

# DUAL-PURPOSE WHEAT

# MANAGEMENT FOR FORAGE AND GRAIN PRODUCTION

## DUAL-PURPOSE WHEAT AS A FORAGE SYSTEM

The unique climate characteristics of the southern Great Plains allow producers to use wheat as a forage and grain crop (dual-purpose), potentially increasing overall profitability compared to grain-only or forage-only systems. Dual-purpose wheat is currently working well on about 8 million acres in southern Kansas, Oklahoma, and Texas.

The fall and winter temperatures in this region generally allow for significant wheat growth before winter and for relatively few snow-covered days that limit grazing. As a result, winter wheat in this region has the potential to be grazed for 120 to 150 days.

Wheat pasture is a valuable source of high-quality forage when most other forage sources are low in quantity and quality (late fall, winter, and early spring). To minimize grazing effects on grain yield, certain adjustments in management practices must be considered.

## CULTURAL PRACTICES

Compared to grain-only management practices, when implementing a dual-purpose wheat system, adjustments are required in planting date, seeding rate, variety selection, and soil fertility. These adjustments help maximize fall forage production while minimizing grain yield losses.

### SEEDING RATE

Seeding rates should be increased to maximize forage yield in dual-purpose wheat systems. Research in north-central Oklahoma has indicated the increase in forage yields associated with increasing seeding rate from 90 to 120 pounds per acre compensated for the increased seed costs (Figure 1a). A seeding rate of 120 pounds per acre is recommended for dual-purpose wheat in irrigated fields and in dryland areas of central and eastern Kansas and Oklahoma. In dryland areas of western Kansas and in the Oklahoma Panhandle, seeding rates should be 90 pounds per acre for grazed acreage as compared to 45 to 60 pounds per acre for grain only.

### PLANTING DATE

Earlier planting dates increase wheat fall forage yield potential. Research in north-central Oklahoma has shown that planting 2 weeks earlier, in early September rather than late September, can increase fall forage dry-matter production as much as 1,000 pounds per acre when wheat was sown at 120 pounds per acre (Figure 1a).

Earlier planting dates may result in suboptimal conditions for grain yield (Figure 1b). Therefore, producers should consider the tradeoff between maximizing forage yield while minimizing grain yield losses when selecting the best planting date. Generally, a good compromise for producing both good forage and grain yields would be to plant 2 to 4 weeks earlier than the optimal planting date for grain yield. This increases the chances of maximizing wheat enterprise profitability in a dual-purpose system.

It is best not to plant any earlier than that unless the wheat is to be produced only for grazing, or “grazeout.” For grain yields, the risks from early planting include an increased potential for wheat curl mite, aphid, and Hessian fly infestations, leading to an increased risk of fall infections by wheat streak mosaic virus (WSMV) and barley yellow dwarf virus (BYDV). These pathogens can not only lead to a significant decrease in grain yield, but also reduce forage production.

Another disadvantage of early planting is that dry and hot soil conditions frequently prevail in late August and early September and may require “dusting-in” the seed. If moisture is not available in the top inch of the profile, it is best to plant wheat shallower (3/4 of an inch) rather than trying to reach deeper soil moisture. Planting into hot soils decreases the length of the seedling’s coleoptile (leaflike structure that emerges from the seed and elongates until it reaches sunlight). The first true leaf then emerges from the tip of the coleoptile. If the coleoptile is shortened by high soil temperatures, the true leaf might emerge below ground and never reach the surface. Coupled with deeper planting, this can lead to variable germination and emergence, causing suboptimal stands and delaying initiation of grazing.

