

WINTER WHEAT

Culture in Michigan



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Winter Wheat Culture in Michigan

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INTRODUCTION

WINTER WHEAT is Michigan's most important cash crop. An average of 33 million bushels of wheat are produced annually on 1.1 million acres. The cash value is 60 million dollars, 8 percent of the total cash income from Michigan farms.

Types of wheat

Michigan's climate is especially suited to the production of soft winter wheat. On the other hand, production of hard types of both winter and spring wheat is unsatisfactory in Michigan because the prevailing climatic conditions prevent them from attaining the degree of hardness and other quality factors desired by the milling industry.

Approximately 83 percent of the Michigan winter wheat crop is soft white, 14 percent is soft red, and the remainder is of undetermined type. Almost all of the soft red wheat is produced in the southern tier of counties.

Uses

The primary use of Michigan-produced soft wheat is for pastry flours used in crackers, cookies, cakes and other pastry products. Some of the flour from soft wheats is blended with flour from other wheat types for special purpose flours. Soft white wheat is also suitable for special breakfast foods.

Soft wheat is especially desirable for pastry flours because of the lower protein content than that of the hard types of wheat. Very little soft wheat is used in Michigan for feed, except as by-products of the milling industry.

Adaptation

Winter wheat has wide adaptation in Michigan and is produced in almost all counties. However, the acreage is small in the northern

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Lower Peninsula and the Upper Peninsula because of winter killing. About 94 percent of the crop is produced south of the Bay County-Muskegon County line.

Wheat does best on well-drained sandy loam to clay-loam soils. It is not well adapted to light sandy, poorly drained, or muck soils.

Michigan climate is best suited to the production of high quality, low protein wheat. In general, the soft white type gives a higher per acre yield than soft red but there is less trouble with sprout damage with red wheat in unfavorable seasons. There are good local markets for white wheat and there has been no surplus as of this time.

Wheat improvement

The wheat crop is beset with many problems which lower its final yield and quality and the final profit margin. Some of the major problems in Michigan are lodging; susceptibility to powdery mildew, leaf rust, loose smut and Hessian fly; winter killing; and the tendency of white wheat varieties to sprout in the head at maturity when wet weather prevails.

With today's high production costs it is essential to minimize the major production problems through (1) plant breeding, (2) research in plant physiology, and crop production, and (3) managerial efforts. Progress along these lines should help insure the grower of high yields of high quality wheat and the processor of an adequate supply of high quality grain.

The wheat improvement program at Michigan State University should benefit the entire Michigan wheat industry — producers, grain merchandisers, and millers.

CULTURE AND MANAGEMENT

Crop rotation

A crop rotation, with wheat appearing no oftener than every third year, appears necessary for continuous high, economical yields per acre and high quality grain. Continuous cropping to wheat on the same field may result in a 10 to 15 percent or more reduction in yield for the second wheat crop and 50 to 80 percent reduction in the third crop because of a build-up of the "Take-all" disease. In addition, the quality of the grain is lowered because of shrunken kernels and the resultant lower test weight per bushel.

There are several crops other than wheat which should not precede wheat in the rotation because they are host plants of "Take-all" dis-

ease. These crops are winter barley, rye, bromegrass, and a legume-grass sod with a high proportion of grass. Quackgrass is also a host plant.

Similarly, there is a good possibility for greater scab infestation of the wheat crop where wheat follows wheat and wheat follows corn for grain. The *Gibberella* organism, which can cause stalk and ear rot in corn, is the same organism which causes scab of wheat.

Choosing a variety

Promising varieties of both soft white and soft red winter wheat are tested each year at Michigan State University and at several locations throughout the state. In evaluating a variety, the following factors are considered:

- Yield per acre
- Lodging resistance
- Disease and insect resistance
- Maturity
- Height of straw
- Color of grain
- Weight per bushel of the grain
- Harvest dormancy
- Suitability for milling

In general, the variety trials show that the best varieties of white wheat give slightly higher yields per acre than the best red varieties. A yield comparison of some of the varieties tested for the past 3 years is given in Table 1, and a listing of the varietal characteristics is provided in Table 2.

