Lesson 1: Planning the Crop

Successful corn and grain sorghum production requires an understanding of the various managment factors affecting crop performance. When planning for corn and grain sorghum crops, important management considerations are the environmental conditions, field history, and fertilizer requirements.

Environmental Conditions

Corn and grain sorghum are warm-season, annual crops. Obtaining an optimum yield will depend on the soil and climate of the particular site. Corn and sorghum are best adapted to well-drained, loamy soils. They can be successfully grown in soil with a pH range of 5.5 (mildly acidic) to 8.0 (moderately basic). Most commercial hybrids are adapted to mature in 130 to 150 days in the central Corn Belt.

Corn and grain sorghum are fast-growing crops that yield best with moderate temperatures and a plentiful supply of water. The ideal temperature is cooler than many think - 75 to 86°F. By this standard the central Corn Belt is often too hot, but overall its temperatures are the most favorable of any region in the United States and about as favorable as any large area in the world. In the Corn Belt, above normal temperatures are advantageous for planting until mid-June. The average planting date in Missouri is typically the average date of the last spring freeze. Refer to Figure 2.1 in Unit IV, Lesson 2 for these dates.

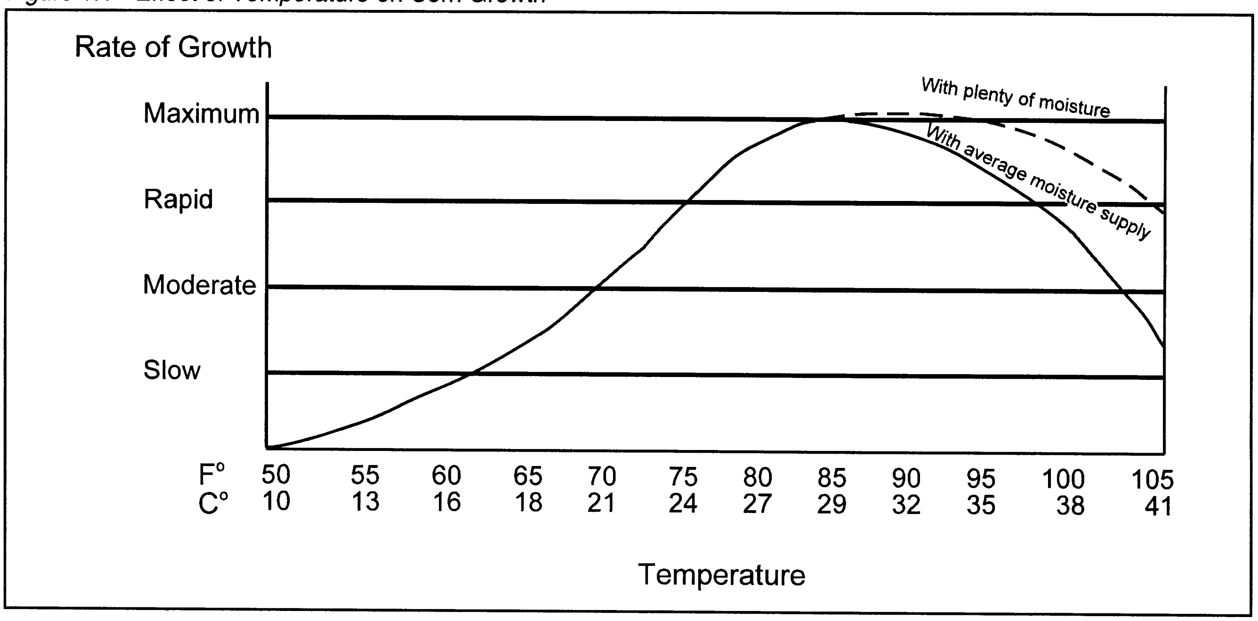
Cool temperatures at planting generally restrict nutrient absorption from soil and cause slow growth. Early planting dates and shallow planting take advantage of the more favorable soil temperatures near the soil surface, resulting in faster germination and emergence. At late planting dates, soil temperatures are generally adequate throughout all planting depths and soil moisture content becomes the limiting factor for rapid growth. Deeper planting depths usually have better moisture content at late spring plantings unless recent rains have occurred.

Slightly below-normal temperatures are better for corn growth from mid-June to early September. It is a misconception that corn and sorghum grow best when the nights are hot. The reverse is actually true. Corn burns up too much energy in cell respiration on warm nights. The ideal situation for maximum growth is cool nights, sunny days, and moderate temperatures.

When the temperatures reach 100°F, adequate moisture is difficult to maintain even with irrigation. Figure 1.1 shows the general effect of temperature for the season using 50°F as the starting point since corn hardly grows at all at lower temperatures.

As shown in Figure 1.1, when the temperature rises to the range of 80 to 86°F, corn and sorghum

Figure 1.1 - Effect of Temperature on Corn Growth



grow faster if moisture is adequate. When the temperature rises above 86°F, the roots have increased difficulty taking in water fast enough to keep the plant cells turgid (full of water). When soil moisture is limited, the optimum temperature is less than 80°F. With perfect moisture supply, the optimum temperature rises to about 90 to 95°F.

The "discomfort index" of corn and sorghum is due to an opposite set of conditions than that of humans and animals. Humans suffer in humid weather because they are not able to lose moisture and therefore cannot benefit from evaporative cooling. Plants suffer when they lose too much water. On clear, sunny days with temperatures of 70°F, plants show moisture stress.

These grains are also produced best in regions that have 25 to 40 inches of annual precipitation or are under irrigation to supplement natural rainfall. Moisture in the summer is critical. Corn and sorghum need 6 to 8 inches of rain (or irrigation) during the preflowering period. These plants use water efficiently. Large quantities are needed for high yields. Drought conditions lead to poor seed set and light test-weight gain, thus lower yields and lower-quality grain.

Sorghum will survive and produce satisfactorily under a wider range of conditions than corn. Sorghum plants are more drought resistant and can tolerate higher temperatures throughout their life cycle. They can also tolerate flood conditions better than corn.

Evaluating Field History

Before planting a stand of corn or grain sorghum on a particular field, there are several factors to consider: previous crops grown; the type, drainage, fertility, and slope of the soil; previous weed problems and herbicide applications; and previous pesticide problems.

There are advantages to planting corn and grain sorghum in a rotation with other crops. If the previous crop was a legume, the nitrogen needs of the corn will be lessened. This will save money in fertilization needs. There may be fewer disease and insect problems. A crop rotation breaks the cycle of some insect and diseases that thrive on corn and sorghum. Also, if a differnt crop was grown before the corn or sorghum, higher yields generally occur than with continuous corn or sorghum crops. Better control of weeds, especially annual weeds, may occur when rotating corn and sorghum with another crop.

There is no substitute for using soil tests when evaluating a field's history and determining its fertility needs. Properly administered soil tests can indicate organic matter and nutrient levels. For the majority of producers, the most important tests are those for lime, phosphorous, and potassium.

Examining the drainage history is more important for corn than for sorghum. Good drainage is indispensable for corn production. Small corn plants are readily killed when water stands on them. A soil that does not drain will interfere with the timing and completion of planting, cultivating, spraying, and harvesting. Well-drained soils are also warmer than wet soils. Warmer soils are important for quick germination and rapid growth of early planted corn and sorghum.

Erodibility of the soil is another important factor to consider in field history. Since corn and sorghum are row crops, the soil on the field will be more exposed to soil loss from wind and water. To determine if corn and sorghum will pose a problem with soil erosion, the producer needs to consider several factors: (1) the amount of rainfall in the area, (2) the length and steepness of the slope on the field, (3) the soil-erodibility factor, which is based on the texture and structure of the field's soil, (4) the different crops grown on the field, (5) and if any special erosion control practices have been performed on the field. These erosion control measures could include terracing, tiling, or contouring.

Disease and insect problems are not as serious as in the past. With today's corn and sorghum hybrids, resistance to diseases and insects are bred into the variety to lessen the damage. Seed treatments and early harvesting have also helped eliminate disease and insect problems.

Fertilizer Requirements

Fertilizer decisions have become more complex because of higher fertilizer prices, lower commodity prices, world food problems, environmental concerns, and more varieties and methods for application. Fertilizer will play an increasing role in feeding the world.

Choosing the right fertilizers and deciding when, where, and how to use them is not easy. However, it has an extremely important influence on profit at the end of the year. Therefore, it is important to follow certain steps in implementing a fertilization program to maximize corn and sorghum yields.

The first step is to understand fertilizers and how they behave in the soil. Though fertilizers come in many forms, brands, analyses, packages and colors, there is nothing very mysterious about them. The nutrient value is always guaranteed to the producer on the bag, tab, or invoice. The primary nutrients - nitrogen, phosphorus, and potassium - are listed in the same order throughout the United States. They are available in a gas, liquid, solid, slurry, and suspension form.

The producer should also understand soils and how to use them for maximum output. Soil samples should be accurately taken and analyzed with the recommendations followed to produce maximum yields. The producer must be able to estimate or determine the kinds and amounts of nutrients the soil will supply. This will be determined by what crop was previously grown on the field and the residual available nutrients in the soil.

The final step is applying the fertilizer when and where it counts.

Nitrogen (N) is the most limiting nutrient for corn production. Corn usually requires more nitrogen than can be supplied by soil or atmospheric sources. Nitrogen is very mobile in soils and undergoes rapid transformations compared with other nutrients. A producer's decision on a nitrogen source should be based on price, availability, ease of application, and potential for volatilization. All sources of nitrogen are equally efficient if they are properly applied in appropriate situations.

Split application of nitrogen fertilizer may substantially improve nitrogen use efficiency. Corn extracts less than 15% of its seasonal nitrogen uptake before rapid vegetative growth begins. The maximum nitrogen use rate occurs just before pollination. However, during early growth stages, considerable nitrogen may be lost due to denitrification and leaching. Apply 1/4 to 1/3 of the total nitrogen recommendation before corn emergence. In corn, the bulk of the split nitrogen application should be delayed until the V5 to V8 growth stages (five to eight emerged leaves with collars present), which occurs about 25 to 35 days after emergence.

Some nitrogen may be band-applied in combination with starter fertilizers but the rate should be less than 20 pounds of nitrogen per acre. Corn roots quickly grow into the soil between the rows. Side-dress nitrogen fertilizers early in the growing season to avoid root pruning. Nitrogen can be applied during early cultivation. Fall application of nitrogen is not recommended for most soils. For grain sorghum, side-dress about 10 to 25 days after planting, but before the five-leaf stage (growth stage 2). Nitrogen use by the sorghum plant increases very rapidly after this stage of growth with about 70% of the required nitrogen taken up by growth stage 5.

A recommended rate of nitrogen for corn is 1.3 pounds of actual nitrogen for each bushel of the yield goal up to 100 bushels per acre. Apply an additional 1.7 pounds of nitrogen for each extra bushel of a realistic yield goal above 100 bushels per acre. For example, the nitrogen recommendation for a goal of 160 bushels per acre is (1.3 lb. N x first 100 bu./A) + (1.7 lb. N x 60 additional bu./A) = 232 lb. N/A. Lower rates of nitrogen are needed for lower production levels because residual nitrogen from the soil and organic matter is used. Grain sorghum requires about 2 pounds of applied nitrogen to produce 100 pounds of grain.

Phosphorus and potassium fertilizers should be applied according to soil test results. Phosphorous nutrition is important to crop maturity, root and stalk development, and energy transfer and storage. Young corn or sorghum plants often turn purple as a result of a phosphorus deficiency. Phosphorus deficiency symptoms begin on lower leaf tips and progress along leaf margins until the entire leaf shows purpling. New leaves emerging from the whorl are usually green but may turn purple shortly after that. Symptoms often occur as young plants are exposed to good growing conditions following cool, wet conditions.

Many cultural or environmental factors may limit root growth, aggravating phosphorus-deficiency symptoms. Examples of such conditions include cool temperatures, too wet or too dry soil, low soil pH, compacted soil, herbicide damage, insect damage, and root pruning by side-dressing knives or cultivators. Fall application of phosphorus is generally recommended for an upcoming crop.

Tillage will help incorporate the fertilizer. Phosphorus injected preplant or with side-dressing equipment increases the availability to corn and sorghum roots.

Corn Belt growers commonly use coulter rigs that band apply starter fertilizer to the side and below the seed. These systems maximize placement efficiency, improve seedling safety, and permit higher fertilizer rates.

Corn and grain sorghum require as much potassium as nitrogen to produce good yields. Potassium is needed to build strong stalks, reduce lodging, fight diseases, and translocate water within the plant. The primary symptom of potassium deficiency is chlorosis (yellowing) followed by necrosis (tissue death) along lower leaf margins beginning at the leaf tip.

Fall application of potassium fertilizer is recommended because, like phosphorus, potassium is relatively immobile in most soils. However, potassium will leach on soils with CECs (cation exchange capacities) less than 8.0. Spring or side-dress application is recommended on sandy soils. Much of the potassium taken up by corn and sorghum is recycled to the soil through crop residue. Potassium recommendations should be increased following forage crop or silage harvest. A good corn or sorghum silage crop removes more than 200 pounds of potassium per acre. Potassium deficiency is common on corn and sorghum grown in a rotation with soybeans, especially in no-till systems.

Attention must also be paid to some minor nutrients such as sulfur, magnesium, and zinc needed for corn and sorghum production. High-yielding corn crops take up more than 30 pounds of sulfur and magnesium. Sulfur and magnesium deficiencies are most likely on sandy soils with less than 1% organic matter, especially during cool, wet conditions.

