Lesson 1: Planning the Crop

Cultivation of wheat and other small grains started some 9000 years ago in western Asia. Wheat and barley served as a primary food source for early civilization in the Middle East. The first wheat plants were derived from a wild variety that had grains that did not thresh out easily. Most of the wheat cultivated today is freely threshed and used in the production of bread. Oats were probably first noticed as weeds in wheat and barley crops and later cultivated as a food and feed crop.

Wheat is the world's leading cereal grain and most important food crop because of its unique bread making ability and diversity of uses in other products. This factor, along with its nutritional value and storage qualities, has made wheat a staple food for more than one-third of the world's population.

Although wheat and the other small grains of oats and barley are not produced as much as soybeans or corn in Missouri, they are considered important crops. In 1999, Missouri ranked 11th among all states in the production of wheat, producing about 57 million bushels per year. Figure 1.1 from the *1999 Missouri Farm Facts* shows the wheat production areas in Missouri by county.

The value of wheat and small grains is seen largely as livestock feed (grain or pasture forage). Wheat and small grains are also an important rotational crop for pest and nutrient management, and they can grow in the same growing season (double cropped) with other crops.

Environmental Conditions

All crops need certain environmental conditions to grow successfully and this is no different for wheat and small grains. Figure 1.2 from the USDA Economic Research Service shows regions of the

Figure 1.1 - Wheat Production in Missouri

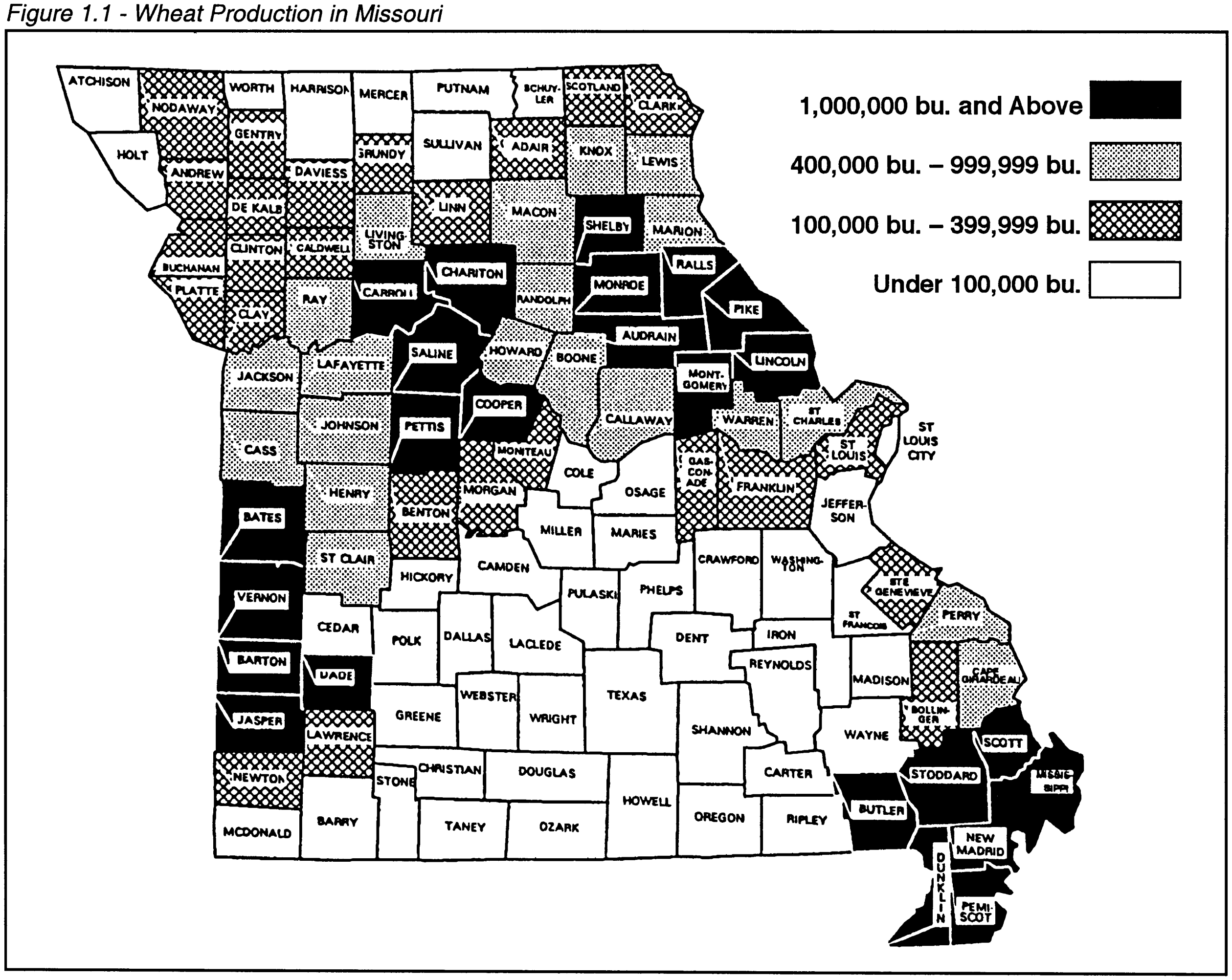
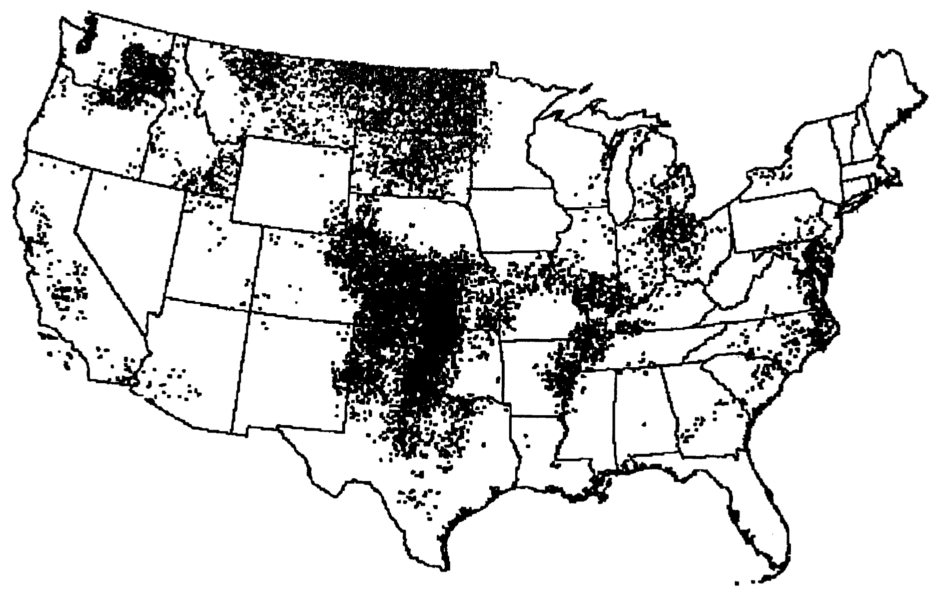


Figure 1.2 - Wheat Growing Regions in the United States



United States where wheat is planted. The following section lists the requirements of wheat and the small grains of barley and oats for growing season, rainfall, and soil type.

Growing season - Wheat and small grains are cool-season crops that grow best under moderate temperatures but can resist both cold and hot weather. This hardiness is essential for these crops to endure the freezing temperatures of winter, the late frosts of spring, the high temperatures of June, and the droughts that can occur anytime. Because of their winter growth habit, wheat and small grains are planted during the fall, become well established before winter, and "green-up" starting their growth quickly when conditions are favorable in spring. These crops not only resist freezing temperatures during winter but need the cold to joint and flower so they can set grain in the spring after the dangers of late frosts are usually past. Extended root systems of these winter crops enable individual plants to obtain moisture from deep in the soil during times of drought making them highly adaptable to Missouri conditions.

Some crops such as wheat have a unique character whereby the germinating embryo, or seedling plant, must undergo a hormonal-controlled conversion from its juvenile stage, or vegetative growth stage, to its reproductive stage. This process is called vernalization and ensures that the growing point remains underground until the arrival of warmer temperatures and is protected from freezing and death. Winter wheat has a prostrate growth habit whereby only leaves are produced aboveground during the fall, whereas the growing points and buds remain underground. This generalized growth habit is typical of grasses.

Winter wheat grows at temperatures as low as 37°F. Optimum growth is between 70 and 77°F with a maximum of about 90°F. Winter wheat crops can be planted from early September to mid-November. Planting wheat in late September or early October in northern Missouri is preferable and by mid-October in southern Missouri. Due to its susceptibility to the Hessian fly, planting should be delayed until after the "fly-free" date. The fly-free date ranges from September 28 at the Iowa line to October 17 at the Arkansas line. The best wheat yields often result from planting just after the fly-free date. Spring wheat is rarely used in Missouri due to the hardiness of winter varieties and the need for other row crops to be planted in the spring.

Oats have a very short growing season compared with other grains. They are very well adapted to grow in cooler temperature climates and therefore do much better than average in northern Missouri. Most oats in Missouri are planted in the spring as early in the year as soil conditions permit.

Barley has similar temperature requirements as wheat for growth; however, it is less winter-hardy than wheat and should be planted earlier. Producers in Missouri should not plant barley north of U.S. Highway 36 because winter injury could be severe in most years. Central and southern Missouri producers should plant early if they are using barley for pasture. If it is to be harvested for feed, producers should plant at later dates to help avoid barley yellow dwarf virus (BYDV) injury. Spring barley is rarely used in Missouri due to the hardiness of winter varieties and the need for other row crops to be planted in the spring.

Spring varieties of these grains are most often used to augment or increase the forage and nutrient value of existing pastures. They may also be used as a cover crop to prevent soil erosion on crop ground to be planted later.

Rainfall - Wheat and small grains combine drought escape and drought resistance to overcome moisture stress. Most of their growth occurs during fall and early spring, which are periods of highest rainfall. Winter varieties are harvested before the dry summer months and in that way escape drought. Nevertheless, times of low moisture and high temperature can limit production of wheat and small grains.

In some areas where available moisture is a concern, planting too early can cause excessive fall growth and soil moisture depletion for early spring growth, but this is not a problem for much of the state. Planting later than optimum often causes limited fall growth of both root and tiller formation, subjecting the crops to wind damage and the possibility of winter-kill damage (when plants are injured due to extreme weather conditions). However, producers may need to plant later when late rains allow grassy weeds to germinate. These weeds will be destroyed by tillage. Also, in areas where wheat and small grains are double cropped after row crops, they will be planted later than optimum.

Soil type and typography - Wheat and other small grains grow well on a wide range of soils but do not grow well on poorly drained soil, especially during wet periods. The major cause of loss is standing water and the formation of ice sheets where water accumulates. Adequate surface and subsurface drainage is absolutely necessary and more important for wheat than for other crops. Soil depressions caused by combines, grain carts, and tractors are major problems in some years. Wheat should not be planted in fields that were wet at the time a double crop of soybeans was harvested or where soil compaction is present. (More information on tillage and planting options will be presented in Lesson 3 of this unit.)

The best soils for wheat and small grains are well-drained loams and clay loams. Because these crops cannot stand "wet feet," producers should avoid flat sites with poor internal drainage, such as the claypan soils found in northeast Missouri.

Evaluating Field History

Two important factors to consider when evaluating the field where wheat and small grains are to be grown are knowing (1) the most recent crop and (2) what type of tillage and/or planting method was previously used.

Knowing what crop was most recently produced on the site allows producers to determine what type of fertilizer may be needed for the new crop. It will also provide insight as to nutrients that may be more available, such as additional nitrogen, following a soybean crop.

Knowing the history of tillage and/or planting methods used on the site can help producers in projecting what pest problems may need to be addressed. This will include the herbicide and pesticide use as well. Tillage and planting history can also determine what methods will be used for the new crop. For example, if erosion is a problem at the site, no-till methods can be used. Whatever the site's history, producers who have a good knowledge of previous crops and management operations will be better able to plan for successful current and future crop production.

Fertilizer Requirements

Adequate nutrients at each stage of development are essential for maximum economic yields of wheat and small grains. Nitrogen, phosphorus, and potassium are the primary nutrient needs for these crops. Most Missouri soils supply adequate amounts of the secondary macronutrients and micronutrients. Nutrient needs can be determined by several methods, including soil tests, field trials, nutrient removal and plant analysis, past experience, or a combination of these. However, the most reliable means of determining lime and nutrient needs is by soil testing regularly with support from the other methods listed. Producers must keep in mind that a soil test is only as good as the sample collected in the field.

Lime - Liming should not be overlooked because wheat and small grains will respond to lime. Lime needs can be accurately determined by soil tests. The greatest need for lime is in the areas of high soil acidity (where pH levels are very low). Oats tolerate lower pH levels than either wheat or barley.

Nitrogen - Nitrogen is the element most frequently lacking for optimum wheat production. Needs will vary depending on the level of available soil nitrogen from existing organic matter, soil texture, and carryover from previous crops. Other factors that determine nitrogen needs are cropping system used and expected yield.

Soil tests measure the quantity of available nitrogen at the time samples are collected. Samples need to be taken after July 1 for applications before fall planting and again after November 1 for topdress applications to be done in the spring. In general, each 1% of organic matter supplies 8 to 12 pounds of nitrogen per acre through organic matter oxidation. Nitrogen available from a previous soybean crop ranges from 20 to 40 pounds per acre. Therefore, starter nitrogen is not usually necessary when wheat and small grains follow soybeans.

Producers should pay special attention to nitrogen fertilization. Too much nitrogen increases the possibility of lodging. If starter nitrogen is used, it should be limited because higher rates may cause excessive vegetative growth and delay the winter dormancy stage. Unless the crop is grazed, this can cause winter injury and reduce winter survival. In addition, small grains produced for hay and grown on droughty soils where nitrogen can accumulate may produce forage that is toxic to livestock.

Spring topdressing is the recommended time of nitrogen application for fall-seeded small grains. Applying anhydrous ammonia with tillage implements is an excellent method of cutting costs of preplant application by combining tillage and fertilizer operations.