It is unlikely that any one particular variety will have all of the most desirable characteristics. Therefore, one must select those varieties which have the best combination of desirable characteristics. With the above comparisons in mind the following varieties of winter wheat are presently recommended:

Genesee soft white
Avon soft white

Dual soft red
Monon soft red

As further information becomes available on wheat varieties, a list of recommended varieties will be published annually in Extension Folder F-289, *Field Crop Recommendations for Michigan*, and in the current issue of the Michigan Certified Seed Directory.

TABLE 1—Winter wheat variety trials at three locations, 1958-60 (bushels per acre)

Variety	Ingham county			Cass county			Monroe county		Average for all locations and years
	1958	1959	1960	1958	1959	1960	1958	1960	
							1958	1960	
*Avon (White).....	57.2	54.9	45.6	....	40.4	41.6	67.7	64.1	53.1
Yorkwin (White).....	45.8	51.2	42.1	....	35.8	39.4	65.8	60.9	48.7
Cornell 595 (White).....	51.8	51.1	42.5	....	37.6	....	....	....	....
*Genesee (White).....	57.1	47.3	50.3	....	38.2	41.4	68.7	60.9	52.0
*Dual (Red).....	55.6	50.6	43.3	41.0	35.9	37.3	68.2	60.3	49.0
*Monon (Red).....	56.6	53.9	44.3	44.3	36.9	38.3	69.5	54.1	49.7
Seneca (Red).....	46.7	53.2	44.8	40.2	37.4	38.0	62.9	60.4	48.0
Genesee (White).....	57.1	47.3	50.3	46.5	38.2	41.4	68.7	60.9	51.3

*Recommended and certified in 1961.

TABLE 2—Summary of characteristics of winter wheat varieties tested under Michigan conditions (1958-60)

Variety	Where and when released	Grain color	Chaff color	Maturity	Straw strength*	Plant height†
Genesee.....	New York 1951	White	Brown	Mid-season	Fair-Good	Medium
Avon.....	New York 1959	White	Brown	Mid-season	Good	Medium
Yorkwin.....	New York 1936	White	White	Mid-season	Poor	Tall
Cornell 595.....	New York 1942	White	Brown	Mid-season	Good	Medium
Dual.....	Indiana 1955	Red	White	Mid-season	Good	Medium
Monon.....	Indiana 1959	Red	White	Early	Fair-Good	Short
Seneca.....	Ohio 1950	Red	Brown	Mid-season	Good	Medium

*Straw Strength: Good—seldom lodged; Fair—often lodged; Poor—frequently lodged.

†Plant Height: Tall—frequently over 45 inches; Medium—usually 40 to 45 inches; Short—usually under 40 inches.

Good seed is important

The first step in obtaining a good crop of wheat is to plant high quality seed of the selected variety. High quality seed should have:

1. High varietal purity
2. High crop purity (90 per cent or higher)
 - Relative freedom from foreign materials (chaff, stems, and cracked seed)
 - Freedom from other crop seeds such as rye and barley, and vetch.
 - Freedom from weed seed such as corn cockle, chess, wild onion, and noxious weeds and relative freedom from other weeds.
3. High germination (90 percent or higher)

Certified seed is the only seed which consistently meets all of the above requirements.

As high quality in the commercial wheat crop is so important, the use of high quality seed is likewise of special importance. Mixtures of white and red wheat are undesirable in commercial use, so certified seed is of special significance because extra attention is given to variety purity.

Whether seed is purchased or homegrown; whether certified or non-certified; one should be careful to plant seed which has been well-cleaned to remove undesirable weed seeds and small, weak, and shrunken kernels which may result in weak plants and a less desirable stand. See Figures 1-4.

The Michigan Seed Law requires that all seed offered for sale in Michigan carry a tag or label showing the following information:

- Germination
- Crop purity
- Foreign material
- Other crop seed
- Weed seed
- Name of the vendor
- Lot number of the seed.

Be sure the seed you buy carries such a label. If you are planting home-grown seed, have a sample germinated and analyzed to determine its suitability for planting.



Fig. 1.—Some of the most troublesome weed seeds in wheat:
Upper left—wild onion
Lower left—quackgrass
Upper right—corn cockle
Lower right—chess



Fig. 2.—An excellent lot. Only a few small and shrunken kernels at top of plate.