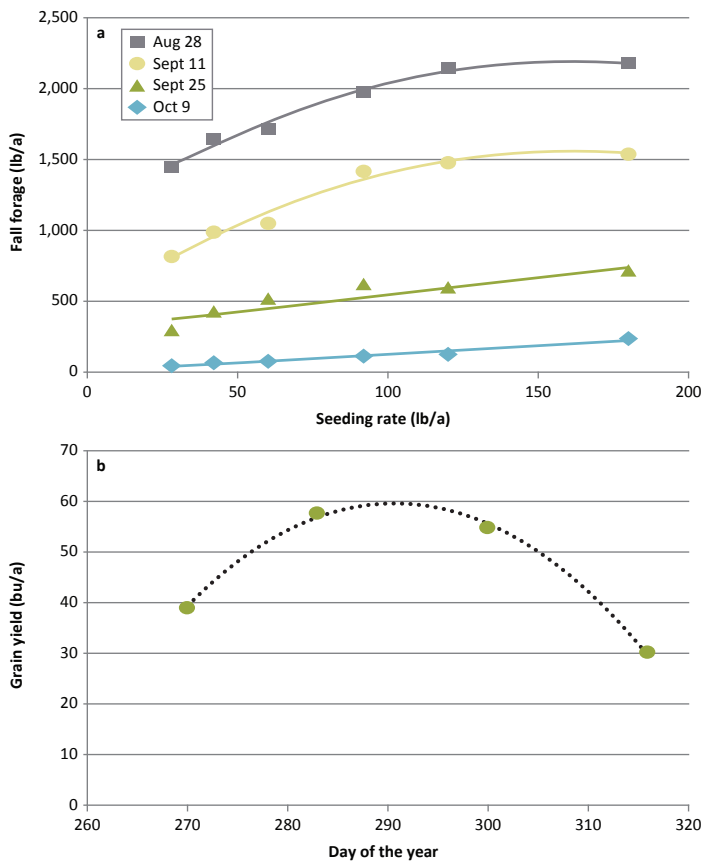


Figure 1. Effect of planting date and seeding rate on wheat fall forage yield in Lahoma, north-central Oklahoma (a) and effect of planting date on wheat grain yield near Hutchinson, south-central Kansas (b).

## WHEAT VARIETY SELECTION

While forage yield potential should be considered when selecting a wheat variety for the dual-purpose system, it should not be the only factor. Plant characteristics that make certain varieties more adapted than others to the dual-purpose system include:

- Forage yield potential.** Most wheat varieties currently grown in the southern Great Plains have relatively good forage production. Research in Kansas and Oklahoma has demonstrated that there are greater year-to-year differences in forage production due to environmental conditions than varietal differences. Additionally, both hard red and hard white wheat varieties can be used in dual-purpose production with no significant difference in forage yield.
- Grain yield potential after grazing.** Wheat varieties differ in their ability to recover and produce grain after removing livestock. Varieties that rely heavily on fall tiller production for grain yield can show a large yield penalty associated with the dual-purpose system. Meanwhile, other varieties are able to maintain yield levels relative to the grain-only system. These varieties should be used in a dual-purpose system (Figure 2).