Zinc deficiencies are most common on sandy, low organic matter soil that has a high pH and phosphorus levels, especially under cool, wet conditions. Zinc deficiencies are evident on small plants as interveinal light striping or a whitish band beginning at the base of the leaf. Follow soil test recommendations to avoid zinc deficiencies.

Summary

With adequate moisture, corn and sorghum are rapidly growing, warm-season crops that do best in temperatures between 70 and 86°F. Conditions in the central Corn Belt present the most ideal conditions in the United States where planting takes place as soon as possible after the last spring freeze. Corn grows best in well-drained, loamy soils with pH level between 5.5 and 8.0. Adequate moisture is needed for corn and sorghum production provided by natural rainfall or irrigation, especially during the midsummer tasseling stage. There are several factors to consider with the history of a certain field before planting corn or sorghum. These include the previous crops grown; type, drainage, fertility, and slope of the soil; and previous problems with insects, weeds, and diseases. Nitrogen is probably the most important nutrient to consider for corn and sorghum fertilization. It is applied in split applications during the growing season and is not recommended for fall application. Phosphorus and potassium may be applied in the fall. Other nutrients such as sulfur, magnesium, and zinc should also be applied according to soil test results.

Credits

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Lesson 2: Selecting a Variety

The first lesson discussed planning the crop and determining fertilizer needs. Another major consideration the producer needs to determine is the seed variety to be planted. This lesson will review the classes of corn and grain sorghum, hybrids, maturity groups, and common diseases that affect these crops.

Classes of Corn and Grain Sorghum

Corn and grain sorghum are both grasses grown primarily for food and livestock fodder. Corn is classified as *Zea mays* and ranks as the largest crop produced in the United States. Grain sorghum is mostly produced as a livestock feed source in the United States but serves as a food staple for millions of people in China, India, and Africa.

Corn

Corn is divided into six main classifications determined by kernel characteristics. This includes dent, flint, popcorn, flour or soft, sweet, and pod or Indian corn. Some specialty corns have been developed but are generally genetic modifications of dent corn including waxy, high lysine, protein, and oil.

Dent corn is the most popular corn grown in the United States. It is characterized by the denting on the crowns of the kernel during ripening. Denting occurs when the soft starch of the endosperm shrinks as the grain dries out. Denting is more pronounced in some varieties with yellow, white, or red seeds. Yellow dent corn is predominantly grown for livestock with white dent corn preferred by cereal manufacturers.

Flint corn is made up of a small amount of soft starch and is covered by a hard starch. Because of this hard outer covering flint corn requires mechanical grinding before being fed to livestock. Flint corn is able to germinate at cooler temperatures and is grown in the northern plains. Because flint corn is resistant to weevils, it is also grown in tropical climates. Most flint corn is currently grown in Argentina.

Popcorn is very popular as a snack food. When the kernel is heated, the moisture in the kernel expands, causing the kernels to pop open. Popcorn is actually a variant of flint corn with small hard kernels. The best popping corn is dependent on the moisture in the kernel. The best results are on kernels with 13.5 to 15.5% moisture. Kernels can be various colors including red, blue, or calico but are generally yellow or white. Regardless of kernel color the popped flake is always yellow or white. Popcorn is divided into two classes depending on the shape of the kernel: pearl and rice. Pearl popcorn is rounder and smoother whereas rice popcorn is relatively long, flat, and slender.

Flour, or soft, corn is composed of a soft starch and a fine, thin layer of hard starch around the kernel next to the hull. Due to this large amount of soft starch, soft corn is easily ground into flour. Flour, or soft, corn is currently grown in the Andean regions of South America.

Sweet corn is chiefly grown for human consumption as a vegetable. The corn is referred to as sweet because the sugar produced by the plant is not converted into starch. The seed will appear wrinkled if the plant is allowed to mature. Sweet corn quality is dependent on harvesting before maturity. A lot of sweet corn is grown for the canning industry and also left on the cob and sold at grocery stores and farmers markets.

Pod and Indian corn are decorative corns and rarely used for human consumption. These varieties consist of multicolored varieties of flour and flint types. Indian corn is very popular as a fall decoration in the United States.

Specialty corns have been developed to meet specific markets including waxy corn, high lysine, high protein, and high oil corn. Waxy corn is used in manufacturing products such as puddings, adhesives, and sizing for paper and fabrics. High lysine, protein, and oil corns were developed to meet additional nutrient requirements needed by livestock but not found in most dent corn. New specialty type corn varieties are expected to be developed rapidly in the coming years as plant breeders everywhere are transferring genes to varieties and parent lines of hybrids. Developments in corn technology could be as important as the discovery of hybrid corn.

Sorghum

Grain sorghum is divided into four classes including grain, sweet, grassy, and broomcorn. Grain sorghum is the most popular sorghum grown in the world. Grain sorghum is very drought tolerant and includes varieties such as milo, kafir, and feterita, which are grown all over the world. Crosses of different groups like milo and kafir are common in the United States and because of the extensive crossing are sometimes hard to classify. Grain sorghum plants can grow from 2 to 5 feet depending on the characteristics of the variety. However, most U.S. grain sorghum plants are dwarf type. Inflorescence of a grain sorghum plant can contain as many as 2,000 seeds.

Sweet sorghums are known as cane. They are generally grown for forage and only a small amount is produced for sugar or syrup. This sorghum type is generally taller than most grain sorghums, with heights as tall as 14 feet. In addition, the inflorescence and seeds are smaller.

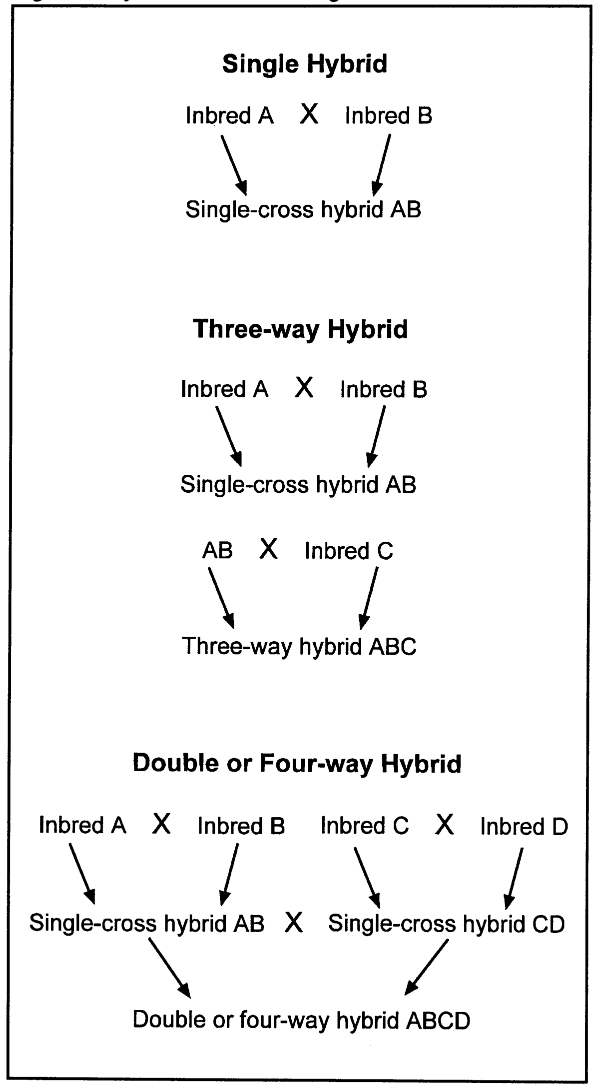
Grass sorghum is most widely known as sudangrass. Sudangrass is grown for various forage uses including pasture, silage, or hay. Sudangrass grows rapidly and requires good management during harvest. Johnsongrass is also a grass type of sorghum. In most states, Johnsongrass is considered a weed with little nutritional value.

Broomcorn sorghum has long, stiff strawlike stalks with very durable inflorescence. Once used widely to make brooms, it is now second to plastic.

Hybrid Corn

Hybrid corn is the result of a cross between two parents that differ in one or more traits. A process of self-pollination over a period of 7 to 8 years can be developed. At the end of this period, plants will be almost genetically identical and are referred to as an inbred line. Desirable inherited qualities are selected from the inbred lines and crossed to produce hybrids. If the inbred lines were selected wisely, the hybrid seed will produce vigorous plants with desirable characteristics. Seeds harvested from the female parent plants are referred to as single-cross hybrid seed. Other hybrid crossing systems used to produce hybrid seed include three-way hybrids and double, or four-way, hybrids. Figure 2.1 shows the different crossbreeding patterns.

Fig 2.1 - Hybrid Crossbreeding Patterns



Hybrid corn developed to increase yields and was available to producers around 1933. The inbred lines were weak, but when the two lines were crossed the resulting seed was much more productive than its parents. Hybridization of corn is considered the single most important advancement in the history of corn production. The higher-yielding hybrids received universal acceptance from producers and by 1960 were planted on over 96% of all U.S. corn acres. Currently, all corn acreage is planted to hybrids. Single-crossed corn hybrids are used for producing canned and frozen corn, whereas most double-crossed hybrids (the cross product of two single-cross hybrids) are used by producers. Some higher-yielding single-cross hybrids are making a comeback with producers.

Hybridization adds to the cost of corn seed, but the overall improvement in yields compensates for the additional expense. Hybrid corn can increase the yield by as much as 25 to 50%.

Selecting a Corn or Sorghum Seed Hybrid

Selecting the correct seed variety of corn or grain sorghum requires knowing the characteristics of the seed hybrid. This information is provided to the buyer on the certified seed tag. There are many considerations for the producer, but the primary items to consider are the maturity, yield, plant populations, seed cost, and replant policy.

Maturity date of the crop will vary throughout the state with some growing seasons being longer than others. In general, full-season hybrids have the greatest yield potential. The number of days from the last frost in the spring until the first frost in the fall affects the growing season. The growing season is also affected by the latitude and altitude, which can cause varying climatic changes in the temperature and moisture conditions.

Yield is another important characteristic to be considered when selecting a hybrid. A consistently high harvestable yield is desirable. Tolerance to stress, such as extremes in moisture or temperature, is extremely important in the yield of a crop. Other factors that will affect yield are resistance to corn borer, stalk rot, disease, and insects. Included with yield characteristics to consider for corn are plant and ear height and root lodging. Producers will need to measure yield under their own conditions over 3 or 4 years in order to reflect the hybrid's ability to produce. Yield potential is lost when varieties are not matched with local growing conditions.

Response to plant populations is another consideration when choosing a hybrid. Some hybrids must be planted at high populations to yield well while others do better at lower populations. In good crop years, high populations can increase profitability but the risk is higher if there should be a crop disaster.

A consideration for any crop is the seed cost. In recent years, cost has become one of the biggest factors as the more specific varieties like Bt corn, herbicide and pesticide tolerant corn, high oil corn, and high protein corn have been developed. The replant policy for the particular seed hybrid should also be a consideration.

Corn Maturity Groups

Several characteristics should be considered when choosing a corn hybrid. One of the most important is maturity. For example, if a corn producer wants to use the crop for silage or grain, the right maturity must be planted.

Full-season hybrids generally yield more than earlier-maturing hybrids. If a hybrid matures too early for the planting conditions, the yield will be less for grain or forage. In some years, the corn may lodge (fall over) more from stalk rot than a full-season hybrid. If the hybrid that is planted is too late in maturing, a yield loss may occur from an early frost. Producers should select a hybrid that will reach or be near physiological maturity 1 to 2 weeks before the average date of the first killing frost.

Hybrid maturity increases in importance as planting dates are delayed. Delays are usually attributed to weather problems. If a hybrid is purchased that matures properly when planted in early May, it may not mature if planted in late May. Seed companies supply the maturity grouping (days to mature) on their product.

In addition to maturity (days), many companies supply the average number of growing degree days (GDD) that are required for a hybrid to reach maturity. GDD are calculated for each 24-hour day and accumulated from the time the hybrid is planted until it reaches physiological maturity in the fall. Growing degree days are calculated as the average daily temperature minus 50. The following formula is used to calculate growing degree days.

<u>Max. Temp. + Min. Temp.</u> - 50 = 2
GDD

For example, if the lowest temperature for that day was 55°F and the high temperature was 82°F, the number of GDD would be 18.5. If the maximum daily temperature is greater than 86°F, 86 is used to determine the daily average. If the minimum daily temperature is less than 50°F, 50 is used to determine the daily average. Producers can calculate their own GDD for their own farm if they keep a record of the minimum and maximum temperatures or use those reported by the local television or radio station. GDD is not a perfect guide to corn maturity but is a more precise description of relative maturity than the previous rough guide such as 100-day or 120-day maturity corn.

Seed corn dealers are the best source of information on the maturity of the hybrids they sell and the recommended production area. Corn performance tests conducted by many state experiment stations are a source of information that can help compare maturity, lodging, and yield of hybrids from different seed companies.

Sorghum Maturity Groups

When selecting grain sorghum maturity groups, the same information and rationale presented on corn may be used for the selection of grain sorghum varieties. In addition, some seed companies rate their sorghum varieties by the number of days from planting to the 50% flowering stage. Most early-maturing varieties are rated at 60 days, whereas later maturing varieties range from 75 to 80 days. Some varieties are sold by a designated number representing the maturity of that particular variety. For example, a variety with a number of 600 would mean it reaches the mid-bloom stage about 60 days from planting.

Common Diseases of Corn and Grain Sorghum

Corn and grain sorghum diseases are managed by planting resistant varieties and adopting appropriate tillage and planting practices. However, diseases still attack these crops, causing lower yields and reduced profits. Some of the more common diseases affecting corn and grain sorghum grown in Missouri will be reviewed.