Fig. 3.—A poorly screened lot. Upper left, cracked seed; upper center, shrunken; and upper right, small seed.

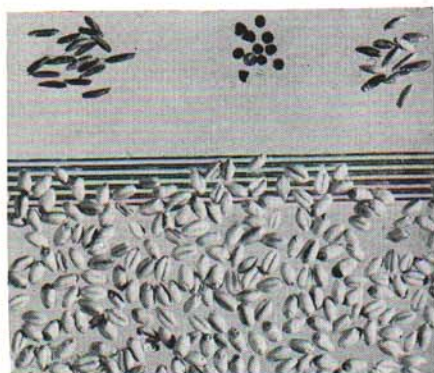


Fig. 4.—A lot with undesirable seeds. Upper left, chess; upper center, corn cockle; upper right, rye.

Seed treatment

Treating seed wheat with a fungicide for the control of seedling diseases and bunt (stinking smut) is essential for an excellent crop of wheat. Losses of yield and quality from bunt infection will not occur when clean seed is used and the seed is properly treated with an effective fungicide. However, seed treatment is not a substitute for high quality seed.

A good seed treatment operation consists of:

- (1) using an effective fungicide,
- (2) applying the fungicide at the proper rate,
- (3) applying the fungicide uniformly, and
- (4) waiting a prescribed time between treatment and planting of the seed.

Fungicides which have given satisfactory control of bunt and seedling diseases in experimental trials are:

Slurry type materials

Ceresan M (mercurial)
HCB, Anticarie, Sanocide,
No-Bunt
Hexachlorobenzene
Terrachlor (Pentachloroni-
tro-benzene)

Liquid type materials

Panogen 15 (mercurial)
Mema (mercurial)
Callotox (mercurial)
Mersol (mercurial)
Ceresan 100 or 200 (mercurial)
Ortho LM (mercurial)

Follow the directions of the manufacturer of the fungicide in treating seed. They are listed on the container label. Undertreatment may result in unsatisfactory control of disease; overtreatment may result in decreased germination.

Treated seed should be labeled clearly to show that treatment has been made and that the seed is unfit for feed or food. The Michigan Seed Coloring Law requires that treated seed be dyed a color contrasting with the normal color of the seed, so that the treated seed may be easily identified. There is no specific requirement as to color of the dye but a red dye is most frequently used.

Treated seed left after planting should be clearly tagged and separated from other grain or destroyed. Do not allow it to be mixed with market wheat.

Soil preparation.

Plowing is usually necessary in preparing a seed bed for wheat except where the crop follows field beans, soybeans, corn for silage, or other row crops. When wheat follows a grain crop, such as oats, the field should be plowed as soon as possible after harvest of that crop. After plowing, disk and drag just before planting to smooth the soil and control weeds. Secondary tillage to control weeds is usually necessary if the field is plowed early. Excessive preparation will pack the soil unduly and should be avoided.

Planting

Tests conducted over a period of years at East Lansing show the best planting rate for wheat is 6 to 8 pecks (1.5 to 2 bushels) per acre of high quality seed. A yield decrease occurred when the rate was less than 6 pecks and more than 8 pecks per acre.

On fine textured soils (loam, silt loam, and clay loam) a planting depth of 1 to 1½ inches is most desirable; on lighter soils a 2-inch depth is preferred. A slightly greater depth would be advisable when the soil is dry.

Wheat should be planted (1) early enough to obtain a good stand of well-developed plants before winter begins, and (2) late enough to miss the fall brood of the Hessian fly.

Wheat seed will sprout at about 35 to 40 degrees Fahrenheit, so seed would germinate if planted in November. However, with such a late planting date, the plants may be too poorly developed to withstand winter injury.

Data have been accumulated over a period of years to arrive at average Hessian fly-free dates for the Lower Peninsula of Michigan. These dates are given for various counties in Figure 5. Planting immediately after these dates is the best time for each area. (See page 18 for discussion of the Hessian fly pest).

Normally it is risky to plant wheat later than 2 weeks after the fly-free date. For example, the best time to plant wheat at East Lansing is about September 18. In experiments, wheat planted October 1 to 13 yielded 70 percent of that planted at the best time.

