Pest Management Strategic Plan for Winter Wheat in the Southern Great Plains

Based in part on a stakeholder workshop 11 August 2010

USDA Grazinglands Research Center, El Reno, Oklahoma

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Colorado State University

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Executive Summary

The purpose of a Pest Management Strategic Plan (PMSP) is to serve as a communication vehicle from growers, industry and other IPM professionals to regulators and granting agencies about the need for, and role of pest management practices and pesticides used in winter wheat production. To obtain broad-based industry input, PMSPs are developed for a commodity via workshops which bring together producers, crop consultants, commodity groups, and pest management specialists from across the production region. PMSPs were originally intended for use by the Environmental Protection Agency (EPA), but have also proved valuable to the United States Department of Agriculture (USDA), Land Grant Universities, and pest management stakeholders at all levels.

Our goal was to develop a PMSP for wheat production in the Southern Great Plains. This PMSP was prepared at a workshop held on the 11 August, 2010, in El Reno, Oklahoma. 30 participants, representing Colorado, Kansas, Oklahoma and Texas attended the workshop. This document is meant to be representative of pest management challenges faced by winter wheat producers in the Southern and Central Plains. In addition to providing input on pests and pest control methodologies, workshop attendees identified research, education and regulatory issues that impact producer profitability and environmental quality. A main task of the attendees was to prioritize the issues deemed most critical to winter wheat pest management.

Additional input was sought from producers in the Southern Plains to assure this reflects all stakeholder priorities. Two surveys of wheat growers were conducted at field days in Lockett and Perryton Texas during the Spring of 2011. Producer input was also included from a survey conducted by Dr. Kathleen Kelsey in 2011 of Kansas and Colorado producers.
During the meeting, it was noted that, although geographic area covered by this Strategic Plan (which includes the states of Colorado, Kansas, Oklahoma and Texas) all grow hard red winter wheat, the production systems, climates and pest problems varied significantly from area to area within the region.

Summary of pest management needs identified at the PMSP meeting in El Reno, OK.

1) There is a significant concern for the maintenance of phenoxy herbicides (primarily 2, 4-D) as a herbicide option for effective weed management and resistance management.
2) Herbicide resistance was a significant concern and needs for research and education into effective resistance management plans and alternatives were brought forward.
3) Major pest concerns include winter annual grasses, Wheat Streak Mosaic Virus, especially in the especially in the winter wheat production areas of the Oklahoma and Texas Panhandles, Fusarium head scab in the wetter areas of the region (east and north) and the associated critical need for full product registration of effective fungicides, and the rust diseases and the associated general lack of genetic resistance to current rust strains in the region. Many other pests were also discussed and are discussed in the specific pest sections.

4) There was a strong need identified for development of effective predictive management models for disease forecasting.

Summary of Pest Management Needs Identified by 12 Producers at Two Field Days in Texas, 2011.

We asked 12 winter wheat producers in Oklahoma and Texas some general questions to help identify some pest management needs for management of disease, insect and weed pests of winter wheat. The survey asked producers to provide information about their management practices in regard to soil fertility, insects, diseases and weeds. The average acres of wheat planted by these growers were 3779 acres. The planted the following wheat varieties in 2010: Coronado, Doans, Dumas, Duster, Endurance, Fannin, Greer, Hatcher, Jackpot, Jagger, TAM111, TAM112, TAM203, TAM304, Winterhawk.

Findings: Producers were asked to rank their concern of the following issues, with a 4 = high concern, 3 = moderate concern, 2 = low concern, 1 = no concern.

The production issues that were identified as the greatest concern by rank:

Fertility	3.5	Moderate-High concern
Disease	3.16	Moderate concern
Insects	3.08	Moderate concern
Weeds,	2.91	Moderate concern
Harvest Issue	2.18	Low concern
Protein content of wheat.	2.16	Low concern

Fertility: 8 of the 12 producers listed nitrogen and phosphorous as their most important problem, and 2 listed soil salinity.

Producers were asked how often, and for what pests, they scouted their fields. All producers indicated that their fields were scouted (minimum 3 times per season, maximum was daily) and all listed insect, disease and weeds.

Plant diseases: Of the disease pests identified as important, producers listed the following from most to least:

Stripe rust	12 of 12 listed
Leaf rust	10 of 12 listed
BYDV	10 of 12 listed
Wheat streak mosaic virus	6 of 12 listed
Powdery mildew	3 of 12 listed
Karnal bunt	2 of 12 listed
Seedling blight	2 of 12 listed
Wheat soil born Mosaic Virus	2 of 12 listed
Tan spot	2 of 12 listed
Common Bunt	2 of 12 listed
Fusarium head blight, Glume blotch and Septoria leaf blotch	1 of 12 listed

5 of 12 producers treated some of their wheat with fungicides that included

Quilt, Folicur, Raxil and Quadris.

Arthropod pests: Of the arthropod pests identified as important, producers listed the following from most to least:

Greenbug	11 of 12 listed
Mites	11 of 12 listed
Bird Cherry Oat aphid	6 of 12 listed
Russian Wheat aphid	6 of 12 listed
Armyworm	4 of 12 listed
Fall armyworm	4 of 12 listed
Hessian fly	3 of 12 listed
Army cutworm	3 of 12 listed
Grasshoppers	2 of 12 listed
White grubs	1 of 12 listed

6 of 12 producers treated some of their wheat with fungicides that included Cruiser, Cobalt, dimethoate, Gaucho, and Lorsban.

Weeds: Of the weed pests identified as important, producers listed the following from most to least:

Field bindweed	8 of 12 listed
Cheat	7 of 12 listed
Marestail	7 of 12 listed
Kochia	7 of 12 listed
Jointed goat grass	4 of 12 listed
Rescue grass	4 of 12 listed
Ryegrass	4 of 12 listed
Wild oats	3 of 12 listed
Downey brome	2 of 12 listed
Vetch	1 of 12 listed

10 of 12 producers treated some of their wheat with herbicides that included Amber, Ally, Banvel, 2,4-D, Finesse, MCPA, Olympus and Osprey. 2,4-D, Finesse, and Ally were applied by the most producers in the survey.

Paragraph on Resistance and IPM issues, secondary pest concerns, new pests, Trade Issues (export and import) and Local regulatory restrictions

Paragraph highlighting identified top priorities that may include solutions to the critical needs of Research, Education, Extension and Regulatory Concerns.

CRITICAL NEEDS: PEST MANAGEMENT PRIORITIES FOR WINTER WHEAT PRODUCTION IN THE SOUTHERN GREAT PLAINS (CO, KS, OK, TX)

RESEARCH PRIORITIES	EXTENSION PRIORITIES	EDUCATION AND REGULATORY PRIORITIES
Herbicide resistant weeds, documentation and management strategies	Programs related to weed identification and management for herbicide resistance	Lower tolerances for weed seeds in certified seed
Soil/pH weed interactions	Demonstrate better use of currently registered pesticides (application timing, use rates, adjuvants and application methods	Harmonize registration of fungicides and insecticides on small grains
Rescuegrass control	Access, use, and adoption of communication with modern technologies for decision making.	Improve detection and quarantine of invasive species.
Improving jointed goatgrass control	Education on cultural control methods with emphasis on crop rotations.	Adoption and realistic use of IPM practices for government programs such as crop insurance
Consequence of tillage and cropping practices on insect abundance	Promote use of pest-resistant varieties	Greater number of undergraduate and graduate students that are prepared to deal with applied agricultural research and directly working with producers.
Improved pest detection and decision-making using current and emerging communication technologies	Increase use of treated, certified wheat seed	
Development of resistant varieties for disease and insects	Regional demonstration and adoption of BMP's and improved cultivars for better, yield, end use quality and profitability in grain and dual purpose wheat.	
Develop disease forecasting models to facilitate foliar fungicide recommendations		

General Production Information

Colorado Statistics, 2005-2010

- Colorado consistently ranks 5th nationally in winter wheat production.
- Approximately 2.1 million acres of winter wheat were harvested each year.
- Colorado's average winter wheat production from 2005-2010 was 75 million bushels, averaging 31 bushels per acre.
- Colorado winter wheat value ranged from $181 million to $273 million from 2005-2010.
- Wheat is produced in 30 counties. The top 5 counties for winter wheat production on order from first to fifth were Kit Carson, Washington, Kiowa, Yuma and Cheyenne.

Oklahoma Statistics, 2005-2010:

- Oklahoma consistently ranks 2 nationally in winter wheat production.
- Approximately 3.7 million acres of winter wheat were harvested each year, with ca. 100,000 acres under irrigation.
- Approximately 2 million acres of wheat in Oklahoma are used for pasture or dual purpose (for forage and grain) to feed to stocker cattle.
- Oklahoma's average winter wheat production from 2005-2010 was 113 million bushels, averaging 29 bushels per acre.
- Oklahoma winter wheat value ranged from $200 million to $1.08 billion from 2005-2010.
- The top five counties in 2008 for wheat production in order from first to fifth were: Grant, Kiowa, Alfalfa, Kingfisher and Jackson.

Kansas Statistics, 2005-2010

- Kansas consistently ranks 1st nationally in winter wheat production.
- Approximately 9 million acres of winter wheat were harvested each year, with ca. 650,000 acres under irrigation.
- Kansas's average winter wheat production from 2005-2010 was 337 million bushels, averaging 38 bushels per acre.
- Kansas winter wheat value ranged from $1.3 to $2.5 billion from 2005-2010.
- The top five counties for winter wheat production in order from first to fifth were Sumner, Reno, McPherson, Harper and Sedgwick.

Texas Statistics, 2005-2010

- Texas consistently ranks 3rd nationally in winter wheat production.
- Approximately 2.9 million acres of winter wheat were harvested each year, with ca. 659,000 acres under irrigation.
- 45% of winter wheat acres are devoted to growing wheat for forage and pasture.
- Texas's average winter wheat production from 2005-2010 was 92.6 million bushels, averaging 30.5 bushels per acre.
- Texas winter wheat value ranged from $150-$750 million from 2005-2010.
- The top five counties for winter wheat production in order from first to fifth were, Sherman, Hansford, Dallam, Ochiltree and Parmer.

Cultural Practices

Colorado

Winter wheat is planted between September 1 and October 15. If the crop is planted too early, there is a higher risk for Hessian fly and viral infestations. However, the Hessian fly is only a minor pest for Colorado wheat growers. However, if wheat is planted too late, the plants may be underdeveloped when overwintering occurs (4 - 5 leaf stage is the optimal stage for overwintering). The wheat plants will vernalize during overwintering if they are properly developed. Vernalization is required to allow the shift from vegetative growth to reproductive growth. Preferred soil texture is well-drained, with a soil temperature of 60 F or lower.

Seed should be planted at a depth of 1 - 3". Rows are generally 7 - 12" wide. Six inch row spacings are primarily used for irrigated systems. Optimal planting density is 500,000 - 1,000,000 plants or more per acre, depending upon whether it is a dryland or irrigated system (in dryland systems, there are fewer plants per acre). This is equivalent to 30 - 50 lb. of seed per acre in dryland systems and 75-90 lb. of seed per acre for irrigated systems depending on the market class planted.

The following are common crop rotations: wheat-corn-fallow; wheat-sorghum-fallow; wheat-proso millet-fallow; wheat-corn-proso millet-fallow. Sunflowers may also be added into the rotation. However, the dominant rotation is still wheat-fallow. It is recommended to plant winter wheat following fallow; if this is not possible, plant a short-season annual forage in the spring and harvest it prior to August 1. No tillage is necessary when planting wheat; wheat is planted directly into forage stubble. However, most growers following a wheat-fallow rotation will clean till the seed bed before planting. Winter wheat is usually harvested from late June to late July. The crop is directly combined unless it is weedy.

Kansas

Hard red winter wheat class is adapted to Kansas temperatures, can withstand both cold and hot weather. Winter wheat in Kansas not only can survive the freezing temperatures of winter, but it needs the cold temperatures to joint and flower so it can set grain in spring. Wheat is planted in early fall (mid-September through October) and harvested in the summer. Normally, Kansas starts harvesting wheat in mid-June and continues through early July.

Optimum seeding dates vary across Kansas due to different environmental conditions. Seeding rates and planting dates vary across the state due to lower rainfall and irrigation systems in western Kansas and high rainfall in the eastern region of Kansas. Optimum seeding rates in western Kansas range from 600,000 to 900,000 seeds per acre planted. In central Kansas, the rate ranges from 750,000 to 900,000 seeds per acre. About 900,000-1,125,000 seeds per acre are planted in eastern part of the state. With irrigation, seeding rates may range from 900,000 to 1,350,000 seeds per acre.

Seedbed preparation varies across the state depending on residue of the preceding crop and the need for moisture conservation. The amount of tillage in Kansas has been reduced during the past decade. Plowing is practiced on a limited basis in the continuous wheat areas of south central Kansas where residue management is difficult. Most farmers use 1 to 2 disking or a chisel operation to incorporate residues followed by another disking or field cultivator as planting time approaches. In this cropping system, resistant wheat varieties to foliar diseases are planted to tolerate tan spot and Septoria leaf blotch. On the heavier, sloping soils of eastern Kansas, soil erosion by water is a major concern. Terraces, waterways, and crop residue management are required on many highly erodible acres.

Where crop rotations are used, the low crop residue after harvest is left until late summer when 1 or 2 disking or field cultivations are used before wheat seeding. Many farmers have saved time and moisture by planting no-till wheat, double-cropping after row crop harvest. In western Kansas where moisture conservation is the most important goal, the wheat-fallow system has been dominant. In this system, a wheat crop is produced every 2 years. But, the wheat, row crop, fallow rotation is gaining acreage and interest. In this system, two crops are grown in three years. Soil moisture is replenished by using conservation tillage methods so that a summer crop (corn, grain sorghum, sunflower, or millet) can be planted to utilize the stored moisture.

Oklahoma

The climate of Oklahoma, which is typically cool and wet in the fall and spring, with cold, dry winters and hot summers, is well suited to the production of high quality winter wheat. Winter wheat may be grown for grain, dual purpose, full-season grazing or for a hay crop. Dual purpose means that cattle graze the field in the fall and early winter and are removed as the crop reaches first hollow stem stage of growth, then is harvested for grain. Winter wheat is typically sown from late August through the middle of November. Grain harvest occurs from the end of May through July 15. Wheat planted for grain production is planted later in October and November at seeding rates of 50-60 pounds per acre. Wheat intended for pasture or dual purpose is planted from late August into September using seeding rates up to two bushels per acre to produce enough forage growth to start grazing cattle in November. High quality silage can still be obtained if harvested when the wheat is in the milk stage of grain-filling. Harvesting wheat to obtain high quality hay is difficult in Oklahoma because it should be harvested in April, when rains frequently occur.