Corn Diseases in Missouri

More than 60 corn diseases have been reported in the United States, although many occur infrequently or are not prevalent enough to cause measurable loss. Some affect the plant or affect the kernel.

Common smut - This disease is caused by a fungus that is widely distributed over the world. Small to large galls (abnormal growth) form on an actively growing, aboveground plant part. The galls are covered by a glistening white membrane that later ruptures to release masses of black smut spores. Large galls on the ear and above are more destructive than galls below the ear. Initial infections to young plants come from spores in corn debris, soil, or manure. Secondary infections occur in the field.

Diplodia stalk rot - This disease is also caused by a fungus. The affected plants often die early with leaves suddenly turning a dull, grayish-green similar to frost injury. The lower parts of the green stalk turn tan to dark brown and the pith (spongy center) disintegrates. Diseased stalks are weakened and break easily. The fungus survives in corn debris and seed.

Gibberella stalk rot - This is another fungus-caused disease that is widely distributed in the northern half of the Corn Belt. External symptoms are much like those of diplodia stalk rot. A pink to reddish rot disintegrates the pith. Black specks that form on the dead stalks can easily be scraped off. This fungus survives in corn debris and rarely on the seed.

Fusarium kernel or ear rot - This is probably the most widespread disease attacking corn ears and is caused by a fungus. The caps of individual kernels or groups of kernels scattered over the ear develop a salmon-pink to reddish-brown discoloration. A powdery, cottony-pink mold forms later. Infection commonly follows some sort of injury. The same fungi may cause a stalk rot that is difficult to tell from gibberella stalk rot. The fungi survive in corn debris and seed.

Gibberella and diplodia ear rot - These ear rots are caused by the same fungi that cause the stalk rots. Gibberella is found most frequently in the cooler, more humid areas of the United States when the weather during the 4 to 6 weeks before harvest is unusually wet. A pink-reddish mold, often starting at the ear tip, grows on and between the kernels and tightly stuck husks. Infected ears are toxic to swine, dogs, and humans. Diplodia ear rot often begins at the base of the ear and progresses toward the tip. Part or all of the ear is rotted with a white mold growing between the kernels.

Aspergillus ear rot - This disease is caused by a number of species of fungi in the genus *Aspergillus*. The powdery mold growing on and between or within the kernels is usually black, greenish-yellow, or tan. The germ is discolored or dead. The disease is most common in the field when the weather is unusually wet for the month prior to harvest. Affected corn kernels may pack together in storage to form a crust, usually at the center and top of the bin. Some strains of this disease occasionally produce mycotoxins that are harmful if fed to poultry, swine, beef, and dairy cattle, or if consumed by humans.

Stewart's bacterial wilt - This disease Is caused by a bacterium and is most severe following mild winters. Long, pale green to yellow or tan streaks with wavy margins form in the leaves. The streaks soon turn dry and brown starting at the feeding scratches made by the corn flea beatle. Dark brown cavities may form in the lower stalk pith. Infected plants sometimes produce premature, bleached, and dead tassels. The bacterium overwinters in the corn flea beetle.

Yellow leaf blight - This disease Is caused by a fungus and is most prevalent in the northern area of the United States after extended cool, moist weather. Rectangular to oval, yellow to tan spots, often surrounded by a red and purple margin and a broad yellowish area, form on the leaves. If the blight becomes severe early, the lower leaves turn yellow, wither, and die. The fungus winters in corn, oxtail, and sudangrass debris on the soil surface.

Northern and southern corn leaf blights - These diseases are caused by a fungus and affect the northern or southern portion of the corn-growing portions of the United States. Both are prevalent following warm, moist weather. The southern leaf blight has two races, Race O and Race T, which devastated the corn crop during 1970 but has been practically eliminated by planting resistant hybrids. Leaf lesions are tan with buff to brown borders, elongated between the veins, and generally parallel sided. The northern leaf blight is recognized by long, elliptical, grayish-green and tan lesions on the leaves. They usually appear first on the lower leaves. When severe, a plant may turn grayish-green and die early. The fungus for both diseases overwinters in corn debris on or close to the soil surface.

Common rust - This disease is caused by a fungus that often appears after silking following warm, moist weather. Small, round to elongate, golden to cinnamon-brown pustules form on both leaf surfaces and other aboveground plant parts. The pustules turn chocolate-brown to black as the plant matures. When severe, the leaves may turn yellow, wither, and die early. The fungus overwinter on living plants in southern states and spread northward by windborne spores.

Corn Stunting Virus Diseases

Stunting virus diseases were first reported in Missouri in 1963 beginning first in three southeastern counties. Since then, virus or virus-like diseases have been reported annually. Infections occur in more than 7,000 acres annually. Losses range from 5 to 95% in individual fields, with the most severe being in bottomland fields along the Gasconade and Missouri rivers. Most of these fields have been surrounded or infested by Johnsongrass, a common perennial weed grass proven to be a principal overwintering host for maize dwarf mosaic virus and maize chlorotic dwarf virus.

Maize dwarf mosaic virus (MDMV) - Symptoms of MDMV vary considerably, even in corn plants of the same hybrid in the same field. One plant may show symptoms early in the season, whereas another may not show symptoms until after pollination. Diseased plants are often found in spots or centers within a field. Symptoms first appear in younger leaves as indistinct light- and dark-green mottling between the veins, or as elongated pale green blotches and interrupted stripes. Sometimes the leaves become quite yellow. Corn plants that show this mosaic pattern are often dwarfed or stunted due to a shortening of the upper internodes. Some plants may only show moderate stunting. Some strains of corn may have reduced ear size, barrenness, and poor seed set. In general, ears remain poorly filled on plants infected early in the season.

Maize chlorotic dwarf virus (MCDV) - Rather than the typical mosaic patterns in the leaf tissues caused by MDMV, the MCDV causes vein clearing. When the leaves are held to the light, vein clearing is observed easily in the tertiary veins near the base of the leaf. Plants are also stunted as with MDMV and a reddening of the leaves may be present in some corn strains.

Wheat streak mosaic virus - Early symptoms of wheat streak mosaic virus appear as small chlorotic spots or broken streaks at the tips of young leaves. Streaks elongate and develop parallel to the veins. Older leaves may become chlorotic near the tips with green margins bordering the veins. General yellowing and stunting of the plant may occur as with MCDV or MDMV. Ears may develop poorly and have poor seed set.

Development of resistant or tolerant corn hybrids offers the best long-lasting method of controls of these stunting viruses. Johnsongrass has been recognized as a source of the stunting virus infestation. The eradication of Johnsongrass in corn and sorghum, and perhaps in other crops, is highly desirable.

Grain Sorghum Diseases in Missouri

Several different, normally harmless fungi in the soil can attack grain sorghum seed and seedlings. The organisms most commonly involved are *Fusarium*, *Pythium* and *Penicillium*. Fungi infection can be enhanced by low soil pH, certain herbicides, and cool temperatures.

Leaf diseases are caused by several organisms, both bacteria and fungi, that attack leaves in the summer and lie dormant in crop residue during the winter. Disease severity varies with the weather and the grain sorghum hybrid.

Bacterial leaf diseases in grain sorghum include bacterial stripe, bacterial streak, and bacterial spot. Bacteria causing these three diseases are believed to survive from one season to another in both seed and infected crop residue. They spread from plant to plant by the wind, splashing rain, and insects and are the most severe during warm, moist weather.

Leaf diseases caused by fungi include helminthosporium leaf blight, target spot, gray leaf spot, zonate leaf spot, rough spot, sooty stripe, and rust. Table 2.1 outlines the leaf symptoms of grain sorghum diseases caused by fungi.

Diseases affecting the leaves and stems of grain sorghum include anthracnose, sorghum downy mildew, crazy top, and maize dwarf mosaic virus. Anthracnose and sorghum downy mildew are generally more serious in the very humid Gulf Coast regions of the United States, but they can also be a problem in Missouri. Crazy top is caused by a fungus that winters in grasses and ditches. In the spring, it can spread in overflow water from ditches to fields. Crazy top is generally not a serious problem in Missouri. Maize dwarf mosaic virus does cause problems in Missouri where Johnsongrass is present. The virus overwinters in the rhizomes of Johnsongrass. The new shoots on the rhizomes are infected and the virus moves via insects to plants such as grain sorghum and corn.

Root and stalk diseases cause more damage to grain sorghum than any other disease in the state. Infected plants usually perform poorly and may lodge. Charcoal rot is the most common and damaging stalk rot. It can cause seedling root rot and stalk rot in grain sorghum with the stalk rot phase being the most common. Damage from this disease is generally worse in areas of a field where plants have been under drought stress.The lower stalk will appear shredded and dark gray. The fungus decomposes the pith within the stalk, leaving the plant weak and vulnerable to lodging. Fusarium stalk rot affects various grasses besides

Table 2.1 Leaf Symptoms of Grain Sorghum Diseases Caused by Fungi

Disease Name	**Lesion Shape**	**Lesion Size**	**Lesion Color**	**Other Characteristics**
Leaf blight (*Setosphaeria turcica*)	Irregular and long	1 inch long or longer	Gray with tan-red borders	—
Target spot (*Bipolaris cookei*)	Round, elliptical spots	1/8 inch to 1 inch	Tan with red borders	—
Gray leaf spot (*Cercospora sorghi*)	Elongate to rounded	1/4 inch or more	Dark purple	Old lesions may be gray
Zonate leaf spot (*Gloeocercospora sorghi*)	Bull's-eye appearance	1/4 inch to 2 inches	Alternating dark purple and tan bands	Lesions resemble a bull's-eye target
Rough spot (*Ascochyta sorghi*)	Broad elliptical	1/4 inch to 1/2 inch	Tan centers with purple borders	Center of the lesion is rough to the touch (feels like fine sandpaper)
Sooty stripe (*Ramulispora sorghi*)	Elongate elliptical	3 to 5 inches long, 3/4 inch wide	Tan center, purple margins	Centers of old lesions will appear sooty
Rust (*Puccinia purpurea*)	Round to elliptical raised pustules or blisters	1/16 inch to 1/8 inch	Light red-brown	Usually confined to older leaves

grain sorghum. Like charcoal rot, *Fusarium* targets weak, drought-stressed plants.

Diseases of the heads of grain sorghum are in the form of smut or mold. Covered kernel, loose kernel, and head smut are all forms of smut that affect the grain sorghum. All three smuts are not serious problems because of fungicide seed treatments. Head molds are more common in Missouri, especially during periods of rainy weather after the plants mature. These molds generally do not cause serious yield losses but can become a concern during storage.

Other plant disorders that may occur in grain sorghum production are not caused by bacteria or fungi. Nutrient deficiencies, extremes in soil pH and temperatures, air pollutants, insect and bird damage, and mechanical injuries can all influence yield potential. For more specific information on the management of grain sorghum diseases, review the University of Missouri Extension Guide G04356, *Management of Grain Sorghum Diseases in Missouri*.

Summary

Corn and grain sorghum are both grasses grown primarily for food and livestock fodder. Corn is divided into six main classifications: dent, flint, popcorn, flour or soft, sweet, and pod or Indian corn. Sorghum is divided into four classes including grain, sweet, grassy, and broomcorn sorghums. Hybridization does add to the cost of the seed, but the overall improvement in yields compensates for the additional expense.

Factors to be considered in selecting either a corn or grain sorghum variety include maturity, yield, and plant populations. Corn and grain sorghum diseases are typically managed by planting resistant varieties and adopting certain tillage practices.

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Lesson 3: Selecting a Tillage and Planting Method

Once the initial planning stages are complete and the variety has been selected, the producer must determine the best tillage and planting methods for the area. Seeding rates should be evaluated to obtain the recommended plant populations at harvest. Planting calendars are useful to help producers estimate the optimum planting time for the area.

Optional Tillage Methods

Tillage practices used in corn and grain sorghum production include conventional tillage, minimum tillage, and no-till. In Unit II, the specific definitions for each tillage practice were outlined. The tillage method chosen to plant corn and grain sorghum should be used to achieve the seedbed that will give satisfactory emergence. Tillage costs producers money in fuel, labor and wear and tear on equipment. By incorporating a tillage method that reduces the number of trips across a field and minimizes tillage depth, costs will be reduced. Added tillage may also increase potential for soil erosion. Producers should evaluate tillage by comparing what is currently needed and what methods were previously used for each field.

Optional Planting Methods

The number of optional planting methods in corn and grain sorghum production are limited. Corn and grain sorghum planted for grain are planted using either the row or drilled method. When using the row method, a producer uses a planter to plant evenly spaced seed in parallel rows. The drill method uses a drill for planting seed in narrow rows at high population counts. Much research has been done to determine the most ideal row width for a desired seed population. The width of the row is limited by the equipment being used. In the Midwest corn is most commonly planted in 28- or 30-inch rows. Grain sorghum may be planted in narrower rows, such as 18 inches. Recent trends in corn and grain sorghum production point toward narrow rows at higher population counts with yield increases of 3 to 5%. Key changes to consider for narrowing rows include tractor and combine rims and tires, combine heads, and planter modifications.

Recommended Seeding Rates

Most seed companies specify a range in seeding rates for the various hybrids they market. Final crop stands will vary depending on the production environment and growing conditions. Adjustments to the seeding rate should be made on a field-by-field basis using the yield potential of a site. Higher seeding rates are recommended for sites with high yield potential with high soil fertility levels and water-holding capacity. Lower seeding rates are preferable when droughty soils or late planting limit yield potential.

Recommended plant populations for corn at harvest range from 20,000 to 30,000+ plants per acre, depending on the hybrid and production environment. Genetically altered corn hybrids may require harvest populations greater than 24,000 plants per acre to achieve their yield potential.

