstrations from 1993 to 1996 and research in surrounding states, there is a need to bring the stands into full production through a management strategy covering 2 to 4 years. CRP stands need to be managed to reach their full productive potential. Several alternatives are possible based on the long-term goals for the land.

Research and experience have shown that developing the full forage potential of the stand is necessary in order to obtain optimum animal performance or hay production. Under the research program, stocking rates were reduced in succeeding years when heavy grazing occurred the first season. By reducing the stocking rate the first year or two, greater long-term production is realized.

The considerations necessary to develop the full potential of CRP grass stands is based on the need to condition the plants to use. After 5 or more years of little or no harvest (removal of old growth by any means), the plants are at a low vigor state and probably have a limited root system. The first requirement is to develop the vigor and root system of the existing plants and to enhance the number of species and plants.

Native Grass Stands. The following guidelines should be considered:

1. The stand should be mowed during March or April or prescribed burned in April to:
   a. Remove standing dead material (for burning, and excessive surface mulch).
   b. Recycle plant nutrients tied up in old growth.
   c. Allow sunlight to reach plant crowns.

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2. Management and use the first year should be to improve the vigor and productivity of the stand.
   a. If possible, hay the stand the first year (early July preferred).
   b. If grazing, use a light stocking rate (see suggested rates in Table 1). Stock to leave an average of 3 to 4 inches of stubble for tall grass stands and 2 to 3 inches of stubble for mid-grass stands at the end of grazing season.
   c. Use half-season grazing if possible (double stocking from May 1 to July 15).
3. Management after the first year.
   a. Do not burn unless heavy growth remains. Annual prescribed burning should be avoided until the stand is completely developed (2 to 4 years). Always burn only in spring when soil moisture will ensure good plant growth following the burn. Dry spring burns should be avoided.
   b. Adjust stocking rate according to stand development. Stocking rates after the first year should be based on the amount of forage left from the previous season. A sustainable stocking rate may require 2 to 4 years to reach.

Cool-season Grass Stands. The following guidelines should be considered:

1. Unless local CRP guidelines prohibit, the following steps are suggested:
   a. Take soil tests in July or August.
   b. Apply all required phosphorus and lime, plus 30 pounds of nitrogen per acre, in late August to early September **if** good soil moisture is available. (If soil moisture is lacking or local CRP guidelines prohibit, apply all fertilizer in late November or early December. Do not apply fertilizer to frozen soil.)

Table 1. *Suggested stocking rates based on remaining top soil for native CRP stands.* ***Rates are in pounds of live animal per acre at start of season.***

Amount of top soil remaining	east	central	west
	stocking rate (pounds/acre)		
no top soil loss	100	80	60
little top soil left	90	70	50
subsoil only	80	60	40

   c. In late November or early December, apply an additional 30 pounds of nitrogen. Do not apply fertilizer to frozen soil.
   d. If soil moisture is adequate for growth in late February to early March, a prescribed burn can be used to remove accumulated dead plant material.
   e. If grazing, use a light stocking rate (approximately 65 percent of stocking on comparable pastures). Stock to leave an average of 4 to 5 inches of stubble at the end of grazing season.
   f. Prescribed burning should be used only as needed to reduce heavy accumulations of dead materials.
   g. Adjust stocking rate according to stand development. Stocking rates after the first year should be based on the amount of forage left from the previous season. A sustainable stocking rate may require up to 4 years to reach.

MANAGEMENT FOR HAY PRODUCTION

Cool-season grasses (brome and fescue). Management should follow the same criteria as non-CRP stands. (See Smooth Brome and Tall Fescue fact sheets in FORAGE FACTS notebook.)

Native grass mixtures. See Native Hay Meadow Management fact sheet in FORAGE FACTS notebook.

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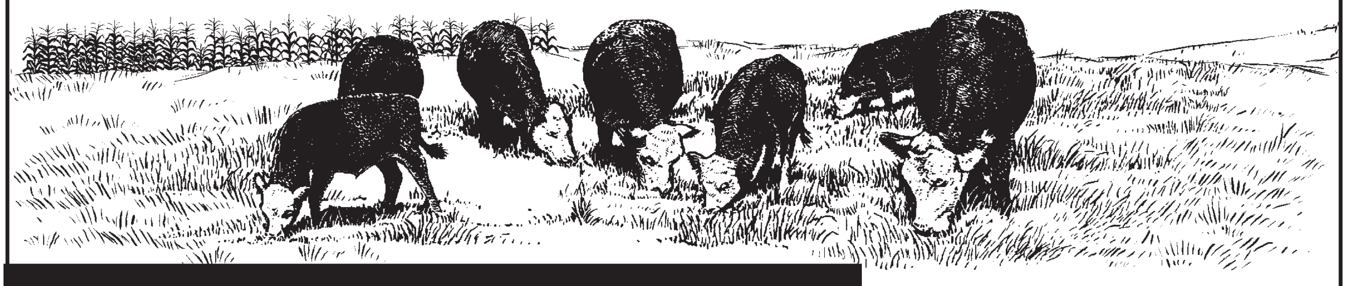

FORAGE FACTS

Publication Series

STORING LARGE ROUND BALES OUTSIDE

INTRODUCTION

One of the most economical hay production packages is large round bales. This is primarily because of low labor requirements. A survey of farmers in south central Kansas found that 72 percent used large round bales as their primary hay package. The survey also revealed that almost 60 percent of respondents store all hay unprotected in large round bales outside.

Baling a well-formed, dense bale is the first step toward minimizing storage losses through improved handling ability and storage. Moisture content at baling also plays an important role. If hay is too wet, quality could decrease due to heating. However, baling too dry could cause baler losses to increase dramatically. Round bales should be baled at moisture contents ranging from 15 to 20 percent. The ideal moisture content for large round bales is about 17 percent.

Storage method and length of storage period have a tremendous impact on weathering losses. Barn-stored hay suffers significantly less weathering loss than unprotected hay stored outside. Dry matter losses for barn-stored hay are typically in the 2- to 8-percent range. Covering outside stored hay can also reduce weathering. The longer hay is stored, the higher the losses. Hay stored outside will continue to deteriorate as long as it is stored, however most spoilage will occur early in the storage period. Hay stored in barns for long periods will also continue to deteriorate, though the rate is much slower. Large round bale storage losses can easily exceed 25 percent when bales are stored outside, unprotected in Kansas, but losses can be minimized through good management. If outside storage is the chosen method, pay close attention to selecting a storage site and stacking method.

CHOOSING A STORAGE SITE

A well-drained site minimizes deterioration on the bottom of the bale. Bales stored on damp soil absorb moisture that causes subsequent damage. If possible, elevate bales by stacking on old tires, shipping pallets or railroad ties. Adding a base layer of 3- to 4-inch crushed rock to the storage site will help minimize losses at the bottom of bales. Weeds or tall grass at the storage site will increase deterioration of the bottom of the bale. Storing bales on the ridge of a hill instead of near the bottom will also reduce bottom deterioration.

Round bales stored outside need air circulation and sunlight to help dry the outer layer after a rain. Storing the bales under trees blocks wind circulation and sunlight, which helps dry the bales. Any protection that trees might offer from rain is more than offset by the damage due to the shading they provide.

STACKING METHOD

There are a wide variety of methods for stacking large round bales. This publication will discuss the methods in three categories.

Individual Bales. Bales are sometimes stored individually without touching other bales for ease of handling with equipment that grabs the bale from both ends. If bales are stored individually, leave at least 18 inches between bales for air circulation. Storing bales with the rounded sides touching is not recommended. This creates a trap for rain and snow. The bales may be easier to handle with some equipment, but losses will be higher.

End to End. Tightly stacking bales end to end better utilizes storage area and protects the ends of bales from weathering. If bales are not stacked tightly against each other, rain could penetrate the ends and increase damage.

Aligning rows north-south allows an equal amount of sunlight on both sides of the bale row which results in more uniform drying. Leaving at least 3 feet between rows allows air to circulate through and sunlight to reach bales. The increased distance between rows reduces the chance of snow accumulation on the bales. If snow accumulation is a possibility, stack rows further apart. The greater distance allows sunlight to melt the snow sooner and reduces weathering losses from the snow.

Table 1 shows dry matter and quality losses associated with weathering for different stacking methods for alfalfa and brome hay storage in Kansas. Though this study found no significant differences between north-south versus east-west row alignment, the former is the preferred method. Quality losses on the north side of the east-west row exceeded those on the south side of the row. The bales used in the study were fairly dense and well formed, which again indicates that minimizing hay storage losses begins at baling. It also indicates that site selection is more important than row orientation.

Stacks. In the past, storing bales in pyramids has been the most popular way to stack large round bales. This is a good way to make the most of minimal storage space, however, if bales are not covered, weathering losses can be devastating. A South Dakota study reported dry matter losses in prairie hay stacked in pyramids at over 10 percent for one year of storage. Dry matter losses in the same study were 4 percent for bales stacked individually and less than 1 percent for bales stacked end to end.

Another method for stacking bales that is becoming popular in Kansas is to turn one bale on end and stack another on top of it. This method has been referred to as the "Canadian" method, though the source of this name is unknown. A K-State Research and Extension study indicates that this could be a feasible stacking method (Table 1). Dry matter and quality losses from bales stored in this manner were similar to those of bales stored end to end in north-south and east-west rows. Hay spoilage at the bottom of the bale was higher for this method, but less hay is exposed to the ground. High density, well-formed bales tied with plastic twine or net are necessary for bottom bales in these stacks. Sisal twine is not recommended since it can rot, causing bales to fall apart.

COVERING BALES

Covering bales offers some promise for reducing weather-related losses for bales stored outside. However, covering bales does have drawbacks. First, if a low-quality cover is used, it may be difficult to keep it on the bale. Wind damage can be devastating for plastic tarps. Any tears must be repaired immediately if the cover is to remain in place. Covers also need to be anchored to the ground or stacked to keep them in place. Reinforced plastic sheeting is more expensive, but will probably require less maintenance and last longer.

Covering bales with plastic will trap moisture the same as wrapping them in plastic. If high moisture hay (over 18 percent) is sealed under plastic, quality losses can result from excessive heating and mold development. Condensation of moisture at the top of the stack could also cause spoilage in high moisture hay. Stacking bales in pyramids before covering minimizes costs associated with the cover, by allowing a tarp to cover more hay.

Table 1. Average dry matter losses for storage sites and stacking methods for alfalfa and brome hay.

Stacking Method	Rooks County (alfalfa)	Wabaunsee County (brome)
E-W Rows	9.8%	11.0%
N-S Rows	10.1%	14.1%
Stacked	7.9%	11.6%

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NITRATE TOXICITY

INTRODUCTION

The potential for high nitrate concentrations occurs when crops such as corn, sorghum, cereal grains and some grasses are exposed to drought, hail, frost, cloudy weather, or soil fertility imbalance. Nitrates accumulate in the lower portion of the plant when stresses reduce the crop yield to less than that expected based on the supplied nitrogen fertility level. When fed to livestock, nitrates interfere with the ability of the blood to carry oxygen.

WHY NITRATES ARE TOXIC

Nitrate toxicity is a misnomer because nitrite (NO_2), not nitrate (NO_3), is poisonous to animals. After a plant is eaten, rumen bacteria rapidly reduce nitrates in the forage to nitrites. Normally, the nitrites are converted to ammonia and used by rumen microorganisms as a nitrogen source. However, if nitrite intake is faster than its breakdown to ammonia, nitrites will begin to accumulate in the rumen. Nitrite is rapidly absorbed into the blood system where it converts hemoglobin to methemoglobin. Red blood cells containing methemoglobin cannot transport oxygen and the animal dies from asphyxiation.

Animals under physiological stress (sick, hungry, lactating, or pregnant) are more susceptible to nitrate toxicity than healthy animals. Toxicity is related to the total amount of forage consumed and how quickly it is eaten, but, generally, if forages contain more than 6,000 ppm nitrate, they should be considered potentially toxic (Table 1).

Symptoms of nitrate toxicity may appear within a few hours after eating or not for several days. Signs of toxicity include reduced appetite, weight loss, diarrhea and runny eyes. However, these are nonspecific symptoms of numerous disorders and are not a reliable diagnosis of nitrate poisoning. Lower nitrate levels can cause abortion without any other noticeable symptoms.

Acute toxicity usually is not apparent until methemoglobin approaches lethal concentrations. Symptoms include cyanosis (bluish color of mucus membranes), labored breathing, muscular tremors and eventual collapse. Coma and death usually follow within two to three hours. Postmortem confirmation of nitrate toxicity is chocolate-colored blood; however, the color will change to dark red within a few hours after death.

Diagnosis and treatment of nitrate toxicity should be performed by a veterinarian. However, in acute cases where time is limited, an antidote of meth-

Table 1. Level of forage nitrate (dry matter basis) and potential effect on animals.

ppm Nitrate (NO_3)	Affect on Animals
0–3,000	Virtually safe
3,000–6,000	Moderately safe in most situations; limit use for stressed animals to 50% of the total ration.
6,000–9,000	Potentially toxic to cattle depending on the situation; should not be the only source of feed.
9,000 and above	Dangerous to cattle and often will cause death.

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ylene blue can be injected to convert the methemoglobin back to hemoglobin.

Forage suspected to contain high nitrate levels should be tested by a laboratory before feeding. Unfortunately, different laboratories may report nitrate level as either nitrate (NO_3), nitrate-nitrogen (NO_3-N), or potassium nitrate (KNO_3). Potassium nitrate, nitrate nitrogen, or percent nitrate can be converted to ppm nitrate using the conversion factors in Table 2.

Table 2. Conversion factors for expressing nitrate content of forages.

Potassium Nitrate x 0.61	= Nitrate (ppm NO_3)
Nitrate-Nitrogen x 4.42	= Nitrate (ppm NO_3)
% Nitrate x 10,000	= Nitrate (ppm NO_3)

PLANT FACTORS

Plant Species. Nearly all plants contain nitrate, but some species are more prone to accumulate nitrate than others. Crops such as forage and grain sorghums, sudangrass, sudan-sorghum hybrids and pearl millet are notorious nitrate accumulators. Weed species such as kochia, lambsquarters, sunflower, pigweed and Johnsongrass also are often high in nitrate. Under certain environmental and managerial conditions, corn and cereal grains like wheat and oats, and other plants can accumulate potentially toxic levels of nitrate. Under extreme stress, legumes like alfalfa and soybean also can accumulate nitrate.

Stage of Growth. Nitrate content generally is highest in young plant growth and decreases with maturity. Sorghums and sudangrasses, however, are exceptions because concentrations can remain high in mature plants. If plants are stressed at any stage of growth, they can accumulate nitrate.

Plant Parts. Highest nitrate levels occur in the lower one-third of the plant stalk and concentrations tend to be low in leaves because nitrate reductase enzyme levels are high there. Grain does not contain appreciable amounts of nitrate.

ENVIRONMENTAL FACTORS

Drought. Nitrates accumulate in plants during periods of moderate drought because the roots continually absorb nitrate, but very high daytime temperatures inhibit its conversion to amino acids. During a severe drought, lack of moisture prevents nitrate absorption by plant roots. Following a rain, however, the roots rapidly absorb nitrate and accumulate high levels. After a drought-ending rain, it requires at least two weeks before the nitrates will be metabolized to low levels, provided environmental conditions are optimum.

Sunlight. Shaded plants lack sufficient photosynthetic energy to convert nitrate to amino acids. Extended periods of cloudy weather increase nitrate content and dangerously high levels can occur when wet, overcast days follow a severe drought.

Frost, Hail, or Disease. Conditions such as hail, light frost, herbicide drift or plant disease can damage plant leaf area and reduce photosynthetic activity. With less available energy, nitrate reduction is inhibited and nitrates accumulate in the plant.

Temperature. Low temperatures (less than 55°F) in the spring or fall retard photosynthesis of warm-season plants and favor nitrate accumulation. Extremely high temperatures also increase concentrations by reducing nitrate reductase activity.

MANAGEMENT FACTORS

Fertilization. Applying high amounts of manure or other fertilizer, particularly in late season, increases concentrations. Split nitrogen applications provide better nutrient distribution and reduce the potential for toxicity.

Harvest Technique. Silages made from stressed forages should be analyzed after ensiling because the fermentation process usually converts about 50 percent of the nitrates to a nontoxic form. If forages are harvested as hay, nitrate concentrations remain virtually unchanged over time.

High nitrate forages may be grazed, but a dry roughage should be fed first to limit intake. Light to moderate stocking rates should be used because overgrazing forces cattle to eat the stems which contain the highest nitrate levels. Cattle should be removed from potentially susceptible forage for at least seven to 14 days after a drought-ending rain. Lush regrowth of heavily fertilized grasses can contain high nitrate levels and should not be grazed. If plants are fed as green chop, the harvested forage should be fed immediately after cutting and not allowed to heat.

FEEDING HIGH NITRATE FORAGES

Before feeding potentially troublesome plants such as sorghum and sudangrass, analyze the forage for nitrates. Environmental conditions in Kansas create high nitrate concentrations in some forages virtually every year. Consequently, nitrate analysis is necessary to determine if the feed is potentially toxic. High nitrate forages can be fed to animals if proper precautions are taken.

Gradually Adapt Cattle to High Nitrate Feeds. Nitrate toxicity frequently occurs in animals without prior exposure to nitrates. If nitrate levels in the forage are not excessively high (e.g., over 9,000 p.m.) the animal will usually be able to adapt somewhat to increasing amounts in the feed. Frequent feeding in limited amounts throughout the day rather than large amounts once daily will increase the total amount that can be safely fed.

Dilute With Other Feeds. Based on nitrate analysis, blend high nitrate forage so that the overall diet contains less than 5000 ppm nitrate on a dry basis. After three to four weeks of feeding, the animals normally become adjusted to nitrates and the proportion of high nitrate forage can be increased somewhat.

Supplement Grain. Feeding 2 to 5 pounds of grain or byproduct dilutes the amount of nitrate in the total ration and provides the energy necessary for bacteria to quickly convert nitrite to ammonia. Molasses also can provide needed energy for nitrite reduction but may be cost prohibitive.

Feed a Balanced Ration. Formulate rations to ensure adequate protein, energy, vitamin A and other nutrients. Nitrates may increase the requirement for vitamin A, but excessive supplementation is unjustified. Non-protein nitrogen (urea) may not be well utilized and should not be fed with high nitrate forages.

Do not Feed to Stressed Livestock. Animals that are sick, hungry, pregnant, or lactating have a lower tolerance for nitrates than healthy animals.

Provide Clean Drinking Water. Frequent intake of high quality water is important for optimal rumen fermentation. Analyze the livestock water supply to determine whether it is contributing to the nitrate burden of cattle. Ponds or ditches that collect runoff from feedlots, heavily fertilized fields, septic tanks, or manure piles are likely polluted with nitrates.

SUMMARY GUIDELINES TO REDUCE NITRATE TOXICITY

- Pay close attention to potentially troublesome plants, such as sorghum, sudangrass and other summer annuals, which often have high nitrate levels.
- Avoid excessive application of manure or nitrogen fertilizer.
- Raise cutter bar 6 to 12 inches to exclude basal stalks. This will also minimize harvesting many weed species that have accumulated nitrate from shading.
- Delay harvesting any stressed forages. Two weeks of favorable weather generally are required for plants to reduce accumulated nitrate.
- Never feed green chop that has been heated after cutting or held over night.
- Harvest plants containing high levels of nitrate as silage rather than hay.
- Have representative samples of suspect forage analyzed before feeding.

OTHER PUBLICATONS

Nitrate and Prussic Acid Toxicity in Forage (MF-1018).

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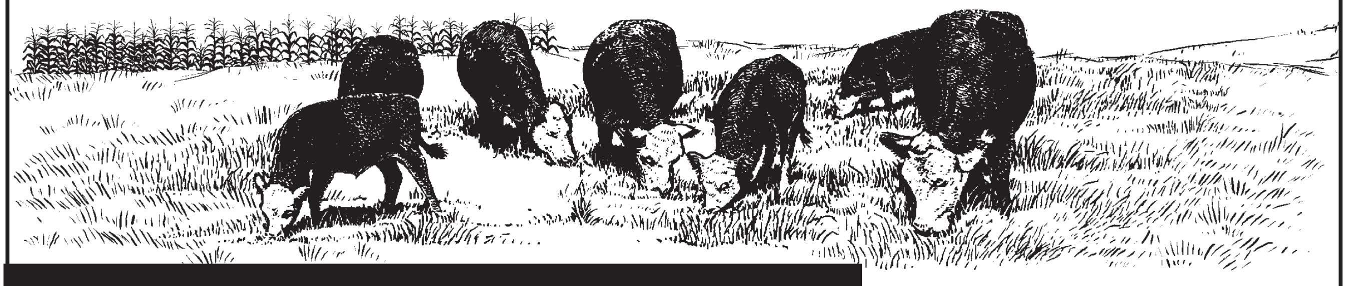

FORAGE FACTS

Publication Series

PRUSSIC ACID POISONING

INTRODUCTION

Prussic acid is also known as hydrocyanic acid or hydrogen cyanide (HCN). Prussic acid poisoning is caused by cyanide production in several types of plants under certain growing conditions. Sorghums and closely related species are the plants most commonly associated with prussic acid poisoning. Prussic acid precursors are degraded by the animal to release hydrogen cyanide (HCN), which affects the animal. Poisoning occurs when livestock consume young plants, drought stressed plants, or damaged plants that are high in prussic acid.

WHY PRUSSIC ACID IS TOXIC

Once eaten, cyanide is absorbed directly into the bloodstream and binds to enzymes in the cell. This cyanide complex prevents blood hemoglobin from transferring oxygen to individual body cells and the animal dies from asphyxiation.

Cyanide poisoning is related to the amount of forage consumed and the animal's physiological condition, but HCN levels exceeding 200 ppm on a wet weight (as is) basis are dangerous. On a dry weight basis, forages with more than 500 ppm HCN should be considered potentially toxic.

Prussic acid acts rapidly, often killing the animal within minutes. Symptoms include excessive salivation, difficult breathing, staggering, convulsions and collapse. Death from respiratory paralysis follows shortly. The clinical signs of prussic acid poisoning are similar to nitrate toxicity, but animals with cyanide poisoning have bright red blood that clots slowly, whereas animals poisoned with nitrate have dark, chocolate-colored blood. The smell of bitter almonds is often detected in animals poisoned with cyanide.

Because it occurs quickly, the symptoms are usually observed too late for effective treatment. In the absence of a veterinarian, and if there is little doubt about the diagnosis, the animal can be treated with an injection of sodium nitrate and sodium thiosulfate. Sodium nitrate releases the cyanide from the cell, which then binds with the sodium thiosulfate to form a nontoxic complex that is excreted. Animals still alive one to two hours after the onset of visible signs usually recover.

PRUSSIC ACID CONCENTRATION FACTORS

Plant Species. Crop species most commonly involved with prussic acid poisoning are forage and grain sorghums, Johnsongrass and sudangrass. Potential cyanide production among varieties and hybrids of most summer annual forages varies widely. Grain sorghums are potentially more toxic than forage sorghums or sudangrass, whereas hybrid pearl millet and foxtail millet have very low cyanide levels. Indiangrass, flax, choke cherry, elderberry and some varieties of birdsfoot trefoil can also cause prussic acid poisoning.

Table 1. Level of prussic acid in forage (dry matter basis) and potential effect on animals.

ppm HCN	Effect on animals
0–500	Generally safe; should not cause toxicity.
600–1,000	Potentially toxic; should not be the only source of feed.
1,000 and above	Dangerous to cattle and usually will cause death.

Plant Age and Condition. Young, rapidly growing plants are likely to contain high levels of prussic acid. Cyanide is more concentrated in the growing point and young leaves than in older leaves or stems. New sorghum growth, especially "suckers" or tillers, following drought or frost are dangerously high in cyanide. Pure stands of Indiangrass that are grazed when the plants are less than 8 inches tall can possess lethal concentrations of cyanide.

Generally, any stress condition that retards normal plant growth may increase prussic acid content. Hydrogen cyanide is released when plant leaves are physically damaged by trampling, cutting, crushing, wilting or chewing.

Drought and Frost. Drought-stunted plants accumulate cyanide and can possess toxic levels at maturity. Freezing ruptures the plant cells and releases cyanide, After a killing frost, wait at least four days before grazing to allow the released HCN gas to dissipate.

Prussic acid poisoning is most commonly associated with regrowth following a drought-ending rain or the first autumn frost. New growth from frosted or drought-stressed plants is palatable but can be dangerously high in cyanide.

Soil Fertility. Plants growing in soils that are high in nitrogen and low in phosphorus and potassium tend to have high cyanide concentrations. Split applications of nitrogen decrease the risk of prussic acid toxicity.

Animals. Most losses occur when hungry or stressed animals graze young sorghum growth. Ruminants are particularly susceptible to prussic acid poisoning because cud chewing and rumen bacteria both contribute to releasing cyanide. The plant enzyme responsible for hydrolyzing HCN from dhurrin is destroyed in stomach acid, which allows monogastric animals, such as horses and swine, to be more tolerant of cyanide than ruminants.

Feeding grain or hay before turning animals to pasture reduces rapid intake and dilutes the amount of cyanide consumed. Animals do not adapt or become immune to cyanide, but they can detoxify low HCN levels.

Harvest Technique. Prussic acid concentrations are higher in fresh forage than in silage or hay because HCN is volatile and dissipates as the forage dries or ensiles. However, if the forage had an extremely high cyanide content before cutting, or if the hay was not properly cured, hazardous concentrations of prussic acid could remain. Hay or silage that likely contained high cyanide concentrations at harvest should be analyzed before it is fed.

GUIDELINES TO AVOID PRUSSIC ACID POISONING

- Do not allow hungry cattle to graze where prussic acid may be a problem.
- Do not allow animals to graze potentially troublesome plants after a light frost or after rain has ended a summer drought.
- Hay or ensile plants high in cyanide to reduce toxin levels.
- Have representative samples of any suspect forage analyzed before feeding.

OTHER PUBLICATIONS

Nitrate and Prussic Acid Toxicity in Forage (MF-1018)

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FORAGE FACTS

Publication Series

GRASS TETANY

INTRODUCTION

Grass tetany, also called grass staggers, wheat pasture poisoning, magnesium tetany and hypomagnesia, is a magnesium deficiency of ruminants usually associated with the grazing of cool-season grasses during spring. It is most prevalent among older cows in early lactation, but may also affect young or dry cows and growing calves. Grass tetany occurs most frequently when cattle are grazing lush, immature grass, but occasionally occurs when cattle are fed dry forages (winter tetany).

CAUSES

Grass tetany is a nutritional or metabolic disorder characterized by low blood magnesium, yet it is not just a simple magnesium deficiency. Low blood magnesium may be caused by (1) a diet low in magnesium, (2) a diet with nutrient imbalances that interfere with magnesium metabolism, or (3) high levels of milk production. When blood magnesium drops too low, proper nerve impulse transmission fails, causing the disorder.

Magnesium needs are greater for lactating than for nonlactating animals and greater for older than for younger animals. There are differences among bovine breeds in susceptibility to grass tetany with Brahman and Brahman crossbreds being more tolerant and European breeds being less tolerant. Many factors influence forage magnesium concentration and availability. The principal factor is a high level of potassium, which negatively affects soil magnesium uptake by plants and the availability of the forage magnesium to the animal. High nitrogen content of grass seems to also be associated with low blood magnesium. High nitrogen fertilizer may reduce magnesium availability, especially on soils high in potassium or aluminum.

Grass tetany occurs most frequently in the spring, often following a cool period (temperatures between 45 and 60°F) when grass is rapidly growing, but also is seen in the fall with new growth of cool-season grass or wheat pasture. It occurs most frequently in cows that are nursing calves under 2 months of age, and is more likely to occur in beef herds than in dairy herds. Grass tetany seldom occurs when legumes and legume grass mixtures are a major portion of an animal's diet. Legumes may contain over twice the concentration of magnesium as do grasses grown on the same soil.

SYMPTOMS

Quite frequently, clinical signs of grass tetany are not observed and the only sign is a dead animal. Affected animals may become excitable—exhibiting a wild stare with erect ears and appear to be blind. They are uncoordinated and tend to lean backward and stumble or go down. The following progressive series of signs have been observed in cattle affected by grass tetany: (1) grazing away from the herd, (2) irritability, (3) muscular twitching in the flank, (4) wide-eyed and staring, (5) muscular incoordination, (6) staggering, (7) collapse, (8) thrashing, (9) head thrown back, (10) coma and (11) death.

PREVENTION

The prevention of grass tetany depends largely on avoiding conditions that contribute to the disorder. Some of the management practices to avoid grass tetany include:

- Avoid grazing cattle on new grass until it is 4 to 6 inches tall because magnesium is less available in very immature plants.
- Feed legume hay or graze mixed legume-grass pastures since legumes are higher in magnesium than grasses.
- Graze less susceptible animals on high risk pastures. Heifers, dry cows or cows with calves over 4 months old, and stocker cattle are less likely to develop tetany.
- Feed a magnesium supplement.

In areas where tetany frequently occurs, routinely feed cattle supplemental magnesium which increases blood magnesium levels and alleviates much of the grass tetany problem. Magnesium is not stored by the body, so care must be taken to ensure that each animal receives the proper amount on a daily basis. Begin supplementation before cattle are turned out on tetany-prone pasture, and continue until the threat is minimal. Magnesium oxide is a good source of magnesium, but since it is not palatable, it should be included in a highly palatable energy or mineral supplement. Magnesium oxide (54 to 60 percent magnesium) can be added at the rate of 75 to 150 pounds per ton of supplement when 1 pound per head is fed daily. Alternatively, a "High Mag" mineral containing 8 to 10 percent magnesium, should be fed free choice.

TREATMENT

Treatment results vary from excellent to poor depending on the clinical stage of the animal at the time of treatment. If treatment is started within one to two hours after clinical signs develop, the results are usually a quick recovery; however, in a large pasture it may be difficult to quickly identify sick cattle. Pasture cattle should be observed at least twice a day when they are first turned to grass. Treatment of animals that are in a coma may be too late. The normal treatment is intravenous injection of a commercial preparation of magnesium and calcium in a dextrose base. Consult your veterinarian, and have medication on hand before turning cattle out to graze.

SUMMARY

Grass tetany is a result of a magnesium deficiency. Clinical signs usually begin with nervousness and staggering and progress to falling, coma and death. Grass tetany is always an emergency requiring immediate medical attention. Treatment consists of intravenous administration of a magnesium and calcium solution. The injection of magnesium sulfate under the skin may provide a high level of magnesium in the blood in 15 minutes. The best prevention methods include keeping cattle off new grass until it is 4 to 6 inches tall and supplementing magnesium on a daily basis when conditions are favorable for grass tetany.

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Small Grain Cereals for Forage

Department of Agronomy

Small grain cereals can be a valuable forage supplement to summer annuals and native grass pastures, and a good primary forage when backgrounding beef cattle. Depending on grain and cattle prices, producers sometimes realize a higher net income by harvesting small grain cereals as forage rather than as grain.

For fall and spring pasture, producers can use winter wheat, rye, barley and triticale. These crops, along with spring oats, can also produce an early summer supply of hay or silage. Animal health concerns, such as nitrate poisoning, are less likely to occur with hay and silage from small grains than with summer annual forages.

Production Factors

Maximizing the forage potential of any of these cereal crops depends on several basic production factors.

Planting date

It is important to follow the recommended planting dates for each crop (Table 1). In general, the earlier the planting, the better—within acceptable ranges. If fall-seeded crops are planted late, total forage production will be reduced. If spring-seeded cereal crops are planted late, hay or silage production potential will be limited.

For best pasture production, planting of small grain cereals should begin about 2–4 weeks before the Hessian fly-free date. When planting wheat for forage, use Hessian fly-resistant varieties if feasible. Rye, barley and triticale generally aren't affected by Hessian fly. If planting is delayed until October and winter or early spring pasture is needed, rye is the most likely to provide ample forage.

Table 1. Suggested Planting Dates for Small Grain Cereals for Pasture.

Crop	Planting Date*
Wheat	Zone 1: 8/25–9/10
	Zone 2: 9/1–10/5
	Zone 3: 9/1–10/10
	Zone 4: 9/5–10/10
Barley	Zone 1: 8/25–9/10
	Zone 2: 9/1–9/20
	Zone 3: 9/10–10/15
	Zone 4: 9/10–10/5
Rye	Zone 1: 8/20–9/10
	Zone 2: 8/25–9/20
	Zone 3: 9/1–9/25
	Zone 4: 9/1–10/1
Triticale	Zone 1: 8/20–9/10
	Zone 2: 8/20–9/20
	Zone 3: 9/1–9/25
	Zone 4: 9/1–10/1
Spring Oats	Zone 1: 3/5–3/30
	Zone 2: 3/1–3/25
	Zone 3: 3/1–3/20
	Zone 4: 2/20–3/15

* With the later dates in these ranges, fall forage yields will be reduced.

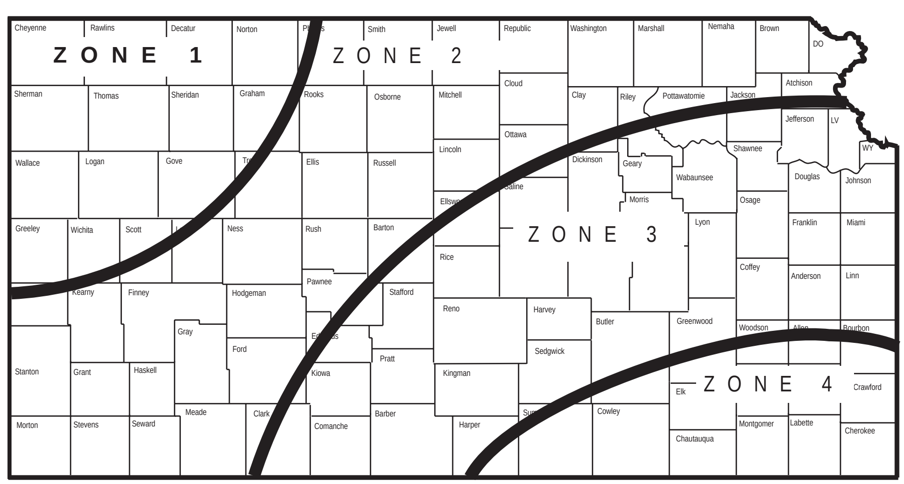


Table 2. Suggested Seeding Rates for Small Grain Cereals for Pasture.

Crop	Seeding Rate (lb/a)
Wheat	West, dryland: 30–60 West, irrigated: 60–90 Central: 60–90 East: 75–100
Barley	West, dryland: 30–60 West, irrigated: 72–96 Central: 60–96 East: 72–96
Rye	West, dryland: 30–60 West, irrigated: 75–100 Central: 60–75 East: 75–100
Triticale	West, dryland: 30–60 West, irrigated: 75–100 Central: 60–75 East: 75–100
Spring Oats	West, dryland: 32–48 West, irrigated: 64–96 Central: 48–64 East: 64–96

Seeding rates

For fall grazing, seeding rates of small grain cereals should be 25–50 percent higher than normal (Table 2). A heavier seeding rate will provide forage earlier in the fall. Spring oats also should be planted at 25–50 percent higher seeding rates when grown for hay or silage rather than for grain. Thicker plantings will reduce stem size and make curing or ensiling easier.

Fertilization

Adequate fertilizer amounts are required for maximum forage production with small grain cereals. All small grains respond to nitrogen. In general, when a small grain cereal is grown for pasture, nitrogen rates should be increased by about 30–50 pounds per acre. The extra nitrogen required can be calculated using the following formula:

Additional lbs nitogen/acre = (No. of animals/acre) x (Lbs. of weight gain/animal) x 0.4

Split applications can help reduce lodging and the possibility of nitrate poisoning. In a total graze-out program, all the fertilizer can be applied preplant—except on sandier soils—or regular topdress applications can be made through the fall and early spring. If the crop is to be grazed until early spring then grown for grain, a split application is often best, with at least half the fertilizer applied preplant and the remainder topdressed after the cattle have been removed.

With small grain cereals grown specifically for silage or hay, use the same nitrogen rates recommended for grain production.

As with other crops, it is important to take a soil test and follow fertilizer recommendations when producing small grain cereals for forage. When sending in soil samples for fertilizer recommendations, be sure to indicate whether the crop will be used for grazing. Extra nitrogen in the spring topdress application will be recommended if the wheat will be grazed.

The optimal soil pH level for small grain cereal production is between 6.0–7.5. This is true for both forage and grain production.

Pasture Production

In Kansas, small grain cereals can be pastured until the jointing stage in late winter or early spring and still produce a grain crop. They also can be used in a total graze-out program, which can be a more profitable option in some years than harvesting the crop for grain.

There is considerable variation in pasture production from year to year and among different varieties of small grain cereals. Generally, rye has the highest total season-long production, followed by triticale, wheat and barley. However, rye becomes stemmy and unpalatable earlier in the spring than other cereals. Since rye is less palatable and higher in fiber than wheat or barley, cattle gains during grazing are normally greater on wheat, triticale and barley pasture.

Small grain cereals usually produce good pasture in late fall and early winter (Figure 1). Production declines during the winter and generally resumes in late February, depending on temperature and moisture conditions. If the crop is left to graze out, forage production and quality begin to decline rapidly after jointing.

Barley produces palatable growth rapidly in the fall under favorable conditions. It is considered superior to other cereals for fall and early winter pasture, but wheat, triticale and rye provide better late-winter and spring grazing. Wheat usually produces most of its forage in late fall and early winter, and again in the spring. Triticale falls in between rye and wheat in its period of peak production.

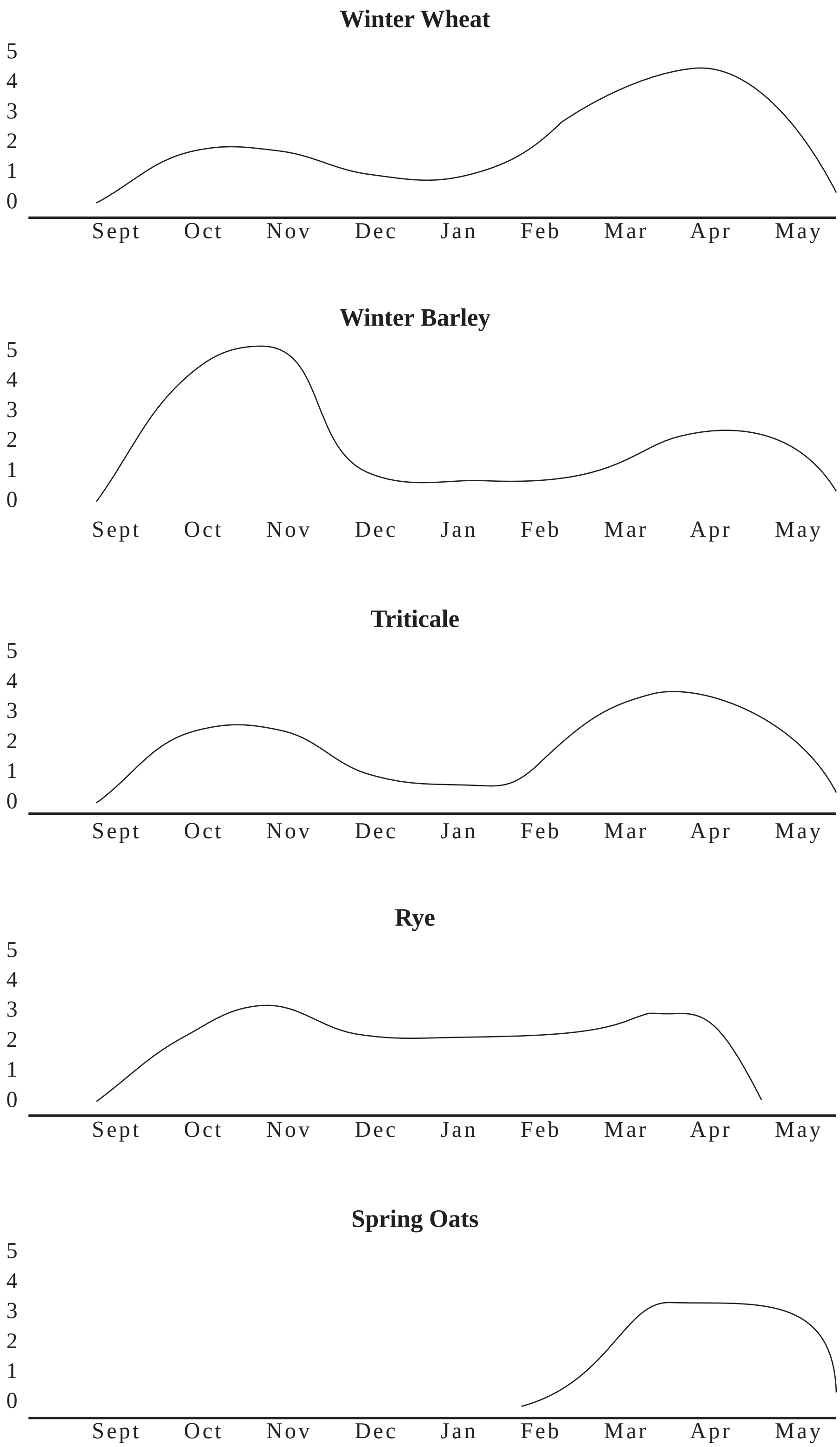
Stocking rates must be adjusted to match the crop's production potential. For example, if the pasture is heavily stocked during the fall, provisions for additional feed must be made to maintain good cattle gains during winter months when pasture production declines. Plan stocking rates to match the seasonal production potential of each crop.

Under good growing conditions, a well-fertilized small grain pasture can carry about 500 pounds of cattle per acre. Under poor growing conditions, stocking rates should be reduced considerably. Cattle gains of 1.5–2.5 or more pounds per day are possible during periods of good pasture production.

In terms of overall forage quality of pasture, barley is highest, followed by wheat, triticale and rye. During the fall and early spring periods of peak production, the crude protein content of small grain pasture is normally about 20–25 percent. Growing cattle require about 12 percent crude protein, thus no protein supplements are necessary.