Summer tillage operations alter the soil structure, manage crops residues, and eliminate weeds, with the ultimate goal of preparing a soil environment conductive to germination and growth. Seed treated with fungicide/insecticide is sometimes used to decrease the potential for seed decay or seedling diseases resulting from planting in cold, wet soils. The optimum seeding depth for wheat is three-fourths of an inch to one and one half inch deep. Under dry field conditions, the semi-dwarf wheat varieties can be safely sown at a two-inch depth and the tall varieties at three inches. If the seed is to be sown into dry soil (dusted in), seeding depth should be approximately one half inch. Planting depth is critical for two reasons. First, as soil temperature increases, the maximum potential length of the coleoptile decreases. Therefore, the seed needs to be planted shallower to ensure the coleoptile reaches the soil surface. Second, since grain is planted in hotter soils and there is concern that the soil will dry before germination occurs, producers tend to plant deeper.

Soil pH is more critical in wheat fall forage production than when the wheat is used for grain only. Low pH primarily affects the wheat plant through aluminum toxicity. When a seedling root emerges into soil with toxic levels of aluminum, root growth is hindered, and the plant takes up less water and nutrients. Therefore, wheat growing in low-pH fields may appear healthier when regrowth occurs in the spring and grain yields are less affected than fall forage yields were.
When wheat is used for dual purpose, timing of grazing termination is critical. To obtain maximum economic return per acre to the cattle-plus-grain system, cattle need to be removed no later than the first hollow stem stage of wheat growth. Research conducted at OSU showed that removing the cattle

two weeks prior to first hollow stem stage had little effect on grain yield while removing them a few days after first hollow stem began to reduce grain yield significantly resulting in significant net returns. More recently, the wheat breeding program in Oklahoma began selecting varieties that perform optimally in dual purpose systems, specifically varieties that have late timing for first hollow stem initiation and minimal impact on yield from grazing.

Yield components for wheat forage are different than for grain only. Therefore, stand establishment and plant density become far more critical for fall forage yields than grain yield.
Drought stress during any phase of wheat germination and growth can reduce forage yield. As with stand establishment for grain, low soil moisture decreases germination, resulting in fewer plants that contribute to forage yield and may also delay germination leaving fewer days for fall forage production, which will produce plants with fewer and smaller tillers. Drought stress during tillering may cause tillers to abort and drought stress also reduces the size of each leaf produced during the stress.

Texas

Planting date. Texas produces both soft and hard-red winter wheat. Planting dates range from late August through early November, depending on location and use of the crop. Hard red winter wheat is for grain or forage. 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. Producers generally plant wheat 2-3 weeks earlier than usual if it is to be grazed. Grazing can begin 6-8 weeks after planting when there is 6-12 inches of growth.
Tillage and seed bed preparation.

Optimum seeding dates vary across Texas due to different environmental conditions. Seeding rates and planting dates vary across the state due to lower rainfall and irrigation systems in western Texas and the Panhandle and high rainfall in the eastern region of Texas. Optimum seeding rates in western Texas range from 600,000 to 900,000 seeds per acre planted. In central Texas, the rate ranges from 750,000 to 900,000 seeds per acre. About 900,000-1,125,000 seeds per acre are planted in eastern part of the state. With irrigation, seeding rates may range from 900,000 to 1,350,000 seeds per acre.

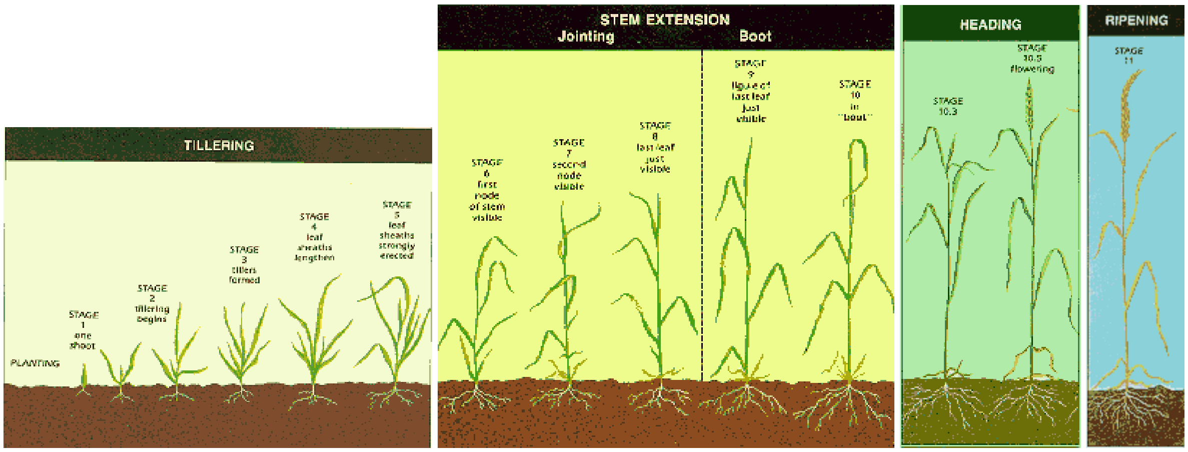
Seedbed preparation varies across the state depending on residue of the preceding crop and the need for moisture conservation. Plowing is practiced on a limited basis in the continuous wheat areas where residue management is difficult. Most farmers use 1 to 2 disking or a chisel operation to incorporate residues followed by another disking or field cultivator as planting time approaches.
Crop rotation can be of significant importance for managing some varieties.

Production issues of importance

Wheat breeding programs are involved in including host plant resistance traits into new varieties. Wheat Streak Mosaic Virus and leaf rust are of great concern to growers. Depending on the location, growers may look at varieties that possess resistance to other diseases, such as smuts, barley yellow dwarf virus, wheat soilborne mosaic virus, stripe rust and stem rust. Insect resistance traits are also being developed, or are available in improved wheat varieties. Of major concern is resistance to the Russian wheat aphid, greenbug, wheat stem sawfly, and more recently, Hessian fly. Three of the aforementioned insects contain biotypes within their population pool which cause more difficulty in choosing resistant varieties.

Wheat Growth Stages

Wheat growth stages are most frequently referred to using the Feekes scale, shown in the figure below.



Identification of the growth stage of wheat is important because some fungicides, insecticides, and herbicides call for applications at a specific Feekes growth stage. There are several other growth stage indices, including the BBCH-scale and the Zadok's scale.

Water stress affects plant during any growth stage, reducing forage and/or grain yield. When wheat is grown strictly for grain, moisture is most critical during stand establishment and flowering through grain filling. If irrigation is available but of limited capacity, the greatest benefit results from targeting irrigation for stand establishment and irrigating when the wheat is flowering.

Although the Feekes scale does not include a growth stage prior to seedling, this stage sometimes is referred to as **germination**. The germination stage lasts from seeding until emergence. During germination, insufficient soil moisture results in inferior stands, which may reduce grain yield, depending on the capability of the plant to compensate during the season. A poor stand will substantially reduce fall and winter grazing potential.

The first above-ground stage is **seedling** (Feekes stage 1), which occurs from the time the plant emerges until the first tiller appears. If desired, the number of leaves present on the first shoot can be designated with a decimal. For example, 1.2 is a single shoot with 2 leaves unfolded, 1.3 is with three leaves, etc.

Tillering begins with the appearance of the first tiller (Feekes 2) and continues until stem extension begins (Feekes 5). In unstressed conditions, the first tiller appears as the fourth leaf is expanding. Plants often begin to become erect, forming "pseudo-stems" from the lengthening sheathes of the leaves.

Stem extension occurs from the time hollow stem is first visible above the crown (Feekes stage 6) until heading begins (Feekes stage 10). A critical stage for dual purpose wheat is a tern called *First Hollow Stem*. This is defined as the growth stage when hollow stem can first be identified above the root system and below the developing head. Stem extension ends when the sheath of last leaf is completely grown out but the head (ear) is swollen but not yet visible (boot).

Heading begins when the spikelet emerges from the flag leaf sheath (Feekes stage 10.1) and continues until all heads are out of the sheath (Feekes 10.5).

Flowering refers to the beginning of flowering (Feekes 10.51) until the kernels become watery ripe (Feekes 10.54).

Ripening refers to the development after the grain after flowering until it has reached maximum dry weight. Within the Feekes scale there are several stages of ripening (grain filling) that occur and are critical for maximum yield. Grain-filling may be separated into the *water, milk, soft dough, and hard dough* stages. Each stage can be identified by removing a kernel and squeezing it. If a clear, watery fluid is exuded, it is classified as *water stage* which is, by strict definition, in the flowering stage (Feekes 10.54). *Milk stage* occurs when a squeezed kernel exudes a milky-white liquid. *Soft dough* is when the material squeezed from the kernel is white but stickier and thicker, with the consistency of flour dough (Feekes 11.2). *Hard dough* is when the kernel can still be dented with the thumbnail, but nothing can be squeezed out (Feekes 11.3). Ripe for cutting (Feekes 11.4) occurs when the straw is dead.

During the grain-filling stage, drought stress affects the wheat plant primarily by decreasing seed size. However, during the first few days of grain-filling, seed that has begun growth may abort.

The components that determine grain yield include the number of plants per acre, number of heads per plant, number of seeds per head, and weight per seed. A decrease in any one factor can decrease wheat yield. However, wheat has a tremendous capacity to compensate among these yield components, which arise from three factors. First, wheat plants can compensate for low seeding rates or poor emergence by producing more tillers. Therefore, it is important to increase seeding rates with later plantings since the plants have less time to produce new tillers. Second, many more flowers are initiated under normal conditions than can ultimately set seed. Thus, if normal conditions exist when the wheat plant is initiating flowers, and ideal conditions exist during flower initiation, jointing, and pollination, a higher-than normal percent of flowers may set seed. Third, a wheat plant can modify seed size. If many seeds are set and conditions become unfavorable, the plant simply produces smaller seeds. This may be caused by hot nights during grain fill, which are common to Oklahoma and Texas, or because disease infections destroy the flag leaf prematurely, or due to drought stress during grain fill. However, the opposite can also occur. If conditions are unfavorable prior to flowering, fewer tillers or seeds may be produced; but a return to favorable conditions during grain fill could result in plants with very large seeds.

Winter wheat may be used for dual purpose, for full-season grazing, for a hay crop, or simply as a cover crop for soil conservation or green manure. Dual purpose means that cattle graze the field in the fall and early winter and are removed as the crop reaches first hollow stem stage of growth. The wheat is then harvested for grain. Forage produced before the wheat reaches flowering stage is highly nutritious. Fall and winter wheat forage is often compared to alfalfa with respect to crude protein and digestibility.

Wheat is winter hardy even when it is planted early in order to maximize fall forage production. This dual purpose of grazing the forage and harvesting the grain makes wheat a flexible and double value crop in some parts of the Southern Plains. Wheat planted in early-mid September in southern Kansas, Oklahoma and parts of northern Texas produces enough fall growth to graze one stocker steer on one to three acres through the winter. Producers are frequently interested in maximizing wheat forage for grazing in the fall and winter. To accomplish this, the crop is planted one to two months before the suggested ideal planting date for grain production at higher seeding rates that are recommended for grain production.

Planting depth is critical for two reasons. First, as soil temperatures increase, the maximum potential length of the coleoptile decreases. Therefore, the seed needs to be planted at a shallower depth to ensure the coleoptile reaches the soil surface. Second, since grain is planted in hotter soils so producers are concerned that the soil will dry before the seeds germinate and tend to plant deeper. A common recommendation is to plant shallower, with the expectation that some of the seed will not emerge until it has rained. This is commonly referred to as “dusting in” the wheat seed.

Soil pH is more critical in wheat grown for fall forage production than when the wheat is grown solely for grain. Low pH primarily affects the wheat plant through enhancing aluminum toxicity. When a seedling root emerges into soil with toxic levels of aluminum, root growth is hindered, and the plant takes up less water and nutrients. Therefore, wheat growing in low-pH fields may appear to be stressed in the fall and look healthier in the spring once regrowth occurs. Typically, grain yields are less affected than fall forage yields in low pH soils.

When wheat is used for dual purpose, timing of grazing termination is critical. To obtain maximum economic return per acre to the cattle-plus-grain system, cattle need to be removed no later than the “first hollow stem stage” of wheat growth. Research conducted at OSU showed that removing the cattle two weeks prior to first hollow stem stage had little effect on net return per acre, while removing them a few days after first hollow stem reduced net return significantly.

Yield components for wheat forage are different than for grain only. Therefore, stand establishment and plant density become more critical for fall forage yields than grain yield.

Drought stress has a large impact on forage yield since each component of yield is reduced. As with stand establishment for grain, low soil moisture decreases germination, resulting in fewer plants that contribute to forage yield. Low soil moisture at planting may also delay germination leaving fewer days for fall forage production, which will produce plants with fewer and smaller tillers when the forage quantity is evaluated. Drought stress during tillering may cause tillers to abort. Since the oldest tillers on early-planted wheat may form secondary or even tertiary tillers, the number of tillers contributing to forage yield is reduced dramatically when stress occurs early in the tillering phase. Drought stress also reduces the size of each leaf produced during the stress.

Small grains also make highly nutritious silage or hay if the forage is harvested at the appropriate stage of maturity and properly processed. The optimum combination of nutritive value and hay quantity occurs when the wheat is heading. Higher yields are obtained by harvesting wheat after it is fully headed; however, the hay will be less nutritious and awns on the wheat can cause feeding problems in cattle. Such hay will still provide adequate maintenance feed for a beef cattle herd. Harvesting wheat to obtain high quality hay is difficult in some parts of the Southern Great Plains because it should be harvested in April, when rains frequently occur. High quality silage can still be obtained if harvested when the wheat is in the milk stage of grain-filling.