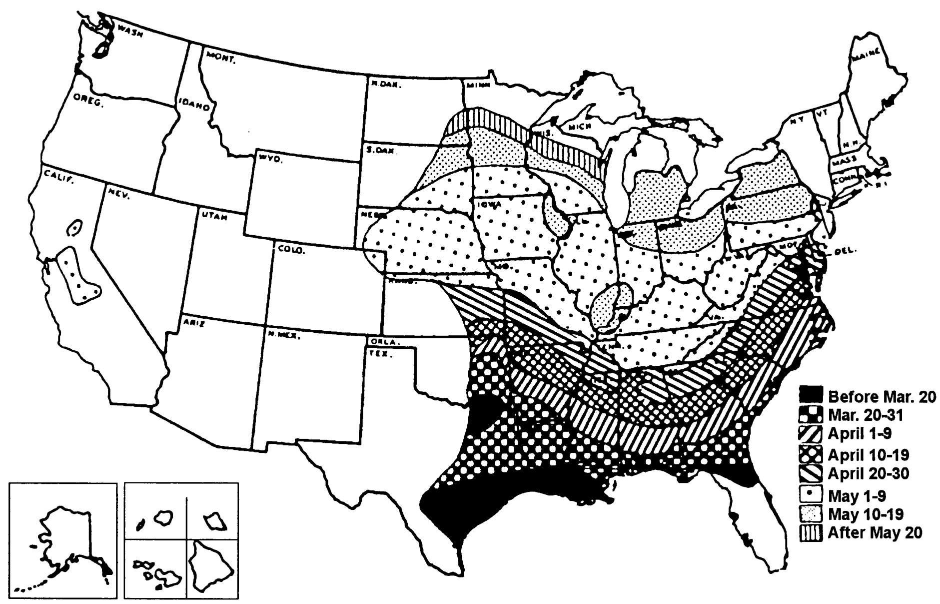
Grain sorghum may have plant populations at harvest as high as 100,000 or more plants per acre. A seeding rate of 5 to 7 pounds per acre is used in Missouri to get the desired plant population. Drier areas without irrigation may require 3 to 4 pounds of seed per acre, whereas irrigated sorghum does best if planted at 12 to 15 pounds of seed per acre.

Corn and Grain Sorghum Planting Calendar

Planting calendars are used to give producers an estimate of when corn and grain sorghum are planted in their local area and/or region. Frost and cool soil temperatures are the biggest limiting factors for planting corn or grain sorghum early in the spring. In Missouri, corn that is planted for grain is generally planted April 5 to June 10. The soil temperature for corn should be 50° to 55°F and 60° to 65°F for sorghum at a 2-inch depth from 8 a.m. to 9 a.m. constantly for 5 to 7 days before planting. In Missouri, soils warm up earlier than states to the north and many producers get "spring planting fever" at the immediate onset of warm weather. Early planting is not always a good strategy for increased yields. If warm weather continues, early planting can help alleviate late-season heat and moisture stress. However, if early planting is followed by cool, damp weather, seedling emergence will be delayed and the probability of seed and seedling injury will increase. Grain sorghum seed is likely to mold or rot in cold wet conditions.

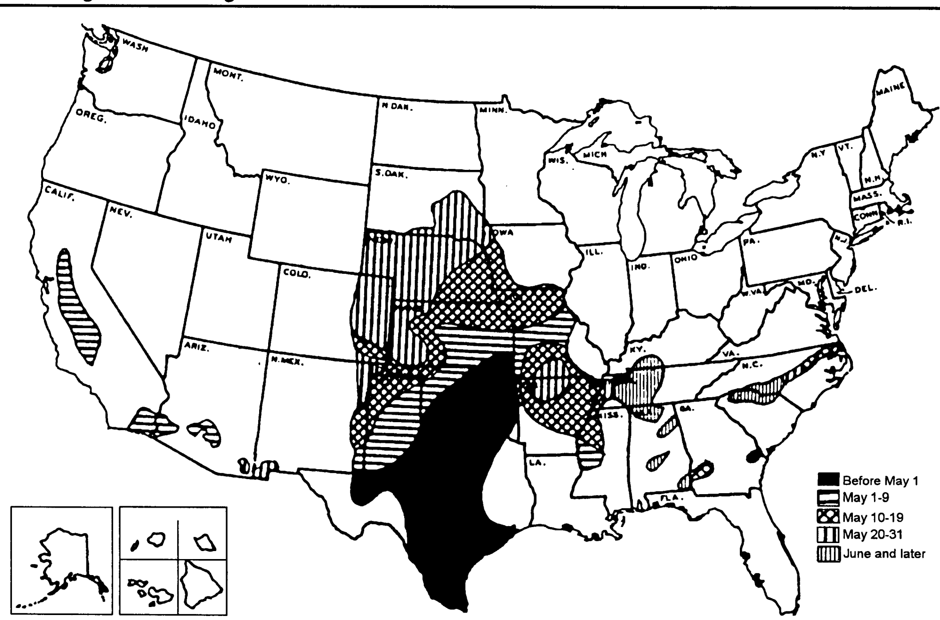
In Missouri, grain sorghum used for grain is planted April 25 to July 1. In the spring, untilled or residue-covered soils often dry and warm up more slowly. Soil temperatures should be checked at a 4-inch depth for fields with heavy residues. Plant conventional tilled acres first, if possible, to allow no-till acres time to dry and warm up. It is not wise to make assumptions about soil moisture or soil temperature. Various farm supply catalogs and stores offer special soil thermometers. Producers should use a thermometer or follow local planting calendars for their region. Figure 3.1 and Figure 3.2 outline the usual planting dates for corn and grain sorghum in the United States.

Figure 3.1 - Corn Planting Calendar



Source: U.S. Department of Agriculture, Statistical Reporting Service

Figure 3.2 - Grain Sorghum Planting Calendar



Source: U.S. Department of Agriculture, Statistical Reporting Service

Summary

Tillage methods used for corn and grain sorghum include conventional tillage, minimum tillage, and no-till. Corn and grain sorghum are planted by either the row or drilled method. Research is ongoing to determine the ideal row width for the most desirable seed population. Seeding rates for corn should have a plant population range from 20,000 to 30,000+ at harvest. Grain sorghum seeding rates have plant populations at harvest as high as 100,000 or more plants per acre. Planting calendars give producers an estimate of when corn and grain sorghum should be planted in their local area.

Credits

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Lesson 4: Selecting a Pest Control Program

Discussion in Lesson 2 dealt with diseases that are problems to corn and sorghum producers. This lesson will give information on the many insect, worm, bird, and rodent pests that plague producers in Missouri. This information will include a description of the pests, damage they may inflict to the crop, and control measures.

Types of Pest Control Programs

The objective of pest control measures is to reduce insect pest populations to acceptable levels. Specific control techniques include chemical, physical, and biological mechanisms.

Chemical agents called pesticides include insecticides and fungicides. Only about 9% of agricultural land in the United States is treated annually with insecticides and 1% with fungicides. About 67% of all insecticides used in agriculture are applied to two crops, cotton and corn. Most of the insecticides applied are long-lasting, synthetic compounds that affect the nervous system of insects on contact. Agricultural pesticides prevent a monetary loss of about $9 billion each year in the United States. For every $1 invested in pesticides, the American producer gets about $4 in return.

Nonchemical methods (using physical and biological mechanisms) include controlling pests by plowing them under in crop residues; introducing predators and parasites that feed on harmful pests; breeding plants that are pest resistant; releasing sterilized male insects into wild pest populations, causing females to bear infertile eggs; and using crop rotations.

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.

Despite the number of different pests that feed on corn, the average field of corn generally exhibits minimal pest problems. This is because the normal activity of most pest populations is too low to inflict significant injury to warrant attention. However, economic levels of pest injury do occur. Economic losses resulting from sudden outbreaks of pest activity can be prevented if the crop producer is aware of the biology of corn pests, monitors fluctuations in pest population activity, and implements timely corrective action.

The use of these corrective actions (chemical or nonchemical) will be determined by the producer. This determination will be based on the following factors.

Cost is probably the largest determining factor. Chemicals are very expensive and costs are rising continually. The amount and kind of chemical are based on the pest problem as observed by the producer when scouting the corn crop. Rising cost is one reason producers are looking for alternatives to pest control other than chemical use.

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 must pest control methods. Also, what one producer uses to solve a pest problem may not be successful for another producer.

Another factor in pest control selection would be considerations for the environment. More producers are becoming aware of harmful effects of overuse of pesticides. 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.

Other factors to consider when deciding pest control methods would involve the specific pest problem, soil types, and refuge requirements. Crop advisors from chemical suppliers, seed companies, and extension agronomy agents are very useful in recognizing specific pests and suggesting control methods. They can also help identify soil conditions and types that may affect chemical control success. Refuge requirements will provide insects with non-resistant varieties to survive on when resistant varieties are planted.

Pests Specific to Corn and Grain Sorghum

About 10,000 species of insects cause problems in food and fiber production or affect the well-being of humans and domestic animals. Of these, fewer than 100 species cause most of the pest damage to corn production in the United States. This discussion will be limited to 20 of the most important insect pests affecting corn production in the Corn Belt area where Missouri is located.

Identifying and managing insect pests in the cornfield is difficult because there is great diversity among the insects themselves and the complex interaction of conditions that affect their movement and growth. Some insects are active only at night or may simply be difficult to find in the cornfield. Some pests are chronic problems and tend to be abundant almost every year. Others are sporadic and only occur every 5 to 10 years in numbers great enough to reach economic importance. Some pests are migratory and must have perfect timing to make a "successful" infestation. Weather must favor their migration or a host plant must be available for the insects to survive and reproduce.

Table 4.1 lists 20 corn pests that may present problems to corn and sorghum production in Missouri. They are grouped into four growth stages of corn when they are most likely to appear and damage the plant. Some pests may affect the plant in more than one stage of growth.

In addition to most of the pests listed in the table, there are three additional insects that are important to sorghum producers. These are the greenbug, sorghum midge and the sorghum webworm.

Greenbugs are aphids with a tiny, light green soft-body with a darker green stripe down their backs. They damage sorghum plants by sucking out plant juices. They also damage plants by injecting a toxin while feeding. They feed in colonies on the underside of leaves and leave behind a substance called honeydew. Sorghum in the seedling, boot, or heading stage will be most affected by greenbug feeding. Damaged leaves will turn from green to yellow to brown as they die. Larger plants are more tolerant of greenbugs, but the pests can reduce the crop's yield potential, especially during booting, flowering, and grain development.

The sorghum midge is an orange fly that lays its eggs on the spikelet of the sorghum plant. The newly hatched larva is colorless. As it feeds on the developing grain, it gradually becomes pale pink, then a deeper pink, finally turning into an orange-colored larva. Areas that are typically infested are areas where sorghum has been grown for several years and where Johnsongrass is prevalent. This pest overwinters in aborted sorghum spikelets and heads of Johnsongrass.

The sorghum webworm begins as a small, whitish moth. The egg of the moth is white with a pale green-yellow tinge when laid, but changes to a straw yellow over a 2-day period. The newly hatched, pale green caterpillar is thickly covered with spines and hairs and has four red-to-brown longitudinal stripes on its back.

Sorghum webworms are a major pest of grain sorghum in North America. They are most damaging during years of high moisture. Although grain sorghum with compact seed heads seem to be their preferred food source, the sorghum webworm will also feed on sweet sorghum, Sudangrass, Johnsongrass, corn, rye, and timothy. The caterpillars feed on the ripening grain, consuming the contents of the individual kernels and leaving the outside hull intact. Losses in individual fields may be as high as 30 to 80%. Extensive damage rarely occurs during periods of hot, dry weather.

Effect of Pests on Yields

Despite all the control efforts used, pests annually destroy about 35% of all crops worldwide. Even after harvest, insects, rodents, and birds inflict a further 10 to 20% loss. In the United States alone, corn borers cost producers and the food system more than $350 million annually in yield losses and crop protection costs. Effects of all pests on corn and sorghum in total losses have not been made available. Loss ranges vary extensively from region to region in Missouri. Some data shows that without soil and foliar-applied insecticides, increased production costs would range from about $1.00 to $6.25 per acre annually.