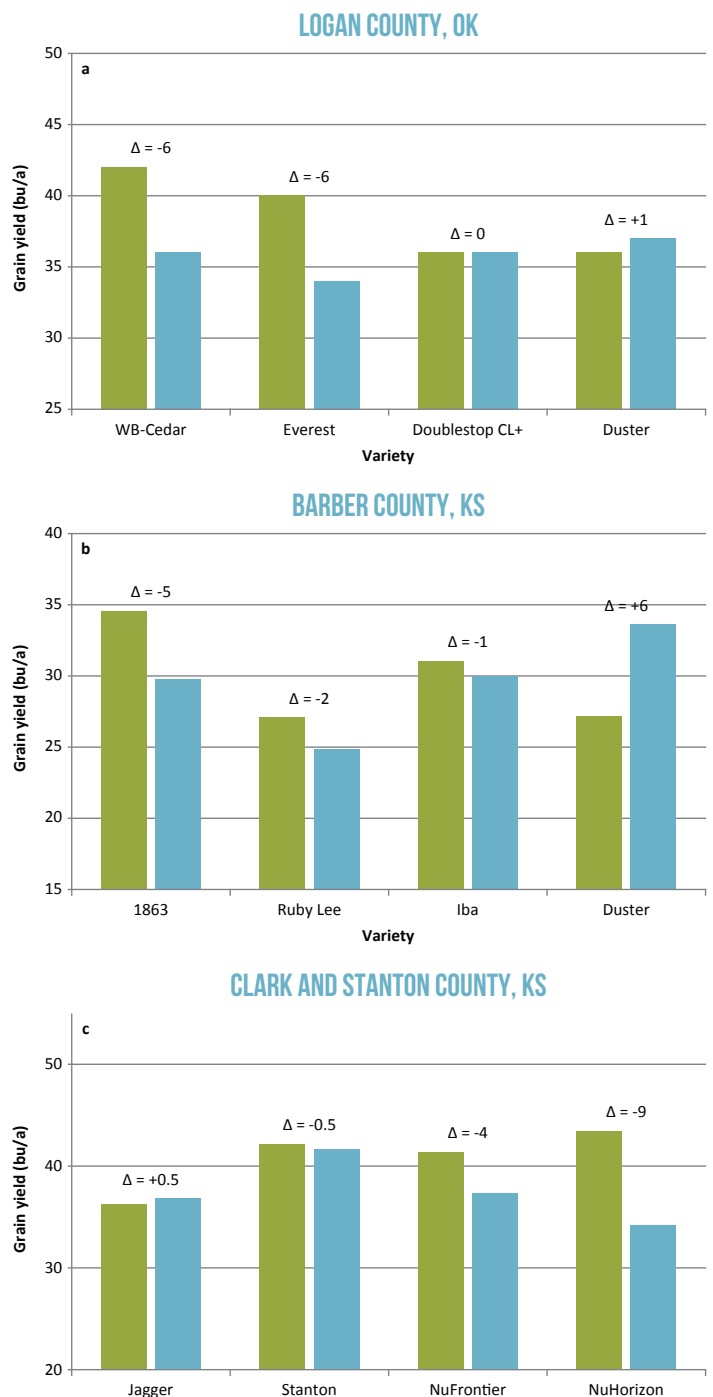


Figure 2. Grain yield as affected by wheat variety and grazing system. The impact of grazing on wheat yield ( $\Delta$ ) is shown. Varieties differ in their ability to produce grain following grazing. A high-yielding variety in a grain-only system may yield less than a variety with good ability to recover from grazing in a dual-purpose system. Data represents 3-year average of each variety under each system in (a) Logan County, north-central Oklahoma; and (b) Barber County, south-central Kansas; and (c) 2-year two-location average Clark and Stanton counties, southwest Kansas. Data indicates that there is generally an effect of grazing on wheat yields, and that some varieties are able to hold their yields better when grazed as compared to other varieties. Still, this recovery potential largely depends on growing season conditions.

- **Resistance to pests and pest-transmitted diseases.** In much of Kansas and Oklahoma, it is important that varieties adopted in a dual-purpose system are resistant to soil-borne mosaic virus and Hessian fly. Additionally, resistance to aphids (or barley yellow dwarf virus) and to wheat curl mite (or wheat streak mosaic virus) might be useful, but it may restrict the variety options a producer has.
- **High-temperature germination sensitivity.** Wheat varieties differ in their ability to germinate in hot soils. Optimum temperature for wheat germination is between 54 and 77 degrees Fahrenheit, but many times wheat is planted into 90 to 100 degrees Fahrenheit soils when planting early for grazing. Varieties that show high-temperature germination sensitivity will not germinate when sown at those temperatures, which can result in suboptimal emergence and stand establishment. Wheat varieties with high-temperature germination sensitivity should be avoided in dual-purpose production.
- **Coleoptile length.** Planting in hot soils decreases the coleoptile length of the wheat plants, which can result in scattered emergence in short-coleoptile varieties. Thus, in a dual-purpose system, producers should consider selecting varieties that have a relatively long coleoptile.
- **First hollow stem date.** First hollow stem is the critical period to remove cattle from wheat to protect grain yield. It occurs after the wheat is released from dormancy in the spring, and there is about 5/8 inch (1.5 centimeters) of hollow stem (roughly the diameter of a dime) below the developing head (Figure 3). Varieties can differ by up to 3 weeks in

first hollow stem date. Choosing a variety with late first hollow stem can increase the time available for grazing during the spring. For more information on measuring first hollow stem, see *First Hollow Stem: A Critical Wheat Growth Stage for Dual-Purpose Producers*, Oklahoma State University Extension Publication PSS-2147.

- **Low soil pH tolerance.** In much of eastern and central Kansas, as well as most of the Oklahoma wheat-growing region, varieties should be tolerant to aluminum toxicity caused by acid soils. Sensitivity to low soil pH is variety specific, but soil pH below 6.0 can severely decrease forage yield in most varieties (5.5 in pH tolerant varieties).

## SOIL FERTILITY

Adequate amounts of all essential plant nutrients are necessary for maximum forage production. In addition, the soil pH should be maintained above 5.5 to 6.0 for maximum forage yield, depending on variety susceptibility to acid soils, and above 5.5 to maximize grain yield. Wheat used for dual-purpose will remove more soil nutrients than wheat grown as a grain-only crop. Nitrogen and phosphorus are usually the most limiting nutrients associated with wheat forage production. Soil sampling before planting and testing for pH and available nitrogen, phosphorus, potassium, and sulfur is helpful in evaluating the amount of supplemental nutrients needed.