Tillering

The number of stems per wheat plant has a positive influence on the yield per acre. Tillers or stools originate at the crown of the plant and develop normal heads and grain. The tillering habit thickens the stand, which partly explains why heavy seeding rates do not always result in higher yields per acre of grain. Tillering also partly explains why fertilizer placed in contact with the seed, even though it may initially reduce the stand, still results in a yield increase.

With seeding rates at about 2 bushels per acre, there should be about 3 or 4 stems per plant. With very thin stands there may be over 20 tillers but they might not all have normal sized heads and grain.

The following conditions favor stooling: (1) cool weather in the

spring, (2) high soil fertility, and (3) thin plant stands. With thin stands a spring application of nitrogen has been known to encourage tillering and thus substantially increase the yield of wheat.

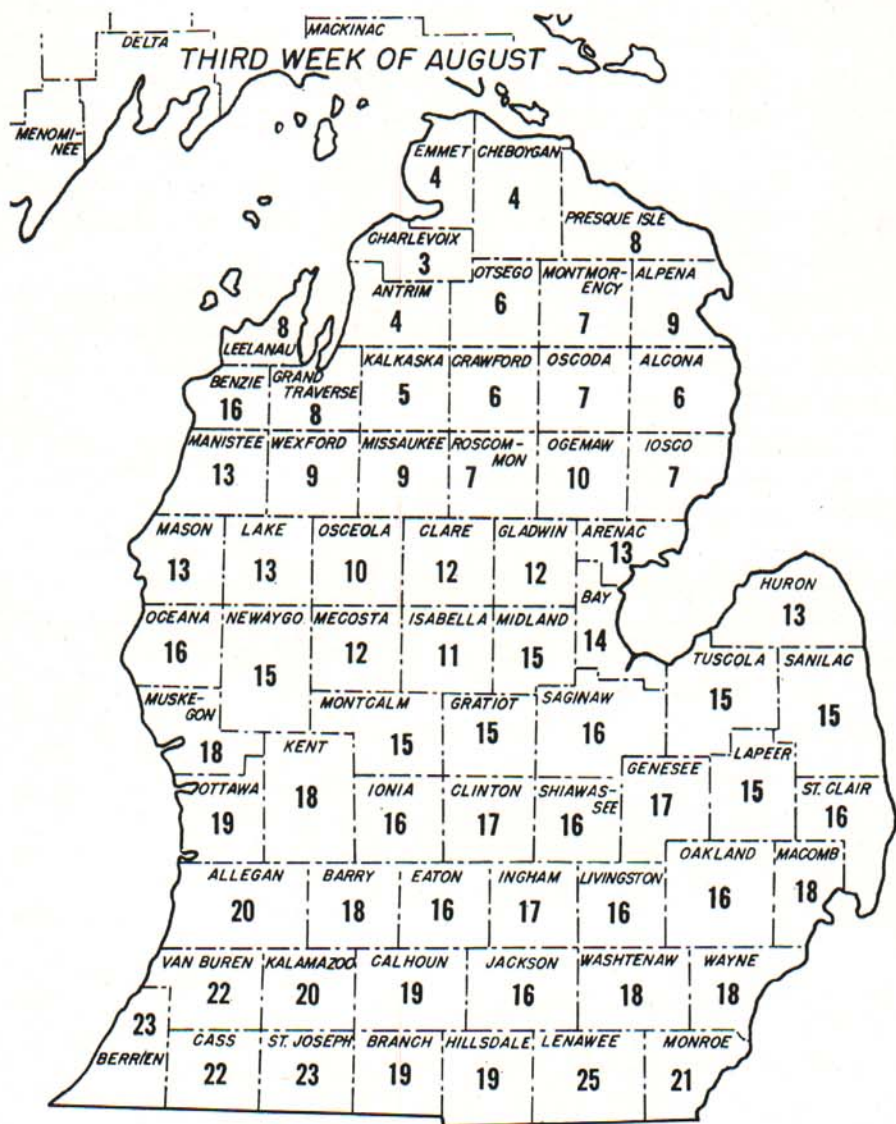


Fig. 5.—Fly-free dates for Michigan counties. The number within the county boundary is the fly-free date in September for that county. The third week of August applies to all Upper Peninsula counties.