Phosphorus - Wheat and small grains are known to respond well to application of phosphorus on soils testing low or very low in available phosphorus. These crops do not tiller well under severe phosphorus deficiency and are often more subject to winter kill. Adequate phosphorus is important in developing good, early root growth. Oats tolerate lower phosphorus levels than either wheat or barley. Unless a well-established root system has been developed, winter oats are extremely sensitive to frost heavage when plant roots are lifted up and out of the soil and exposed to weather and insect injury.

Phosphorus for wheat and small grains should be applied by broadcasting and then incorporation, injected in concentrated bands preplant, or banded at planting. Band applications of this plant nutrient with the seed at planting or injected preplant are recognized as generally more efficient than broadcast treatments, particularly when low rates are applied on acid soils that are low in available phosphorus. When phosphorus is incorporated into the soil, plants can continue to use it even when the surface is dry. Combining nitrogen and phosphorus applications at planting can save time and money.

Potassium - Wheat and small grain response to potassium application is less than that of phosphorus. Sandy soils are often found low in potassium and in need of fertilization. Potassium may either be applied as a planting time starter or broadcast and incorporated ahead of planting. Both methods should provide equal results. Applications of potassium in direct contact with the seed should be limited to avoid possible germination damage.

Research has shown all nitrogen, phosphorus, and potassium carriers to be essentially equal in supplying these nutrients to wheat and small grains when properly applied. Therefore, selection of these nutrient sources should be based on cost, availability, and adaptability to the overall farm operation.

Summary

Wheat is the world's leading cereal grain and most important food crop. It is also a staple food for more than one-third of the world's population. Although wheat and other small grains such as barley and oats are not produced as much as soybeans or corn in Missouri, they are still considered important crops valued mostly as livestock feed, rotational crops for pest and nutrient management, and in their ability to be double cropped.

Wheat and small grains are cool-season crops that grow best under moderate temperatures but can resist both cold and hot weather. These crops are planted during fall, become well established before winter, and "green up" in the spring. They resist freezing temperatures during the winter and can obtain moisture from deep in the soil during times of drought. Winter varieties can be planted September through November. Spring wheat, oats, and barley are rarely used in Missouri due to the need for other row crops to be planted in the spring. These crops are most often used to augment existing pastures or used as a cover crop.

These crops can tolerate a wide range of topography but perform best as grain crops on flat or gently rolling fields. The best soils for wheat and small grains are well-drained loams or clay loams and they do not grow well on poorly drained soils.

When evaluating field history, producers should know what crop was most recently produced on the site to determine fertilizer needs. Producers should also know what tillage and/or planting method was previously used to project pest problems and to determine current tillage and/or planting methods to employ.

Adequate nutrients are essential for maximum economic yields of wheat and small grains. Nitrogen, phosphorus, and potassium are the primary nutrients needs of these crops.

Credits

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Lesson 2: Selecting a Variety

Before planting, the producer must decide what type or class of wheat or other small grains will be selected. Before this selection is made, research information must be gathered on the types and varieties available. Consideration must be given to adaptations needed for the producer's area.

Classes of Wheat

There is great diversity with the wheat plant (genus *Triticum*). To classify this diversity, wheat differences are examined by growth habit, kernel color, and kernel hardness.

Growth habit refers to when the seed is planted and the stages of plant growth. Some wheat is planted in the fall with only the leaves aboveground and their growing point and buds remaining underground until spring. About 70 to 80% of U.S. wheat production is winter wheat. Other wheats are spring planted.

Kernel color is either red or white. Red predominates and the vast majority of crop improvement research in the United States is devoted to red-kernel wheat. The only advantage of white kernel color is the improvement of flour yield by allowing millers to be less stringent in removing seedcoat fragments from flour.

Kernel hardness of wheats in the United States is classified as "hard" or "soft" depending on endosperm granularity. Hard wheat has a protein-like material on the surface of the starch granules that causes the granules to adhere to the cell walls. Soft wheat does not have this strong starch granule-protein matrix. Therefore, soft wheat will yield large quantities of fine granulated flour when ground, whereas hard wheat yields a more coarse product. Soft wheats' fine granules are actually harder to control and will clog sifters in industrial bread-making equipment. Most bread is made from hard wheat because of the cohesive and elastic properties, which yield a bread with good volume and texture. Soft wheat flour is used mostly for cakes, cookies, and doughnuts.

Based on these differences, wheat grown in the United States is divided into five major classifications.

Hard red winter - This class is grown mostly in Nebraska, Kansas, Oklahoma, Texas, and parts of Missouri. In addition to bread making, another major use of this wheat is in livestock feeds.

Hard red spring - This class is grown primarily in the north central states, such as North Dakota and Minnesota, where the winters are too severe for winter wheat production.

Soft red winter - The main growing area for this class extends from Texas through parts of Missouri, northward to the Great Lakes and east to the Atlantic Coast but is mostly concentrated in Illinois, Indiana, and Ohio.

White - This class, which can be both a winter and spring variety, is produced in the Pacific Northwest and to a lesser extent in southern Michigan and western New York. White wheat is also a soft wheat used mostly for cereals.

Durum - Production is centered in North Dakota, with lesser amounts in Minnesota, Montana, South Dakota, and Arizona. Durum wheat contains more protein than any other classes of wheat and produces a dough that when mixed with water can be pressed through dies, making it desirable for products like spaghetti, noodles, and macaroni.

Wheat Varieties

Seed companies have many wheat varieties for producers to select from. Descriptions of these varieties can be obtained from the dealer or by using their Internet web site for information. The University of Missouri tests a number of varieties each year and publishes their results. These results may be obtained from University Extension centers around the state, or as with seed companies, from the Internet at the Agricultural Electronic Bulletin Board (AgEBB).

Since winter wheat is the predominant type of wheat raised in Missouri, performance tests were conducted on both hard red and soft red winter wheat. Results of the tests vary each year depending on the amounts of fall moisture for germination and early growth; mildness or severity of the winter weather, which determines winter survival; and spring moisture and temperatures, which affect tillering and stand development.

Environmental conditions and their effect on wheat yields during the test periods and at state testing locations are also reported. Periods of excessive rainfall during grainfill may cause certain diseases and lodging. Delayed harvests, which may result in shattering and yield loss, are also reported. The University of Missouri test results reported under these conditions will list the varieties tested and their yields in all of the areas of testing across the state.

Figure 2.1 gives an example of how a wheat variety may be listed by a commercial seed company. The variety name or number is listed with its characteristics and a rating is given of how that variety performs in specific areas on a 1-10 scale with 10 being best. A short narrative describing the variety is also provided.

Producers should obtain information from seed companies as shown in the example and investigate University performance tests before making a wheat seed selection.

Class of Other Small Grains

Barley is one of the four major feed grains grown in the United States. It is a hearty plant, able to withstand many different growing conditions. However, barley is least tolerant of hot, humid conditions, which makes it unsuitable for the subtropical regions of the southeastern United States.

Figure 2.1 - Example of Information Provided by Commercial Seed Company

Characteristics	Rating	Description of Variety
		Variety X
Yield	9	Strong candidate for double cropping. Impressive yields and test weight. Superior standability. Strong drought tolerance. Best grown in areas not prone to winterkill.
Lodging resistance	7	
Test weight	8	
Drought tolerance	7	
Winter hardiness	4	
		Variety Y
Yield	9	Above average test weight and excellent yield. Superior winter hardiness and good standability. Excellent resistance to powdery mildew and stem rust.
Lodging resistance	6	
Test weight	6	
Drought tolerance	5	
Winter hardiness	7	
		Variety Z
Yield	9	Soft red wheat with superb yields and dependable winter hardiness. Adapted to a wide range of environments. Good test weight, and strong resistance to powdery mildew and stem rust. Superior resistance to soilborne viruses and moderate resistance to leaf rust.
Lodging Resistance	5	
Test weight	6	
Drought tolerance	4	
Winter hardiness	7	
		Variety X1
Yield	9	Broadly adapted variety that provides good overall disease resistance. Sound winter hardiness and top yields. Good standability. Resistant to soilborne viruses, scab and leaf rust.
Lodging resistance	6	
Test weight	4	
Drought tolerance	6	
Winter hardiness	7	

There are many different varieties of barley grown in the United States. But there are two basic types that are classified based on the number of rows of grain seen when the heads of the stalks are viewed from above. The two types are the two-row and the six-row. Most barley raised in Missouri is the six-row type because two-row barleys have not achieved the yield potential of six-row barleys. The two-row barley produces 15-30 kernels on each head of grain, and the six-row barley produces 25-60 kernels on each head of grain.

Oats are grown primarily in the north central states because the oat plant requires plenty of moisture and relatively cool weather. As with wheat and barley, oats may be planted in the fall or spring. In Missouri, most oats are planted in the spring.

Four varieties of oats are grown in the United States. White oats, which account for most U.S. production, are grown north of the Ohio River and east of the Rocky Mountains. This is the variety most likely to be planted in Missouri. Red oats are grown south of the Ohio River in Texas, Oklahoma, and Kansas. Gray oats are produced in the Pacific Northwest, and black oats are gown in small amounts in various parts of the country.

Selecting a Seed Variety

Although yield is often the key factor in variety selection, other characteristics can be important. Today's wheat and small grain varieties are quite similar in yield performance. Rarely do we find one variety that consistently out yields all others. What this means to producers is that factors other than yield should receive greater attention as varieties are selected for production.

Disease and stress resistance - Diseases can be a major problem across the state; however, the disease type and the disease pressure vary by location around the state of Missouri and from year to year. Select a variety with resistance and tolerance to the diseases and stresses commonly found in the producer's region of the state.

Height and lodging - Varieties differ in height and lodging resistance. Though generally correlated, taller varieties are not necessarily more prone to lodging. Lodging reduces both grain yield and grain quality. As soil fertility levels increase, stiffer-strawed varieties should be used. Careful attention must be given to both timing and rate of fertilizer applications and irrigation when used.

Maturity - As a group, barleys mature earlier than other grains, oats later. Wheat has early-, mid-, and late-season varieties. Differences among varieties with each grain type can be significant. Early-maturing varieties can avoid yield and quality reductions caused by heat or drought in mid-to-late summer. They can also be used for double cropping. Later-maturing varieties yield more when moderate temperatures and favorable moisture conditions persist into midsummer. Choose a variety that matches the environment and cropping needs of the region.

Winter hardiness - As a group, winter barleys are less winter tolerant than wheats; however, some winter barley varieties have better hardiness than most wheats. Winter hardiness is a complex characteristic determined not only by a variety's tolerance of cold, but also by its resistance to other stresses encountered during winter months. If winterkill is a problem in the region, select varieties with a higher winter-hardiness rating or consider using a mixed variety planting. Oats are the least hardy of the winter cereals.

Yield potential - Yield potentials vary from one area to another and from year to year. Yield potential is a genetic trait but is moderated by other factors such as disease and stress tolerance. To evaluate the yield potential of a variety, review data from test sites with an environment similar to that in the producer's area. Compare performance over several years if possible because a single year's data can be misleading.

Intended use - Barley varieties are classified as either feed or malting types. Feed types are generally classified as such because they did not meet malting barley quality requirements, not because they were bred specifically for feed use. When raising barley for feed, select varieties with consistently high test weight.

Grain quality - Test weight (bushel weight) is a price-determining factor in the marketplace. Choose varieties with good test weight records. Quality is a function of the bran-to-endosperm ratio. The endosperm (82-84% of the kernel) is the source of starch and protein. The bran is the covering or coating of the kernel. Higher test weights equal higher quality and command a higher market price.

Prevalent Diseases in the Area

Wheat diseases are major hazards in wheat production, causing losses through reduced yield and quality of grain. Wheat diseases are caused by parasitic bacteria, fungi, and viruses. Wheat is subject to attacks from about 50 different pathogens, but not all of the diseases will occur in a particular area or in a certain year.

Estimated annual losses vary from 10 to 25%, depending on many factors such as weather conditions, soil moisture, soil fertility, crop rotation, prevailing winds, and susceptibility of particular varieties to various diseases. Some disease losses cannot be prevented because no successful means have been devised for controlling some of the most destructive diseases. However, a considerable part of these losses can be prevented by using proven methods for disease prevention and control.

Recognition of the most common and destructive diseases is important to apply control measures whenever possible. Wheat diseases may be grouped in the following categories: (1) seedling blights, root rots, and crown rots, (2) leaf diseases, (3) diseases of heads, and (4) viral diseases.

Seedling blights and root rots are usually present every year in most wheat fields. Importance varies greatly with season, locality, and cropping practices. Wheat plants are subject to attacks from seed to maturity. Root decay, stunting, and premature death of older plants are characteristic of root rot infections. Root rots are caused by many species of fungi and are more severe in moist soils. Root rots cannot be completely prevented but they can be reduced. General control measures to reduce problems from seedling blights and root rots include buying sound seed of recommended varieties, cleaning and discarding shriveled seed, treating seed with a recommended fungicide to eliminate pathogens, sowing deep enough for adequate moisture for germination, planting in well-prepared seedbeds, and rotating crops.