Table 1. Wheat Calendar (Growth)

Crop Growth Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Emergence (F 1)								C	CKOT	CKOT	KOT	T
Tillering (F 2)	CKOT	CKOT	CKOT						CKO	CKOT	CKOT	CKOT
Tillers Formed(F3)			CKOT	CKOT								
Winter Dormancy (F 3)	CKOT	CKOT	C								C	CKOT
Begin Erect Growth (F 4)		OT	CKOT	CK								
First Hollow Stem (Ca. F5.0)		KOT	CKOT	C								
First Node Visible (F 6)		KOT	CKOT	CKOT								
Second Node Visible (F 7)		T	CKOT	CKOT								
Flag Leaf Visible (F 8)				CKOT	CK							
Ligule of Flag Leaf Visible (F9)				CKOT	CK							
Boot (F 10)				CKOT	CK							
Ripening (F 11)				T	KOT	CKOT	CK					

F = Feekes stage
(C=Colorado, K=Kansas, O=Oklahoma, T=Texas

Table 2: Wheat Calendar (Production Management)

Production Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Select, Clean and Treat Seed						OT	CKOT	CKOT	CKOT			
Seed Bed Preparation						CKOT	CKOT	CKOT	CKOT	CKOT		
Pre-Plant Weed Control						CKOT	CKOT	CKOT	CKOT	CKOT		
Pre-Plant Fertilizer								CKO	CKOT	CKOT	T	
Seeding								COT	CKOT	CKOT	OT	
Pre-emergence weed control								COT	CKOT	CKOT	OT	
Livestock Grazing	CKOT	CKOT	CKOT	CKOT	CKOT					CKOT	CKOT	CKOT
Topdress Nitrogen	KOT	CKOT	CKOT	CK								KO
Post-emergence weed control	KOT	KOT	CKOT							C	CKOT	CKOT
Remove livestock	T	KOT	CKOT	CKOT	CKOT	CK						
Harvest				T	OT	CKOT	CKO					

(C=Colorado, K=Kansas, O=Oklahoma, T=Texas

Pest Management

A wheat producer can assemble various tools into a pest management plan to reduce or prevent pest-related losses. A grower should start by selecting winter wheat varieties that are adapted to the climate, soil conditions, and pests in the region. Next, the crop must be provided with its essential requirements for health, which include optimal fertility and soil pH, and a properly prepared seedbed. Because wheat is grown for forage, forage plus grain, or grain only, the grower should select planting dates that are compatible with the overall production goals. However, planting dates can also be selected to help avoid unnecessary exposure to pest problems. Crop rotations can aid in managing some pest problems, and some pests have natural enemies that help keep pest populations in check. Tillage operations can reduce certain pests. Pesticides can be used to control wheat pests. A pesticide application can result in increased yields and should be viewed as a business decision that can affect overall crop profitability, but it should be applied in a safe, responsible manner.

Variety Selection

Variety selection can help avoid or mitigate losses from diseases such as leaf rust wheat soilborne mosaic virus, or greenbug. Some pests undergo population shifts that allow the pest to overcome the resistance genes incorporated into varieties of wheat. A newly released variety that initially has excellent resistance to a specific pest may become moderately or fully susceptible within two to four years after its release because the genetic nature of the pest population has changed. The fungus that causes leaf rust and the greenbug are examples. Producers need to continually evaluate the field performance of their varieties and make changes as needed.

Fertility Management

In general, the use of nutrient management programs that promote optimal plant growth and development will result in healthy plants that are better suited to resist infestations. Overfertilizing (especially nitrogen) results in excessively succulent plant growth that facilitates increased incidence and severity of some wheat diseases such as powdery mildew or insects such as armyworm and the cereal aphids. If wheat plants do not receive enough nutrients, they become stressed and may be more susceptible to attack by insect and disease pests.

Planting Date

Wheat that is intended for forage production is usually planted early. A later planting date is recommended when wheat is planted strictly for grain production. Planting wheat early favors the incidence and severity of diseases such as root rots, barley yellow dwarf virus (BYDV), and wheat streak mosaic virus (WSMV), as well as insects such as cereal aphids and fall armyworms, and some winter annual weeds. This is because an early planting date extends the length of time during which these pests can develop in the fall. If the pathogens that cause root rots, BYDV, and WSMV infect plants in the fall, yield losses will be greater than if the infection occurs during the late winter or spring.

Controlling Weeds and Volunteer Wheat

Weeds compete with winter wheat for resources. Competition from weeds directly reduces yield and profitability, and indirectly by slowing harvest operations and increased machine repair. Some weeds also reduce the harvest quality of the wheat taken from the field. Some weeds serve as hosts for arthropod and disease pests of winter wheat.

The control of volunteer wheat helps reduce the incidence and severity of several pests. This practice limits the development of WSMV and its vector, the wheat curl mite. Wheat curl mites have a life span of about 10-12 days. Producers can control WSMV by destroying volunteer wheat at least two weeks prior to wheat emergence. This practice eliminates the wheat curl mites that spread WSMV. Coupling volunteer wheat destruction with a late planting schedule can greatly reduce losses from WSMV. This is especially important in the Panhandle and northwestern Oklahoma, where fall infections of WSMV are more likely to occur and cause substantial yield loss. Volunteer wheat can also serve as a host for aphids that spread BYDV, for Hessian fly, and for leaf rust. Thus, controlling volunteer wheat may reduce the potential pests before they become problematic.

Crop Rotation and Residue Destruction

Crop rotation and residue destruction can help limit pests by reducing the initial level of pests that overwinter or oversummer in a harvested wheat field. This is especially true for diseases such as tan spot, Septoria or Stagonospora leaf and glume blotches, for arthropod pests such as Hessian fly or winter grain mite, and for a number of weed pests. Until recently, most choices for rotations involved summer crops such as corn, sorghum or soybean. Canola has been increasing in acreage in the Southern Great Plains because it is a winter broadleaf crop that allows for the control of some difficult grassy weed problems.

Natural Enemies

Some wheat pests have natural enemies that help limit them from causing economic damage. Several insects can help reduce cereal aphid numbers, including the wasp *Lysiphlebus testaceipes*, and several species of lady beetles. There are even some natural enemies of weeds that can play a role in pest management, including a mite that feeds on field bindweed. Research is currently underway to evaluate and utilize these natural enemies in a pest management program. An aphid sampling program called “Glance ‘n Go” has been developed for management of greenbugs in winter wheat, and it also takes into account the level of activity of the wasp *Lysiphlebus testaceipes*.

Scouting and Monitoring

Integrated Pest Management (IPM) of wheat is an information intensive system. This requires regular field scouting for the presence of signs and symptoms of pests (arthropods disease and weeds) and their damage. It also involves recordkeeping so that long term adjustments of the management plan can be made, based on observed changes. It should also be used before any pesticide application is made. Scouting should begin before the crop is planted, to evaluate weed presence and continue through harvest, to evaluate any adjustments that might be needed for the next crop. This process should include soil sampling for fertility management plans.

Chemical Controls

Chemicals can be used to control a number of diseases, insects, and weeds that disrupt wheat production. They can be applied as preventative or corrective controls. Seed treatments can control plant diseases such as root rots, certain foliar wheat diseases in the fall, common bunt (stinking smut), and loose smut. Seed treatments are designed to help control insects such as wireworms and cereal aphids. Preplant applications of herbicides can control various weeds, and some insecticides are applied at planting. Pesticides applied as foliar sprays can control certain diseases, insects, and weeds common in wheat fields. Yield increases that result from chemical application are not always economically beneficial. For example, the yield increase obtained may not compensate for the costs incurred for chemicals and their applications. Generally, producers that grow a susceptible wheat variety with a high yield potential (at least 30-40 bu/acre), depending on the price of wheat, are more likely to obtain an economic benefit from chemical applications.

Summary:

Now is the time

Table 3: Wheat Pest Management Practices in the Southern Great Plains (Disease, Insect and Weed Pests; Percent Acres Practiced, 2009)

Prevention, Avoidance, Monitoring, Suppression	Colorado (%acres practiced)	Kansas (%acres practiced)	Oklahoma (%acres practiced)	Texas (%acres practiced)
Biological pesticides used	2	0	4	0
Beneficial organisms released	1	1	0	0
Crop residues removed or burned down	4	11	17	7
Crop rotation	35	39	11	29
Encouraging natural enemies	5	1	4	8
Ground covers, mulches	71	30	33	32
Planting date/Harvesting date adjusted	40	32	25	19
Resistant varieties	39	35	22	26
Row spacing, plant density, or row directions adjusted	20	13	10	20
Pesticide Mode of Action Rotation for Resistance Management	5	5	9	3
Sanitation (Implements cleaned after field work to reduce pest dispersion)	44	48	49	20
Scouting data compared with published thresholds	11	12	18	5
Tillage: Conventional	31	35	48	57
Trap Crop for Insect Management	0	0	0	1
Tillage: No-till or Conservation Tillage	79	47	44	35
Use of certified pest-free seed treated with pesticide seed treatment	6	12	19	24

Source: USDA NASS Quick Stats, 2009

Table 4: Scouting/Decision-making Practices in the Southern Great Plains (Disease, Insect and Weed Pests, Percent Acres Practiced, 2009)

	Colorado (% acres practiced)	Kansas (% acres practiced)	Oklahoma (% acres practiced)	Texas (% acres practiced)
Scouted for Disease	58	51	59	64
Scouted by Operator, Partner, Family member	89	85	93	86
Scouted by commercial scout	9	12	5	4
Scouted by Farm Supply or chemical dealer	2	0	1	2
Scouted by employee	-	2	1	8
Scouted for Insects/Mites	73	50	78	75
Scouted by Operator, Partner, Family member	95	85	93	83
Scouted by commercial scout	4	12	7	3
Scouted by Farm Supply or chemical dealer	1	0	1	3
Scouted by employee	-	2	1	7
Scouted for Weeds	89	84	76	83
Scouted by Operator, Partner, Family member	92	92	91	88
Scouted by commercial scout	6	8	7	3
Scouted by Farm Supply or chemical dealer	1	0	1	2
Scouted by employee	1	0	1	7
Established Scouting Process used	14	7	15	4
Field Mapping used	8	9	10	1
Weather Data Used to assist Decisions	28	18	21	14
Written or Electronic Records Kept	17	9	13	4

Source: USDA NASS Quick Stats, 2009

Table 5: Fungicide, Herbicide, Insecticide Use in the Southern Great Plains; (Percent Acres Applied, 2009)

	Colorado (% acres treated)	Kansas (% acres treated)	Oklahoma (% acres treated)	Texas (% acres treated)
Fungicide: Any	-	-	-	-
Fung: Azoxystrobin				
Fung: Propiconazole				
Fung: Prothioconazole				
Fung: Trifloxystrobin				
Herbicide: Any	75	51	53	36
Herb: 2,4-D	78		16	14
Herb: Bromoxynil	-			
Herb: Chlorsulfuron	-	17	10	
Herb: Dicamba	5	10	9	5
Herb: Flucarbazone	31			
Herb: Fluroxypyr	-			
Herb: Glyphosate	40	16	30	23
Herb: Imazamox	95			
Herb: MCPA	4			
Herb: Metsulfuron-methyl	31	22	10	10
Herb: Propoxycarbazone	-			
Herb: Pyroxsulam	-			
Herb: Thifensulfuron	21	6		7
Herb Triasulfuron	89			8
Herb: Tribenuron-methyl	21	6		
Insecticide: Any	17	-	12	9
Insect: Azadiractin				
Insect: chlorpyrifos	10		10	7
Insect: dimethoate				
Insect: Lambda-cyhalothrin				

Source: USDA NASS Quick Stats, 2009

Arthropod Management

Aphids

Aphids are soft bodied insects with twin projections, called cornicles that resemble exhaust pipes protruding from the back of their abdomen. They have needle-like mouthparts that they insert into plants and suck plant juices. Aphid populations are capable of increasing quickly because the aphid matures rapidly (sometimes in 7 days or less), and will give birth to live young, which are normally all females. Aphids often feed in colonies comprised of adults and immature nymphs.

Aphids can cause damage to plants in several ways. They can reduce plant growth directly as they remove plant sap. Some aphids inject a toxin with their saliva that injures the plant host. Many aphids are known to transmit plant diseases caused by viruses.

Aphids have many natural enemies, including lady beetles, parasitic wasps, lacewings, syrphid flies and other insects. Parasitic wasps lay an egg inside a living aphid, and the immature wasp larva feeds on the aphid. Parasitized aphids, called mummies, become swollen and turn tan or black in color. They remain attached to the leaf until the adult parasite emerges. The presence of mummies and natural enemies such as lady beetles should be noted before a decision to spray for aphids made.

Greenbug: S*chizaphis graminum*
Lime-green colored with a darker green stripe on its back-. When mature, it measures about 1/16 inches long.

Nature of Damage: The greenbug is one of the most important insect pests of winter wheat. Greenbug feeding causes yellowing of young wheat leaves, and orange-red spots on the leaves of older plants. They often in concentrated patches within a field, and damage often occurs as small circular patches radiating out from dead spots. When numerous, they can stunt plants and eventually kill them. If seedlings are infested in fall, they seem to be more susceptible to winter kill. Greenbugs are also carriers of the virus that causes Barley Yellow Dwarf disease.

Management: Planting at optimal times for grain production will reduce the risk of greenbug infestations. Grazing wheat for winter pasture can also reduce greenbug numbers. There are a few winter wheat varieties that have resistance to greenbugs. Natural enemies such as the parasitic wasp, *Lysiphlebus testaceipes* can keep populations from reaching damaging levels. Fields should be scouted before applying an insecticide. Current recommendations include using the Glance 'n Go scouting system, or scouting in at least five locations in a 40 acre field.

Russian wheat aphid: *Diuraphis noxia*
1/16 inches long, light green, spindle shaped with short antennae and no prominent cornicles. It has a projection above the "tail" that gives it a "double tail" appearance.

Nature of Damage: Russian wheat aphid is another important aphid pest of winter wheat. It feeds on the newest growth on the plant, and contains substances in its saliva that effectively causes cessation of chlorophyll production. As it feeds, it causes the leaf to curl, creating an enclosure that protects it from climate, natural enemies, and insecticides. Damage symptoms include white, yellow or purple longitudinal streaks on the leaf and prostrate growth of the plant. This insect is normally more of a problem in Colorado, western Kansas and the Oklahoma and Texas Panhandles.

Management: Resistant varieties are available, but it is crucial to know what biotype is most common in order to select the variety. Fields should be scouted before applying an insecticide. Scouting for Russian wheat aphid requires practice, but an efficient, precise sampling method is available.