- **Soil pH.** Low soil pH increases aluminum solubility. This reduces root growth and consequently its capacity to explore the soil for nutrients and water. As a result, forage yield is severely impaired for most varieties at soil pH below 6.0 (Figure 4). A few

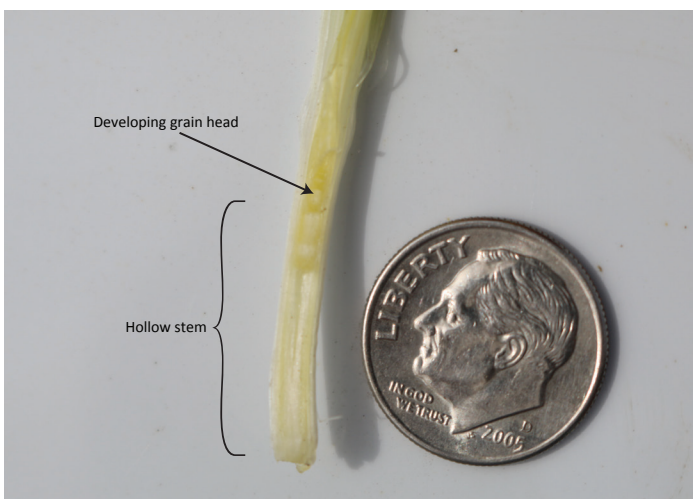


Figure 3. First hollow stem occurs when there is approximately 5/8 of an inch (1.5 centimeters) of hollow stem below the developing wheat head. This length is roughly equivalent to the diameter of a dime. Grazing wheat past first hollow stem can lead to yield reductions of 5 percent per day or more. Photo by Romulo Lollato, Kansas State University Wheat and Forages Specialist.

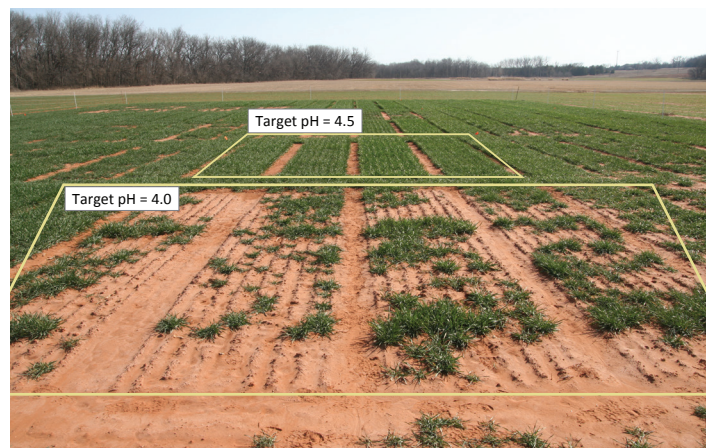


Figure 4. Wheat fall forage yield as affected by soil pH and wheat variety. Every two rows in the photo is planted to a different wheat variety. Every 30-ft length is a different target soil pH, ranging from 4.0 to 7.0 in 0.5 unit increments. Varieties differ in their tolerance to low soil pH, but the forage-production ability of most varieties is severely impaired at pH < 5.5 to 6.0. Experiment performed near Stillwater, north-central Oklahoma. Photo by Romulo Lollato, Kansas State University Extension Wheat and Forages Specialist.

varieties with improved tolerance to low soil pH might result in good forage yield in a pH of 5.5, but lower pH levels decrease forage yield regardless of variety selection. Liming based on soil test results is the recommended practice to overcome low soil pH. When liming is not feasible due to high product costs, banding phosphorus fertilizer with the seed can increase forage yield in moderately acid soils. Previous research in the southern Great Plains showed that banding pelletized lime with the seed is not recommended to remediate low soil pH.

- Nitrogen (N).** Wheat grown for dual-purpose requires more nitrogen than grain-only production. A growing animal will use most of the nitrogen available in the forage for growth, whereas a mature cow returns a high percentage of nitrogen consumed in forage to the soil as bypass urea through urination. Wheat forage containing 25 percent crude protein will have 40 pounds of nitrogen in each ton of dry matter. A general recommendation is to increase nitrogen rates greater than what is required for grain production by 30 to 40 pounds of nitrogen per acre for every 1,000 pounds per acre of dry forage yield or for every 100 pounds per acre of beef harvested (animal weight gain). A single nitrogen application, at or before, planting is an accepted practice. However, a split application between fall and spring allows more efficient nitrogen use, particularly in sandy soils susceptible to leaching and heavy soils subject to denitrification from standing water.

