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Chapter

# Small Grains as Winter Pasture in the Southern Great Plains of the United States

*Tadele T. Kumssa, Joshua D. Anderson, Twain J. Butler and Xue-Feng Ma*

## Abstract

Small-grain cereals are widely adapted and used as annual cool-season pastures in the Southern Great Plains (SGP) of the United States, where livestock and forage production are the largest contributors to agricultural income. The advantage of growing small grains in the region is evident due to the widespread adoption and flexibility of production for grain only, forage only, or both grain and forage (i.e., dual purpose). Farmers in the SGP often prefer the use of small grains for dual purpose mainly because of alternative income options from livestock and/or grain, ensuring stable income especially when product prices fluctuate with market demands. Small-grain forage is exceptionally important during autumn, winter, and early spring when forage availability from other sources is low. By providing nutritionally high-quality forage, small grains minimize the need for protein and energy supplements. Besides being used for winter pasture, small grains also serve as cool-season cover crops. While small grains offer different advantages in the integrated crop-livestock system in the region, farming management practices can play an important role to maximize the benefit. The objectives of this chapter are to summarize the significance of small grains as winter pasture and highlight the production status of each small-grain species in the SGP of the United States.

**Keywords:** forage, oat, rye, small grains, Southern Great Plains, triticale, United States, wheat

## 1. Introduction

Small grains, such as wheat (*Triticum aestivum* L.), rye (*Secale cereale* L.), triticale (*X Triticosecale* Wittmack), and oat (*Avena sativa* L.), are an integral part of the forage-livestock system in the Southern Great Plains (SGP) of the United States, as they can be grazed during cool-season months when other forage species are not productive. On average in the last 3 years (2016–2018), 7 million hectares of land was planted annually by wheat alone for forage and grain production in the SGP, including Kansas, Oklahoma, and Texas [1], which is the largest area of low-rainfall winter wheat cropland worldwide. The SGP (32–40°N; 96–104°W) is generally classified as grassland, cropland, and forest land [2]. Although many crop species grow in the area, winter wheat covers the largest amount of cropland in the region. Small grains are well adapted to the SGP's environment, for both forage and grain (i.e., dual

purpose) production. The warm autumn and mild winter with little snow coverage enable the small grains to grow fast and serve as ideal cool-season grazing pasture.

As a dual-purpose crop, small-grain cereals have other unnoticed advantages, such as weed and disease suppression by grazing animals. However, grazing small grains at the vegetative stage can reduce grain yield later in the summer depending on management practices and growing conditions, especially moisture. Farmers in the SGP often prefer the use of small grains for dual purpose mainly because of alternative income options from livestock and/or grain, ensuring relatively stable income especially when product prices fluctuate with market demands. As one of the crop-livestock integration methods, dual-purpose cereal crops can advance sustainable development through increased environmental balance, livelihood diversification, and flexibility to economic stresses, thus reducing risks [3].

Another aspect of crop-livestock integration is the use of cereal as both a cover crop and forage where plants seasonally cover the soil while serving as forage. Cover crops protect the soil primarily from wind and water erosion, improve soil quality, and increase nutrient cycling [4–6]. While small grains offer different advantages in the integrated crop-livestock system in the SGP, farming management practices, such as planting date and grazing intensity and duration, which depend on the weather and growth stage of the crop, can maximize the benefits [7, 8]. However, understanding overall management practices and fitting crops to climatic conditions is necessary for reliable accomplishment [9]. In this chapter, we present the significance of small grains as winter pasture in the SGP.

## 2. Agroecology and farming systems in the Southern Great Plains

The SGP of the United States extends from east of the Rocky Mountains in Colorado and New Mexico to Oklahoma and Kansas. The region also includes the Texas Panhandle and adjoining areas of West Texas and eastern New Mexico [10, 11]. The majority of the region is represented by Kansas, Oklahoma, and Texas. Agriculture is the most important land use in the region, where farming is more common in the east, while ranching dominates in the western part. The region mainly consists of mixed-grass and shortgrass terrestrial ecosystems. The main agricultural activity in the shortgrass prairie is animal grazing, while wheat cultivation dominates in the mixed-grass prairie [12]. Overtime, much of the native ecosystems have been converted to either farmland or pasture grazed by domestic livestock [13]. In 2012, the value of agricultural activities in the region surpassed $59 billion, of which livestock contributed more than half of the total [2]. Farming is generally water-limited in the region, as drought occasionally occurs and impacts the whole agricultural system [14, 15].