Bird cherry-oat aphid: *Rhopalosiphum padi*
Aphids are olive-green with a red-orange patch surrounding the base of each cornicle. "Old", wingless overwintering adult aphids may appear black 'm color.

Nature of Damage: This aphid does not cause visible injury symptoms; however research in the northern plains and unpublished research from Oklahoma suggests that it can cause yield loss at levels of 20-50 or more per tiller before boot to heading stage. Heavy infestations in spring may cause the flag leaf to roll up into a corkscrew shape that can trap awns, and will cause plants to become sticky with honey dew, the liquid waste that is excreted by aphids as they feed. They are very efficient vectors of Barley Yellow Dwarf virus, and depending on the timing of infestations from virulent aphids, can cause substantial yield loss.

Management: Fields should be scouted before applying an insecticide. Thresholds are simple and need refinement.

English grain aphid: *Sitobion avenae*
Description: Aphids are bright green with long legs and cornicles which gives it a "spidery" appearance. Measures 1/8 inches when mature. Both the legs and cornicles are black.

Nature of Damage: English grain aphid is more common late in the growing season, and prefers to feed on the awns and wheat head. It is a vector of Barley Yellow Dwarf virus.

Management: English grain aphid is not an economically important pest of winter wheat in Oklahoma.

Corn leaf aphid: *Rhopalosiphum maidis*

Description: Aphids are bluish-green with short cornicles. The antennae, legs and cornicles are black.

Nature of Damage: An occasional pest of winter wheat. Sometimes infest seedling wheat in the fall. It is a vector of Barley Yellow Dwarf virus.

Management: Corn leaf aphid is not an economically important pest of winter wheat and control is not recommended, since natural controls seem to keep it in check.

Rice root aphid: *Rhopalosiphum rufiabdominalis*

Description: Aphids are olive-green with a red-orange patch surrounding the base of each cornicle. This aphid looks nearly identical to bird-cherry oat aphid.

Nature of Damage: An occasional pest of winter wheat, occurring most frequently on seedling wheat in the fall often the first aphid found infesting wheat. It shows a preference to feed at or below the soil surface on the crown and roots of seedling plants. It is a vector of Barley Yellow Dwarf virus.

Management: Rice root aphid is not considered an economically important pest of winter wheat and control is not recommended. However, they are suspected to be a cause of early-season infestations of Barley Yellow Dwarf virus. Field tests suggest that foliar insecticide applications are not very effective at reducing rice root aphid infestations.

Caterpillars

Armyworm: *Mythimna* (*Pseudaletia) unipuncta*

Description: Caterpillars are 1 ½ inches long when mature, smooth bodied, dark gray to greenish black in color with 5 prominent longitudinal stripes along the length of the body.

Nature of Damage: Armyworms typically become a pest of wheat just before, and during heading. Damaging outbreaks are usually associated with cool, damp springs. Armyworms are often more numerous in low-lying areas, areas where wheat has lodged, or in fields that have dense plant stands. Caterpillars feed first on the leaves, then on the awns, and may finally feed on immature kernels that have not reached soft dough stage. They hide during the day, preferring to feed at night or on overcast days. Armyworms have been known to eat the green stem tissue just below the base of the grain head and clip it off; however, head clipping in wheat is rare. These caterpillars will leave mature fields "en mass" and attack lawns, corn, or sorghum fields.

Management: Armyworm infestations can be reduced by taking care not to over-fertilize with nitrogen. Adult female moths prefer to lay eggs in lush, thick plant stands. Fields should be scouted by counting the number of larvae in one linear foot of row at 10 different locations. During daylight, check for caterpillars underneath the dead plant material; or take counts in late evening when they become more active. Parasitic wasps (*Apantles* spp.), tachinid flies(*Nemosturimia* spp.) and other predators coupled with bacterial and fungus diseases (*Metarhizium anisopliae* and *Furia virescens*) along viruses often kill virtually all armyworms during periods of outbreak before they complete their lifecycle. The treatment threshold for armyworms is 3-5 larvae per linear foot of row.

Army cutworm: *Euxoa auxilaris*

Description: This caterpillar is gray striped, pale greenish-gray to brown caterpillar. They curl up into a fight "C" when disturbed.

Nature of Damage: The first indication of army cutworm injury appears as semi-circular areas eaten from the edge of the leaf, or as holes chewed through the leaf. If plants are slow to grow, army cutworms will eat the plant down to the soil line. Damage may appear in "spots" in a field. Army cutworms overwinter in the soil as partially grown larvae. They can tolerate cold temperatures, and often become active early in winter anytime climb above freezing. This insect is more of a problem when wheat planting and/or growth is delayed as adult moths prefer to lay eggs in bare fields.

Management: Late planting increases the likelihood of an infestation. Check fields regularly for army cutworms throughout the winter. They can be found by disturbing the top 2 inches of soil. Check 5-1 0 locations in a field, and take extra samples in "hot spots. Under optimal growing conditions, it takes 4-5 larvae per linear ft of row to cause economic injury, but under dry, cool conditions, control may be warranted when 2-3 worms are found per linear ft. of row.

Fall armyworm: *Spodoptera frugiperda*

Description: Caterpillars may reach 1 ½ inches when mature, green or black in color, with a prominent inverted white "Y" on the front of its head.

Nature of Damage: Fall armyworms are typically a problem on newly seeded winter wheat before a killing frost occurs. Young larvae will not chew completely through a leaf creating a "window pane" effect' on the leaf. As they grow, they chew along the margins of leaves. Heavy numbers can completely destroy a planting. They are often more numerous along the edge of a field.

Management: Fall armyworms cannot tolerate freezing temperatures, so they typically are killed after a killing frost. Fall armyworms are rarely present in large enough numbers to cause economic injury, but early planted fields are at greatest risk. In seedling wheat, the treatment threshold is 2-3 larvae per foot of row and increases to 3-4 per foot of row as plants get older.

Pale Western cutworm: *Agrotis orthogonia*

Description: Larvae are grayish white as small (less than ½ inches) or gray (greater than ½ inches) with no conspicuous markings and reach 1 ½ to 2 inches. They grow through 6-8 instars. They will feed through the spring, much like army cutworms.

Nature of Damage: Pale Western cutworms cut seedlings under the soil surface; the depth at which they feed depends on soil moisture because they feed just above the moisture line of the sub-soil moisture. Because of their feeding habits, it takes fewer caterpillars to cause the same level of damage when compared to army cutworms. Injury from small cutworms appears as semi-circular areas eaten from the edge of the leaf, or as holes chewed through the leaf. Damage may appear in "spots" in a field. Pale Western cutworms overwinter in the soil as partially grown larvae. They can tolerate cold temperatures and prefer dry soil conditions. This insect is more of a problem when wheat growth is delayed due to moisture stress.

Management: Fields should be scouted before applying an insecticide. They rarely require control.

Wheat head armyworm: *Faronta diffusa*

Description: Larvae vary from greenish to cream colored, depending on the maturity of the gran they have consumed but all have pair of longitudinal lines down each side of their body; one white and one brown.

Nature of Damage: Multiple generations occur, but they are most damaging to mature grain kernels. They feed on them causing them to be blown out of the combine, or if they remain, the grain may be docked as it is brought into a grain elevator because the damaged kernels resemble IDK (insect damaged kernels).

Management: Fields should be scouted before applying an insecticide.

Other Insects

False wireworm (Coleoptera: Tenebrionidae) and Wireworm (Coleoptera: Elateridae)

Description: Both are cylindrical, yellow worm-like larvae that live in the soil. As they age, they darken to a brownish color. There are several species that cause injury so their size is variable.

Nature of Damage: False wireworms and wireworms tend to cause greatest injury in a dry fall that followed a dry summer, especially if the seed was "dusted in" and did not receive an activating rain for rapid germination. Larvae follow the drill row and eat inside of the seed. Because they are not uniformly distributed in a field, injury may occur in spots within a field.

Management: Seed treated with a neonicotinoid insecticide can reduce stand loss. The damage potential of false wireworms can be evaluated by sifting through one-square-foot samples of soil taken to a depth of 2-3 inches at several locations.

Grasshoppers: (Orthoptera: Acrididae)

Description: Grasshoppers are long, cylindrical with a long pair of hind legs that are modified for jumping. There are numerous species that commonly occur in the Southern Great Plains.

Nature of Damage: Grasshoppers are most likely to damage wheat in the fall. They eat leaves and stems as they emerge from the ground. They typically move in to field margins, which suffer greatest damage. In late spring and early summer, they may climb stalks and chew on kernels causing damage that resembles granary weevil feeding. They can also clip heads like armyworms.

Management: Check fields for grasshopper numbers before applying an insecticide treatment. If 10-15 grasshoppers are present in field borders, or 3 -4 are in planted fields, then an insecticide may be warranted. A few insecticides are labeled for border treatments, and may provide some relief against moderate infestations. According to Nebraska recommendations, the treated strip will work best if it is at least 150 ft. wide.

Hessian fly: *Mayetiola destructor*

Description: The adult fly is tiny, fragile and mosquito-like and measures 1/8 inches. The legless maggot-like larvae are reddish or orange when newly hatched and mobile. They crawl and begin to feed at the crown or joust above the joint of a stem. After molting they remain stationary and turn whitish-green as they feed. When they are ready to pupate, they form a dark brown puparium which is normally the most common sign of Hessian fly infestations.

Nature of Damage: Injury is caused by larval feeding on stem tissue at the crown of young plants, or just above the nodes of jointed wheat. Young plants suffer the most serious injury, as plants become stunted, and secondary tillers that tested fail to develop. Young plants that are infested are actually a darker green to bluish-green color, and the leaves are thicker. When larvae feed on jointed stems, they become weakened and lodge. They are most likely to occur in eastern Oklahoma.

Management: Cultural control and resistant varieties are the most effective way to manage Hessian fly. Planting after the fly-free date, coupled with the use of resistant varieties is very effective management strategy. Fly-free dates work well in Colorado and most of Kansas, but are not effective in Oklahoma and Texas. Additional controls include burying stubble, and eliminating volunteer wheat stands. Until very recently, no effective chemical control options were available for Hessian fly, but imidacloprid or thiomethoxam applied as a seed treatment are labeled for suppression.

Wheat stem maggot: *Meromyza americana*

Description: Wheat stem maggot is the larvae of a fly. It measures ¼ inch long and is greenish in color. It lives inside the stem of the wheat plant.

Nature of Damage: Up to 3 or more generations per year. Adults lay eggs on the stems and leaves of late jointing or early heading plants. Larvae hatch and bore into the upper stem, usually above the top node. As they tunnel, they sever the stem, which in turn, causes the wheat head to turn white and die.

Management: No resistant varieties are known, but delayed planting and destruction of volunteer plants may reduce populations.

White grub: *Cyclocephala spp., Phyllophaga spp.*

Description: Immature stage of May/June beetles. They possess a white body with a brown head capsule, 3 pair of brown legs, and a bulbous last abdominal segment is usually filled with digested plant material and soil giving it a darker, greyish color. They typically curl up in a distinctive C shape when disturbed.

Nature of Damage: White grubs are sporadic pests,. They can cause direct damage by feeding on the roots of plants. As they feed on seedlings, they can cause stand loss. Look for wilted seedlings after emergence.

Management: Control summer weeds, as that is when eggs are laid in the soil. Seed treated with a neonicitenoid has shown to reduce damage.

Mites

Mites are not true insects, but are closely related to ticks and spiders. As adults, they possess 4 pair of legs. Their mouthparts are modified to suck plant juices. Three mites are potential pest problems in winter wheat in Oklahoma.

Brown wheat mite: *Petrobia latens*

Description: Tiny, about the size of a period on newsprint. They are brown, with four pairs of yellowish legs. The front pair of legs are about twice as long as the back pair.

Nature of Damage: Brown wheat mites injure wheat by extracting plant sap with their mouthparts, which causes plants to dry out and appear withered and scorched. They are more common in western Colorado, western Kansas, Oklahoma and Texas and the Oklahoma and Texas Panhandle.

Management: Control with chemicals can be difficult because they tend to infest plants that are already drought stressed, and insecticides registered for control will be less effective. Treatment thresholds are not well defined; treat when mites are present and injury is evident.

Wheat curl mite: *Eriophyes tulipae*

Description: Sausage-shaped, white, with four legs, measures about l/100 inches long. Requires a magnifying glass to see it on the leaf.

Nature of Damage: While this mite can cause direct injury to wheat, it is an important pest because it transmits High Plains virus, Wheat Streak Mosaic virus. Feeding causes leaves to roll up, giving the leaf an "onion leaf' appearance. Mites can be seen by carefully unrolling the leaves, and examining it with a 10x hand lens.

Management: Wheat curl mite infestations are encouraged by volunteer wheat that grows throughout the summer. The mite is carried on winds into newly planted fields where it transmits the disease. Clean tillage, destruction of volunteer wheat, and late planting will aid in managing wheat curl mite. There are no effective chemical controls registered for wheat curl mite.

Winter grain mite: *Penthaleus major*

Description: Dark brown, with eight orange-red legs and an orange or red spot on the upper abdomen.

Nature of Damage: There are two generations of winter grain mite each year. The first begins in the fall, as over-summering eggs hatch. The second generation begins sometime in January, and reaches peak numbers in March. These mites feed on the leaf sheaths and shoots near- the ground. They move up the plant at night and on cloudy days. Leaves take on a silvery gray color when injured and leaf tips may turn brown.

Management: Problems with winter grain mite are associated with continuous wheat production, so crop rotation is an effective management strategy. They are also more numerous under minimum tillage. Thresholds have not been developed, but treatment is recommended when the wheat sustains visible injury, and mites are present in numbers that exceed 200-300 mites per plant.