<table>
<tr><th colspan="2">Seedling Blights and Root Rots</th></tr>
<tr><td>Helminthosporium crown and root rot</td><td rowspan="6">Circular patches of dwarfed, reddish-brown plants scattered throughout a field
Dark brown lesions on the surface of the coleoptile of plant that progresses inward and may spread into the roots
Infection of crowns, roots, and basal portions of the stem
Distinct rotting of affected parts, typically a dry rot
Widely distributed on wheat seedlings, causing failure to emerge</td></tr>
<tr><td>Fusarium root rot</td></tr>
<tr><td>Gibberella root rot</td></tr>
<tr><td>Pythium root rot</td></tr>
<tr><td>Rhizoctonia root rot</td></tr>
<tr><td>Wheat take-all</td></tr>
</table>

<table>
<tr><th colspan="2">Leaf Diseases</th></tr>
<tr><td>Leaf rust</td><td>Found mainly on leaves but may occur on stems, especially between head and flag leaf
First appears on older leaves and spreads up the plant to the flag leaf as the season advances
Small, round or oblong, raised orange-red pustules on the surface of the leaf
Most abundant on the upper leaf surface</td></tr>
<tr><td>Stripe rust</td><td>Pustules are light yellow and arranged in distinct straight-sided stripes about 1/16 inch wide and of irregular length
Heavily invaded leaves may die
Not common in Missouri wheat but it has been identified in some variety trials in the 1980s
Like leaf rust, develops from spores blown in from southern wheat growing regions</td></tr>
</table>

Leaf Diseases	
Powdery mildew	Affected plants usually in parts of the field where growth is dense and the air moist, conditions ideal for infection Small, irregular or circular light gray spots on the upper surface of the leaves Spots enlarge as fungus grows and take on a floury appearance due to the production of an enormous number of spores Lower surface of the leaves beneath diseased spots turns yellow and older parts of the spots turn brownish Can develop on heads and stems under favorable conditions
Septoria leaf blotch	Appears first as light green to yellow spots between the veins of the leaves Lesions spread rapidly to form light brown irregular blotches with a speckled appearance Small submerged brown pycnidia in the blotches are the final diagnostic symptom Moves from lower leaves upward toward flag leaf Attacks leaf sheaths, stems, and flumes occasionally
Downy mildew (crazy top)	Infected plants are erect, yellowish green, somewhat dwarfed, and they tiller excessively - many tillers only a few inches tall Thickened leaves may be twisted, curled and stiff, and stand erect Stems may be thick and deformed, especially at the base of the head Heads may be distorted and open; chaff fleshy and green
Tan spot (yellow leaf spot)	Appears early in the season At first the spots are yellow-brown, bordered by yellow Round spots are oval to elongated, usually less than 1/16 inch long Found on both surfaces of leaves Spots increase in size as season advances Dead brown area of a spot may be 1/4 inch wide and 3/4 inch long and usually tapered
Cephalosporium stripe (fungal stripe, C-stripe)	This is a vascular disease Infected seedlings show yellowing, but most conspicuous symptoms appear after jointing Long, chlorotic stripes form on sides of the leaf midribs and run the entire length of the leaf Stripes extend down into leaf sheaths

Stem Diseases	
Stem rust	Wheat stem rust usually appears in Missouri every year, but severity of attack will vary Red spore stage is encountered during growing season and may occur on any aboveground parts Elongated ragged pustules on stem, leaf sheath, blade, or chaff usually begin to appear in mid-June Pustules rupture tissue, exposing powdery, brick-red mass of summer spores. As wheat nears maturity, black pustules filled with black spores appear
Leaf rust	See discussion under leaf diseases

Head Diseases	
Loose smut	Easily recognized by the characteristic dusty black appearance of diseased heads As a rule, glumes and grain are completely transformed to black powder, which shatters off, leaving a bare spike at harvest
Common bunt (covered smut, stinking smut)	Heads affected by bunt have a blue cast when they emerge from the boot Infected kernels are transformed into smut balls during growth Smut balls consist of masses of foul-smelling, dark brown powder, which are the spores of the fungus
Scab (head blight)	Premature ripening of one or more spikelets of a head any time after flowering When wheat is in the dough stage, light yellow color of diseased spikelets of the head shows in sharp contrast with healthy green of rest of head Light pink or salmon color may appear at bases of infected spikelets Kernels become grayish-white, badly shrunken and wrinkled, with rough, flaky seed coat called "tombstone"
Glume blotch	Causative fungus attacks heads most often Produces brownish blotches near the tip of the chaff Severely infected heads are chocolate brown and produce shriveled kernels May be found on leaves and joints Hard to distinguish from Septoria leaf blotch on leaves
Basal glume rot	Dull, brownish-black discolored area found at the base of each of the glumes covering a kernel Discoloration more pronounced on the inside than on outside of the diseased glume Some kernels are brown or black at germ ends
Black chaff	Attacks wheat (also barley, rye, and some grasses) Known as bacterial blight on barley and rye Occurs chiefly on the chaff of glumes Longitudinal, dark, more or less sunken stripes or spots, more abundant and noticeable as a rule on the upper than the lower halves of the glumes In moist weather, tiny yellow beads of bacteria ooze to the surface of black lesions and dry as minute, yellow scales Symptoms on leaves appear as water-soaked spots and streaks that eventually turn brown
Black point (kernel smudge)	Diseased kernels are discolored and appear weathered Black point describes the darkened and sometimes shriveled embryo end of the seed. Germinability is decreased
Black (sooty) head mold	Superficial head molds develop on the heads, especially if rainfall is high after senescence Infections progress to the seed, causing black point disease
Ergot	Empty florets occur in addition to kernels that are replaced by a plump, hard, purplish body larger than healthy kernels, usually two to five per head More common on barley but can be on wheat, oats, and some grasses

Viral Diseases	
Barley yellow dwarf virus (BYDV)	Most widespread virus disease of wheat in Missouri Stunting and yellowing are most the noticeable symptoms Symptoms are usually observed in late spring at about jointing Leaf yellowing begins at leaf tips and along midribs Flag leaves may have a reddish-purple tip Also causes "red leaf" in oats and "yellow dwarf" in barley
Soilborne wheat mosaic (SBWM)	Occurs on fall-sown wheat (also rye, barley, and some grasses) Detected in spring by presence of light green to yellow patches in the fields, from small areas to areas 50 feet or more in diameter Plants are dwarfed, tiller excessively, and have mottled leaves consisting of light green or pale yellowish stripes or blotches that tend to run parallel with the long axis of the leaves Occurrence of the disease depends on weather of fall and winter, which influences the growth and dormancy of the plants
Wheat yellow mosaic (WYM)	Soilborne virus common to Missouri More commonly seen in southeast Missouri, but can occur in other areas Tends to be more uniformly spread than soilborne mosaic Symptoms appear in early spring as yellow-green mottling dashes and streaks on leaves Streaks running parallel to veins taper to form chlorotic spindles Reddish streaking at the leaf tips often precede necrosis Some stunting and poor tillering.
Wheat streak mosaic virus (WSMV)	Most infections occur in the fall but symptoms are observed after the arrival of warm spring weather Yellowish streaking and mottling of leaves Plants may be stunted Leaf margins often rolled toward midrib As plants approach maturity, mottling disappears, leaves turn brown and die Heads that form may be totally or partially sterile

General control measures for wheat and small grain diseases include:

- Use sound seed of recommended varieties.
- Clean seed and discard shriveled seed.
- Use a recommended EPA-registered fungicide for a seed treatment.
- Use resistant varieties.
- Eradicate disease hosts (other plants).
- Use foliar application of fungicides.
- Practice crop rotation.
- Practice crop sanitation by plowing under crop residues.

Summary

Before producers begin to plant a crop of wheat or other small grains, they must secure and analyze information concerning what types and varieties of small grains are available and recommended for their location. Seed companies and University of Missouri recommendations should be considered when making these decisions. Producers should also be familiar with the many diseases they may encounter and be knowledgeable of prevention or control procedures to eliminate or reduce the risk of damage these diseases may inflict.

Credits

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Lesson 3: Selecting a Tillage and Planting Method

To optimize wheat and small grain yields, it is important for producers to have a good understanding of proper seedbed preparation, planting methods, and seeding rates. Producers have several choices when selecting which cultural method they want to use.

Tillage Methods

Seedbed preparation varies across the state depending on residue from the preceding crop, the need for moisture conservation, and the producer's personal preference toward tillage. The amount of tillage for seedbed preparation has been reduced during the past decade. Conventional tillage, which was prevalent in the 1970s and 1980s, is practiced only on a limited basis in the continuous wheat fields of the state.

Minimum tillage, including no-till, has several advantages. These include (1) reduced fuel costs, (2) reduced equipment costs, (3) decreased operator time, (4) less soil compaction, (5) less soil erosion, (6) improved soil moisture retention in many instances, and (7) maintenance of soil organic matter.

Factors to Consider When Choosing a Tillage Method

Producers should strive for a firm seedbed, which promotes good seed-to-soil contact and results in rapid germination and stand establishment at the lowest possible cost. Frequently, producers will till in an attempt to cover all their acres when the soils are too wet for tillage equipment. This contributes to compaction and tillage pans that can cause problems later in the growing season.

In continuous wheat fields, residue management is difficult. Most producers use one or two diskings or a chisel operation to incorporate residues. This is followed by another disking or the use of a field cultivator as planting time approaches. With more residues remaining on the soil surface, foliar diseases are increased. Resistant varieties are important in this cropping system. On the heavier, sloping soils, 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 row crop residue after harvest is left untouched until late summer when one or two diskings or field cultivation is used before wheat seeding. Many producers have saved time and soil moisture by planting no-till wheat double cropped after harvest. Most drills are able to no-till into soybean residue in a wheat double-cropping system. No-till drills are also effective for planting into corn and sorghum residues. If the row crop is corn, some tillage may be performed to destroy the residue, which lowers the incidence of disease.

Residues reduce evaporation, soil erosion, runoff, and increase water infiltration and snow catch during the winter. After wheat harvest in the summer, a residual herbicide replaces several tillage operations to control summer weed growth. To maximize moisture savings, the wheat residue is left undisturbed until the summer crop (usually soybeans in Missouri) is planted no-till into the stubble. After the summer crop (soybean) harvest, the residue is left untouched until the following fall when wheat can be planted no-till, or if there is ample moisture in the soil profile in the spring producers may opt to plant a summer crop again.

Residue management, through conservation tillage, is an effective tool for reducing soil erosion. The percentage of the soil surface covered with residue is important in determining how much erosion will occur from rainfall runoff. Crop residue shields the soil surface from the rainfall impact, thus reducing the amount of particle detachment. Residue also reduces the amount of crusting, which allows more water to soak into the soil and creates numerous small dams, which reduce runoff velocities and capacity to carry sediment. As mentioned earlier, standing residue increases snow catch in the winter and increases moisture storage for the next crop.

If wheat diseases are a concern, moldboard plowing or deep disking buries residue containing the Hessian fly and other destructive insects. Control of volunteer wheat plants, either by mechanical or chemical means, can reduce the incidence of wheat streak mosaic virus by controlling the wheat leaf curl mite, particularly in the Plains states. Destruction of previous crop residue also helps control diseases such as *Rhizoctonia* root rot in areas of the state that may receive higher than normal amounts of rainfall.

Planting Methods

Most wheat or other small grains are planted with a drilling method. Planting wheat with a drill into a prepared seedbed will result in the optimum placement of seeds and number of seeds per unit area. Producers should strive for uniform stands to decrease lodging potential, to more uniformly extract soil moisture and nutrients from the soil, and to more efficiently intercept incoming light energy, all of which will optimize yield. Planting in rows as narrow as possible for expected moisture conditions helps accomplish these goals and will help control weeds.

Seeds that are broadcast and then disked or harrowed into the soil result in about 20% of the seed being either too deep or too shallow. Those seeds that are too shallow are subject to desiccation (drying up) after germination, and those planted too deep will leaf-out under the soil and die.

Planting equipment should be calibrated to place the appropriate number of seeds per linear foot of row to maximize yield. The number of seeds per pound varies from 12,000 to 20,000 depending on the type of wheat and the environment in which the planting seeds were produced. Planting too few seeds per acre could result in excessive tillering that may delay maturity and/or increase weed competition. Planting too many plants per acre is an unnecessary expense and may result in increased lodging and decreased yields due to lack of nutrient and moisture support.

Seeds should be planted into moisture if possible. Wheat and other small grain cultivars (varieties) that have long coleoptiles can be planted up to 3 inches deep, whereas semi-dwarf varieties should not be seeded more than 2 inches deep. In either case, deep placement of seeds can result in delayed emergence and erratic stands.

Recommended Seeding Rates

Seeding rates for wheat will vary across the state because of environmental conditions. In areas of lower rainfall, recommended seeding rates are lower. Recommended seeding rates for Missouri depend on whether the seed is broadcast and then incorporated or drilled. Recommended broadcasting rates range from 120 to 180 pounds per acre. This equates to 2 to 3 bushel per acre using wheat with a test weight of 60 pounds per bushel. When drilling, producers should use seeds per acre, not bushels per acre as shown in Table 3.1.

Table 3.1 - Wheat Seeding Chart

Plant Seeds Per Acre						
		Drill Row Spacing				
Desired Population Seeds/Acre	Seeds/sq. ft.	6 in.	8 in.	10 in.	12 in.	14 in.
(x 1,000)		Seeds per linear foot of row				
500	11	6	8	10	11	13
750	17	9	12	14	17	20
1,000	23	12	15	20	23	27
1,250	29	14	20	24	29	33
1,500	34	17	23	30	34	40
1,750	40	20	27	33	40	47
2,000	46	23	31	38	46	54

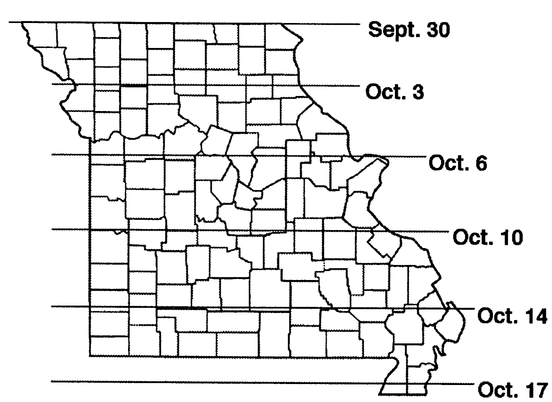
Actual rate = (seed per linear foot of row / % Germination) x 100
Example: (23 / 95) x 100 = 24 seeds per linear foot of row needed to seed 1.5 million seeds per acre drilled with an 8" row spacing
Source: Missouri Seed Improvement Association

The recommended seeding rates for barley are 96 to 120 pounds per acre if broadcast and 72 to 96 pounds when drilled. Barley has an average test weight of 48 pounds per bushel. The recommended seeding rates for oats are 96 to 120 pounds if broadcast and 48 to 96 pounds per acre if drilled. Oats have an average test weight of 32 pounds per bushel.

Using a Planting Calendar

Climatic conditions vary across the state causing the recommended planting dates to vary for different areas. Producers try to plant winter wheat at a time when seedlings have well-established crown roots and three to five tillers before winter dormancy. This enables the plants to reduce winterkill damage. Planting within a week of the Hessian fly-free date for an area will usually allow enough time for adequate fall growth. Figure 3.1 shows those dates for areas of Missouri. Planting too early increases the hazards of insects and diseases, such as the Hessian fly, leaf rust, and wheat streak mosaic virus. Planting later than optimum often causes limited fall growth, both root and tiller formation, and subjects the wheat or barley to increased potential for winterkill damage.