Fertilizing

The above ground portion of the wheat plant contains 1.6 pounds of nitrogen, 0.6 pounds of $P_2 O_5$ (phosphorus), 1.2 pounds of $K_2 O$ (potassium), 0.2 pounds each of calcium and sulfur, and less than 0.1 pounds of magnesium per bushel of grain produced. These nutrients must be supplied by the soil or by commercial fertilizer. When they are not present in adequate and balanced quantities, wheat yields are limited.

SOIL TESTING

A soil test is the easiest and most scientific way of determining the kind and amount of fertilizer to use. Fertilizer recommendations based on soil tests are backed up by more than 30 years of research in the field, greenhouse, and laboratory. Modern fertilizer recommendations take into consideration:

- | | |
|------------------------------|---|
| (1) Soil test results | (4) Expected yield per acre |
| (2) Kind of crop to be grown | (5) Kind of soil in which the crop is grown |
| (3) Crop sequence | |

Whenever one or more of these points are not considered, the opportunity for efficiently producing a crop and effectively using commercial fertilizer are reduced many fold.

For additional information on soil testing and fertilizer recommendations refer to Extension Folder F-278, *How to Take Accurate Soil Samples* and Extension Bulletin E-159 (revised), *Fertilizer Recommendations for Michigan Crops*.

Wheat is one of the most responsive field crops to application of commercial fertilizer. It should never be planted without the use of some fertilizer—particularly phosphate fertilizer at planting time.

FERTILIZER PLACEMENT

The proper placement of fertilizer for wheat is one inch to the side and one inch below the seed. Most grain drills, however, place fertilizer in contact with the seed. This placement can injure the seed when large amounts are applied or when the soil is dry.

In general do not apply more than a total of 120 pounds per acre of nutrients ($N + P_2 O_5 + K_2 O$) in direct contact with the seed. For example do not apply more than 270 pounds of a 5-20-20 fertilizer. If more is needed, broadcast it before planting.

The use of complete liquid fertilizer is increasing. The same principles hold for both the liquid and dry forms. Liquid fertilizer containing phosphate should be banded at planting time. Spray applications of liquid fertilizer containing phosphate, placed on top of the soil, are frequently ineffective.

NITROGEN

The nitrogen fertilizer needs of wheat depend more on the system of management than on soil type or tests. Animal manures are relatively high in available nitrogen unless they contain large quantities of straw. A ton of manure will supply about 4 pounds of immediately available nitrogen. A number of commercial nitrogen materials are sold in Michigan. In most cases the liquid and dry forms are equally effective. Nitrogen should be purchased on the basis of (1) cost per pound of *actual* nitrogen and (2) convenience or cost of application. On cold, poorly drained soils or in cool seasons, the nitrate form may produce higher yields than other forms.

On sandy soils, loamy sands, and sandy loams, nitrogen should be applied only in spring because of leaching losses during the winter. On fine textured soils, especially those high in organic matter, fall application, in many instances, has produced as high wheat yields as spring application. Figure 6 shows the effect of nitrogen topdressing.



Fig. 6.—Effect of nitrogen topdressing on wheat. Previous crop was beans with planting time fertilizer 400 pounds per acre of 5-20-10. On the right no supplemental nitrogen; on the left 40 pounds of nitrogen applied in the spring.

TOPDRESSING WITH A COMPLETE FERTILIZER

Topdressing in the spring with a complete fertilizer is practiced in some parts of the state. Field research shows that frequently this practice does not supply enough nitrogen. Where a legume is seeded in the wheat, topdressing with a complete fertilizer sometimes stimulates the seeding so it appears to be thrifty and vigorous but this stimulation is not generally reflected in increased hay yields the following year.

MINOR ELEMENTS

Only two minor fertilizer elements are known to have increased wheat yields in Michigan. Manganese deficiency may occur on soils having a pH of 6.5 or higher, especially on soils high in organic matter, but it occurs most frequently on cold, wet soils. Such a deficiency may be corrected by applying manganese salt; or it may be prevented by using a fertilizer containing manganese. If fertilizer is banded near the seed, 5 pounds per acre of manganese usually eliminates the deficiency, whereas 10 pounds per acre is usually required if it is broadcast.