The climate of the SGP is typically characterized with low precipitation, high evaporation rate, windy hot summers, and a wide range of daily and seasonal temperatures [10, 11]. The weather is highly variable, spanning from extreme cold to extreme heat and from very limited or no rain to extreme rainfall or flooding conditions, which often affect the overall socioeconomic system in the region [16]. These extreme weather conditions sometimes enable proliferation of invasive weeds and pests, leading to ecosystem imbalance.

Although temperature and precipitation are highly variable, making it difficult to define a crop that performs well region-wide [17], the mild winter favors cool-season crops for grazing animals [18]. The region is known for its mixed farming practices, producing both livestock and grain. The most common crop-livestock integration methods in the United States are sod-based crop rotations, livestock grazing of crops within cash crop rotations, grazing of crop residues, sod intercropping,

dual-purpose cereal crops, and silvopasture [19]. Wherever it is practiced, crop-livestock integration in the United States can be implemented either within the farm, in which crops and livestock produced at the same time and space, or among the farms, in which farmers work together in agreements to attain the intended synergies between production systems [20]. Dual-purpose cereal production has been the preferred system in the SGP because it gives relatively stable income [21]. In dual-purpose settings, small grains are grazed without removing terminal meristems so that plants regenerate and grow for grain production. Based on grain and cattle (*Bos* spp.) prices, producers decide whether to use small grains as forage only, grain only, or both forage and grain, enabling flexibility to ensure greater income.

## 3. Significance of winter small grains as pasture in the Southern Great Plains

Small-grain forage is important in agricultural systems worldwide. In some parts of the world, intensive grazing of small-grain pasture occurs only once but continuously for days [22–24]. In the Central and Southern Great Plains of the United States, however, grazing is often at lower stocking rates for an extended period of time (months) [25, 26]. The grassland in the SGP is predominantly warm-season species, and hence the cool-season small-grain pasture plays critical roles in supplying nutritionally high-quality forage in winter when the quantity and quality of warm-season forage become low [27, 28].

Forage-based livestock production is an important element of the SGP agricultural economy [29]. This region plays an important role in the beef industry of the United States due to the strategic location between the humid southeast where a majority of the cow/calf enterprises reside and the High Plains region where the grain production and the finishing feedlots exclusively reside. Millions of stocker calves from more than 500,000 farms across the southern United States pass through the SGP on their way to the feedlots [30]. Managing small grains for both grazing and grain is an alternative and sustainable practice that supports the crop-livestock system in the region [30–32]. Cool-season small-grain forage provides more flexible and profitable crop-livestock systems, in which producers can adjust production outcomes they want based on market values of grains and livestock [28, 33]. In the past, it has been estimated that 30 to 80% of the total wheat area planted in the SGP is grazed at some time during the growing season and 10 to 20% of the area is grazed throughout the spring and not harvested for grain, which is referred to as "graze-out" [34]. When combined with summer annual forages, the winter annual small-grain forages can result in the best net return in unit area of land [35].

Small grains generally grow faster in winter than most other pastures and can also recover after grazing [36]. Small grains are also known to have high tillering capacity that enables them to tolerate stress from grazing. The average autumn-winter forage yield of small grains in the SGP is about 2500–3500 kg $ha^{-1}$; however, large yield variation was observed depending on growing conditions [37, 38]. In addition, small-grain forage is high in protein content and digestibility and hence promotes more weight gain in grazing animals [39]. In Texas, Oklahoma, and Kansas, small grains are a good source of high-quality pasture from late autumn to early spring [40]. Several studies indicated that small grains produce about 1.0 kg $d^{-1}$ of average daily gain (ADG) in grazing animals [41, 42].

To maximize the advantage of small grains as winter pasture, proper management practices should be followed. For example, early planting in a prepared seedbed is important to ensure early availability of the pasture for grazing. However, early planting may not be feasible if there are biotic and abiotic stresses in the farm.

Grazing too early when plants are small (not well-rooted) leads to pulling up of plants and also severe damage from trampling. In the dual-purpose production system, termination of grazing at the first hollow stem (jointing) stage is critical to achieve the best economic return [43]. Delaying the termination of grazing will reduce subsequent grain yield by approximately as much as five percent per day for every day past the first hollow stem [8].