- Phosphorus (P).** Wheat responds well to phosphorus applications on soils testing low in available phosphorus. Tillering and resulting forage yield are also increased by banded phosphorus, even when soil test phosphorus is adequate (Figure 5). Livestock return most of the phosphorus they consume to the system, but forage production is reduced without adequate soil phosphorus levels. Phosphorus deficiency reduces tillering and makes plants more susceptible to winterkill. Banded phosphorus applications at 50 to 60 pounds per acre of diammonium phosphate (DAP), or the equivalent in phosphorus from other fertilizer sources, at planting is more efficient than broadcasting, especially on acid soils low in available phosphorus.
- Potassium (K).** Potassium deficiency can limit forage production, and low potassium levels are common in sandy soils. A soil test is the best guide for sound potassium recommendations. Potassium may be applied either as a starter or broadcast and incorporated ahead of planting. To avoid possible germination problems, no more than 20 pounds per acre of potassium should be in direct contact with the seed.
- Sulfur (S).** Soils low in organic matter may benefit from sulfur application. Sulfur deficiency symptoms resemble those of nitrogen deficiency, with yellowing leaves and slow growth. However, sulfur deficiency occurs in the upper (newer) leaves, while nitrogen deficiency is first observed in the lower (older) leaves. Similar to potassium, soil testing is the recommended practice for appropriate sulfur recommendations.

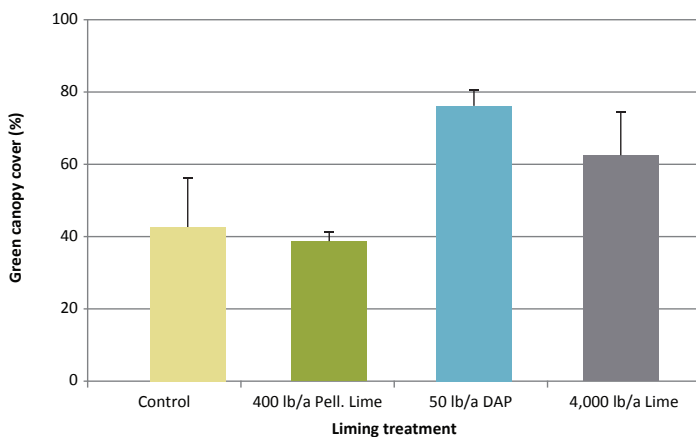


Figure 5. Green canopy cover in late fall, before winter dormancy, as affected by liming treatment in an acid soil (pH < 4.7) near Waukomis, in north-central Oklahoma. “Pell. Lime” represents in-furrow pelletized lime; “DAP” is diammonium phosphate; and “Lime” refers to broadcasted and incorporated agricultural lime.

## GRAZING MANAGEMENT

Grazing initiation, intensity, and termination are crucial factors in determining wheat’s recovery potential and ability to produce grain following grazing. Depending on climatic conditions, a wheat pasture may be grazed in the fall, spring, or both. In Kansas and Oklahoma, most grazing occurs during late fall into early winter and again in early spring, with animals removed early enough to allow good grain production. In years with low wheat prices and high beef prices, producers have the option to completely grazeout the wheat, forgoing a grain harvest.

## GRAZING INITIATION

Grazing should not begin until plants have adequate crown root (secondary root) development to prevent being uprooted by grazing animals. Although an accumulation of one ton of dry matter per acre (6 to 12 inches tall) before grazing initiation results in excellent season-long pasture production, aboveground growth does not

always correlate with root growth. It is important to sample whole wheat plants to assess root development before grazing initiation. The primary root system alone will not provide enough anchorage to prevent plants from being uprooted by cattle. Therefore, a well-developed crown root system with secondary roots is needed before grazing initiation.

## GRAZING INTENSITY AND LIVESTOCK MANAGEMENT

Both growing calves and mature animals can effectively graze wheat pasture. However, stockers and fall-calving cows can use the forage more effectively and profitably because they can more fully take advantage of the high nutritional value of wheat forage. Both continuous and rotational grazing systems are acceptable for stocker cattle. Average daily gain of stockers on a good wheat pasture is similar with either system, ranging between 1.5 and 3.0 pounds. Weight gain depends on the condition and type of cattle grazing, and the amount of forage available. The primary advantage of rotational grazing is better use of available forage by reducing spot grazing and extending the grazing season in a grazeout situation.

Optimum year-to-year stocking rates vary considerably, depending on climatic and management factors that influence wheat forage yield. Earlier planting, irrigation or high rainfall, and more heat units during the fall and winter of Texas, Oklahoma, and southern two tiers of Kansas counties contribute toward higher forage yield. Managers need to evaluate wheat forage yield potential and make stocking rate decisions based on annual growing conditions. Recommended fall and winter stocking rates will range from 250 to 600 pounds of animal per acre (1 to 2 acres per stocker, depending on weight). Spring stocking rates are usually 1.5 to 2 times greater than for fall (0.75 to 1.3 acres per stocker, depending on weight). Providing stockers with dry feed in addition to the wheat pasture allows increased stocking rates, better use of the high nutritional value (high crude protein, low acid detergent fiber and neutral detergent fiber) of wheat forage, and may improve general animal health.