Figure 3.1 - Hessian Fly-free Dates



Winter barley is planted the same time as winter wheat. Barley is also attacked by essentially the same insects and diseases that attack wheat.

Spring oats are the first crop to be planted in the spring in Missouri. Selecting fields with well-drained soil to permit timely planting is essential. Spring oats should be seeded as early in the spring as soil conditions permit, preferably between March 1 and April 15. Grain yields will decrease rapidly because seeding is delayed past mid-April.

Summary

Most producers of wheat and small grains are practicing conservation tillage methods. Using these methods or no-till methods has several advantages. Seldom are fields prepared using the moldboard plow. Although crop residue could harbor some wheat and small grain diseases, there are also several benefits for leaving some residue in the field. These include conservation of soil and soil moisture. Most wheat in Missouri is planted with either a conventional drill or a no-till drill. Larger and more uniform plant populations are established using these methods. Planting dates for fall seeded grains usually follow the recommended Hessian fly-free date, whereas spring grains such as oats are planted as early as soil conditions would allow.

Credits

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Lesson 4: Selecting a Pest Control Program

Lesson 2 discussed diseases that affect wheat and other small grains. This lesson will concentrate on insects in wheat and small grain. Information will be given on specific insects and pests that affect these small grains and how they may be controlled. Producers should become familiar with life cycles, appearance, and damage caused by insects that are recurring pests in their area.

Factors That Determine a Pest Control Program

The major objective of a pest control program is to reduce insect pest populations to an acceptable level. There are some factors to consider when selecting what type of control program is right for the area and for the level of production.

Many producers select their pest control action from previous experience or observing what other producers are using for control methods. This may not be the best rationale to use when making pest control decisions. Conditions change and so should pest control methods. Also, what one producer uses to solve a pest problem may not be successful for another producer.

Cost is probably the first factor to consider. Chemical control programs are very expensive and costs are rising continually. The amount and kind of chemical used will be based on the pest problem as observed by the producer when scouting the wheat or other small grain crop. Fields should be observed frequently during April, May, and June. Rising costs of chemical control measures are one reason producers look for alternatives to pest control other than chemical use.

Another factor to consider in pest control selection would be consideration for the environment. More producers are becoming aware of harmful effects when pesticides are overused. Educational efforts of groups and agencies responsible for land and water quality are making an impact on choices of pest control measures used by crop producers.

Some producers will consider nonchemical methods (using physical and biological mechanisms) for their pest control measures. These include controlling pests by plowing them under in crop residues, introducing predators and parasites that feed on harmful pests, using plant varieties that are pest resistant, and releasing sterilized male insects into the wild populations that cause females to bear infertile eggs.

Integrated pest management (IPM) is a more recently developed technology for pest control aimed at achieving the desired control while reducing the use of pesticides. Combinations of chemical, biological, and physical controls are used. If properly implemented, IPM can reduce pesticide use by as much as 50% while also improving pest control. Environmental problems can be reduced and producers and society as a whole will see significant benefits.

Other factors to consider when deciding pest control measures would involve the specific pest problem and the type of soil conditions where the small grains are being produced. Crop advisors from chemical suppliers and extension agronomy agents are very useful in recognizing specific pests and suggesting control methods. They can also help identify soil types and conditions that may affect chemical control success.

Pests Specific to Wheat and Small Grains

Wheat and other small grains are attacked by many insects. Fortunately, only a few insect species cause severe damage over large geographical areas that are very important. Most pests are only "occasional" pests and/or not geographically widespread. The status of many pest species is not always well documented.

Barley and oats are attacked by essentially the same insect complex that attacks wheat; therefore, the following list can apply to all cereal grains.

Aphids - Aphids are widespread pests on cereal grains. When feeding in sufficient numbers, they can cause significant damage. In addition to feeding damage, they may act as "vectors" (transmits, carries, or spreads) of barley yellow dwarf virus. Aphids are nearly transparent, soft-bodied, sucking insects. When present in sufficient numbers, they can cause yellowing and premature death of leaves. They exude drops of sugary liquid known as "honeydew," which may cause tiny scorch marks on the foliage and encourage the development of sooty molds.

Some aphid feeding may result in the development of necrotic (dead) areas, sometimes accompanied by purpling and rolling of the infested leaves. The life cycle of the aphids involve the winged, wingless, sexual, and asexual forms. When feeding on cereals such as wheat, barley and oats, the females of most aphid species reproduce asexually (without being fertilized), producing nymphs rather than eggs. Species of aphids commonly found on cereals include bird cherry-oat aphid, greenbug, corn leaf aphid, rose grass aphid, English grain aphid, and the Russian wheat aphid.

Stink bugs - Losses due to stink bugs are extremely variable and depend on the density of the insects, weather conditions, and duration of the crop-growing period. Mild winters and low rainfall encourage outbreaks of the insects. Stink bugs will feed on most cereals and grasses and a large range of weeds. Losses result primarily in reduced baking quality of the grain. Adult stink bugs feed on stem tissue or developing kernels. Saliva from this insect is toxic to the plant, and a single feeding puncture can kill a stem. Feeding on kernels during the milk dough stage will destroy the kernel, while feeding during later development stages will badly shrivel the grain. Feeding on the developing head may cause partial or total sterility. Adult stink bugs have a shield-shaped body and emit a disagreeable odor when crushed. Adult stink bugs hibernate under dead leaves and grass. In the spring they lay eggs on various parts of the plant. Their hatched nymphs feed on the plant.

Armyworms, cutworms, and stalk borers - These pests sporadically cause severe damage, and when they do, they can devastate large areas. The primary symptom of these insects is defoliation of the plant. Larvae feed on leaves, chewing from the edges to the midrib, or on the heads of cereal plants. Heavy infestations can be very destructive. Larvae may climb the plant and sever the neck just below the head. Some species may be found feeding at the soil surface, others underground feeding on roots, and still others feeding inside the stem. The adult worms lay eggs on the leaves and leaf sheaths near the ground. These eggs hatch within a few days and initially the larvae may feed where they hatch, feeding at night or early in the morning. In damp weather, they may feed all day.

Cereal leaf beetle - Significant yield losses can occur in winter wheat and fall-sown spring wheat. Yield losses of 15% to more than 25% have occurred with natural infestations. Adult beetles are 4-5 mm long, have a black head, light brown thorax, and a shiny blue-green wing covered with parallel lines of small dots. The most prominent symptoms of cereal leaf beetle infestations are the distinct, longitudinal stripes on leaves. These stripes are produced by the feeding of the adult beetles and of larvae. The insect produces one generation per year. Adults begin their feeding activity in the spring. They lay yellow eggs, either singly or in small chains, covered with a sticky film. The adults emerge in the summer. Adults overwinter in plant debris on the soil surface, in leaf sheaths, on ears of corn, or under the bark of trees. Wheats with hairy leaves are affected less.

Thrips - Thrips are small (1 mm), brown or black insects with a tapering, segmented abdomen. They have piercing and sucking mouthparts and usually have two pairs of narrow wings. They are usually found behind the sheath of the flag leaf, feeding on the stem. However, some leaves, stem, and heads may be attacked. Adults and nymphs both can cause damage and, if present in large numbers, may cause the tissue on which they are feeding to take on a silver coloration. Eggs are inserted into or attached to the host tissue. The generation time is very short and there may be 10 or more generations per year. Heavy rains will usually destroy most the population. Several thrips species live exclusively on cereals and on forage or weed grasses. Thrips rarely cause serious damage and it is unusual to find infestations at such a level as to warrant control measures.

Hessian fly - This is one of the most destructive insect pests on cereals. Widespread outbreaks have occurred, and in some locations the pest recurs annually. The Hessian fly is mainly a pest of wheat, but it may attack barley, rye, or other grasses. This pest has been reported in most wheat-growing areas of the world. Severe infestations of Hessian fly result in stunting of the plants, thin stands, lodging, and reduced yield. Injury is caused entirely by the larvae, which sucks juices from plant tissues. If infestations occur during jointing, infested stems will often break before maturity. The Hessian fly is 3-4 mm long, has a black head and thorax, and a pinkish or yellow-brown abdomen. Adult flies emerge in the spring from pupae that have overwintered in straw or stubble. The minute, oblong eggs are reddish in color and are laid in rows on the upper sides of leaves. The eggs hatch within 1 week. The legless larvae settle behind the leaf sheaths and suck the sap of the plant. The larvae develop into translucent, pale-green, slug-like maggots.

Wheat stem maggot - In infested fields, 10-15% of the plants may be injured. Damage can be severe in some years, but the insect seldom causes widespread damage. Heavy infestations of individual wheat stands may kill a significant portion of the tillers. Wheat stem maggots attack young tillers in the fall or early spring. The tillers usually die and infected plants show the "white head" condition typically produced by stem-boring insects. Adults are about 6 mm long and pale green to yellow with dark stripes. Larvae overwinter in cereal plants or grasses. Females lay small white eggs, one per stem, near the sheath of the flag leaf. The larvae burrow into and consume the interior of the stem, killing the upper part of the stem and head. There are normally three generations per year; one in the spring, one in the summer, and a third in the fall that overwinters as larvae.

Sawfly - This insect can cause significant damage in some years, but infestations are usually not continuous. Nearly all cultivated cereals and native grasses act as hosts, although wheat is preferred. Fall-sown cereals are more commonly attacked. Wheat varieties having solid or partially solid stems are much less susceptible to attack. Damage by sawflies includes premature yellowing of the head and shriveling of the grain. The larvae girdle the stem and later in the crop cycle cause lodging. Sawflies produce one generation per year. Larvae overwinter in the straw. Adult sawflies are small, fly-like wasps and appear from late spring to midsummer. Females deposit small, white eggs in the upper nodes of stems just below the heads. Upon hatching, the larvae bore into the stem and tunnel downward, feeding on the pith of the stem.

White grubs - Many species of white grubs attack wheat and many other plant species. Cereal crops may suffer significant damage if seeded into heavily infested grasslands. White grubs are the larvae of May or June beetles. Eggs are deposited in the soil and the hatched larvae feed on roots. White grubs can partially or completely sever the roots of the host plants. This causes patches of wilting and dying wheat plants (especially in the seedling stage), symptoms that could be attributed to root rots. However, when stunted patches are observed, the surrounding soil should be examined for the larvae. When fully grown, the largest of these larvae may be several centimeters long and nearly 1 cm thick.

Wireworms - These insects are among the most damaging soil-infesting pests. Damage is usually most severe where wheat has been seeded after fallow or after of number of years of grass. Many species of wireworms are found throughout the world, all of which can attack wheat. Wireworm damage is similar to that caused by other soil-inhabiting chewing insects. The only sure way of identifying wireworm damage is to find them in association with the damaged seedlings. The name "wireworm" refers to the tough, wire-like appearance of the larvae. They are 20-30 mm long and are often smooth, hard, and highly polished. Larvae may attack wheat as soon as the crop is seeded, eating the endosperm of the kernels and leaving only the seed coat. A common sign of wireworm attack is the wilting and/or dying of many adjacent plants, either in a row or patch. Stems of affected seedlings will be chewed just above the seed. Wireworms are the larvae of click beetles, of which there are many species. The eggs are laid in the soil, usually in the spring, and the larvae take several years to develop. Generations overlap so all stages and sizes of larvae may be found in the soil at the same time.

Grasshoppers - Grasshoppers can severely damage full-seeded small grains, especially following a dry growing season. If grasshopper populations are high, treat fence rows and other areas before the grain germinates. Treating the margins of the fields after the grain emerges give adequate control. But if one or more grasshoppers per square yard are found throughout the field, apply chemical controls.

Pest Control Options

The measure or action taken for the prevention or control of wheat and other small grain insects will depend on the pest and the time of the year.

Some measures should be taken before planting. These would include plowing under residue to eliminate a place, or host, for some insects to winter. Some insects such as grasshoppers should also be scouted before planting. Three to five grasshoppers per square yard warrant control spraying. Also, when scouting before planting, if wireworms are noticed, a seed treatment would be in order.

During the growing season, foliar sprays should be used at the first sign of infestation of any of the insect problems discussed in this lesson. Most foliar sprays can be repeated if necessary after 14 days. Directions on the use of such sprays must be followed. As an example, foliar sprays must not be used a certain number of days before harvest. These may vary from 7 to 45 days.

Consideration should also be given to the control of insects and rodents that present a problem during storage. Storage bins should be cleaned thoroughly. Some control sprays must be used before filling with grain with a 24-36 hour waiting period before placing grain in the storage facility. Some sprays are placed on the grain as it enters the bin. Poisons may also be purchased for rodent control in stored grain.

Summary

It is very important that a producer of wheat or small grains such as barley or oats understands how to select a pest control program. The management and control of insects that may affect the yield potential of a crop will play a large role in the success of the crop. Producers must also be aware of the many pests that may invade the soil or growing plant, how to identify them, the damage they may cause, and methods of control.

Credits

Agronomy Guide 2000, MFA, Inc. Columbia, MO 2000.

A Guide to Wheat Diseases and Pests. Cornell University Extension. May 2000.

The Wheat Production Handbook. Kansas State University Cooperative Agricultural Extension Service. May 1997.

Lesson 5: Scouting and Maintaining the Crop

During the growing season, wheat and small grain producers must evaluate the crop to determine if and when problems may develop and know what corrective actions may be warranted. Examinations must also take place to evaluate cultural and mechanical practices the producer has used to plant and establish the crop.

Plant Condition Factors

During the growing season, the producer should know how the crop and individual plants are progressing. Are the plants being allowed to develop to reach their maximum yield potential? Several plant condition factors should be considered when evaluating the growing crop.

The first factor is to evaluate the crop regularly to determine if the fertility program is meeting expectations. The grower should be able to recognize problems that were caused by nutrient deficiencies. Sometimes corrective measures can be taken such as a nitrogen top-dressing in the spring.

Tillage and planting methods used by the producer should also be evaluated. The condition of the seedbed plays a large role in the successful establishment of the stand in the fall. Management of the previous crop residue should be evaluated to determine if a problem developed because of residue left on top of the ground. Did the conservation tillage or no-till planting procedure yield expected stand densities?