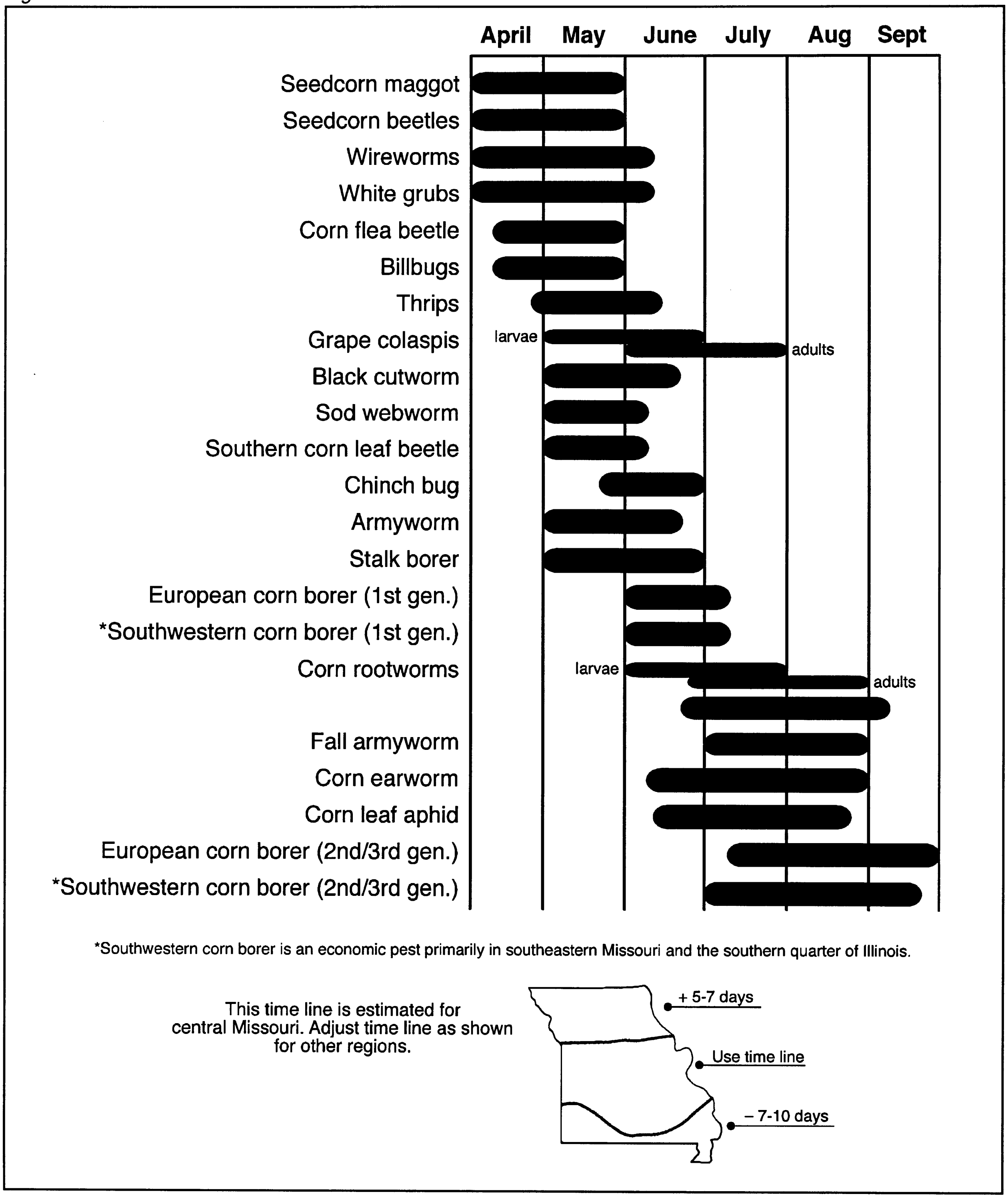
Available Pest Control Options

When planting corn or grain sorghum, there are four pest management options. They include (1) application of a granular or liquid soil insecticide at planting to prevent stand loss or reduce potential rootworm losses, (2) application of an insecticide in a herbicide tank mix applied as a preplant or preemergence treatment to prevent stand loss, (3) application of a seed treatment to prevent insect damage to seeds, (4) use of no treatment to prevent pest losses, and (5) planting pest-resistant hybrids.

Table 4.1 - Corn Pests

Growth Stage	Pest	Damage
Planting to Emergence (V2)	Birds, rodents	Seedlings pulled up and eaten
	Seedcorn maggot, seedcorn beetles, wireworms	Seeds bored into or hollowed out
Emergence to knee-high (VE-V8)	Wireworms, white grubs, grape colaspis larva, chinch bug	Stunting or wilting
	Wireworms, black cutworm, stalk borer	"Dead heart" (center leaves dying or dead)
	Stalk borer, billbugs, stink bugs	Unnatural growth (twisting, tillering)
	Thrips	Speckled or "sandblasted" leaves
	Corn flea beetle	Irregular narrow lines or "tracks" scratched from top layer of tissue
	Black cutworm, sod webworm	Plant cut off near base
	Cutworms, sod webworm, leafrollers, southern corn leaf beetle, stalk borer, armyworm	Chunks of leaf tissue or entire leaf eaten
	Billbugs	Small, symmetrical, rounded holes in leaves
	Southern corn rootworm beetle	Lacy, skeletonized leaves
Knee-high to tasseling (V8 to VT)	Stalk borer, armyworm, fall armyworm, grasshoppers, corn earworm	Chunks of plant tissue removed from leaf margins or ragged holes in leaves
	European corn borer, southwestern corn borer	Small, circular holes or elongated lesions in leaves
	Corn rootworm larvae	Stalks malformed: Lodging or growing upward in a gooseneck shape
	Stalk borer, European corn borer, southwestern corn borer	Holes bored in stalk
Tasseling to maturity (VT to R6)	Armyworm, fall armyworm, grasshoppers	Chunks of plant tissue removed from leaf margins, or ragged holes in leaves
	European corn borer, southwestern corn borer, corn rootworm beetle	Small, circular holes or elongated lesions in leaves
	Corn rootworm larvae	Lodging or growing upward in a gooseneck shape
	European corn borer, southwestern corn borer	Stalks broken
	European corn borer	Tassels broken
	Fall armyworm	Tassels eaten (in whorl)
	Corn leaf aphid	Tassels discolored
	Grasshoppers, corn rootworm adults, corn earworm, Japanese beetle, yellow woollybear	Silks clipped
	Grasshoppers	Large chunks of kernels removed, often at blister and milk stages
	Fall armyworm, European corn borer, corn earworm	Tunneling or chewing damage
	European corn borer	Ear drop

Figure 4.1 - Time Line for Corn Insects in Central Missouri



Applying a soil insecticide at planting may be warranted if pest populations threaten to cause stand loss or if rootworm threaten to attack corn root systems. Although the use of soil insecticides at corn planting time represents the leading use of insecticides in the Midwest and North America, a majority of the corn in Missouri is planted without the use of a soil insecticide because of limited pest pressure.

Soil insecticide treatments at planting time will aid in reducing stand losses from the following pests: seedcorn maggots, cutworms, grubs, and wireworm. Each of these pest problems is often associated with unique conditions and should not be considered a widespread problem applicable to all corn-growing habitats. Seedcorn maggots are more of a problem where organic matter levels are high and climatic conditions delay seed germination and seedling emergence. Cutworm problems will develop only if significant populations immigrate from the south or if a certain field is an attractive location to the immigrating populations. Fields with minimal weed problems are not attractive to cutworms.

Wireworms and grub infestations associated with stand loss are relatively uncommon. They may be more of a problem when corn follows either pasture, sod, forage, or fallow ground where specific grasses have aided development of wireworm or grub populations. In these cases, a soil insecticide with strength against wireworms and grubs is recommended. A seed treatment should be used to guard against damage to seeds.

After the corn stand is established, the frequency of severe pest problems tends to decline. However, periodic inspections should be conducted to detect pest problems. The primary pest problem during midstages of growth is infestation by corn borers. Less than 5% of corn stands exhibits significant infestations of European corn borer and few fields ever have infestations warranting corrective action. Corrective action involves spraying insecticides on the plant. This is usually more expensive and not warranted according to yield loss.

Another pest that may show up during midstages of growth is the corn rootworm. However, once it occurs, nothing can be done. If rootworm is significant, lodged plants will be evident.

Few pest problems occur as plants enter the tasseling and silk stages. Most of these pest problems are associated with the corn leaf aphid and various beetles. These are generally associated with dry conditions. Abundant corn leaf aphids on 70% or more of the stand may warrant rescue treatment, but the activity of beneficial predators usually takes care of such infestations when they occur.

As the ears mature, the second brood of European corn borer may become a problem. If detected early, rescue treatments (spraying) may be necessary to prevent excessive stalk injury and ear infestation. Fields with severe infestations should be flagged for early harvest. Significant lodging may occur if harvest is delayed.

Certainly one of the latest pest control options is that of planting insect-resistant hybrids. Corn growers and consumers already benefit greatly from biotechnology in the form of Bt corn that protects itself against the European corn borer by producing a larvae-killing chemical. A recent discovery by the Agricultural Research Service may help with this pest. Scientists have discovered a strain of corn from Argentina that possesses a chemical that female European corn borers find unacceptable for egg laying. Breeding this trait into corn could take several years. Other genetically improved hybrids, such as rootworm-resistant corn, are nearing commercialization.

Greenbugs will not be evenly distributed in a field, so it is wise to examine plants from all parts of a field. A control treatment should be used on greenbugs when 20% of the plants show yellowing leaves and insects are found on young plants from emergence to 6 inches tall. Treat larger plants up to the boot stage when greenbugs are causing red spotting or yellowing of leaves.

Several cultural practices have been recommended for control of the sorghum midge. These include preventing Johnsongrass or other hosts from producing heads in and around sorghum fields before the crop blooms, planting at the time of year best suited for the variety selected, and destroying crop residues that contain overwintering larvae. When a large adult population is detected at bloom, an insecticide treatment is warranted.

Control practices of the sorghum webworm include the destruction of crop residues to destroy overwintering larvae and early planting to escape the late-season buildup in webworm populations. Warm, dry weather also effectively deters damaging infestations.

Summary

Corn and sorghum producers have always been faced with the problem of pest control. Producers must consider the cost of control measures, previous experiences with pest controls, observing what other producers use, environmental considerations, specific pest problem, time of the growing season, and soil types when determining what pest control methods they may use. Of the thousands of plant pests today, only about 20 are of importance to corn and sorghum producers. These pests may invade the crop during one or more of the plant's growth stages. Producers should know how to recognize the pest problem and understand what control options are available for their treatment. This may include planting insect-resistant hybrids.

Credits

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Lesson 5: Scouting and Maintaining the Crop

During the growing season, certain decisions are made that may affect the growing conditions of the corn and sorghum crop. These decisions may determine if the maximum production potential, bushels or pounds per acre, will be achieved.

Plant Condition Factors to Consider When Evaluating the Growing Crop

Evaluation of corn and sorghum crops should begin at the time of germination and continue through harvest. During this period, the producer should look for specific problems that may develop at the different stages of growth and development of the plant.

At germination, the producer should dig into the soil and evaluate the germination process. At different locations in the field, an evaluation should be made to determine possible germination problems and percentages. Problems affecting germination may be related to disease, insect, soil moisture, soil temperature, soil crusting, herbicide injury, or nutrient inefficiency.

Early stages and middle growth should be scouted to look for insect or disease problems. Most spring plantings have adequate moisture for growth. As the plant develops and grows, the moisture requirements increase until after pollination. As the crop nears harvest, moisture needs decline as the grain starts maturing and drying. Early stages of growth should also be evaluated for insecticide- or herbicide-related problems. Excessive herbicide usage could cause burning and plant loss.

The effectiveness of the producer's fertilization program may also be evaluated during the early and middle growth stages. Adjustments may need to be made next planting season to secure optimum yields. Crop nutrients may need to be increased for increased yields.

Determining When Replanting Is Appropriate

It is common that 10 to 15% of planted seeds fail to establish healthy plants. Additional stand losses resulting from insects, frost, hail, flooding, or poor seeding conditions may require a decision on whether or not to replant a field or part of a field.

The first rule is not to make a hasty decision. Corn plants can and often do outgrow leaf damage, especially when the growing point is protected beneath the soil surface (up to the six-leaf stage). If new leaf growth appears within a few days after the injury, then the plant is likely to survive and produce normal yields.

When deciding whether to replant a field, gather the following information: (1) original planting date and plant stand, (2) earliest possible replanting date and plant stand, and (3) input costs such as cost of seed and pest control for replanting and replant policy on the seed that was purchased. Table 5.1 and Table 5.2 may be used as a guide to assist in this decision.

Table 5.1 - Effect of Planting Date on Corn in Central and North Missouri

Corn Planting Date	Yield as % of Normal
May 11	100
May 16	99
May 21	97
May 26	94
May 31	90
June 5	85
June 10	80
June 15	75

Table 5.2 - Effect of Planting Date on Corn in Southeast and Southwest Missouri

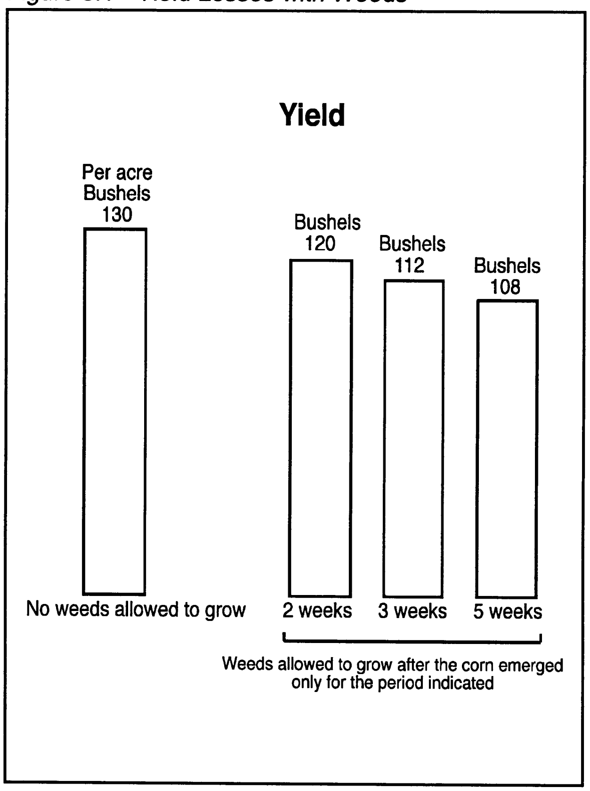
Corn Planting Date	Yield as % of Normal
April 1	100
April 10	99
April 30	92
May 10	87
May 20	83
May 30	79
June 10	72
June 20	59

To determine whether replanting is appropriate, compare the net income from replanting with the income from a sparse stand. Even if this comparison is positive, replanting may still be desirable. Other demands on the producer's time and competing crop management issues are important considerations. A spreadsheet program from the University of Missouri-Columbia is available on the Agricultural Electronic Bulletin Board (AgEBB) web site to help analyze the situation. The web site address is <http://agebb.missouri.edu>. This worksheet will figure seed cost, fuel, machinery, labor, loans for replanting, and possible increased dryer costs for late maturing corn.