Small grain pastures can cause bloat. Daily supplementation with poloxalene (Bloat Guard) is highly effective in reducing bloat. Feeding high-quality grass hay, silage, and/or an ionophore such as Rumensin or Bovatec can also provide some protection against bloat. Rumensin and Bovatec have also been shown to increase stocker cattle weight gains on wheat pasture. Mineral supplements

Figure 1. Relative Pasture Production of Small Grain Cereals.



containing magnesium are necessary when grazing cattle on small grain pasture to minimize the occurrence of grass tetany.

Fall grazing management is critical to the success of small grain pastures. Begin grazing when the plants are well-rooted and tillered, usually about 6–8 weeks after planting. If the foliage is too tall when the animals are introduced, or if the crop is overgrazed, the plants will be more susceptible to winterkill. Make sure some green leaves remain below the grazing level. The minimum stubble height should be about 3–4 inches. Rye has a more upright growth pattern than most wheat varieties, so it should not be grazed as low. Barley and triticale are more susceptible to winterkill than rye or wheat. Varietal differences exist within plant species.

If wheat is to be grown for grain, cattle should be removed in the spring before jointing, and fertilizer should be applied to the field. In a graze-out program, stocking rates should be increased through the spring to keep up with forage production. For more information, see KSU Extension publication C-713, “Wheat Pasture in Kansas.”

For pasture production, choose soils with good surface drainage. Soils with high clay content and fields that are prone to be boggy are not suitable for small grain pasture production. Well-drained, slightly rolling land generally produces the most usable forage because of the greater number of grazing days. On sandy soils, rye and barley perform best. On heavier soils, wheat and triticale perform best.

Best fall grazing is often obtained on bottomland soils with good moisture. In the spring, the best grazing is often obtained on upland soils that warm up early.

Spring oats can be pastured, but the total length of grazing is limited. Spring oats for grazing should be planted as early as possible in the spring. The quality of oat pasture is very high.

Silage Production

Producing small grain silage allows greater use of existing ensiling facilities. Harvesting small grain cereals as silage rather than grain also permits double-cropping and reduces the risk of drought, hail and other adverse weather conditions during the late stages of growth.

Small grain cereals can produce average to high-quality silages (Table 3). Mid- to late-dough stage barley silage generally has the highest quality among the cereals. At the late-milk to late-dough stages, barley has the greatest grain-to-forage ratio, followed by wheat, triticale and oats. Wheat, barley, triticale and spring oat silage yields are similar—about 5–7 tons of 35 percent DM forage per acre in the late-boot stage and 8–10 tons in the late-dough stage—depending on growing conditions. Wheat and triticale yields are generally more consistent than barley or oat yields.

Table 3. Silage Quality of Small Grain Cereals Harvested at Dough Stage.*

Crop	% TDN (dry basis)	% Crude Protein (dry basis)
Barley	64–68	9–11
Wheat	58–64	9–11
Oats	56–62	8–10
Triticale	54–58	8–10
Rye**	52–56	7–9

* KSU Extension publication L-884, "Nutritional Composition of Feedstuffs for Beef Cattle," and Morrison, F.B. "Feeds and Feeding" (22nd ed.)

** Estimated

Total production of digestible energy and crude protein per acre in wheat, barley and oat silages is highest when they are harvested at the mid- to late-dough stages. Although the percentage of crude protein decreases as cereals mature from the boot to late-dough stages (Figure 2), the tonnage of silage dry matter (DM) nearly doubles during this period, so that the total protein production per acre is higher.

Late-milk to late-dough stage wheat, barley and oat silages are usually about 2–4 percentage points higher in crude protein than corn and forage sorghum silages. The feed value of small grain silage for growing/backgrounding cattle can be compared with that of whole-plant corn silage as follows:

- Barley 90–100 percent of corn.
- Wheat 70–90 percent of corn.
- Oats 60–80 percent of corn.
- Triticale 50–70 percent of corn.
- Rye 50–65 percent of corn.

When fed to finishing cattle in high-grain rations, wheat, barley and corn silages support similar feedlot performance. Growing beef cattle should gain 1.5–2.25 pounds per day when fed rations containing 85–90 percent good-quality wheat or barley silages. Feeding cereal silages can produce up to 50 percent more beef per acre than feeding the grain alone.

Silage palatability generally is not affected by the presence of awns, although awns in hay can be a concern.

Because cereals advance from boot to dough stages rapidly, producing a high-quality cereal silage is often more difficult than producing high-quality corn or sorghum silages. The mid- to late-dough stages of wheat, for example, normally last only a few days. The crop becomes too mature to ensile successfully at later growth stages. If large acreages are to be harvested, it is a good idea to start cutting at the late-milk stage so that all the crop can be in the silo before the end of the late-dough stage. If silage harvest is delayed, the cutter bar can be raised and the upper half of the plant direct-cut as "head chop" silage. This will reduce harvesting time, increase the density of the ensiled material and increase the energy and protein value of the silage. Barley usually matures a week earlier than wheat; and wheat matures 1–3 weeks before spring oats, depending on the late-spring and early summer weather conditions.

Small grains should be ensiled at 62–68 percent moisture in most bunker, trench, or upright silos. Moisture levels above 70–75 percent can cause seepage and result in a clostridial (butyric acid) silage; lower moisture levels result in excessive air entrapment due to the hollow stems. Cereals must be chopped finer than corn or sorghum, using a recutter screen if necessary to aid packing and minimize air entrapment. The silo should be filled as rapidly as possible and the surface sealed with a weighted plastic sheet.

Hay Production

Small grain cereals can be used as a hay crop, either as an emergency feed or as part of a planned early summer forage program. Yields often average about 2–4 tons (air dry) per acre. The moisture content at baling should be about 15–20 percent for small, rectangular bales.

The quality of hay made from wheat, barley, oats and rye at the late-boot stage is similar (Table 4). Of the small grain cereals, triticale hay is the most variable in quality. Hay quality is more dependent on stage of maturity at harvest than is silage quality. Small grain hays will have the highest quality when harvested at the late-boot stage. A popular time to harvest small grain cereals for hay is at the early milk stage, however. This is the best compromise between highest DM yield and maximum hay quality (Figure 2). If protein content is an overriding factor, the crop should be harvested at the late-boot stage. DM yields are

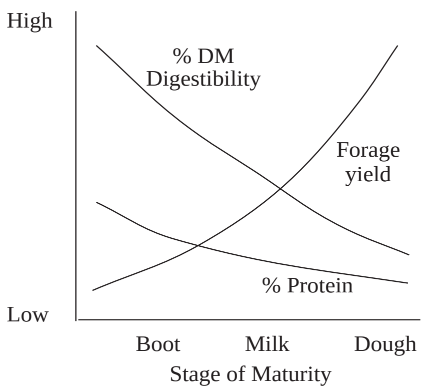
Table 4. Hay Quality of Small Grain Cereals Harvested at Dough Stage.*

Crop	% TDN (dry basis)	% Crude Protein (dry basis)
Barley**	62–66	9–11
Wheat	56–62	8–10
Oats	54–58	10–12
Triticale**	52–54	8–10
Rye**	48–52	7–9

* KSU Extension publication L-884, "Nutritional Composition of Feedstuffs for Beef Cattle," and Morrison, F.B. "Feeds and Feeding" (22nd ed.)

** Estimated

Figure 2. How Stage of Maturity Affects Forage Quality of Wheat.



about 20–40 percent lower at this stage compared with the dough stage.

Although the feeding value of small grain hays is less than that of small grain silages, hay can be an excellent forage for young calves, replacement heifers, beef cows and dry dairy cows.

Rough awns in small grain hay can cause cattle considerable soreness and irritation to the eyes, mouth, lips, gums, and lower surface of the tongue. A crop with rough awns should be ensiled rather than baled to minimize this occurrence. Also, harvesting at the late-boot stage rather than the dough stage reduces palatability problems caused by rough awns. Producers may want to consider planting awnless varieties of hard red winter and soft red winter wheat.

When harvesting small grains for hay in the late-boot stage, a crimper or crusher attachment will help speed the drying. But when harvesting in the milk or dough stages, these attachments increase kernel shattering losses. If the crop is harvested in the dough stage, plants will not contain an excessively high moisture content, so crimping or crushing is seldom beneficial.

Occasionally, nitrates accumulate in small grain cereals. This tends to occur as a result of drought, hailstorms or late frosts. Nitrate accumulation in small grains is more of a concern with hay than with silage. Oat hay is more likely to have a high nitrate level than other small grain cereal hays.

Additionally, small grain hays tend to be more slippery than alfalfa or native grass hays, and the bales will be more difficult to stack.

Crop Selection

Wheat

Wheat has good potential for pasture, silage or hay production. It is not used as an all-purpose forage crop to the extent that it could be. Wheat is usually higher in quality than oats, rye and triticale, and can produce more forage DM per acre than barley. Very short semi-dwarf varieties have less forage yield potential than taller varieties.

When grown for forage instead of grain, wheat should be planted earlier and at a higher seeding rate. Hessian fly and wheat streak mosaic can be greater concerns in early planted wheat.

Plant height may become a more important consideration than grain yield potential when growing wheat for graze out, silage or hay. However, if wheat is to be grazed and then used for grain production, grain yield potential should be an important factor in variety selection. Another consideration in variety selection is the length and roughness of awns.

Forage potential is greatly reduced when wheat is grown on soils with a pH of 5.5 or less.

Winter Barley

Barley is generally more susceptible to winterkill than wheat, especially when it has been overgrazed. It should not be grazed as short or as late into the fall as wheat. Barley does best on fertile, well-drained soils, but is also well adapted to sandy soils.

Some varieties have barbed awns which can affect palatability in hay, while other varieties have smooth awns.

Barley yellow dwarf, leaf rust and smut can be serious problems for winter barley. Early planting tends to favor the occurrence of barley yellow dwarf.

Triticale

The use of triticale as a forage crop is gaining popularity throughout the Midwest. Triticale generally has a higher forage yield, but lower quality than wheat. Triticale is a cross between rye and wheat. Although pure triticale will not contaminate adjacent wheat fields with rye, triticale seed is sometimes contaminated with rye seed.

For forage purposes, triticale is better suited as pasture than as hay or silage. Like rye, it has larger stems than wheat, barley or oats, which makes it more difficult to field wilt for hay or to pack for silage. There is little or no cash market for the grain.

Rye

Rye is the most cold tolerant and least exacting in its soil and moisture requirements of the small grain cereals. Some commonly used rye varieties are Bonel, Elbon, and Maton.

Wheat producers often shun growing rye because of the chance of contamination of adjacent wheat fields. However, if rye is not allowed to head and produce seed, contamination can be eliminated. After pasturing, destroy the crop with tillage or herbicides, or cut it for hay or silage at the late-boot stage.

Quick fall and spring growth make rye the most productive of the small grains for pasture. It is a more consistent producer of spring pasture than wheat, although it quickly becomes stemmy and unpalatable in late spring.

Spring Oats

Spring oats must be planted early when grown for forage. If not planted by April 10, other crops should be considered.

Select a high-yielding, grain-type variety that is resistant to barley yellow dwarf, crown rust and stem rust. Oats are also susceptible to wheat streak mosaic. “Forage-type” oats are later maturing varieties than grain-type oats and are likely to fill only small, shriveled grain in Kansas.

Oats are best used as hay or silage.

Summary

Small grain cereals provide excellent forage, either as an emergency feed or as part of a planned, year-round forage program (Table 5).

Their pasture, silage or hay potential should not be overlooked by Kansas livestock producers.

Table 5. Best Uses of Small Grain Cereals for Forage.

Crop				
Rye	Triticale	Winter Barley	Winter Wheat	Spring Oats
Pasture (Fall, winter, early spring)	Pasture (Fall and spring)	Pasture (Fall)	Pasture (Fall and spring)	
	Silage/Hay (Boot)	Silage/Hay (Boot to dough)	Silage (Boot to dough) Hay (Boot to milk)	Silage (Milk to dough) Hay (Boot to early heading)

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Grazing Distribution

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Grazing distribution is defined as the pattern created by livestock grazing an area of rangeland or pasture. Uniform distribution is essential for the long-term management and effective use of the forage resource and plays a role in protecting local water resources.

By keeping forage value high and groundcover adequate, uniform distribution helps keep populations of noxious weeds and unpalatable forages to a minimum. This reduces the potential need for chemical treatments, reducing operating costs and environmental concerns.

Grazing patterns are established as soon as livestock enter a new pasture. Therefore, it is essential to have a management system in place to encourage uniform distribution from the first day of grazing. Grazing animals tend to graze in spotty, localized patterns unless the land is managed to encourage widespread movement. When patchy grazing occurs, forage availability is reduced and grazing selectivity is lost, resulting in reduced animal performance.

Uneven grazing patterns can occur for several reasons:

Pasture shape, terrain, and water location. The shape of a pasture can affect uniformity of grazing. For example, in a large "L" shaped pasture with the water in one end, the end farthest from water will usually be underutilized. Even utilization of these areas is often difficult and requires changing the grazing animals' habits and patterns. Rough terrain and/or poorly distributed water often results in underused areas within a pasture. Animals will readily travel over a mile to water on level terrain, but they may not travel even a half-mile in steep or heavily rolling terrain.

Spot grazing. Animals create and maintain grazing patches. Forage outside the patches is not utilized until regrowth on overgrazed patches slows. An effort should be made to increase the utilization of forage by increasing the number and size of spot grazing areas.

Grazing preference. Grazing animals prefer certain forages over others. Preferred forages are said to be more palatable. The relative palatability of a plant species depends on factors such as the palatability of other species present, stage of growth and water content of each species, and soil fertility level. Grazing animals will concentrate where the plants are most palatable. In Kansas rangeland, highly palatable species include eastern gamagrass, big bluestem, Indiangrass, little bluestem, and sideoats grama. Switchgrass, blue grama, and buffalograss will be grazed the least when more palatable species are present. Western wheatgrass is palatable in the early spring, but it is rarely grazed during late spring and summer. In the fall, new growth again makes it palatable. Tame pastures, such as smooth brome and tall fescue, are more uniformly grazed, unless a physical barrier is present.

Some forages are rarely preferred when other plants are available. These species are readily grazed only when planted and managed as a pure stand or when high stock density forces animals to consume plants they normally would not consume. Examples would be the Old World bluestems, tall fescue, and sericea lespedeza.

Forbs (broadleaf plants) and browse (woody plants) vary in palatability. Examples of highly palatable forbs are showy partridgepea and compass plant, while leadplant and Russian olive are examples of browse that are palatable at certain times of the season.

Seasonal nutritional needs. Forbs and shrubs often fill nutritional needs during certain periods of the year and may cause seasonal variations in grazing animal distribution.

Managing for Grazing Distribution

Several management practices can be used to improve grazing distribution. These can be divided into two groups:

- Adjustments in normal management practices
- Management changes and/or capital improvements

■ Adjustments in Normal Management Practices

Many normal management practices can be adjusted to help encourage more uniform grazing patterns, such as salt/mineral placement, oilers and dust bags, winter feeding, riparian zone management, and prescribed burning.

Salt/mineral feeders should be placed away from water to improve grazing distribution. They should be located in undergrazed areas and livestock should know where they are. It may be necessary to move the salt/mineral feeders whenever livestock congregate and begin to trample the vegetation.

Traditionally, people believed livestock must have water after salting. However, the utilization of salt or minerals and water are not related. In areas where water has a high salt content or natural salt licks occur, changing salt locations will not influence grazing distribution.

Oilers, rubbing posts, or dust bags can be used to attract cattle in the same way as salt and mineral feeders. These items should not be located with the salt/mineral or near water. Oilers or rubbing posts should not be placed between water and salt. Oilers, rubbing posts, or dust bags should be located throughout the pasture as needed to gain uniform animal distribution.

Winter feeding location is one of the most underutilized grazing distribution practices. The goal should be to move feeding grounds throughout the pasture into areas not normally grazed by animals. Placement of feeding areas should avoid environmentally sensitive areas. Whenever possible, locate feeding areas away from streams, ponds, and windbreaks.

Winter feeding livestock on grazingland continually in the same location results in overutilization or trampling of the vegetation, opening the area to erosion. In the spring, the bare areas will be the first to green up with cool-season species, particularly grasses, causing livestock to begin grazing these areas first. These areas also will be the first invaded by broadleaf annuals. Once the grazing pattern is established, livestock will return to the winter feeding area throughout the season.

Riparian areas require special consideration in grazing distribution management. Riparian areas include streambanks and possibly part of the adjoining floodplain. Water quality, both for the grazing animals and downstream users, is a consideration. Well vegetated, stable riparian areas can provide forage, shade, and water. When flowing streams are a source of livestock water, trampling and bedding along the banks can lead to erosion of the banks and deposition of animal wastes directly into the water. Under these conditions, water in the area and downstream can be contaminated by bacteria and other pathogens, plant nutrients (nitrate and phosphate), and sediment.

Providing an alternate water source and moving salt and mineral feeders away from the stream are useful in shifting the grazing pattern away from riparian areas. When winter feeding, feed away from streams and stock ponds to help change the grazing pattern. Fencing of the riparian area should be considered as a last resort when other practices fail. Fencing will affect how the area is managed for the grazing that will be needed to maintain quality of the vegetation.

Prescribed burning can be a grazing distribution practice. When distribution problems exist, prescribed burning can be used together with the previously mentioned practices to change the grazing distribution on the pasture. Livestock prefer forage in burned areas. A uniform burn is essential for uniform grazing distribution.

Other options are available that require only adjustments to normal management or the outlay of limited capital. One option is spot treatment of underutilized areas with prescribed burning or fertilizer. It is possible to promote livestock use in under-utilized areas by spot burning or fertilizing small areas (2 to 5 acres) with 20 to 30 pounds per acre of nitrogen. When spot fertilizing, be sure to use low rates of nitrogen. Phosphate and potassium will be unnecessary in spot treatments. Producers should be aware that fertilization may result in a change in vegetation. These practices should be limited to extreme cases where more routine management practices have not accomplished grazing distribution changes. Spot treatments should not be used on the same area for 2 years in a row.

Another management option is the use of drift fences. Short fences across trails or other access areas can force livestock to use alternate routes.

■ Management Changes and Capital Improvements

If adjustments in normal management practices fail to produce the desired results, a management change or capital improvement may be necessary. This may include water developments or cross fencing. Water placement can be the most powerful attraction for livestock. Fencing can modify the influence of water placement. Used together, water placement and fencing can either improve grazing patterns or make them worse. A management change also could involve the use of more intensive grazing management options.

Water Developments

Water is the most important, but often the most overlooked, nutrient or management tool. It also is a critical component of management-intensive grazing options. Lack of adequate water, poor quality water, or poorly placed watering facilities are the usual problems encountered. The following are brief discussions of water development options available, with emphasis on improvements or new technology.

Water developments can have a significant impact on grazing distribution if properly located and developed. They also can be some of the most expensive grazing distribution tools to develop.

Considerations. If a new water location is needed, four criteria need to be considered: 1) the amount of water available; 2) water quality; 3) how the water source could be integrated with existing physical features, management tools, and other factors to best encourage uniform distribution; and 4) design of the water source.

Quantity and quality of water are the most important factors in developing a new watering location. Beef cattle consume up to 15 gallons of water per day per 1,000 pounds of body weight. If a pond or spring is used, it may be necessary to haul water during extremely dry periods.

If a new water source is developed in a pasture where an old pond is still in use, the distribution pattern may be reversed, since the quality of the new water source may be higher than that of the pond. If the availability of water from the new source can be controlled, the livestock can be shifted between watering sources.

Water developments include ponds, springs, dugouts, water wells, and pipelines.

Ponds

Ponds have historically been the most common method of storing water. Two basic designs are used: stock ponds and pit ponds. Both have advantages and disadvantages. Any open water is a potential hazard in the winter since cattle can fall through ice and drown. Ponds can be fenced to restrict access by the animals, reduce silting in, and maintain water quality.

Stock ponds are effective distribution aids in areas where the subsoil strata can be sealed. Properly built and protected, they will supply livestock water plus improved wildlife habitat, fishing (if stocked), and can provide recreational opportunities. Construction costs have increased rapidly in recent years, making stock ponds expensive investments. They also are prone to sedimentation if fed by runoff from cropland that is lacking proper conservation practices.

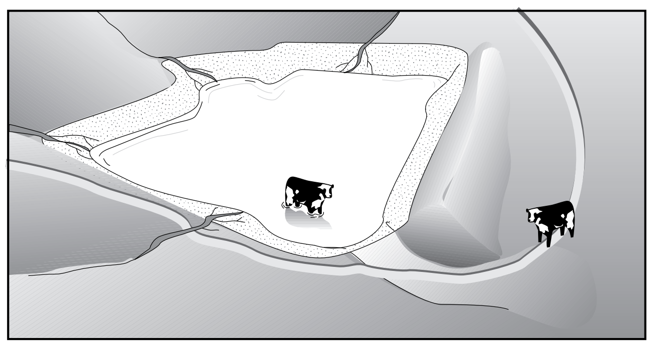
One way to reduce sedimentation, improve water quality, and provide a controlled water supply is to lay a pipeline through the dam to a trough while fencing the entire pond (pool, dam and adjacent area) to exclude livestock.

Pit ponds are small excavations, usually in streambeds, drainages, or areas with water at or near the surface. A pit is dug so that at least one side has a gentle slope (4:1 or less). The soil removed may be piled to one side or used to build a low dam around the pit. Check state and local regulations before excavating a streambed or streambank.

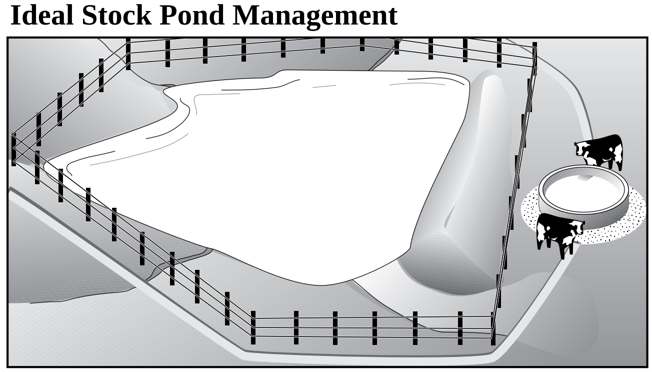
Wells

Water wells are a common source of livestock water. Most utilize groundwater strata. Aquifers occur

Typical Stock Pond Management



Ideal Stock Pond Management



Putting a pipeline under a new stock pond dam and fencing the pond allows the development of a cleaner, more controllable water supply.

at varying depths across most of the state and vary in the amount and quality of water provided. Wells should have a minimum capacity of 5 to 10 gallons per minute, unless a larger stock tank is used. Storage for two or three days should be considered as a minimum. Water wells require a pump to lift the water to the surface. Many different power sources can be used.

Windmills have supplied livestock water for over a century, although the basic design has changed a little. A revival in their use has occurred in the last 15 years. Windmills are for use in areas where other power sources are unavailable or expensive.

Advantages:

1. Power is supplied by the wind, which is readily available.
2. Can operate in remote areas, often with minimal maintenance.

Disadvantages:

1. Relatively high initial cost.
2. Maintenance costs can be high in some cases.
3. If winds fail for extended periods, reliability of the water supply is compromised.

Electric pumps, both above-ground and submersible, can supply livestock water. Water systems using electric pumps can supply large areas through storage tanks and pipelines.

Advantages:

1. Can pump significant amounts of water quickly within well limits.
2. Water can readily be pumped to multiple watering points.
3. Water can be pumped long distances economically.
4. Maintenance costs are normally very low.

Disadvantages:

1. Requires an electrical source.
2. Can be relatively expensive to install, especially if more than a half-mile from the existing power line.
3. Requires constant monitoring. Power outages are always a possibility.
4. Pump maintenance is normally accomplished by a contractor, not the landowner.

Solar-Powered Pumps are relatively new. Solar panels have been designed to power low-volume pumps capable of raising water from as deep as 200 feet. Solar-powered pumps should be considered in areas where electricity is not available or where windmills are not cost-effective. Low-volume, solar-powered pumps are a versatile tool for grazingland management. Selection and use of these pumps will depend on the depth of the well.

Shallow wells. The pump is normally a small, low-voltage centrifugal pump. Typically, a corrugated steel culvert is buried vertically in the ground, with the pump mounted inside near the top. Water rises inside the tube. The solar panel is mounted above the unit to either charge a battery or power the pump directly. The unit can be obtained for continuous or controlled flow.

Wells to 200 feet. The pump is normally a 12- or 24-volt diaphragm pump installed in a similar manner as electric submersible pumps. The solar panel is mounted above ground to charge a battery that powers the pump.

Advantages:

1. Allows the use of water strata where topography does not permit gravity flow and other power sources are not practical.
2. Allows development of “seeps” or “wet spots” for livestock water.
3. Controlled flow design allows efficient use of limited water.
4. Solar panel and pump can be used in more than one location to reduce cost.

Disadvantages:

1. Requires regular maintenance to ensure operation.
2. Limited volume.
3. Ability to pump water during cloudy weather may be limited, depending on battery storage or tank size.

Pipelines and Troughs

Changes in materials for pipelines have opened new possibilities for supplying livestock water. Improved materials for pipelines and new designs for troughs to withstand freezing have reduced the installation and maintenance costs. Pipelines and troughs can be used with all water sources. Water can be moved through the pipeline by use of either pressure or gravity flow.

Pipe used is similar to that used for domestic water use. Troughs have been improved to make them more durable and/or to reduce storage requirements. To reduce freeze damage, concrete troughs with sloped inside walls have been developed. Troughs with large diameters (over 20 feet) also can be used for storage.

Advantages:

1. Water can be placed at the best locations to benefit grazingland management and animal performance.
2. Adequate water supply can be made available where wells, ponds, and other water sources are not possible.

3. Allows multiple waterings from one water source.

Disadvantages:

1. Requires initial installation cost.
2. Increased maintenance of the system may be necessary compared to other possible options.

Spring Developments

The newer types of pipe and troughs have made spring development a better option. Often, livestock water can be collected from locations too wet for livestock use and piped to a trough in a more suitable location. This provides clean water under controlled conditions. With the use of gravity flow pipeline, troughs may be located some distance from the spring.

Advantages:

1. Makes good use of limited water sources.
2. Provides clean water away from low, wet areas.
3. With a continuous flow of 1 to 2 gallons per minute, water seldom freezes.
4. Relatively low cost and low maintenance in many cases.

Disadvantages:

1. Site availability may limit development.
2. Some sites may be difficult to develop without increased costs.
3. Installation procedure results in bare ground that may need erosion protection.
4. Volume and dependability of water flow may not be accurately determined before beginning development.

Design and development of a water source site. Stock tank capacity is an important factor in any water development. Adequate capacity of the tank plus a reserve supply of two or three days, in case the water source fails, are the key considerations. It is also important to have some kind of device, such as a bubbler or heater, to prevent the stock tank from freezing.

To protect the trough and provide a stable surface for animals to stand on, develop a 12-inch deep rock area in a 12-foot area around the perimeter of the tank.

Cross-Fencing

Adequate fencing is required to manage the grazing resource. Manipulating the grazing animal to benefit the plants and to effectively harvest the forage are the primary goals of cross fencing. Design of the fence should consider location and the animals to be controlled.

One of the most effective management changes is cross fencing large pastures to change grazing patterns. Cross fencing can be designed to separate vegetation types or topographic areas. The following factors should be considered in determining where to fence: 1) current grazing patterns; 2) how the fencing pattern will affect the ability to manage the resulting pastures; and 3) barriers (vegetation types, topography, water locations, etc.) to livestock movement. All fencing will require extra bracing in rough terrain.

Conventional Materials for Cross Fencing Pastures

For cross fencing, a three-strand barbed wire fence with post spacing of one rod (16.5 feet) or more is conventional. The posts may be wood or steel. This design has been used for many decades.

Advantages:

1. Proven method.
2. Relatively low maintenance.
3. Long life.

Disadvantages:

1. High initial cost.
2. Easily damaged by wildfires and lightning.
3. Can injure livestock (cuts and scratches).

High Tensile Steel Wire

High tensile steel wire has an old reputation to live down. Historically, this wire was difficult to splice, hard to keep tight, kinked easily, and broke when kinked. Today's wire is vastly improved. Compression splicing sleeves, special tighteners to maintain the tension, and other options make high tensile steel wire a management option to consider. Use a $12^1/_2$ gauge Class III galvanized wire, with a tensile strength of at least 110,000 pounds per square inch and a breaking strength of at least 1,100 pounds.

Advantages:

1. No barbs to cause injury to livestock.
2. Lower cost than barbed wire.
3. Repairs may be reduced.
4. Best adapted to uniform terrain.

Disadvantages:

1. Requires stronger braces to sustain wire tension.
2. Increased maintenance to sustain wire tension.
3. Usually requires more wires to control animals.
4. Acceptance may be difficult due to local traditions.

High Energy - Low Impedance Fencing

Electric fences provide a "mental" or "psychological" barrier to livestock rather than the "physical" barrier provided by a barbed wire fence. High energy - low impedance fencing is different from conventional electric fencing. A solid state "energizer" is used to charge a high-tensile steel wire fence. Developed in Australia and New Zealand, these fences were first brought to the U.S. to keep out predators.

They are a relatively low-cost option to permanent barbed or netting wire for cross fencing. High-energy, low-impedance fencing is not recommended for legal perimeter fence along county or state roads due to the potential liability created by escaped livestock.

Two wires (high tensile steel wire) are a minimum for reliability. Spacing and height above the ground will vary with the livestock and/or wildlife being controlled. Brace and stretch posts must be better than conventional fences to maintain the 150 to 200 pounds of stretch needed. Line posts can be made of several materials, but self-insulating posts (fiberglass and certain woods) are desirable. Power for the energizer can be from batteries, solar panels, or a 110/120-volt power source. Energizers should be either UL or Canadian approved. Never connect a 110/120-volt power source directly to a fence without use of an energizer.

Proper grounding of the energizer and fence is critical. Most energizers operate at 3,000 volts or higher for cattle. Installation must be in accordance with the manufacturer's recommendations.

Advantages: (two or more wires)

1. Lower cost than barbed wire.
2. Effective livestock control when properly designed, installed, and maintained.
3. Can be designed for predator and wildlife control.
4. Fencing over uneven terrain, especially streams and other depressions, can be simpler.

Disadvantages:

1. Tradition - acceptance by ranchers and others may be slow.
2. Higher voltage (3,000 volts or higher) results in a highly unpleasant shock to people. "Electric fence" warning signs along fence are highly recommended.
3. Prolonged contact with the fence may cause injury under some conditions, although this has not been adequately verified.
4. Durability of fencing materials is unclear when prescribed burning is practiced. Some poles and plastic insulators may be lost to fire.

Grazing Management Strategies

There are two basic grazing management strategies in use: conventional season-long grazing and management-intensive grazing systems. Grazing methods can influence distribution patterns. The type of grazing distribution tools used, and how those tools are applied, influences the selection of a grazing management strategy. Likewise, grazing methods can limit the use of certain grazing distribution tools.

Season-Long Grazing

The easiest grazing management strategy is season-long grazing, in which cattle simply remain on a single pasture for the entire season. Stress on the animals is minimal. For growing cattle, season-long grazing often results in the best weight gains. The challenge with season-long grazing is to maintain adequate grazing distribution so adequate forage production is provided.

Management-Intensive Grazing Systems

Management-intensive grazing systems are a specialized form of grazing management in which periods of grazing and rest alternate in a systematic way. These systems have become popular in the past 20 years. There are many different kinds and each has advantages, disadvantages, and limitations.

Designing and implementing a grazing system is more than just moving livestock from pasture to pasture. Designing the system requires a knowledge of the resources (land, labor, and capital), kind of livestock and their management, managerial ability of the operator, and the management goals of the owner/operator. Careful attention to details of physical developments (water, fencing, etc.), timely decision-making, and financial considerations are major concerns in designing a system.

Animal performance on a per-animal basis is normally slightly below that for season-long grazing. With improper management, animal performance can be drastically lower. Overall animal production per acre, however, may be enhanced.

Kinds of Management-Intensive Grazing Systems. The following are several categories of management-intensive grazing systems in use today (some are known by other names). As the complexity of the system increases, the level or intensity of the management must also increase. Many systems can save on labor (time), but they will require more management (time) instead. Some systems are designed to benefit the plants, some to benefit the animals, and some will benefit both.

Sequential or complementary forage grazing systems (using two or more forages in combination during the grazing season) have only been used for about 30 years. These combinations provide high-quality forage for the longest feasible period. Normally, producers design a system to graze each forage at its highest quality. Properly designed and managed, these systems benefit both the plant and the animal.

Sequential forage systems are those where two or more forages are grazed in sequence. To properly design a sequential forage grazing system, forages must have different growing seasons and be separated by fences. Each forage is grazed only during its vegetative growth period. Regrowth may be stockpiled for dormant season use. When moving livestock from one forage to another, the change should not have a significant impact on the nutritional level of the animal.

Complementary forage systems are those that use two or more forages simultaneously. One forage is used to “supplement” the major forage. Generally, the second forage is an annual such as sudan, wheat, or triticale. The complementary forage is grazed with the primary forage to increase quality of the animals’ diets. As with sequential forage systems, when changing forages, the nutritional level of the animal should not undergo major changes.

Partial-season grazing is a system in which livestock are allowed to graze the forage during only part of the growing season. Partial-season grazing is best used for stocker operations, not cow-calf. Intensive early stocking, used only on rangeland, is an example. Doubling the number of stockers during the first half of the grazing season (late April or early May until July 15) benefits both forage and livestock production. After grazing during the early part of the season, the pasture must not be grazed again until after the plants are dormant.

Deferred grazing is a system in which a pasture is grazed or hayed during the dormant season and rested during the season of growth. This system does not require a systematic rotation of pastures. The major disadvantage of this system is low-quality forage. Advantages include: 1) low cost, compared to harvested forage, 2) ability to meet the nutritional needs of cows in mid-gestation, and 3) protection for calving. Pastures used during the dormant season and rested through the growing season are usually in the best condition in terms of density and growth. The nutritional quality is relatively poor, however. Unless adequately supplemented, animal performance may be reduced.

Two-to-four pastures/one-herd systems, often called “rotation grazing,” require livestock to be moved from pasture to pasture, with each pasture being grazed only once a year. With each new year, grazing begins in a different pasture. To maintain nutritional quality, the rotation should be managed so that animals do not face major palatability and/or nutritional changes. For a two- or three-pasture program, the first move must occur in mid- to late-June. Palatability and quality of the forage are the main criteria to use in determining when the move is made. With the three-pasture program, the second move should come in mid-August, based on the same considerations. With four-pasture programs, moves are dictated by a combination of forage availability, palatability, and quality. Forage potential is usually improved by these systems, but animal performance may be reduced unless careful management of their nutritional needs is maintained.

Rapid rotation systems utilize fewer than six pastures and have relatively short grazing periods in relation to the long rest periods. Each pasture is grazed two or more times during the season. The length of the grazing period will vary according to the number of animals (grazing demand) and the growth or regrowth of the forage. Moves must be made to ensure adequate nutrition of the animal. These systems can be used on rangeland, tame pasture, and irrigated pasture. Properly designed and managed, they benefit both plant and animal performance.

Cell or time-controlled grazing is an intensified rapid rotation system. Grazing periods and move dates are strictly on a decision basis. Generally, there are six or more pastures involved. The goal is to utilize the best parts of all the plants and not just the most palatable (making it a form of nonselective grazing). Relatively long rest periods follow the grazing period. This is the most intensive of any of these grazing management systems. Research and experience indicate both the plant and animal can benefit **if** the system is carefully designed, implemented, and managed. Disadvantages of cell grazing include: 1) start-up costs are high, 2) costly water developments are required, 3) animals must be moved every few days, and 4) non-selective grazing usually reduces animal performance.

Designing a Management-Intensive Grazing System

A management-intensive grazing system involves more than just moving livestock around. It must be designed to accomplish specific goals and objectives within the resources available (land, labor, and capital). Design considerations must include not only the mechanics of the system, but also the animal, marketing, and financial management. Above all, the attitude, understanding, and ability of the operator is important.

Three major concerns must be addressed: water, fencing, and animal nutrition.

Water for the grazing animals must be adequate and a reserve must be available in case the source fails. Generally, wells and springs are more reliable than stock ponds and streams. Clean, high-quality water is the major requirement.

Fencing is another important consideration. Fences control the movement of animals while insuring that the animals are constrained.

Animal nutrition is directly related to animal performance. One concern in many systems is the varying level of nutrition resulting from the rapid movement of animals from grazed to ungrazed forages. Moving animals before non-selective grazing becomes excessive will help ensure that nutritional needs are met.

Other Factors to Consider

Management intensive grazing systems should be suited to the kind of plants and soils present. A good system will improve forage condition and production by favoring desired plants. Changes in species composition and reduction in forage production will occur with systems that do not allow desirable perennial grasses time to replenish their food reserves.

A system should benefit both livestock and forage. Forage production and animal performance are influenced by stocking rate. Individual animal performance should not be sacrificed for high livestock production per acre. The type of livestock operation and managerial ability are important in considering a system.

Summary

A management plan for improving grazing distribution should be a priority for grazingland managers. Livestock establish their grazing habits when they first enter a new pasture. Therefore, it is important to establish good livestock grazing patterns from the first day the pasture is used. Uniform distribution of livestock on grazingland is essential for the efficient use of the forage resource. Uniform distribution also plays a role in protecting water quality.

Other Publications

C-402	Smooth Brome Production and Utilization
C-729	Tall Fescue Production and Utilization
C-567	Range Grasses of Kansas
L-514	Management Following Wildfire
L-565	Prescribed Burning: Safety
L-664	Prescribed Burns: Planning and Conducting
L-815	Prescribed Burning: A Management Tool
MF-1020	Rangeland Weed Management
MF-1021	Rangeland Brush Management
MF-1118	Stocking Rate and Grazing Management
SRP-718	Chemical Weed Control for Field Crops, Pastures, Rangeland & Noncropland

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Tall Fescue Production and Utilization

COOPERATIVE EXTENSION SERVICE
KANSAS STATE UNIVERSITY
MANHATTAN, KANSAS

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Introduction

Introduction

Tall fescue is a cool-season perennial grass species, adapted to the climate and soils of the eastern one-third of Kansas. It is well adapted to the low pH and slowly drained soils in southeast Kansas. Tall fescue can persist under limited fertility conditions and, when compared with smooth brome, tolerates wet soils, grazing abuse, claypan soils, and summer drought better.

Fescue can be used not only for forage but also for waterways, pond dams, farm lanes, and lawns. Fescue will grow when average temperatures are as low as 34°F but does better with temperatures above 45°F. Summer growth is retarded by high temperatures and low moisture, with little growth occurring above 85°F.

Animals readily graze fescue during April, May, and June and again in the fall. With consideration for both the grass and animals, grazing should be avoided during late June, July, and August. Tall fescue grazed during the summer results in low animal performance and possible damage to the grass. It should be "rested" during summer months to allow the plants to increase vigor.

Tall fescue is the best adapted cool-season grass in Kansas for winter use. Thus, fescue can provide most of the spring, fall, and winter feed for a beef-cow herd. Tall fescue should be used in conjunction with warm-season forage crops such as native grasses, bermudagrass, or summer annuals to provide summer forage.

Tall Fescue Toxicity

In 1973, a USDA researcher observed fescue pastures being grazed by two separate herds of cattle on a farm near Mansfield, Georgia. One herd looked unhealthy, while the herd in the adjacent pasture appeared healthy. During the next three years, Joe Robbins and C.W. Bacon studied the pastures and cattle. In 1976, plants from the pasture with the cattle that looked unhealthy were found to be 100 percent infected with an endophytic fungus *(Acremonium coenophialum).* The other pasture was less than 10 percent infected with the endophyte. That association marked a major breakthrough in finding the cause of fescue toxicity.

Fescue Toxicity Syndrome in Cattle

Three separate syndromes appear to be associated with tall fescue toxicity. A brief description of each follows:

Fescue toxicity or summer slump. Livestock show poor gains, reduced conception rates, intolerance to heat, failure to shed the winter hair coat, elevated body temperature, and nervousness. This summer slump is most noticeable during summer, but the adverse effects can occur throughout the year. This syndrome has serious effects for Kansas cattle producers.

Fescue foot. The clinical signs are rough hair coat, weight loss, elevated body temperature and respiration rate, leg tenderness and actual loss of hooves and/or tail switch. Fescue foot occurs mainly in winter and may be noticed a few days after the first real cold snap of winter. Cattle must be eating infected grass or hay at the time. This is a serious syndrome, but its occurrence in Kansas is infrequent in relation to the large acreage of tall fescue.

Bovine fat necrosis. Cattle with this syndrome have hard masses of fat in the abdominal cavity. This syndrome, which results in upset digestion and difficult births, has been associated with very high nitrogen rates commonly associated with poultry litter applications. This syndrome hasn't been identified in Kansas but has been found in the poultry-growing areas of southwest Missouri and northwest Arkansas.

Fescue Toxicity Syndrome in Horses

Fescue toxicity has serious reproduction effects on mares. Specific indicators are abortion, prolonged gestation, difficult birth (dystocia), thick placenta, foal death, retained placenta, little or no milk production (agalactia) and, sometimes, death of mares during foaling. Pregnant mares should not be allowed to feed on infected tall fescue grass or hay during the final 60-90 days of the expected gestation period.

Biology of the Fungal Endophyte

The terms “fescue fungus,” “endophyte,” “fungal endophyte,” and “fescue endophyte” have been used to denote the organism in question. “Endo” (within) plus “phyte” (plant) means a plant that lives within another plant. The fungus lives its entire life cycle within the fescue plant.

Two characteristics of the endophyte are significant: The organism does not affect either the growth or appearance of the grass and requires microscopic examination to detect, and it is seed transmitted only.

The alkaloid, ergovaline, is thought to produce the animal symptoms observed in livestock feeding on infected tall fescue. Ergovaline is found in the fescue plant and threshed seed of infected plants. In southern states, researchers have found that the endophyte fungus may actually help the tall fescue plant survive and improve its durability. They associate it with insect resistance and improved drought tolerance. To date that connection has not been proven in Kansas, Missouri, or other states farther north.