Table 6: Arthropod Pest Activity Calendar

Insect/Mite	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Aphids	KOT	KOT	KT	CKOT	CKOT	C		OT	CKOT	CKOT	KOT	OT
Army cutworm	CO	CKO	CKT	CKT	CT				C	C	CK	CKO
Armyworm			T	KOT	CKOT	CK						
Brown wheat mite	C	CK	KT	CKT	CT					C	CK	CK
Fall armyworm			T	T	T	T			TK O	KOT	K T	T
False Wireworm	CK	CKO	CKO	CKO	CKO	C		O	CKOT	KOT	CKTO	CKTO
Grasshopper				KO T	KO T	CT			CK	C		
Greenbug	T	KOT	CKOT	CKT	CKT	C			CKO	CKOT	KOT	KOT
Hessian fly	KOT	KOT	KOT	KOT	KOT				KOT	KOT	KOT	KOT
Pale Western cutworm			KT	CKT	CKOT	KOT						
Russian wheat aphid	CKOT	CKOT	CKOT	COT	C	C		O	CO	COT	COT	COT
Wheat curl mite	COTK	COTK	COTK	COTK	COTK	C		O	CKOT	CKOT	CKOT	CKOT
Wheathead armyworm				CK	CK							
Wheat stem maggot					CK	CK			K	K		
Wheat stem sawfly		C	C	C	CK	CK	C					
White grub	CKO	CKO	CKO	CKO	CKO	C			CKOT	C	C	COT
Winter grain mite	KOT	KOT	KOT	KOT								
Beneficial Insects	CKOT	CKOT	CKOT	CKOT	CKOT	CKOT			CKOT	CKOT	CKOT	CKOT

(C=Colorado, K=Kansas, O=Oklahoma, T=Texas)

Table 7: Wheat Arthropods (Biological Control Efficacy)

Biological Control Organism	Arthropod Pest																
	Aphids	Army Cutworm	Armyworm	Brown Wheat Mite	Fall Armyworm	False Wirewrom	Grasshopper	Greenbug	Hessian Fly	Pale Western Cutworm	Russian wheat aphid	Wheat curl mite	Wheat head armyworm	Wheat stem maggot	Wheat stem sawfly	White Grub	Winter grain mite
Aphid midges	F	P						F			F						
Bacillus popillae (Milky spore disease)																P	
Beneficial mites		P															
Big-eyed bugs	P	P									G						
Beneficial nematodes																	
Green lacewings	F							F			P						
Ladybird beetles	G	P						G			G						
Parasites	G	P	G		P			E-G	F-P		F-P	P	P			P	P
Spiders	G	P	G		P			E-P			F						

E=Excellent, G=Good, F=Fair, P=Poor, Blank=Unknown

Table 8: Wheat Arthropods (Cultural Control Efficacy)

Cultural Practice	Arthropod Pest																
	Aphids	Army Cutworm	Armyworm	Brown Wheat Mite	Fall Armyworm	False Wirewrom	Grasshopper	Greenbug	Hessian Fly	Pale Western Cutworm	Russian wheat aphid	Wheat curl mite	Wheat head armyworm	Wheat stem maggot	Wheat stem sawfly	White Grub	Winter grain mite
Baited traps	P	U	P	P	P							P					G
Crop rotation	F	U				G			F	F	G-F	P		F			
Resistant varieties	P	U					G	G	G		G	F		G	G		
Sanitation		U		G		G			G		G	G			F		
Sticky traps		U															
Use of certified pest-free seed		U									F						
Weed control	F	F					G					G				F	G
Fertility management	F	U		F							F						
Irrigation management	G	U		F													
No-till/ Conservation till	F	U						F						P	P		
Encouraging natural enemies	F	U						G		G	G	F					
Reducing nitrogen levels																	
Proper harvest times													G				
Spot spraying							G										
Preventing plant stress	G			F													
Planting date	G	G-F		E			F	G			F		G		F		
Tillage							F	F								F	

E=Excellent, G=Good, F=Fair, P=Poor, Blank=Unknown

Table 9: Wheat Arthropods (Insecticide/Acaricide Efficacy)

Registered Insecticide	Arthropod Pest																	
	Aphids	Army Cutworm	Armyworm	Brown Wheat Mite	Fall Armyworm	False Wirewrom	Grasshopper	Greenbug	Hessian Fly	Pale Western Cutworm	Russian wheat aphid	Wheat curl mite	Wheat head armyworm	Wheat stem maggot	Wheat stem sawfly	White Grub	Winter grain mite	Beneficial Insects Toxicity
carbaryl (Sevin)	P	F	G		G	G	G	P		P	P	F						M
chlorpyrifos (Lorsban)	E	F-P	G	G	G		G	E		P	E							L
chlorpyrifos + gamma cyhalothrin (Cobalt)	E	E	E		E		G	G		E	E							L
cyfluthrin (Baythroid)	G	E	E	G	E		G	G		E	F			G				H
dimethoate	G	P	P		F		G	G		P	G							H
gamma cyhalothrin (Proaxis)	G	E	E		E		G	G		E	G			G				H
imidacloprid (Gaucho)	E			F		G	G	G	F	P	G					F		M
lambda cyhalothrin (Karate)	G	E	E		E		G	G	F	E	G			G				H
Lannate	G	F	E		E		G	F		P	F							H
malathion	F	P	F		F		F	E		P	F							M
methyl parathion	E	E			E		E	F		E	E	F					G	H
spinosad (Tracer)			G-E		G-E		G	G		P	F							L
thiamethoxaam (Cruiser)	E	E				G			F	P	E					G		L
zeta cypermethrin (Mustang)	G		E	F	E		G	G	P	E	G			G				H

Efficacy E=Excellent, G=Good, F=Fair, P=Poor, NL = Not Labeled, Blank=Unknown
Beneficial Toxicity H=Highly toxic, M=Medium, L=Low

Disease Management

Diseases Caused By Fungi

Common Bunt (Stinking smut): *Tilletia spp*.

Symptoms: Infected plants may be stunted, but symptoms generally don't appear until emergence of heads. Bunted heads remain green longer than healthy heads. Glumes become spread apart, and the seed is converted into totally to gray-blackish-brown balls of spores. Spores have a foul, fishy odor. Heavily infested fields produce dark clouds of spores when harvested.

Management: Common bunt is typically managed by planting noninfested certified seed that has been treated with a labeled chemical seed treatment. Resistant varieties also are available, but reaction of current varieties to common bunt is not known. Planting early in warm (>75 F) soils can help wheat to avoid infection; however, use of labeled seed treatments is the best tool to manage this disease.

Common Root Rot: *Bipolaris sorokiniana*

Symptoms: Common root rot can be expressed as a seedling blight, root rot, and/or foot rot. Symptoms indicative of common root rot include a dark-brown to black subcrown internode that may extend onto the crown. The primary and secondary root systems may become discolored. Infected plants typically mature early and produce shriveled seed or no seed at all.

Management: As with other root rots, common root rot can be managed through shallow seeding in cool soils to encourage emergence and growth, chemical seed treatments and planting pathogen-free seed. Avoid excessive nitrogen fertilization. Crop rotation with a broadleaf, non-host crop also can limit disease.

Dryland Root Rot (*Fusarium culmorum*, F. *pseudograminearum*, F. *graminearum*)

Symptoms: The roots, crown, and lower nodes and internodes of wheat will turn brown on infected plants. Discoloration may extend up to two internodes above the soil, and cottony pink-colored mycelium will often grow within or between the culm and lower leaf sheath.

Management: Dryland root rot can be managed through shallow seeding, chemical seed treatments and planting pathogen-free seed. Avoid excessive nitrogen fertilization. Crop rotation with a broadleaf, non-host crop also can help reduce disease

Rhizoctonia Root Rot: *Rhizoctonia solani*

Symptoms: Plants or seedlings killed by Rhizoctonia root rot often occur in patches scattered throughout a field. Diseased plants in such areas may developed stiff, bluish-colored foliage. Lesions on roots are usually small and root ends often appear tapered as a result of rotting by the fungus.

Management: Rhizoctonia root rot is difficult to control. Although there are fungicides labeled for use, these offer only partial protection or suppression at best. Tillage and other practices that facilitate breakdown of residue as can contribute to controlling this root rot.

Fusarium Head Blight (scab)

Karnal bunt: *Tilletia indica*

Symptoms: In contrast to common bunt, developing wheat kernels become infected and are completely or *incompletely* converted into smut spores. Typically, only a few seeds in a head are infected. As with common bunt, spores have a foul, fishy odor.

Management: Karnal bunt is difficult to control because infection occurs at flowering. However, prevention via quarantine methods currently is used to keep Karnal bunt from becoming established in the major wheat growing areas of North America.

Leaf Rust: *Puccinia triticina*

Symptoms: Leaf rust is one of the most widely distributed diseases of winter wheat. Spores produced by *P. triticina* appear in pustules formed on wheat foliage, stems and/or heads in the fall or spring. Some chlorosis (yellowing) or necrosis (flecks of dead tissue) also can be associated with this disease. As wheat nears maturity, the orange-colored spores are replaced with dark-grey to black teliospores.

Management: Management of leaf rust is accomplished through use of resistant cultivars, the use of seed treatments, and timely applications of fungicides.

Loose Smut: *Ustilago tritici*

Symptoms: The disease becomes most visible just after heading. Loose smutted heads are blackened, and have masses of dry, black teliospores where grain would typically be formed. Within a few days, the spores are dislodged so that only the bare spikelet remains (unlike common bunt). Also unlike common bunt, spores of loose smut have no odor.

Management: Cultivar resistance exists, but the reaction of most current cultivars is not known. Hot-water or heat seed treatments and sanitation via seed certification also help to manage loose smut, but treating seed with labeled seed treatments is the most effective management practice.

Powdery Mildew: *Blumeria gramminis*

Symptoms: Powdery mildew is most prevalent on the upper surface of lower leaves, where whitish or greyish patches of cottony mycelium and conidia are formed. The other side of the leaf will often show chlorotic patches directly opposite where the fungus is growing on the leaf. Later, sexual fruiting bodies, called cleistothecia, develop and show up as black or brown dots within the old fungal colonies on the leaf.

Management: Resistant cultivars, labeled foliar fungicides, crop rotation, clean cultivation and volunteer wheat destruction coupled with judicious use of nitrogen fertilizer can reduce infections.

Seedling Blight: *Bipolaris, Fusarium, Rhizoctonia, Pythium*

Symptoms: Brown lesions that develop on the coleoptiles, roots and culms.

Management: Seedling blight can be managed through shallow seeding, chemical seed treatments and planting pathogen-free seed. Avoid excessive nitrogen fertilization. Crop rotation with a broadleaf crop can limit disease.

Septoria leaf blotch: *Septoria tritici*

Symptoms: Symptoms of *Septoria tritici* (leaf) blotch initially appear as tan or brownish oval or irregularly shaped lesions on leaves. With time, small dark-brown to black specks appear in these lesions. It is in these specks, which are called pycnidia, that spores of the fungus are produced. Cool (59-68°F), moist conditions favor the spread and severity of this disease.

Management: Resistant cultivars, foliar fungicides, and residue elimination can be effective in controlling Septoria leaf blotch.

Stagnospora Glume Blotch: *Stagnospora nodorum*

Symptoms: Symptoms of *Stagnosporia nordorum* (glume) blotch are similar to those of Septoria leaf blotch. This fungus tends to infect the upper leaves and glumes of developing wheat heads because its optimum temperature for infection is slightly higher (68-81°F) than that for *Septoria tritici*. It produces pycnidia in lesions, similar to those seen in Septoria leaf blotch.

Management: Minimum tillage, coupled with continuous planting of wheat may increase the risk of this disease. Effective management practices include planting disease-free seed, crop rotation with a broadleaf (non-host) crop and use of wide row spacing to increase aeration. Systemic fungicides applied to foliage can be effective, but application must be made early (GS 7-8), which often would indicate a second application later to control other foliar diseases such as leaf rust.

Stem rust (*Puccinia graminis sp. tritici*)

Symptoms: Stem rust has pustules similar to leaf rust on that can be found on stems, leaves, and/or heads. However, the spores of stem rust tend to be more of a brick-red to brown color rather than the reddish-orange spores indicative of leaf rust. Pustules of stem rust also tend to be larger and sometimes more diamond shaped compared to leaf rust, which are more circular.

Management: Management of stem rust can be accomplished through use of resistant cultivars and timely applications of fungicides.

Stripe Rust (*Puccinia triiformis . sp. tritici*)

Symptoms: Symptoms initially appear as chlorotic flecks or patches on leaves. Small, yellow-orange pustules develop. In seedlings distinct stripes do not develop, but on more mature plants that have begun stem elongation, pustules form in stripes between leaf veins. With plant maturity, the yellowish-orange pustules turn black.

Management: Management of stripe rust can be achieved through use of resistant cultivars, use of seed treatments, and timely applications of fungicides.

Tan Spot (*Phrenophora tritici-repentis*)

Symptoms: Tan spot lesions on leaves characteristically have a small, tan to brown center, which is surrounded by a yellow circular border. As leaves mature, lesions expand, kill tissue, and can impart a tannish hue to leaves. Lesions, which initially are found in late winter or early spring on lower leaves, result from infection by spores released from fruiting bodies that formed on wheat residue left in the field after harvest**.**

Management: Crop rotation with non-host crops is effective, as is clean tillage. Systemic fungicides also can be used to reduce disease severity.

Take all: *Gaeumannomyces graminis var. tritici*

Symptoms: Development of take-all is favored in moist, neutral-to-alkaline soils. The presence of takeall is indicated by the production of whiteheads similar to other root rots, but can be reliably diagnosed by the presence of blackened roots and dark runner hyphae on roots.

Management: The fungus survives on wheat residue, which means that rotation with a non-host crop for 1-2 years is an effective management strategy to control take-all. Eliminating grassy weeds that serve as a host for the fungus also can help, as can clean tillage.

Diseases Caused By Viruses

Barley yellow dwarf : Caused by numerous viruses in either the genus *Luteovirus* or *Polerovirus* that are transmitted by many aphis including bird cherry-oat aphid, *Rhopalosiphum padi*; the corn leaf aphid, *Rhopalosiphum maidis*; the greenbug, *Schizaphis graminum*; and the English grain aphid, *Sitobion avenae*, and the rice root aphid; *Rhopalosiphum rufiabdominalis*.

Symptoms: Symptoms of barley yellow dwarf may appear in the fall or more commonly in the spring, depending on the time of infection and weather. Infections in fields often appear in inverted cone-shaped "pockets" interspersed throughout the field with the centers of the pockets most severely stunted and discolored. These pockets occur where infected aphids land and begin feeding and developing into larger populations. Seedling infections may be lethal and cause older leaves to become bright yellow. However, if the infection occurred later in the growing season, flag leaves may exhibit a reddish/purple or yellow discoloration.