Another factor to consider would be the soil moisture level. The producer may dig into the soil to determine the soil moisture and its depth. If soil moisture is determined to be inadequate, the producer may be able to provide irrigation to the plants.

The type of weeds and the weed pressure (density) should also be examined. This should be done in the fall as the plants are starting to emerge and again in the spring when plants start to "green-up" after the winter. Decisions must be made whether a corrective action, such as spraying, is warranted.

Plants should be examined regularly for disease and insect damage. The success of any corrective treatment to counter pest and disease problems will be determined not only by what action is taken, but also the timeliness of that action or treatment.

Replanting Decisions

Replanting decisions are complicated by not knowing what future seasonal growing conditions will occur. Decisions should be based on historic trends plus current environmental and economic conditions. Two questions should be addressed when considering replanting: (1) Is there an economic advantage to replanting? (2) Should the same crop be replanted? The advisability of replanting must be carefully considered, keeping in mind that the cause and severity of injury, soil moisture, replanting costs, previous herbicide use, and replanting date all influence whether a crop should be replanted or if a different crop should be planted.

The cost of replanting must be recovered from a later maturing crop that typically has a lower yield potential than the original crop. Replanting also results in additional moisture loss.

While maximum wheat and small grain yields are obtained at plant populations of 28 to 30 plants per square foot, acceptable yields can be achieved with populations of 12-18 plants per square foot. A uniform stand, even at very low densities, will often produce above expected yields. Generally, replanting should be considered only for those fields with stands below 30% of intended plant densities or regions with 4- to 6-foot gaps.

Weed Pressure

Winter and summer annual broadleaf weeds have an important economic impact on winter wheat and other small grains. They compete with small grains for light, water, space, and nutrients, reducing some wheat yields by an estimated 10% each year. Weeds will also slow harvest and increase combine repair costs. Producers may be docked at the elevator for excessive grain moisture and/or weed seeds in their grain.

In 1982, only about 10% of the winter wheat acres in Missouri were sprayed with herbicides to control weeds. By 1998, however, approximately 60% were sprayed. Effective weed control in winter wheat can eliminate or greatly reduce losses due to weeds and increase net returns.

Success with reduced and no-till programs is improved with weed-free winter wheat stubble after harvest. In addition, weed seed from the current crop will survive in the soil and cause problems in future crops. These potential problems underscore the importance of broadleaf weed control in small grains. An effective weed control program considers the entire cropping system. This approach involves the use of preventive, cultural, and chemical weed control methods.

Prevention, or stopping the advancement of weed infestations, is an important part of a total weed management program. It requires diligence from the producer but offers low-cost, effective control. Some rules for preventive weed control are (1) use crop seed that is weed free; (2) clean tractors, implement, and combines before moving them from infested to clean fields; (3) keep uncropped areas (fence lines and field borders) weed free; (4) do not allow livestock to move directly from infested to clean areas; and (5) spray or mow to prevent weed seed production in all areas.

Cultural weed control involves manipulating the crop/weed environment so conditions are favorable for crop plants but unfavorable for weeds. Crop competition and crop rotation are two important cultural control practices in small grain production.

Crop competition involves establishing a vigorous crop that can compete more effectively than weeds for water, light, space, and nutrients. Several factors contribute to competitive crops: proper seedbed preparation; adequate fertilization; high-quality crop seed; careful variety selection; and proper date, rate, and depth of seeding. These factors will also result in high-grain yields.

Crop rotations that include spring-seeded crops break the life cycle of problem weeds, particularly annual broadleaf weeds, and allow the use of tillage and herbicides that may not be feasible in a small grain monoculture. Adapted rotational crops include corn, grain sorghum, and soybeans.

Several herbicides provide excellent broadleaf weed control with minimal damage to small grain crops; however, some varieties are more sensitive to herbicides than others. Research has not been conducted on the herbicide sensitivity of many varieties presently planted. The following fundamentals should be considered before selecting a herbicide: (1) identify the weed problem, (2) spray when weeds are small and actively growing and at the proper stage of the small grain growth for the herbicide use, (3) use 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, and (6) know the rotational plans to avoid herbicide carryover problems to sensitive crops.

Timely weed control is important to reduce early season weed competition with the crop. Research has found that weeds that emerge at the same time as the small grain plant or within a week of emergence may cause as much as 35% reduction in yields. However, in stands where the weeds did not emerge until the third or fourth week after the grain emergence, the reduction in the grains yields was only about 8 to 12%.

Insect Pressure

Small grain fields provide an ideal habitat for many beneficial as well as harmful insect species. Some closely resemble each other so the producer has to be careful; accurate identification is important. Insects can be identified by visual appearance, location in the field, and seasonal occurrence.

After identification, it is necessary to carefully determine population numbers to decide when the insect levels have increased to the point of economic damage. This level is called the economic threshold and refers to the projected loss of a crop that is equivalent to the cost of treatment. Many factors influence how much damage occurs. Determining when an insect infestation caused economic damage is the basis of good pest management.

It is a good management practice to check grain fields for damaging infestations in the fall during the first 20 to 50 days after planting. This is when insect control with a foliar spray can provide greatest economic returns. Check fields as often as possible after this time, particularly before applying fertilizer, herbicides, or fungicides. If insect populations exceed thresholds, it may be possible to apply an insecticide as a tank mix with another chemical.

Check at least five spots in the field, examining at least 1 row-foot at each location. Include at least two samples near the field edges. Check closely because insects, particularly aphids and pupae of the Hessian fly, can sometimes be found at the base of the plant below ground level. It may be necessary to pull some plants out of the ground to sample for insect infestations at the root level. For larger plants, slap the plants to jar insects to the ground for counting.

If an infestation of a particular insect is light (i.e., 50 or fewer per linear foot), try to determine an exact count. If the population is heavy, making an estimate is acceptable. The following is a more in-depth discussion of how the insects discussed in the previous lesson impact wheat and other small grains in Missouri.

Aphids include several species of insects that are problems to wheat and other small grains. Aphids directly feed on the grain plant and indirectly transmitt viruses that cause disease. The four main aphids that infest wheat are the greenbug, English grain aphid, oat bird cherry aphid, and the corn leaf aphid.

The greenbug is particularly prevalent in the fall and it can cause economic losses due to direct feeding. The greenbug sucks plant juices and at the same time injects a toxin that can kill the plant. The English grain aphid is more common in the spring and can cause reduction in yield during heading. Mild, dry winters and cool, dry springs often favor aphid outbreaks. Setting threshold levels for aphids is difficult because of the influence of factors other than number of aphids per foot of row. The size and vigor of the plants, the temperature, time of year, moisture conditions, stage of growth, and presence of parasites and predators all need to be considered in deciding whether to apply insecticides. Refer to Table 5.1 for threshold levels for aphids in wheat.

The fall armyworm attacks wheat and other small grains from September to frost. They can destroy young plants, but most years the armyworm does not occur in sufficient number to cause damage. Fall armyworm damage is not likely after a dry summer.

Record the number of armyworm caterpillars per linear foot of drill row. Include even the small larvae. Be sure to take samples in the interior of the field because this pest is often heaviest near the field margins. Sometimes, only the field margins require treatments. Because armyworms attack grain in the fall in the seedling stage, a small number of larvae per linear foot or row can cause heavy damage. Threshold levels range from two to three larvae per linear row-foot for seedling wheat. For older plants, three to four larvae and obvious foliage loss justify control measures.

“True” armyworms feed on winter grains (wheat and barley) near the heading stage. They are referred to as true armyworms to separate them from fall armyworms and cutworm. On wheat, the larvae feed first on the leaves, next the beards, and then the kernel. The most severe damage in wheat is caused by cutting through the stem below the head and separating it from the plant. They mainly feed at night.

The heaviest infestation of the true armyworm is found near field margins and in low-lying areas of growing grain, especially where it is lodged. Check for pests in and under plant debris and in

Table 5.1 - Aphid Threshold in Wheat

Growth Stage	Treat If There Are More Than:
Seedling (0-30 days after planting)	3 aphids /row foot
Vegetative plants (30-60 days after planting)	6-8 aphids/row foot
Vegetative plants (60 days after planting to start of jointing)	10 aphids/row foot
Jointing	2 aphids/stem
Boot/flag leaf stage	5 aphids/stem
Head emergence to dough	10 aphids/head, including the flag leaf
Mid-dough to maturity	Do not treat

the heads. Shake or beat the heads and straw to dislodge the larvae. Check several locations in the field and average the count. Three to four armyworms per linear row-foot is a commonly accepted threshold. However, if the crop is nearly mature and there is no evidence of head clipping, control may be delayed. If the larvae are all mature, insecticidal control is not advised because these larvae will drop to the soil and pupate.

Cereal leaf beetles may infest late-planted winter grains but are most damaging to spring-planted oats. They may also feed on other wild and cultivated grass plants. The adults mate in the spring and lay their eggs on upper surfaces of the leaves from late March to late April. Closely examine plants and determine the average number of beetle larvae per tiller in several locations in the field. Population levels of one-half to one larva per tiller when 30% of the cereal leaf beetle eggs have hatched should be controlled in wheat. The threshold level in barley and oats is one and one-half adults or larvae per flag leaf.

The Hessian fly is the most damaging pest of wheat and barley. Oats are never infested by the Hessian fly. The adult fly lays eggs on the upper sides of the leaves and the small white maggots feed on the joints along the stem, discharging a toxic salivary secretion that stunts plant growth. Plants infested in the fall may die, and wheat infested in the spring often lodges and has smaller heads.

The best way to avoid Hessian fly is to plant resistant varieties and follow the planting calendar to observe the "fly-free" date. Planting fly-susceptible varieties after that date may help producers in some years, but it is not guaranteed. Growers who plant resistant varieties should inspect the wheat before making their customary nitrogen applications in the spring. If 20% of the tillers are infested with Hessian fly maggots or pupae at this time, significant yield losses can be expected and the nitrogen application may not produce the yield response to justify the additional cost. Before next planting season, producers should consider rotating wheat fields, turning under wheat stubble, and destroying volunteer wheat before planting.

Summary

Producers of wheat and other small grains should know what to look for when scouting their growing crop. Evaluations should be made to determine the effectiveness of their nutrient program, the tillage and planting methods used to prepare the crop, and weed pressure and control methods. Producers should also inspect for disease and insect damage and use appropriate controls. The small grain stands should be evaluated on an economic basis to determine if replanting is feasible. Generally, if the stand is 30% or more below the intended population, replanting may be justified. It is also important for producers to know how to control weed infestations by preventive measures, using cultural controls and knowing when chemical controls should be used. Producers should scout their fields often and be able to identify and know what pest pressure would also justify pest control measures.

Credits

Annual Broadleaf Weed Control in Winter Wheat. Nebraska Cooperative Extension Publication. January 1999.

Insect Pest Management. Integrated Pest Management. Alabama Cooperative Extension System. 1999.

Wheat Production Guide. North Dakota Extension Service Publication. May 2000.

Lesson 6: Harvesting the Crop

After all the work of tilling, planting, and caring for the crop during the growing season, the next important phase of wheat or other small grain production is the harvesting period. The objective at this time is to secure the most kernels of the grain at the proper moisture level and place them in a proper storage facility or deliver them to a local elevator for sale.

Factors Determining Harvest Time

Harvesting winter wheat may begin before June 1 in the southeast portions of the United States and as late as July 15 or later in Montana. Figure 6.1 illustrates the usual beginning times for winter wheat harvest.

As seen from the map, the usual beginning harvest times for Missouri would be June 16 to June 30. These times of course would vary with the condition of the crop. Harvesting barley and oats would take place during the same approximate period. Refer to Table 6.1 for harvesting information.

Grain should be harvested quickly and before shattering and sprouting of seeds in the head occur. Wheat harvested at less than 12.5% moisture is dry enough for storage. However, producers may harvest wheat at moisture levels as high as 20% if they can dry the grain quickly after it is placed in storage bins. High-moisture wheat delivered immediately to commercial buyers will be devalued (docked) according to the amount of water in the grain.

Figure 6.1 - Beginning Harvest Dates of Winter Wheat

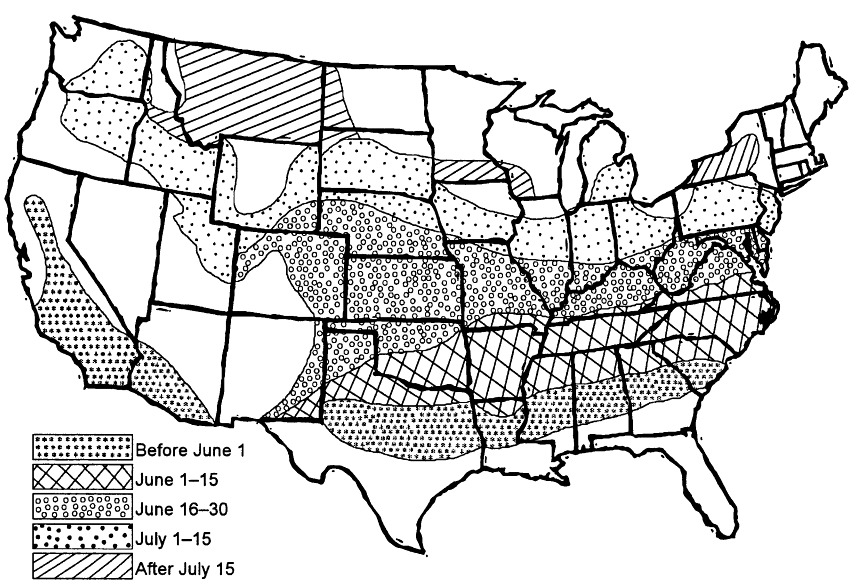


Table 6.1 - Harvesting Information

Crop	Percent Moisture	Plant Maturity Stage	Physical Plant Signs for Harvest	Method Used to Harvest
Wheat	below 14%	a little past hard dough stage	majority of kernels shell out when rubbed between hands	direct combine
Oats	no more than 13-14%	hard-dough or 2-3 days later	when the straw shows no greenness and the heads have turned a dull white	direct combine or windrow-pickup combine
Barley	below 14%	hard-dough stage	when heads have turned golden yellow but straw may be slightly green	direct combine or windrow pickup combine

Begin wheat harvest when the crop has field dried enough that it can be handled safely (not shatter from the head). A moisture meter is useful in giving a quick determination of crop condition. Most hand-held meters are calibrated for corn or soybeans and have charts for converting readings to other crops. If a meter is not available, weigh a 1/4- to 1/2-pound sample, dry it on a cookie sheet in a 260°F oven overnight (10 hours), and reweigh the sample. Calculate the moisture content by the following formula:

$$\text{Seed moisture (\%)} = \frac{\text{wet weight - dry weight}}{\text{wet weight}} \times 100$$

Some producers may choose to harvest wheat at moisture levels above 15% when growing grain in a double-cropping system. Significant profit potential exists for earlier wheat harvesting because of the increased yield of the second crop. For each 1-week delay in planting soybeans after the middle of June, decreased yields of 4 to 7 bushels per acre may occur. This potential yield loss alone provides enough incentive to offset the cost of drying high-moisture wheat. Other advantages of early harvesting would include increased yields owing to higher test weight and less shatter loss at the header during combining.