In some instances where wheat has been grown on acid peat soils, the use of copper has greatly stimulated yields. However, wheat is not so well adapted to these soils as other crops.

Weed control

Successful weed control may be obtained by the use of clean seed, crop rotation, hand hoeing and pulling, and by chemical means. Poor weed control in one or more years adds to the weed problem in future years.

Herbicides should not be applied to wheat in the fall because of damage to the young wheat plants. Where there is a legume seeding (other than sweet clover) in the wheat, use $\frac{3}{8}$ pound per acre of active ingredient of MCP amine. Where no legume seeding is involved, it is possible to obtain good control of many broadleaved annual weeds, such as mustard and pigweed, with $\frac{1}{4}$ to $\frac{1}{2}$ pound per acre of active ingredient of 2,4-D amine. Both of these herbicides should be applied in the spring when the wheat is fully tillered (6 to 8 inch height) but before the jointing stage.

Perennial weeds such as curled dock, wild onion, bindweed, and thistles are difficult to kill and are some of the most troublesome weeds.

One-half pound per acre of active ingredient of 2, 4-D ester, applied at the fully tillered stage, will give good control of these weeds with little damage to the wheat. See Extension Folder F-222, *Weed Control in Field Crops*, for current information.

Where weed infestation is slight, hand pulling, cutting, or hoeing may be profitable. One curled dock plant produces several thousand seeds so it pays to spend some time in the field to reduce future infestation. As there is no other means of controlling corn cockle and chess in wheat, these weeds must be hand-pulled.

Forage seedings

Seeding alfalfa or clover in wheat on light sandy soils or soils low in fertility is not recommended. Many farmers have had good success with seedlings on fertile, moisture retentive soils.

Red clover may be broadcast during the freezing and thawing period in the spring with good chances of obtaining a satisfactory stand. It may also be seeded later with a disk drill.

Alfalfa should be seeded in the spring with a grain drill or grass seeder equipped with disks which will allow shallow coverage of the seed. Disks should be set to cut the soil about $\frac{1}{2}$ inch deep. Plant as soon as the soil is firm enough to hold the tractor and drill.

Bromegrass or timothy should be planted in the fall along with the wheat seed.

HARVESTING AND STORAGE

When to harvest

Wheat is ready for combine harvest when the moisture content of the grain is 14 percent or less. The best time to combine is the first time the grain reaches this moisture content. Subsequent wetting and drying of the grain results in a loss of weight per bushel.

If there is a prolonged period of high moisture conditions, the kernels may mold or sprout. If grain having a moisture content of above 14 percent is combined and stored, it may heat, killing the embryo, therefore it should be dried before storing or continuously aerated with forced air to prevent heating.

Commercial grain elevators in Michigan are equipped with moisture testers for grain. Obtain a moisture test on a *representative* sample of the grain before starting to combine.

Some important steps

Adjust the combine to do a good job. In making adjustments refer to the directions in the Operators Manual furnished by the combine manufacturer.

Check the grain to avoid excessive cracking and splitting of kernels.

Check the threshed straw to be sure the machine is threshing all the wheat. Cylinder speed, concave clearance and air blast are a few of the items that need to be checked to insure a good threshing job.

Remember, a proper combine setting at 10:00 a.m. may be improper at 2:00 p.m.

Storage tips

A grain moisture content of 14 percent or less is a "must" in preventing damage to wheat by overheating, insects, or mold. Insects and micro-organisms develop rapidly in high-moisture grain. To successfully store wheat:

1. Sell all grain or keep it in a storage well-removed from new grain. Do not place new grain on top of old grain.
2. Thoroughly "house-clean" the storage. Repair all rat and mouse holes.
3. Treat walls, ceiling, and floors with methoxychlor or pyrethrum-piperonyl butoxide at least 2 weeks before storage of new grain.
4. Keep in a dry storage—check frequently.

Mix 2 pounds of 50% methoxychlor, wettable powder, to 5 gallons of water and apply at the rate of 2 gallons per 1,000 square feet with a broom, knapsack sprayer or a power sprayer. Apply pyrethrum-piperonyl butoxide according to directions of the manufacturer. Leave the storage undisturbed for 2 weeks and then sweep to remove dead insects and loose spray material.