Management: Resistant varieties are available. Planting later in the growing season reduces the length of time for infection by viruliferous aphids to occur in the fall, which typically caused the most severe disease. Removal of grassy weed hosts also can help. Control of aphid vectors through insecticide seed treatments can reduce early spread of the disease., and spraying with insecticide also can reduce BYD spread if scouting detects aphids before they reach high levels.

High plains disease: *High plains virus*, (*Wheat mosaic virus*) which is transmitted to wheat via the wheat curl mite, *Aceria tosichella*.

Symptoms: Infected leaves exhibit a mosaic pattern and chlorotic spots. Co-infection with *Wheat streak mosaic virus* results in plants that are mottled, chlorotic, severly stunted, and may result in the death of the plant. Mottling and a yellow mosaic pattern in parallel, discontinuous streaks develops on leaves.

Management: Elimination of volunteer wheat at least 2-3 weeks before planting reduces mite numbers to infect seedling wheat. Late planting reduces the time in the fall for infection to occur. Some wheat varieties perform better in wheat streak infested fields.

Wheat soilborne Mosaic: (Wheat soilborne mosaic virus, which is transmitted into wheat roots via a soilborne fungus-like protist, *Polymyxa graminis*)

Symptoms: Symptoms of wheat soilborne mosaic typically appear from late February or March. Symptomatic plants usually are observed in low-lying, wet areas and are stunted, with yellowish-green foliage. Closer examination of the leaves reveals a mosaic pattern; that is, the foliage will have small green spots or islands on a light green or yellowish green background.

Management: Planting resistant varieties is the only effective available management tactic.

Wheat Spindle Streak Mosaic: *Wheat spindle streak mosaic virus*, which is transmitted into wheat roots via a fungus-like protist, *Polymyxa graminis*

Symptoms: Wheat plants infected by *Wheat spindle streak mosaic virus* generally appear from early February to early March. Infected plants most often are in low-lying wet areas and appear similar to those infected with wheat soilborne mosaic virus; that is, stunted and appearing to have yellowish-green foliage. However, in contrast to wheat soilborne mosaic, plants infected with wheat spindle streak mosaic will have leaves that are light to medium green with yellowish spindles or streaks.

Management: Planting resistant varieties is the only effective available management tactic.

Wheat Streak Mosaic: *Wheat streak mosaic virus*, which is transmitted to wheat via the wheat curl mite, *Aceria tosichella*).

Symptoms: Leaves of plants infected with wheat streak mosaic virus generally appear light to medium green with yellow streaks, which usually are longer than the streaks on leaves of plants infected with wheat spindle streak mosaic virus. Varying degrees of yellowing (chlorosis) and tissue death (necrosis) are associated with wheat streak mosaic. Additionally, symptoms of wheat streak mosaic usually begin to appear in late April and May as temperatures increase, rather than in March as with wheat soilborne mosaic or wheat spindle streak mosaic.

Management: Elimination of volunteer wheat at least 2-3 weeks before planting reduces mite numbers available to infect seedling wheat. Later planting reduces time for seedling wheat to become infected in the fall, which is the most damaging. A few wheat varieties are now resistant to wheat streak mosaic, but most of this resistance is temperature dependent.

Wheat Disease Activity Calendar

It is difficult to summarize disease activity in the Great Plains due to wide differences in climatic conditions. Often, the overwintering structures or vectors are present throughout the growing season, and outbreaks are dependent on weather conditions that may or may not encourage disease development.

Table 10: Wheat Disease (Cultural Control Efficacy)

Cultural Practice	Plant Disease																		
	Common Bunt	Common Root Rot	Dryland Root Rot	Fusarium head blight	Glume Blotch	Karnal bunt	Leaf Rust	Loose smut	Powdery Mildew	Seedling Blight	Septoria leaf blotch	Stinking Smut	Stripe Rust	Tan spot	Virus: Barley yellow dwarf	Virus: High plains disease	Virus: Wheat soilborne Mosaic	Virus: Wheat spindle streak	Virus: Wheat streak mosaic
Crop rotation	P	P	P	F-P	F		P	P	F-P	P	F	P	P	F	P	P	P	P	P
Resistant varieties		P	P	F	F		E-G	P	E-G	P	F	P	E-G	E-G	G-F	P	E	E	F
Sanitation (Cleaned seed, tillage, burning)	P	P	P	F-P	F		P	P	F	P	F	P	P	F	P	P	P	P	P
Fertility management									F				E-F						
Irrigation management													G-F						
Weed (volunteer) Control																G			G
Proper harvest times	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Spot spraying	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

E=Excellent, G=Good, F=Fair, P=Poor, Blank=Unknown

Table 11: Wheat Diseases (Fungicide Efficacy)

Registered Fungicide	Plant Disease																		
	Common Bunt	Common Root Rot	Dryland Root Rot	Fusarium head scab	Stagnospora Glume Blotch	Karnal bunt	Leaf Rust	Loose smut	Powdery Mildew	Seedling Blight	Septoria leaf blotch	Stinking Smut	Stripe Rust	Tan spot	Virus: Barley yellow dwarf	Virus: High plains disease	Virus: Wheat soilborne mosaic	Virus: Wheat spindle streak	Virus: Wheat streak mosaic
Azoxystrobin				NR	G	NR	E		F(G)		VG	E	E	E					
Fluoxastrobin				NR			VG		G										
Pyraclostrobin				NR	VG		E		G		VG	E	G	E					
Trifloxystrobin																			
Cyproconazole																			
Metaconazole				G	VG		E		VG			E		VG					
Propiconazole				P	VG		VG		VG		VG	VG		VG					
Prothioconazole				G	VG		VG				VG			VG					
Tebuconazole				F	VG		E		G		VG	E		VG					
Prothioconazole + Tebuconazole				G	VG		E		G		VG	E		VG					
Metconazole + Pyraclostrobin				NR	VG		E		G		VG	E		E					
Propiconazole + Azoxystrobin				NR	VG		E		VG		VG	E		VG					
Propiconazole + Azoxystrobin				NR	VG		VG												
Propiconazole + Trifloxystrobin				NR	VG		VG		G		VG	VG		VG					
Tebuconazole + Trifloxystrobin				NR			E		G										
Seed treatments																			

Captan										G									
Carboxin										G									
Difenoconazole																			
Imadicloprid															F-G				
Imazilil			G							G									
Maneb																			
Mefenoxam																			
Metalaxyl		G	G																
Pentachloronitrobenzene																			
Tebuconazole																			
Thiamethoxam															F-G				
Triticonazole	G	G	G									G							
Thiram										G									
Triadimenol										G									

E=Excellent, VG = Very Good, G=Good, F=Fair, P=Poor, NR-Not Registered, Blank=Unknown

Weed Management

A well-designed weed management program should include as many of the following tactics as practical: delayed planting and harvest, crop rotation, use of quality seed, good seed bed preparation and other cultural practices, tillage, and chemical control before and after harvest with herbicides. Field monitoring (scouting) is an important way to determine the spectrum of weeds present in a field. An important activity in scouting for weeds is preparing a weed map. A weed map is a diagram of the field with notations on weed location, identification, and the estimated size of the weed-infested areas. Maps that show locations of different weed infestations are helpful in planning short- and long-term weed control programs. A good weed map may be a way of catching a herbicide-resistant weed problem before it becomes widespread.

A weed map should be made prior to treatment either in the fall or early spring. Knowing the location of annual weeds aids in spot treatments and will allow efficient and timely herbicidal application. Growers may be better prepared to select the most appropriate herbicide and proper treatment rate.

Another time to prepare a field weed map is during the last visit to the field prior to harvest. Familiarity with the location of perennial weeds such as bindweed will help the grower to develop special tillage programs and future spot treatments with herbicides. Information taken earlier on winter weeds such as mustards will be important in preparing a weed map. Many of these weeds mature before the last trip over the field. Weed maps of annual weeds permit long-range integrated annual weed control planning, including spot treatments, tillage, and timeliness of herbicidal applications.

Winter Broadleaf Weeds

Bushy wallflower: *Erysimum repandum*
A winter annual in the mustard family that will reach 1-2 feet when mature. It reproduces by seed. Flowers are arranged in a raceme, are pale yellow with 4 petals; leaves alternate; blades simple and linear tapering at the base. Stems are usually branched.

Management:

Carolina geranium: *Geranium carolinianum*
A winter annual or biennial in the geranium family that can reach 28 inches. It reproduces by seed. Flowers are arranged in two or more clusters at the tips of stems and branches, with 5 – white-pink petals. Leaves are divided; stems are erect, branching near the base.

Management: Herbicide applications should be made in late winter or very early spring before they bolt to effectively control them.

Chickweed: *Stellaria media*
Common chickweed is an introduced winter annual in the pink family with a prostrate growth habit that will reach 20 inches long. It reproduces by seed. Flowers are arranged in a cyme cluster. Flowers are white with 5 petals. Stems are prostrate, multi-branched. Seeds are round and 1.1 mm, flattened, orange-tan.

Management:

Blue mustard *Chroispora tenella*
Blue mustard is a winter annual that germinates in the fall and produces a rosette with deeply lobed leaves, similar in appearance to a dandelion. Blue mustard bears purple or blue flowers at the top of the plant in March through April. Leaves on the flowering stems are coarsely toothed and have wavy margins. The plant may grow from 1 to 1 1/2 feet in height. Two-inch long, bean-like seedpods (siliques) that resemble "beaks" mature in early summer.

Management: Mustards are the most difficult of the winter annual broadleaf weeds to control because they bolt early. Herbicide applications should be made in late winter or very early spring before they bolt to effectively control them.

Corn Gromwell: *Lithospermum arvense L.*
Corn gromwell is an introduced weed in the borage family that can be classified as a winter annual or a biennial, depending on whether the weed problem is coming from seeds or roots. It can reach 1-2 feet. It reproduces by seed. Flowers are white or cream-colored to bluish-white arranged in a corolla. Leaves are alternate, blades simple. Stems simple, erect.

Management: Cultivation is effective for control At present this weed problem results from seeds germinating in the fall. This could change if no-till practices are used, as roots would not be destroyed in land preparation.

Cutleaf Evening Primrose: *Oenothera biennis L.*
Cutleaf evening primrose is a native weed in the primrose family that can be classified as a winter annual. It can reach 1-1.5 feet. It reproduces by seed. Flowers are yellow with four petals and arranged in a spike that lengthens as the plant matures. Leaves are alternate, blades simple. Stems are erect, hairy and highly branched.

Management: Several herbicides can be used to control cutleaf evening primrose in wheat.

Flixweed: *Descuraninia sophia* and **Tansy mustard** *Descurainia pinnata*:
Flixweed is an introduced weed in the mustard family that can be classified as a winter annual or a biennial. It reproduces by seed. Flowers are bright yellow to whitish, with 4 petals arranged in a raceme. Leaves are alternate, stalked and 2 to 3 times divided. Stems are erect, simple or branched and sometimes glandular. Tansy mustard is very similar in appearance and growth habits.

Management: Herbicide applications should be made in late winter or very early spring before they bolt to effectively control them.

Greenflower Pepperweed (ALS Res.) *Lepidium densiflorum*
Greenflower peperweed is a native weed in the mustard family that can be classified as a winter annual or biennial. It can reach 1.6 feet. It reproduces by seed. Flowers are greenish, petals absent or very short and linear. The flower is arranged in a raceme. Leaves are alternate, blades are simple. Stems are erect and highly branched.

Management: Herbicide applications should be made in late winter or very early spring before they bolt to effectively control them.

Henbit: *Laminum amplexicaule L.*
Henbit is an introduced weed in the mint family that is classified as a winter annual. It can reach nearly one foot. It reproduces by seed. The flowers are purple to pink corolla arranged in the axils of bracts. Leaves are opposite blades simple with lobed margins. Stems are prostrate with the tips growing upwards, and will often root at the nodes.

Management: Results from experiments near Enid show that yields were not affected by henbit competition unless wheat is moisture stressed. Extremely heavy populations are competitive and can be harmful in establishing an adequate stand of wheat and getting the desired number of tillers.

Prickly lettuce: *Lactuca serriola*
Prickly lettuce is an introduced weed that is classified as an annual and can reach nearly 5 feet. It reproduces by seed. The flower is yellow, with a dark blue stripe on the lower side, and many petals. Flowers are arranged in a panicle containing up to 100 flowers. Leaves are alternate, attached basaly and simple. Stems are erect, with some branching.

Management: Herbicide applications should be made in late winter or very early spring before they bolt to effectively control them. Some populations have becme resistant to ALS-inhibiting herbcides.

Shepherdspurse: *Capsella bursa-pastoris*
Shepardspurse is an introduced weed in the mustard family that is classified as an annual, or rarely a biennial. It can reach nearly 2 feet and reproduces by seed. The flower is white with petals twice as long as the sepals and arranged in a raceme that elongates as it matures. Leaves are alternate, blades simple. Stems are erect and slightly branched.

Management: Herbicide applications should be made in late winter or very early spring before they bolt to effectively control them.

Vetch spp. *Vicia spp. (V. sativa, V. villosa)*

Two common species (common and hairy vetch) are considered to be desirable forage species. They are two introduced cool season winter annuals in the bean family. The reproduce by seed. The flower is five-petaled, 1-3 centimeters and ranges in color from whitish to bluish to red or bright pink. The flowers occur in the leaf axils. Leaves are alternate, pinnately compound. Stems are four-sided, hollow, prostrate, and can reach 4-6 feet.

Management: There are several herbicide applications that can be made to control vetches, especially since they are often encouraged to use as a cover crop or intercrop.

Wild flax or plains coreopsis: *Coreopsis tinctoria* Nutt.
Plains coreopsis is a native annual forb in the sunflower family that can reach 2 feet. It reproduces by seed. The flowers are composed of ray and disk florets arranged in a head. Leaves are opposite or alternate, bipinnate and stems are erect, single at the base but branching midway.

Management: Herbicide applications should be made in late winter or very early spring before they bolt to effectively control them.

Summer Broadleaf Weeds

Curly dock: *Rumex crispus*
Curly dock is an introduced, perennial forb in the knotweed family that can reach nearly 3.5 feet. The flower is green, turning reddish-brown when mature, and is arranged in a panicle of vertical growing racimes. The leaves are alternate, with simple blades on an erect, unbranched stem.

Management:

Field Bindweed: *Convolvulus arvensis*.
Field bindweed is an introduced perennial broadleaf weed in the morning glory family that can reach 4 or more feet. It reproduces by seeds and the rhizomes. The solitary flower is trumpet-shaped, white with a 5 lobed calyx. The leaves are alternate, simple. Stems are twining or trailing.