Seed Damage at Harvest

The major damage that may occur to the grain at harvest takes place from the threshing operation of the combine. Ideally, threshing removes all grain from the head of the plant without damaging the grain or the straw.

Threshing occurs at the cylinder or front portion of the rotor and is affected by concave clearance and cylinder/rotor speed. Cylinder/rotor speed determines how much grain damage will occur and the amount of seeds threshed from the head. Clearance will determine how many seeds are separated and drop through the concaves.

Symptoms of overthreshing are cracked grain and excessive amounts of return. The cracked grain is more likely to be blown over the shoe, and even if retained in the grain tank, it causes problems in handling and storage. To avoid overthreshing, set the cylinder no faster and not tighter than absolutely necessary to thresh the grain from the heads. Some operators prefer to leave an occasional kernel in the head as a sign of the best balance in threshing action. Table 6.2 shows the recommended initial settings for combines used to harvest wheat. Consult the operator's manual for barley and oat settings.

Crop Loss During Harvest

Today's modern, high-capacity combines are designed to do an excellent job of threshing and cleaning wheat and other small grains. All too often, however, part of the crop is left in the field or the quality of the grain harvested is less than desirable. Even in good harvesting conditions, combine losses as high as 8-10 bushels per acre of wheat can occur. Usually, a few minor adjustments can drastically reduce losses or improve grain quality. Since any additional grain saved is clear profit and clean samples are not docked, a little extra attention to combine adjustment can pay off.

As a rule, start with the machine adjusted according to the specifications in the operator's manual. Engine speed is often taken for granted, but it is one of the most important adjustments. If the engine speed is too slow, separator speed will also be too slow and performance will suffer. Be prepared to fine-tune the combine as required. To fine-tune a combine, the functions of the machine need to be considered.

Table 6.2 - Recommended Initial Combine Settings for Harvesting of Wheat

	Range	Recommended
Chaffer opening (inches)	1/4 to 3/4	5/8
Sieve opening (inches)	1/8 to 3/8	1/4
Fan setting (speed or choke)	medium to high	near high end
Cylinder/rotor speed (rpm)	750 to 1350	1000
Cylinder/rotor & concave spacing (inches)	1/8 to 1/2	1/4

The five basic functions are (1) cutting and feeding, (2) threshing, (3) separating, (4) cleaning, and (5) handling. The crop moves through the combine in this order.

Cutting and feeding take place at the header and feeder house. Adjustments include header or cutting height, reel speed and height, and reel position (fore/aft). The cutting height is controlled by the operator as conditions change. The goal should be to harvest all grain with the minimum amount of chaff and straw. The reel should be adjusted to gently move the wheat into the cutter-bar by positioning it slightly ahead of the cutter-bar. It should turn slightly faster than ground speed and be far enough down in the wheat to lay the heads onto the platform. The sickle should be sharp and in good condition. A dull sickle can limit ground speed and cause shatter loss.

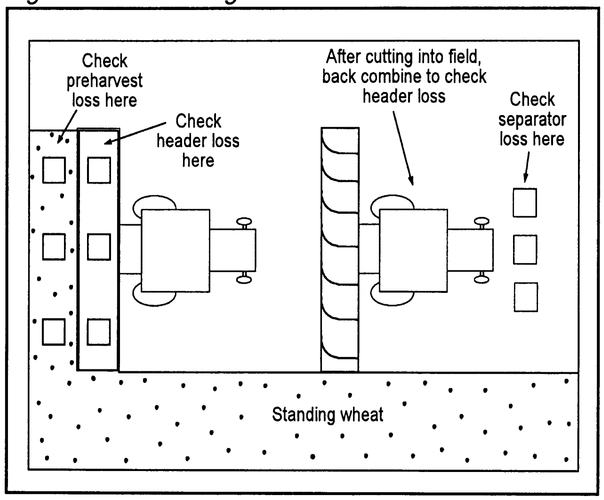
Threshing occurs at the cylinder or front position of the rotor and is affected by the concave clearance and cylinder/rotor speed. Cylinder adjustment is important and greatly affects the performance of the combine. Verify that the cylinder clearance indicator on the machine is accurate. The bars and concaves may be worn so that the clearance is greater than shown by the pointer. The concave and cylinder must be parallel from side to side. The operator's manual should provide adequate instructions on how to adjust these items. Since threshing plays an important role in grain cleaning, the cleaning shoe should not be adjusted until satisfactory threshing occurs.

The chaffer and shoe openings should be adjusted properly to allow the correct amount of airflow over the separators. Airflow should be adjusted so that the grain falls through the first 2/3 of the chaffer. If chaffer openings are too small, the passage of grain through them is limited, increasing losses and limiting the overall capacity of the combine. Sieve openings should be set large enough to let all grain through without allowing foreign material into the grain bin.

Combine capacity is the maximum rate at which a properly adjusted combine can harvest a crop while maintaining an acceptable loss level. A common limitation on conventional combines in wheat is the straw walker overload. If the combine is pushed beyond a reasonable rate, walker overloading will cause the losses to increase rapidly. Therefore, ground speed is very important. Reducing ground speed by 25% on an overloaded combine can easily cut harvesting losses in half.

Check the machine frequently to ensure efficient harvesting. During a single afternoon, conditions can change enough to require resetting some of the machine's components. A few simple ground counts will give an indication of combine performance. See Figure 6.2 for an example of how to check for wheat harvest losses.

Figure 6.2 - Checking Wheat Harvest Losses



Follow these steps, as indicated on the graphic, to determine losses.

1. Cut through a typical area at the usual speed, stop the combine and back up about 20 feet.
2. In the area behind the separator discharge, lay a 1-foot square frame down three times and take ground counts. Average the three counts. This is the separator count.
3. In the area between the cutter-bar and the standing wheat, take three more ground counts and average them. Do not forget to look for heads. This is the header count.
4. Take a final three ground count in the standingwheat and average them. This is the preharvest count.
5. Calculate header loss in bushels per acre with the following formula.

$$\text{Header loss} = \frac{\text{header count} - \text{preharvest count}}{20}$$

6. Calculate the separator loss in bushels/acre with the following formula.

$$\text{Separator Loss} = \frac{\text{separator count} - \text{header count}}{80}$$

Since the header width for most combines is about four times as wide as the separator, it takes about

80 kernels per square foot behind the separator discharge to equal 1 bushel per acre if no spreading devices are being used. If the combine has a bat-type spreader, use 65 kernels per square foot instead of 80. If a straw chopper is used, use 50 kernels per square foot, and if a chaff spreader is used, use 25 kernels per square foot.

What are acceptable losses? This depends on the condition of the crop and the attitude of the operator. However, for standing wheat under good harvesting conditions, machine losses can usually be held to 2% of the total yield. Higher losses will have to be tolerated in downed or damaged grain.

Since many factors can create combine losses, an organized approach to correcting the problem is needed. Figure 6.3 shows one method for pinpointing the cause of the lost grain. When fine-tuning a combine, try to change only one thing at a time so the effects can be seen. Keep referring to the operator manual; it seldom pays to deviate very far from suggested settings.

Local Storage Options

There are several important storage alternatives and substitutes for storage. Two important objectives of all of them are (1) higher net prices for the grain and (2) a more efficient use of labor, management, and machinery resources. Storage alternatives or substitutes include:

1. On-farm storage in grain bins
2. Commercial elevator storage
3. Price-later contracts
4. Buying futures positions to offset the cash sale of the grain at harvest

On-farm storage - Storage of grain on the farm for later cash sale is more popular with producers than are the off-farm storage alternatives and storage substitutes. Several primary advantages are:

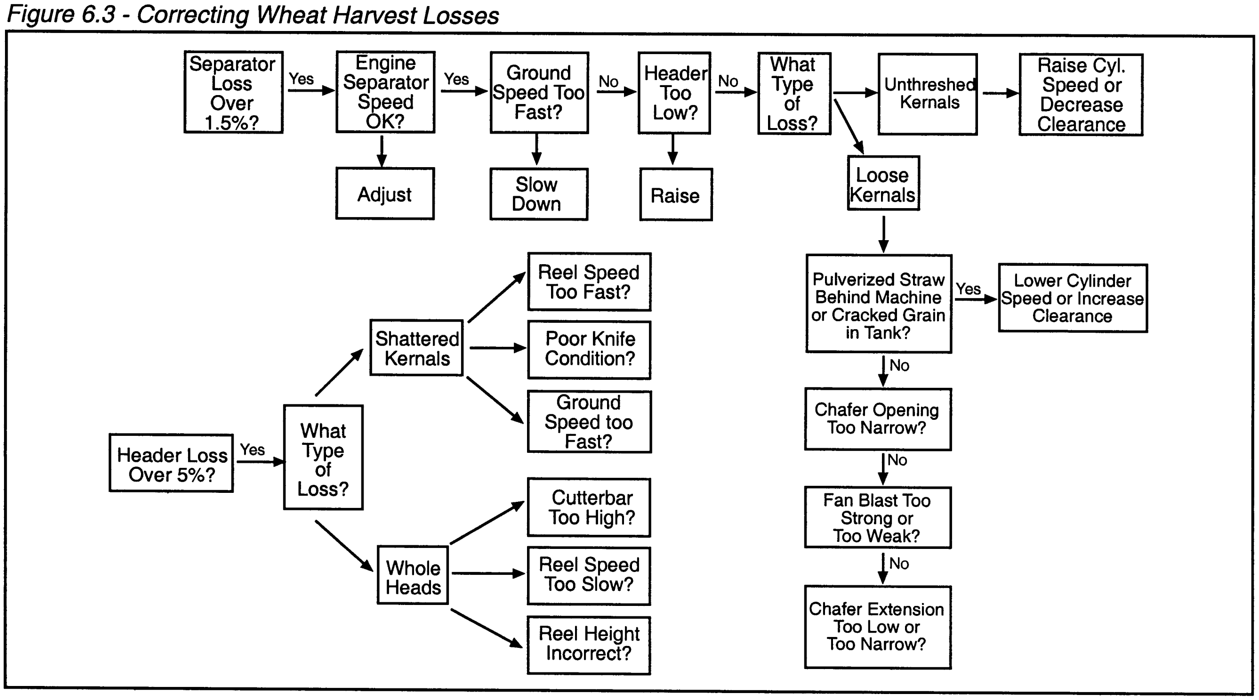
1. More efficient use of labor and equipment
2. Earlier harvest
3. Potential for grain drying returns
4. Additional marketing flexibility
5. Potential for higher net price
6. Provides tax management flexibility

Some on-farm storage limitations would include:

1. Costly on-farm storage of grain
2. Additional labor and management
3. Risk of grain quality loss
4. Potential for lower net prices
5. Risk of selling overdry grain

Commercial storage - Grain elevators seldom have excess capacity but those that do may be

Figure 6.3 - Correcting Wheat Harvest Losses



willing to rent this space to a producer for several months. The rental rate varies but it is typically about 3 to 4¢ per bushel per month with a minimum number of months guarantee. With commercial storage arrangements, the grain remains at the elevator location and can be retrieved by the producer. Because of combining grain at the elevator, the producers cannot recover the "exact" kernels of grain they delivered, but instead may withdraw the same "quality" as they delivered.

Price-later contracts - This type of contract is also known as deferred price agreements. With this type of arrangement, price is not established at the time of delivery but is deferred or delayed until a later time. This eventual pricing decision is made by the producer. Usually producers follow a "cash" plan whereby they retain the right to price at a later date, usually the same price being offered on the particular day on the cash grain market. The price-later (delayed pricing program) involves the delivery of the grain to the participating elevator at harvest. Ownership is transferred to the elevator and producers receive a "promise to pay" or "IOU" agreement from the elevator.

Futures market positioning - Another substitute for storage involves selling the cash grain at harvest and then taking a long (buy) position in the grain futures market. The advantage of this type of arrangement is that it is cheaper to "store on paper" than with the physical grain facilities. Producers who consider this method of "storage" should also realize there is substantial risk involved. Prices may decline after the futures position is taken and considered the same as a cash loss.

Storage Problems

Even if grain is dried to the correct moisture levels for the desired length of storage, storage problems may result.

Poor initial grain quality - Many kernels may be cracked during threshing and even in the field. Broken kernels and fragments are common to most grain going into storage. Kernel damage can be especially excessive when harvest conditions are unfavorable. The damaged kernels are very vulnerable to storage mold development and insect invasion.

Moisture migration - Moisture may shift from place to place in a bin of stored grain. The transfer of moisture is usually greatest in cool weather or during seasonal temperature changes when the grain is much warmer or cooler than its surroundings. When these changes in temperature occur, this may lead to convective air currents carrying moisture from one area of the bin to another. This creates pockets of wet grain that can spoil. This problem can be corrected with proper aeration.

Storage mold development - Storage molds can cause significant damage in stored grain. Storage fungi are always involved whenever spoilage occurs. This can happen both in the presence or absence of insects. Storage molds are caused by several species of fungi that grow on the grain and use it as a food source. If conditions are right (high moisture, high temperature), fungi can quickly cause serious grain quality losses. Fortunately, good engineering techniques can reduce losses from storage molds.

Insect and rodent invasion - Insects and rodents are a major cause of loss in stored grains, as well as in many other kinds of stored food products. They not only consume these materials but also contaminate them with fragments, feces, webbing, and bad smelling metabolic products. They therefore cause a major sanitation and quality control problem.