When planting new stands of fescue, the producer should use seed that contains no live endophyte. Infected pastures come from infected seed. Fungus free plants remain fungus free. The only way a fungus free pasture becomes infected is when fungus-infected seed is brought into the pasture. When those seeds germinate, they produce an infected plant. Seed can be brought into pastures by the grazing animal being moved from one pasture to another and by feeding hay that contains mature infected seed. A small amount of seed will pass through the animal and also may produce infected plants. A study in Cherokee County, reported in Table 1, indicates that a renovated pasture has shown some increase in infected plants since initial sampling in 1986. One can expect, some increase in infected plants when the original stand is thinned by drought and infected plants are present in the pasture.

Live endophyte in seed can be reduced when seed is stored for a period of time, or aged. A study in Kansas showed that seed cleaned, bagged, and stacked on pallets in an unheated warehouse reached zero live endophyte level when stored for 15 months (Table 2). Data from Georgia indicate that 10 months of storage is adequate, and a study in Oregon showed that 24 months was required to reach the zero level. Seed piled in a bin may require considerably more time to age than that which is bagged and stored on pallets.

Table 1. Endophyte infection over time in a renovated pasture in Cherokee County (Wary & Kilgore, unpublished data).

Sampling Date [1]	Endophyte Infection, %
May 86	9.4
May 87	2.9
December 88	6.4
May 90	9.0
October 91	6.0
October 92	30.0

[1] Plants sampled at random throughout pasture but always greater than 50 ft. from fence row.

Table 2. Effects of time in storage on tall fescue seed germination and live fungus infection. (1985-86 Kilgore, unpublished data).

Months After [1] Seed Harvest	Germination, %	Live Endophyte Infection, %
1	97.0	79.8
5	96.0	69.1
6	90.6	66.0
7	97.4	61.3
8	96.0	52.7
9	93.4	56.7
10	95.4	58.0
11	98.7	37.3
12	99.3	48.0
13	94.7	6.7
14	94.7	1.3
15	93.8	0.0
16	94.0	0.0
17	93.0	0.0

[1] Seed was cleaned, bagged in 50 lb. bags, and stored on a pallet in an unheated shed. Sampled monthly as indicated.

The fungus is found in the crown of the fescue plant during winter. As spring growth occurs, the fungus slowly grows into tillers and eventually makes its way into the seed head. This growth is mycelium, or strands of the fungus. Fungus mycelium can be found in plant crowns, tillers, leaf sheaths, seed stalks, heads and seeds. Little, if any, is found in the leaf blade. The toxins that affect animal performance are present in infected plants. Testing plants for the endophyte and finding it equates to toxic plants.

Over 500 pastures in Kansas have been tested for the endophyte, and approximately 95 percent were found to have infection. The average infection rate was 64 percent, with a range from 0-100 percent. Only about 20 pastures have been found free of the endophyte. The specific instructions on sampling pastures and testing seed for endophyte can be found in Extension publication AF-139, "Sampling and Testing Procedures for Fungal Endophyte of Tall Fescue."

Cattle that consume infected fescue plants react to toxins that are produced either by the fungus or by the plant in reaction to the fungus. These toxic compounds remain indefinitely in stored hay or seed and can affect animals that eat it. Data from several states, including Kansas, suggest that for each 10 percent increase in endophyte level, there is reduction of approximately 0.10 pound in average daily gain (ADG) of growing beef animals. This can be much lower when tall fescue is only grazed March through May and September through November. Grazing infected pastures during July and August is especially deleterious to animal performance.

The initial steer grazing study at Auburn University showed an 82 percent increase in ADG, and a 42 percent increase in gain per acre with endophyte-free fescue compared with endophyte-infected fescue. Research in Kentucky showed a 34 percent reduction in pregnancy in spring-calving cows grazing high-endophyte fescue pastures compared with grazing low-endophyte pastures. More data is shown in Table 3.

Table 3. Effect of fungus-infected tall fescue pastures on growth and reproduction of replacement beef heifers at two locations in Alabama Black Belt and Tennessee Valley Substations (1984-86).

Fungus Level, %	ADG, lb	Pregnant, %
0-5	1.20	96
25-60	0.96	82
80-99	0.87	55

The level of the endophyte fungus in a stand of tall fescue has more effect on animal performance than most management practices. Because these animals are also more susceptible to heat stress when the temperature is above 85°F, the effects of the endophyte fungus are more apparent.

Given a choice, grazing animals will spend much more time grazing endophyte-free pastures, with greater forage intake, thus requiring a lower stocking rate. Fungus-free pastures are much more subject to damage by overgrazing. Fungus-free pastures require lower stocking rates but produce higher average daily gain and more beef per acre on grazing yearling cattle compared with pastures infected with the endophyte.

Establishment and Maintenance

Soil Selection

Fescue will grow on almost any soil but produces best on fertile moist soils. The ability of fescue to withstand low fertility and wet soil is excellent. Tall fescue can also withstand submersion for a few days. It will produce on soils with pH of 5.2-8.0, but optimum growth occurs in the 5.8-7.0 pH range.

Varieties

Several new varieties are suitable for Kansas. New certified varieties are free of the endophyte fungus. Endophyte-free seed of older varieties like Kentucky-31 are also available. Check the seed tag to be sure of the endophyte level.

To avoid reduced animal performance resulting from endophyte-infected grass that is fed or grazed, livestock producers should plant seed free of live endophyte. Plants produced from fungus-free seed remain free of the endophyte. Information regarding several available tall fescue varieties is shown in Tables 4 and 5. The new variety Martin has produced well in Kansas. It has excellent quality and was selected for higher magnesium content to help reduce incidences of grass tetany in cattle. Pastures planted to fungus-free seed will have a 20-30 percent lower carrying capacity because the grazing animal eats more endophyte-free grass.

Table 4. Tall fescue varieties, by date of release, source of release, and varietal characteristics.

Variety	Year Introduced	State Releasing	Characteristics
Kentucky-31 (KY-31)	Early 1940's	Kentucky	Collected in Menifee County, Kentucky, in 1931. Apparently grown on farm since 1887. Most popular variety in Kansas, grows on wide variety of soil types, highly productive, low palatability. Remains green well into winter.
Alta	1940	Oregon & USDA	Not as high in yield as Ky-31. Resists cold and drought.
Goar	1946	California	Early maturity, coarse. High seedling vigor, adapted to heavy texture alkaline soils.
Kenmont	1963	Montana	Similar to Ky-31, but sod more dense.
Fawn	1964	Oregon	About one week earlier in maturity than Ky-31. Narrow leaves, slightly higher protein, lower yield than Ky-31.
Kenwell	1965	Kentucky	Improved palatability, some disease resistance, not aggressive.
Kenhy	1977	Kentucky	Ryegrass-tall fescue derivative, much more palatable and digestible than Ky-31. Excellent animal performance, may not withstand hot dry summer as well as Ky-31.
Missouri-96 (Mo-96)	1978	Missouri	Excellent animal performance, matures later than Ky-31, but gives less fall growth.
Mozark	1985	Missouri	Superior crown rust and leaf spot resistance. Best adapted to the northern half of the tall fescue belt.
Martin	1985	Missouri	Excellent crown rust and leaf spot resistance. Excellent production in Kansas.

Table 5. Performance of fungus-free tall fescue varieties.

Entry	Yield, ton/a: Labette Co. 5-yr average	Yield, ton/a: Franklin Co. 3-yr average	Relative Maturity [1]	Relative Maturity [2]
Phyter	6.91	-	-	2.3
Martin	6.64	3.69	-11	3.0
Forager	6.60	-	-	4.8
Festorina	6.71	3.54	-1	2.0
Mo-96	6.67	3.62	0	1.8
Kenhy	6.69	-	-	1.5
Cajun	6.42	-	-	4.0
Ky-31	6.55	3.72	0	3.1
Triumph	6.25	-	-	4.5
Fawn	6.38	-	-	4.3
Mozark	6.60	3.63	-11	3.8
Johnstone	6.08	3.39	0	1.8
Stef	5.59	3.20	+10	1.5
Average	6.47			
LSD(.05)	0.61	0.17		

[1] Days earlier(-) or later(+) in heading than Ky-31. Data from Franklin County trial. Janssen.
[2] Degree of heading. 0 = no heading, 5 = 100% headed, Labette County trial. Moyer.

Seedbed Preparation

Fescue establishes best in a well-limed and fertilized seedbed that has been tilled 4-6 inches deep, leveled, and firmed before seeding. Several producers report successful stands by simply broadcasting the seed into existing over-grazed grass pastures in the fall. Even though the practice works, it is not recommended. A well-prepared seedbed improves chances of rapid stand establishment.

Stand Establishment

Figure 1 shows the proper planting time for each area in Kansas. On droughty, claypan soils, only fall plantings are recommended because winter and spring plantings will not survive when a hot dry summer follows planting. Deeper soils and/or good moisture supplies will result in successful winter or spring seedings. When planting in a well-prepared seedbed, 15 pounds per acre of clean, high germinating seed is adequate. When seed germination is not known or the seedbed is less than desirable, a rate of 20-25 pounds per acre may be required for a satisfactory stand. For best results, seed should be covered with 1/4-3/8 inch of soil.

Seeding fescue with winter wheat is often desirable. Planting a cover crop like wheat can protect the soil from erosion and furnish additional grazing or grain production income in the seeding year. If wheat is grazed, avoid grazing in fall or spring when new grass seedlings could be injured by trampling during wet weather.

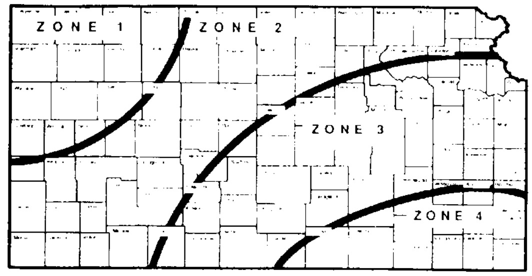
Fertilization

A soil test should be taken well ahead of planting to determine lime and fertilizer needs, and needed lime and phosphate should be incorporated into the seedbed prior to planting. Your local Extension agriculture agent can provide fertilizer recommendations based on your soil test results. Once established, fescue production will depend on the amount of fertilizer applied and when it is applied.

Table 6. Tall fescue response to fertilizer applications (KSU, Kilgore. 1978-1986).

Nutrient Rate, lb/a			Yield
N	P_2O_5	K_2O	ton/a
0	0	0	1.0
100	0	0	1.6
100	50	0	3.4
100	50	30	3.7
50	50	30	2.5

Table 6 shows how important balanced fertility is for a low fertility soil. If soil tests show phosphate and/or potash is needed, additions of these nutrients can make the difference between good and poor yields. Research shows that 100 pounds of actual nitrogen produced only 1.6 tons of dry matter per acre; however, when adequate phosphate and potash were applied with the nitrogen, yields increased to 3.7 tons. Nitrogen rates should be adjusted to reflect forage production potential (Table 7).



	Zone 1	Zone 2	Zone 3	Zone 4
Fall	Aug 10-Sep 10	Aug 15-Sep 15	Aug 20-Sep 20	Aug 15-Oct 1
Winter	*	*	*	*
Spring	Mar 1-Apr 1	Feb 15-Mar 15	Feb 15-Mar 15	*

*Not Recommended

Figure 1. Planting dates for cool-season grasses.

Phosphate and potash should be applied once a year and can easily be applied with nitrogen. If only small amounts of phosphate and potash are needed, a two-year supply could be applied every other year.

Table 7. Tall fescue response to various rates of nitrogen (KSU, Kilgore. 1988-91).

N Rate lb/a	Yield lb/a	lb Response To Added N	lb Dry Matter Per lb Added
0	2,000	-	-
50	3,600	1,600	32
100	4,800	1,200	24
150	5,200	400	8

[1] Plots also received P_2O_5 and K_2O when soil test called for it. Yield response to nitrogen would be much less if other nutrients were in short supply.

If fescue is grazed in the spring and fall, nitrogen should be applied in the winter and late summer. Research indicates that spring-applied nitrogen does not carry over for fall growth; likewise, fall applications of nitrogen do not increase spring performance. Table 8 shows that when nitrogen is applied in February, or winter months, the crude protein in April is high, but crude protein the following October and December is no higher than in unfertilized grass. The only way to increase protein in the fall and winter is to apply nitrogen before fall growth starts. Table 8 also shows that fall-applied nitrogen does not increase the crude protein the following spring.

Several nitrogen sources such as liquid urea-ammonium nitrate, dry urea or ammonium nitrate, or anhydrous ammonia are available for use on fescue pasture. Nitrogen source experiments generally have shown little difference under most conditions. However, differences have been found in a few cases. On a damp soil surface covered with grass residue, urea containing fertilizer falling onto the

Table 8. Effect of nitrogen rate and time of application on fescue crude protein content at four sampling dates (KSU, Kilgore. 1984-85).

Nitrogen lb/a	When Applied	Crude Protein, % April	June	October	December
0	-	11.6	5.1	10.1	7.4
50	February	18.2	5.3	10.5	7.9
100	February	21.4	6.0	10.4	7.8
50	August	11.0	5.0	14.2	13.8
100	August	11.8	5.4	16.4	14.0

residue can be converted to ammonia by the urease enzyme, and some loss of the ammonia can occur. This is especially true under relatively warm temperatures, with extended periods of high evaporation rates and no rainfall to wash the nitrogen into the soil after fertilizer application. Additional research is needed on the frequency and extent of that loss.

Although anhydrous ammonia has been an attractive form of nitrogen for cultivated crops because of its low cost, it has not been used extensively on permanent pastures because of difficulty in application. Conventional equipment has not been satisfactory for anhydrous ammonia application on fescue because of high power requirements, difficulty in avoiding nitrogen losses, grass-root destruction by applicator knives, and problems associated with application on rocky, shallow soils. Rolling coulter applicators with thin knife blades will eliminate some of those problems. If anhydrous is used, it must be placed deep enough to minimize volatilization losses. When properly applied, good yield responses occur.

Recent research has evaluated placement methods for liquid nitrogen and phosphorus. Generally, nitrogen and phosphorus application knifed 4-6 inches deep has shown consistent yield responses when compared with surface broadcast applications. Special applicators are required for this practice.

Soil pH

An existing tall fescue stand will tolerate pH as low as 5.0. On existing pastures with pH less than 6.0, 2 tons of ag-lime per acre, topdressed, will increase life of the stand and growth if legumes are present. Again, apply lime based on soil test results before stand establishment, and incorporate the lime.

Effect of Nitrogen Fertilizer on Grass Quality

Fall-applied nitrogen on tall fescue compared with no fertilizer can increase the protein levels affecting cattle performance and forage intake. Table 8 shows the effect of fall nitrogen fertilizer on crude protein level, and Table 9 shows the effect of grass quality on animal intake.

The increase in crude protein from nitrogen fertilizer for April forage samples may not be beneficial because 11.6 percent crude protein is normally high enough to meet the needs of most classes of cattle (Table 8). In December, however, unfertilized fescue crude protein level dropped to 7.4 percent which is below the level of crude protein needed for performance of certain classes of cattle. Fall-fertilized fescue was 13.8-14 percent crude protein, which is above the level needed for cattle performance. Therefore, fall nitrogen fertilization can affect the supplementation program needed for stocker cattle and cows during winter months.

Table 9. Brome and tall fescue intake study.

Date of Cutting	Protein, %	Estimated TDN[1], %	Daily Hay Intake as Fed/lb	Body Weight on DM Basis, %
Brome				
June 7	9.35	54.17	16.81	2.16
June 16	9.03	55.76	18.18	2.34
June 27	7.17	53.64	15.76	2.03
Fescue				
May 15	11.50	57.40	13.10	1.77
July 14	4.30	48.30	9.44	1.39

[1] Total digestible nutrients

Seed Production

Seed Production

Most of the fescue fields harvested for seed in Kansas also are used for fall and winter grazing. This maximizes the total fescue crop but often reduces seed yields compared with fescue managed primarily for seed.

Two management practices are important in producing good seed yields. They are clipping soon after the seed stalks are mature, or a seed crop is removed, and application of nitrogen during late fall to early winter.

The stubble should be clipped to a height of 3-4 inches as soon as possible after harvesting the seed crop. If the fescue was not harvested for seed the previous year and is intended for seed the next season, clipping should be done by the time seed stalks are mature. It is best to remove the residue. This practice is necessary for the development of tillers. They develop during the fall and early winter and are responsible for next year's seed crop. Failure to clip and remove residue can reduce next year's seed crop as much as 30 percent. The new growth should be grazed only moderately and only in the late fall and winter. Grazing should be light until November 1, and all growth can be removed by grazing during the winter.

Timing of nitrogen application affects seed yields. For best seed production, fescue should be topdressed with 70-100 pounds of nitrogen during December or January. Phosphate and potash should also be applied according to soil test. Later nitrogen applications can cause lodging.

Tall fescue seed may be harvested by direct combining, or put in a windrow then combined. Fescue shatters easily when mature. Yields in standing fescue can be reduced at least 50 percent by shattering. Mowing should begin when the straw in the head starts to "yellow." Extension publication MF-924, "Seed Production Management for Bromegrass and Fescue," provides additional tips regarding seed production.

Hay Production

Tall fescue has a reputation of being poor hay, but most of the reason for that reputation is the haymaker, not the grass. Anytime a cool-season plant matures, forage quality drops rapidly. In fact, crude protein will drop 0.5 percent per day from boot stage to mature seed stage. The secret to quality fescue hay production is adequate fertility and early cutting. Fescue hay should be cut no later than mid-May in southeast Kansas. Cutting the grass for hay at this stage also results in lower levels of the endophyte in the hay. Hay made late not only is low quality but also may contain higher levels of toxins, which reduce animal performance. Cut fescue when it starts to show a few heads. Delayed haying to get a seed crop results in very poor quality forage.

Nitrogen rates should be approximately 100 pounds of actual nitrogen. Rates higher than that frequently cause lodging. Phosphate and potash should be applied as needed.

Tall fescue hay can also be used as a summer grazing supplement. Research in Missouri shows that yearlings grazed in July and August showed good daily gains on fescue baled (small round bale) in mid-May and left in the field.

Tall Fescue-Legume Mixtures

Some producers like to grow legumes in their fescue. Legumes that can be used successfully in Kansas include medium red clover, ladino clover, and annual lespedeza.

Red clover is a short-lived perennial and will disappear from a stand in 2-3 years. Red clover can last longer by overseeding every other year or allowing existing clover plants to produce seed. Soil pH should be above 6.3, and annual applications of phosphorus and potassium may be necessary. Don't fertilize with much nitrogen, because fescue can smother the legume crop. Overseed current pasture with 8-10 pounds of seed per acre during winter months.

Ladino clover is an excellent fixer of nitrogen and is palatable. It is more tolerant in lower pH soils and withstands close grazing. It may not stand drought as well as red clover. To get a stand of ladino clover, broadcast 1.5-2 pounds of seed per acre along with phosphate and potash fertilizer as required on a closely grazed pasture in February.

Common lespedeza is popular in fescue pastures in southeast Kansas. It is an annual, reproducing by seed each year. Most lespedeza production is after June 15 and does especially well in August if it rains. It is a relatively low fixer of nitrogen, but nitrogen applications over 40 pounds per acre will reduce lespedeza levels in the pasture. Application of nitrogen in September will result in increased grass production in the fall without an overall effect on the lespedeza. There must be enough lespedeza growth in late August and September for it to reseed.

Lespedeza seed can be broadcast into closely grazed fescue pastures during winter months. Seeding rates of 20-30 pounds per acre will assure an adequate seed supply. Top dressed lime application generally will stimulate lespedeza growth.

Tall Fescue Utilization by Cattle

The following management practices help reduce the effect of the endophyte fungus.

Grazing Management. Grazing high-endophyte fescue pastures when they are lush and rapidly growing results in better animal gains. The reduction in average daily gain (ADG) of stocker cattle grazing highly infected tall-fescue pastures is less in April-May and September-November than the 0.10 pound per day for each 10 percent higher level of infection suggested by earlier research. Therefore, high-endophyte tall fescue pastures should be grazed only in the spring and fall to reduce the endophyte effect.

The toxin believed to cause fescue toxicity is ergovaline, and the concentration of ergovaline is lower in the leaves than in the sheath, stem, and seeds (Table 10). Grazing when the grass is lush with a high percentage of leaves would result in less toxicity occurrence compared with grazing mature grass. The seed head needs to be clipped early to prevent grazing by cattle and should improve animal gains and help reduce eye problems associated with grazing tall fescue pastures.

Table 10. Level of ergovaline in tall fescue herbage and seed *(11).*

Plant Part (June 1)	Ergovaline Level, ppm	Infection Rate, %
Leaf blade	.247- .357	85-100
Sheath & stem	.208- .495	85-100
Seed heads	.976-1.534	85-100

Legume Interseeding. Legumes may be planted in high-endophyte fungus pastures to dilute the amount of tall fescue consumed. This practice is most beneficial if pastures are grazed during the summer. Legume interseeding has improved average daily gain of stocker cattle (Table 11) and conception rates in spring-calving cows.

Table 11. The effect of ladino clover on gains of steers grazed April-November (6, 18).

	High Endophyte Ky-31	Ky-31 & Ladino
ADG	.85	1.05

Table 12. Effect of zeranol on steers grazing high- and low-endophyte fungus tall fescue pastures (8).

	Low Endophyte (20%)			High Endophyte (82%)		
		Zeranol			Zeranol	
	Control	36 mg	72 mg	Control	36 mg	72 mg
No. animals	50	50	50	50	50	50
ADG (lb)	1.29	1.43	1.48	.95	1.29	1.38
Improvement (%)		10	17		37	47

Implanting. Implanting with 36 mg of zeranol (sold as Ralgro) has been shown to improve ADG more on high-endophyte pastures than on low-endophyte pastures (Table 12). A study with calves nursing cows grazing high- and low-endophyte fungus tall fescue pastures showed an improvement in ADG by implanting with 36 mg zeranol, but the magnitude was lower than in the previously mentioned experiment. For the first 66 days in a feedlot study, steers previously fed high-endophyte hay showed a greater response to zeranol than steers fed low-endophyte hay (Table 13).

Table 13. Effect of zeranol on early feedlot gains after consuming high- and low-endophyte fungus tall fescue hay *(14).*

	Low Endophyte		High Endophyte	
	Control	36 mg Zeranol	Control	36 mg Zeranol
No. steers	24	24	24	24
Starting wt. (lb)	661.0	659.0	633.7	636.8
Final wt. (lb)	804.0	815.3	797.5	834.3
ADG (lb)	2.16	2.37	2.48	2.99
Improvement (%)		9.70		20.0

Kentucky research (*14*) showed implanting with 24 mg estradiol 17-B (sold as Compudore) resulted in a 26 percent improvement in ADG on highly infested Ky-31 pasture compared with a 7 percent improvement on low-infested pastures. However, the response per day to implanting was no different.

Feeding Low Levels of Antibiotics. Aureomycin or terramycin at 300-500 milligrams per animal per day has improved steer gains 0.10-0.15 pound per day, improved weaning weights 20 pounds, and improved conception rates by 4-5 percent. Aureomycin 50 or Terramycin 50 can be added to mineral mixtures at the rate of 8-10 pounds per 100 pounds. Results of research in Southeast Kansas are shown in Table 14.

Table 14. The effect of Terramycin on gain of steers grazing 65-70 percent endophyte-infested tall fescue pastures *(15).*

	Control	Terramycin Mineral
No. steers	25	28
Starting weight (lb)	518	508
ADG (lb)	.98	1.24
Body temp. °F	103.3	103.1
mg/head/day	-	600

Kentucky research data (Table 15) shows a beneficial effect of feeding antibiotic to cows grazing tall fescue pastures. Antibiotic feeding improved conception percentage and weaning weight, and reduced the incidence of pinkeye.

Table 15. The effect of Aureomycin fed to cows grazing tall fescue. Antibiotic feeding started 30 days after calving *(16).*

	Control	Aureomycin
No. months fed	5.5	5.5
Calf gain (lb)	243	264
Conception (%)	74.3	77.0
Pinkeye incidence (%)	10.7	2.4

Vitamin A. Vitamin A supplementation during the summer may help reduce heat stress. However, vitamin A did not improve weaning weight or cow conception rates in a four-year Kentucky *(16)* study in which cow-calf pairs were grazing high-endophyte tall fescue pastures.

Mineral Supplementation. A good mineral program is needed on high-endophyte fungus tall fescue pastures. There appear to be some absorption problems with phosphorous even though the level in the plant is high. If cattle normally consume a mineral mixture at the rate of 0.10 pounds per animal per day, then a mineral mixture containing 10 percent phosphorous is needed for most classes of cattle. Research from West Virginia (2) showed phosphorous absorption problems when lambs were fed tall fescue hay (Table 16). It appears that phosphorous supplement is very important for cows grazing tall fescue pastures because of the role of phosphorous in reproductive efficiency.

A selenium deficiency has been suggested as being related to fescue grazing. Research *(5)* suggests that selenium deficiency is not a concern in Kansas but can be in states where tall fescue is grown on selenium-deficient soils. In those states, it may be necessary to add selenium to the mineral mixture. Cattle shipped from states where fescue is grown on soils that are low in selenium may need selenium supplementation for a short time after arriving in Kansas.

Table 16. Mineral concentrations and absorptions by lambs *(2).*

	Smooth Bromegrass	Orchard Grass	Tall Fescue
		%	
In grass			
Calcium	.33	.35	.41
Phosphate	.27	.28	.28
Magnesium	.10	.15	.24
Potassium	2.64	2.86	2.91
Sulfur	.21	.21	.28
Apparent absorption			
Calcium	30.1	31.2	20.2
Phosphate	20.6	14.7	-7.3
Magnesium	34.6	43.5	29.5
Potassium	89.6	88.8	88.3
Sulfur	61.5	59.8	67.9

Research in Kentucky *(14)* showed a 3 percent improvement in pregnancy rates when selenium was injected every 28 days. Data in Missouri *(4)* showed a 0.2 pound gain response to selenium supplementation on grass, but that advantage was lost during the finishing period.

Grass tetany may occur in early spring when tall fescue starts growing. To prevent it, a mineral mixture containing 12-15 percent magnesium oxide is needed during March and April. Magnesium oxide is not very palatable; consequently, adding 10 percent soybean meal or dried molasses may be required to ensure proper intake by grazing cattle. Fertilization beyond potassium requirements may increase the occurrence of grass tetany.

Breed Effect. Brahman and Brahman-cross cattle may be more tolerant of the endophyte fungus and heat stress than other breeds of cattle grazing high-endophyte fungus tall-fescue pastures.

Grain Supplementation on Lush Tall Fescue. The potential exists to improve cattle gain through use of grain supplementation on lush fescue. Research at the Southeast Kansas Experiment Station has shown good response to feeding 2 pounds of grain on lush brome (Table 17). When an ionophore was added to the grain, the conversion of grain to gain was further improved. Early brome and fescue are high in protein but limited in energy. Grain may be required to get better protein utilization in the early pasture, and the amount of grain needed on high-endophyte fescue pastures should be evaluated. The dry matter intake is lower on high-endophyte fungus pasture compared with brome or fungus-free fescue, which would make energy even more limited. Supplementation with 4-5 pounds of grain may be necessary to dilute the intake of the endophyte and to help restore the energy lost through lower dry matter intake.

In most cases, limited energy is a factor with cattle grazing tall-fescue pasture. However, some of the protein in lush tall fescue is nonprotein nitrogen, which may be better utilized with the addition of grain. The concern in grain supplementation on lush pasture is that fiber digestibility declines as a result of lower rumen pH. A study on lush fescue, *(7)* however, showed that feeding 3 pounds grain with sodium bicarbonate did not improve ADG. Therefore, the change in pH may not be great enough to affect fiber digestibility to the point of reducing animal performance.

Feedlot Performance Following Grazing Tall Fescue. Performance of cattle following removal from infected fescue has been variable. Research in Kansas *(6)* in 1986 showed feedlot daily gain by cattle that previously had grazed infected tall fescue was greater than for cattle that had grazed fungus-free or tall fescue interseeded with ladino clover. Feed-to-gain ratios for steers from infected tall fescue were lower than for steers from interseeded or fungus-free pastures.

Table 17. Energy supplementation on brome. 500-600-pound steers, 127 and 140 days on brome from May to August *(1, 3).*

	Pounds of Grain/Head/Day				
	0	2	2 plus Rumensin	4	6
ADG 1978, lb/day	.9	1.3	1.4	-	
ADG 1979, lb/day	.8	1.2	-	1.6	1.8
lb Feed/extra lb gain, 1978	-	4.9	3.5	-	-
lb Feed/extra lb gain, 1979	-	5.0	-	5.0	6.0

Hancock *(9)* reported reduced daily gains from the first 56 days in the feedlot but similar gains over the entire feeding period by steers that previously grazed tall fescue compared with orchardgrass-red clover or bromegrass-red clover pastures. However, Coffey *(13)* reported lower feedlot gains by steers that previously grazed 70 percent endophyte-infected tall fescue than those that previously grazed endophyte-infected tall fescue interseeded with ladino clover or Midland bermudagrass.

Others have reported that grazing endophyte-infected tall fescue had no effect on subsequent feedlot performance *(12,19)*. Cole *(10)* and McDonald *(17)* reported compensatory gain by steers that formerly grazed endophyte-infected tall fescue. The effect on feedlot gains of cattle previously grazing endophyte-fungus tall fescue pastures may vary with location, climate, season, weather, and other factors.

Handling Infected Pastures

- Manage to reduce effects. Keep grazed plants young. Use in March-May and September-November.
- Harvest for hay prior to heading. Don't stockpile for winter grazing.
- Implant calves and yearlings with 36 milligrams Ralgro every 100-120 days while grazing infected pastures.
- Dilute the endophyte. Use legumes in the pasture or supplement with other feeds such as grain or hay.
- Kill infected stands and replant. This process is complicated and methods depend on slope, rocks, and other factors. Producers should contact their local Extension agriculture agent to assist in developing a revegetation plan. Remember, any infected fescue pasture which will be replanted must not produce seed in the year prior to re-establishment to avoid volunteer plants with live endophyte.

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Summer Annual Forages

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Summer annual forages are warm-season grasses that tolerate hot, dry weather and are adapted to most areas of Kansas. They include forage sorghums, sudangrass, sorghum-sudangrass hybrids, hybrid pearl millet (*Pennisetum glaucum*), and foxtail millet (*Setaria italica*). The timeliness of growth and the potential for high-yielding, high-quality forage can make summer annuals an important component of forage programs.

Selecting a type or variety of summer annual should be based on the needs of individual livestock programs. Summer annual grasses have different growth characteristics which influence how they are best used. Large differences in yield and quality occur among species, varieties, and hybrids. Many cultivars are adapted to specific areas in Kansas.

Sudangrass. Sudans produce less forage than most other summer annuals, but their small stems, extensive tillering, and rapid regrowth potential are ideal for grazing and haying operations.

Hybrid sudangrasses are variety crosses that are more productive than the parents. They primarily are used for grazing, haying, and green chop operations.

Sorghum-sudangrass hybrids. Sorghum-sudangrass hybrids are the most common summer annual grasses in Kansas. They can produce high forage yields, but over 50 percent of the production is stem. Consequently, the plants are better suited for silage or green chop than grazing.

Forage Sorghum. Forage sorghums are robust plants with succulent stems that mature late in the growing season. They produce high yields but have limited regrowth ability, making them best suited for one-cut silage operations.

Hybrid Pearl Millet. Hybrid pearl millet is a leafy summer annual that is more drought-resistant than sudangrass. Because it has high forage quality and regrows rapidly, it is ideally suited for haying and grazing operations. Hybrid pearl millet, however, is sensitive to overgrazing, and at least eight inches of stubble is necessary for regrowth.

Foxtail Millet. Foxtail millet has low quality and palatability, and forage yields are relatively poor. It is shallow-rooted and easily pulled out of the ground when grazed. If harvested after heading, the awns and bristles can injure livestock. Foxtail millet has limited value in Kansas because other summer annuals are better suited for forage programs.

Planting

Time of Planting. Summer annuals should be planted when the soil temperature reaches 70°F to 75°F. Planting in cooler soils reduces seed germination and emergence. Hybrid pearl millet and foxtail millet seeds are particularly intolerant of cold, wet soils and should not be planted until late May or early June.

Seeding date should be timed so the forage becomes available when it is needed. It usually takes four to six weeks after planting before summer annuals can be used.

Seeding Method. Most summer annuals can be planted with a grain drill. Sorghums usually are planted in 30-inch rows, but row width has little effect on total forage production.

Optimum planting depth of summer annual grasses varies with soil type and moisture, but generally is 1–1½ inches. Hybrid pearl millet and foxtail millet have small seeds and should be planted three-fourths to one inch deep. Germination is enhanced by covering the seed with moist soil to provide firm seed-to-soil contact.

Seeding Rate. Seeding rates for summer annuals are relatively high because only 65–70 percent of the seeds normally emerge. Rates vary across the state depending upon plant variety, rainfall, growing conditions, and intended use of the forage.

When drilling in narrow rows, hybrid pearl millet and forage sorghums should be planted at 10–20 pounds per acre; foxtail millet planted at 15–30 pounds per acre; and sudangrasses and sorghum-sudangrass hybrids planted at 20–25 pounds per acre. Seeding rate of forage sorghums planted in wide rows is 4–6 pounds per acre. Use the lower rates in dry areas and the higher rates in irrigated areas. For pasture and hay operations, seed at the higher rates to produce plants with fine stems.

Fertilization

Summer annual forages have nutrient requirements similar to grain sorghum and must be fertilized to be productive. Fertilizer and lime needs are best determined by soil tests.

Nitrogen is the nutrient most frequently lacking for optimum production. On nitrogen deficient soils, apply 30-40 pounds of nitrogen per acre for each expected ton of dry matter production. Split applications provide better nutrient distribution and reduce the potential for nitrate or prussic acid toxicity. Nitrate accumulation is likely if excessive nitrogen is applied or if production is limited by drought. To minimize nitrate accumulation potential, application rates should be based on a profile nitrogen soil test and previous crop and manure credits.

Phosphorus, potassium, and other nutrient applications should be based on soil test recommendations. Because phosphorus does not appreciably move in the soil, it should be applied either preplant or banded at seeding. Lime is recommended if the soil pH is 6.0 or less in the eastern third of the state, or less than 5.5 in other areas. Iron chlorosis is likely a problem on calcareous, high pH soils in central and western Kansas. Foliar application of iron and preplant incorporated manure are the most effective methods of correcting iron chlorosis; however, manure should not supply nitrogen in excess of recommended nitrogen rates.

Weeds

Rapidly growing summer annual grasses are competitive with weeds that emerge after seeding, and weed control may not be cost-effective. Cultivation can control weeds if row spacing is adequate.

Herbicides are an alternative for problem weed species, although there are few herbicides labeled for weed control in most summer annual forages. Atrazine may be either soil-applied or foliar-applied on forage sorghum and sorghum-sudan hybrids. Other herbicides are brand specific and should not be applied unless specifically approved on the label. **Follow label instructions carefully and use herbicides with caution.** Refer to the annual KSU Extension publication, “Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland,” for recent information on herbicides for summer annual forages.

Insects

Many summer annual forages are susceptible to insects that attack sorghums. Infestation problems vary throughout the state and from season to season. Greenbugs generally are a concern because they occur statewide and are capable of causing serious damage to sorghums and sudangrasses. Hybrid pearl millet is highly resistant to greenbug damage.

Chinch bugs are often a problem in central and eastern Kansas, particularly during dry seasons or if the summer annual is planted into wheat stubble. Heavy infestations of destructive insects may necessitate spraying with an approved insecticide. **Follow label directions carefully when applying insecticides.**

Utilization

Harvesting summer annuals depends upon the livestock operation, weather, available equipment, storage facilities, and the needs, abilities, and preferences of the producer.

Grazing. Sudangrasses and hybrid pearl millets can provide high-quality forage when the nutritional requirements of livestock are not being met by native pasture. Sorghum-sudangrass hybrids can be grazed, but are less palatable than sudans or hybrid pearl millet, and livestock performance is lower. Because forage sorghums have thick stems, limited regrowth ability, and are notorious prussic acid producers, they are undesirable for grazing operations.

The objective of a grazing program is to keep the plants in a vegetative stage and prevent them from seeding. Sudangrasses and hybrid pearl millet should not be grazed until 18 inches tall; sorghum-sudangrass hybrids should not be grazed until 24–30 inches tall. Ideally, the pasture should be rapidly grazed to a six- to eight-inch stubble, rested until regrowth reaches the appropriate height, and then regrazed. Overstocking removes too much stubble and severely reduces regrowth production. At the other extreme, if a pasture is understocked, the plants mature and become stemmy. Forage production thus is wasted because cattle selectively graze the leaves and avoid the stems. If the grass is more than 36 inches high, remove the cattle and cut the forage for hay or silage.

Summer annual grazing programs may either supplement or complement native grass. A supplementary system allows livestock to graze summer annual pasture simultaneously with native range. Supplementary systems require tillable land adjacent to native range at an approximate ratio of one acre cropland to three acres rangeland. Once the summer annual is ready to graze, cattle are allowed free access between native and planted forages.

In complementary or sequential grazing programs, native and summer annual pastures are grazed as separate entities. Livestock are moved from native grass to summer annual pasture around mid-July and remain until the end of the growing season. The livestock thus receive a higher quality forage, and the late-season rest benefits native range by increasing vigor of the perennial grasses.

Complementary annual pastures often are continuously grazed during the summer because that approach requires minimal management and labor input. Continuous grazing of summer annual pastures, however, is wasteful and inefficient. Depending upon moisture, fertility, and temperature, regrowth varies widely from week to week through the growing season. Because stocking rates cannot be periodically adjusted to correspond with fluctuations in forage production, continuously grazed complementary pastures generally either are under-or overused.

Highest stocking rates and most efficient use of summer annual pastures are obtained with a rotational grazing system. This system involves subdividing a pasture and stocking one section with enough cattle to graze the plants to a six- to eight-inch stubble in 10–14 days. The cattle then are moved to the next field. With three or more fields in the rotation, the planting dates can be staggered so the cattle are sequentially rotated to a field that is ready to graze (Table 1). Implementing a rotational system requires controlled management and constant monitoring because the number of days each field is grazed in succeeding rotations varies according to regrowth production. Applying 30 pounds of nitrogen per acre after the cattle are removed will hasten regrowth.

With a rotational grazing system, summer annuals can provide nearly 90 days of high-quality forage. During this time, each acre can supply forage for two to six yearling steers. Actual stocking rates are difficult to predict because they depend upon plant species, cattle size, soil type, fertilization, moisture, and other managerial and environmental factors. Highest stocking rates occur with irrigation, fertilization, and attentive planning. Until the ability and commitment of each producer is established through experience, conservative stocking is a prudent approach.

Table 1. Rotational grazing scheme for summer annual forages.

Pasture A. Plant in late May. Begin grazing when the grass is 18 inches high. Move cattle to Pasture B when the stubble height reaches 6–8 inches.

Pasture B. Plant 10–14 days after Pasture A. Allow cattle to graze until stubble height reaches 6–8 inches and then move to Pasture C.

Pasture C. Allow cattle to graze until stubble height reaches 6–8 inches and then move back to Pasture A.

Hay. Sudangrasses and hybrid pearl millets are best adapted for hay operations. Sorghum-sudangrass hybrids can be cut for hay, but their thick stems are difficult to cure, and crushing, crimping, or a hay conditioner is required to speed drying.

For high-quality hay, plants should be cut before the heads emerge. Harvesting after heading substantially reduces forage quality. Summer annuals can produce two or three hay crops if six to eight inches of stubble is left for regrowth. Applying 30 pounds of nitrogen after the first cutting will hasten regrowth and increase protein content.

Silage. Forage sorghums and sorghum-sudangrass hybrids are best suited for silage. Important characteristics of a variety or hybrid include potential yield, quality, and grain production. Late-maturing hybrids may produce high forage yields but little or no grain. Highest quality silage is from forages having at least 20 percent of their dry matter as grain.

Moisture content in the forage is a critical factor affecting sorghum silage. Harvest should be delayed until the hard dough stage when the plant water content normally reaches 60–70 percent. If cut earlier, the forage must be field wilted or mixed with dry feed to reduce moisture levels. High moisture silage becomes moldy, low-quality, and unpalatable. For more detailed information, see KSU Extension publication AF-144, “Producing Sorghum Silage,” and Experiment Station Bulletin SB-642, “Summer Annual Forages for Livestock Production in Kansas.”

Haylage (Low-Moisture Silage). Haylage is low-moisture forage that has higher dry matter than silage. The forage is cut when it is 30–50 inches tall, left to wilt until the moisture content reaches 40–50 percent, and ensiled in an airtight silo. Haylage that is too dry will not preserve and can heat spontaneously if exposed to oxygen.

Green Chop. Sorghum-sudangrass hybrids are best suited to a green chop program. Once the crop reaches 30 inches it can be cut and fed daily as needed. With a cutting height of six to eight inches and adequate moisture and fertility, the regrowth can be harvested within 30 days.

Green chop is high-protein forage and commonly is fed to dairy cattle and other high-producing livestock. Field losses are low, but forage quality varies throughout the season. After heading, quality and digestibility are greatly reduced. The harvested forage should be fed immediately after cutting and not allowed to wilt and heat in the wagon or feed bunk.

Livestock Poisoning Potential

Summer annual forages may be potentially dangerous to livestock. Horses occasionally develop kidney problems and bladder paralysis if sorghums, sudangrasses, or foxtail millet are a major component of the diet. Hybrid pearl millet does not cause cystitis. New cultivars have reduced the hazard; however, horses should not consume high amounts of sorghums, sudangrasses, or foxtail millet.

Nitrate Toxicity. Under certain environmental and managerial conditions, all summer annual forages can accumulate potentially toxic nitrate levels. When plants are stressed by drought, shade, frost, or temperature extremes, nitrates accumulate. Heavy nitrogen fertilization, especially late in the growing season, increases the likelihood of nitrate accumulation.

Nitrates normally are highest in young plant growth; however, concentrations remain high in mature sorghum and sudangrass. Highest levels occur in the lower one-third of the plant stem. Thus, the cutter bar should be raised 6–12 inches to exclude basal stalks. Nitrate concentrations remain virtually unchanged over time if summer annuals are harvested for hay.