Management: It is classified as a major perennial weed problem in Oklahoma wheat fields. Herbicides provide the most effective method to control it; however, several types of treatments and proper timing of applications are required for success. Bindweed eradication necessitates both a continuous management program and a follow-up program for seedling control. The focus should be on using relatively low herbicidal rates applied in the fall at least six weeks after the last tillage operation and a week before subsequent tillage.

Marestail (Horseweed): *Conyza canadensis,* Marestail is a native annual forb in the sunflower family. It can reach 3 feet and reproduces by seed. The flower contains pinkish ray flowers and numerous disk flowers arranged in a panicle of heads. Leaves are alternate, blades simple arranged on an erect simple, unbranched stem.

Management: Marestail can germinate in fall, or spring. If it germinates in March, this weed can reduce wheat yields due to competition with the wheat crop and create difficulty at harvest. Marestail is very tolerant to glyphosate. Best control is achieved when the plants are small and in the rosette stage of growth.

Kochia (ALS Suscept.): *Kochia scoparia***.**
Kochia is an introduced annual weed in the goosefoot family. It forms a bushy plant and grows to 6 feet. It reproduces by seed. The flower is green and arranged in a spike. Stems are erect, highly branched and turn red as they age.

Management: If it germinates in March, this weed can reduce wheat yields due to competition with the wheat crop and create difficulty at harvest. Most kochia in Oklahoma has developed resistance to sulfonylurea herbicides.

Pigweeds: *Amaranthus spp***.**
Pigweeds are annual weeds in the pigweed family. They form bushy plants that can reach 6 feet. They reproduce by seed. Flowers are male and female flowers on the same plant, or male and female flowers in separate plants, with or without petals and are set at the base of the branches of the plant. They are abundant in Oklahoma wheat fields. Of the several species found in Oklahoma, the most common are the smooth pigweed, redroot or rough pigweed, tall waterhemp, and tumble pigweed.

Management: Prostrate pigweed may be present in high populations during the summer where reduced tillage has been practiced. Tumble pigweed is one of the major weeds found in wheat fields during the summer and can be spread easily if left to produce seeds. Tall waterhemp is known to have populations of herbicide resistant plants in North America.

Red horned poppy: *Glaucium corniculatum*
Red horned poppy is an introduced annual or sometimes biennial broadleaf weed in the poppy family that can reach 16 inches. It reproduces by seed. The flowers are solitary and orange, yellow or red. Leaves are deeply lobed with short gray hairs. Stems are erect and branched.

Management: Red horned poppy can serve as a contaminant to harvested wheat as seed and green plant material. Herbicide applications should be made in late winter or very early spring before they bolt to effectively control them.

Russian thistle: *Salsola iperica*
Russian thistle is an introduced, annual broadleaf forb in the goosefoot family that can reach 3.3 feet. It reproduces by seed. The flower is perfect and sessile and arranged in a spike. Leaves are alternate, filiform and attached to an erect, multi-branched stem.

Management: Herbicide applications should be made in fall or very early spring before they bolt to effectively control them. Some populations are becoming resistant to ALS-inhibiting herbicides.

Smallseed falseflax: *Camelina microcarpa*
Small seeded falseflax is an introduced, annual forb in the mustard family that can reach 2.6 feet. It reproduces by seed. The flowers are pale yellow with 4 petals. The leaves are alternate, simple and covered with pubescence. Stems are erect, unbranched (sometimes branched at top).

Management:

Sunflower: *Helianthus annuus*.
This weed is also a cultivated crop. It is native broadleaf plant is in the sunflower family and can reach 7 feet. It reproduces by seed. Flowers consist of ray and disk flowers arranged in a head. Leaves are alternate and attached to an erect stem that is course and branched above, single at base.

Management:

Wild Buckwheat:
Wild buckwheat is now found across most of central Oklahoma. It is an annual weed that starts germinating in late February or early March after the weather begins to warm. Wild buckwheat climbs and wraps around the wheat, causing severe lodging and harvesting problems. It prefers moist soils and high nitrogen levels. Wild buckwheat, referred to by farmers as black bindweed or climbing bindweed, is
not in the same family as bindweed. Wild buckwheat is a member of the smartweed family.
It is distinguished from field bindweed by an annual taproot. Wild buckwheat infestations have increased in recent years. Some contributing factors of wild buckwheat include:
• The seeds are similar in diameter to wheat
• The seeds don’t thrash completely
• The seeds are often planted with wheat
• It has tremendous seed production

Management Wild buckwheat has been added to the list of noxious weeds under the Oklahoma Seed Law. Another reason for the buildup of this weed is its partial resistance to 2,4-D and MCPA, used to control other weeds, such as the mustards. With competing weeds controlled, the wild buckwheat can grow rapidly and produce a heavy crop of seeds that reinfest the area. Wild buckwheat is competitive with wheat for water and nitrogen, particularly in April and May. Wheat harvesting becomes extremely difficult because wild buckwheat matures late. During late April, May, and early June, the green wild buckwheat vines grow and twist around the wheat plants, causing severe lodging, harvesting difficulty, and equipment damage, which result in lower grain quality and the heating of stored grain. There are several herbicides approved for wild buckwheat control for wheat crops. They will control this weed only if used at the proper stage of growth. Each chemical has unique characteristics, which are important for maximum performance; therefore, it is necessary to carefully follow the instructions

Winter Grasses

Cheat: *Bromus secalinus*
Cheat is an introduced, annual weed in the grass family that can reach 2 feet. It reproduces by seed. The flower has 4-7 spikelets arranged in an upright panicle. The leaves are blades with sheathes and the stem is erect.

Management: Crop rotations with a broadleaf crop (either winter or summer) warm season grassy crop such as corn or grain sorghum, or through deployment of a rotation/fallow program provide flexibility for herbicide control of grassy weeds. The choice of a system will depend on climate conditions. It is critical to effectively manage grassy weeds during this time.

Downy & Jap. Brome: *Bromus tectorum & Bromus japonicus*
Downy and Japanese brome are introduced, annual weeds in the grass family that can reach 2 feet. They reproduce by seed. The flower has 4-7 spikelets arranged in a panicle. The leaves are blades with sheathes and the stem is erect.

Management: Crop rotations with a broadleaf crop (either winter or summer) warm season grassy crop such as corn or grain sorghum, or through deployment of a rotation/fallow program provide flexibility for herbicide control of grassy weeds. The choice of a system will depend on climate conditions. It is critical to effectively manage grassy weeds during this time.

Jointed Goatgrass: *Aegilops cylindrica*
Jointed goatgrass is a winter annual grass that was introduced from Turkey in the late 1800's. It reproduces by seed. It will grow to 30 inches with erect stems. Seeds are similar to wheat in size and shape, making it difficult to separate from harvested wheat seed.

Management: The following cultural methods are used to help control jointed goatgrass infestations: burning wheat stubble, rotating crops, increasing the wheat seeding rate, seeding a competitive cultivar, using a drill with narrow row spacing, and planting wheat late after a shallow fall tillage. Moldboard plowing and post-harvest offset disc tillage are effective control methods to bury goatgrass seed because, like volunteer wheat, most of it will germinate during the summer. Proper planning for harvesting an infested field is important. By seeding early maturing wheat and matching the combine reel speed to that of the ground speed, most jointed goatgrass seed will be collected by the combine and removed from the field.

Rescuegrass: *Bromus catharticus*

Rescuegrass is an introduced, annual weed in the grass family that can reach 3 feet. It reproduces by seed. The flower has 4-9 spikelets that are laterally compressed and arranged in a panicle. The leaves are blades with sheathes and the stem is erect.

Management: Crop rotations with a broadleaf crop (either winter or summer) warm season grassy crop such as corn or grain sorghum, or through deployment of a rotation/fallow program provide flexibility for herbicide control of grassy weeds. The choice of a system will depend on climate conditions. It is critical to effectively manage grassy weeds during this time.

Rye: *Secale cereale*
Rye is a cereal grain that is also a weed of winter wheat. It is an annual weed in the grass family that can reach 4-5 feet. It reproduces by seed. Flowers have 2-3 spikelets arranged on a compound spike, attached to an erect stem.

Management: Crop rotations with a broadleaf crop (either winter or summer) warm season grassy crop such as corn or grain sorghum, or through deployment of a rotation/fallow program provide flexibility for herbicide control of grassy weeds. The choice of a system will depend on climate conditions. It is critical to effectively manage grassy weeds during this time.

Italian Ryegrass : *Lolium edwardii*

Italian ryegrass, also known as Marshal ryegrass, is an introduced winter annual weed in the grass family that can reach 2.5 feet. It reproduces by seed. Flowers have from 7-17 flowers arranged in a spike. Stems are purplish at the base and erect.

Management: This introduced weed is commonly found in winter wheat fields throughout Oklahoma and parts of Texas. Italian ryegrass is very competitive with winter wheat for moisture and nutrients and can cause substantial reductions in yield and grain quality when not adequately controlled. Italian ryegrass is also a prolific seed producer, capable of producing several thousand seeds per plant. Furthermore, Italian ryegrass is an especially important problem in Oklahoma wheat production due to the widespread presence of herbicide-resistant populations. Management includes crop rotation and cultivation.

Wild Oats: *Avena fatua*
Wild oats is an introduced, winter annual weed in the grass family that can reach 4 feet. It has an open-branched, nodding flower. This weed is very competitive with wheat for moisture, space, light, and nutrients. In southern Oklahoma and Texas, wild oats will produce up to 30 or more tillers per plant.

Management: Preventive measures are most effective in reducing wild oat infestations. Wild oats are usually inadvertently introduced through purchased seed or mechanical spreading. Inspect all purchased seed for wild oats. Trucks that haul wild-oat-infested wheat in an open trailer spread wild oats. Contaminated equipment may also spread wild oats. A combine that harvests wild oats and is later taken to a clean field can spread them into the wheat crop. Once they are found in a field, it is important to use both cultural and mechanical methods to eliminate wild oats. Practices include crop rotation, late cultivation prior to planting, mowing or plowing before wild oat plants produce seeds, and pulling scattered plants from a field before they produce seeds. Several herbicides are also available that effectively control wild oats.

Preventive Weed Control

Integrated Weed Management uses a combination of different practices to manage weeds. By reducing the reliance on one or two specific weed control techniques (for example, relying solely on the use of herbicides), weeds are less likely to adapt to these methods. The objective of integrated weed management is to maintain weed densities at manageable levels while preventing weed shifts to more difficult-to-control species. This objective is met by preventing weed problems before they start, helping the crop gain the competitive advantage over weeds, and making it difficult for weeds to adapt to a cropping system. All of these factors contribute to a healthy, competitive crop.

The best way to control weeds is to keep them out of fields in the first place. Prevention, or stopping the advancement of weed infestations, is an important part of an integrated weed management program. It requires time and diligence from the grower, but offers an effective, low cost control.

Cultural Control

Cultural weed control involves manipulating the crop-weed environment so that conditions are more favorable for crop plants than weeds. Crop rotation and crop competitiveness are important cultural control practices in winter wheat production.

Research and field surveys have shown a large difference in weed suppression characteristics of winter wheat varieties. Tall varieties competed with weeds better than short varieties in two out of three years. Other factors that may improve wheat's competitiveness with weeds include rapid early fall growth, good tillering, winter hardiness, and extensive leaf display. The same weed suppression characteristics have been observed in wheat varieties commonly grown in Oklahoma in studies conducted with feral rye.

Planting crop seeds contaminated with weed seeds has been the most common method of spreading weeds for centuries. Drill box surveys in Kansas, Nebraska, and Oklahoma have shown that many growers are planting unacceptable levels of weed seeds with their crop. Using trashy wheat seed will not only increase the weediness of a field, but it also reduces the seeding rate, resulting in a lower wheat population and a less competitive crop. At the very least, farmers should have their seed cleaned at certified seed conditioners. To ensure you are planting high quality, weed-free seed, purchase certified seed. The benefits, which include increased forage and grain yields, far outweigh the cost.

Crop rotation is an important component of integrated weed management. The use of diverse crops with different life cycles, seeding dates, herbicide options, and competitive abilities will prevent weeds from adapting and thriving in fields and will help prevent weed shifts as well. The most common crop rotation in the southern Great Plains is continuous winter wheat, although rotations of wheat with canola, corn, sorghum, and soybean do occur. Continuous, dual purpose wheat rotation has led to major winter annual weed infestations. In the southern Great Plains (Oklahoma and northern Texas), successful summer crop production is difficult due to high temperatures and limited rainfall. A winter broadleaf crop, such as winter canola, would be a better fit for rotation with winter wheat. This crop would allow application of several different herbicide modes of action that are not typically used in wheat. Other benefits may include the breaking of disease cycles that normally plague continuous winter wheat and improving certain soil characteristics with the deep tap-rooted crop. Crop rotations with canola have increased from 5,000 acres planted in 2005 to nearly 250,000 acres in 2012.

Seeding time can affect weed competitiveness. Weeds are more prevalent in wheat that is seeded before the optimum date and can affect the weed populations of the following summer crop For example, grain sorghum, was found to have more weeds when it was planted into early seeded winter wheat residues rather than winter wheat seeded near the optimum date. Similarly, winter wheat seeded too late may not tiller enough to suppress weeds in the spring, and yield may be reduced. If wheat can't be seeded at the optimum time, the competitive edge can still be achieved by altering other factors such as seeding rate and row spacing. By increasing seeding rate and decreasing row spacing, wheat competitiveness can improved even when seeding date is less than optimum.

Tillage has traditionally been a method to control weeds in winter wheat. Clean till is widely practices, but more recently, there has been a shift to no-till, strip till, or other minimum tillage systems, because of the expense for fuel and wear and tear on equipment. Much of the tillage expense saved by no-till wheat production will be spent on chemical weed control practices, but by planning the switch in advance, producers can keep their fields with problem weeds in tillage and only move cleaner fields into no-till production. Producers should avoid no-tilling fields infested with weeds that have no good in-season chemical control measures (e.g. jointed goatgrass, feral rye, rescuegrass etc.). Still, there are solutions to even these problem weeds, such as rotating to a summer crop, winter canola, or using the Clearfield wheat production system.