Amount of Weed Pressure to Justify Herbicide Application or Mechanical Removal

The major objective of a weed control plan should be to control those weeds that emerge at or about the same time as the corn. Early planning should be followed by early action. Early action starts with good cultural practices such as seedbed preparation, adequate fertilization, crop rotation, optimum row width, and optimum population.

Figure 5.1 - Yield Losses with Weeds



The first 3 to 5 weeks are critical in controlling weeds in corn. Research shows that when weeds are only 6 to 8 inches tall, they have already cut corn yields. Figure 5.1 shows that allowing weeds to grow only 2 weeks after the corn came up caused a yield loss of 10 bushels per acre. Allowing weeds to grow 3 weeks and 5 weeks after the corn came up caused further losses.

Tables 5.3 and 5.4 show the effect on corn yields by two common weed problems in Missouri, infestations of pigweed and giant foxtail.

Many weed problems can be prevented with the application of preemergence herbicides or the use of mechanical or cultural practices. Seedbed preparation and the use of cultivators or rotary hoes would be examples of mechanical practices that are effective in controlling weeds. Selecting a planting rate for optimum stands would be an example of a cultural practice. Thin stands of corn favor a heavy population of weeds in the row.

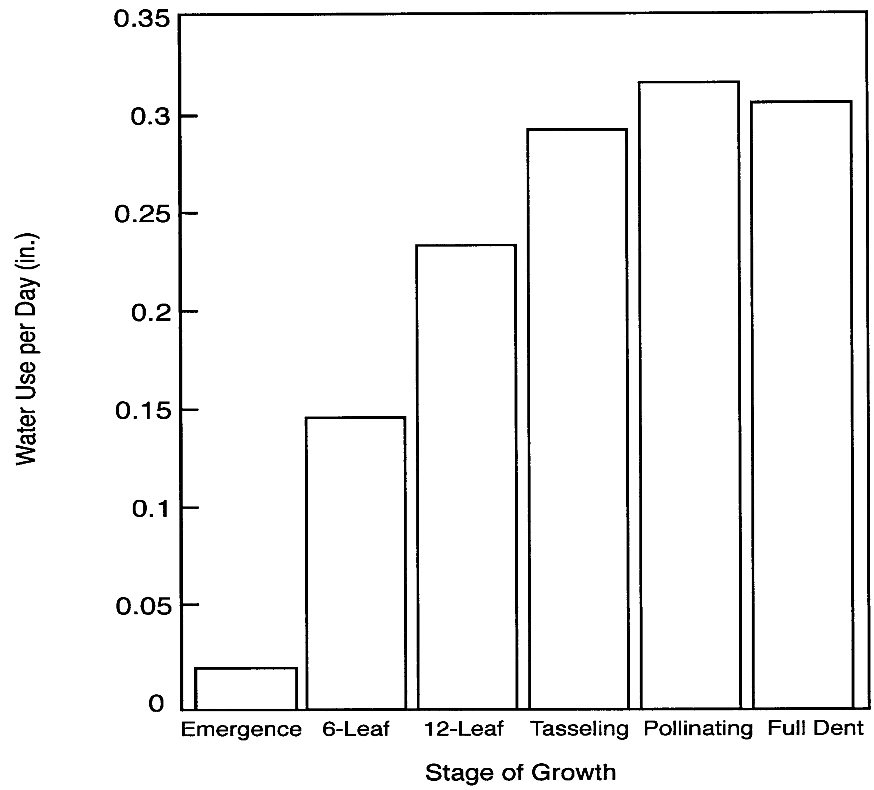
Table 5.3 - Effect of Pigweed Stand on Corn

Pigweed Stand in the Corn Row	Yield Per Acre (bushels)	Yield Loss (bushes/acre)
None	108	0
1 per 40 inches	101	7
1 per 20 inches	92	16
1 per 10 inches	91	17
1 per 5 inches	78	30
1 per inch	67	41
Band of weeds	64	44

Table 5.4 - Effect of Giant Foxtail on Corn Yield

Time Foxtail Emerged After Corn Planted	Average Bushels/Acre
Same day	115
3 weeks later	131
6 weeks later	132
12 weeks later	132
Weed Free	132

Figure 5.2 - Moisture Requirements for Corn



Amount of Insect Pressure to Justify an Insecticide Application

When trying to justify the application of an insecticide according to the amount of insect damage, there are several major factors to consider. These factors include identification of the pest or insect, stage of growth for the corn plant and/or grain sorghum plant when the problem develops, the severity of the damage to the individual plants, and the size of the damaged area in numbers of acres.

Scouting the corn and sorghum fields often at germination and during the plant growth stages will be important to recognize the development of a problem. Early evaluation and initiation of a treatment program could reduce the damage done by the pest. To aid in the decision of replanting from pest damage, follow the information given above.

Ask the pesticide dealer, an extension agronomy agent, or other crop experts for advice when monitoring pest populations and choosing the proper pesticide program and timing.

Environmental Conditions During Pollination That Affect Yields

Four environmental conditions or factors are of most concern to corn producers during pollination. These factors include moisture amounts, nutrient deficiencies, high temperatures, and weather factors, such as hail.

Larger seed yield reduction will result from water stress occurring from 2 weeks before silking to 2 weeks after silking than similar stress at any other period of growth. The largest yield reduction will result from stress at silking (early R1 stage) with smaller reductions resulting the further away from silking that the stress occurs. This is generally true with the other types of stress such as nutrient deficiencies, high temperatures and hail.

This 4-week period around silking is the most important time for the plant to have adequate moisture. Refer to Figure 5.2. If adequate rainfall is not present during this period, yields do not reach their full potential. If irrigation is available, this will be the most important time to monitor its use. The water needs for grain sorghum range from about .05 inch daily at planting to a little more than .3 inch at day 50 of growth, and then tapers off gradually again to about .05 inch daily as it reaches maturity.

Planning for adequate nutrition for the corn plant should take place before planting. If soil tests are followed and nutrients added in sufficient amounts for the crops yield potential, this factor should not be a problem at this time.

Extreme high temperatures accompanied with hot winds during the day and at night are very stressful on the young plant during pollination. Stress at this time will cause a lag between ear development (beginning silking) and pollen shedding. Delaying the silking until after pollen shed will result in unfertilized ears.

During this stage the corn plant is more vulnerable to hail damage than at any other period because the tassel and all the leaves are completely exposed. Complete leaf removal by hail at this stage will result in essentially a complete loss of grain yield.

Some factors such as moisture and proper nutrient availability may be controlled by the producer. Weather problems such as hail cannot be controlled but their effects on the producer's income may be reduced with hail insurance.

Summary

From germination to harvest, the corn and sorghum producer needs to scout and evaluate the growing crop to look for possible problems and solutions to maximize yields. These may or may not be related to factors the producer may control. Producers need to know factors that must be considered to determine if replanting is justified and how to make those decisions. Evaluations of weed and pest pressures must be also used to determine appropriate corrective actions. Environmental factors such as moisture, temperatures, and weather damage must be considered to determine their effects on crop yields and goals.

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Lesson 6: Harvesting the Crop

Harvesting is one of the last steps a producer takes in preparing a crop for market. Before, during, and after the harvest, the producer must make a number of decisions to ensure the maximum return on his or her investment. As the grain is gathered, the producer is faced with several challenges. Crop losses, seed damage, and storage problems compound the efforts associated with harvesting. Once the grain is gathered, the producer must decide if drying grain is in his or her best interest and choose a method by which to dry. These issues will be covered in this lesson.

When to Harvest

Determining the optimum harvest time is critical for profitable grain production. The best time to harvest is when the producer can receive the highest yield with the highest quality. Factors that determine the proper time to harvest grain crops are divided into three categories: plant characteristics, weather conditions, and harvesting methods.

Plant characteristics refer to the plant's stage of maturity, tendency to lodge, and tendency to shatter. Lodging refers to breaking or bending the stalk below the ear. Shatter is the loss of grain from inflorescence. If the plant is not harvested at the appropriate maturity stage, it may cause a decrease in the yield and increase the possibility of loss due to lodging and shattering. A loss of grain nutrients for feed can also occur.

Corn harvested for grain is considered mature when the kernel moisture content is 20 to 28%. As a rule, corn with more than 15.5% moisture will need artificial drying if it is to be stored. High moisture corn can be used for feed if it is stored in an airtight container. Corn harvested for silage should be harvested after the ear is well dented but before the leaves turn brown and dry. Ears will be well dented between the 32 to 35% moisture stage. Grain sorghum should have a moisture content of no more than 20% and should be harvested after the heads have matured and the stalks begin to dry. Table 6.1 identifies the characteristics that indicate the proper harvest time. Moisture levels will vary depending on the storage system being used.

Weather is a consideration in harvesting because of the effect it has on mature crops. Rainfall, humidity, wind, and temperature affect crop moisture content. Harvesting crops with high moisture content may increase mold and cause overheating during storage. Adverse weather conditions such as heavy rains, hail, or strong winds can damage crops that are ready for harvesting. Also, harvesting equipment may not be usable in wet fields.

The harvesting method used will also influence the optimum harvest time. Corn or grain sorghum that is chopped for silage will have a much higher moisture level than for corn or grain sorghum that is being combined for grain.

Harvesting Methods

The two primary harvesting methods for corn and grain sorghum are combining and silage chopping.

Table 6.1 - Characteristics of Proper Harvest Time

Crop	Percent Moisture	Plant Maturity Stage	Physical Plant Signs for Harvest
Corn (Grain)	15.5%	50-60 days after pollination	Kernels are nearly all well glazed and dent corns, well-dented husks and bottom leaves dry, upper leaves 1/4 to 1/2 green
Corn Silage	65-70%	Medium to hard dent	Kernels fully dented and well glazed, husks begin to turn yellow although most leaves are green
Grain Sorghum	18-20%	Mature heads	Stalks begin to dry
Grain Sorghum Silage	60%	Dough stage	Before leaves begin to deteriorate

Corn is grown primarily for grain and is harvested with a combine equipped with a corn head known as a picker sheller. The ear is removed from the plant, the husks are removed from the ear, and the grain is shelled by removing the kernels from the cob. Corn that is used for silage is harvested by using a chopper that cuts the stalk into small particles. Generally, silage particles should be about 1/2 inch long, with 15 to 20% of the particles being 1 inch in length. The particle size has an effect on the ability to pack tightly to reduce air from the silage mass, which in turn allows for a more desirable type of fermentation. Manipulations in the particle size can be made through machine adjustments on the knives and shear bar.

Grain sorghum grown for grain is combined with a regular combine grain head. It should be cut as high as possible without skipping too many heads. Cutter bar guard extensions are helpful if heads droop. If lodging is a problem, a row-crop attachment is useful for pick up and intake of the crop. Threshing action should be only enough to detach the seed from the heads. Grain sorghum can also be harvested for silage by green chopping the standing crop in the field. As with corn silage, the particle size is important to obtain optimum conditions for desirable fermentation of the crop.

The estimated yield of a crop may be a determining factor as to which harvesting method will be used. Combining is generally used for a high-yielding crop that will be used for grain. Corn and grain sorghum that has a low yield will generally be used for silage. Corn yields can be estimated by counting the number of ears per acre and the number of kernels per ear. Multiple these two numbers to get an estimate of the number of kernels per acre. Divide by an average number of kernels in a normal bushel to get the yield in bushels per acre. Yield estimation can be done after the kernel number is fixed, about 2 weeks after the end of pollination.

Major Sources of Crop Loss During Harvest

Grain left behind when a field is harvested represents a loss of profits. Harvest loss cannot be reduced to zero but skilled equipment operators can reduce harvest losses to an acceptable level without affecting the rate of harvest. Before harvest losses can be identified and measured, the cause of harvest losses must be understood. The major sources of crop losses include preharvest losses, header ear loss, header kernel loss, combine cylinder loss, and combine separation loss.

Preharvest losses occur from plant lodging and appear as whole ear losses. Whole ear loss increases as the season progresses and is generally out of the producer's control at harvest. Average preharvest losses should be less than 1% of total crop yield. This loss can go much higher in adverse crop years or when harvest is delayed.

Header ear loss occurs when harvest equipment is driven at a ground speed that is too fast or too slow. Loss can also occur by driving off the row or operating the header too high, resulting in loss of whole or broken ears. Losses average 3 to 4% of the total crop yield. With proper machine operation and adjustments, losses can be held to 1%.

Header kernel loss occurs when kernels are shelled out and lost by the header at the gathering snouts or snapping bars and rolls. Losses generally average about 0.6%. Proper adjustments and machine operation along with good field conditions can hold kernel losses to about 0.4%.

Combine cylinder loss happens when unsatisfactory shelling action causes some kernels to remain on the cob or stalk as they pass through the machine. With correct cylinder or rotor speed and correct concave clearance adjustment, this loss should not exceed 0.3%. Correct adjustment results in few or no broken cobs with no kernels attached to them. Shelling action that is too vigorous will result in excessive kernel breakage.

Combine separation loss occurs when kernels pass over the sieves and out the combine. Correct sieve and wind adjustment can usually correct these losses, which should be held to 0.1% of the total crop yield.