Potentially troublesome plants, such as sorghum and sudangrass, should be analyzed before feeding. Environmental conditions in Kansas create high nitrate concentrations in some forages virtually every year. Consequently, analysis is necessary to determine if the feed is potentially toxic. Toxicity is related to the total amount of forage consumed and how quickly it is eaten. Generally, if forages contain more than 6,000 ppm nitrate, they should be considered potentially toxic (Table 2.)

High nitrate forages still can be fed if proper precautions are taken. These include not feeding to hungry, sick, pregnant, or stressed animals; diluting the forage with other feeds; supplementing grain; and gradually adapting the animal to increasing nitrate amounts.

Prussic Acid Poisoning. Prussic acid, or hydrogen cyanide (HCN) poisoning, is caused by cyanide production in some summer annual forages under certain growing conditions. Sorghums and sudangrasses are commonly involved with prussic acid poisoning, but cultivars and hybrids vary widely in their potential cyanide production. Toxic cyanide levels are not a problem with pearl millet and foxtail millet.

Cyanide is concentrated in young, actively growing leaves. Prussic acid poisoning is commonly associated with cattle grazing new shoot growth at the end of a summer drought or after the first autumn frost. Plants growing in soils high in nitrogen and low in phosphorus and potassium tend to have high cyanide concentrations.

Precautions to avoid prussic acid poisoning include not allowing hungry or stressed animals to graze where prussic acid may be a problem; feeding grain or hay before turning animals to pasture; and not allowing animals to graze sorghum after a light frost or after rain has ended a summer drought. The minimum plant height for safe grazing is 18 inches for sudangrass and 24–30 inches for sorghum-sudangrass hybrids. After a killing frost, cyanide is slowly released and the plant can be grazed after four days if no regrowth occurs.

Nitrate and prussic acid toxicity problems can be minimized with careful management. Their potential occurrence should not be a deterrent for incorporating summer annuals into a forage program. For more detailed information, see KSU Extension publication MF-1018, “Nitrate and Prussic Acid Toxicity in Forage.”

Summary

Summer annual forages suitability potential.

Utilization	Pearl Millets	Sudans	Sorghum-Sudans	Forage Sorghums
Grazing	Excellent	Excellent	Fair	Poor
Haying	Excellent	Excellent	Fair	Poor
Silage	Fair	Fair	Excellent	Excellent
Green Chop	Fair	Fair	Good	Excellent

Table 2. Level of nitrate in forage (dry matter basis) and potential effect on animals.

ppm Nitrate	Effect on Animals
0-3,000	Virtually safe.
3,000-6,000	Moderately safe in most situations; limit use for stressed animals to 50% of the total ration.
6,000-9,000	Potentially toxic to cattle depending on the situation; should not be the only source of feed.
9,000 and above	Dangerous to cattle and often will cause death.

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Wheat Pasture in Kansas

Cooperative Extension Service
Kansas State University
Manhattan

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Introduction

Many producers in the southern Great Plains use wheat as a dual crop. Wheat is a cash grain crop as well as forage. Wheat pasture is a valuable source of high-quality forage, typically available in late fall, winter, and early spring, when other forage sources are low in quality and quantity. The crude protein content of wheat pasture commonly ranges from 20–30 percent. The stocking rate during fall and winter ranges from 250–500 animal pounds per acre, depending on growing conditions. During the spring, stocking rates usually can be increased to 500–1,000 animal pounds per acre to utilize the lush growth. Average daily stocker gains are commonly 1.5–2.0 pounds.

In Kansas, the cash grain value of wheat is approximately $1.2 billion on 10–12 million acres. Three to six million acres of wheat, primarily in the southern half of the state, could be grazed without detrimental effects on grain yields. Wheat pasture allows grain/cattle producers to utilize their acreage more effectively. Many producers have decided that it is more profitable to graze out their wheat than to harvest it for grain. These decisions must be made on a field-to-field and producer-to-producer basis.

Cultural Practices

Planting Date. Early planted wheat has the potential to produce excellent fall growth if soil moisture allows rapid germination and emergence. Dry soil nullifies the advantages of early planting. Wheat planted late in the season limits fall grazing potential. Producers generally plant wheat 2–3 weeks earlier than usual if it is to be grazed. Grazing can begin 4-6 weeks after planting when there is 6–12 inches of growth. Producers usually try to plant in late August or early September, to promote enough growth to allow fall grazing.

There are disadvantages in planting wheat for pasture too early. The incidence of diseases such as wheat streak mosaic may increase, which would reduce forage production. Early planted wheat serves as a host, spreading the disease to fields planted later. Early planting also encourages heavy Hessian fly infestations. Dry soil conditions frequently prevail in late August and early September and may necessitate "dusting-in" the seed. Variable germination and emergence may cause erratic stands and delay initiation of grazing.

Planting rate. Producers interested in early fall grazing increase planting rates by 50–100 percent, depending on planting date and soil moisture. The earlier the planting date, the less the need to increase seeding rates. Higher rates, however, will promote greater upright growth. If planting is delayed, it is important to increase seeding rates as much as 100 percent.

In irrigated fields and in eastern Kansas where rainfall is higher, seeding rates commonly are 90–120 pounds/acre. In dryland areas of western Kansas, seeding rates should be no more than 50 percent above those of wheat planted for grain. In central Kansas, seeding rates for wheat pasture often will be 75–120 pounds/acre. Because high seeding rates can cause moisture stress, it is necessary to monitor soil moisture carefully to determine when the top growth should be removed.

Varieties. There are probably greater year-to-year differences than varietal differences in total forage produced. A Kansas grazing study found a difference of 2,000 pounds forage dry matter/acre between years with the same variety, but only 800 pounds forage dry matter/acre difference among varieties. In a five-year Texas grazing study, seasonal forage yields ranged from 2,700–8,800 pounds dry matter/acre, but the difference among 13 varieties ranged from 600–2,500 pounds/acre.

Some plant characteristics make certain varieties more useful for grazing. Producers should select varieties that tiller profusely, have rapid, upright fall growth, and good regrowth potential after grazing. In much of Kansas, it is important that grazing varieties be resistant to soilborne mosaic virus and Hessian fly. In much of eastern and central Kansas, varieties should be tolerant to aluminum toxicity caused by acid soils. These problems can reduce forage yields dramatically and require careful management to avoid losses.

In other regions of the Great Plains, producers mix species such as rye and annual ryegrass to promote growth throughout the year. Because rye has excellent fall growth, it maybe mixed with wheat to improve early fall growth for graze-out. Wheat ordinarily will produce more spring forage than rye. Species mixtures are not a good practice for a field that will be combined, because of the potential for dockage at the elevator. Farmers should destroy the rye after grazing to eliminate seed production.

Fertility. Adequate amounts of all essential plant nutrients are necessary for maximum forage production. Wheat used for grazing will remove more soil nutrients than the wheat grain crop. Nitrogen (N) is usually the most limiting nutrient associated with wheat forage production. A soil test for available nitrogen is helpful in evaluating the amount of supplemental nitrogen needed.

Wheat forage containing 25 percent crude protein will have 80 pounds of nitrogen in each ton of dry matter. Realistic forage yields and the growing season are factors to consider when applying fertilizers. A general recommendation is to increase nitrogen rates by 30–50 pounds/acre for wheat as forage or for more specific recommendations, this formula can be used: (animals/acre) x expected pounds of weight gain x 0.4 = amount of nitrogen/acre to add. Many producers who utilize wheat as grain make only one nitrogen application at or prior to planting. Others use split applications, applying a portion of the nitrogen in the spring. This increases application costs, but particularly with sandy soils susceptible to leaching and heavy soils subject to standing water (denitrification), it allows more efficient use of the nitrogen. Split applications are best suited for grazing situations because producers can adjust N-rates to forage removal and environmental conditions. If conditions are favorable for heavy fall and/or spring grazing, additional N maybe necessary, especially for a grain crop.

Wheat responds well to phosphorus (P) application on soils testing low in available phosphorus. Phosphorus deficiency reduces wheat tillering and makes the plants more susceptible to winterkill. Phosphorus fertilization should be based on a soil test. Banded phosphorus applications, preplant or at planting, are more efficient than broadcasting, especially on acid soils low in available phosphorus. Incorporating phosphorus fertilizer into the soil increases the efficiency of broadcast applications. Dual applications of nitrogen and phosphorus in a band with a tillage implement save time by combining fertilization with tillage prior to planting.

Potassium (K) deficiency also can limit forage production. A soil test is the best guide for sound K applications. Low potassium levels are common in southeastern Kansas soils and in sandy soils. Potassium may be applied either as a starter or can be broadcast and incorporated ahead of planting. To avoid possible germination problems, no more than 20 pounds/acre of potassium (or combination of N and K) should be in direct contact with the seed.

Soils low in organic matter may benefit from sulfur. Sulfur deficiency symptoms resemble those of nitrogen deficiency, with yellowing leaves and slow growth. Studies at Kansas State University have shown grain yield increases and a forage greening effect with the addition of sulfur on sandy, low-organic-matter soils.

In south central Kansas, low soil pH can dramatically reduce forage and grain yields. Low soil pH can be corrected by liming. Tolerant varieties do not replace a liming program and should be used in combination to reduce the pH effect. See the "Wheat Production Handbook," C-529, for more details regarding production practices.

Nutritive Value of Wheat Pasture

Wheat forage provides succulent and highly nutritious forage for cattle and sheep. It is palatable; high in protein, energy, and minerals, and low in fiber. Because of its high moisture content, it is sometimes difficult to meet the daily dry matter needs of cattle. Making some dry, high-quality forage or grain available often improves animal performance.

The crude protein (CP) content is particularly high, usually between 20 and 30 percent, and sometimes above 30 percent. The CP component is highly soluble and available to animals. Properly managed wheat can be an effective protein supplement for livestock simultaneously grazing or eating other lower quality feedstuffs.

Stage of maturity influences chemical composition of wheat. In vitro dry matter digestibility decreases from 80 percent or more during the vegetative stages of fall and early spring to less than 60 percent by the soft dough stage. The major decline occurs by the heading stage. Crude protein also declines rapidly, dropping from 25–30 percent for vegetative wheat forage to 12–15 percent by heading and 9–10 percent by the soft dough stage.

Conversely, cell wall components increase with advancing maturity. Total cell wall (neutral detergent fiber) increases from less than 40 percent to the mid-50 percent range, and acid detergent fiber, primarily cellulose and lignin, increases from 20–25 percent to more than 30 percent.

Mineral content [potassium, calcium (Ca), phosphorus, and magnesium (Mg)] also declines considerably with maturity. The Ca:P ratio is often as low as 1:1.1 compared with a desired 2:1 ratio, and Mg levels can be low or inadequate for animal needs. A free-choice "wheat pasture mineral" containing 6–8 percent calcium and magnesium is often recommended for livestock on wheat.

Although many trials comparing types and varieties of wheat have noted differences in quality, the growth stage, climatic differences, and rate and timing of nitrogen fertilizer applications regularly overshadow such differences.

In summary, wheat pasture is high in moisture content, crude protein, and digestible nutrients prior to heading. It is palatable and digestible, and has a fast rate of passage because of its low content of cell wall constituents (fiber and lignin).

Grazing Management

Depending on climatic conditions, wheat pasture may be grazed in the fall, in the spring, or both. During mild winters with adequate rainfall, some growth occurs. In Kansas, most grazing occurs during late fall and early winter and again in spring, with animals removed early enough to allow good grain production. Some producers completely graze out the wheat, precluding grain harvest.

To maximize forage for grazing, early seeding, increased seeding rate, and more nitrogen fertilizer are recommended. Depending on rainfall and stored soil moisture, wheat pasture is generally available for 120–150 days. Grazing cannot begin until the plants have adequate root development to prevent their being uprooted by grazing animals. Ordinarily, wheat is available for grazing between October 15 and November 15. An accumulation of one-third to one ton of dry matter/acre (6–12 inches tall) will result in excellent season-long pasture production, provided moisture, temperature, and management are reasonable. More typically, however, an accumulation of one-fourth to one-half ton of dry matter/acre (4–8 inches tall) should be available before grazing begins.

Wheat tends to produce more tillers and leaves than are necessary for maximum grain yield. However, research literature and producers' experiences disagree on the beneficial and detrimental effect of grazing on grain yields when animals are removed before stem elongation (jointing). Some researchers say yield loss is related to the amount of leaf area lost due to spring grazing. There is, however, definite agreement on the sharp, steady decline in grain yield if grazing continues after jointing.

Grazing wheat generally affects maturity, the number of culms (tillers) produced, lodging, and available soil moisture. Grazed wheat usually matures 1–4 days later than ungrazed, with more severe grazing resulting in longer delays. Delayed maturity may expose the crop to increased stress from high temperatures and/or disease pathogens during grain filling.

The number of culms per acre is reduced in direct proportion to grazing severity. This reduction in tiller number will reduce yields in favorable years, but can be beneficial if moisture or other stresses follow in late spring.

Grazing wheat tends to reduce lodging. With the advent of semidwarf wheats and optimum fertilizer applications, however, grazing is less advantageous than with older, taller varieties. Risk of lodging is usually lower in western and central Kansas than in eastern Kansas.

Grazing removes excessive top growth, which conserves soil moisture by reducing the amount of water transpired by the leaves. This can be particularly advantageous in seasons with adequate or surplus fall precipitation but limited spring moisture.

In summary, studies in Kansas and throughout the Great Plains indicate that grazing appears to have little effect on grain yields when fertility is adequate, grazing is not too heavy, cattle are removed before jointing, top growth removal reduces water use, and lodging is reduced.

Grazing may reduce grain yields when nutrients are limited, grazing is severe, water stress is limited or nonexistent, lodging is not a problem, or wet soil conditions cause compaction and trampling of the wheat plants.

Livestock Management

Both stocker cattle and mature animals can effectively utilize wheat pasture. Because of its high nutritive value, stockers and fall-calving cows can utilize the forage more profitably.

Both continuous and rotational grazing systems are acceptable for stocker cattle. Average daily gain of stockers on good wheat pasture is essentially the same with either system. This is true as long as adequate forage is available because the quality of vegetative wheat forage is generally high.

The primary advantage of rotational grazing is better utilization of available forage. It reduces spot grazing and often results in 10–15 percent increased animal gain/acre. Better utilization often is perceived as increased forage production. The more often wheat is grazed, the longer the period for forage production.

Many farmers do not use rotational grazing because of added fencing and water costs and because it requires more planning. It may require more labor to move animals from field to field, particularly if fields are some distance apart.

Optimum stocking rates vary considerably from year to year, depending on many climatic and management factors that influence wheat forage yields. Recommended fall and winter stocking rates often range from 250–500 pounds of animal/acre (1–2 acres/stocker, depending on weight). Spring stocking rates usually are 1.5-2.0 times greater than for fall (0.75-1.3 acres/stocker, depending on weight), although rates as high as 1,400 pounds of animal/acre (2.5 stockers/acre) have been noted in some research trials during late spring graze out.

Providing stockers with dry feed in addition to the wheat pasture allows increased stocking rates and may improve general animal health. Grass hay, silage, or limited grain may be fed, or adjacent sorghum stubble or cornstalks may be grazed along with wheat pasture. Providing some dry feed may offset possible animal digestive problems—including bloat—that result from the succulent, laxative wheat forage.

To avoid overgrazing and damage from trampling, it is best to provide an area (preferably grass) near the wheat pasture for water, salt-mineral, supplemental feeding, and animal loafing. If this is not feasible, provide them at different field corners or borders to improve grazing distribution. Remove animals from the pasture during extremely wet weather, particularly on fine-textured soils. During periods of extreme cold—about 15°F or less—remove animals to prevent injury to plants.

Average daily gains of stockers on wheat pasture regularly range between 1.5–2.0 pounds. Gains under 1.0 pound/day indicate that the pasture probably is overstocked and/or other key management practices are lacking.

Grazing Problems

Two potential problems when grazing wheat pasture are bloat and grass tetany. High crude protein and low fiber contents in wheat pasture are associated with bloat. Cool, moist conditions also favor bloating.

To aid in preventing bloat, do not put hungry cattle on lush pasture. When grazing begins, carefully monitor to identify animals more susceptible to bloat, so they can be removed before chance of loss. Observing the cattle often to detect bloat can prevent loss. Bloat potential is greatest during the 3- to 4-week periods of lush growth in the fall and early spring. Feeding Bloat-Guard (poloxalene) as a dry or liquid energy supplement, molasses block, or mineral supplement is the most effective procedure to prevent bloat. Feeding high-quality grass hay, silage and/or grain with Rumensin or Bovatec also will minimize the bloat potential.

Tetany is characterized by a low blood magnesium level in livestock. It occurs more often in older cows nursing young calves, but may affect stockers as well. Tetany frequently occurs during rapid spring growth following cool temperatures (45º–60ºF), but may occur in fall. The easiest prevention is to provide 6–8 percent magnesium in a palatable, free-choice mineral supplement.

Wheat Pasture in a Forage System

In addition to its high quality a major advantage of wheat pasture is its time of availability. Producers need good-quality roughage in late fall, winter, and early spring to complement perennial warm- or cool-season grass pastures. Wheat pasture alone, or in conjunction with crop residues, can reduce cowherd feed costs when perennial grasses are dormant.

Another excellent way to utilize wheat pasture is to graze out some acreage before turning stockers or cows into native range. Frequently, producers start utilizing native range too early in the spring because they have no more stored hay reserves. Grazing out some wheat pasture can delay the beginning of grazing native range, thereby improving grassland stands and vigor. Rotational grazing during rapid spring growth will keep the wheat plant vegetative longer for graze-out purposes.

As the season progresses, stocking rates must be increased to utilize all the forage being produced; pasture must be stocked heavy enough that the wheat won't get "ahead" of the cattle. Increased stocking rates are especially important at and after jointing stage. Plant growth rates are high and forage nutritive value is declining rapidly. If sufficient cattle are not available to provide a stocking rate high enough to fully utilize wheat forage, consider fencing off a portion of the pasture to be harvested as hay or silage.

What is Wheat Pasture Worth?

Determining a realistic dollar value for wheat pasture is important to wheat and livestock producers desiring an equitable means of establishing rental rates. It is also important to those who simply want to evaluate the "opportunity cost" of forage in a wheat grazing enterprise. In addition to budgeting the profit potential of grazing wheat, producers often use a couple of simple methods to estimate the economic value of this forage. Several methods of charging for or valuing wheat pasture in Kansas are:

- $/cwt/month based on initial body weight
- $/cwt/month based on average weight
- $/pound of gain
- $/head/day
- $/acre

With the exception of $/acre, these methods express the pasture cost on an animal-unit basis rather than per acre. While any of the methods is accepable, it is important to recognize financial risks associated with each for both the cattle owner and the wheat pasture owner.

For example, if the wheat pasture charge is based on average daily gain, the cost of gain for the cattle owner will not be affected with poor gains, but the wheat owner may feel compensation for the wheat is not high enough. If the pasture charge is based on initial body weight, however, the cost of gain for the cattle producer will be high with poor gains while the compensation to the wheat owner will not be affected. Some producers use a combination of several methods to reduce the financial risk to both parties. An example of this would be a fixed rate plus an additional charge based on cattle gains.

The rate should reflect the local supply and demand for wheat pasture. If the owner provides any feed or management such as fencing and cattle handling facilities, water, mineral, supplemental feed during snow cover, animal care, and guaranteed head count, the rate should compensate for each. The charges for these items can be separate from the standard pasture cost. It is important that the stocking rate and all other terms be negotiated and agreed to before the cattle are placed on the wheat.

Livestock producers who own wheat pasture should make optimum use of this high-quality forage. It should not, however, be viewed as free. If local demand for rental wheat pasture exists, the "opportunity cost" based on one of the methods above can be used to determine the economic value of wheat forage to the farming enterprise. This also makes it clear whether the cattle or the wheat are "making the money." If the feasibility of renting the wheat pasture as a cash crop does not exist, its opportunity cost would be zero. However, the additional out-of-pocket expenses incurred because of grazing, such as higher seeding and nitrogen fertilization rates, still must be included when developing budgets.

Should I Graze Stockers on Wheat Pasture?

Livestock producers use wheat pasture because it is generally a high-quality forage and costs of gain on wheat pasture are often lower than those of a conventional backgrounding program. Wheat producers use wheat as pasture because it maybe the most profitable use of the wheat. There are three basic wheat grain and forage strategies wheat producers need to consider: harvest the wheat for grain only, harvest as forage and grain, harvest as forage only (graze out).

Determining whether it is profitable to graze wheat requires both livestock and wheat producers to do partial budgeting. The livestock producer is interested in returns per head, whereas the wheat producer is interested in how grazing affects per-acre returns. Therefore, the budget of a livestock producer will differ from that of a wheat producer.

Livestock Owner's Perspective

A livestock producer's budget will include the income and costs per head associated with owning cattle and grazing them on wheat pasture. Returns to livestock depend on the purchase price of cattle, costs of wheat pasture, supplemental feed and other production inputs, the timing of forage production, the efficiency of the livestock in converting forage to weight gain, death loss, and sale price of the cattle.

Forage yields depend on planting date, weather, variety selection, and fertilization. Because many of the factors affecting forage yields are decided by the wheat producer, it is important for the livestock producer and the wheat producer to communicate prior to planting the wheat.

The livestock producer must consider all factors affecting profitability when budgeting for wheat pasture profitability. Even though all costs will affect profitability, only variable costs need to be considered in making management decisions. Fixed costs such as depreciation, interest, and taxes on equipment and facilities will affect profitability and will be incurred with or without cattle purchase. Because these costs are fixed in the production year, they can be left out of budget projections and should not affect production decisions. In addition to estimating profitability, it is beneficial to estimate the cost of gain on wheat pasture and compare it with the cost of gain in a drylot feeding program. Table 1 is an example of the type of budget a livestock producer who is considering renting wheat pasture should develop.

Table 1. Cost return budget for winter wheat grazing (steers) [1].

	Example	Your Farm
VARIABLE COSTS PER HEAD:		
1. Wheat Pasture ($2.25 /cwt/mo x 4.5 cwt x 4 mo)	$40.50	
2. Silage (900 lb @ $16/ton)	7.20	
3. Hay (___lb @___/ton)		
4. Grain (2.4 cwt @ $4.45 /cwt)	10.68	
5. Protein (___ lb @ ___ /ton)		
6. Vitamins-salt (30 lb @ $.15/lb)	4.50	
7. Feed Processing (____ bu @ ____bu)		
8. Labor (0.5 hr @ $8.00/hr)	4.00	
9. Veterinary, Drugs, and Supplies	10.00	
10. Marketing Costs	3.50	
11. Freight, Yardage	12.00	
12. Utilities, Fuel, and Oil		
13. Repairs	1.00	
14. Miscellaneous	2.50	
15. Interest on Purchased Livestock		
+ ½ Variable Costs @ 10% (120 days)	16.67	
A. TOTAL VARIABLE COSTS	$112.55	
FIXED COSTS PER HEAD:		
16. Depreciation on Equipment and Facilities	$ 6.88	
17. Interest on Equipment and Facilities @ 10%	3.28	
18. Insurance on Equipment and Facilities @ .25%	0.16	
B. TOTAL FIXED COSTS	$10.32	
C. TOTAL COSTS PER HEAD (A + B)	$122.87	
RETURNS PER HEAD:		
19. Market Animal: 690 lb @ $84.50/cwt	$583.05	
20. Less Cost of Animal: 450 lb @ $100.50/cwt	452.25	
21. Less Death Loss: 2% of line 19.	11.66	
D. GROSS RETURN PER HEAD	$119.14	
E. RETURNS OVER VARIABLE COSTS (D - A)	$ 6.59	
F. RETURNS OVER TOTAL COSTS (D - C)	–$ 3.73	
G. AVERAGE SELLING PRICE NEEDED:		
22. To Cover Variable Cost and Feeder	$83.55	
23. To Cover Total Cost and Feeder	$85.04	
H. TOTAL FEED COST (lines 1 thru 7)	$62.88	
24. Cwt produced (gain)	2.40	
25. Feed cost per cwt gain	$26.20	

[1]Source: KSU Farm Management Guide MF-1009, 1992 Revision

The factors that have the biggest effect on livestock profitability are purchase price, average daily gain, and sale price. Producers must decide how much risk they can bear and the best way to manage the risk associated with each factor. Table 2 shows the sensitivity of breakeven price to purchase price and average daily gain (ADG). Table 3 shows the sensitivity of returns to the same factors. The selling price in Table 3 is adjusted by a sliding scale based on selling weight. For more information on the effects of selling weight on selling price see "Factors Affecting Auction Prices of Feeder Cattle," Kansas State University Extension bulletin C-697.

Table 2. Sensitivity of breakeven price to purchase price and average daily gain.

	Cattle Purchase Price (per cwt)					
ADG	$85	$90	$95	$100	$105	Selling Weight[1]
	Selling price per cwt needed to cover total costs					
1.50	$81.48	$85.26	$89.05	$92.83	$96.62	630
1.75	77.78	81.39	85.00	88.61	92.22	660
2.00	74.40	77.85	81.31	84.76	88.21	690
2.25	71.30	74.61	77.92	81.23	84.54	720
2.50	68.44	71.62	74.80	77.98	81.16	750

[1]Based on initial weight of 450 pounds and 120 days on pasture.

Table 3. Sensitivity of returns per head to average daily gain and purchase mice.[2]

	Cattle Purchase Price (per cwt)					
ADG	$85	$90	$95	$100	$105	Selling Weight[1]
	Returns per head over total cost					
1.50	–$50.28	–$42.62	–$34.96	–$27.29	–$19.63	630
1.75	– 33.18	– 24.02	– 14.86	– 5.69	– 3.47	660
2.00	– 16.53	– 5.87	4.79	15.46	26.12	690
2.25	–0.33	11.83	23.99	36.16	48.32	720
2.50	15.42	29.08	42.74	56.41	70.07	750

[1]Based on initial weight of 450 pounds and 120 days on pasture.

[2]Based on a $13/cwt buy-sell margin for 450 pound-690 pound steers and a $1.25/cwt price slide for every 50-pound change from 690 pounds.

Wheat Producer's Perspective

Wheat producers want to maximize returns per acre, so they have more options than the cattle producer. Returns to the wheat grain enterprise increase if the livestock enterprise generates positive returns. If livestock returns are negative, however, they will reduce returns to the grain enterprise. This is true whether the wheat producer owns the livestock or is leasing the wheat pasture to someone. The following are producer's options for the wheat enterprise:

- Harvest as grain only
- Harvest as grain and forage
  - a. Own cattle and graze wheat
  - b. Lease wheat pasture to someone
- Harvest as forage only (graze out wheat)

The production of grain only is common, but the next two options require more intense management. Harvesting the wheat as grain and forage requires judicious management to maximize cattle gains while minimizing potential yield reductions. Harvesting the wheat as forage only requires managing the wheat to maximize cattle gains per acre. The decision to graze out the wheat or remove the cattle and harvest grain generally does not need to be made at planting time. If the wheat is to be harvested for grain, removing cattle by jointing stage is important to minimize yield reductions. Thus, producers considering a graze-out program can delay their decision, and monitor wheat and cattle prices during the winter.

The examples that follow are based on harvesting the wheat as grain and forage. There will be years when the decision to graze out wheat may be necessary before the wheat reaches the jointing stage. In those cases, the budget format in the example can still be used.

The production of wheat for grain only is used as the baseline for profitability comparisons. The wheat producer should develop a budget to analyze whether returns per acre can be increased by harvesting the wheat as grain and forage or as forage only (graze out) compared with harvesting as grain only. A partial budget can be used to compare the returns of grazing wheat with harvesting for grain only.

A partial budget only includes the costs and income that change from the baseline. This makes it easy to see if grazing the wheat increases or decreases the income per acre compared with harvesting for grain only. It does not, however, indicate if all costs associated with wheat production are covered.

Table 4 is an example of a budget that a wheat producer who owns cattle would use to compare the returns of harvesting wheat as grain and forage with harvesting grain only. The first step in analyzing whether grazing will increase returns per acre is the per head cattle budget. All costs directly related to the cattle must be included in the

Table 4. Grazing wheat and harvesting grain versus harvesting grain only (wheat producer owns cattle).

	Example	Your Farm
A. CATTLE RETURNS PER HEAD (TABLE 1)		
1. Returns over variable costs	$ 6.59	
2. Returns over total costs	– 3.73	
B. STOCKING RATE (HEAD/ACRE)	1.25	
C. CATTLE RETURNS PER ACRE		
3. Returns over variable costs (line 1 x B)	$ 8.23	
4. Returns over total costs (line 2 x B)	– 4.67	
INCREASED (DECREASED) WHEAT PRODUCTION COSTS PER ACRE		
5. Seed cost ($4.00/acre x 50% increase)	$ 2.00	
6. Fertilizer (.12/lb x 40 lb. increase)	4.80	
7. Irrigation cost		
8. Harvest cost		
9. Yield reduction (10% x 35 bu x $3.00)	10.50	
D. TOTAL INCREASED (DECREASED) COST PER ACRE	$17.30	
E. INCREASED RETURNS PER ACRE [1]		
10. Returns over variable cost per acre (line 3 – D)	–$ 9.07	
11. Returns over total cost per acre (line 4 – D)	– 21.97	
F. INCREASED RETURNS PER ACRE (with no charge for wheat pasture)[1]		
12. Wheat pasture charge per head (Table 1)	$40.50	
13. Total wheat pasture cost per acre (line 12 x B)	50.63	
14. Returns over variable cost per acre (lines 10 + 13)	41.56	
15. Returns over total cost per acre (lines 11 + 13)	28.66	

[1]Positive number indicates per acre returns are increased by grazing wheat; negative number indicates harvesting wheat as grain only is more profitable.

partial budget because they "change" compared with the baseline of harvesting wheat for grain only. These costs will depend on whether the wheat producer is the cattle owner or is leasing the wheat pasture to someone. The costs included in the cattle budget will be basically the same as those of the cattle producer in Table 1.

The wheat producer is interested in income per acre, so the net returns must be adjusted to a per acre basis. This adjustment will be based on the stocking rate (see section on Livestock Management). Table 4 shows the increase (decrease) in returns per acre from grazing wheat for a wheat producer who also owns cattle.

After the per head returns are converted to a per acre basis, the next step is to account for the effect grazing has on wheat production costs and yield. The only costs of wheat production that will be affected by grazing are seed cost (higher seeding rate), fertilizer cost (increased nitrogen requirement) and possibly irrigation costs (see section on Cultural Practices). Harvest cost may be slightly lower if yields decrease and will be eliminated with graze-out wheat. If grain yields decrease with grazing wheat, this yield reduction is an "opportunity cost" of grazing and must be included in the budget. All other wheat production costs will be basically the same whether the wheat is harvested as grain only, grain and forage, or grazed out.

The increased cost of wheat production due to grazing (Table 4, line D) is subtracted from the per acre cattle returns. The resulting value (Table 4, line E) shows how much the returns per acre increase or decrease by grazing the wheat. It is important to remember that the increased return per acre is not a cash-flow return because the wheat pasture charge and yield reduction were included, even though they are not out-of-pocket cash expenses.

Section F of Table 4 allows the wheat producer to calculate the increased returns per acre from grazing the wheat when no charge

Table 5. Grazing wheat and harvesting grain versus harvesting grain only (wheat producer leases out wheat).

	Example	Your Farm
A. INCOME AND COSTS PER HEAD:		
1. Wheat pasture income per head (Table 1)	$40.50	
2. Costs per head (fence, care, feed, etc.)	0.00	
3. Net returns per head (line 1 - 2)	40.50	
B. STOCKING RATE (HEAD/ACRE)	1.25	
C. INCOME AND COSTS PER ACRE:		
4. Wheat pasture net income per acre (line 3 x B)	$50.63	
5. Increased wheat production costs per acre (Table 4)	17.30	
6. Increased returns per acre (line 4 – 5) [1]	33.33	

[1]Positive number indicates per acre returns are increased by grazing wheat; negative number indicates harvesting wheat as grain only is more profitable.

Table 6. Sensitivity of returns per acre to wheat price and yield loss associated with grain.

Grain	Wheat Selling Price				
Yield Loss	$2.00	$2.50	$3.00	$3.50	$4.00
	Increased return per acre				
0%	$43.83	$43.83	$43.83	$43.83	$43.83
10%	36.83	35.08	33.33	31.58	29.83
20%	29.83	26.33	22.83	19.33	15.83
30%	22.83	17.57	12.32	7.07	1.82
40%	15.82	8.82	1.82	– 5.18	– 12.18

Assumptions: Wheat yield without grazing = 35 bushels/acre
Increased wheat production cost = $6.80/acre ($4.80 fert, $2.00 seed)
Wheat pasture income = $50.63/acre ($40.50/head x 1.25 head/acre)

is assigned to the wheat pasture. This value is found by adding the wheat pasture charge back to the returns (Table 4, line E) No other costs or income should change.

Table 5 is an example of a budget that can be used by a wheat producer who leases wheat pasture to someone. Basically, it will be profitable to graze the wheat if the grazing income is greater than the increased wheat production costs and yield reduction. Leasing wheat pasture to someone is attractive because there is less financial risk than with owning the cattle. The wheat producer can eliminate some of the financial risk that exists by charging for the wheat pasture with one of the methods that does not rely heavily on gain. The increased production costs are fairly easy to project, but the "cost" of potential yield losses can vary significantly. Table 6 shows the sensitivity of increased returns per acre to percent yield loss and the price of wheat for the producer who leases out the pasture. In the example, returns ranged from an increase of $43.83/acre to a decrease of $12.18/acre. Negative returns were not obtained in this example until yield was reduced by 40 percent and the price of wheat was over $3.00. In order to prevent yield losses of this magnitude, it is important to put the cattle on the wheat and remove them at the right times (see section on Grazing Management).

Summary

Producing wheat as a forage crop as well as a grain crop can be a way for many wheat producers in Kansas to enhance the income from their wheat enterprise. Livestock producers like to use wheat as a forage crop because it is a high-quality forage and costs of gain on wheat pasture generally compare favorably with other backgrounding or growing programs. Wheat grazing can be profitable for both wheat and livestock producers, but it also can reduce income or generate losses. It is important that both parties put together budgets to help determine if wheat grazing will be profitable for them. In addition to budgeting, it is helpful for the producers to identify their production and financial risks. Once they have identified the factors that most affect profitability, they can more easily manage the associated risk.

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Emergency and Supplemental Forages

Department of Agronomy

Despite the best plans, shortages of forage commonly occur some time during the year in Kansas. Drought, hail, early freezes, crop failure, harvest delays and unusually cold and wet winters can cause forage shortages.

In response, producers may choose to buy the extra forage needed or sell off some cattle. But in many cases, it may be more economical to bridge the gap by:

- Planting a small grain cereal, summer annual grass, or nontraditional forage; or
- Utilizing crop residue or weather-damaged crops.

The best options for supplying emergency forage depend on what is available locally and at what time of year the shortage occurs (Table 1).

Table 1. Emergency Forage Utilization Possibilities.

Time of year shortage occurs	What can be done to supply forage quickly
Winter	Use pasture from fall-planted small grain cereals Graze corn/sorghum stubble Use ammoniated corn or sorghum stover Use silage or hay from summer annuals
Spring	Plant spring oats for pasture or hay Use pasture, silage or hay from fall-planted small grain cereals
Summer	Graze wheat stubble Use ammoniated wheat straw Plant sudangrass, sorghum-sudan, or silage or hay Graze or harvest the weather-damaged crops Graze or hay soybeans Use kochia, and other nontraditional forages
Fall	Graze corn/sorghum stubble Ammoniate corn or sorghum stover Graze or harvest the weather-damaged crops Plant barley, wheat, rye or triticale for pasture and spring supply of silage or hay

Small Grain Cereals

When an unexpected shortage of forage occurs, small grain cereals, summer annual grasses, and certain nontraditional forages can provide pasture, hay or silage within a reasonably short time (Table 2).

Winter wheat, winter barley, triticale, rye and spring oats are the small grain cereals best adapted for forage production in Kansas. For more detailed information, see KSU Extension publication MF-1072, *Small Grain Cereals for Forage*.

Pasture. Small grain cereals intended for emergency fall pasture should be planted as early as feasible. Where soil moisture is adequate, late August to early September seedings usually result in optimum pasture production in all areas of Kansas. Under good conditions, the plants will be well-rooted, tillered and ready for grazing within 30–40 days.

Pasture production declines with later planting dates. By mid-October in northwestern Kansas to late-October in southeastern Kansas, it is too late most years to plant small grains for fall and winter pasture. If pasture is absolutely needed in late fall beyond the range of optimal planting dates, producers have the best chance for success by planting rye.

Under good growing conditions, a well-fertilized small grain pasture can carry about 500 pounds of cattle per acre. Under poor growing conditions,

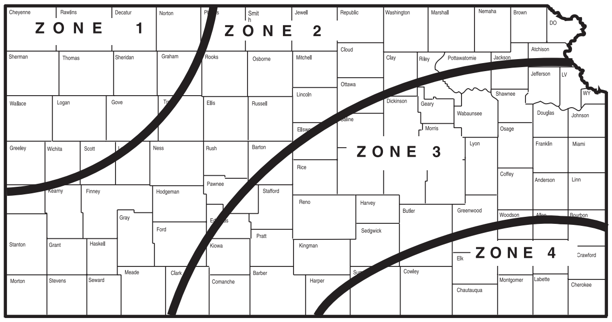

Table 2. Quick Pasture From Supplemental Forages.

Crop	Suggested planting dates for pasture zone 1	2	3	4	Average days from seeding to grazing
Small grain cereals:					
Wheat	8/25–9/10	9/1–10/5	9/1–10/10	9/5–10/10	30–40
Barley	8/25–9/10	9/1–9/20	9/10–10/15	9/10–10/5	30–40
Rye	8/20–9/10	8/25–9/20	9/1–9/25	9/1–10/1	30–40
Triticale	8/20–9/10	8/20–9/20	9/1–9/25	9/1–10/1	30–40
Spring oats	3/5–3/30	3/1–3/25	3/1–3/20	2/20–3/15	30–50
Summer annual grasses:					
Pearl millet	6/1–7/10	6/1–7/10	6/1–7/10	6/1–7/10	30–40
Foxtail millet	6/1–7/10	6/1–7/10	*	*	20–30
Sudangrass	5/15–7/10	5/20–7/10	5/20–7/10	5/20–7/10	30–50
Sorghum–sudan	5/15–6/15	5/20–7/1	5/20–7/5	5/15–7/1	30–50
Forage sorghums	*	*	*	*	*

* Not recommended for pasture in this area.

stocking rates should be reduced considerably. Cattle gains of 1.5–2.5 pounds per day are possible during periods of good pasture production.

In general, small grain cereals produce good pasture in late fall and early winter. Production declines during the winter and generally resumes in late February, depending on temperature, moisture conditions and fertilization. Winter barley has the best forage yield potential in fall and early winter. When planting a small grain cereal for pasture in late February to early March, spring oats is the only choice.

Hay. Hay yields of small grain cereals often average 2–4 tons per acre (air dry basis). The quality of small grain hay depends primarily on the stage of maturity of the crop when harvested, and how it was handled and protected after harvest. Small grain hay can be similar to bromegrass hay in nutritional value.

Small grain cereals can be harvested for hay any time up to the milk stage of grain development. This is the best compromise between the highest dry matter yield and maximum hay quality. Later cutting will yield more, but digestibility and protein levels will decline and, on many varieties, awns (beards) will be more fully developed. Forage quality is highest at the boot stage. The quality and palatability of rye hay, in particular, declines rapidly in the spring.

For an early spring planting, spring oats is a much better option in Kansas than spring wheat, spring barley, or any of the fall-seeded small grain cereals. Oat hay has very good quality when harvested in the early boot stage. Spring oats usually will be ready to harvest for hay about 60 days after planting.

Rough awns (beards) in small grain hay will cause irritation for cattle. Considerable soreness and irritation to the eyes, mouth, lips, gums and lower surface of the tongue can occur. To minimize this occurrence, a crop with rough awns should be ensiled or grazed rather than baled for hay. If hay-making is the only practical option, harvest awned varieties while they are immature or tub-grind the hay.

Silage. Small grains, especially winter barley, can provide silage nearly equivalent in feed value to corn silage. Small grain cereals normally produce about 5–7 tons per acre of 35 percent dry matter silage when cut at the late-boot stage and 8–10 tons when cut in the late-dough stage.

For silage purposes, small grains should be cut at the mid- to late-dough stages, or earlier. Ensiling small grain cereals properly can be difficult because of their hollow stems. To optimize ensiling conditions, chop finely at 60–70 percent moisture, pack thoroughly, and cover the forage with plastic.

Summer Annual Grasses

Sudangrass, sorghum-sudangrass hybrids, forage sorghum and hybrid pearl millet are potentially high-yielding sources of high-quality pasture, hay or silage. Foxtail (German) millet is another possibility, especially in western Kansas. Foxtail millet has reduced quality and palatability with advancing maturity, and forage yields are relatively poor, but it can be planted later than other summer annual grasses in an emergency and provide quick cover.

Sudangrass and hybrid pearl millet will provide the quickest source of forage in early summer, either as pasture or hay. In an emergency, sudangrass can be planted earlier than the millets. In general, summer annual grasses should be planted when soil temperatures reach 70–75°F at the planting depth, usually sometime in May. Hybrid pearl millet and foxtail millet are especially intolerant of cold, wet soils and should not be planted until late May or early June.

Sorghum-sudangrass hybrids produce higher forage yields than sudangrass or the millets, but more than 50 percent of their production is stem. Therefore, sorghum-sudangrass is better suited for late-summer silage or green chop than early summer grazing. High-yielding forage sorghums mature late in the growing season and are best suited for one-cut silage operations.

For complete details on these crops, see KSU Extension publication MF-1036, *Summer Annual Forages*.

All summer annual grasses can cause livestock poisoning due to nitrate toxicity. Nitrate toxicity occurs when the plants are stressed by drought, shade, frost or temperature extremes. Analysis is necessary to determine if the feed is potentially toxic. Prussic acid, or hydrogen cyanide poisoning, occurs only in sorghums and sudangrasses, not pearl millet or foxtail millet. It occurs most often when cattle graze new shoot growth at the end of a summer drought or after the first fall freeze. For complete details, see KSU Extension publication MF-1018, *Nitrate and Prussic Acid Toxicity in Forage*.