Although winter wheat is the main cool-season forage source in the region, other small grains in general are also important for their wide adaptability and versatility in forage use, such as pasture, green cut, silage, and hay. The most commonly grown small grains for winter pasture in the region are wheat, rye, triticale, and oat. Compared to wheat, other small grains (rye, triticale, and oat) can produce greater forage yield in a specific season (autumn, winter, or spring), and they have competitive advantage in graze-out systems. Farmers select the crop that fits the need of winter pasture based on the characteristics of the crops, available management practices, and production goals.

## 4. Small grains commonly grown in the Southern Great Plains

### 4.1 Wheat

Wheat is the largest and most important crop in the SGP, with 3.1, 1.8, and 1.8 million hectares being planted in Kansas, Oklahoma, and Texas, respectively, in 2018 [1]. Wherever growing conditions are favorable, the economic advantage of managing wheat as a dual-purpose crop is better than managing it as a grain-only or forage-only crop [44, 45]. Wheat cultivars, such as "Endurance" and "Duster," with superior dual-purpose production have been released by the Oklahoma Agricultural Experiment Station [46, 47].

Obviously, the main reason why wheat is the most commonly planted small-grain species for grazing is its dual-purpose economic flexibility in the SGP. However, wheat is below average in amount of early growth and total forage yield compared to other small grains. Wheat is considered more tolerant to wet clay soils than the other small-grain species. Wheat forage is high in protein, energy, and minerals but low in fiber. To maximize forage yield in a dual-purpose winter wheat production system, the crop is often planted early in the autumn so that grazing can begin in late autumn. It is also very important to stop grazing at the first hollow stem stage when dormancy of the crop is released. Depending on the availability of moisture, wheat pasture can last 4–5 months.

### 4.2 Rye

Although rye acreage in the United States is much lower than wheat and oat acreages, it is an important forage crop in the SGP. Only 20% of the rye acreage in the United States is harvested [1], indicating that the majority of the crop is used for grazing animals. Oklahoma is the largest rye-growing state in the United States [1], at least partially because of the historical contribution of the Noble Research Institute in releasing a few well-known rye cultivars, such as "Elbon" (1956), which is still widely grown today. The Noble Research Institute has also released "Maton" (1975), "Oklon" (1993), "Bates" (1995), "Maton II" (2007), and "Bates RS4" (2013) rye cultivars, which were primarily selected for increasing autumn-winter production.

Among all small-grain cereals, rye is the most winter-hardy crop. It is proved to be the best in performance, especially under stressed growing conditions, because of its excellent biotic stress tolerance to multiple diseases and abiotic stress tolerance to

frost, drought, low pH, and marginal soil fertility [48, 49]. Rye performs better than other small grains, especially in the light-textured sandy soils, due to its prolific root system. It grows faster and produces more forage than wheat from autumn to winter. Livestock producers consider rye the most dependable cereal for winter grazing because of its reliable and great forage production [50, 51] and lower potential for causing grass tetany (livestock disease caused by magnesium deficiency) [52].

The main drawback of rye is that it is considered a terrible weed in wheat grown for grain, so it should not be planted in areas expected to be used for wheat grain production in the future. In addition, since rye develops fast and matures early, rye flowers often encounter late-spring freezing damage, causing potential seed yield loss.

The progress of increasing rye forage yield has been minimal because of limited breeding efforts, as only a few institutes, such as the University of Florida and the Noble Research Institute, have rye breeding programs. Cultivars commonly grown in the southern United States are those released many years ago. Rye is also an important grain crop worldwide, with 75% of grain production from Russia, Poland, Germany, and Ukraine [48].

In addition, rye is the most widely grown cover crop for sustainable agriculture because of its competitive ability to suppress weeds and scavenge residual soil nitrogen after other crops. Cereal rye is used widely as a winter annual cover crop in the United States because of its winterhardiness, high biomass production, and residues against weed species [53]. Studies have indicated that rye cover crop improves soil organic matter, nitrogen mineralization, and particulate organic matter [54].

### 4.3 Triticale

Triticale is a man-made crop from hybridizing wheat (*Triticum* spp. L.) and rye for combining the best traits from the two parental species. This artificial cereal inherited its cold tolerance, disease resistance or tolerance, and adaptation to unfavorable soil and climatic conditions from the male parent, rye, and its yield and nutritional quality from the female parent, wheat [55, 56]. Although breeding efforts on triticale have been limited compared to those on other small grains, improved triticale cultivars produce competitive biomass and grain yield, making it a viable alternative crop especially under unfavorable growing conditions with diverse biotic and abiotic stress factors [56].