Preventing Grain Damage at Harvest

To maintain high-quality grain, the percentage of damaged grain must be kept to a minimum. Major factors affecting the physical condition of the grain include improper combine or harvesting equipment settings, improper moisture at the time of harvest, weather conditions, plant maturity, and excessive handling.

Improper settings on equipment can range from harvesting at the wrong speed to incorrect operational settings on the combine. Settings for cylinder speed, concave clearance, and the sieve should all be adjusted for the crop being harvested and the equipment ground speed. The equipment operator manual will give guidelines that should be followed for correct equipment operation.

Producers should also harvest grain at a moisture level conducive to maintaining the physical structure of the grain. Crop moisture and maturity at harvest should be inspected to avoid grain seed damage. Underdeveloped seeds and poor moisture both contribute possible seed damage. Once harvested, handling the grain seed should be kept to a minimum. The fewer times the grain is augured or dumped the less injury to the seed.

Local Storage Options

Producers generally have a number of possible storage options for their harvested crop. These include on-farm storage bins or silos, local county elevators, local processing facilities, and regional transport facilities.

On-farm storage is generally practiced by all producers if the total area available is significant enough to house the crops harvested. However, many producers who lack on-farm storage or who wish to market their grain early may opt to store grain in a local county elevator. Various processing facilities like ethanol plants, feed mills, or feedlots may be located near enough so producers can market their grain at higher profits and alleviate storage problems. Grain may also be trucked to a regional transport facility such as a railroad or river terminal to market or store harvested grain.

Storage Problems

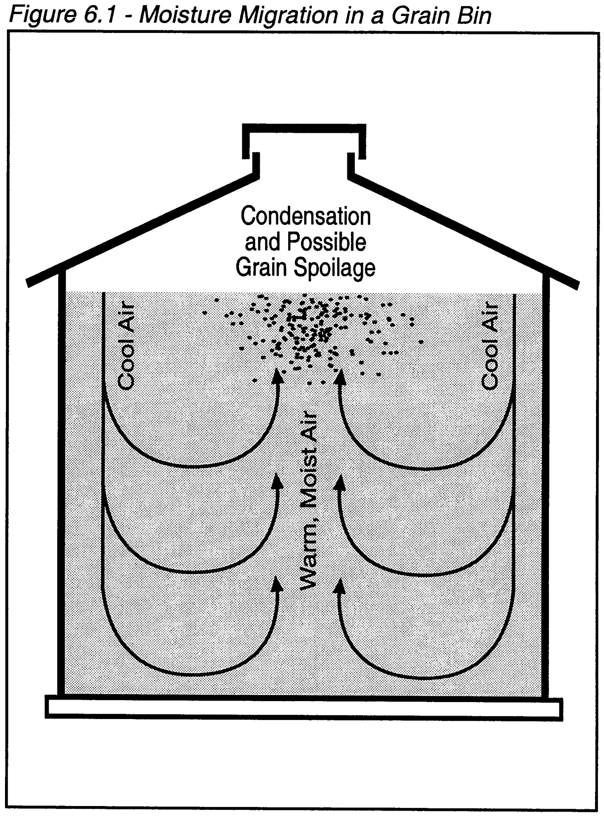
Improper storage can cut into the potential profits in corn and grain sorghum production. Economic loss to these grains during storage may be caused by high moisture content, improper drying, foreign material, and insect and rodent infestations. Mold can be a problem if grains are harvested and stored when the moisture content is too high. If moisture content is too high, the grain will heat up, encouraging rotting and spoilage. Improper drying can include both over- and underdrying, thus reducing quality. Foreign material in the grain such as weed seeds, plant parts, and insect parts can encourage grain spoilage. If adequate storage is not provided, insects and rodents can infest the grain and reduce the quality by contamination.

Figure 6.1 shows airflow in a grain bin and the possibility of grain spoilage from condensation. Grain near the outside walls will cool in the late fall and winter. The grain in the interior will remain warm. As the air is warmed during its upward movement, it releases moisture. Condensation forms on the surface of the grain, providing an ideal place for mold to grow.

Factors That Determine Whether to Dry Corn

The main goal of all grain producers is to limit harvest loss, and the ability to dry corn allows a producer to limit those losses. The factors that influence a producer's decision to dry corn are largely dependent on the weather, market price, grain quality, storage availability, drying equipment, and the cost of drying.

Figure 6.1 - Moisture Migration in a Grain Bin



Unfavorable weather conditions during harvest contribute to excessive harvest losses. A producer may harvest early and dry corn to prevent late harvest losses. In addition, the market price for corn may be higher early in the harvest season. By harvesting early at higher moisture content and then drying the corn to an acceptable merchandising moisture content, producers can capitalize on those higher market prices. Marketing options will be discussed in more detail in Lesson 7.

Grain quality is another factor influencing the decision to dry corn. Losses from molds, heat, and spoilage from higher moisture corn may be alleviated by the drying process.

The amount of storage available, dryer cost, and operational costs must all be considered before choosing to dry corn. Each of these will add to the cost of production and the individual producer must compare expected profit with the added costs to determine whether to dry the crop.

Methods of Drying Corn and Grain Sorghum

Methods for drying corn and grain sorghum include using heated or unheated air, as well as field drying. Drying methods are similar for corn and grain sorghum; however, an individual sorghum seed exposed to airflow will dry faster than when drying corn. The sorghum seed is smaller and the interior moisture can get out faster. But the greater flow resistance of a layer of sorghum in a bin reduces the quantity of airflow for a given static pressure. As a result, both the drying time and the cooling rates will be 2/3 to 3/4 that of corn for the same moisture content and drying equipment.

Unheated air may be used to dry harvested grain that contains no more than 15% moisture. To decrease the grain moisture content, unheated air must have a relative humidity of 70 to 75% or less. During the final drying stages, unheated air must contain less than 50 to 60% humidity to reduce the grain moisture content to 13%. Bins for drying must be equipped with perforated ducts or false floors to allow the air to be forced through all parts of the bin by a ventilating fan. Table 6.2 outlines the grain drying potential for corn given the relative humidity and temperature.

Table 6.2 - Humidity Chart for Drying Corn

Current Relative Humidity Reading	Current Temperature Reading 30°F	40°F	50°F	60°F	70°F	80°F
30%	10.3	10.0	9.6	9.2	8.4	7.5
35%	10.8	10.5	10.1	9.7	9.0	8.3
40%	11.3	11.0	10.6	10.2	9.7	9.1
45%	12.2	11.7	11.3	10.9	10.4	9.8
50%	13.1	12.5	12.0	11.6	11.1	10.5
55%	13.5	13.3	12.7	12.1	11.5	11.5
60%	14.6	14.0	13.3	12.7	12.0	11.2
65%	15.5	14.8	14.1	13.4	12.8	12.1
70%	16.4	15.5	14.8	14.2	13.5	13.0
75%	17.4	16.6	15.8	15.0	14.5	13.9
80%	18.7	17.8	16.9	16.0	15.4	14.8
85%	20.2	19.4	18.6	17.8	16.8	15.8
90%	22.5	21.5	20.5	19.5	18.5	17.4

Example: When temperature is 60°F and humidity is 60%, corn may be dried to 12.7% using unheated air.

The advantages of drying with unheated air include lower energy expense, decreased fire hazard, lower initial equipment costs, less management and supervision, less chance of overdrying, and a high-quality dried grain. Disadvantages arise because the unheated air uses outside air that is affected by natural weather conditions. Unheated air systems are not effective in cold, damp conditions. Other disadvantages are slower drying rates, more drying time required, bin fill limitations, and a greater possibility of damage from mold due to prolonged drying times.

Drying with heated air is accomplished by heating the air with natural gas or petroleum fuels and forcing the heated air throughout the storage bin. The heat from each gallon of fuel will evaporate 50 to 85 pounds of water from the grain if direct heat drying is used. If indirect heating is used, 35 to 60 pounds of water can be removed.

The advantages of using heated air include an increased ability to dry the wettest grain, no dependency on weather conditions, shorter and faster drying times, and high drying capacity. The disadvantages of using heated air drying include higher initial cost, higher fuel expense, some fire hazard, potential to overdry grain (thus reducing quality), and more careful management and supervision are required.

In field drying, the crop is allowed to dry to the appropriate moisture content while standing. The standing crop is harvested with the appropriate combine head attachment to prevent kernel damage and pick up lodged corn.

Maintaining Grain Quality During Storage

The primary goal of a grain storage facility is to retain the quality of the stored grain. Factors that affect grain quality include the purity of the crop and variety, percentage of weeds and other mixtures, and percentage of diseased and damaged kernels.

Maintaining crop quality for corn is dependent on the following management steps: (1) store grain at a moisture content of 14% or less; (2) level the top surface to the grain; (3) aerate in the fall to cool the grain to 40°F; (4) do not allow the grain to freeze; (5) check and record the grain temperature every 21 days with aeration as soon as any increase in temperature is evident; (6) warm the grain to 65°F in the spring by running an aeration fan; and (7) try to maintain less than a 20-degree difference between average outdoor temperature and grain temperature.

Grain sorghum storage is essentially the same as shelled corn. Cooling is the first consideration with humidity and moisture control is secondary. Run the fan, regardless of weather conditions, whenever the grain is heating or over 22% moisture content. When the grain is below 22% moisture and not heating, run the fan whenever the outside air is 10 degrees cooler than the grain mass until the grain is cooled down to 40°F to 50°F. The increased airflow resistance of grain sorghum reduces aeration flow rates compared to corn. This may not be as critical as in drying, however, because of the low airflow rates and the greater latitude in aeration.

Silage Storage Problems

To maintain quality in corn or grain sorghum silage during storage, it is important to understand the ensiling process. The ensiling process occurs as chopped forages and grains are compressed and placed in the silo. The cells of the plants are still alive and breathing. Breathing plant cells and microorganisms form carbon dioxide and heat using the trapped air. As carbon dioxide increases, anaerobic bacteria form in the silo. These bacteria do not require the presence of free oxygen for metabolism. These desirable bacteria start the fermentation process when plant respiration stops. Therefore, it is important to control air exposure to silage. By limiting air during the ensiling process, carbon dioxide is maintained and the fermentation process can occur. If carbon dioxide levels are not maintained, mold will grow and nutrient losses will occur. In trench or bunker silos, the silage is immediately covered with a plastic cover after the last load has been included.

Silage is harvested at a recommended dry matter content of 30 to 40% and during storage, moisture contents are a concern. Silage high in moisture will seep or water will leak to the bottom of the silo or bunker taking vital nutrients with it. In addition, silage too low in moisture is hard to pack or store because of the extra air present. The extra air will also cause problems in fermentation and mold will grow. If silage contains over 50% dry matter, it is recommended that water be added in the ensiling process to obtain correct moisture content.

Temperature is critical in the fermentation process. The recommended temperature for desirable bacterial decomposition is between 80°F and 100°F. If the temperature becomes too hot, silage will appear to be black or brown with a caramel odor like burnt brown sugar. Freezing or low temperatures are of lesser concern in silage storage. If silage in bunkers or trenches becomes frozen, digestive problems can occur in livestock.

Silage should be properly packed or stored to prevent seepage, poor fermentation, and loss in storage capacity. Silage is kept fresh and spoilage is prevented on the feeding surface in upright silos if 2 inches of silage are removed daily in winter or 3 inches in summer. In trench or bunker silos, producers should remove 3 inches daily in winter and 4 inches in summer. If silage fails to have a light, pleasant smell with only a slight vinegar odor or a color other than slightly brown to dark green, the quality of the silage would be questionable.

Summary

Once a crop is grown and ready for harvesting, a producer's job is far from over. The producer wants to receive the best possible price for his or her efforts, so different factors have to be considered before the crop is sold. Crop loss and seed damage must be minimized. Decisions need to be made whether it is more profitable to assume the burden of drying the grain or selling it with a moisture dock in the price. Storage of the crop must also be arranged. The decision to sell the crop immediately or hold onto it for a while is complex. A producer must be aware of economic conditions and decide which option is the most profitable. All of these decisions require careful consideration to achieve the best possible profit.

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Lesson 7: Marketing the Crop

Toward the end of the 20th century, the U.S. government was trying to have less influence on farm income. The Freedom to Farm Act and the NAFTA trade agreement had been enacted to allow producers to trade more freely in the global marketplace. However, no one had considered the impact of large grain importing countries like Japan falling into financial turmoil and responding by reducing imports. The American producer suddenly had much more freedom in a dwindling marketplace. With this knowledge of global market fluctuation, today's producer must place extreme emphasis upon making a profit. By studying the various options available, producers, grain buyers, and elevator managers can determine profitable levels at which to operate their enterprises.

Options for Marketing Corn and Grain Sorghum

Corn and grain sorghum producers have six basic choices when it comes to marketing their crops. They can (1) sell the crop when it is harvested, (2) store the crop and sell it later, (3) feed the crop to their own livestock, (4) forward price the crop through cash contracts, futures contracts, or options, (5) use a combination of these methods, or (6) participate in commodity price support programs from the government. What producers choose to do depends on the current cash price, the price of futures, and what they think is going to happen to corn and grain sorghum prices in between. To gain a better understanding of market price trends, producers can review average yield and price variations from previous years and current USDA or AgEBB crop reports.

Determining When to Sell, Feed, or Store Crop

If producers grow corn or grain sorghum for the market, they must decide whether the most profit will occur by selling directly from the field, feeding it to the livestock, or storing the crop for awhile. Factors that affect this decision are the cost of farm storage, the producer's prediction on trends in grain and livestock prices after harvest, and interest rates. Simply stated, if the price of corn is high and looks to drop in the future - sell. If the price of corn is low and looks to rise in the future - store. If the price of corn is low and livestock prices are looking up for the future - feed. However, the futures market can change drastically so a producer must pay close attention to global markets when making marketing decisions.