Pasture. Sudangrass and hybrid pearl millets can provide high-quality pasture within about 4–6 weeks of seeding. Foxtail millet is less productive than other supplemental forages, but can provide a small amount of pasture within about 3–4 weeks. Sorghum-sudangrass hybrids can be grazed, but are less palatable than sudangrass and the millets. Forage sorghums are a poor choice for grazing.

With a rotational grazing system in which each subdivided section of a pasture is grazed to a 6- to 8-inch stubble every 10–14 days, sudangrass and hybrid pearl millet can provide nearly 90 days of high-quality forage. During this time, each acre can supply forage for about 1,000–3,000 pounds of cattle.

Hay. Sudangrass and hybrid pearl millet are the best adapted summer annual grasses for multiple hay cuttings. Foxtail millet can provide hay a little later in the season than the other summer annuals if needed, but it is less productive. Sorghum-sudangrass hybrids can be cut for hay, but their thick stems are difficult to cure. For high-quality hay, plants should be cut before the heads emerge. Mouth irritation and lump-jaw can develop in cattle fed millet hay cut after heading.

When planted as soon as soil temperatures reach 70–75°F at the planting depth, sudangrass and pearl millet can produce two good hay crops, or even three in higher rainfall areas. Be sure to leave 6–8 inches of stubble for regrowth. Sudangrass has greater regrowth potential than pearl millet. Sudangrass and pearl millet can also produce a hay crop when planted as late as mid-July, provided adequate moisture and nutrients are available. Foxtail millet normally produces only one hay crop.

Silage. Sorghum-sudangrass hybrids and forage sorghums can provide high silage yields late in the growing season. Highest quality silage is from forages having at least 20 percent of their dry matter as grain. Grain sorghum also makes good silage. Harvest should be delayed until the hard dough stage because high-moisture silage has poor quality and low palatability. For more detailed information, see KSU Extension publication AF-144, *Producing Sorghum Silage*.

Nontraditional Forages

In an emergency, it's possible to use a number of crops and weeds as nontraditional forage. Among the possibilities that have proven useful in Kansas are:

Soybeans. Although no longer used as a forage, soybeans once were routinely grazed and hayed. Cattle do quite well on grazed soybeans, although bloat can occur. Pasturing can begin as soon as the plants are 12–18 inches tall. If the cattle are removed once most of the leaves have been eaten, there can be enough regrowth for the crop to be grazed again in about a month. Soybean hay is a satisfactory substitute for alfalfa or clover hay in feeding beef or dairy cattle if it is put up before pods are an inch long. A mixture of chopped soybeans with corn or sorghum forage at the rate of 1 ton of soybeans with 2–4 tons of corn forage produces good silage.

Kochia. This hardy weed can be used in central and western Kansas as an emergency forage crop for calves, yearling cattle and cows. It does not grow well in the eastern third of the state. Kochia can be cut and baled or ensiled for winter feed, or grazed. It is a low-fiber, high-protein forage, with protein levels comparable to those of alfalfa during the early stages of its growth. Kochia should not comprise a major portion of the diet for cattle, even under extreme circumstances. Weight loss and toxicity symptoms, such as photosensitization, occasionally have been reported in cattle grazing older, mature stands of kochia. Nitrate and oxalate toxicity is also possible with kochia. Steers that graze kochia gain less than those grazing native grass pastures, but they perform well once moved to a feedlot. Caution is advised in the management of livestock grazing kochia pastures. Remember, kochia is a weed, and seed in the hay can be spread to crop fields.

Amaranth. Although normally considered an alternative grain crop, amaranth (red pigweed) can be cut for hay or silage. Some studies suggest that amaranth might be superior to soybean and oat forage, but inferior to sudangrass or sorghum-sudangrass hybrids in forage yield and crude protein. Amaranth forage feeding studies indicate good performance by ruminants. Poor performance by nonruminants has been reported. As a forage, amaranth can produce nitrate and oxalate toxicity. High nitrate and/ or oxalate levels appear to be most common in mature and drought-stressed amaranth, and the risk of toxicity is higher when amaranth is the sole source of feed.

Brassicas (kale, rape, turnips). Forage brassicas are high-quality, fast-growing cool-season crops that can offer good grazing potential throughout the entire state. Both tops and roots can be consumed. The brassicas can be seeded from mid-March through May for summer grazing, or in June to August for fall/winter grazing. Brassica forage has exceptionally high digestibility, crude protein levels and energy content. Fiber content is low, however, so roughage must be provided to cattle grazing on brassicas. Nitrate toxicity is also possible where excessive nitrogen has been applied.

Certain rape varieties have produced large quantities of palatable high-protein forage for sheep in northwestern Kansas. It can be planted in March and ready for grazing within 60 days if a good stand has been established. Forage rape can also be planted in late summer for fall and winter grazing. Turnips can provide good grazing throughout the state if there is good root development. The bulblike root is also eaten by cattle after the leaves and stems have been grazed off. Turnips can be seeded in April for mid-summer grazing, or in August for fall and winter grazing. Grazing usually begins about 45–60 days after seeding.

When planted immediately after wheat harvest on irrigated ground and provided some water for emergence, brassicas can make an excellent forage to carry livestock through the summer into the early small grain pasture season.

Crabgrass. Crabgrass can make an excellent forage for grazing. The palatability of immature crabgrass is as high as native grasses. Cattle should be removed or rotated to another pasture when the crabgrass is grazed down to about 3 inches. Regrowth will then occur after a rain. Crabgrass is also an excellent source of hay. It should be cut prior to maturity. Remember, crabgrass is a weed and seed will be spread in the hay.

Johnsongrass. Johnsongrass, a noxious weed in Kansas, has significant forage potential as a hay crop in an emergency. It must be harvested in the boot stage for highest quality. Johnsongrass can also serve as a source of grazing forage. It is palatable to cattle, and the animals will selectively graze it. Prussic acid poisoning is a concern when grazing Johnsongrass that is drought-stressed or experiencing regrowth in the fall after a frost. Prussic acid is not a problem in well-cured Johnsongrass hay or silage. Because Johnsongrass is a noxious weed, it should not be allowed to produce seed.

Cattails. Cattails normally grow in wet areas that are inaccessible to cattle. During periods of extreme drought, however, it may be possible to gain access to cattails for grazing or hay. Little information is available on the forage quality of cattails, but there have been reports in Kansas of using cattails for emergency hay or grazing with no apparent drawbacks.

Other Weeds. Some weeds and weedy grasses are palatable, but others are unpalatable or are associated with toxicity. Among the weeds and grasses that have been found to have acceptable palatability to sheep are yellow foxtail, barnyardgrass, green foxtail, redroot pigweed, Pennsylvania smartweed and common lambsquarters. Unapalatable species are giant foxtail, wild mustard, giant ragweed and common cocklebur. Common ragweed and velvetleaf are somewhere in between. Palatability is not related to nutritive value. Redroot pigweed, common lambsquarters and common ragweed have nutrient composition and digestibility similar to that of average-quality alfalfa. There have been reports of nitrate toxicity in redroot pigweed, common lambsquarters, barnyard grass and Pennsylvania smartweed. Wild mustard seed, which contains toxic glycoside, has been reported to be poisonous to cattle and cause gastrointestinal distress. Young cocklebur seedling have been reported to be poisonous to cattle, sheep, and hogs.

Using Weather-Damaged Crops

Drought, hail and freeze damage can affect forage and grain crops in Kansas. In many cases, these weather-damaged crops can be used as forage. Feed value is often affected less by weather damage than yield. The most important thing to do before feeding any weather-damaged crop is to have it tested. Forage testing can provide two valuable types of information: the nutritional value—especially crude protein, acid detergent fiber (ADF) as an indication of energy, and moisture content; and the presence of any potential toxins, especially nitrate and prussic acid (Table 3). For more information on nitrate and prussic acid toxicity, see KSU Extension publication MF-1018, *Nitrate and Prussic Acid Toxicity in Forages*.

Table 3. Relative Toxicity Risk of Harvesting Stressed Forages.*

Harvest method	Prussic acid**	Nitrates
Grazing	High	Moderate
Green chop	Moderate	High
Hay	Low	High
Silage	Low	Low

* From KSU Extension Animal Sciences handouts

** Only a concern with sudangrass, sorghum-sudans, forage sorghums and Johnsongrass

Don't underestimate the feed value of drought- or frost-damaged forages. Typically, grasses compensate for reduced yield by increasing their nutritional content. On the other hand, grain-producing forages are usually lower in feed value when weather-stressed, depending on grain stage.

Some special considerations for making silage from sorghum and corn stressed by drought or frost are listed in Table 4. Grain sorghum, in particular, often suffers from poor weather in late summer and fall. Weathered- and sprout-damaged grain sorghum can be used, with the following points taken into account:

■ There is a major loss in yield, but not in feed value.

■ There will be higher field, harvesting, and handling losses.

■ Mycotoxin problems are rare while in the field.

■ The grain is stable in storage when dried properly.

■ There is usually little change in nutrient content. Digestibility of protein and starch increases. The grain is softer and dustier.

■ The feed value for cattle is at least 95 percent of normal. The grain will be dirtier, and must be processed finely. Palatability may be reduced due to dust. It should be blended with other grains or forage if possible.

Weather-induced problems often result in light test-weight grain sorghum, but this may not lower its feed value. The feed value of 40–60 pound test grain sorghum is similar. When test weights are below 40 pounds per bushel, however, starch content decreases and fiber level increases. Light-weight grain sorghum generally has smaller seed size, greater variation in seed size and more trash than normal. Fine processing is critical with small sorghum berries.

Weather-damaged feeds can be successfully used for feeding cattle. The key is to have the feed tested for nutritional content and potential toxins.

Table 4. Making Silage from Drought- and Frost-Stricken Sorghum and Corn.

1. Feed value is normally 75–95 percent of normal silage when properly ensiled.
   - ■ There will be more carbohydrate in the stalk than normal, which compensates for loss of grain content.
   - ■ The feeding value varies, depending on the severity and timing of stress.
2. Proper ensiling moisture content is extremely important.
   - ■ Plants usually look drier than they really are due to wet stalks.
   - ■ Ensiling when too wet results in excessive fermentation and seepage.
   - ■ Ensiling when too dry causes poor fermentation and heating.
   - ■ Allow the forage to dry down to 65–70 percent moisture, if possible.
   - ■ The weather-stressed forage can be mixed with drier chopped feeds to reduce moisture content.
3. Crude protein content is usually higher than normal.
   - ■ Drought-stressed forages will have about 10–11 percent crude protein, compared with 7–8 percent in a nonstressed condition.
   - ■ Soluble protein is 2–3 times higher in the stalk than normal silage.
   - ■ Supplement the silage with natural protein supplements.
4. Test for nitrate content before feeding. There is typically a 40–50 percent loss during fermentation.

Using Crop Residues

One of the most cost-effective ways of providing forage is to use existing crop residues. Wheat, corn and grain sorghum stubble can be grazed. The stover of these crops can also be ammoniated for improved feed value. Before using crop residues on highly erodible land, check the regulations regarding conservation compliance.

Grazing Wheat, Corn and Grain Sorghum Stubble

Crop stubble can provide up to 100 days of grazing for cows and steers, depending on the amount of residue, stocking rate and weather conditions. Wheat stubble has limited feed value because of its low energy and protein content. But nonlactating, spring-calving beef cows can be maintained on diets comprised primarily of corn and grain sorghum residues from weaning until mid- to late-pregnancy with a minimum of protein supplementation. Supplementation with protein and possibly energy may be necessary later in the season as the cows' nutritional requirements increase 50–60 days before calving.

The greatest feed value from grazing stubble comes shortly after harvest. During that period, cattle use about 25–35 percent of the available residue from leaves, husks and lost grain.

Table 5. Nutritional Value of Crop Stubble.*

			Carrying capacity (AUM/Acre)**		
			Crop Production		
Type of stubble	Crude protein	Digestibility	Low	Medium	High
Corn	4–7%	35–55%	1.0	1.5	2.0
Grain Sorghum	5–7%	35–50%	0.8	1.3	1.8
Wheat	3–5%	30–40%	0.6	1.0	1.5

* From P.D. Ohlenbusch, 1992. "Kansas Grazingland Management" workbook.

** AUM/Acre (Animal Unit Month per Acre) is the amount of forage required to sustain for 30 days one 1,000-pound mature cow of average milking ability with a calf less than 3–4 months postpartum. One AUM works out to be 750 pounds of air dry forage.

The carrying capacity of crop residues depends on the amount and type of grain and residue left in the field, method of pasturing and weather conditions (Table 5). The most efficient way to graze stubble is by using more cattle for shorter periods of time. By pasturing intensively, there will be less selective grazing, and cattle will consume more low-quality material.

Prussic acid toxicity is a concern when grazing grain sorghum stubble if regrowth is occurring. The new growth should be tested. Otherwise, after harvest or a light frost, wait until 18–24 inches of growth has occurred before grazing. After a killing freeze, wait 7–10 days before initiating grazing.

Ammoniated Wheat Straw, and Corn and Grain Sorghum Stover

A good source of emergency feed is ammoniated wheat straw, and corn and grain sorghum stover. Only low-quality forages, such as crop residues and mature grass hay, should be ammoniated. Hay from bromegrass, fescue, small grains, forage sorghums or sudans should not be ammoniated as this can create toxicity potential.

Table 6. Ammonia Increases Protein, Digestibility and Intake.*

Residue	% Crude Protein		% Digestibility		Increased Intake
	Control	Treated	Control	Treated	
Wheat straw	3.7	9.7	38.9	48.0	18%
Corn stover	6.2	11.0	48.0	56.2	22%
Sorghum stover	5.4	16.8	46.2	61.3	20%

* From KSU Extension Animal Sciences handouts

Ammonia treatments can dramatically increase the feed value of crop residues (Table 6). Application of 3 percent anhydrous ammonia to wheat straw, for example, will more than double its crude protein content and increase intake and digestibility.

Generally, ammoniating low-quality forages increases total digestibile nutrients (TDN) by 10–15 percentage units, which increases the available energy content. Ammoniation also increases crude protein levels. Ammoniated residues are readily consumed if the material is allowed to air out for 3–5 days before feeding. Gain is greater for cattle eating ammoniated versus nonammoniated residue.

Summary

■ Various alternatives exist for obtaining an emergency source of forage. It may not be necessary to buy additional forage or reduce cattle numbers.

■ Small grains, summer annual grasses, nontraditional forages, weather-damaged crops and crop residues can provide emergency forage on short notice nearly any time of the year.

■ Emergency forages should be tested for nutritional content and toxicity potential before feeding. Forage testing is a useful and economical management tool, even in normal years.

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Livestock Production

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Stocking Rate and Grazing Management

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Grazing management is the art of integrating animals, feed, and other inputs with land, labor, and capital resources. In this publication, land includes rangeland, tame pasture, annual forages, and crop residues. Labor includes the owner/operator, family, and hired help. Capital includes cash, other assets that can be easily converted into cash, and available credit.

The goal of grazing management is to market a valuable product at a profit, while maintaining or improving the productivity of grazing land resources. Grazing management relies on several principles and practices. Of these, stocking rate has the largest impact on both animal performance and forage resources. Understanding grazing management principles is one of the keys to the ultimate profitability of the operation.

Stocking Rate

Stocking rate is defined as the land area allocated to each grazing animal for a specific length of time. Stocking rate influences:

- How well the plant can recover from grazing during the growing season
- Future forage production
- The quality of the available forage
- Animal performance
- Long-term change in species composition

Many livestock operations base their stocking rate on tradition, the advice of their neighbors, financial pressure, research results, or simply a best guess. For grazed forages to remain productive, grazing use must be matched to the individual pasture's carrying capacity.

Determining stocking rates requires knowledge of forage production and grazing pressure. The amount of forage available for harvest is affected by climate; soil characteristics such as depth, slope, and texture; and the extent of unproductive areas where rocks, brush, and unpalatable species are prevalent. Of these factors, climate has the most significant and overriding influence on forage production. Forage production varies between pastures and locations within a pasture.

Grazing pressure is the ratio of forage demand to the amount of forage available. It is usually measured in terms of the number of animal unit months (AUM) per acre, although it may also be measured by AUMs per ton or pound of available forage. An animal unit (AU) is defined as the average annual amount of forage required for a 1,000-pound mature cow of above-average milking ability with a calf less than 3–4 months old, weaned at 400 pounds. After 4 months of age, a 400-pound calf requires an additional 0.3 AU equivalents (AUE). Other classes of livestock are defined in terms of AUEs. For example, a 1,000-pound dry cow has an AUE of 0.9. A 500-pound calf has an AUE of 0.5. One AUE consumes about 750 pounds of air dry forage per month.

Changes in the type of grazing animals, the animals' physiological stage, and forage availability can each cause a change in grazing pressure.

When matching grazing pressure and carrying capacity, the goal is to devise a management system that will optimize animal and forage production over the long-term, rather than attempting to maximize either factor by itself. The graphs in Figure 1 depict the relationships between animal production and stocking rate (Georgia — Hoveland, 1986; Virginia — Blaser, et al., 1986; Texas — Kothmann, 1975; Wyoming — Hart, et al., 1988). The results of these four research efforts, designed to maintain or improve long-term forage productivity, were essentially the same even though they were conducted at different locations with different forage types.

This relationship, along with long-term research in Kansas and other Great Plains states, indicates that a moderate grazing intensity will result in the best long-term economic gain. The goal of moderate stocking in this sense is to attain the best compromise between maximum gain per animal and maximum gain per acre, rather than to maximize either by itself.

Hart, et al. (1988) developed an economic relationship from their Wyoming stocking rate information (Figure 2). Maximum profits occur about midway between the maximum animal production per acre and the point at which individual animal performance begins to decline. These results are similar to those obtained by Bement (1969) on shortgrass plains in northern Colorado.

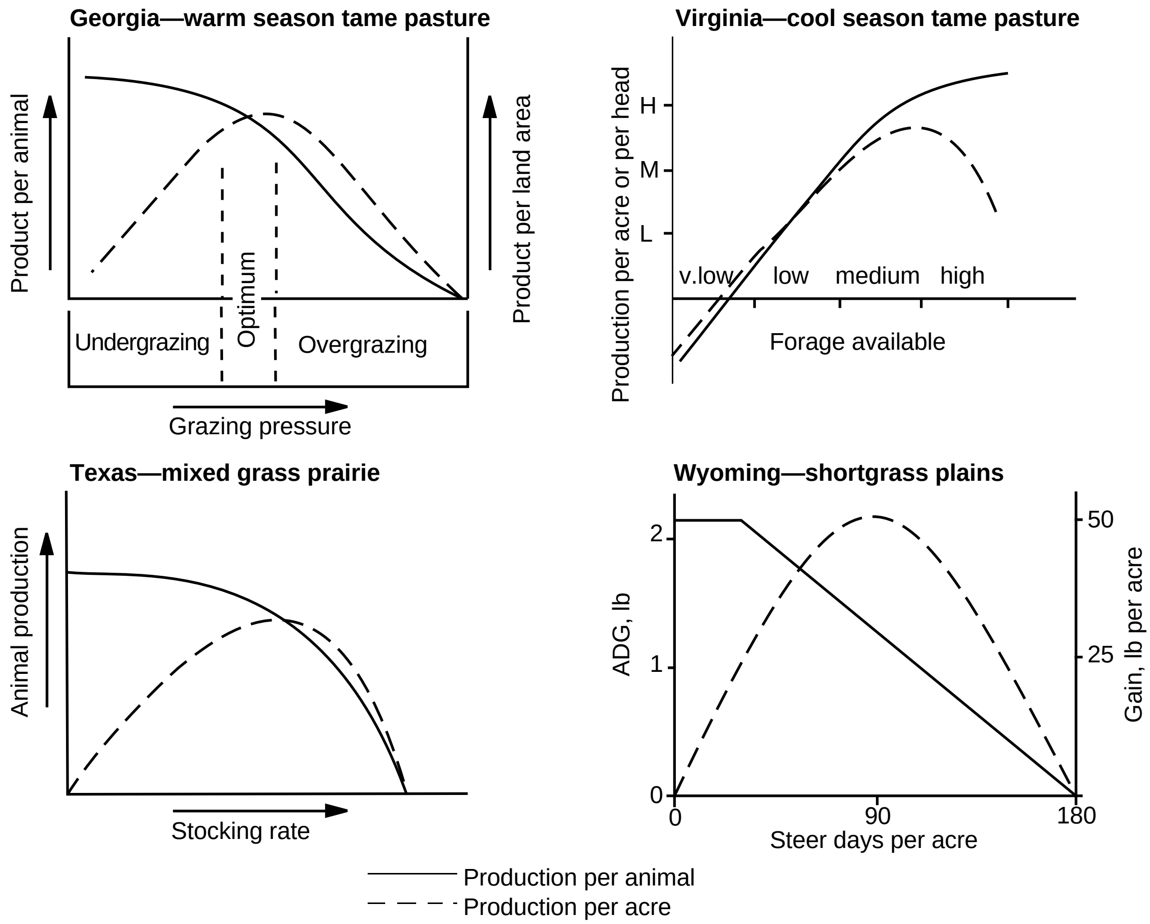


Figure 1. The relationship of animal production to stocking rate based on research on different forage types.

A manager's goal should be to use a moderate stocking rate, but be prepared to change stocking rate, remove livestock or supply additional feed during periods of drought or other stress situations.

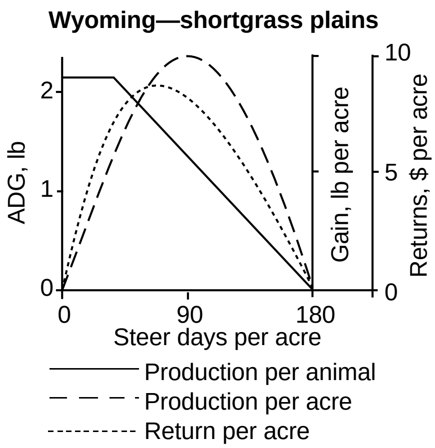


Figure 2. Economic returns maximize midway between the peak production per acre and the point that animal performance begins to decline.

Uniform Utilization

Grazing animals usually will not graze an area uniformly. When patchy grazing occurs, forage availability will suffer, resulting in reduced animal performance. Uneven grazing patterns can occur for several reasons:

Pasture shape, terrain, and water location. Rough terrain and poorly distributed water will often result in underused areas within a pasture. The shape of a pasture can also affect uniformity of grazing. For example, in a large "L" shaped pasture with the water in one end, the end farthest from water will usually be underused. Even utilization of these areas is often difficult and requires changing the grazing animals' habits and patterns. Animals will readily travel more than one mile to water on level terrain, but may not travel ½ mile in steep or heavily rolling terrain.

Grazing preference. Grazing animals will often prefer certain forages over others, and those preferred forages are said to be more palatable. The relative palatability of a plant species depends on factors such as the other species present, stage of growth of each species, and soil fertility level.

Grazing animals will concentrate in areas where the plants are most palatable. Highly palatable species include eastern gamagrass, big bluestem, Indiangrass, little bluestem, and sideoats grama.

Switchgrass, blue grama, and buffalograss will be grazed the least when the more palatable species are present. Western wheatgrass is palatable in the early spring, but rarely grazed during late spring and summer. In the fall, new growth again makes it palatable.

Some plants are almost never preferred when other forage is available. These species are readily grazed only when planted and managed as a pure stand. Examples would be the Old World bluestems and tall fescue.

Forbs (broadleaf plants) and browse (woody plants) vary in palatability. Examples of highly palatable forbs are showy partridgepea and Illinois bundleflower, while leadplant and Russian olive are examples of browse that are palatable only at certain times of the season.

Seasonal nutritional needs. Forbs and shrubs often fill nutritional needs during certain periods of the year and may cause seasonal variations in grazing animal distribution. Western ragweed is consumed at higher rates in late spring and early summer because of its high dry matter content. Warm-season grasses are high in quality during this period, but are low in dry matter.

Many options are available to help encourage more uniform grazing patterns, such as salt/mineral movement, water developments, prescribed burning, and cross fencing. A more complete discussion of these management options is found in KSU Extension publication MF-515, *Grazing Distribution.*

Degree of Utilization

Degree of utilization refers to the proportion of the current year's forage production that is consumed and/or destroyed by grazing animals. Each pasture has an optimal degree of utilization, depending on the palatability of the plant species, the season that the pasture will be grazed, and the kind and class of livestock.

In determining stocking rates, only the palatable species on the areas normally grazed should be considered. If unpalatable species or ungrazed areas are included when determining the total forage production of the pasture, overuse of the most palatable species may occur.

Three questions should be answered in determining how much available forage the palatable plant species can produce:

How much of the herbage should remain when the animals are removed? As a general rule, no more than 50 percent of the current season's growth should be removed during the growing season. By leaving sufficient leaf area, the plants can produce enough foodstuffs for current growth and to rebuild stored food reserves. To maintain 50 percent of the leaf area, about $^2/_3$ of the current season's leaf length can be removed at any one time (Figure 3). Season of use, length of the grazing period, time available for regrowth after grazing, condition of the grazed plants, and current weather conditions influence this decision.

How much of the total plant biomass is expected to be lost during the season due to trampling, insects, leaf drop, disease, and wildlife? These are competing losses that must be considered in the determination of utilization. Normally, 25 percent of the current year's dry matter is considered lost through natural processes under season-long grazing.

How much of the herbage produced will be available for harvest by livestock? Season of use and forage nutrient content are major considerations in animal performance.

The estimated percentage of the forage actually harvested changes with the type of grazing method used. Indications are that harvest efficiency increases as the rotation interval is shortened. According to estimates, as much as 40 percent of the forage is harvested with intensive rotation systems. If these estimates prove to be real and animal performance can be maintained at or near season-long grazing values, increased harvest efficiency will result.

Specialized intensive-management grazing programs may increase the relative amount of forage harvested. The more intensive systems are normally used on irrigated, tamegrass, or annual pastures. Their use on rangeland is recommended only when the manager commits to the higher management level required.

Season of Use

There is an optimum season of use for every combination of plant and grazing animal. Vegetative plant growth prior to seed stalk development is the period of highest nutritional quality and highest animal performance. After seed stalk development, forage quality declines. This is true for both warm- and cool-season forages, whether annual or perennial.

Likewise, there is a period during the plants' growth cycle when grazing pressure should be reduced. For warm-season plants, this period is during early vegetative growth (late April to early May) and again during reproductive development (July to frost). For cool-season plants it is in early spring and again in the July-August and early fall periods. During these periods, heavy grazing should be avoided.

Reducing the leaf area of a perennial plant during the late summer and early fall restricts its ability to produce foodstuffs for current growth needs, stored food reserves and root growth. Each growing season, approximately one-third of the root system must be replaced by new growth due to losses caused by root pruning, shrink-swell of

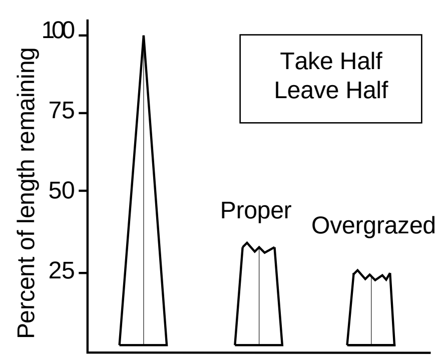


Figure 3. Removing ⅔ of the current season's leaf length (equivalent to 50% of total leaf area) will not reduce plant productivity.

the soil, and diseases. Under heavy grazing pressure, this new root growth may stop and existing roots may die back even further.

Developing a grazing management strategy that meets both plant and animal needs is a challenge. Consideration should be given to using forages that have different growing seasons. Combining a cool-season pasture (such as smooth brome, tall fescue, wheat, rye, and triticale) with a warm-season pasture (such as rangeland, bermudagrass, sudangrass, and millet) can be a way to increase carrying capacity and animal production. This type of system provides a longer green forage period. A complete economic analysis of the alternatives should always be made **before** beginning the system. For more information on economic budgets, see the most recent set of KSU Extension Farm Management Guides available at your county Extension office

Kind and Class of Livestock

The kind and class of livestock influences stocking rate. Different animals prefer different forages, as shown in Table 1 (Taylor, 1981):

- Cattle diets consist primarily of grass.
- Sheep tend to prefer forbs over grass and browse.
- Goat and deer diets contain large amounts of browse compared to cattle and sheep diets.

Because of the differences in dietary preference, mixing kinds of livestock under certain conditions to increase carrying capacity and production is possible. However, the forage source must have the necessary diversity and production for the animals to meet their dietary preferences. For example, cattle and sheep will compete if grazed together in a predominately grass pasture. However, they will complement each other if grazed together in a pasture

Table 1. The relative proportions of grass, forbs, and browse in the diets of cattle, sheep, and goats.

Kind of Forage	Cattle	Sheep	Goats
Grass	60%	40%	20%
Forbs	20%	40%	30%
Browse	20%	20%	50%

with a high proportion of forbs and browse. Whatever the forage source, grazing cattle and sheep together will place increased management requirements on the operator.

The size, age, and reproductive stage of an animal determines forage needs. As an animal's size increases, its forage requirements also increases. Forage requirements also increase for rapidly growing animals. Pregnant and lactating females have added demand for forage from the last trimester of pregnancy through weaning.

The AU method, defined in a previous section, is a convenient way of adjusting stocking rate for size, age, and

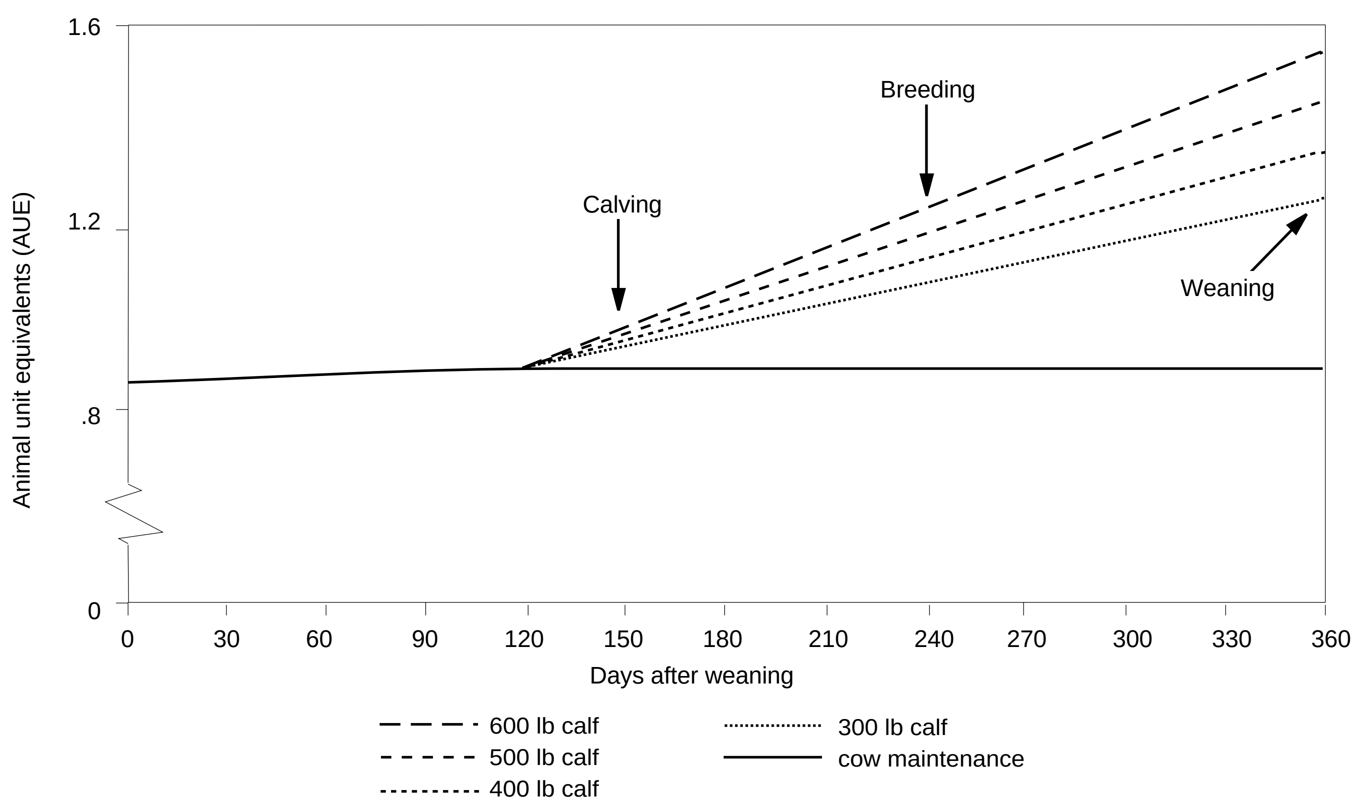


Figure 4. The relationship of weaning weight to animal unit equivalents for a 1,000-pound cow with various weaning weights, based on NRC requirements.

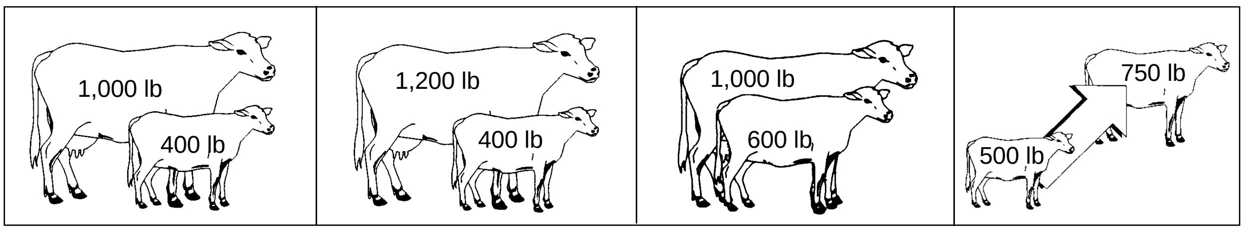
reproductive status. An AUM is the amount of forage intake for one AU for 30 days—about 750 pounds of air dry forage. Figure 4 depicts the AU changes for a 1,000-pound cow weaning different size calves for one year. A dry cow requires approximately 0.9 AUE of forage. By weaning time, 1.2, 1.3, 1.4, and 1.5 AUEs are required for weaning weights of 300, 400, 500, and 600 pounds respectively. A cow weighing 1,200 pounds has an AUE of 1.2 plus the requirement for the calf.

To estimate the AUE of growing cattle (stockers, replacement heifers), the following equation can be used:

$$\frac{(\text{weight on grass} + \text{weight off grass})/2}{1{,}000}$$

As an example, a 500-pound stocker going on grass is expected to weigh 750 pounds coming off the pasture. The AUE is 0.625. Figure 5 illustrates the AUE calculation for four examples: a standard animal, a cow-calf pair with a heavier cow, a cow-calf pair with a heavier calf, and a stocker.

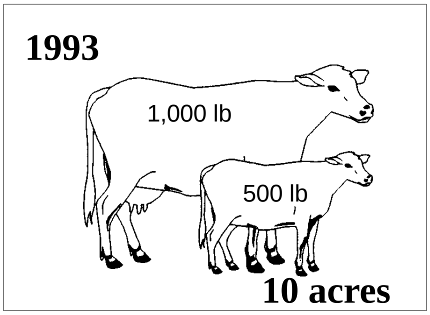
AUE's can be used to adjust stocking rates for the class of livestock being grazed. The method to use is illustrated in Figure 6. In the example given, a 1,000-pound cow weaning a 500-pound calf (1.4 AUE) were grazed on a 10-acre pasture during the previous year. Assume that this stocking rate was satisfactory. During the current year, stocker cattle with an AUE of 0.625 (as

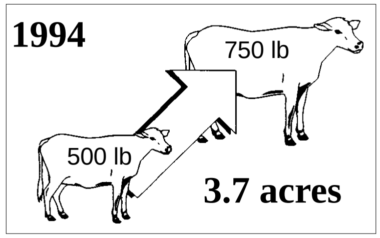


	Standard Animal			
Animal	1,000-lb cow Above-average milking Graze 6 months Wean calf at 400 lb	1,200-lb cow Above average milking Graze 6 months Wean calf at 400 lb	1,000-lb cow Above average milking Graze 6 months Wean calf at 600 lb	500-lb stocker Graze 5 months to 750 lb
Change	—	Cow is larger	Cow is larger	Stockers
AUE				
Cow	This 1,000-lb cow is defined as 1.0 AUE	$\frac{1{,}200 \text{ lb}}{1{,}000 \text{ lb}} = 1.2$ AUE	$\frac{1{,}000 \text{ lb}}{1{,}000 \text{ lb}} = 1.0$ AUE	NA
Calf	A 400-lb calf averages 0.3 AUE over a 6-month period	0.3 AUE	$0.3 + \frac{(600 - 400)}{1{,}000} = 0.5$ AUE	NA
Stocker	NA	NA	NA	$\frac{(500 \text{ lb} + 750 \text{ lb})/2}{1{,}000} = 0.625$ AUE
AUM				
Cow	1.0 AUE × 6 months = 6.0 AUM	1.2 AUE × 6 months = 7.2 AUM	1.0 AUE × 6 months = 6.0 AUM	NA
Calf	0.3 AUE × 6 months = 1.8 AUM	0.3 AUE × 6 months = 1.8 AUM	0.5 AUE × 6 months = 3.0 AUM	NA
Stocker	NA	NA	NA	0.625 AUE × 5 months = 3.125 AUM
Total AUM	7.8	9.0	9.0	3.125
***Forage equivalent**	7.8 AUM × 750 lb = 5,850 lb	9.0 AUM × 750 lb = 6,750 lb	9.0 AUM × 750 lb = 6,750 lb	3.125 AUM × 750 lb = 2,345 lb

*750 lbs of air dry forage per AUM

Figure 5. Calculating the AUE of different classes of livestock.





Assumptions:

- 1993 stocking rate was correct.
- Length of time on pasture was 6 months for 1993 and will be 5 months for 1994

AUE	Cow/calf = 1.4 AUE	Stocker = 0.625 AUE
AUM	1.4 x 6 = 8.4 AUM	0.625 x 5 = 3.125 AUM
Stocking rate	10 acres per pair	(3.125 AUM/8.4 AUM) x 10 = 3.7 acres per stocker

Figure 6. Adjusting Stocking rate for different classes of livestock

described in Figure 5) will be grazed on that same pasture. To adjust the stocking rate for the new class of animal, calculate the AUM's of grazing each will require. The ratio between the new stocker animal (3.125 AUM) and the previous cow-calf pair (8.4 AUM) should be determined. This ratio is 3.125/8.4, or 0.37. Now, instead of one cow-calf pair per 10 acres, the 500-pound stocker animal would require less than half as much acreage, or 3.7 acres. If the grazing season length is different between the two animals, adjust the stocking rate by the proper ratio. Suppose the stocker will be grazed for 5 months compared to 6 months for the cow-calf pair. The stocking rate for the stocker would be 5/6 of 3.7 acres, or 3.1 acres per animal.

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For additional information:

Tame Pasture:

Smooth Brome Production and Utilization, (C-402)

Tall Fescue Production and Utilization, (C-792)

Rangeland:

Range Grasses of Kansas, (C-567)

Management Following Wildfire, (L-514)

Grazing Distribution, (MF-515)

Rangeland Weed Management, (MF-1020)

Rangeland Brush Management, (MF-1021)

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Nitrate and Prussic Acid Toxicity in Forage

Causes, Prevention, and Feeding Management

Departments of Agronomy & Animal Sciences

Nitrate toxicity

Nitrate is a natural product formed from the oxidation of organic compounds. Most of the soil nitrogen absorbed by plant roots is in nitrate form. Normally, nitrate in a plant is rapidly converted to amino acids by the enzyme nitrate reductase. This reduction requires energy from sunlight, adequate water, nutrients, and favorable temperature. When plants are stressed, the nitrate-to-protein conversion is disrupted and nitrates begin to accumulate.

Why nitrates are toxic

Nitrate toxicity is a misnomer because nitrite (NO_2), not nitrate (NO_3), is poisonous to animals. After a plant is eaten, rumen bacteria rapidly reduce nitrates in the forage to nitrites. Normally, the nitrites are converted to ammonia and used by rumen microorganisms as a nitrogen source. If nitrate intake is faster than its breakdown to ammonia, however, nitrites will begin to accumulate in the rumen. Nitrite is rapidly absorbed into the blood system where it oxidizes hemoglobin to methemoglobin. Red blood cells containing methemoglobin cannot transport oxygen, and the animal dies from asphyxiation.

Animals under physiological stress (sick, hungry, lactating, or pregnant) are more susceptible to nitrate toxicity than healthy animals. Toxicity is related to the total amount of forage consumed and how quickly it is eaten, but, generally, if forages contain more than 6,000 ppm nitrate, they should be considered potentially toxic (Table 1).

Although all livestock are susceptible to nitrate toxicity, cattle and horses are affected most often. Sheep and swine generally do not eat enough high nitrate forage to cause problems.

Symptoms of nitrate toxicity may appear within a few hours after eating or not for several days. Signs of chronic toxicity include reduced appetite, weight loss, diarrhea, and runny eyes. However, these are nonspecific symptoms of numerous disorders and are not a reliable diagnosis of nitrate poisoning. Low nitrate levels can cause abortion without any other noticeable symptoms.

Acute toxicity usually is not apparent until methemoglobin approaches lethal concentrations. Symptoms include cyanosis (bluish color of mucus membranes), labored breathing, muscular tremors, and eventual collapse. Coma and death usually follow within two to three hours. Postmortem confirmation of nitrate toxicity is chocolate-colored blood; however, the color will change to dark red within a few hours after death.

Diagnosis and treatment of nitrate toxicity should be performed by a veterinarian. However, in acute cases where time is limited, an antidote of methylene blue can be injected to convert the methemoglobin back to hemoglobin.

Forages suspected to contain high nitrate levels should be tested by a laboratory before feeding. Unfortunately, different laboratories may report nitrate levels as either nitrate (NO_3), nitrate-nitrogen (NO_3-N), or potassium nitrate (KNO_3). Potassium nitrate, nitrate-nitrogen, or percent nitrate can be converted to ppm nitrate using the conversion factors in Table 2.