Triticale is an important crop especially in livestock farming systems, in which the crop is mainly produced for animal feed grain and/or forage [57–60]. In the SGP, triticale is grown mainly for grazing because of its superior performance in forage biomass production [56]. The forage yield of triticale is similar to that of rye but greater than that of wheat and oat in the southern Oklahoma [61]. Triticale also has greater forage quality for grazing animals when compared to rye [56]. In addition, triticale is a preferred forage crop for producing silage to cover the forage quality gap during dry, hot summers because of its high yielding and nutritional forage [56, 62]. Therefore, triticale is becoming more popular as an alternative forage to wheat and rye in the SGP, and it has the greatest potential for improvement due to its short breeding history [56].

### 4.4 Oats

Oat is another cereal commonly grown for grain and forage throughout the world. It is produced mainly in temperate, cool, and subtropical climates for grain and different forms of animal feed [63]. In the United States, spring oat is primarily produced for grain, while winter type is often grown for forage and in some cases as a dual-purpose crop [63].

The use of winter oat as pasture or forage is common in the SGP of the United States [64]. Oat is an important forage crop in the region and is a useful alternative to forage wheat for stocker cattle production [63]. Oat grows fast and generates very competitive forage biomass yield in autumn and spring when air temperature is optimal for the crop; however, it produces much less forage in winter than wheat, rye, and triticale because of its sensitivity to freezing temperatures. Therefore, improving winterhardiness is one of the main breeding objectives for winter forage oat. In addition, compared to other small grains, oat is in general more susceptible to various diseases, and it does not grow well in low-input systems; thus, it is not recommended for marginal land. Oat is generally the most preferred forage to grazing animals among all small grains due to its superior palatability.

In summary, pasture production varies greatly among small-grain cereals. Comparing forage, especially for stocker development, requires different

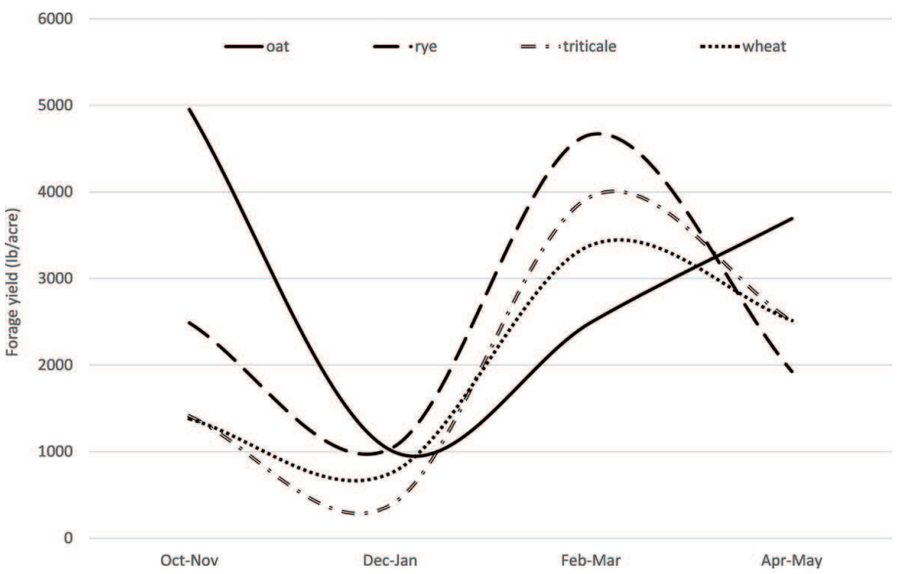


**Figure 1.**
*Relative pasture production distribution of cool season small grain crops on heavy soil at Ardmore, Oklahoma.*