Overgrazing the wheat crop can result in winter-kill and lower grain production. To avoid overgrazing, a minimum of approximately 50 percent green canopy cover should be maintained during the fall and about 60 percent green canopy cover during late winter at grazing termination. The amount of green cover, or leaf area, at grazing termination is crucial in determining wheat recovery from grazing as the leaves produce photosynthates needed for biomass production and grain yield. To avoid damage from trampling, provide an area (preferably grass) near the wheat pasture for water, salt and mineral, supplemental feeding, and animal loafing. If cattle are traveling to water,

have several access points out of the field to adjacent water points to limit animal trails. If this is not feasible, provide water and supplements at different field corners or borders to improve grazing distribution. During periods of extreme cold—about 15 degrees Fahrenheit or less—remove animals to prevent plant injury.

## GRAZING TERMINATION

First hollow stem (Figure 3) is the optimal time to remove cattle from wheat pastures to protect grain yield potential. Terminating grazing at first hollow stem protects grain yield by avoiding removal of the growing point by grazing animals. The developing head is still below ground at the first hollow stem stage, but the developing head begins to move above ground after that stage.

Removing cattle at the first hollow stem stage also allows the wheat plant enough time to recover leaf area before jointing. Previous research in Oklahoma has shown that grazing for a week past first hollow stem can lead to yield losses ranging from 8 to 10 percent, and grazing 2 weeks past first hollow stem results in an average yield loss of 30 percent.

The level of yield loss depends on weather conditions. Grazing past first hollow stem under hot and dry conditions often leads to grain yield losses as much as 5 percent per day, while cool and wet conditions can minimize yield losses to 1 percent per day (Figure 6). In the past, producers would remove cattle from wheat pasture either at a fixed date, such as March 15, or at jointing. Both approaches have been shown to be too late, resulting in grain yield reductions from grazing past first hollow stem. Producers also need to be aware of insurance guidelines for their area regarding grazing termination dates,

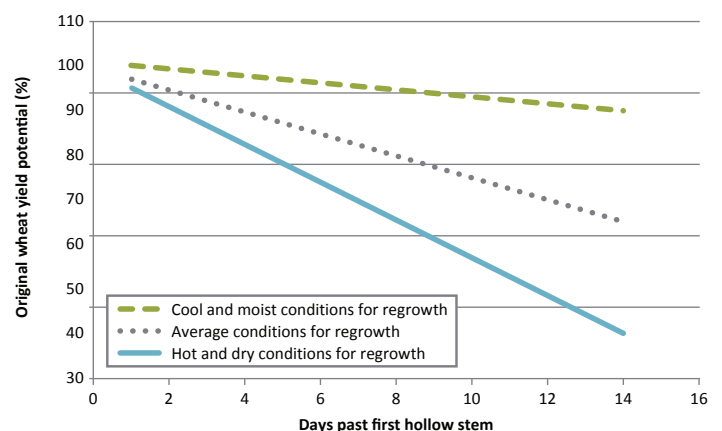


Figure 6. Percent of original wheat yield potential as affected by days of grazing past first hollow stem and weather conditions following grazing termination. Average yield losses by grazing for 14 days past first hollow stem ranged from 10 percent under favorable conditions to 60 percent under unfavorable conditions. Research conducted by Oklahoma State University in north-central Oklahoma.

which may or may not coincide with wheat growth stage requiring removal. Producers should check for first hollow stem in each individual wheat field by splitting several main stems collected from a nongrazed area of that field. The date of first hollow stem is variety specific and also depends on soil temperature; therefore, it is important to scout each individual field for first hollow stem.

## NUTRITIONAL VALUE OF WHEAT PASTURE

Wheat forage produced during the fall, winter, and early spring is high in forage nutritive value [high in crude protein and low in acid detergent fiber (cellulose and lignin) and neutral detergent fiber (cell wall components)] and is an excellent feed source for cattle or sheep. Properly managed wheat can be an effective protein supplement for livestock simultaneously grazing or eating lower quality feedstuffs; this would require limit feeding wheat pasture and may require restricting access to grazing for only a portion of the day. Crude protein content is particularly high, usually between 20 and 30 percent, and sometimes greater than 30 percent. The crude protein component is highly soluble and available to animals. Acid detergent fiber is generally less than 25 percent. Neutral detergent fiber is often below 45 percent, and total digestible nutrients are greater than 80 percent.

## CONSEQUENCES OF GRAZING TO THE WHEAT CROP

### SOIL WATER USE AND LODGING POTENTIAL

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 followed by a dry spring. In growing seasons characterized by the opposite weather, with surplus precipitation and greater potential for lodging, grazing can be beneficial as it has been shown to reduce lodging.