Table 1. Level of nitrate in forage (dry matter basis) and potential effect on animals.

ppm Nitrate	Effect on Animals
0-3,000	Virtually safe.
3,000-6,000	Moderately safe in most situations; limit use for stressed animals to 50% of the total ration.
6,000-9,000	Potentially toxic to cattle depending on the situation; should not be the only source of feed.
9,000 and above	Dangerous to cattle and often will cause death.

Table 2. Conversion factors for expressing nitrate content of forages.

Potassium Nitrate x 0.61	= Nitrate (ppm)
Nitrate-Nitrogen x 4.42	= Nitrate (ppm)
% Nitrate x 10,000	= Nitrate (ppm)

Plant factors

Plant Species. Nearly all plants contain nitrate, but some species are more prone to accumulate nitrate than others. Crops such as forage sorghum, grain sorghum, sudangrass, sudan-sorghum hybrids, and pearl millet are notorious nitrate accumulators. Weed species such as kochia, lambsquarters, sunflower, and pigweed also are routinely high in nitrate.

Under certain environmental and managerial conditions, wheat, corn, alfalfa, soybeans, oats, Johnsongrass, and other plants can accumulate potentially toxic levels of nitrate.

Stage of Growth. Nitrate content generally is highest in young plant growth and decreases with maturity. Sorghums and sudangrasses, however, are exceptions because concentrations usually remain high in mature plants. If plants are stressed at any stage of growth, they can accumulate nitrate.

Plant Parts. Nitrates normally accumulate in stems and conductive tissues. Highest nitrate levels occur in the lower one-third of the plant stalk. Concentrations tend to be low in leaves because nitrate reductase enzyme levels are high there. Grain does not contain appreciable amounts of nitrate.

Environmental factors

Drought. Nitrates accumulate in plants during periods of moderate drought because the roots continually absorb nitrate, but high daytime temperatures inhibit its conversion to amino acids. During a severe drought, lack of moisture prevents nitrate absorption by plant roots. Following a rain, however, the roots rapidly absorb nitrate and accumulate high levels. After a drought-ending rain, it requires 7 to 14 days before the nitrates will be metabolized to low levels, provided environmental conditions are optimum.

Sunlight. Nitrate reduction occurs in young leaves and requires light as an energy source. Shaded plants lack sufficient energy to convert nitrate to amino acids. Plants growing in field corners may be shaded and are frequently high in nitrates. Extended periods of cloudy weather increase nitrate content. Dangerously high levels can occur when wet, overcast days follow a severe drought.

Frost, Hail, or Disease. Conditions such as hail, light frost, or plant disease can damage plant leaf area and reduce photosynthetic activity. With less available energy, nitrate reduction is inhibited and nitrates accumulate in the plant.

Temperature. Low temperatures (less than 55°F) in the spring or fall retard photosynthesis of warm-season plants and favor nitrate accumulation. Extremely high temperatures also increase nitrate concentrations by reducing nitrate reductase enzyme activity.

Management factors

Fertilization. Nitrogen fertilization increases soil nitrate levels and the subsequent uptake by plant roots. Nitrogen from decomposing organic matter also can contribute to nitrate accumulation. Applying high amounts of manure or other fertilizer, particularly in the late season, increases concentrations. Split nitrogen applications provide better nutrient distribution and reduce the potential for toxicity.

In addition to excess nitrogen, an imbalance of other soil nutrients can affect forage nitrate levels. Plants growing in soils deficient in phosphorus, potassium, and some trace elements have high nitrate concentrations.

Herbicides. Most broadleaf weeds which accumulate nitrate normally are not eaten by cattle, and weed control is generally unnecessary. However, selectively spraying weeds routinely high in nitrates can reduce the potential hazard to livestock. Weeds damaged but not killed by a herbicide will have high nitrate levels because of depressed enzyme activity and reduced leaf area.

Harvest Technique. When roughages are made into silage, fermentation normally reduces nitrate levels by 40 to 60 percent. Forages with extremely high nitrate levels at harvest may still be dangerous after ensiling and should be analyzed before feeding. If forages are harvested as hay, nitrate concentrations remain virtually unchanged over time.

High nitrate forages may be grazed, but a dry roughage should be fed first to limit intake. Stocking rate should not be too high because overgrazing forces cattle to eat the stems, which contain the highest nitrate levels. Cattle should be removed from potentially susceptible forage for 7 to 14 days after a drought-ending rain. Lush regrowth of heavily fertilized grasses contains high nitrate levels and should not be grazed.

If plants are fed as green chop, the harvested forage should be fed immediately after cutting, not allowed to heat up. As the plants respire, nitrates are converted to nitrites, which are about 10 times more toxic than nitrates.

Feeding high nitrate forage

Before feeding potentially troublesome plants such as sorghum and sudangrass, analyze the forage for nitrates. Environmental conditions in Kansas create high nitrate concentrations in some forage virtually every year. Consequently, nitrate analysis is necessary to determine if the feed is potentially toxic. It is critical that representative samples be collected. Your Extension agent or laboratory representative can provide information on random sample collection and delivery to the lab. High nitrate forages still can be fed to animals if proper precautions are taken.

Adapt Cattle to High Nitrate Feeds Gradually. Nitrate toxicity frequently occurs in animals without prior exposure to nitrates. If nitrate levels in the forage are not excessively high (e.g., over 9,000 ppm) the animal will usually be able to adapt to increasing amounts in the feed. Frequent feeding in limited amounts through the day rather than large amounts once daily will increase the total amount that can be safely fed.

Dilute with Other Feeds. Blend high nitrate forage on a 1:1 basis with other feeds that are low in nitrates. After three to four weeks of feeding, the animals normally become adjusted to nitrates and the proportion of high nitrate forage can be increased.

Supplement Grain. Feeding 2 to 5 pounds of grain dilutes the amount of nitrate in the total ration and provides the energy necessary for bacteria to quickly convert nitrite to ammonia. Molasses also can provide needed energy for nitrite reduction but may be cost prohibitive.

Feed a Balanced Ration. Formulate rations to ensure adequate protein, vitamin A, and other nutrients. Nitrates may increase the requirement for vitamin A, but excessive supplementation is unjustified. Nonprotein nitrogen (urea) may worsen the situation and should not be given with high nitrate forages.

Do not Feed to Stressed Livestock. Animals that are sick, hungry, pregnant, or lactating have a lower tolerance for nitrates than healthy animals.

Provide Clean Drinking Water. Frequent intake of water dilutes nitrate levels. Ponds or ditches which collect runoff from feedlots, heavily fertilized fields, septic tanks, or manure piles are likely polluted with nitrates.

Table 3. Level of prussic acid in forage (dry matter basis) and potential effect on animals.

ppm HCN	Effect on animals
0-500	Generally safe; should not cause toxicity.
600-1,000	Potentially toxic; should not be the only source of feed.
1,000 and above	Dangerous to cattle and usually will cause death.

Prussic acid poisoning

Prussic acid also is known as hydrocyanic acid or hydrogen cyanide (HCN). Prussic acid poisoning is caused by cyanide production in several types of plants under certain growing conditions. Sorghums and closely related species are the plants most commonly associated with prussic acid poisoning. These plants possess a cyanogenic molecule called dhurrin in their epidermal cells. In healthy, intact leaf tissue dhurrin is nontoxic. However, mesophyll cells located beneath the epidermis have an enzyme that removes HCN from dhurrin. If the leaves become damaged, dhurrin and its hydrolyzing enzyme will intermix and release cyanide.

Why prussic acid is toxic

Once eaten, cyanide is absorbed directly into the bloodstream and binds to enzymes in the cell. This cyanide complex prevents hemoglobin from transferring oxygen to individual cells and the animal dies from asphyxiation.

Cyanide poisoning is related to the amount of forage consumed and the animal's physiological condition, but HCN levels exceeding 200 ppm on a wet weight (as is) basis are dangerous. On a dry weight basis, forages with more than 500 ppm HCN should be considered potentially toxic (Table 3).

Prussic acid acts rapidly, frequently killing the animal within minutes. Symptoms include excess salivation, difficult breathing, staggering, convulsions, and collapse. Death from respiratory paralysis follows shortly. The clinical signs of prussic acid poisoning are similar to nitrate toxicity, but animals with cyanide poisoning have bright red blood that clots slowly, whereas animals poisoned with nitrate have dark, chocolate-colored blood. The smell of bitter almonds is often detected in animals poisoned with cyanide.

Because it occurs quickly, the symptoms are usually observed too late for effective treatment. In the absence of a veterinarian, and if there is no doubt about the diagnosis, the animal can be treated with simultaneous injections of sodium nitrate and sodium thiosulfate. Sodium nitrate releases the cyanide from the cell, which then binds with the sodium thiosulfate to form a nontoxic complex that is excreted. Animals alive one to two hours after the onset of visible signs usually recover.

Prussic acid concentration factors

Plant Species. Crop species most commonly involved with prussic acid poisoning are sorghums, Johnsongrass, and sudangrass. Potential cyanide production among varieties and hybrids of most summer annual forages varies widely. Grain sorghums are potentially more toxic than forage sorghums or sudangrass, whereas hybrid pearl millet

Summary Guidelines To Reduce Nitrate Toxicity

- ■ Pay close attention to potentially troublesome plants, such as sorghum and sudangrass, which often have high nitrate levels.
- ■ Avoid excessive application of manure or nitrogen fertilizer.
- ■ Raise cutter bar 6 to 12 inches to exclude basal stalks. This also will minimize harvesting many weed species that have accumulated nitrate from shading.
- ■ Delay harvesting any stressed forages. A week of favorable weather generally is required for plants to reduce accumulated nitrate.
- ■ Never feed green chop that has been heated after cutting or held over night.
- ■ Harvest plants containing high levels of nitrate as silage rather than hay.
- ■ Have representative samples of suspect forage analyzed before feeding.

Table 4. Millet and sorghum types and their potential cyanide accumulations.

Millet or Sorghum Types	Cyanide Potential
Pearl and Foxtail millet	very low
Sudangrass varieties	low to intermediate
Sudangrass hybrids	intermediate
Sorghum-sudangrass hybrids	intermediate to high
Forage sorghums	intermediate to high
Shattercane	high
Johnsongrass	high to very high
Grain sorghums	high to very high

and foxtail millet generally have very low cyanide levels (Table 4). Indian-grass, flax, choke cherry, elderberry, and some varieties of birdsfoot trefoil can also cause prussic acid poisoning.

Plant Age and Condition. Young, rapidly growing plants are likely to contain high levels of prussic acid. Cyanide is more concentrated in young leaves than in older leaves or stems. New sorghum growth following drought or frost is dangerously high in cyanide. Pure stands of Indiangrass that are grazed when the plants are less than 8 inches tall can possess lethal concentrations of cyanide.

Generally, any stress condition that retards normal plant growth may increase prussic acid content. Hydrogen cyanide is released when plant leaves are physically damaged by trampling, cutting, crushing, chewing, or wilting.

Drought and Frost. Drought-stunted plants accumulate cyanide and can possess toxic levels at maturity. Freezing ruptures the plant cells and releases cyanide. After a killing frost, wait at least four days before grazing to allow the released HCN to dissipate.

Prussic acid poisoning is most commonly associated with regrowth following a drought-ending rain or the first autumn frost. New growth from frosted or drought-stressed plants is palatable but dangerously high in cyanide.

Soil Fertility. Plants growing in soils that are high in nitrogen and low in phosphorus and potassium tend to have high cyanide concentrations. Split applications of nitrogen decrease the risk of prussic acid toxicity.

Animals. Most losses occur when hungry or stressed animals graze young sorghum growth. Ruminants are particularly susceptible to prussic acid poisoning because cud chewing and rumen bacteria both contribute to releasing cyanide. The enzyme responsible for hydrolyzing HCN from dhurrin is destroyed in stomach acid, which allows monogastric animals, such as horses and swine, to be more tolerant of cyanide than ruminants.

Feeding grain or hay before turning animals to pasture reduces rapid intake and dilutes the amount of cyanide consumed. Animals do not adapt or become immune to cyanide, but they can detoxify low HCN levels.

Harvest Technique. Prussic acid concentrations are higher in fresh forage than in silage or hay because HCN is volatile and dissipates as the forage dries. However, if the forage had an extremely high cyanide content before cutting, or if the hay was not properly cured, hazardous concentrations of prussic acid could remain. Hay or silage that likely contained high cyanide concentrations at harvest should be analyzed before it is fed.

Summary Guidelines To Avoid Prussic Acid Poisoning

- Do not allow hungry cattle to graze where prussic acid may be a problem.
- Do not allow animals to graze potentially troublesome plants after a light frost or after rain has ended a summer drought.
- Chop or ensile plants high in cyanide to reduce toxin levels.
- Have representative samples of any suspect forage analyzed before feeding.

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Smooth Brome Production and Utilization

COOPERATIVE EXTENSION SERVICE
KANSAS STATE UNIVERSITY
MANHATTAN, KANSAS

Introduction

Smooth bromegrass *(Bromus inermis)* is a long-lived perennial, sod-forming grass introduced into the United States from Hungary in 1884. It is a cool-season grass that grows best during months with cooler weather, primarily March through June and September through November, and becomes semidormant during the hot, dry summer months. Most production occurs during the spring growth period, generally peaking in May through early June. The amount of fall growth depends on available moisture. Mature plants are 18-48 inches tall with erect leafy stems. Smooth brome spreads by strong, creeping rhizomes and seed dispersion.

Smooth brome is one of the more important cool-season grasses in the eastern half of Kansas and in favorable dryland locations-deep, well-drained soils receiving runoff from adjacent areas-in central and western Kansas. It is productive as far west as Rawlins County on subirrigated bottomland and is well adapted for irrigated pasture.

Smooth brome provides excellent pasture with a high carrying capacity and excellent hay when properly managed and harvested. Forage yields can be exceptional—3-4 tons per acre or more—with good management when rainfall is adequate. Smooth brome also provides excellent permanent cover for sites such as waterways, eroded areas, rocky areas, and farm lanes.

Varieties

Two distinct types of smooth brome have been identified—Northern, which is adapted to western Canada and the northern Great Plains, and Southern, which is adapted to the Corn Belt states and central Great Plains. Because of their superior drought and heat tolerance, only Southern varieties should be grown in Kansas. The following varieties are recommended for use in Kansas:

- Achenbach, a typical Southern type, is the variety commonly grown in Kansas. It is a heavy producer of both seed and forage. Achenbach was named in 1944 by the Kansas Agricultural Experiment Station. Much of the seed sold in Kansas as “common” is from this source. No certified seed is available.
- Southland is a variety from the Oklahoma Agricultural Experiment Station and was released in 1953. Southland has greater resistance to leaf diseases than most Southern strains, but its chief advantages are greater yield capacity, better seedling vigor, and better adaptation to southern conditions. Certified seed is available.
- Lincoln was developed at the Nebraska Agricultural Experiment Station. Lincoln is well adapted for conservation purposes because of good seedling vigor and ease of establishment on critical planting sites. Lincoln shows good early spring growth and fall regrowth. Certified seed is available.

Other varieties of the Southern type of smooth brome available either as certified seed or commercial seed include Baylor, Blair, and Fischer.

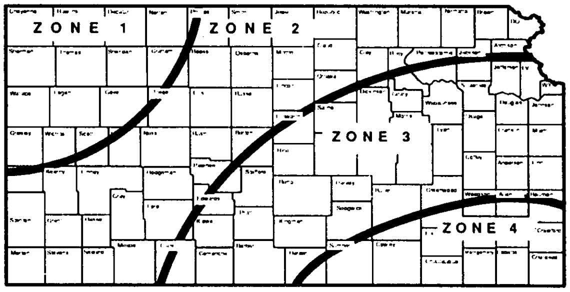
Establishing Smooth Brome

Smooth brome has been successfully established under many circumstances. Eroded and rocky areas, unproductive weed patches, bluegrass pastures, brush infested areas, and marginal cropland are all possible sites.

Time of Seeding

Smooth brome can be planted in late summer, early fall, winter or early spring (Figure 1). Winter and spring plantings are not recommended on droughty clay-pan soils because bromegrass will not survive if a hot, dry summer follows planting. Cool-season grasses are established most successfully with late summer or fall plantings. Adequate time must be allowed for summer tillage and soil moisture storage.

Good weed control is essential. Germinating weeds encouraged by summer tillage can be destroyed by light discing or other tillage operations. Tillage should be done no later than mid-August for a late August or early September planting. When moisture is available, several tillage operations maybe needed to control weed growth and thus conserve soil moisture. Excess tillage may increase moisture loss. No-till seeding of brome has emerged as a viable planting method. With no-till seeding, existing weeds are controlled by use of nonselective or



	Zone 1	Zone 2	Zone 3	Zone 4
Fall	Aug 10-Sep 15	Aug 15-Sep 20	Aug 15-Sep 20	Aug 15-Oct 1
Winter	Nov 1-Mar 1	Nov 15-Feb 15	Dec 1-Feb 15	*
Spring	Marl-Apr 1	Feb 15-Apr 1	Feb 15-Apr 1	*

*Not Recommended

Figure 1. Optimum seeding dates for smooth brome.

nonresidual herbicides. Land subject to wind or water erosion should be protected by terracing or other appropriate soil conservation measures.

Seedbed Preparation

Proper seedbed preparation is essential for a good stand. The ideal seedbed is firm, moist, free of weeds, and adequately fertilized and limed. Such a seedbed can be obtained by planning and using good techniques.

Seedbed preparation on land suited for cultivation is relatively simple. For best results, minimize weed competition, obtain uniform seed distribution, plant shallow and evenly cover seed with soil. Many smooth brome pastures have been established on sites that cannot be adequately tilled because soil is too shallow and/or slopes are too steep. On these areas, little seedbed preparation is possible.

Lime. Soil testing is essential to determine lime needs. Smooth brome will grow on moderately acid soils, but does best on near neutral pH soils. Because smooth brome stands can remain productive for 20 years or longer, correcting soil pH prior to seeding is essential. Needed lime should be added and thoroughly mixed to a soil depth of six inches as far ahead of planting as possible.

Nitrogen. Table 1 shows nitrogen recommendations for new seedings of smooth brome. Applying 30-40 pounds of nitrogen before seeding will help ensure vigorous establishment of brome. Nitrogen could be applied with needed phosphorous and potassium and incorporated prior to seeding or broadcast after planting.

Phosphorous and Potassium. Soils in Kansas vary in levels of phosphorous and potassium present. A soil test is essential to determine requirements for these nutrients. Based on the soil test, addition of phosphorus and potassium will help establish smooth brome stands and ensure subsequent growth. Tables 2 and 3 list phosphorus and potassium recommendations for establishing new stands

Table 1. Nitrogen recommendations for smooth bromegrass.

Type	Area of State	lb/a N[1]
New Seeding	Entire	30-40
Established Stands:		
Nonirrigated	Eastern	80–1 20
Nonirrigated	Central	40–80
Irrigated	Entire	125–200

[1] In established stands, the lower recommended N rates are for hay management only. The higher rates are for grazing or grazing and haying management.

of smooth bromegrass. Broadcasting and incorporating recommended rates of phosphorus and potassium during seedbed preparation is the most desirable practice. Phosphorus and potassium also may be applied with the drill at seeding. Avoid placing more than 20 pounds per acre of nitrogen plus potash in direct contact with the seed at planting.

Seed Source and Rate

High-quality seed of known germination and purity is important. Seeding rate depends on seed quality and method of seeding. When planting in a well prepared seedbed, 10–15 pounds of pure live seed (PLS) is adequate. PLS refers to the amount of live seed of the desired species in a bulk lot. As an example, 100 pounds of bulk smooth brome seed that has a germination of 90 percent and a purity of 95 percent contains 85.5 pounds of pure live seed (100 x .90 x .95= 85.5).

If a poor seedbed exists, seeding rates as high as 20 pounds PLS per acre may be required to obtain satisfactory stands. Higher seeding rates should be used when brome is broadcast on the surface and covered.

Method of Seeding

Drilling smooth brome seed is the preferred method of seeding. Drilling ensures uniform seed distribution, accurate seeding rates, and uniform depth of coverage. For best results, smooth brome should be seeded ¼ to ½ inch deep.

Broadcasting brome on the surface with shallow incorporation can result in good stands of brome. Wheat can be used as a cover crop in establishing a stand of smooth brome. Start by broadcasting 20 pounds PLS of brome seed on the surface of soil prior to wheat seeding. As the wheat is drilled, the brome seed is covered. After the wheat is taken for hay or grain, the brome is usually established, provided sufficient moisture is available for both crops. This is a slow establishment method, but it is desirable on soils subject to erosion or to obtain a return from the field the first year.

Managing Smooth Brome

New Stands

New stands of brome should be protected from grazing until the grass is well established. With proper management, fall seeded smooth brome usually can be grazed the next year. Light grazing with haying at the bloom stage should be considered the first spring. Spring seedings should not be grazed until the following spring.

Established Stands

Brome requires annual fertilization for optimum production. Soil test bromegrass pastures and meadows during July. This will provide an accurate picture of the nutrients available. Particular attention must be paid to pH, phosphorus, and potassium. Phosphorus and potassium rates for established stands of smooth bromegrass are listed in Tables 2 and 3, respectively.

Balanced fertility is essential. For example, if phosphorus is low, added nitrogen will not produce optimum yields. Soils low in phosphate limit plant and root growth. Phosphate and/or potassium should be applied by broadcasting in the fall or before spring growth begins.

Nitrogen Source. Nitrogen management is critical for optimum smooth brome production. Several nitrogen sources are available—liquid nitrogen solutions, urea, ammonium nitrate, and anhydrous ammonia. Anhydrous ammonia is not extensively used on permanent pastures because application is difficult. Nitrogen source research generally has shown little difference among sources under most conditions. When urea fertilizers—including liquid nitrogen—are applied to moist soils covered with grass residue, an enzyme called urease can break down the urea to ammonia which is lost to the air. This can occur fairly rapidly when moist conditions followed by warm temperatures and rapid drying occur without rain to move the urea into the soil. If urea is applied from November through February, volatilization loss should be minimal.

Application Timing. When brome is grazed in the fall, the yearly nitrogen application should be split. If adequate soil moisture is available for good growth in late August and early September, apply all phosphorus and potassium indicated by a soil test plus 30-40 pounds of nitrogen per acre. Before the soil freezes in November or December, apply the remainder of the nitrogen recommended for haying or grazing. Split or late fall applications generally initiate earlier green up in the spring.

If soil moisture is limited, apply all nitrogen, phosphorus and potassium before the soil freezes in November or December. **Do not apply fertilizer to frozen soil.**

Spring applications as soon as the soil thaws are acceptable for spring-only grazing. Timely application is often delayed because of wet soils.

Nitrogen Rate. Nitrogen rate recommendations for established stands of smooth bromegrass are shown in Table 1. When brome is to be utilized for hay production, excessive nitrogen may cause lodging and reduce the amount of harvestable hay. In Table 1, the lower values in the rate range are for hay production. Nitrogen rate should be selected based on factors such as fertilizer cost,

Table 2. Phosphorus recommendations for smooth bromegrass.

Type	Soil Test Level (ppm P)				
	Very Low (0-5)	Low (6-1 2)	Medium (13-25)	High (26-50)	Very High (51 or more)
	----- lb/a P_2O_5 -----				
New Seeding	60–80	40–60	20–40	None	None
Established Stands					
Nonirrigated	30-50	20–40	0–30	None	None
Irrigated	50–60	40–50	20–40	1 0–20	None

Table 3. Potassium recommendations for smooth bromegrass.

Type	Soil Test Level (ppm K)				
	Very Low (0-40)	Low (41 -80)	Medium (81-120)	High (121-160)	Very High (161 or more)
	----- lb/a K_2O -----				
New Seeding	80-100	60–80	30–60	0-30	None
Established Stands					
Nonirrigated	30–50	20-40	0–30	None	None
Irrigated	50–60	40–50	20–40	0-20	None

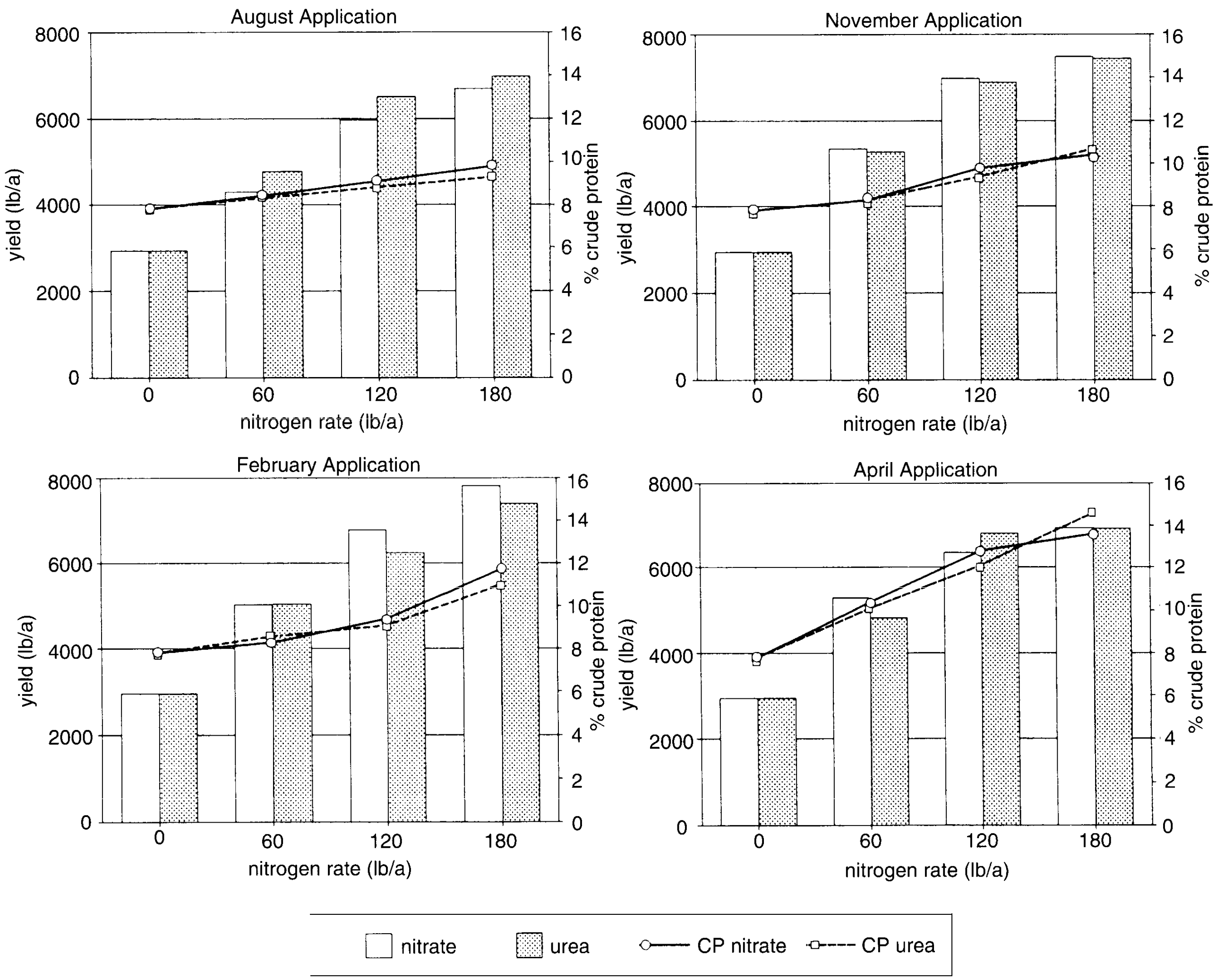


Figure 2. Production and crude protein content as influenced by timing of nitrogen application and nitrogen source based on eight years of data.

hay price, and/or grazing pressure. For brome seed production, nitrogen should be applied in November through early December. Figure 2 summarizes effects of N rates (O, 60, 120, 180 lb N/a), sources (ammonium nitrate and urea), and application timing on brome forage yields and crude protein levels.

Lime. Brome forage production response to lime is hard to document, unless the pH drops below 5.5. However, keeping the pH at or above this level can improve stand longevity. When lime is recommended, surface apply no more than 2,000 pounds effective calcium carbonate (ECC) per acre at one time.

Weed Control

Invasion by weedy plants can occur. Often, a well managed smooth bromegrass pasture will have weeds in areas such as corners, around water, mineral sources, and other areas where cattle concentrate. These disturbed areas may become weedy, but controlling the weeds is rarely profitable.

When smooth bromegrass plants lose their ability to compete, weedy plants invade. This can result from a fertility imbalance, low fertility—particularly nitrogen and/or phosphorus—unfavorable weather, repeated heavy summer grazing, and numerous other factors. In the past, chemical control was often used because herbicides were relatively inexpensive. With increased herbicide costs and changes in labels, improved production and grazing management must be combined with herbicides to be profitable. Adequate fertility and proper grazing management will minimize most weedy plant invasions. For the latest chemical control recommendations, see your county Extension agent and ask for “Chemical Weed Control for Field Crops, Pastures, Rangeland & Noncropland,” a publication issued annually.

Smooth Brome Utilization

Grazing Management

The carrying capacity of smooth brome pasture is determined by several production factors previously discussed. If smooth brome is to be grazed the entire season, stocking rates must be adjusted so that enough forage remains for grazing during summer months when production is low.

Smooth brome should not be grazed below a stubble height of four inches. If warm-season native grass, bermudagrass or a summer annual pasture is available, an alternative is to heavily stock brome pastures during the spring, utilize the warm-season grass in summer, and then move back to the brome with moderate stocking in the fall. This management technique is preferred because cool- and warm-season forages are grazed when quality is best.

If brome is to be grazed during the dry summer months, it is necessary to stock moderately during the early part of the grazing season so more forage will be available during summer months. Mineral supplementation to meet local deficiencies should be provided with any grazing management program.

Rotational Grazing. In recent years, some producers have been rotating their cattle on two or more pastures to increase the carrying capacity and/or better utilize the forage. Rotational grazing does not increase forage production. Concentrating animals from several pastures into a single pasture for a shorter grazing period ensures that more forage is harvested. Once livestock are moved, regrowth is quicker and more uniform. This will help to maintain an adequate nutrition level for the animals. Use of rotational grazing should be considered for the summer months. By alternating grazing and resting, regrowth in rested pastures can be used to the best advantage.

When using rotational grazing, animals are grazed in one pasture for a selected time and then moved to another. The grazing interval is determined by forage availability, length of time needed for regrowth, and animal nutrition requirements. Grazing should be long enough to harvest all of the required quality forage, to allow rapid regrowth, and to allow harvest when needed.

Hay Production

Production of high-quality brome hay requires adequate fertility and timely cutting. Smooth brome hay can bean extremely high-quality forage if harvested at the bloom stage. Producing quality hay, however, eliminates producing a seed crop. Brome hay should be cut between early heading and full bloom—usually mid-May to June l—to optimize quantity and quality. Smooth brome should never be cut before the early heading stage or below a stubble height of four inches as stand reduction or loss can occur, particularly during dry soil conditions.

Hay Quality. As grass plants mature, forage quality drops rapidly. Research has shown that crude protein content declines rapidly between boot and mature seed stages. Crude protein levels in well fertilized hay harvested at early heading range from 10–1 8 percent, but drop rapidly after heading (see Figure 3). Decreases in crude protein levels by as much as one-half percent per day after heading have been recorded.

Two of the most important factors affecting nutritive value of a forage are its digestibility and dry matter intake. Forage digestibility and intake both decrease with maturity. Digestibility of smooth brome declines rapidly after heading (Figure 4). When cut at or past the dough stage, brome hay often is not adequate to meet the energy requirements of a mature beef cow. Unlike protein and digestibility, fiber concentrations of smooth brome increase with advancing maturity. The fiber content of a forage-commonly estimated by the neutral detergent fiber or NDF concentration—is a measure of components that contribute to "fill" in ruminant animals. Therefore, NDF is inversely related to animal intake potential—a low NDF value would indicate high intake potential. For the data in Figure 4, brome hay harvested at the dough stage of maturity had an NDF content five percentage units higher than brome hay harvested at early heading. Although seemingly small, this increase in fiber content would result in significant reductions in the intake of brome hay.

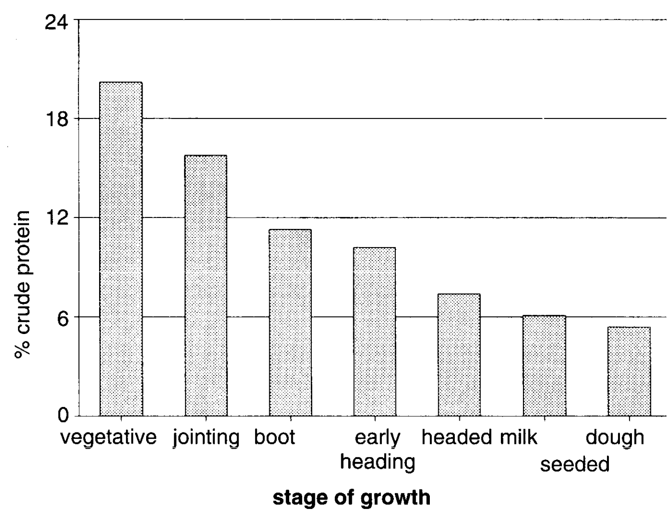


Figure 3. The crude protein content of smooth bromegrass as influenced by stage of growth.

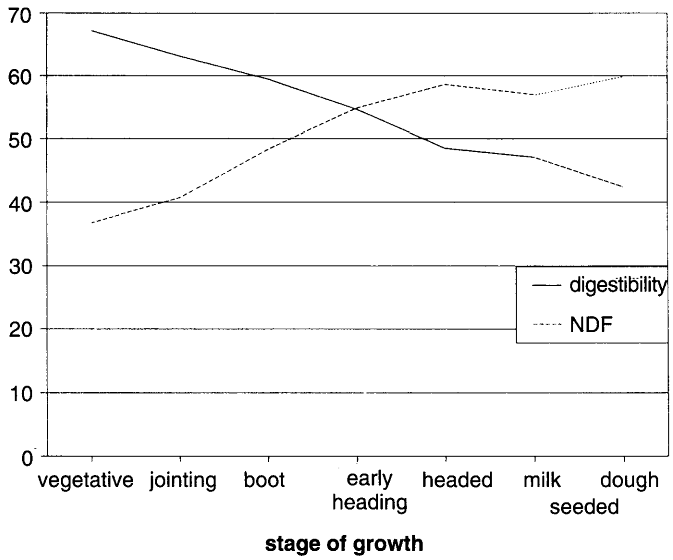


Figure 4. The relationship between digestibility and NDF (a measure of intake) is greatly influenced by growth stage at hay harvest.

Seed Production

Smooth brome seed production can be a profitable enterprise when used in combination with hay production and/or livestock grazing.

Seed is harvested when the stem just below the head has matured. Freshly harvested seed can contain enough moisture to cause the seed to heat when piled, which can reduce seed germination. Brome seed should be harvested on days when the relative humidity is below 50 percent, and harvested seed should be turned and stirred daily to ensure that heating does not occur. After the seed is harvested, the stubble and regrowth can be used for hay or grazing, but the quality will be much lower than for early harvested hay. Nitrogen rates for seed production in eastern Kansas are 80–100 pounds per acre applied in November or early December. Apply needed phosphorus and potassium at the same time. Excessive nitrogen can cause lodging. Seed yields of well managed brome range from 300–1 ,000 pounds per acre.

Noxious weed seed in smooth brome seed renders the seed unsalable. Controlling noxious weeds such as musk thistle, quackgrass, and Johnsongrass is required to meet the seed laws of Kansas.

Other publications

Seed Production and Management for Bromegrass and Tall Fescue (MF-394)

Chemical Weed Control for Field Crops, Pastures, Rangeland & Noncropland (Report of Progress issued annually)

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Rangeland Brush Management

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Brush invasion competes with desirable forage for moisture, light, and nutrients, and can be a major limitation to rangeland production. Dense brush stands obstruct grazing, reduce livestock performance, and interfere with livestock handling. Removing trees and brush from rangeland can increase forage production and livestock carrying capacity.

Eliminating all woody plants, however, is not always practical, necessary, or desirable. Isolated trees provide shade for livestock and can improve grazing distribution. Trees and shrubs shelter livestock from wind and snow, furnish suitable areas for calving, and provide food and cover for wildlife. Clearing woody plants along streams and ravines can increase soil erosion, reduce water quality, and destroy wildlife habitat. Because of the potential aesthetic, economic, and recreational value of wildlife, scattered stands of woody plants are compatible with livestock production.

Historically, woody plants were confined to riparian areas along creeks, streams, and rivers where soil moisture was high. Three factors prevented woody plants from encroaching into the prairie: recurrent fires, continuous grazing pressure from numerous herbivores, and periodic drought. Suppressing fire and replacing native herbivores with domestic livestock contributed to brush species progressively invading grazingland.

Management Decisions

Brush invasions frequently are ignored until they become severe. Control can be difficult and expensive, and the cost of attempting to eradicate a species usually exceeds any benefits gained. The decision to treat brush must balance the expected value of potential benefits with the cost of control.

Depending on management objectives, leaving some brush areas for wildlife or erosion control may be more economically feasible than trying to reclaim the land for grazing. On areas that potentially could produce economic returns, undesirable woody plants should be reduced to tolerable levels, then managed to prevent further encroachment.

Because woody species differ in their response to control attempts, accurate identification of the target plant is important to successful management.

Brush Control Methods

Prescribed Burning

Prescribed burning is the most economical and important tool for managing brush, especially in the eastern half of Kansas. In the absence of fire, woody species progressively invade and eventually dominate tallgrass prairie. Mulch provides favorable conditions for the germination of many woody species, particularly when a wet spring follows a dry year.

Effective control of woody plants with fire depends upon the species, amount of fuel, when the burn occurs, and burning frequency. Nonsprouting species such as eastern redcedar are readily killed by a single burn if they are less than five feet tall and adequate fuel is available. Resprouting species, however, require two or three consecutive years of prescribed burning at the proper time for successful control.

The best time to control most species with fire is when the plant reaches its low point in food reserves. That normally occurs in mid- to late-April when dominant warm-season perennial grasses (e.g., big bluestem and Indiangrass) are one to two inches tall. Smooth sumac and leadplant, however, have root reserve cycles similar to warm-season perennial grasses and are unharmed by late-spring burning.

Prescribed burning is most successful in controlling woody species if fuel is abundant and environmental conditions are favorable for a hot fire. Headfires pushed by a 10–15 mph wind are necessary to damage large trees. Dense brush stands may require an initial herbicide treatment before fire can carry through the area. Resprouting brush then can be suppressed with a systematic burning program.

Mechanical

Mechanical brush control is labor intensive, expensive, and generally only feasible for small or scattered patches. Nonsprouting trees can be killed any time if cut off at ground level. Resprouting species, however, need to be cut when their root reserves are low. Mowing in late-April will control woody plants such as buckbrush, but smooth sumac must be cut in early June.

Two or three consecutive years of cutting at the proper time are required to kill most woody species. Resprouting of some trees, such as hedge and honeylocust, can be prevented by applying a herbicide to the stump immediately after cutting.

Dense stands of trees or brush can be cleared with bulldozers; however, surviving roots may resprout. Bulldozing also destroys desirable plant species, and reseeding usually is necessary to prevent erosion.

Herbicides

Most woody plants are susceptible to properly applied herbicides. Herbicide effectiveness depends upon using the proper chemical at the correct time and rate. Each species has a period when it is most susceptible. Environmental factors such as precipitation, temperature, and wind also affect herbicide activity.

Herbicides should not be applied unless registered for use on the site and target brush species. Application equipment should be accurately calibrated to obtain maximum control and prevent environmental damage. **Follow label instructions carefully** and use herbicides with caution. Consult your county Extension office for the latest herbicide recommendations.

Herbicides can be applied several ways, but methods used in combination with mechanical control are time consuming and only practical for individual trees or minor invasions.

Broadcast spray. Foliar herbicides may be applied either with ground equipment or aircraft. Ground equipment sprays are suited for individual plants or scattered brush stands, but aerial applications are necessary for dense stands, large areas, or rugged terrain.

Timing is critical for successful brush control. Normally, foliar herbicides are applied in the spring after leaves have fully expanded and plants are actively growing. Good spray coverage is important. Dense brush stands require high application volumes to ensure coverage on understory plants. To be effective, foliar herbicides must be absorbed and translocated. Consequently, optimum control requires thoroughly wetting the leaves and favorable growing conditions.

Soil Applied. Applying pellet, granular, or liquid herbicides to the soil surface in a grid pattern or evenly spaced under the drip line controls many brush species. Treatment should be timed to coincide with anticipated rainfall in early- to late-spring. Soil applied herbicides should not be applied when the soil is frozen or saturated with water.

Basal bark. Applying a herbicide and diesel oil mixture (see label instructions) to the lower portion of the trunk will control many species. Large trees or species with thick bark may not be susceptible to this treatment. The entire circumference of the trunk up to 18 inches above ground should be soaked. Basal bark sprays are most successful from mid-July to mid-January, but should not be applied when the bark is wet or when the temperature is below freezing.

Girdle or Frill. For trees larger than five inches in diameter, grooves or notches can be cut in the trunk. Herbicides applied to the cuts will penetrate the sapwood and control most species.