Newly stored grain should be thoroughly ventilated for 2 weeks following harvest through open or screened doors and windows or by mechanical means. This helps to cool the grain and control insect infestation.

Grain with a moisture content of above 14 percent may be safely dried to preserve quality and allow safe storage. Details for grain drying may be found in Extension Bulletin E-316, *Drying Grain with Forced Air*.

Fumigation

Fumigation of the grain 6 weeks after harvesting will prevent insect damage. To fumigate properly, make certain the floors and sidewalls of the bins are tight, the grain level, and piled not higher than 6 inches from the top of the boards in the bins.

Use a mixture of ethylene dichloride and carbon tetrachloride; 1 gallon to each 150 bushels in small storages and 5 gallons to each 1,000 bushels of grain stored in bins with grain more than 4 feet in depth. Other fumigants and additional information on storage are given in Extension Folder F134 (Revised), *Prevent Damage to Stored Wheat*.

INSECTS AND DISEASES

Field insects

Hessian fly.—Wheat infested with Hessian fly lodges and has light-colored heads with shrunken grain. A small maggot (3/16 inch long when mature), white to greenish white, shiny, legless, with a pointed head, feeds between the stalk and the leaf sheath near the ground. The adult female fly lays eggs in newly planted wheat, from which the maggot develops. Just prior to harvest, the pupa (flaxseed) may be found by pulling back the lower leaf sheath. This is the common method of distinguishing Hessian fly damage in wheat abnormally developed at harvest.

The best means of control is to plant after the fly-free date for a given locality. This date is a period in the fall after which the adult female fly ceases to lay eggs. Weather, especially lower temperatures, is responsible for this condition. In general, the fly-free date will be earlier for the northern than for the southern part of the state. See Figure 5 on page 12 for fly-free dates for the state. Another method of control is to use resistant varieties. Plant recommended fly-resistant varieties for the class of wheat grown (red or white).

Billbugs.—Billbug infested wheat plants mature early and have short heads at harvest, or stalks may lodge. Short, white, legless, curved grubs with brown heads tunnel into the base end of the stalk leaving the tunnel packed with frass (sawdust). Wheat heads on infested plants are lighter in color than normal.

Generally, damage is not serious enough to require insecticide control. Damage is usually heaviest on sod ground, in low areas of the field, or along edges of fields. Soil drainage and keeping down grass and weeds will help control this insect.

Insecticides used to control billbugs must be applied and disked immediately into the top 4 inches of soil before planting wheat. Some effective materials are:

Aldrin.—12 pounds of 25% wettable powder, 120 pounds of 2½% dust, or 120 pounds of 2½% granular formulation per acre.

Dieldrin.—6 pounds of 50% wettable powder or 50 pounds of 5% granular formulation per acre.

Diseases

Disease takes a considerable toll from the Michigan wheat crop. Occasionally disease is prevalent enough that the crop is not worth harvesting and sometimes grain quality is low enough so that the crop cannot be marketed without dockage.

Disease may occur in the fall but more often occurs in the spring or early summer. The above-ground parts of the plants are usually affected; occasionally the roots. Some diseases affect the yield or quality of the grain while some affect both. Weather, soil conditions, cultural practices, and seed have an important bearing on the severity of infection and spread of diseases.

As a group, wheat diseases are best controlled by the use of resistant varieties. However, few varieties have resistance to any disease and none have extensive resistance. Satisfactory control of a few diseases may be obtained by using good seed, seed treatment, and crop rotation. Details regarding symptoms, methods of transmission, and control measures of the most common wheat diseases in Michigan are given in Table 3.