### NUMBER OF TILLERS

The number of tillers per acre is reduced in direct proportion to grazing intensity. Wheat tends to produce more tillers and leaves than are necessary for maximum grain yield, so a reduction in tiller number may have no effect on grain yields. However, reducing tiller numbers reduces yields in favorable years when weather conditions can sustain the increased growth. On the other hand, reduced tiller number can be beneficial if moisture stress follows late spring.

## WHEAT MATURITY

Grazing generally delays wheat maturity 1 to 4 days compared to a nongrazed crop, and severe grazing can result in longer delays. Delayed maturity may expose the crop to increased stress from high temperatures and disease pathogens during grain filling, but delayed maturity can be beneficial in avoiding early spring freeze injury in years when these occur.

## SOIL COMPACTION AND WATER HOLDING CAPACITY

A recent study conducted in Oklahoma measured soil compaction and soil moisture under grazed and nongrazed no-till wheat. In general, grazing did not cause changes in soil density. However, soils under grazing were drier than soils under nongrazing, which led to increased root penetration resistance for the grazed wheat. Measurable changes in the soil's physical properties are usually limited to the top 2 inches of the soil profile, which can be loosened by freezing-thawing and wetting-drying cycles. No-till soils are less compactable than tilled soils. Soil texture also affects the compaction risk; sandy loam is the most compactable soil texture. Other variables such as crop rotation, tillage system, and soil moisture conditions also affect soil compaction.

## IS THERE A GRAIN YIELD PENALTY ASSOCIATED WITH THE DUAL-PURPOSE SYSTEM?

The effect of grazing on wheat grain yield is quite variable from one year to the next. Previous research has shown the effect of grazing on subsequent wheat grain yield depends on wheat management (e.g. soil fertility, planting date and rate, and variety selection), livestock management (timing of grazing initiation and termination, and grazing intensity), and weather conditions following grazing termination.

### GRAIN YIELD UNAFFECTED BY THE DUAL-PURPOSE SYSTEM

The dual-purpose system is likely to have little effect on wheat grain yield when soil fertility is adequate, grazing is initiated after a good root system is developed, grazing intensity allows for more than 60 percent green canopy cover at grazing termination, cattle are removed before first hollow stem, and wheat grazing termination is followed by cool and moist weather that allows for leaf area recovery before jointing.

### GRAIN YIELD REDUCED BY THE DUAL-PURPOSE SYSTEM

Research in north-central Oklahoma evaluating several commercial varieties for more than 20 years has

demonstrated that the dual-purpose system (planted in September, higher seeding rate, grazed) generally decreases wheat yield about 14 percent compared to the grain-only system (planted in October, normal seeding rate, nongrazed). This yield decrease is due to a combination of an earlier-than-optimal planting date as well as the direct and indirect effects of grazing (biomass