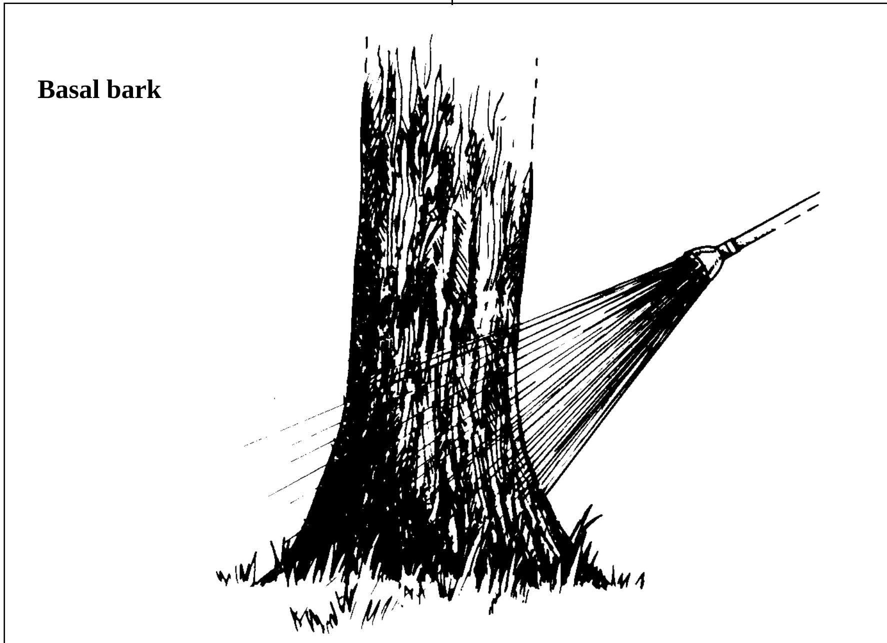
Cut stump. Cutting woody species at ground level and immediately applying the proper herbicide to the cut surface will usually prevent resprouting.

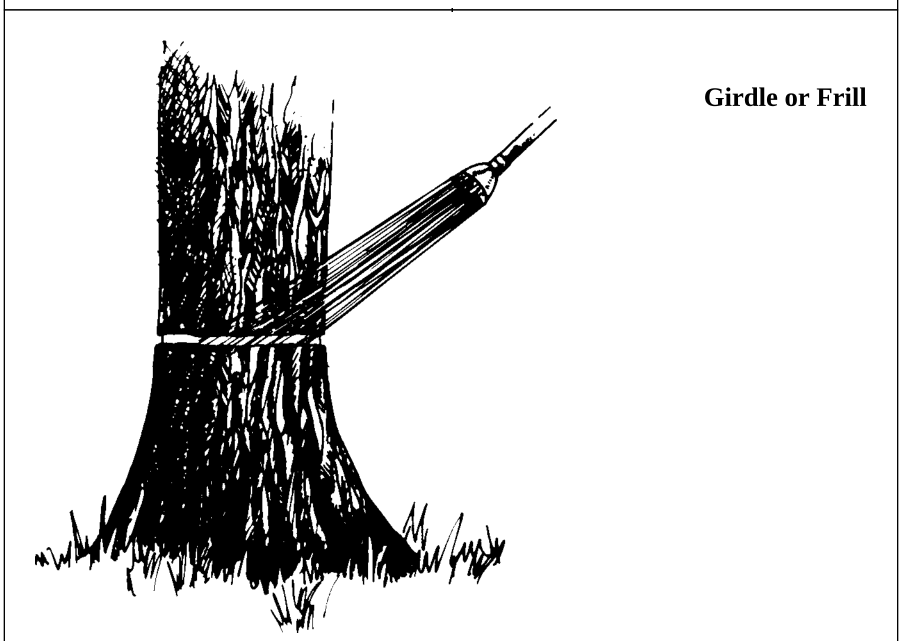
Grazing Management

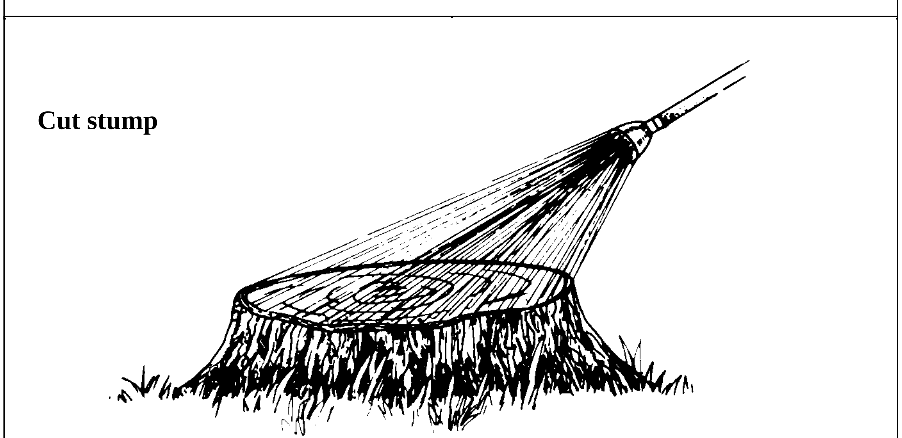
Woody plant seedlings and sprouts are stunted by livestock browsing in moderate or heavily stocked pastures. Consequently, woody plants seem to spontaneously appear if livestock are removed from heavily grazed range. Deer and goats consume large amounts of browse. Cattle, however, normally do not eat mature woody plants except for occasional variety. An exception is yucca, which can be controlled in western Kansas with continuous grazing by cows during winter.

Which Method To Use?

Selecting a brush control method depends on the plant species, size of invasion, topography, economics, adjacent land use, and management objectives. Combinations of methods often are less costly and more effective than a single method, particularly with mixed brush species. Prescribed burning followed by herbicide applications on the regrowth improves control







of persistent species. Because successful brush control normally requires follow-up treatments, applying herbicides to prevent sprouting is more efficient than repeatedly killing regrowth.

Summary

Brush management is an important factor in properly managing rangeland. The key to brush management is recognizing potential problems and controlling them before they become severe. Once brush is reduced to tolerable levels, good grazing and pasture management can limit recurrence.

Related Publications

Prescribed Burning Safety (L-565)
Prescribed Burning: A Management Tool (L-815)
Prescribed Burns: Planning and Conducting (L-664)
Rangeland Weed Management (MF-1020)
Chemical Weed Control for Field Crops, Pastures, Rangeland and Noncropland (Report of Progress issued annually)

Cooperatively developed by

Kansas State University
State Board of Agriculture—
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KANSAS STATE UNIVERSITY

Cooperative Extension Service, Manhattan, Kansas

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Rangeland Weed Management

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Rangeland plants not readily grazed by livestock generally have been considered undesirable weeds that should be eliminated. Many plants regarded as weeds, however, are intricate components of the grassland ecosystem. Therefore, it is important to distinguish between desirable rangeland species and weeds that adversely affect forage or livestock production.

Weeds and Forbs

A weed is any plant growing where it is not wanted. In general, weeds are opportunistic plants that compete with desirable forage for moisture, nutrients, and space. Forbs are broadleaf herbaceous plants that may be either desirable or undesirable. The presence and abundance of weeds and forbs help determine range condition, and are useful indicators of management problems.

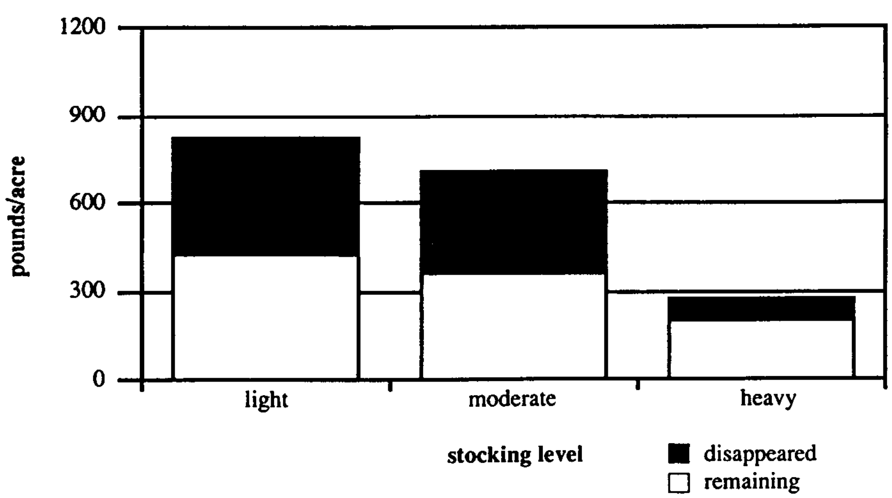
Livestock routinely graze forbs to help meet nutritional and dry matter requirements. Native legumes such as catclaw sensitivebriar, partridgepea, and leadplant are palatable and provide a good source of protein. Some perennial forbs, such as blacksamson and compassplant, are relished by livestock and will decrease under heavy grazing. As stocking rate increases, desirable forb production decreases (Figure 1).

Grazing intensity also influences the relative abundance of undesirable forbs and grasses. Perennial forbs such as verbena, goldenrod, and ironweed. and many annual forbs, such as broomweed and snow-on-the-mountain, are not eaten by cattle and increase on overgrazed rangeland. Annual bromes (Japanese brome, downy brome, and cheat) will persist in lightly and moderately stocked pastures; however, in heavily stocked pastures, the annual bromes are grazed out and replaced by little barley, an unpalatable annual grass.

Some weeds are unpalatable when mature but are grazed when young. Western ragweed contains over 20 percent crude protein and is palatable in the early growing season, but cattle will not eat mature ragweed. Annual bromes also provide forage in the early growing season, although extensive stands will reduce warm-season grass production and overall livestock gains.

Removing weedy species that compete with perennial grasses can increase forage production. Rhizomatous forbs, such as asters and goldenrods, have fibrous root systems that compete with grasses for water and nutrients. However taprooted forbs, such as scurfpea and false boneset, have extensive root systems that extract water from deeper soil horizons than grasses (Figure 2).

Figure 1. Perennial forb production at Hays decreases as stocking leve1 increases (Launchbaugh and Owensby, 1978).



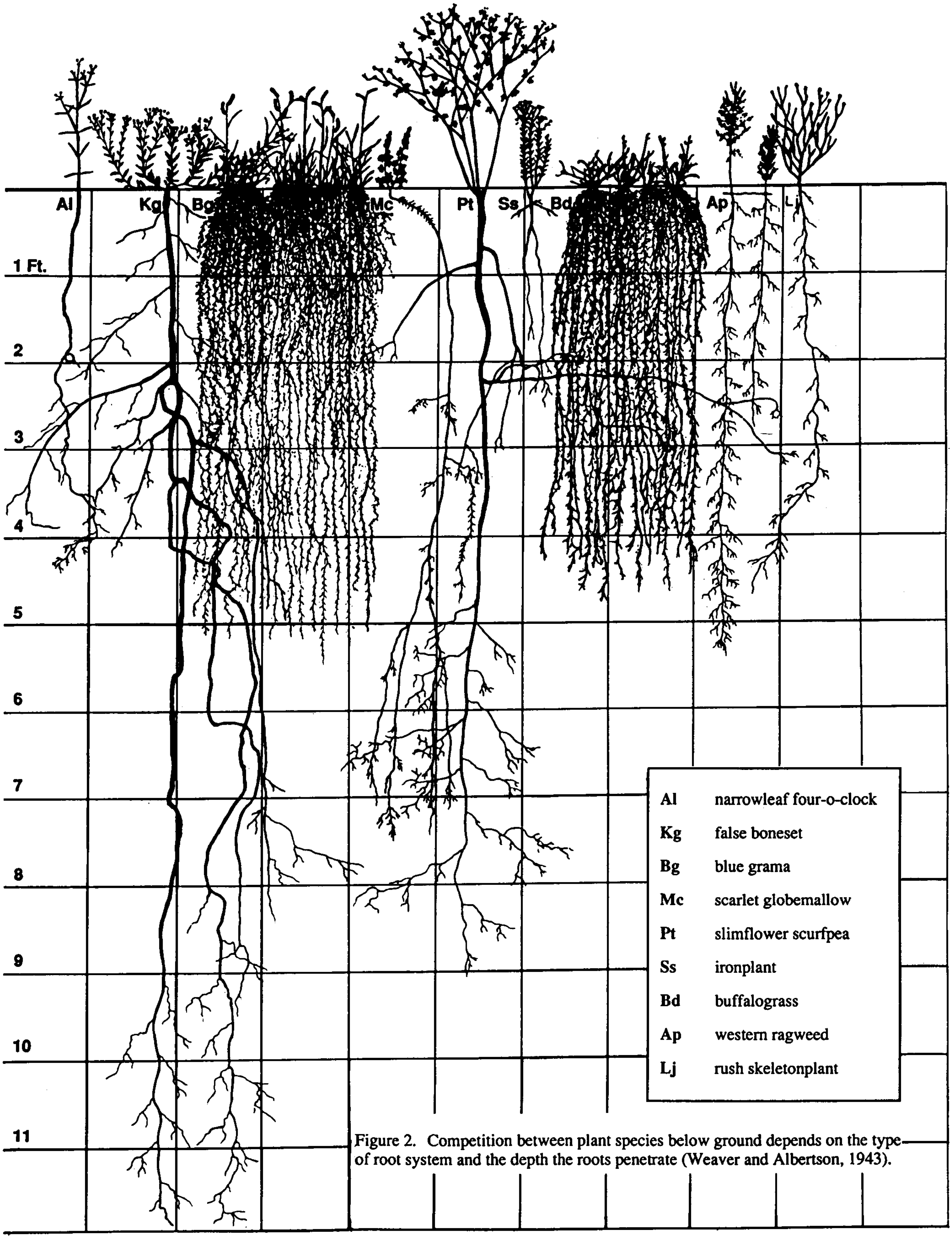


Figure 2. Competition between plant species below ground depends on the type of root system and the depth the roots penetrate (Weaver and Albertson, 1943).

Forbs can actually benefit grass production by modifying the microclimate. By providing shade and shelter from the wind, forbs reduce evaporation and temperature of nearby grass plants, which increases water use efficiency. In Kansas midgrass prairie, blue grama and buffalograss yields are increased if westem ragweed is present in amounts up to 1,200 pounds per acre.

Weeds are pioneer species in the succession of disturbed sites. Annual weeds can respond rapidly to fluctuations in temperature and moisture, and are more opportunistic than perennials. Low precipitation and above normal temperatures in the spring produce favorable conditions for warm-season annual weeds (e.g., green and yellow bristlegrass). Disturbed sites, heavily grazed pastures, and bare areas caused by spot grazing are particularly susceptible to annual weed invasion whenever a wet spring follows a dry year.

Some weeds may not directly reduce herbage production but can adversely affect livestock performance. Dense stands interfere with grazing and hinder livestock travel. Weeds with spiny leaves, awned seeds, or a pungent odor discourage grazing of nearby forage.

Wildlife Habitat

A balance of grasses, forbs, and woody plants increases habitat diversity and benefits wildlife. Edge, the boundary between different vegetation types, also is important in providing food, protection, and space. As a rule, good grazing management is not detrimental to wildlife.

Many forb species provide forage for wildlife, and are important in attracting and maintaining wildlife populations. Forb seeds, such as sunflower and ragweed, have higher energy content than wheat and sorghum and are valuable food sources for many birds.

Control Methods

Controlling unwanted plants can be expensive and difficult. Poisonous, noxious, and invading weeds that are not compatible with range forage should be targeted for control. Many "weeds" are actually beneficial to livestock and wildlife, and the consequences of their removal should be considered before a control program bcgins. Because species respond differently to control attempts, accurate identification of the undesirable weed is important for successful management.

Forage production decreases as weed encroachment increases; at some level, weed populations become high enough to warrant control. To be justified, control of undesirable species must increase forage production or availability for livestock. Reducing unwanted plants to a tolerable level generally is more economical than attempting to eliminate them. Cost effectiveness increases when weeds are controlled on sites with high production potential, such as lowlands and meadows.

Grazing Management

Grazing management is the most economical way to manage weeds. Livestock will graze many weeds early in the growing season. Continuous, moderate stocking allows cattle to select weeds and cool-season grasses that are growing before the warm-season perennial grasses emerge. Because their growing points are exposed, forbs are weakened more than grasses by repeated grazing.

The competitive ability of warm-season perennial grasses is improved if rangeland is periodically rested during the last half of the growing season. For yearling cattle operations, intensive stocking in the first half of the growing season and then resting the pasture from grazing, can effectively reduce many weed species and improve range condition.The absence of late season grazing supplies abundant fuel for burning the following spring. Additionally, an overwintering mulch layer protects the soil and provides an environment that is unfavorable for the establishment of annual weeds.

Selective grazing by different kinds of animals also can affect weed populations. Livcstock and wildlife species prefer different types of forage. Horses eat very few forbs and their intense grazing pressure on grasses favors weed establishment. Sheep eat less grass and more forbs than cattle and will consume many forb species that are unpalatable to cattle. Deer and goats primarily consume forbs and browse, and generally do not compete with cattle for forage.

Prescribed Burning

Fire played an important role in the development of the Great Plains grasslands. Prescribed burning is a valuable tool for managing weed and grass populations in the tallgrass prairie. Most annual weeds and grasses and many undesirable perennial forbs can be controlled with fire.

The response of forbs to fire depends upon the timing of the burn. Prescribed burning in late spring when the forbs are actively growing is the best time to control most forbs. Burning in early spring increases perennial forbs but generally reduces warm-season grass production. Prairie threeawn is unique because it must be burned in November to be controlled. Biennial weeds that are in the rosette stage are not controlled by fire. Fire should be used with caution in western Kansas because soil moisture loss may reduce forage production.

Mechanical Control

Mechanical controls such as hoeing and grubbing are effective but are labor intensive and expensive. Consequently, mechanical control measures are only feasible for small or scattered patches. Often, grubbing initial invading weeds can prevent severe infestations. If taprooted weeds such as musk thistle are dug, the root must be cut several inches below ground to prevent regrowth.

Mowing weed-infested areas temporarily removes top growth but often stimulates vigorous regrowth. Because desirable forage is also clipped, mowing should be limited to dense weed stands. Undesirable annual grasses should be mowed after the seed stalk has elongated but before seeds mature.

Annual forbs can be controlled by cutting below the lowest leaf early in the growing season. Annual forbs also may be mowed before seed formation, but many species become woody at maturity and remnant stems can injure livestock feet. Mowing may be aesthetically satisfying, but it seldom eliminates annual weeds because viable seed in the soil and dispersa1 from surrounding areas continually invade. Mowing generally is not effective in controlling perennial forbs, although repeated mowings will reduce their vigor and limit their spread.

Herbicides

Applications of 2,4-D and other herbicides have reduced forb populations on many grasslands. Removing all forbs from rangeland with indiscriminate spraying, however, is not desirable. Elimination or large scale reduction of beneficial forbs will reduce animal gains, disturb wildlife habitat, and produce a plant community that has a shortened season of high quality forage.

Herbicides are most effective on annual weeds that are in the seedling stage or less than 8 inches tall. Biennial species require two years to complete their life cycle and are easiest to control in the rosette stage. Perennial weeds are most susceptible to herbicides during the bud to early bloom stage. Optimum weed control is obtained if conditions that are favorable for plant growth follow the herbicide application. Careful and selective use of herbicides, combined with proper management, can hasten recovery of weed-infested areas.

Apply only herbicides labeled for the target weed species and registered for rangeland use. Application equipment should be accurately calibrated to obtain maximum weed control and prevent environmental damage.

Follow label instructions carefully and use herbicides with caution. Consult a county Extension office for the latest recommended chemicals.

Summary

Weed management is an important factor in properly managing rangeland. Determining whether or not a "weed" is detrimental is the first step of a control program. Weed infestations are often the symptom of underlying problems, and unless the problem is corrected, weeds will recur. The key to weed management is recognizing potential problems and controlling them before they become serious.

Cooperatively developed by
Kansas State University
State Board of Agriculture-
Plant Health Division
Department of Wildlife and Parks
Soil Conservation Service-USDA

References

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Weaver, J. E., and F. W. Albertson. 1943. Resurvey of grass, forbs and underground plant parts at the end of the great drought. Ecological Monographs 13:63-118.

Related Publications

Range Grasses of Kansas (C-567)
Prescribed Burning Safety (L-565)
Prescribed Burning: A Management Tool (L-815)
Prescribed Burns: Planning and Conducting (L-664)
Rangeland Brush Management (MF-1021)
Stocking Rate (L-690)
Grazing Distribution (MF-515)
Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland (Report of Progress issued annually)

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Cooperative Extension Service, Manhattan, Kansas

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PRESCRIBED BURNING

A MANAGEMENT TOOL

Cooperative Extension Service
Kansas State University
Manhattan Kansas

Fire was a part of the development of Great Plains grasslands. Natural fires, started by lightning, burned areas whenever conditions were favorable. Based on early records, these fires varied from only a few acres to some that covered thousands of acres and lasted weeks. In addition, the Plains Indian started fires to attract game into certain areas.

To the early settlers, fire was a feared enemy that destroyed everything in its path. As more settlers came, roads, fences, plowed fields and overgrazing created barriers to wildfires. These obstructions reduced their occurrence to the point that large wildfires became rare.

In Kansas, the same pattern occurred, except in the area known as the Flint Hills. Here, fire was and continues to be used virtually uninterrupted since settlement. As a result, large expanses of almost treeless prairies are common in the central and southern Flint Hills. Fire plays an important role in preventing the invasion of woody plants. In some areas, woody plant invasion has progressed to the point of forming closed woodland communities. Essentially no grass remains in such areas.

Use of fire as a management tool is steadily spreading westward across the state. Its use in western Kansas is primarily limited to controlling brush and weeds and improving grazing distribution. Using fire also is limited to certain moisture and weather conditions.

Benefits of Prescribed Burning

Research and experience have shown that fire can be a major management tool for native grasslands, native hay meadows, and in establishing new native grass stands. It can recycle nutrients tied up in old plant growth, stimulate tillering, control many woody plants and herbaceous weeds, improve poor grazing distribution, reduce wildfire hazards, improve wildlife habitat, and increase livestock production in stocker operations. To gain these benefits, fire must be used under specific conditions, with proper timing. This is called "prescribed burning."

Timing

Timing of the burn is the most critical element for obtaining the desired response. The kinds and amounts of various plants in rangeland can be changed by fire. The presence and abundance of plant species, forage yields, and range condition all are affected by the time of burning.

Burning at the weakest point in their growth stage will control or reduce undesirable plants. In order to damage a particular plant, burning must occur when the plant is actively growing or has buds above the soil surface. For perennial plants, the plant's food reserves should be at or near their lowest point to make regrowth difficult. Fire will damage or destroy annuals that have their growth point above the soil surface.

Some examples of how fire affects plants may help in understanding why timing is important. Buckbrush (coralberry), a woody perennial, must be burned in late

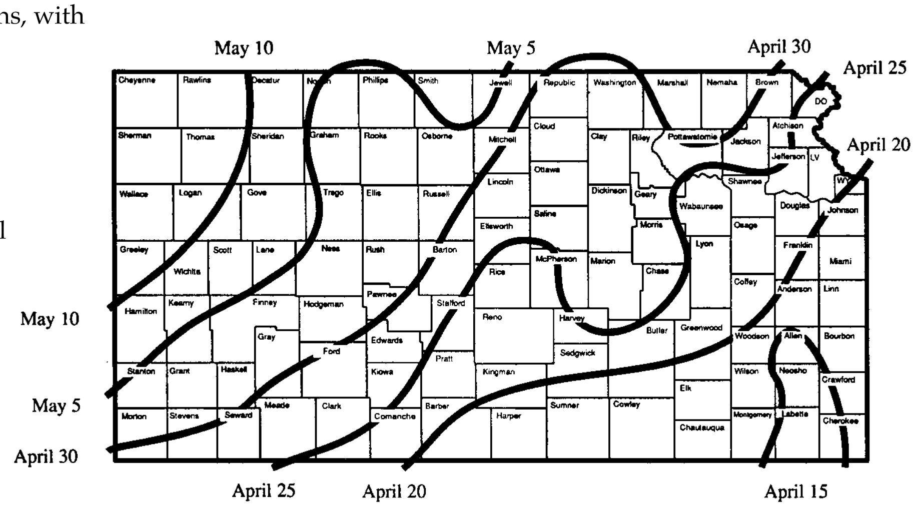

Figure 1. *Average burn dates in Kansas.*

spring for 2 to 3 consecutive years to effectively control it. During late spring, it is actively growing and fire destroys its top growth. Regrowth is slow since its food reserves are low. Successive burns prevent build-up of these reserves and kill the plant. Smooth sumac, another woody perennial, has a life cycle similar to warm season grasses in that it reaches the lowest point in its food reserves in late May or June. Burning in late spring will kill the top growth but results in an increase in the number of stems. The net result is an accelerated increase in the size of the smooth sumac invasion area. Eastern red cedar is readily killed by burning, especially when it is less than 5 feet tall. It does not have buds which can resprout, so when the plant is defoliated it dies.

Much the same response can be obtained with forbs. Western ragweed and western ironweed are perennial forbs which can be reduced with 2 or 3 consecutive annual burns.

Fire also can reduce the amount of undesirable grasses. A late spring fire greatly reduces low producing cool season grasses, such as Kentucky bluegrass and annual bromes. They are actively growing at the time of the burn and have difficulty regrowing after the burn.

Burning to favor desired grasses should take place when they are starting to green up. The grasses should have 1 to 1.5 inches of new growth, which occurs in mid to late spring. At this stage the plants are able to grow quickly. Ideally, the soil profile should be full of water at the time of burning and the surface should be damp. Big bluestem and Indiangrass increase when the range is burned in late spring. The amounts of sideoats grama, blue grama, and buffalograss increase only slightly. A late spring burn maintains or decreases little bluestem and switchgrass.

Figure 1 shows average recommended burning dates. These dates may be as much as 10 days earlier or later, depending on growing conditions.

Forage Yield

Timing of the burn affects forage yield. Research at Kansas State University has shown that the earlier the burning date, the lower the forage yield (Figure 2). The difference in forage yield between a late spring burn and unburned range is not significant.

Changes in forage yield associated with the burning date are due to moisture and temperature changes. Soil moisture in early burned areas can evaporate at rates as high as one-half inch per week. Rainfall can result in soil puddling and may not be taken into soil as readily as on the late burned or unburned areas. Soil temperature rises quickly following the burn as sunlight warms the darkened soil (old growth insulates the soil) and results in faster plant growth compared to unburned areas. Properly timed burns result in little change in soil moisture conditions, soil structure and soil erosion due to runoff.

Grazing Distribution

Fire is an excellent management tool for improving grazing distribution. Areas that are not usually grazed or are undergrazed can be burned. The animals are attracted to grasses in the burned areas since they are more accessible and palatable. Overgrazed areas generally will not have enough fuel to carry a fire, will be used less and can recover. Burning changes the grazing pattern and evens out grazing distribution. Prescribed burning also has great value in reducing grazing distribution problems caused by a wildfire over part of the pasture.

Livestock Production

Research shows that stocker animals can gain 10 to 12 percent more on late-spring burned pastures than on either unburned or early burned pastures (Figure 3). This response apparently is due to higher quality forage being available in the first half of the grazing season. These benefits occur only during the year of burning.

Cow-calf gains on burned versus unburned pastures have not shown any significant differences. Burning primarily is used to control weeds, cool season grasses and brush, improve grazing distribution, and reduce litter buildup. The benefits to the cow-calf operator are in

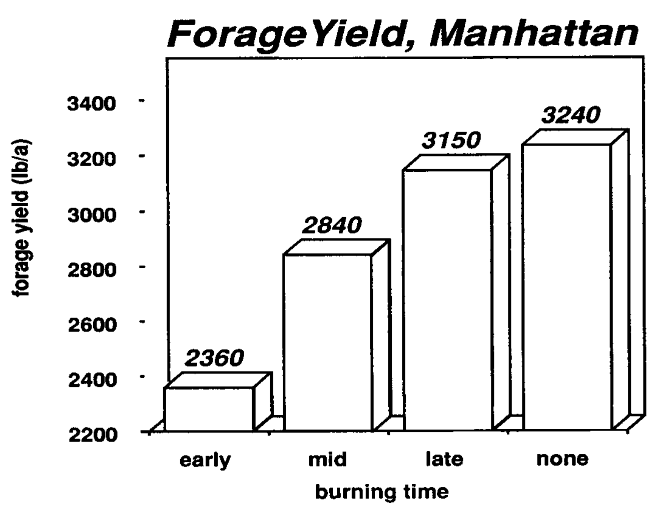

***Figure* 2.** *Average forage yield after 17 years of annual burning at the times indicated at Manhattan.*

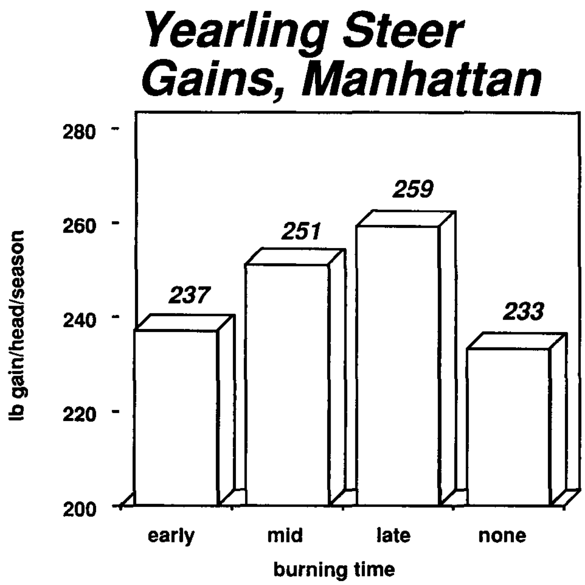

Figure 3. *Average season-long stocker gains after 17 years of annual burning at the times indicated at Manhattan.*

maintaining a highly productive grassland. Without burning, litter can accumulate and reduce grass production. A program of burning 2 or more consecutive years and then waiting until it's needed again can provide the above benefits.

Hay Meadows

Prescribed burning on hay meadows will stimulate tillering, control weeds and brush, and remove old mulch left by haying. Timing of the burn is the same as for native grass pastures. A program of burning two or more consecutive years and then waiting until it's needed again will provide the needed benefits.

Wildlife

The majority of wildlife on Kansas prairies evolved with the grassland. Fire is a critical factor in wildlife habitat management. Properly timed burns can increase desirable warm season grasses and forbs which improves food supply and nesting and brood-rearing cover for ground-dwelling birds. Early spring burns are preferred over late burns for maximum wildlife benefits. In addition, removal of the litter improves access to insects while increasing mobility and brood survival of the birds. Prescribed burning also benefits some wildlife by controlling woody vegetation. Prairie chicken populations will decline if woody vegetation becomes too dominant. Prairie chicken booming grounds may be abandoned when vegetation from the previous year is so dense or tall that courtship activities are inhibited. Bobwhite quail show remarkable responses to fire management. Feeding, roosting and travel are enhanced for quail on newly burned ranges. One and two-year-old burns provide greater amounts of quail food than older burns. If all pastures in a grazing unit are not burned in the same year, vegetation will be more diverse and birds will have suitable areas for nesting, brood rearing and winter cover.

Native Grass Seedings

Experience has shown that prescribed burning can hasten the development of newly seeded native grasses. As early as the spring after the seeding year, burning stimulates tillering, controls annual weeds and removes accumulated mulch. Having adequate soil moisture is essential to ensure regrowth after the burn.

Wildfire Hazard Reduction

Using fire to reduce the wildfire hazard may seem unusual. In years of high precipitation or underuse, large amounts of old growth accumulate. This litter provides ideal conditions for wildfires to occur during dry periods. Burning in late spring will eliminate this hazard, thereby reducing the possibility of large and extremely hot, damaging wildfires.

Effects on Soil Conditions

When a fire is properly timed, some moisture conditions change little. The earlier the rangeland is burned, the greater the moisture loss. The soil surface readily absorbs heat, greatly increasing evaporation rates.

Soil moisture should be considered when determining the timing of a burn. Table 1 defines the preferred soil moisture conditions for a successful burn. Rangeland burned too early will be subject to excessive run-off, erosion and evaporation. When soil is exposed to heavy rain, its surface structure may be destroyed. This makes it more difficult for water to get below the soil's surface layer. The longer the time between the burning date and the greening up of warm season perennials, the greater the problem.

Properly timed burns coincide with the greening up of warm season perennials. This allows them to grow quickly, leaving the soil surface bare only a short period of time. The erosion hazard and evaporation decrease, and water is able to penetrate the soil.

Air Quality

The smoke from a range fire causes few long-term detrimental effects to air quality. In fact, there is no known permanent damage. The fire, however, must occur under proper conditions. The wind should be stable, with a speed of 5 to 15 mph to help disperse smoke quickly. The amount and type of fuel present, the fuel moisture content, and the fire spreading rate determine the amount of smoke produced.

Summary

Prescribed burning is a major management tool for rangeland. Properly used, it can be a cost effective method for increasing the productivity of rangeland as well as controlling many undesirable plants. It also can reduce the hazards of wildfires and benefit both domestic livestock and wildlife.

Table 1. *Preferred soil moisture and surface moisture conditions needed to ensure a proper burn on established CRP native grass stands based on location or soil characteristics.*

Location or soil conditions	Soil moisture[1]	Surface moisture[2]
Eastern Kansas	enough to ensure growth to cover the soil surface after burn	Damp
Central Kansas	moisture to major rooting depth	Damp
Western Kansas	moisture to full rooting depth	Damp
sandy soils	moisture to full rooting depth	Damp to Moist
sub-irrigated soils	enough to ensure growth to cover the soil surface after the burn	Damp

[1] Rooting depth varies with soils. Normally, the rooting depth should be considered as either the soil depth to an impervious lay er that restricts root growth or the soil depth to which heavy root growth penetrates.

[2] Damp = wet to touch but no free water
Moist = excess water when soil is squeezed in hand

Other Useful Publications

Planning and Conducting Prescribed Burns (L-664)
Prescribed Burning Safety (L-565)
Chemical Weed Control for Field Crops, Pastures, Rangeland and Noncropland (issued annually)
Range Grasses of Kansas (C-567)

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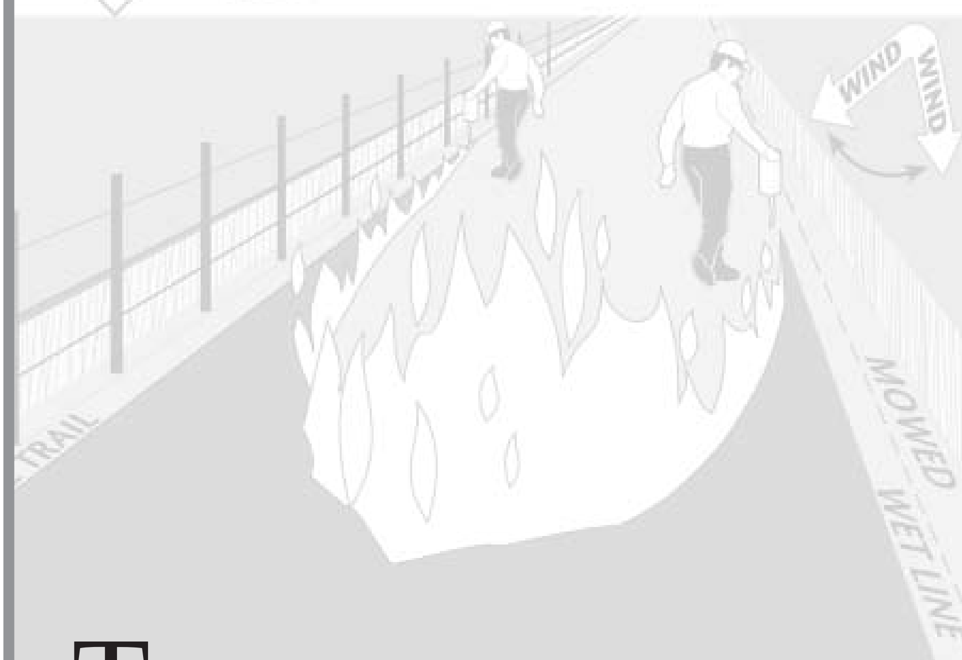
Prescribed Burning

Planning and Conducting



The role of fire has come full circle in managing the grasslands of the Great Plains. Wildfires occurred naturally before the settlers arrived. As settlements grew and the rangeland was plowed and fenced, the wildfires became smaller and less frequent. Over the years, some ranchers and researchers have continued to work with fire. Research and experience have shown that when properly applied, fire can benefit not only the grassland but also the animals that graze it.

With the benefits fire can provide also come dangers. Many dangers can be minimized by careful planning weeks or months in advance. A plan for burning should outline weather conditions, manpower, equipment, and other needs as well as how to conduct the burn.

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Natural Resource Conservation Service-USDA, and
Kansas Department of Wildlife and Parks

Planning the Burn

Planning the burn involves determining what to burn and why, how, when, precautions to take, and conditions for a successful burn. The burn then can be carried out quickly when conditions are right.

Area Inventory

Using an aerial photo or map of the area to be burned, draw in all features such as fences, buildings, powerlines, water sources, roads, and gates. This should include access routes to all parts of the area and to neighbor's property. Note features on the boundary of the planned burn area that will affect how to conduct the fire. These include steep slopes, impassable areas, fields, streams, rock ledges, livestock trails, roads, nearby buildings, and others. Next, mark areas that can be developed for firebreaks, either burned or cleared; areas to be protected such as buildings and windbreaks; and areas which can best serve for setting the headfire.

Once this inventory is complete, it is possible to make decisions considering the other important factors.

Weather Conditions

Weather has an overriding effect on a prescribed burn. Wind direction and speed, frontal passages, precipitation, relative humidity, and temperature affect how the fire will behave and how it should be conducted.

Consider wind direction and speed when evaluating the wind needed for a good burn. A wind speed of 5-15 mph is an ideal range for late spring burning. It is adequate to allow the headfire to move across the soil surface fast enough to remove excess litter and accumulated growth. Physical features of the burn area determine the best wind direction. In general, choose a direction with the least hazards downwind. Consider natural barriers such as streams, rock ledges, fields, tree lines, and little used roads including pasture trails as ideal locations for fireguards. Locations with major hazards -nearby buildings, roads, highways, power lines and towns—as areas for the fire to move away from.

The Weather Bureau issues 24- and 48-hour forecasts, including temperature, wind direction and speed, anticipated wind changes, precipitation chances, and relative humidity. Weather information can be obtained from local radio stations, TV news reports, or the National Oceanographic and Atmospheric Administration (NOAA) Weather Radio.

Local radio stations and TV news should be used for obtaining 3- to 5-day outlooks to establish the exact burn date. Their reliability for accurate 24-hour forecasts varies greatly.

The Rangeland Fire Danger Index is a part of all weather forecasts during periods of dry weather. Five factors important to the ignition and spread of fire are used in computing the index. They are temperature, humidity, wind speed, cloud cover, and percent of green. Five categories are defined: low, moderate, high, very high, and extreme. The levels have the following meaning for prescribed burning:

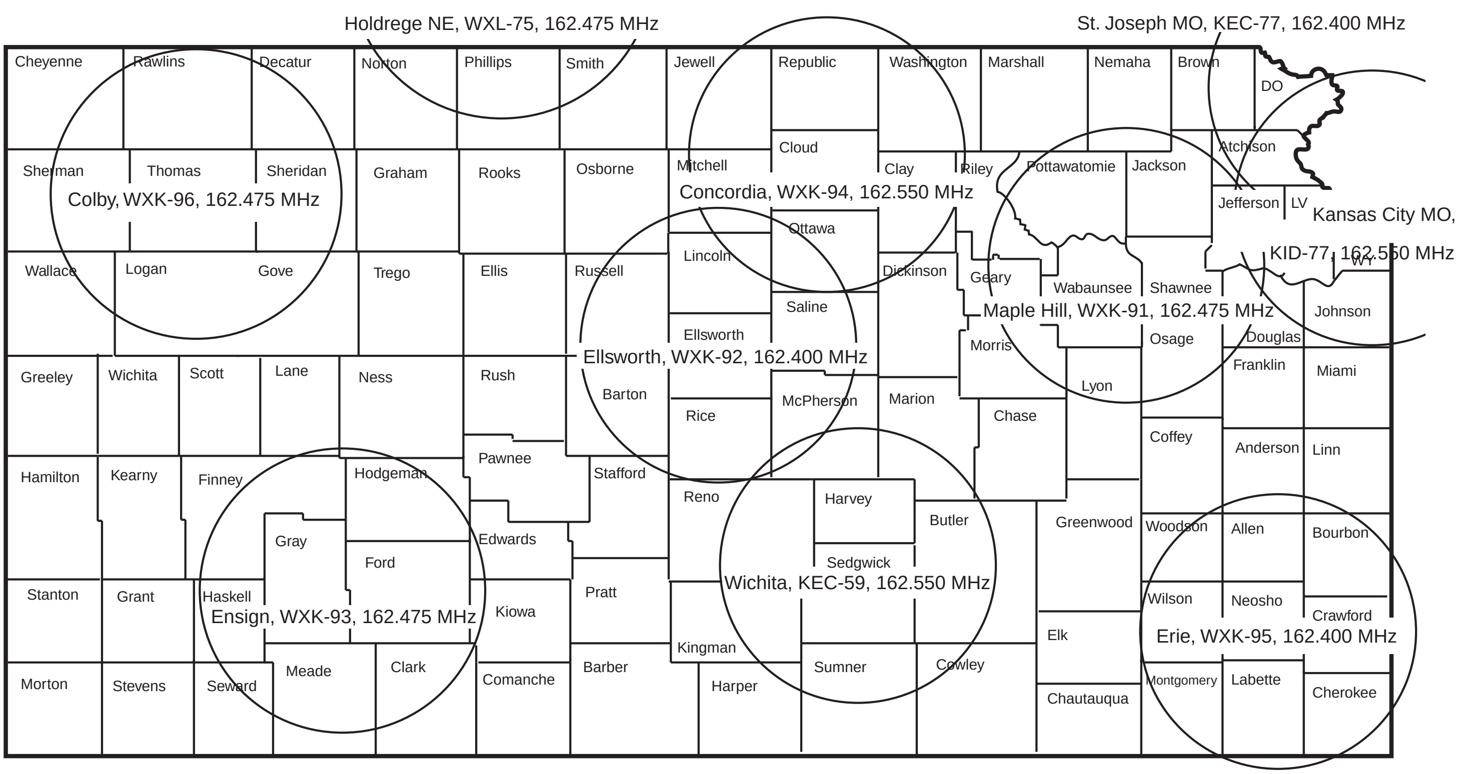

Figure 1. *Locations of the broadcast towers for NOAA Weather Radio stations in Kansas. The circle around each location represents the approximate boundary of the major reception area. Each station can be received outside the designated area if receiver is on higher ground.*

Low. Virtually impossible for a fire to occur; precipitation or high humidity will prevent the ignition and/or spread of fire.