Several hundred species of insects are associated with stored grains and their products. Fortunately, only a few species cause serious damage. Some feed on the fungi growing on stored grain. Others feed on broken fragments, while others can attack the whole kernels. Insect invasion is usually associated with dirty facilities and inadequate control of moisture and temperatures in stored grain. Proper insect identification and control measures are important to prevent serious losses.

Maintaining Crop Quality During Storage

Many physical factors (moisture content, test weight, shrunken and broken kernel content, etc.) affect the market quality and therefore the price of wheat and other small grains. Only a few of these physical factors are normally affected by deterioration during storage. The economic impact of deterioration during storage depends on the type and severity of the damage.

Deteriorated grain - Damaged kernel count may increase if molds are allowed to discolor the germs of the grain. Discounts may range from 1¢ per bushel to 15¢ per bushel or more, depending on the percent of damaged kernels. The presence of live insects often causes the price to be discounted 5¢ per bushel to 10¢ per bushel.

Uncontrolled mold or insect deterioration may result in objectionable odors or increase the number of insect damaged kernels. This may cause the wheat to be designated "Sample grade," with discounts of 10¢ per bushel or complete rejection.

Insect-damaged kernels are a type of damage produced by lesser grain borers or weevils and contribute to the damaged kernel count, usually causing a discount of 3¢ per bushel or more. Certain preferred buyers, such as flour mills, usually reject grain with live insects or grain with more than five insect-damaged kernels per 100 grains.

Preventing discounts requires sanitation, monitoring, aeration, and proper use of chemicals. Grain damaged by mold is the simplest damage to prevent since it is caused by excess moisture somewhere in the grain mass.

High moisture grain must be dried to less than 12.5% moisture and preferably cooled within 4 days to ensure against the growth of molds and deprivation by insects. Heat must be added in areas of high humidity and airflow rate must be adjusted appropriately. At 85% relative humidity, wheat will equilibrate at about 18.5% moisture. Air alone at a relative humidity of 60% will dry wheat to 12-12.5% moisture over time. The higher the moisture of stored grain, the faster heated air should be moved through the storage bin.

Insect damage - Insect damage is the most difficult part of small grain storage because incoming grain must be held through the summer before cool weather arrives. There are more than 20 different species of insects adapted to survive in grain or grain products. Common stored grain insects have a life cycle of 4 to 12 months. Insect reproduction is definitely related to temperature through the life requirement ranges. Optimal feeding and reproduction of most storage insects typically occur from 70° to 90°F. The lesser grain borer is the most damaging grain insect in farm-stored grain. As grain temperature drops near 50°F, reproduction falls off rapidly as well as visible grain activity, including feeding.

Discounts related to insect presence can be reduced using integrated pest management (IPM) techniques. "What is the minimum insect density at which fumigation is cost-effective?" is a common question relative to insect control. The following guidelines are based on field research and surveys. The guidelines assume the grain will be moved to market in the winter and that the objective is to keep insect levels below detectable levels.

1. If more than two insects are found in samples, take a total of five samples in each bin.
2. If lesser grain borers or weevils (internal feeders) are found in more than one sample, or if more than one of these insects is found in a single sample, fumigation may be necessary unless the entire grain mass can be cooled to below 50°F within 3 weeks.
3. If only external-feeding insects (flat or rusty grain beetles, flour beetles, meal moths, sawtooth grain beetles, etc.) are found, an average of two per sample is usually acceptable if the grain can be cooled to below 50°F within 2 months.

Structures - The structure in which the grain is binned can help prevent loss and quality deterioration during storage. Structures used for grain storage should:

1. Hold the grain without loss from leaks or spills.
2. Prevent rain, snow, or soil moisture from reaching the grain.
3. Protect grain from rodents, birds, objectionable odors, and theft.
4. Provide safety from fire and wind damage.
5. Permit effective treatment to prevent or control insect infestation.
6. Provide headroom over the binned grain for sampling, inspecting, and ventilating.

Sanitation - Sanitation is critical to maintaining wheat or other small grain quality while in storage. The optimum time to clean a bin is immediately after emptying and again 4 to 6 weeks before refilling. Critical areas where infestation can normally be found include the floor area, unloading pits, sump pits, bin walls, ladder rungs, and openings if debris remains attached to them after unloading. Handling equipment and aeration ducts should also be cleaned. Crossover infestation may also occur if an unclean bin is close to bins used for storage. New grain should not be stored on top of old grain.

After cleaning, bin walls may be treated with insecticides. Grain protectants (insecticides) may be placed on grain kernels entering storage. These may come in a spray form or as a dust for application. Apply chemicals according to the label recommendations. Fumigants may also be used after applying plastic to the top of the grain. Fumigation requires special training and is usually done by a commercial applicator.

Monitoring - Best management practices require monthly inspection throughout the storage period. Risk of major deterioration can effectively be eliminated by frequent monitoring. This requires a grain probe, moisture meter, temperature measuring device, and screening pans. Changes in moisture, temperature, insect activity, and odor can best be detected by inspections. Inspections should be made of more than just the surface of the grain. Insects may concentrate near the top of the grain and give false impressions of the infestation level.

Summary

Wheat and other small grain producers must be aware that harvesting is controlled by the calendar and the moisture content of the grain. Most winter grains are harvested between June 16 and June 30 in Missouri. The moisture content may vary, depending on the drying capabilities of the producer. Harvest losses can be reduced by the correct combine settings and adjustments. Threshing is when most grain is lost. Producers should know how to take harvest counts ahead of the combine and behind the machine to determine the cause of the grain loss. There are several storage options, but the most popular is on-farm storage maintained by the grower. This provides marketing flexibility and potential for higher net returns. Storage problems may be the result of poor initial grain quality, moisture migration, storage mold development, and/or insect invasion. Preventing storage losses requires proper sanitation, monitoring, aeration, and proper use of chemicals when treating grain problems.

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Lesson 7: Marketing the Crop

To the grain producer, marketing means more than just selling. It encompasses setting financial goals, assessing risk, exploring pricing and delivery options, tracking market opportunities, and controlling one's ego.

No one can outguess the market and sell as prices peak with any assurance. Producers either sell too soon before the price peaks or too late because the price was never good enough. More often, grain producers sell with the bottom 50% of average prices offered during the crop year. Few producers sell within the top 1/3 of average prices. Those that do, however, spend considerable time and personal experience watching for the premium selling opportunities and following through on securing marketing contracts.

Marketing Options

The following facts related to common grains in Missouri will help in understanding how these grains are used or marketed.

Wheat

- More than 50% of wheat grown in the United States is exported as grain to foreign customers.
- About 33% of wheat is consumed domestically as a food product. Most wheat is sold to a nearby elevator that then markets the grain to a larger terminal market where it is then sold to flour and milling operations.
- About 8% of wheat is used as feed for livestock.
- About 4% of wheat is used as seed.

Barley

- About 57% of barley is used as feed for livestock and poultry.
- Food, alcohol (including malting), and industrial uses account for about 40% of the barley used.
- The remaining 3% is used for seed.

Oats

- About 55% of the oats grown in the United States are harvested for grain. Of this, about 50% is fed to livestock; 25% used for food, seed, and industrial uses; about 2% is exported to foreign customers; and the remainder is stored for future use.
- The remaining 45% of oat acreage is used for grazing cattle or sheep, as a cover crop to protect farmland from wind or water erosion, or as oat hay used as winter forage feed for livestock.

As indicated, wheat and small grain producers have three basic options, or choices, for marketing their crop: (1) harvest for grain only, (2) use for grazing and then harvest for grain, or (3) use in a forage system exclusively.

Most of the small grains produced in Missouri are harvested and marketed as grain. After harvest producers have two choices: (1) they must decide to price and sell the grain or (2) hold the grain. If they decide to price and sell the grain, they must then choose the most appropriate method of pricing - cash sale, forward contract, or hedging.

If producers decide to hold the grain (not to sell at harvest), they must choose the most appropriate method of retaining ownership. At least two methods of holding grain may be available to a producer. The first and most obvious method is to retain ownership through storage. For a period following harvest, the producer stores the grain and incurs the cost of that storage and the cost of the interest lost on the money not received from selling. For grain commodities traded on the futures market, such as wheat, producers can use an alternative method and buy a futures contract to replace cash grain sales. In this case the producer owns a futures contract rather than the actual stored grain. However, the idea is the same because the producer is speculating on higher cash grain prices. By owning futures contracts, the producer is speculating on higher futures prices.

Some grain buyers also offer producers the opportunity to price grain some time after delivery or some time after the title of the grain has passed to the buyer. These deferred pricing agreements are alternative methods of speculating on price changes. Although the ownership of the grain is transferred to the buyer, the producer retains the opportunity to benefit from higher prices. Producers also run the risk of lower prices, just as with ownership of grain in storage on their farms or owning a futures contract.

Deciding to use the crop for grazing and then harvesting is a second marketing option. If other forages (traditional pasture, hay stocks, etc.) are low or depleted, or if the planting date, growing conditions, and moisture levels have produced expected growth for the vegetative stage of the grain crop, producers may choose to harvest part of the crop through grazing. Therefore, one method, or option, of marketing the wheat or small grain crop could be through the extra weight produced through the livestock operation. Research has shown that if managed properly, there is almost no effect on grain yields of wheat grazed in the fall and some in the spring. This method of grazing requires removal of the livestock before the plant's jointing stage in the fall and application of fertilizer in the spring after grazing animals are removed.

Some grain crops, such as oats, may be used solely for forage use. Cattle producers may use the oat crop for some early spring pasture; remove the animals; and then cut, bale, and store the forage for use the following winter. Determining the value, or net returns, from marketing the entire crop or part of the crop through livestock feeding may be difficult to determine. Production costs are figured the same as with harvesting the grain and selling it on the cash or futures market; however, the value received would depend on livestock-related factors. The genetic potential of the animals, feed conversions, and setbacks to the animals through disease and/or parasites will affect the value received through the forage.

Determining When to Sell, Feed, or Store

Good marketing takes planning, selling discipline, and a clear picture of pricing and delivery alternatives. Marketing goals should aim to net higher returns than average prices for the entire crop, not just one truckload. Producers often sell for reasons not related to maximizing returns: bin space is limited, fertilizer payments are due, the end of the year is near, the weather is good with the promise of bumper future crops, or they are simply making room for the next year's crop.

Experienced marketers have two things in common - a market plan and a selling discipline. Planning to market means assessing costs of production and the appetite for risk at the individuals level. Keep in mind, accepting total risk runs the chance of not being in business next year.

One of the first things producers must consider before determining whether to sell, feed, or store the grain is the cost of production. Knowing exact breakevens using realistic yield expectations and assessing the producer's ability to control production risk must also be assessed. Establish a profit goal to arrive at a minimum selling target price.

Another option to consider is spreading sales over a 12- to 24-month period. Spreading sales allows the opportunity to price into three or four market rallies in an average crop year. Experienced marketers seldom incorporate all or nothing approaches to selling their grain. They will also try to avoid heavy delivery points during the year. Price slumps contribute seasonally to the price of grain. Some typical periods to avoid are during harvest, during 90-day storage expiration periods, and during cash flow selling periods such as in the spring.

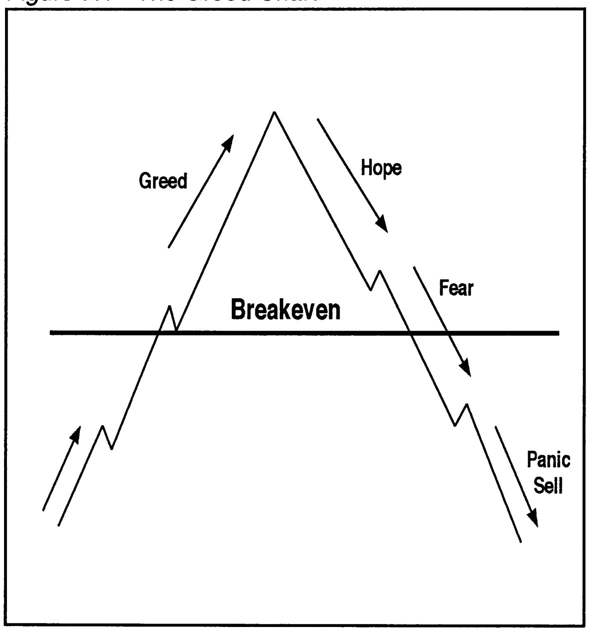
Another key to market determination is staying informed. Gather sources of information. Direct contact by telephone is still the most powerful marketing tool and information source. When deciding to sell, producers should contact a variety of sources. Maintaining regular contact with local buyers, grain dealers, millers, commodity brokers, and market analysts will provide well-rounded opinions required to make selling decisions. Additional information and market knowledge can be gained from the Internet, printed market reports, and television and radio market news services.

An experienced marketer will also have a thorough understanding of the terms and details of contracts used. Each grain dealer may have terms specific to the individual company.

The most common farm selling strategy is the "wait and see" approach. Often, producers store grain on a farm until cash flow needs dictate that they sell. Greed can distort sound marketing judgments. Marketing requires pricing discipline to control ego. See Figure 7.1.

The typical reaction to an upward (bullish) market is greed. Prices are rising, so grain marketers hold back deliveries in an attempt to sell at the top. Once the market peaks and starts to decline, greed turns to hope that prices recover, so producers do not sell. The market continues to fall and hope now turns to fear. Some producers are still reluctant to sell. Local cash bids are now too

Figure 7.1 - The Greed Chart



low to cover costs of production, so grain remains in farm storage. The market fails to recover. Now, fear has turned to panic, bills are due and cash grain is sold to cover payments.

Good marketing principles are just the beginning. To sell into the top 1/3 of the average yearly prices requires designing a personal marketing plan with discipline and market awareness.

Grain Quality and Effect on Price

The quality of small grains, such as wheat, is characterized by its protein content, strength of gluten, weight per bushel, amount of dockage, grades, milling data, and physical dough analysis. These qualities have an impact on the use of the grain for flour and therefore its price in the marketplace.

Information on grain quality indicated by its grade helps producers obtain the best prices. Grain traders (buyers) are also in a better position to know if the quality of the small grains meets their requirements and direct their purchases accordingly.