Sanitation

Clean tractors, implements, trucks, and combines before moving them from weed-infested fields to clean fields. This should include inspecting equipment of hired contractual operators before they enter your fields, especially harvesting equipment that may introduce weed seed from other counties or states. Proper cleanout of a combine can reduce the spread of undesirable weeds. Also if hay is being purchased to supplement cattle feeding in fallow fields, make sure the hay is certified.

Chemical Control

Herbicides have provided excellent control of broadleaf weeds in winter wheat for many years. In more recent years, herbicides have been developed to selectively control winter annual grasses in winter wheat. In order to get the best weed control with the least crop injury, be sure to:

1. Correctly identify the problem weed(s).
2. Apply herbicides when weeds are small and actively growing.
3. Use proper spray equipment that is in good condition and not contaminated with previously used herbicides.
4. Calibrate the sprayer to ensure application accuracy.
5. Read and follow directions on the herbicide label.
6. Know your rotational plans to avoid herbicide carryover problems to sensitive crops. Be aware that crop disasters such as winter injury, hail, or disease occur, and previously applied herbicides may limit the choices for re-cropping.
7. Check current local weed management recommendations for options in addition to those mentioned, because new herbicides are continually entering the market.

Chemical control in winter wheat involves the use of pre-emergent (PRE), early pre-plant (EPP) pre-plant incorporated (PPI) and post-plant herbicides. There is also a newer technology available, so called herbicide tolerant wheat, which allows certain herbicides to be sprayed post emergence on the crop that, without the tolerant trait, would have been significantly damaged.

A common one is Clearfield Wheat® which consists of a herbicide-tolerant wheat that was developed so Beyond® herbicide can be applied to the wheat with not resulting crop injury. Clearfield is a non-transgenic wheat because it was developed using conventional breeding technique. It allows for the effective control of some weed species, but requires some recommended stewardship activities to preserve its effectiveness and avoid selection of herbicide resistant weeds.

Keep uncropped areas (fence lines and field borders) weed-free by establishing a good stand of a perennial grass or spraying annually with herbicides. A typical 20-foot long fence surrounding a section of wheat amounts to less than 10 acres. Compare the cost of preventing weed establishment on the 10-acre border (with relatively low-cost options) versus the long-term control of weeds on 630 acres of cropland (with typically more expensive measures).

Table 12: Winter Broadleaf Weeds (Cultural Control Efficacy)

Cultural Practice	Weed											
	bushy wallflower	Carolina geranium	chickweed	corn gromwell	Cutleaf Evening primrose	flixweed	GF Pepperweed (ALS Res.)	henbit	prickly lettuce	purple deadnettle	shepherd's purse	vetch spp.
Crop rotation												
Sanitation												
Use of certified pest-free seed												
Fertility management												
Irrigation management												
Re-tilling fields												
Reducing nitrogen levels												
Proper harvest times	G	G	G	G	G	G	G	G	G	G	G	G
Spot spraying												
Preventing plant stress												

E=Excellent, G=Good, F=Fair, P=Poor, NL = Not Labeled, Blank=Unknown

Table 13: Summer Broadleaf Weeds (Cultural Control Efficacy)

Cultural Practice	Weed									
	curly dock	field bindweed	marestail/ horseweed	kochia (ALS Suscept.)	pigweed spp.	plains coreopsis	red horned poppy	Russian thistle	smallseeded f alseflax	wild buckwheat
Crop rotation	**G**	**P**	**G**	G	**G**	**G**	G	**G**	**G**	**G**
Sanitation	**G**	**F**	**G**	G	**G**	**G**	G	**G**	**G**	**G**
Use of certified pest-free seed	**G**	**G**	**G**	G	**G**	**G**	G	**G**	**G**	**G**
Fertility management					**G**			**P**		
Irrigation management										
Re-tilling fields	**G**	**F**	**G**	G	**G**	**G**	G	**G**	**G**	**G**
Reducing nitrogen levels										
Proper harvest times										
Spot spraying		**F**								
Preventing plant stress										

E=Excellent, G=Good, F=Fair, P=Poor, NL = Not Labeled, Blank=Unknown

Table 14: Winter Grass Weeds (Cultural Control Efficacy)

Cultural Practice	Weed						
	cheat	downy & Jap. brome	jointed goatgrass	rescuegrass	rye	ryegrass (ALS Suscept)	wild oats
Crop rotation	**G**	**G**	**G**	G	**G**	**G**	G
Sanitation	**F**	**F**	**F**	F	**F**	**F**	F
Use of certified pest-free seed	**G**	**G**	**G**	G	**G**	**G**	G
Fertility management							
Irrigation management							
Re-tilling fields	**G**	**G**	**G**	G	**G**	**G**	G
Reducing nitrogen levels							
Proper harvest times	**F**	**P**	**P**	P	**P**	**P**	P
Spot spraying							
Preventing plant stress							

E=Excellent, G=Good, F=Fair, P=Poor, Blank=Unknown

Table 15: Winter Broadleaf Weeds (Herbicide Efficacy)

Herbicide	Weed											
	bushy wallflower	Carolina geranium	Chickweed	cCrn gromwell	cutleaf evening primrose	flixweed	GF Pepperweed (ALS Res.)	henbit	prickly lettuce	purple deadnettle	shepherd's purse	vetch spp.
(EPP-PPI-PRE)												
2,4-D	G					G	G	P	F-G		G	P
Chlorsulfuron (Glean)	G	G	G	G	G	G	G	G	G		G	
Glyphosate	G	G	G	G	G	G	G	G	G	G	G	
Chlorsulfuron + Metsulfuron (Finesse)	G	G	G	G	G	G	Z	G	G		G	
Quinclorac Drive, Paramount												
Triasufluron (Amber)	G	G	G		G	G	Z	G	F-G		G	
(POST)												
Bromoxynil (Buctril)	F-G					F-G		F-G	F-G		F-G	F
Carfentrazone (Aim)	F-G		P		P-F	F-G	F	F-G	P-F	F-G	F-G	Z
Chlorsulfuron (Glean)	F-G					F-G		Z	F		F-G	
Dicamba Banvel	E					E		E	F		E	G
Diclofop-methyl Holeon	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z
Fenoxyprop Fusion, Puma	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z
Flucarbazone Everest												
Flufenacet Axiom, define												
Imazamethabenz Assert												
Imazamox Beyond	F-G					F-G		Z	Z		F-G	Z
MCPA												
Mesosulfuron Osprey			P-F		P			P			P	P
Metribuzin Sencor,												
Metsulfuron methy Ally l	F-G					F-G		Z	F		F-G	Z
Pinoxaden Axial	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z
Propoxycarbazone Olympus	F-G	P	F-G	P	P	G		P	P-F		G	P
Prosulfuron Peak	F-G		F-G		F-G	G		P	F-G	F-G		Z
Pyrasulfotole huskie												
Pyroxsulam power flex	G			G	G	G		G				G
Quincloac												
Sulfosulfuron Maverick	F-G					F-G		Z	P-F		F-G	P
Thifensulfuron methyl Harmony	G								F			P
Triasulfuron Amber	G	G	G		G	G	Z	G	F-G	G	G	F-G
Tribenuron-methyl Express	F-G					F-G			F		F-G	P

E=Excellent, G=Good, F=Fair, P=Poor, Z= Zero Control NL = Not Labeled, Blank=Unknown

Table 16: Summer Broadleaf Weeds (Herbicide Efficacy)

Herbicide	Weed										
	curly dock	field bindweed	marestail / horseweed	kochia (ALS Suscept.)	pigweed spp.	plains coreopsis	red horned poppy	Russian thistle	smallseeded falseflax	wild buckwheat	Wild sunflower
(EPP-PPI-PRE)											
2,4-D	**P-F**	**P**	**P-F**	7	**7**						
Chlorsulfuron (Glean)	**F-G**		**F-G**			**G**	G		**G**	**G**	**G**
Glyphosate	**G**	**F-G**	**P-F**	G	**G**						
Chlorsulfuron + Metsulfuron (Finesse)	**F-G**		**F-G**	**F-G**	**G**	**F**		**F-G**	**F-G**	F-G	G
Quinclorac Drive, Paramount											
Triasufluron (Amber)	**F-G**		**F-G**	**F-G**	**G**	**G**		**F-G**	**F-G**	F-G	G
(POST)											
Bromoxynil (Buctril)			P-F	G	F			F-G		F	F-G
Carfentrazone (Aim)		F		F-G	F-G			F-G		F	F
Chlorsulfuron (Glean)					G	F	G		G	G	P-F
Dicamba Banvel			P-F	G	G			**G**		F	G
Diclofop-methyl Holeon	**Z**	Z	Z	Z	Z	**Z**	Z	Z	Z	Z	Z
Fenoxyprop Fusion, Puma	**Z**	Z	Z	Z	Z	**Z**	Z	Z	Z	Z	Z
Flucarbazone Everest											
Flufenacet Axiom, define											
Imazamethabenz Assert											
Imazamox Beyond			Z	Z	Z			Z		Z	Z
MCPA			P	P	P			P		P	P
Mesosulfuron Osprey					**P**						
Metribuzin Sencor,											
Metsulfuron methy Ally l			**F**	**P-F**	**F**			**P**		P	P-F
Pinoxaden Axial	**Z**	**Z**	**Z**	**Z**	**Z**	**Z**	Z	**Z**	**Z**	Z	Z
Propoxycarbazone Olympus		**P**		**P**	**P**	**P**		**P**	**G**		
Prosulfuron Peak			**P-F**	**P**	**F**			**F-G**	**F-G**	F	F
Pyrasulfotole huskie											
Pyroxsulam power flex											
Quincloac											
Sulfosulfuron Maverick			**P**	**P**	**P**			**P**		P	P
Thifensulfuron methyl Harmony			P-F	F-G	F-G			F		F	F
Triasulfuron Amber			F-G	F-G	F	F-G		F-G	F	F	G
Tribenuron-methyl Express			P-F	F-G	F			F		P-F	P-F

E=Excellent, G=Good, F=Fair, P=Poor, Z= Zero Control NL = Not Labeled, Blank=Unknown

Table 17: Winter Grass Weeds (Herbicide Efficacy)

Herbicide	Weed: cheat	downy & Jap. brome	jointed goatgrass	rescuegrass	rye	ryegrass (ALS Suscept)	wild oats
(EPP-PPI-PRE)							
2,4-D							
Chlorsulfuron (Glean)						**F-G**	
Glyphosate							
Chlorsulfuron + Metsulfuron (Finesse)						**F-G**	
Quinclorac Drive, Paramount							
Triasufluron (Amber)						**F-G**	
(POST)							
Bromoxynil (Buctril)	**Z**	Z	Z	Z	Z	**Z**	Z
Carfentrazone (Aim)	**Z**	Z	Z	Z	Z	**Z**	Z
Chlorsulfuron (Glean)	**Z**	Z	Z	Z	Z	**Z**	Z
Dicamba Banvel	**Z**	Z	Z	Z	Z	**Z**	Z
Diclofop-methyl Holeon	**Z**	Z	Z	Z	Z	**G**	G
Fenoxyprop Puma	**Z**	Z	Z	Z	Z	**F-G**	G
Flucarbazone Everest							
Flufenacet Axiom, define							
Imazamethabenz Assert							
Imazamox Beyond	**G**	G	G	F-G	F-G	**F-G**	G
MCPA	**Z**	Z	Z	Z	Z	**Z**	Z
Mesosulfuron Osprey	**P-F**	P-F	Z	Z	Z	**G**	G
Metribuzin Sencor,							
Metsulfuron methy Ally l	**Z**	Z	Z	Z	Z	**Z**	Z
Pinoxaden Axial	**Z**	Z	Z	Z	Z	**G**	G
Propoxycarbazone Olympus	**G**	**F**	**P**	**P**	**Z**	**F-G**	G
Prosulfuron Peak	**Z**	Z	Z	Z	Z	**Z**	Z
Pyrasulfotole huskie							
Pyroxsulam power flex	**G**	**G**		**P**		**F-G**	F
Quincloac							
Sulfosulfuron Maverick	**G**	**P**	**Z**	**P**	**Z**	**P**	P
Thifensulfuron methyl Harmony	**Z**	Z	Z	Z	Z	**Z**	Z
Triasulfuron Amber	**Z**	Z	Z	Z	Z	**Z**	Z
Tribenuron-methyl Express	**Z**	Z	Z	Z	Z	**Z**	Z

E=Excellent, G=Good, F=Fair, P=Poor, Z= Zero Control NL = Not Labeled, Blank=Unknown

Worker Activities and Potential Exposure to Pesticides

Worker activity in is very limited due to the mechanized nature of wheat production. Most wheat farms are family operations with mainly family members or a one or two person labor force. All tillage, planting, and harvesting is done by mechanical means. Harvesting is typically done through custom harvesters, hired by the producer to harvest their crop. Wheat grown for seed can be hand weeded or rouged for rye or other crop or weed contamination if it is in small areas. In Oklahoma electric fence will be used for cattle grazing on wheat. The electric fence is used temporarily and is put up prior to introducing the cattle and taken down after the cattle have been removed from the wheat. With the exception of a primary herbicide and insecticide seed treatment application, which are used on 95% or more of planted acres, nearly all other pesticide applications are dependent on environmental conditions present throughout the year.

Potential worker exposure times include:

1. Pre-planting burndown herbicides
2. At-planting seed treatment fungicides and insecticides. Most are pre-treated, so hazards related to handling of treated seed are of greatest concerns
3. In general, the primary herbicide application is at the 3-5 leaf vegetative growth stage. Early fungicide application may occur at the same time.
4. Insecticide application from emergence through heading for control of insect and mite pests.
5. Fungicide application at flag leaf stage (late vegetative growth).
6. Pre-harvest herbicide use.
7. Post-harvest burndown of volunteer grain and perennial weeds.

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PSS-2139 Farmer-saved Wheat Seed in Oklahoma: Questions and AnswersPSS-2139 Farmer-saved Wheat Seed in Oklahoma: Questions and Answers

By Jeff Edwards. This fact sheet provides commonly asked questions and the answers about saving wheat seed for the next planting.

PSS-2132 No-till Wheat Production in Oklahoma
By Jeff Edwards, Francis Epplin, Bob Hunger, Case Medlin, Tom Royer, Randy Taylor, and Hailin Zhang. This fact sheet discusses the many considerations to be taking into account when making a decision of switching from conventional till to no-till method of wheat production.