The corn market today differs in important aspects from the 1930s to the middle 1970s. The U.S. corn crop is now an important part of the world market for feed grains. Crop sizes in other parts of the world influence the U.S. price.

Corn is an important item in the balance of trade with other countries. Corn shipments overseas help the United States import needed materials such as fuel oil. The federal government is much less involved in support prices and does not provide grain storage bins. Corn prices are likely to have higher peaks and valleys today than when the government purchased large amounts of grain to raise the price in years of surplus and released feed grains from storage to dampen the price rise in years of short supply.

There has been some interest in establishing world grain reserves. A great increase has occurred in the amount of corn moved directly from the field to local elevators in cash grain areas. This has put a heavy strain on storage facilities and transportation. Railroad grain cars have often been inadequate to move all of the corn during the rush period. The situation is aggravated when the weather is ideal and the harvest is rapid.

In summary, based mainly upon the U.S. situation, (1) the odds favor regularly storing corn and grain sorghum for a short time after harvest, (2) storing until the next fall is risky, (3) success with corn and grain sorghum storage over a period of years depends upon selecting the right time to sell in individual years, and (4) feeding corn or grain sorghum is a good option when the cash price is low and livestock futures are trending steady to high.

Except for the period right after harvest, the average rise in price is little more than the cost of storage. Having storage capacity on the farm increases a producer's flexibility in deciding when to sell the crop. Some large local or regional elevators will accept delivery of a producer's crop and then let the producer decide when to declare it sold even though the buyer may already have moved it into the grain marketing channel.

If producers dry their grain and store it for an anticipated market increase, they must also consider additional costs for that storage and figure a break-even cost to justify that storage. When doing so, producers must include the loss of interest on the money they would have received if the corn was sold on the cash market at the time of harvest. The following formula may be used to figure the cost of storage on a per month basis. Normal storage is 12¢ per bushel for the first 3 months of commercial storage (as a minimum charge) and 3¢ per bushel for each month after that.

(interest X current price ÷ 12) X 1 month + storage cost for that month =
Monthly storage cost

If corn is selling for $2.25 per bushel and interest is 9%, the first month's cost of storage would be as follows:

[9% (.09) X $2.25 ÷ 12] X 1 + 12¢ (.12) =
13.7¢ for that month

A spreadsheet may be found on the Internet at <http://agebb.missouri.edu/download/university> to figure storage costs for a given period. The file "cropstor.exe" can be downloaded to a hard drive for use. This spreadsheet was designed by the University of Missouri Extension Agronomy and Agricultural Economics staff.

Effect of Grain Quality on Market Price

In Lesson 6, the factors that affect seed damage at harvest or during storage were discussed. The efforts producers made to limit seed damage and thereby preserve grain quality will pay off when the grain is sold. The USDA has set standards by which all grain is tested and graded when it is purchased by licensed buyers. Factors used in grading include (1) test weight, (2) moisture content, (3) seed damage (cracked kernels), (4) foreign material present, and (5) special discounts such as musty, sour, heating, weathered, foreign odor, or discolored.

Producers need to be familiar with the grading levels because this will determine what price their grain will bring when it is sold. Corn is graded on a scale of 1 - 5, with 1 being the highest grade, or best quality. See Table 7.1. Likewise, grain sorghum is graded on a similar scale of 1 - 4, as shown in Table 7.2. Corn that falls below Grade 5 and sorghum that falls below Grade 4 is called "Sample" grade and is considered low quality. Corn's Sample grade will also have one or more of the following characteristics: contains stones, musty, sour, heating, and/or has a foreign odor. Sample grade for grain sorghum characteristics is the same as corn with the addition of badly weathered.

Comparing Moisture Docking to Drying Costs

Test weight of corn determines the weight of a bushel volume (1.244 cubic feet) of grain. Test weights determined on dry (15.5% moisture) corn indicate whether the grain crop reached full maturity. Low test weights indicate immaturity. If bushel test weight of mature corn is determined at harvest when grain moistures are greater than 15.5%, the test weights will be biased downward.

One of the biggest decisions a producer faces with marketing corn and grain sorghum is whether to sell the crop wet and take the moisture dock (reduced price) or spend the time and money to dry the grain to a moisture level that eliminates any dock. If cash grain prices are high enough or the producer has little or no available storage, the answer is easy—sell and take the dock. However, if grain prices are high and steady, or close to breakeven, then the producer should consider drying the crop.

High-moisture corn sells for less because it has less dry weight, costs more to dry, and discourages producers from selling it. The dock on high-moisture corn is often 3¢ per bushel for every 1/2% above 15% moisture. The cost for drying high-moisture corn is normally figured at 3¢ per bushel per 1% of moisture removed. Producers can use an on-farm moisture tester and figure their costs of drying or the amount of dock they would receive, compare this to the cash price of corn at that time, and determine their marketing strategy.

Shelled grain weights can be adjusted using a grain shrink table. Shrink represents both the moisture loss and 0.5% dry matter loss encountered during drying and grain handling. To estimate the amount a given wet weight of corn will lose during the drying process, multiply the wet weight by the shrink factor from the shrink table.

Table 7.1 - Grade Requirements for Corn

Grade	Minimum test weight per bushel (pounds)	Maximum limits of:		
		Damaged kernels		Broken corn and foreign material (%)
		Heat-damaged kernels (%)	Total (%)	
U.S. No.1	56.0	0.1	3.0	2.0
U.S. No.2	54.0	0.2	5.0	3.0
U.S. No.3	52.0	0.5	7.0	4.0
U.S. No.4	49.0	1.0	10.0	5.0
U.S. No. 5	46.0	3.0	15.0	7.0

U.S. Sample grade is corn that:
(a) Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, 4, or 5; or
(b) Contains stones that have an aggregate weight in excess of 0.1% 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 cockleburs (*Xanthium* spp.) or similar seeds singly or in combination, or animal filth in excess of 0.20% in 1,000 grams; or
(c) Has a musty, sour, or commercially objectionable foreign odor; or
(d) Is heating or otherwise of distinctly low quality.

Table 7.2 - Grade Requirements for Grain Sorghum

Grade	Minimum test weight per bushel (pounds)	Maximum limits of:		
		Damaged kernels		Broken kernels, foreign material, and other grains (%)
		Heat damaged (%)	Total (%)	
U.S. No. 1	57.0	0.2	2.0	4.0
U.S. No. 2	55.0	0.5	5.0	7.0
U.S. No. 3*	53.0	1.0	10.0	10.0
U.S. No. 4	51.0	3.0	15.0	13.0

U.S. Sample grade is sorghum that:
(a) Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, or 4; or
(b) Contains stones that have an aggregate weight in excess of 0.2% of the sample weight, 1 or more pieces of glass, 2 or more crotalaria seeds (*Crotalaria* spp.), 1 or more castor beans (*Ricinus communis* L.), 3 or more particles of an unknown foreign substance(s), 7 or more cockleburs (*Xanthium* spp.) or similar seeds singly or in combination, 9 or more particles of animal filth per 1,000 grams of sorghum, or
(c) Has a musty, sour, or commercially objectionable foreign odor (except smut odor); or
(d) Is badly weathered, heating, or distinctly low quality

* Sorghum that is distinctly discolored shall not be graded higher than U.S. No. 3.

Corn Checkoff Dollars

For every bushel of corn sold in Missouri and 18 other states, a specified rate, or checkoff, is invested by the seller at the first point of sale. Since 1984, Missouri corn producers have been investing ½¢ per bushel of corn sold. Monies collected are sent to the Missouri Corn Growers Association, a state corn promotion board. The board is run by farmer-directors who invest checkoff monies in state programs of research, market development, and education to increase the demand for corn. Part of the fund is sent to the National Corn Growers Association (NCGA). Checkoff dollars are invested in the same areas as on the state level. These dollars along with the investment from NCGA members and state associations provide the funding base for new the National Corn Growers Association (NCGA). Checkoff dollars are invested in the same areas as on the state level. These dollars along with the investment from NCGA members and state associations provide the funding base for new product development and help maintain traditional markets. Therefore, individual producers play an important role through checkoff dollar contributions by supporting the mission of NCGA "to enhance corn profitability and usage to improve the quality of life in a changing world."

Summary

By studying available market options, producers, grain buyers, and elevator managers can determine profitable levels at which to operate their enterprises. Corn and grain sorghum producers have five basic marketing options: (1) sell the crop when it is harvested, (2) store the crop and sell it later, (3) feed the crop to their own livestock, (4) forward price the crop through cash contracts, futures contracts, or options, or (5) use a combination of these methods. Producers must also decide when it is appropriate to sell direct from the field, feed, or store the crop. The main factors affecting these decisions are the cost of farm storage and predictions on future price trends in grain and livestock.

Several crop and noncrop factors influence prices in the United States. However, the odds favor storing corn and grain sorghum for a short time after harvest and feeding it when cash prices are low and livestock futures are high. Having storage capacity on the farm increases a producer's flexibility in deciding when to sell his or her crop.

The USDA has set standards by which all grain is graded for sale. Factors used in grading include (1) test weight, (2) moisture content, (3) seed damage (cracked kernels), (4) foreign material present, and (5) special discounts. Comparing moisture docking to drying costs is another important consideration for corn and grain sorghum producers.

Missouri corn producers play an important role through checkoff dollars to promote research, market development, and education to increase the demand for corn.

Credits

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USDA Grain Inspection Handbook. Grain Inspection, Packers, and Stockyards Administration, Federal Grain Inspection Service, 1997.

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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 corn or grain sorghum crop. An approved accounting system must be adopted and understood by the producer for it to be worthwhile. Time must be planned during the season to record and enter costs. Plan time during the nongrowing season to analyze these costs to make changes to improve the net returns.

Variable Costs Associated with Corn and Grain Sorghum Production

To determine the break-even costs of a corn or grain sorghum crop, producers must be able to track all of their variable costs. Variable costs are also known as operating costs. Variable costs increase or decrease with the volume of output. For example, if a greater yield from the corn production is desired, an option is to increase the plant population. This will mean that additional seed must be purchased, therefore increasing the cost of production. Decreasing planting rates requires less seed, but the crop yield will also be less. Other types of variable costs include fertilizer, chemicals, and labor.

Detailed records are necessary to allocate costs correctly. For example, farm utilities include electricity expenses. These can be broken down into 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 will give examples and amounts of possible variable costs that may be incurred with a corn or grain sorghum crop. These figures are from MIR (mail-in-records) enterprise records for the 1998 Missouri average crop costs from the University of Missouri Extension Service.

As can be seen from the information in Table 8.1, variable costs for the production of grain sorghum are less per acre than for corn. Comparable figures for the same year indicate the variable costs for grain sorghum production to be about 20 to 25% less than for an acre of corn; however, yield per acre and cash prices must also be evaluated when comparing the two crops.

Table 8.1 - Variable Costs per Acre for Corn and Grain Sorghum

	Corn	**Grain Sorghum**
Number of Farms Reporting	89	13
Average Number of Acres	332	119
Average Yield/Acre (bushels)	121	99.3
Average Variable Costs/Acre		
Seed	$27.89	$9.86
Plant food (fertilizer & lime)	50.50	45.33
Crop chemicals and materials	31.34	21.85
Machinery fuel, oil & repair	26.04	20.90
Machinery hire & services	6.30	4.18
Average labor cost/acre	26.56	4.16
Taxes and insurance	3.75	1.08
Miscellaneous	13.70	12.16
Operating interest	14.55	12.83
Total Variable Costs/Acre	$200.63	$152.35

Fixed Costs Associated with Corn and Grain Sorghum Production

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

Table 8.2 shows examples and amounts of possible fixed costs that may be incurred with a corn or grain sorghum crop. These figures are from the MIR enterprise records for 1998 Missouri average crop costs from by the University of Missouri Extension Service.

Table 8.2 Corn and Grain Sorghum Fixed Costs/Acre

	Corn	Grain Sorghum
Average Fixed Costs/Acre		
Machinery depreciation, taxes, and interest	$ 36.10	$24.87
Land costs, taxes, and interest	$ 93.45	$66.65
Total Fixed Costs/Acre	$129.55	$91.52

As shown with the variable costs, fixed costs per acre for the production of grain sorghum is lower than for the production of corn.

Determining an Acceptable Return on Investment

As with all crop enterprises, the net returns for the enterprise are determined by subtracting the total costs (variable and fixed costs) from the returns. This is most commonly done on a per-acre basis. From the examples from the tables, the total of all costs for corn production was an average of $330.18 per acre. With the production averages listed, this results in a cost of $2.74 per bushel of corn produced ($330.18 ÷ 121 = $2.74).

The corn crop must bring a return above $2.74 (in 1998) per bushel for a positive net return. However, in 1998 corn prices were suffering from a depressed market where there were surpluses, and prices were below average costs. Producers received a negative return per acre for that year. However, in 1996, 2 years earlier, producers received an average $141.44 net return per acre due to strong market prices.

As with all markets, yearly cycles exist. Producers must accept years where weaker markets cause lower prices in hopes there are more years where the net returns are higher. Total returns will depend on the total number of acres in production. A producer with a large number of acres will receive larger total returns. If a producer had 400 acres of corn and received $50 net return per acre, this would yield a total net return of $20,000 for the corn crop.

Calculating Cost Per Acre

As indicated previously, the total costs 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 a corn or grain sorghum producer determine crop costs. These costs are a total of the variable and fixed costs incurred in producing the crop. These 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 real estate. Total costs are determined by adding all fixed and variable costs.

Credits

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