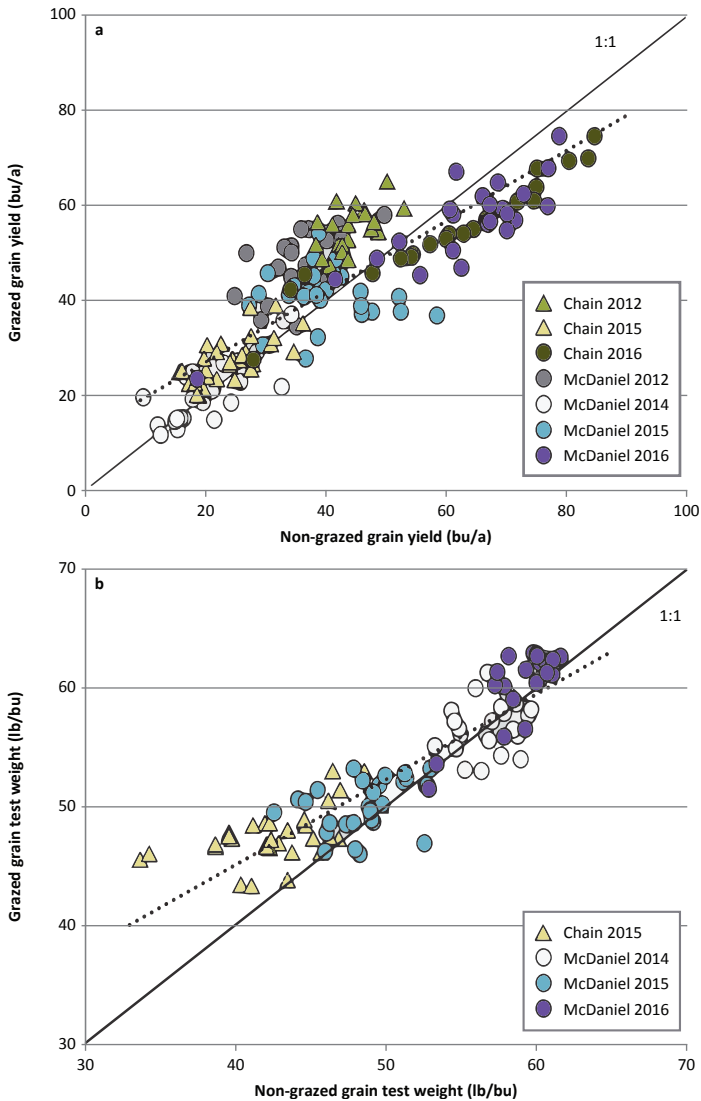


Figure 7. Comparison of grazed versus nongrazed early-sown wheat (a) grain yield and (b) grain test weight performance in seven site-years in south-central Kansas. Points above the solid line (1:1) are cases in which the measured value was higher for grazed plots as compared to nongrazed. Dotted line is the regression between grazed and nongrazed. In (a), wheat grain yield was higher where the wheat was grazed than in the early-planted ungrazed wheat in low-yielding environments, mainly because grazing reduced the amount of excessive top-growth, decreasing crop water needs and possibly disease pressure due to a thinner canopy. In high-yielding environments, grain yield was lower in the grazed wheat than in the ungrazed wheat. In (b), grain test weight was increased by grazing, especially in low test weight growing seasons, most likely due to a decrease in grain number and increased source-sink ratio in the grazed plots.

removal, trampling of plants, reduced root growth due to drier soils, possible soil compaction, etc.). Generally, the dual-purpose system is more likely to have grain yields lower than grain-only systems when nutrients are limited, lodging is not a factor for nongrazed wheat, grazing pressure is high, wet soil conditions cause compaction and trampling of the wheat plants, grazing termination occurs later than first hollow stem, or wheat recovery after grazing is hampered by hot and dry conditions. Additionally, grazed wheat may have lower grain yields than ungrazed wheat in high-yielding growing seasons when the weather allows for the realization of high yield potential (Figure 7a).

### GRAIN YIELD INCREASED BY GRAZING

Grain yields in dual-purpose systems can be higher than in grain-only systems, especially in low-yielding growing seasons. Examples include when a spring freeze occurs and damages the more advanced grain-only wheat fields or when spring moisture is limited. Additionally, when the dual-purpose system is compared to nongrazed wheat planted at the same early date, research conducted in Oklahoma and Kansas indicates the relative yield advantage of the grain-only system decreases. This is due to the suboptimal planting date for the grain-only system, and in many cases, this results in a yield advantage to the grazed system (Figure 7a). A yield advantage in grazed systems is generally due to removal of excess top growth induced by an earlier-than-optimum planting date. This decreases the water needs of the crop and may also decrease incidence and severity of foliar diseases due to the reduced canopy growth.

### TEST WEIGHT

Studies performed in north-central Oklahoma and south-central Kansas have shown wheat grain test weight is generally increased by grazing, especially in growing seasons characterized by low overall test weight (Figure 7b). The dual-purpose system often has a reduced number of grains per area due to removal of at least of few developing heads by grazing. As a result, similar amounts of carbohydrates produced by green leaf tissue are distributed to fewer grains. This increases average wheat grain test weight due to an increased source-sink ratio.

## ADDITIONAL INFORMATION

Animal-related grazing problems. Please see *Forage Crops Grazing Management: Toxic Plants*, K-State Research and Extension publication MF3244.

Economics of winter wheat grazing. Please see *Winter Wheat Grazing* K-State Research and Extension publication MF1009.

Effects of selling weight on selling price. Please see *Factors Affecting Auction Prices of Feeder Cattle*, K-State Research and Extension publication C697.

High temperature germination sensitivity and coleoptile length. Please see *Factors Affecting Wheat Germination and Stand Establishment in Hot Soils*, Oklahoma State University Extension Publication PSS-2256.

First hollow stem. Please see *First Hollow Stem: A Critical Wheat Growth Stage For Dual-Purpose Producers*, Oklahoma State University Extension Publication PSS-2147.

New technology and use of phone app to manage grazing. Please see *Improving In-Season Grazing Management of Dual-purpose Winter Wheat Using the Canopeo Smartphone Application*, K-State Research and Extension publication MF3304 and Oklahoma State University Extension Bulletin PSS-2170.

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