Moderate. Best conditions for a prescribed burn. Weather parameters are within acceptable and legal limits.

High. Marginal conditions for a prescribed burn. Wind speed or humidity will be beyond acceptable limits, reducing the chances of controlling the fire.

Very High or Extreme. DO NOT BURN! When these forecasts are issued, atmospheric conditions are such that a fire will move extremely fast and be large and hot. Control of fires using normal fire-fighting tactics will be extremely difficult if not impossible. Avoid burning under these conditions.

The best source of weather information is NOAA Weather Radio. Weather Radio is a 24-hour broadcast of the current weather conditions and forecasts. These broadcasts are received on special radios at three different frequencies (Figure 1). Weather radios are available from many sources.

As the time of burning approaches, listen to forecasts several times a day, especially late afternoon and evening forecasts. Make judgments on the basis of the forecasts and modify the plan according to existing conditions.

Regulations and Safety

A safe burn involves planning, skill, and experience as well as knowing safety requirements and state regulations. To ensure that legal requirements are met, be aware of state regulations listed below. See "Prescribed Burning Safety," L-565, for safety measures. It is available from county Extension, Soil Conservation Service, or Wildlife and Parks offices.

Manpower and Equipment

Once the plans for firebreak placement and headfire lighting are complete, estimate manpower and equipment needs. Neighbors often work together to burn so that everyone has as much help and equipment as possible. A minimum crew should be four people: one to light the fire, one to drive the sprayer, one to handle the sprayer hose, and one to follow up and make sure all fires are under control. By pooling labor, equipment, and experience, a larger and better equipped crew can burn an area faster and safer. Examine and repair all equipment before the burn to ensure workability.

Notification

State regulations require that the local fire department be notified before burning. Also, check with local authorities to determine if other requirements are needed before bunring. For both safety and legal reasons, certain groups should be notified before a burn to prevent unnecessary concern and danger. Notifying neighbors, the fire department and law enforcement officials is part of the prescribed burning process. Such notification can prevent misunderstandings, unnecessary fire calls and poor public relations. The procedure discussed here has been developed based on state regulations, experience and common sense

Neighbors. Notifying neighbors of a burn can accomplish several things. It provides opportunities for cooperation in burning, and for sharing labor and equipment if prescribed burning is common in the area. Likewise, it helps in determining attitudes and finding help if prescribed burning is being introduced.

Fire department. Working with the fire department is crucial. Contact the fire chief to determine local regulations and how to request emergency help. Determining which neighbors, if any, report all fires also will help avoid problems.

Law enforcement. The need to notify local law enforcement personnel varies with the burn location and the hazards. Discuss the location with law enforcement officials to determine what to do.

The Notification Procedure

Three separate notifications are necessary: 1) the intent to burn; 2) before the burn begins; and 3) after the burn is complete.

Intent to burn

Well before the actual burn time, prepare a list of all neighbors, the fire department, and law enforcement officials. A suggested form is on the back page of this publication. List and contact any neighbor who has property adjoining or close to the burn area. Inform each of the intent to burn, the approximate date, and precautions taken to protect their property. For future reference, note reactions to initial contact.

Contact the fire department to determine current county burn policy, to develop procedures for obtaining emergency help during the burn, and to review the burn plan.

Contact law enforcement officials to determine the extent of their involvement.

Before the burn

The morning of the burn, begin notification by contacting each neighbor. The message should be similar to the following:

"We will begin our prescribed burn about (time). If you see a fire before that time, report it to the fire department. If you see a fire other than ours during our burn, report it to the fire department including the specific location and the fact that it is not our burn."

At the time the burn begins, notify the fire department with a message similar to the following:

"We are beginning our burn at (location). All neighbors have been notified and will only report fires other than ours. If we need your assistance, (name) will call and request it at the exact location of the fire."

Prepare a written statement to request emergency assistance. Wording should be similar to the following:

(Fire department name and number)

"This is (name). We need the fire department at our prescribed burn at (location). Please come to (exact location of emergency)."

Do not hang up after delivering the message. Remain on the phone to answer questions for the fire department.

Use a similar procedure for law enforcement if required.

After the burn

When the prescribed burn is complete, repeat the notifications using the procedure outlined below. After all mop up operations are complete, immediately notify the fire department with a message similar to the following:

"This is (name). We have completed our prescribed burn at (location) and will begin notifying our neighbors. If any fires are reported, please respond immediately."

Immediately notify neighbors, beginning with those closest to the burn area. Use a message similar to the following:

"We have completed our prescribed burn at (location). If you see a fire, call the fire department immediately. If you believe the fire is a result of our burn, call me after you call the fire department."

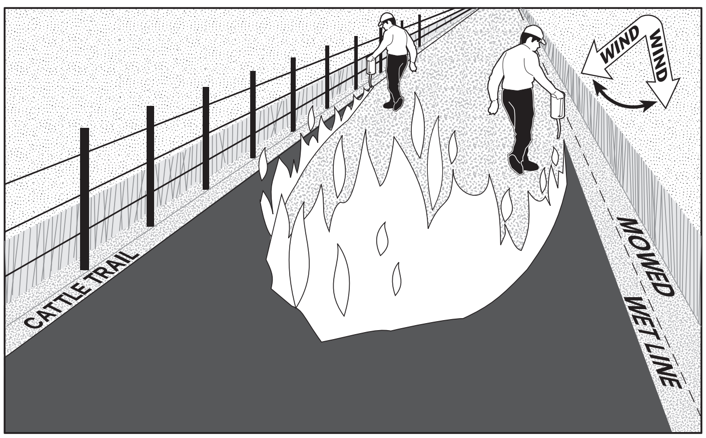

Figure 2. *Firebreaks are a key part of prescribed burning. Begin by lighting next to a natural barrier (cattle trail) and moving into the wind. Ensure that the resulting headfire does not cross the downwind barrier.*

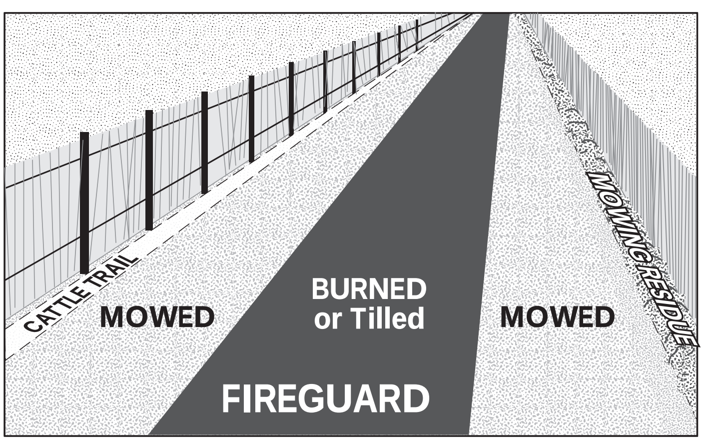

Figure 3. *When mowing the edges of the burn area, the minimum width mowed must be at least six feet, or twice the height of nearby vegetation, whichever is greater. This is necessary to prevent seed stalks or weed stems from falling across the mowed area, providing an escape route for fire when the area is burned.*

If necessary, make a similar call to law enforcement personnel.

The notification process outlined here is designed to protect those conducting the prescribed burn as well as the public. Careful planning and notification will help to maintain good relationships with neighbors and emergency personnel.

Conducting the Burn

As time for the burn nears, final preparation requires following weather forecasts to set the date of the burn more accurately. Also, determine exactly who will be able to help and what equipment will be available.

Weather forecasts are issued several times daily. Primary concerns for the burn are temperature, relative humidity, wind direction and speed, and predicted changes in each. Be sure to adapt the forecast to local conditions.

Follow the Plan

On the day of the burn, assemble the crew and review the plan. Each crew member must be familiar with the basic safety requirements, communication methods, equipment uses, and other information. Test equipment before lighting the fire. Begin the burn as planned, including notification, and adjust as needed to maintain fire control.

In general, the burning sequence is divided into two parts: establishing firebreaks, and lighting the headfire.

Establishing Firebreaks

Firebreaks are necessary to prevent the fire from escaping. They may be burned or cleared. Burned firebreaks are preferable since cleared or tilled firebreaks on sloping areas tend to erode. Both types are effective if properly prepared. Firebreaks should be twice as wide as the tallest adjoining herbaceous material. A minimum width of six feet is required. Firebreaks may be established in advance or at the time of the burn, as needed. If burned in advance, a firebreak must be relit at the time of the burn.

Burned firebreaks. Burned firebreaks are established along the perimeter of the area, taking advantage of natural barriers such as livestock trails, heavily grazed areas, pasture roads, rock outcrops, stream beds, and other bare areas. When natural barriers are not available, mowing to reduce vegetation height will aid in establishing the firebreak. Completed firebreaks must be wide enough to prevent the headfire from escaping and limit the possibility of burning embers and other material escaping the area.

Firebreaks are prepared by lighting short lengths of vegetation along a natural barrier or mowed area, moving into the wind on the downwind side of the burn area (Figure 2). This fire is allowed to back away from the barrier. Exercise caution to prevent the fire from crossing the barrier. When both sides of the fire are under control, repeat the process on a new length of vegetation.

When preparing firebreaks in advance, modify the above procedure by putting the backing fire out when it has burned at least 6 feet (Figure 3). Preburned breaks must be relit before starting the headfire.

Cleared firebreaks. Cleared firebreaks are bare soil lines prepared mechanically. They should be used only where erosion is not a concern.

Lighting the headfire

Once firebreaks are in place, the headfire can be started. It must be lit as rapidly as possible for the fire to be effective. Under most conditions, the headfire can be lit up to 30 feet downwind from the perimeter. A follow-up crew can put out the resulting backing fire.

Firing Techniques

Two firing techniques are available to accomplish the completion of the burn: strip-head fire and ring fire. Each has a specific purpose and specific requirements.

Strip-head Fire Technique. The strip-head fire technique (Figure 4) requires setting a line or series of lines of fire upwind from a firebreak so no single line can develop enough heat or convection to escape or cross the firebreak. The width of the strips depends on fuel type, amount, slope, and uniformity. As the distance from the firebreak increases, the width of the strips can be increased. It is most useful to quickly widen firebreaks and burn areas adjacent to hazards (controls size of fire and amount of smoke). Disadvantages are high heat concentration as the lines come together and the necessity of a well developed firebreak.

Ring Fire Technique. A ring fire (Figure 5) requires a firebreak downwind that provides adequate width to prevent escape of the fire. On level to gently rolling topography, a minimum 150-feet-wide firebreak is adequate at the point where the headfire will have the longest run. Once the firebreak is secure, the remaining sides of the burn area should be lit as rapidly as possible. The resulting headfire will sweep rapidly across the area. As the headfire builds in heat and size, a draft from the front draws the backing fire of the firebreak into the headfire. A strong convection column develops in the center of the ring. Once this convection column develops, the fires are drawn rapidly to the middle of the burn area, resulting in a fast, hot burn. Ring fires are the safest since once the ring is closed and the perimeter fires are extinguished, little chance remains for the fire to escape. Ring fires should be used where brush control, weed control and mulch removal are reasons for burning.

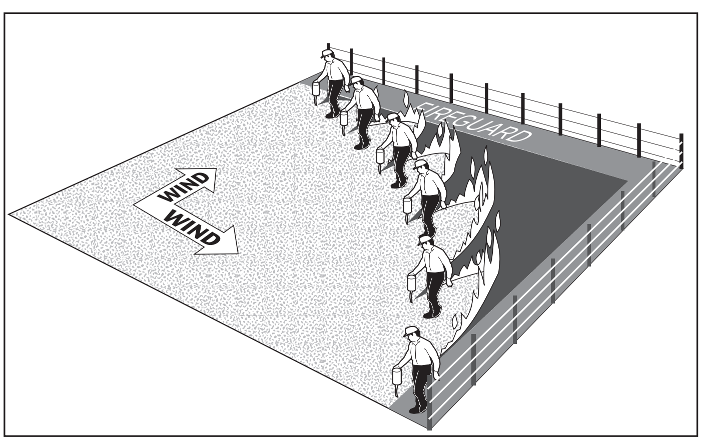

Figure 4. *The strip-head fire technique involves lighting one or more fire lines into or perpendicular to the wind direction. The width of the strips depends on fuel type, amount, slope, and uniformity.*

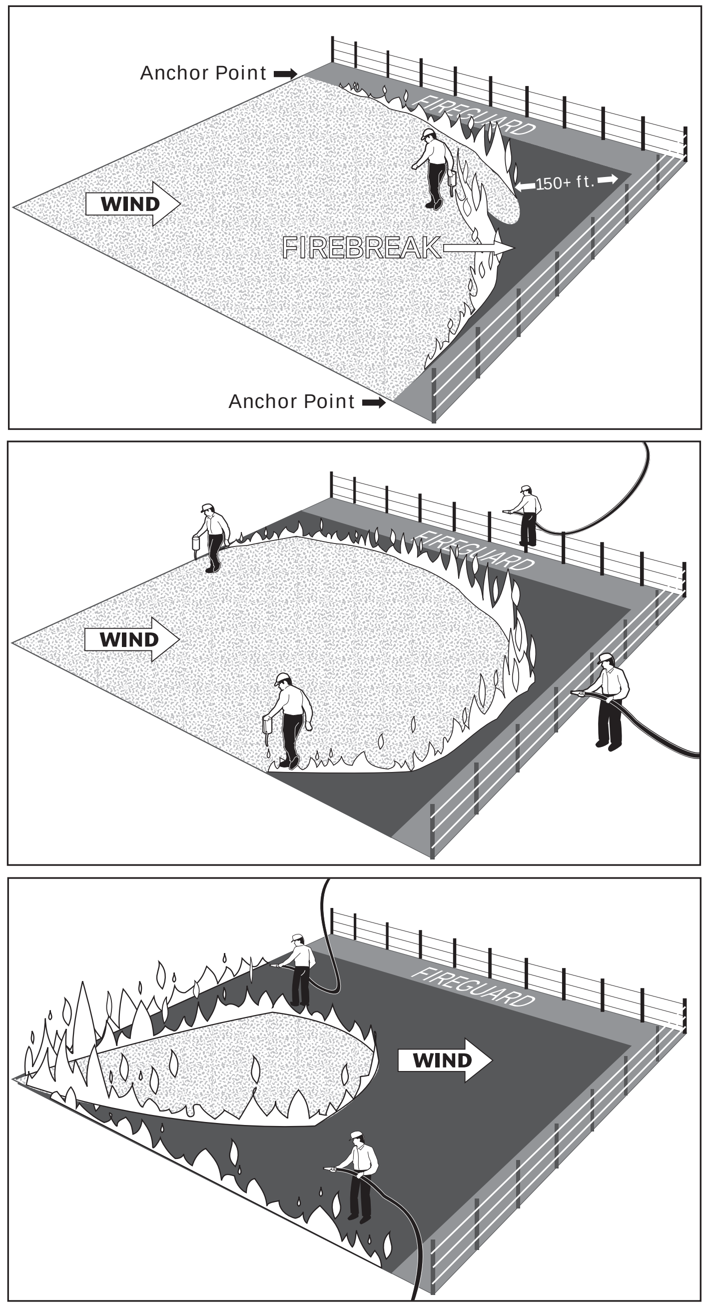

Figure 5. *The ring fire technique usually is used for prescribed burning. After the firebreaks are established and burning, the upwind sides are lit as rapidly as possible. The fire then creates its own chimney, resulting in a fast, hot burn.*

After the Burn

Once the headfire has burned out, make sure small fires, burning logs, smoldering cow chips, and similar hazards are under control. Also, notify neighbors, fire department, and others. Clean up and repair all equipment.

Mop Up

Mop up is the process of checking the entire perimeter of the burn area to ensure that all fires or smoldering materials are out or removed to a safe area. This includes cow chips, logs and dead trees, small areas still burning, and fenceposts. Never bury cow chips as they can hold fire a long time. Water does not always extinguish the embers, but detergent mixed with water will help penetrate the cow chips. Burning logs and dead trees can produce embers that are easily carried by wind to unburned areas. Carefully wet down and break apart or move logs from the edge of the burn. Dead trees that are burning should be cut down and treated the same as logs. Relight small areas of slow-burning grass and allow them to burn out rapidly. Check the perimeter at least twice.

Notification

After the burn and mop up are complete, notify the same list of people and agencies contacted before the burn. This will ensure that help will be summoned immediately if a wildfire or accidental escape occur due to incomplete mop up.

Clean Equipment

After the burn is complete, clean, repair and store all equipment. This prolongs equipment life and ensures that equipment is ready when needed again.

State Regulations

28-19-645. Open burning prohibited.

A person shall not cause or permit the open burning of any wastes, structures, vegetation, or any other materials on any premises except as authorized by K.A.R. 28-19-647 and K.A.R. 28-19-648. (Authorized by K.S.A. 1994 Supp. 65-3005; implementing K.S.A. 1994 Supp. 65-3005, K.S.A. 65-3010; effective March 1, 1996.)

28-19-646. Responsibility for open burning.

It shall be prima facie evidence that the person who owns or controls property on which open burning occurs has caused or permitted the open burning. (Authorized by K.S.A. 1994 Supp. 65-3005; implementing K.S.A. 1994 Supp. 65-3005, K.S.A. 65-3010; effective March 1, 1996.)

28-19-647. Exceptions to prohibition on open burning.

(a) The following open burning operations shall be exempt from the prohibition on the open burning of any materials imposed by K.A.R. 28-19-645:
  (1) open burning carried out on a residential premise containing five or less dwelling units and incidental to the normal habitation of the dwelling units, unless prohibited by any local authority with jurisdiction over the premises;
  (2) open burning for cooking or ceremonial purposes, on public or private lands regularly used for recreational purposes;
  (3) open burning for the purpose of crop, range, pasture, wildlife or watershed management in accordance with K.A.R. 28-19-648; or
  (4) open burning approved by the department pursuant to paragraph (b).

(b) A person may obtain an approval from the department to conduct an open burning operation that is not otherwise exempt from the prohibition imposed by K.A.R. 28-19-645 if it is demonstrated that the open burning is:
  (1) necessary, which in the case of burning for the purpose of disposal of any materials, shall mean that there is no other practical means of disposal;
  (2) in the public interest; and
  (3) is not prohibited by any local government or local fire authority.

(c) Open burning operations for which an approval is required but which are deemed to be necessary and in the public interest include the following:
  (1) the use of safety flares for disposal of flammable gases;
  (2) fires related to the training of government or industrial personnel in fire fighting procedures;
  (3) fires set for the removal of dangerous or hazardous liquid materials;
  (4) open burning of trees and brush from nonagricultural land clearing operations; and
  (5) open burning of clean wood waste from construction projects carried out at the construction site.

(d) Each person seeking an approval to conduct an open burning operation pursuant to this regulation shall submit a written request to the department containing the following information:
  (1) the location of the proposed open burning and the name, address and telephone number of the person responsible for the open burning;
  (2) a description of the open burning including:
    (A) the estimated amount and nature of material to be burned;
    (B) the proposed frequency, duration and schedule of the burning;
    (C) the size of the area to which the burning will be confined;
    (D) the method of igniting the material;
    (E) the location of any public roadways within 1,000 feet of the proposed burn;
    (F) the number of occupied dwellings within 1,000 feet of the proposed burn; and
    (G) evidence that the open burning has been approved by appropriate fire control

authority having jurisdiction over the area; and
(3) the reason why the proposed open burning is necessary and in the public interest if the activity is not listed in subsection (c) of this regulation.

(e) Each open burning operation for which the department issues an approval pursuant to paragraph (b) shall be subject to the following conditions, except as provided in paragraph (f):
(1) The person conducting the burning shall stockpile the material to be burned, dry it to the extent possible before it is burned, and assure that it is free of matter that will inhibit good combustion.
(2) A person shall not burn heavy smoke-producing materials including heavy oils, tires, and tarpaper.
(3) A person shall not initiate burning during the nighttime, which for the purposes of this regulation is defined as the period from two hours before sunset until one hour after sunrise. A person shall not add material to a fire after two hours before sunset.
(4) A person shall not burn during inclement or foggy conditions or on very cloudy days, which are defined as days with more than 0.7 cloud cover and with a ceiling of less than 2,000 feet.
(5) A person shall not burn during periods when surface wind speed is less than 5 mph or more than 15 mph.
(6) A person shall not burn within 1,000 feet of any occupied dwelling, unless the occupant of that dwelling has been notified before the burn.
(7) A person shall not conduct a burn that creates a traffic or other safety hazard. If burning is to take place within 1,000 feet of a roadway, the person conducting the burn shall notify the highway patrol, sheriff's office, or other appropriate state or local traffic authority before the burning begins. If burning is to take place within one mile of an airport, the person conducting the burn shall notify the airport authority before the burning begins.
(8) The person conducting the burn shall insure that the burning is supervised until the fire is extinguished.
(9) The department may revoke any approval upon 30 days notice.
(10) A person shall conduct an open burning operation under such additional conditions as the department may deem necessary to prevent emissions which:
(A) may be injurious to human health, animal or plant life, or property; or
(B) may unreasonably interfere with the enjoyment of life or property.

(f) The department may issue an approval for an open burning operation that does not meet the conditions set forth in subsection (e) upon a clear demonstration that the proposed burning:
(1) is necessary and in the public interest;
(2) can be conducted in a manner that will not result in emissions which:
(A) may be injurious to human health, animal or plant life, or property; or
(B) may unreasonably interfere with the enjoyment of life or property; and
(3) will be conducted in accordance with such conditions as the department deems necessary.

(Authorized by K.S.A. 1994 Supp. 65-3005; implementing K.S.A. 1994 Supp. 65-3005, K.S.A. 65-3010; effective March 1, 1996.)

28-19-648. Agricultural open burning.

(a) Open burning of vegetation such as grass, woody species, crop residue, and other dry plant growth for the purpose of crop, range, pasture, wildlife or watershed management shall be exempt from the prohibition on the open burning of any materials imposed by K.A.R. 28-19-645, provided that the following conditions are met:
(1) the person conducting the burn shall notify the local fire control authority with jurisdiction over the area before the burning begins, unless the appropriate local governing body has established a policy that notification is not required;
(2) a person shall not conduct a burn that creates a traffic safety hazard. If conditions exist that may result in smoke blowing toward a public roadway, the person conducting the burn shall give adequate notification to the highway patrol, sheriff's office or other appropriate state or local traffic control authorities before burning;
(3) a person shall not conduct a burn that creates an airport safety hazard. If smoke may affect visibility at an airport, the person conducting the burn shall give adequate notification to the appropriate airport authorities before burning; and
(4) the person conducting the burn shall insure that the burning is supervised until the fire is extinguished.

(b) Nothing in this regulation shall restrict the authority of local jurisdictions to adopt more restrictive ordinances or resolutions governing agricultural open burning operations.

(Authorized by K.S.A. 1994 Supp. 65-3005; implementing K.S.A. 1994 Supp. 653005, K.S.A. 65-3010; effective March 1, 1996.)

Prescribed Burning Notification

Name	Telephone Number	Intent to Burn	Before Burn	After Burn

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Kansas State University Agricultural Experiment Station and Cooperative Extension Service

L-664 March 1996

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Kansas Crop Planting Guide

Kansas is agronomically rich, with diverse soils and growing conditions. The average number of freeze-free days ranges from 150 in the northwest to 200 in southeastern Kansas. The average date of the last 32°F freeze in the spring is May 5 in the northwest and April 10 in the southeast. The average date of the first 32°F fall freeze is October 5 for the northwest and October 25 for the southeast.

Our rich soils and climatic conditions make Kansas the number one state in wheat and grain sorghum production. These conditions not only dictate the type of crop that will grow, but also cause wide differences in the optimum planting dates and seeding rates across the state. It is important that producers recognize optimum planting dates and rates for various crops, but just as important, producers need to recognize and understand the differences between growing conditions on their farms and those of their neighbors.

Tables in this publication show ranges of optimum planting rates and dates for various crops within a given zone.

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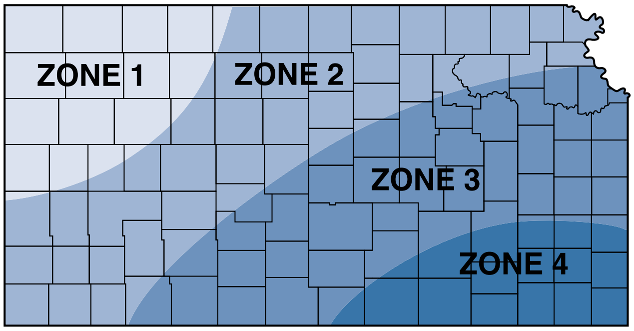


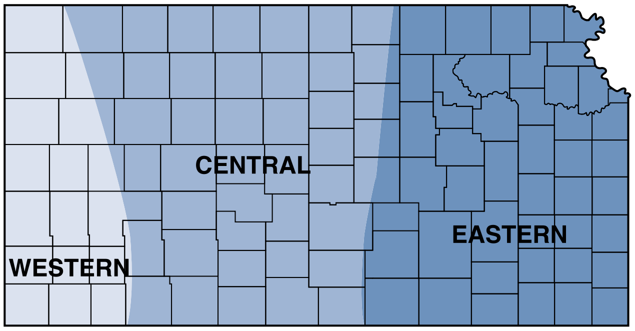
Planting Dates

Generally, the earlier planting dates of the planting range are for spring-planted crops in eastern and southern areas, while for fall-planted crops, they apply to northern and western areas **(Table 1)**.

Table 1. Suggested planting dates for Kansas crops.

Crop	Zone 1	Zone 2	Zone 3	Zone 4
Wheat	Sept 10–30	Sept 15–Oct 20	Sept 25–Oct 20	Oct 5–25
Triticale	Aug 20–Sept 15	Aug 20–Sept 25	Sept 1–25	Sept 1–Oct 1
Winter barley	Sept 10–20	Sept 10–Oct 5	Sept 15–Oct 10	Sept 20–Oct 10
Spring barley	Feb 25–Mar 15	Feb 25–Mar 15	Feb 25–Mar 15[1]	Not recommended
Spring wheat[1]	Feb 25–Mar 15	Feb 25–Mar 15	Feb 25–Mar 15	Not recommended
Winter oats	Not recommended	Not recommended	Not recommended	Sept 20–Oct 10
Spring oats	Mar 5–20	Feb 25–Mar 15	Feb 25–Mar 15	Feb 20–Mar 15
Corn	Apr 20–May 20	Apr 15–May 20	Apr 1–May 10	Mar 25–Apr 25
Sorghums	May 15–June 10	May 15–June 20	May 15–June 20	May 1–15 / June 5–25
Sudangrass	May 15–July 1	May 20–July 10	May 20–July 10	May 20–July 10
Soybeans	May 10–June 1 Irr.	May 5–June 10	May 5–June 10 W 1/2 May 15–June 15 E 1/2	May 10–June 25 W 1/2 June 1–30 E 1/2
Alfalfa				
Fall	Aug 10–30	Aug 15–Sept 10	Aug 15–Sept 10	Aug 15–Sept 15
Spring	Apr 25–June 1	Apr 20–May 10	Apr 10–May 10	Apr 10–May 10
Sweet clover				
Fall	Not recommended	Aug 15–Sept 10 E 1/3	Aug 15–Sept 10 E 1/2	Aug 15–Sept 10
Spring	Mar 5–20	Mar 1–15	Mar 1–15	Feb 20–Mar 15
Red clover	Not recommended	Mar 1–15 E 1/3	Mar 1–15 E 1/3	Feb 20–Mar 15
Millets				
Pearl	June 1–July 1	June 1–July 1	June 1–July 1	June 1–July 1
Proso	June 1–July 1	June 1–July 1	June 1–July 1	June 1–July 1
Foxtail	June 1–July 1	June 1–July 1	June 1–July 1	June 1–July 1
Lespedeza	Not recommended	Not recommended	Feb 15–Mar 15 E 1/3	Feb 10–Mar 10
Cool Season Grasses				
Fall	Aug 10–Sept 10	Aug 15–Sept 15	Aug 20–Sept 20	Aug 25–Oct 1
Winter	Not recommended	Not recommended	Not recommended	Not recommended
Spring[1]	Mar 1–Apr 1	Feb 15–Mar 15	Feb 15–Mar 15	Feb 15–Mar 15
Warm Season				
Native Grasses	Mar 15–May 15	Mar 15–May 15	Mar 15–Apr 30	Mar 1–Apr 30
Sunflower	May 7–June 20	May 15–July 1 S 1/2 May 15–July 10 N 1/2	May 10–July 10 W 1/2 June 10–July 10 E 1/2	June 10–July 15

[1]Not recommended, but if planted these are best times.



Planting Rates

As one moves from west to east within each area, planting rates for the various crops increase **(Table 2).** For example, the seeding rate for wheat in western Kansas ranges from 40 to 60 pounds per acre, and increases from 50 to 60 pounds per acre and 60 to 75 pounds per acre in central and eastern areas, respectively. These differences are due to increased rainfall from west to east.

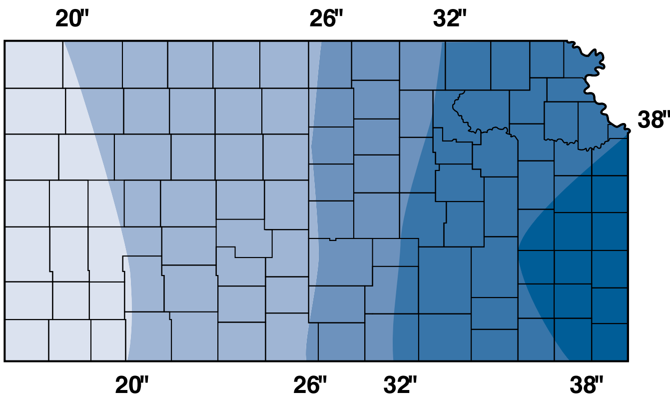
Table 2. Suggested planting rates for Kansas crops.

Crop	Rainfall: Western 20" or less	Rainfall: Central 20–30"	Rainfall: Eastern 30" or more	Irrigated
		(pounds per acre)		
Wheat	40–60	50–60	60–75	60–90
Triticale	45–60	60–75	75–90	60–90
Winter barley	40–50	60–96	72–96	75–96
Spring barley	60–96	60–96	72–96	75–96
Spring wheat	75–100	90–120	90–120	90–120
Winter oats	–	–	64	–
Spring oats	48–64	48–64	64–96	64–96
Sudangrass–drill	10–15	12–20	20–30	30
Hybrid pearl millets–rows	10	10	10	10
–drill	5–15	10–20	10–20	10–20
Alfalfa	8–10	10–15	10–15	10–20
Sweet clover	8–10	10–15	10–15	10–15
Red clover	–	–	8–10	–
Lespedeza	–	–	20–30	–
Cool Season Grasses				
Smooth brome (pure live seed)	–	10–15	10–15	10–15
Tall fescue	–	–	15–20	–
Tall wheatgrass[4]	10	10	10	NR[2]
Native grasses (pure live seed)				
Native mixtures	5	5	6	NR
Pure stand of:				
Big bluestem	NR	8	8	NR[3]
Indiangrass	NR	8	8	NR
Switchgrass	4	4	4	NR
Sideoats grama	8	8	8	NR
Sand lovegrass	2	2	2	NR
Western wheatgrass	10	10	10	NR
		(seeds per acre)		
Sunflower				
Oilseed	16,000–20,000	17,000–24,000	17,000–24,000	22,000–26,000
Confectionery	12,000–16,000	14,000–18,000	16,000–20,000	15,000–20,000

[2]Not recommended for irrigated production

[3]Individual species not recommended for irrigated pure stand production. Mixtures of 2 or more species recommended.

[4]Mainly for wet and / or saline sites.



Grain Sorghum Plant and Seed Spacings

The recommended plant population and seed spacing for grain sorghum is dependent on rainfall **(Table 3)**. A dryland grain sorghum producer who farms in the 20- to 26-inch rainfall zone uses a lower plant population than producers in higher rainfall zones or producers using irrigation. Thus the plants per square foot or plants within a foot of row will be fewer and the spacing between seeds will be greater in the lower rainfall areas.

Table 3. Plant and seed spacings of grain sorghum.

Recommended population and spacing	Average annual rainfall: Less than 20"	20–26"	26–32"	More than 32"	Irrigated
Plant population plants / acre[5]	24,000	35,000	45,000	70,000	100,000
Plant population plants / ft^2	0.6	0.8	1.0	1.6	2.3
Within row seed spacing at planting[6]			Inches between seeds		
10-inch rows	16.5	12	9.0	6	4.5
20-inch rows	8.5	6	4.5	3	2
30-inch rows	5.5	4	3.0	2	1.5

[5]Plant populations may be increased or decreased by at least 25 percent from the values given depending upon the expected growing conditions without significantly affecting yields.

[6]Assuming 65 percent field emergence. Calibration of plants should be based on seed spacing. Seeding rates based on lbs / A have little meaning since seed size commonly varies from 13,000 to 24,000 seeds / pound.

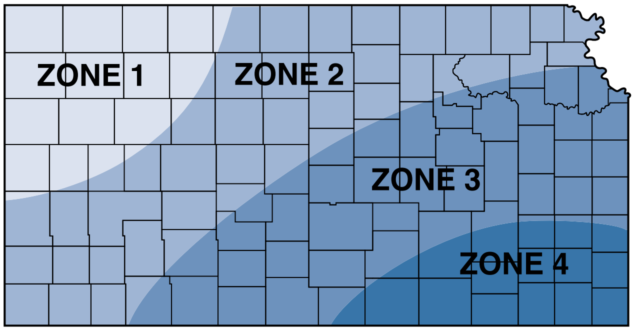
Soybean Planting Rates

The suggested soybean planting rates and final stands for different row spacings are provided in **Table 4**. If a producer wants to keep the population the same while decreasing row spacing, it is necessary to reduce the number of seeds or plants per foot of row. For soybeans planted on droughty soils in central and eastern Kansas or on dryland conditions in western Kansas, the plant population may be reduced by 25 percent. Also, the population may be adjusted upward slightly for late plantings to encourage rapid closing of the rows.

Table 4. Suggested statewide soybean planting rates.

Row width inches	Seeds / linear foot	Plants / linear foot[7]
30	10.0	8.0
20	6.6	5.3
10	3.3	2.7

[7]Assuming 90 percent germination and 80 percent emergence.



Corn Planting Dates, Populations and Seed Spacings

The suggested planting dates for corn range from late March to May 1 in southeastern Kansas (Zone 4), to April 25 to May 20 in Zone 1 **(Table 5)**. As with the other crops, the suggested final corn populations are lower in western areas and increase as one moves eastward **(Table 6)**. Corn planted under limited irrigation systems will have lower plant populations than corn under full irrigation systems. The seed spacings for a range of harvest populations are provided in **Table 7**.

Table 5. Suggested corn planting dates.

Zone 1: April 20–May 20
Zone 2: April 15–May 20
Zone 3: April 1–May 10
Zone 4: March 25–April 25

Table 6. Suggested final corn populations.

	Plants per acre
Northwest (dryland)	13,000 to 18,000
Northeast	18,000 to 24,000
East central and Southeast	
(normal planting dates)	16,000 to 20,000
Central	16,000 to 22,000
Early planting with early hybrids	
dryland	18,000 to 24,000
irrigated	28,000 to 36,000
Irrigated	24,000 to 34,000
Limited irrigation	18,000 to 26,000

Table 7. Seed spacings required for harvest populations of 10,000 to 36,000 plants per acre.

Harvested population	Seeds / acre[8] planted	Row width 30"	Row width 36"	Row width 30"	Row width 36"
		seed spacing, inches		seeds / 10 ft. of row	
10,000	11,800	17.75	14.75	7	8
12,000	14,100	14.75	12.25	8	10
14,000	16,500	12.50	10.50	10	11
16,000	18,800	11.00	9.25	11	13
18,000	21,200	9.75	8.25	12	14
20,000	23,500	9.00	7.50	13	16
22,000	25,900	8.00	6.75	15	18
24,000	28,200	7.50	6.25	16	19
26,000	30,600	6.75	5.75	18	21
28,000	32,900	6.25	5.30	19	23
30,000	35,300	6.00	5.00	20	24
32,000	37,600	5.60	4.60	22	26
34,000	40,000	5.25	4.35	23	28
36,000	42,400	5.00	4.10	24	29

[8]Assuming high germination and that 85 percent of seeds produce plants.

Wheat Seeds and Seeding Rates per Acre

Wheat producers are aware there are big differences in seed size or the number of seeds per pound among varieties. Planting a large-seed variety at 60 pounds per acre may be equivalent to 50 pounds per acre for a smaller-seed variety. **Table 8** shows the number of wheat seeds per acre at different seeding rates (pounds per acre), as well as thousand kernel weights and number of seeds per pound. For example, if one variety has 20,600 seeds per pound and another has 11,300 seeds per pound and both are planted at 30 pounds per acre, one can see there is a big difference in the number of seeds per acre (618,000–339,000=279,000).

Table 8. Number of wheat seeds per acre based on thousand kernel weight or seeds per pound and seeding rates per acre.

TKW (thousand kernel weight)[9]	Seeds per pound (× 1,000)	Seeding rate (lbs / a) 30	40	50	60
		seeds per acre (× 1,000)			
22	20.6	618	824	1,030	1,236
24	18.9	567	756	945	1,134
26	17.4	522	696	870	1,044
28	16.2	486	648	810	972
30	15.2	453	604	755	906
32	14.1	423	564	705	846
34	13.3	399	532	665	798
36	12.6	378	504	630	756
38	11.9	357	476	595	714
40	11.3	339	452	565	678

[9]Grams per 1,000 seeds.

Wheat Seeds per Foot of Row

In **Table 9**, the desired seeds or plants per foot of row can be determined if the producer knows the number of seeds per pound, drill row width and the seeding rate. For example, if a producer wants to plant 30 pounds per acre in 7-inch row widths and the seedlot contains 12,000 seeds per pound, the producer finds 4.8 seeds per foot of row.

Table 9. Number of wheat seeds per foot of row at different seeding rates and row widths of 7, 10, and 12 inches.

	Seeding rate (lbs / a)											
	30			40			50			60		
	row width			row width			row width			row width		
Seeds / lb	7"	10"	12"	7"	10"	12"	7"	10"	12"	7"	10"	12"
	seeds per foot of row											
12,000	4.8	6.9	8.3	6.4	9.2	11.0	8.0	11.5	13.8	9.6	13.8	16.5
14,000	5.6	8.0	9.6	7.5	10.7	12.9	9.4	13.4	16.1	11.2	16.1	19.3
16,000	6.4	9.2	11.0	8.6	12.2	14.7	10.7	15.3	18.4	12.8	18.4	22.0
18,000	7.2	10.3	12.4	9.6	13.8	16.5	12.0	17.2	20.7	14.5	20.7	24.8
20,000	8.0	11.5	13.8	10.7	15.3	18.4	13.4	19.1	30.0	16.1	22.9	27.5
22,000	8.8	12.6	15.2	11.8	16.8	20.2	14.7	21.0	25.3	17.7	25.2	30.3

Plants or Seeds per Acre and Seeds per Foot of Row

In **Table 10**, if a producer counts the number of seeds per foot of row in a given drill row width, the seeding population can be determined. For example, if a producer finds 6 seeds per foot of row in a 7-inch row width, the seeding population is 448,045 seeds per acre.

Two formulas can help producers determine plant populations for any crop. The first formula shows the number of seeds per foot row needed for a desired seeding rate or plant population.

Table 10. Seeds or plants per acre at various drill row widths and seeds per foot of row.

Seeds per foot of row	Row width 7"	8"	10"	12"
	seeds or plants per acre			
2	149,348	130,680	104,544	87,120
4	298,697	261,360	209,088	174,240
6	448,045	392,040	313,632	261,360
8	597,394	522,720	418,176	348,480
10	746,742	653,400	522,720	435,600
12	896,091	784,080	627,264	522,720
14	1,045,440	914,760	731,808	609,840
16	1,194,788	1,045,440	836,352	696,960
18	1,344,137	1,176,120	940,896	784,080
20	1,493,485	1,306,800	1,045,440	871,200
22	1,642,834	1,437,480	1,149,984	958,320
24	1,792,182	1,568,160	1,254,528	1,045,440

Formula 1:

$$\frac{\text{desired seeding rate or population}}{\text{43,560 square feet per acre}} \times \frac{\text{row spacing}}{\text{12 inches}} = \text{seeds or plants per foot of row}$$

Example 1:

$$\frac{70{,}000}{43{,}560} \times \frac{\text{30 inches}}{\text{12 inches}} = \text{4 seeds or plants per foot of row}$$

The second formula will show the final seeding rate or plant population when the producer uses a given number of seeds per foot of row.

Formula 2:

$$\left(\text{43,560 square feet per acre} \div \frac{\text{row spacing}}{\text{12 inches}}\right) \times \text{seeds or plants per foot of row} = \text{seeding rate or plant population}$$

Example 2:

$$\left(43{,}560 \div \frac{\text{30 inches}}{\text{12 inches}}\right) \times \text{9 seeds or plants per foot of row} = \text{156,816 seeds per acre}$$

Test Weights and Seeds per Pounds

Producers often want to know the official test weight and the approximate number of seeds per pound for various Kansas crops. This information is provided in **Table 11**. Producers must keep in mind that test weights are subject to change. The latest information is available from official sources. Also, the number of seeds per pound of a specific crop may range dramatically due to differences in variety and growing conditions.

Table 11. Official test weights and approximate seeds per pound of various crops.

Crops	Standard lbs / bu	Approximate seeds / lb
Wheat	60	11,000–20,000
Triticale	50	15,000–20,000
Barley	48	13,000
Oats	32	14,000
Corn	56	1,200
Sorghum	56	15,100
Soybeans	60	2,000–3,500
Sudangrass	40	55,000
Alfalfa	60	220,000
Sweet clover	60	250,000
Red clover	60	260,000
Lespedeza[10] (Korean)	45	240,000
Millet–pearl	60	85,000
proso	56	80,000
foxtail	50	220,000
Sunflower	28	3,000–9,000

[10]Kobe 30 lb / bu
Korean 45 lb / bu

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