Tables 7.1, 7.2, and 7.3 describe the characteristics of wheat, barley, and oats to qualify for placement into a numerical grade.

An example of how these grades relate to prices received can be obtained from a description of a futures contract on the Chicago Board of Trade. A futures contract not only includes the size or number of bushels of the contract, the contract price, date of delivery, etc., it also states the "quality" or "grade" of grain contracted. For example, a wheat contract is priced on the delivery of U.S. No. 2 grain. If the producer delivers U.S. No. 1 grain, a 1 1/2¢ per bushel premium will be received. If the grain grades as U.S. No. 3, then a 3¢ per bushel discount, or dock, will be imposed.

Effect of International Markets

Markets for U.S. agricultural products have undergone an enormous change over the past few decades. World markets have replaced domestic markets in determining farm prices and income. Consequently, world markets dictate the state of rural agricultural economy in the United States. This transformation means U.S. agriculture and producers must compete and survive in a complicated global economic environment. This internationalization of U.S. agriculture creates many opportunities and challenges.

What does this mean to producers of wheat and other small grains in Missouri? First and most obviously, it means that markets exist where they would not have existed before. These markets must be identified and cultivated. Missouri, as well as other agricultural states, has developed International Marketing Specialists with offices in several foreign countries. They seek out markets and promote the sale of various agricultural products.

Wheat is the principal food grain in the United States and throughout the world. The United States is the third largest wheat producer in the world, accounting for about 11% of world production. Price determination for wheat is controlled by the interaction of the supply and demand factors, some of which are influenced by governmental policies. These price-determining factors are also influenced by growing (weather-related) and market (use-related) conditions in other countries.

Supply factors that affect price include beginning or carryover stocks of grain from the previous

Table 7.1 - Grades and Grade Requirements for Wheat

Grading Factors	Grades U.S. Nos.				
	1	2	3	4	5
Minimum pound limits of:					
Test weight per bushel					
Hard Red Spring or White Club wheat	58.0	57.0	55.0	53.0	50.0
All other classes and subclasses	60.0	58.0	56.0	54.0	51.0
Maximum % limits of:					
Defects:					
Damaged kernels					
Heat (part of total)	0.2	0.2	0.5	1.0	3.0
Total[1]	2.0	4.0	7.0	10.0	15.0
Foreign material	0.4	0.7	1.3	3.0	5.0
Shrunken and broken kernels	3.0	5.0	8.0	12.0	20.0
Total	3.0	5.0	8.0	12.0	20.0
Wheat of other classes[2]					
Contrasting classes	1.0	2.0	3.0	10.0	10.0
Total[3]	3.0	5.0	10.0	10.0	10.0
Stones	0.1	0.1	0.1	0.1	0.1
Maximum count limits of:					
Other material:					
Animal filth	1	1	1	1	1
Castor beans	1	1	1	1	1
Crotalaria seeds	2	2	2	2	2
Glass	0	0	0	0	0
Stones	3	3	3	3	3
Unknown foreign substances	3	3	3	3	3
Total[4]	4	4	4	4	4
Insect-damaged kernels in 100 grams	31	31	31	31	31

U.S. Sample grade is wheat that:
(a) Does not meet the requirements for U.S. Nos. 1, 2, 3, 4, or 5; or
(b) Has a musty, sour, or commercially objectionable foreign odor (except smut or garlic odor); or
(c) Is heating or of distinctly low quality

Table 7.2 - Grades and Grade Requirements for Barley

Grade	Minimum limits of		Maximum limits of				
	Test weight per bushel (pounds)	Sound barley (%)	Damaged kernels[5] (%)	Heat-damaged kernels (%)	Foreign material (%)	Broken kernels (%)	Thin barley (%)
U.S. No. 1	47.0	97.0	2.0	0.2	1.0	4.0	10.0
U.S. No. 2	45.0	94.0	4.0	0.3	2.0	8.0	15.0
U.S. No. 3	43.0	90.0	6.0	0.5	3.0	12.0	25.0
U.S.No. 4	40.0	85.0	8.0	1.0	4.0	18.0	35.0
U.S.No. 5	36.0	75.0	10.0	3.0	5.0	28.0	75.0

U.S. Sample grade is barley that:
(a) Does not meet the requirements for the grades U.S. Nos. 1, 2,3,4, or 5; or
(b) Contains 8 or more stones or any number of stones that have an aggregate weight in excess of 0.2% of the sample weight, 2 or more pieces of glass, 3 or more crotalaria seeds (*Crotalaria* spp.), 2 or more castor beans (*Ricinus communis* L.) 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), 8 or more cocklebur (*Xanthium* spp.) or similar seeds singly or in combination, 10 or more rodent pellets, bird droppings, or equivalent quantity of other animal filth per 1 ⅛ to 1 ¼ quarts of barley; or
(c) Has a musty, sour, or commercially objectionable foreign odor (except smut or garlic odor); or
(d) Is heating or otherwise of distinctly low quality.

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[1]Includes damaged kernels (total), foreign material, and shrunken and broken kernels.

[2]Unclassed wheat of any grade may contain not more than 10.0 % of wheat of other classes.

[3]Includes contrasting classes.

[4]Includes any combination of animal filth, castor beans, crotalaria seeds, glass, stones, or unknown foreign substance.

[5]Includes heat-damaged kernels. Injured-by-frost kernels and injured-by-mold kernels are not considered damaged kernels.

Table 7.3 - Grades and Grade Requirements for Oats

Grade	Minimum limits		Maximum limits		
	Test weight per bushel (pounds)	Sound oats (%)	Heat-damaged kernels (%)	Foreign material (%)	Wild oats (%)
U.S. No. 1	36.0	97.0	0.1	2.0	2.0
U.S. No. 2	33.0	94.0	0.3	3.0	3.0
U.S. No. 3[6]	30.0	90.0	1.0	4.0	5.0
U.S. No. 4[7]	27.0	80.0	3.0	5.0	10.0

U.S. Sample grade are oats that:
(a) Do not meet the requirements for the grades U.S. Nos. 1, 2, 3, or 4; or
(b) Contain 8 or more stones that have an aggregate weight in excess of 0.2% of the sample weight, 2 or more pieces of glass, 3 or more crotalaria seeds (*Crotalaria* spp.), 2 or more castor beans (*Ricinus communis* L.) , 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), 8 or more cocklebur (*Xanthium* spp.) or similar seeds singly or in combination, 10 or more rodent pellets, bird droppings, or equivalent quantity of other animal filth per 1 ⅛ to 1 ¼ quarts of oats; or
(c) Have a musty, sour, or commercially objectionable foreign odor (except smut or garlic odor); or
(d) Are heating or otherwise of distinctly low quality.

year's production, import amounts from other countries, and the amount of grain produced in the United States and other countries. Demand factors include food, seed, and industrial uses of wheat, the feed usage for livestock, and wheat exported to other countries.

Since wheat can be grown in more climates than some other major U.S. crops (corn and soybeans), the United States has a less dominant role in the international wheat market than with global corn and soybean markets. The major wheat competitors include the European Union (EU), Canada, Australia, and Argentina. A crop shortfall in one of these major wheat-producing countries can increase the demand for U.S. exports, strengthening U.S. prices. An abundant crop in one of these importing countries can reduce demand for U.S. wheat exports, lowering U.S. prices.

As stated, the major exporters of wheat are the United States, the European Union, Argentina, Australia, and Canada. The major importers of wheat include North African nations of Algeria, Morocco, and Egypt, the Middle Eastern nation of Iran, the Asian nations of China, Indonesia, Philippines, and Pakistan, and former Soviet Union countries of Kazakstan, Russia, and Ukraine.

Another factor related to international grain markets is government programs that contribute to carryover stocks of wheat. The Food Security Wheat Reserve (FSWR) was created in the 1980/81 marketing year to provide government-held reserves of wheat for emergency food needs in developing countries. This was replaced by the 1996 Farm Act with the Food Security Commodity Reserve (FSCR) that included other grains. In 1996, this amounted to 93 million bushels of wheat. These carryover stocks have an inverse relationship with wheat prices. If ending year stocks decline, farm prices for wheat tend to increase.

Global carryover of wheat stocks also affects the international wheat market. As global stocks decline, world wheat prices tend to increase. Their effect on global wheat prices also follows an inverse relationship. At the end of the last century (1999/2000), wheat stocks were approaching a 20-year low, causing a strengthening of wheat prices internationally.

Summary

To be successful in marketing a small grain crop, producers must understand their marketing options and have a thorough knowledge of the grain marketing process. The three basic options would include harvesting and marketing the entire grain crop, using part of the crop as forage for livestock and then harvesting and selling the grain, or harvesting the crop completely as a forage by pasturing or baling it for livestock use. Most of the small grain crops in Missouri are harvested as grain and either sold on the cash market or marketed with the purchase of a futures contract. Both involve some risk; however, if the producer is an informed marketer who develops a market plan, this risk may be reduced. The producer must also be aware of the factors that affect grain quality because grain quality has a direct effect on the price for grain when sold. In today's

[6] Oats that are slightly weathered shall be graded not higher than U.S. No. 3.
[7] Oats that are badly stained or materially weathered shall be graded not higher than U.S. No. 4.

agriculture, what happens with international grain production and markets greatly affect the prices of U.S. commodities such as wheat.

Credits

Introduction to Grain Marketing. Alberta Agriculture, Food, and Rural Development - Agricultural Marketing Manual. February 1999.

Official United States Standards for Grain. May 1999. U.S. Department of Agriculture, Grain Inspection, Packers and Stockyards Administration. <http://www.usda.gov:80/gipsa/strulreg/standard/stindex.htm> 22 May 2000.

Price Determination for Corn and Wheat. Economic Research Service/USDA Technical Bulletin 1878. U.S. Department of Agriculture. <http://www.econ.ag.gov/briefing/wheat/articles> 19 May 2000.

World Wheat Situation and Outlook. USDA Foreign Agricultural Service. U.S. Department of Agriculture.<http://fas.usda.gov/grain/circular/2000/00-05/wht_txt.htm> 19 May 2000.

Lesson 8: Figuring Crop Costs

The most important step in figuring crop costs is to keep an accurate and complete set of records of all costs incurred to produce the wheat or small grain crop. An approved accounting system must be adopted and understood by the producer to be worthwhile. Time must be planned during the season to record and enter costs. Time must be planned during the nongrowing season to analyze these costs and make changes to improve the net returns.

Variable Costs

To determine the break-even costs of wheat or small grain crops, producers must be able to determine all variable costs. Variable costs are also known as operating costs. These costs increase or decrease with the volume of output. For example, to obtain a greater yield from the small grain production, the plant population should be increased. This means that additional seed must be purchased and thereby increase the cost. Decreasing planting rates requires less seed, but the yield will also be less. Other types of variable costs include fertilizer, chemicals, and labor.

Detailed records are necessary to allot costs correctly. For example, farm utilities include electricity expenses. These can be from crop drying or ventilation and lighting for the farrowing facility. Applying the entire electric bill to crop production would be incorrect. Some form of monitoring must be done to appropriate costs to the proper enterprises.

Table 8.1 gives examples and amounts of possible variable costs that may be incurred with a wheat crop. These figures were received from the MIR (mail in records) enterprise records for the 1998 Missouri average crop costs publication assembled by the University of Missouri Extension Service.

Table 8.1 - Variable Costs for Wheat per Acre

Number of farms reporting	54
Average number of acres	157
Average yield/acre (bushels)	51
Average Variable Costs/Acre	
Seed	$ 15.26
Plant food (fertilizer and lime)	38.33
Crop chemicals and materials	1.70
Machinery fuel, oil, and repair	19.22
Machinery hire and services	5.36
Average labor cost/acre	16.06
Taxes and insurance	2.25
Miscellaneous	10.38
Operating interest	6.13
Total Variable Costs/Acre	$114.69

Fixed Costs

As with variable costs, producers must also know their fixed costs of producing an acre of wheat or other small grain to determine net returns. Fixed costs, also known as ownership costs, are costs that are unavoidable. Whether the farm produces at a record pace or nothing at all, fixed costs must be paid. They include such expenses as land rent or mortgage payments, insurance, and taxes. Insurance costs include premiums directly related to the farm business, not personal health or life insurance. Cash rent/mortgage includes interest and principal due in the coming year.

Table 8.2 gives examples and amounts of possible fixed costs that may be incurred with a wheat crop. These figures were received from the MIR (mail in record) enterprise records for 1998 Missouri average crop costs publication assembled by the University of Missouri Extension Service.

Table 8.2 - Wheat Fixed Costs per Acre

Average Fixed Costs/Acre	
Machinery depreciation and interest	$ 24.71
Land costs	82.82
Total Fixed Costs/Acre	$ 107.53

Determining an Acceptable Return on Investment

The decision to produce wheat or other small grains will depend primarily on the costs and expected returns for these crops in comparison with other crop alternatives. Type and amount of equipment, crop rotations, and farm size all affect the cost of producing crops. Tillage practices used and their timing also affect yields and production costs. Expected returns above costs for the farm operation must be computed to select the crops and the acreage of each crop to produce.

Returns above costs will depend on yields and prices received for that crop. Producers should use yields and prices (per bushel) that are reasonable for their location in the state. According to information from the University of Missouri Extension Service, the total cost of production (fixed and variable) in 1998 was $222.22. Using an average yield of 51 bushels per acre for that same year, the producer would need to receive $4.36 per bushel to break even.

Calculating Cost per Acre

As indicated above, the total cost of production per acre is determined by adding the total variable (operating) costs with the total fixed (ownership) costs.

Summary

Only through complete and accurate records can wheat or small grain producers determine crop costs. These costs are a total of the variable and fixed costs incurred in producing the crop. They are usually figured on a per-acre basis. Variable costs are those costs that will increase or decrease with production goals. These include seed, fertilizer, and chemicals. Fixed costs are those costs that must be paid and will be the same no matter what the level of production or yield. These include depreciation and taxes on the producer's equipment and land. Total costs are determined by adding all fixed and variable costs.

Credits

Massey, Raymond. *1998 Missouri Crop Costs and 2000 Crop Cost of Production Estimates.* University of Missouri Extension Publication FM2000-1, January 2000.

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