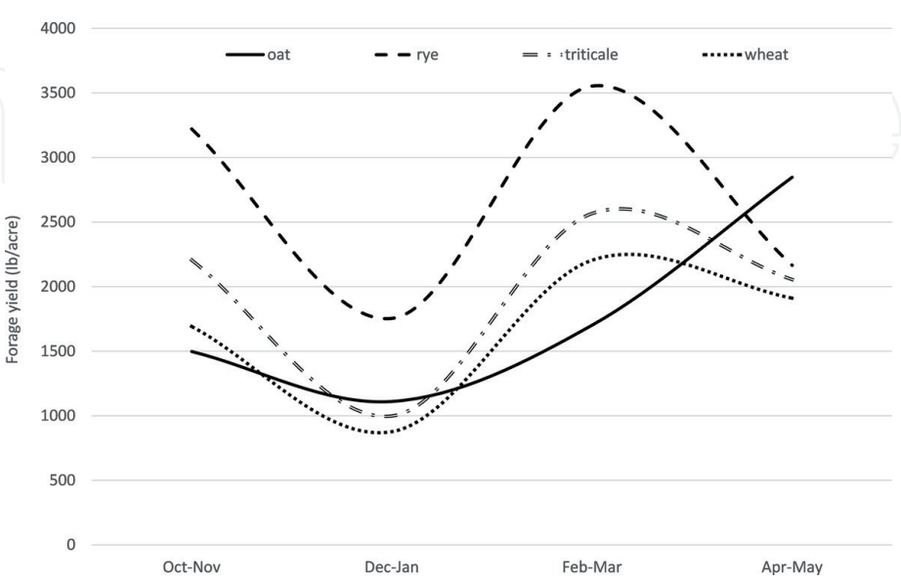


**Figure 2.**
*Relative pasture production distribution of cool season small grain crops on sandy soil at Burneyville, Oklahoma.*

considerations specific to the farm, growing season, and climatic conditions. For example, oat is the best for autumn forage yield on clay soil at Ardmore, Oklahoma, while rye is the best on sandy soil at Burneyville, Oklahoma (**Figures 1** and **2**). Therefore, a holistic understanding of production environment, available management options, and economic analysis is key to attain the intended use. The availability of alternative forage options of small grains enables producers to make decisions that best fit their specific farm and climatic conditions.

## 5. Improving small grains for winter pasture in the Southern Great Plains

Since small-grain cereals are produced mainly for grain, breeding efforts to improve small grains mostly focus on increasing grain yield and quality worldwide. Although small-grain cereals are also widely used as forage crops, cultivars being used for winter pastures were mostly developed for grain rather than forage. Therefore, there is a need to improve small grains for winter forage or dual-purpose production, especially in the SGP where livestock and forage production are the largest contributors to agricultural income. Ideally, small grains for grazing are those with tolerance to early planting, animal grazing, and various seedling biotic and abiotic stresses and those with vigorous early growth and regrowth and/or extended periods of vegetative growth.

In the southern United States, institutes that have breeding programs to improve cereals for forage or dual purpose include the Noble Research Institute (formerly the Samuel Roberts Noble Foundation), the Oklahoma State University, the Texas A&M AgriLife Research (Texas A&M University), the University of Georgia, and the University of Florida [46, 63, 65]. However, only the Noble Research Institute has a forage-focused small-grain breeding program, while other universities mainly deliver dual-purpose cultivars from their grain-focused breeding programs. The Noble Research Institute started its small-grain breeding program with rye in the early 1950s. Since then, the institute has expanded its breeding program to include wheat, triticale, and oat with the objective of increasing forage or dual-purpose production. The research has particularly focused on developing cultivars with improved early vigor and regrowth vigor, improved grazing tolerance, and increased autumn-winter forage yield or total forage yield. The program has developed multiple improved forage cultivars of wheat, rye, oat, and triticale.

Biomass yield is the main target for forage crop improvement. The trait is usually measured through multiple clipping over seasons, posing difficulty in biomass yield estimation, especially when a large number of samples need to be evaluated at field scales [63]. Other physical methods of estimating biomass involved rising plate meters, capacitance meters, and clipping samples with meter sticks [66–69]. However, not only are these methods time-consuming, but it is also difficult to establish a reliable model for estimating biomass yield [70].

To augment breeding efficiency, high-throughput phenotyping platforms using remote sensing have been adopted recently in forage breeding and have facilitated biomass yield estimation for breeding selection [70–73]. Over the last few years, the Noble Research Institute has developed ground-based high-throughput phenotyping platforms and improved biomass prediction accuracies by incorporating normalized difference vegetation index (NDVI) with proximal sensors, such as ultrasonic and laser height measurements [70]. Similar phenotyping platforms have also been used in other breeding programs.

## 6. Summary

Cool-season annual small grains remain the most important forage for stocker cattle producers in the SGP of the United States due to their high forage quality, adaptation to the environment, and economic contribution. They are also valuable for filling forage gaps and extending the grazing season as a complement to other grasses. Wheat, rye, triticale, and oat are the most common small-grain forages that provide production flexibility and economic stability with an alternative dual-purpose option. Wheat is the most commonly grown because of its alternative value as a cash crop; rye is currently the best forage option on sandy, drought-prone soils or in graze-out systems; oat can be the most valuable when providing autumn forage; and triticale has the greatest potential for improvement and increased adoption.

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## Conflict of interest

The authors declare no conflicts of interest.

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