TABLE 3—Diseases affecting wheat in Michigan

Disease and symptoms	Methods of transmission and time of occurrence	Control measures and remarks
<p>POWDERY MILDEW—Fungus (<i>Erysiphe graminis</i>) Gray powdery-surfaced lesions scattered or completely covering the leaf blade with a yellowing, browning and gradually drying out of leaf tissue. Later, numerous round dark spots (perithecia) develop in these areas.</p>	<p>Spores are largely wind-borne from old infected plant refuse. Usually occurs in fall, sometimes in spring, during cool humid weather. Development is aggressive during the period of rapid growth and spike development of the wheat.</p>	<p>No control measures. Efforts to produce resistant varieties appear encouraging but none are available. Damage may be slight to severe and varies greatly from season to season.</p> <p>Crop rotation may be of some help. Mildew reduces both quantity and quality of the grain.</p>
<p>LEAF RUST—Fungus (<i>Puccinia rubigovora tritici</i>) Pustules of orange-red spores cover the leaves and part of the stems.</p>	<p>Wind-borne from infected plants and infected volunteer plants. May occur at any time from seedling stage to maturity. Spores move by wind from Southern to Northern United States. Infection usually shows up in late spring and early summer.</p>	<p>Control by the use of resistant varieties appears to be the most practical method. No resistant varieties recommended.</p> <p>Leaf rust reduces both yield and test weight of the grain.</p>
<p>LOOSE SMUT—Fungus (<i>Ustilago tritici</i>) A loose, dark-colored spore mass replaces the seed in the head. It is evident from heading to blossoming time of the wheat. Spores are washed and blown away by rain and air to leave the bare rachis.</p>	<p>Seed-borne within the wheat kernel. The spores are windborne and land on the wheat flowers, and at blossoming time move into the newly developing kernel. The infected kernel develops normally without showing infection. When infected kernel is planted, the spore germinates at the same time as the kernel, and replaces the grain in the new head of wheat.</p>	<p>Seed treatment fungicides are ineffective because spores are carried within the kernel. Hot water treatment is effective but not economical for large lots of seed. It is used with smaller lots of foundation seed to give partial control of the disease in the certified seed program. The most practical means of control is with resistant varieties. Varieties differ in their resistance to the different races of loose smut. See Extension Folder F-289, <i>Crop Recommendations for Michigan</i>, for latest information. Loose smut reduces yield but does not affect grain quality.</p>

TABLE 3—Continued

Disease and symptoms	Methods of transmission and time of occurrence	Control measures and remarks
<p>BUNT OR STINKING SMUT—Fungus (<i>Tilletia laevis</i>) Bunt balls replace wheat kernels in the head. Infected heads are abnormal in shape and size and are grayish green in color. The dark smut balls are easily recognized as the heads mature. They contain numerous dark spores which give off a fishy odor.</p>	<p>Usually seed-borne on the outside of wheat kernel or as smut balls in the seed. Balls and spores are spread widely during the harvest operation. Infection from soil-borne spores may occur. Actual infection of the wheat plant occurs when the newly planted seed is germinating and the new shoot is emerging from the kernel.</p>	<p>Cleaned seed from which all smut balls have been removed, plus seed treatment with an effective fungicide, are positive methods of controlling bunt. See page 10 for a list of effective fungicides. Resistant varieties are in the process of development. Michigan wheat is damaged only by the bunt fungus which affects the head. The dwarf bunt type, which causes dwarfing of the plant, has not been found in Michigan. Bunt reduces both quantity and quality of the grain.</p>
<p>TAKE-ALL—Fungus (<i>Ophiobolus graminis</i>) The base of the stem shows a brown to black discoloration when the leaf sheath is pulled back. Infected plants are easily pulled up. Small patches or large areas may be affected and contain stunted and bleached plants or single plants may be scattered throughout the field. Usually all heads of an infected plant will be light-colored.</p>	<p>Soil-borne. May occur at any time during the life of the plant but is most noticeable from heading time to maturity.</p>	<p>Crop rotation is the only known method of control. Continuous cropping of wheat may lead to serious build-up of the disease. Other crops which are known hosts and which should not precede wheat in the rotation are winter barley, rye, bromegrass, and quackgrass. To reduce infestation, grow at least 2 years of crops such as corn, oats, soybeans, and straight alfalfa or clover directly before wheat in the rotation. Take-all reduces both quantity and quality of the grain.</p>
<p>FOOT ROT OR CULM ROT—Fungus (<i>Cercospora herpotrichoides</i>) (commonly called Strawbreaker) A root rot similar to Take-All but the lower stem is not discolored. Boat-shaped lesions may be found on the base of the stem. Stems often break over before harvest.</p>	<p>Soil-borne. Usually first noticed just prior to harvest when stems begin to break over.</p>	<p>Control measures are similar to those for Take-all with crop rotation being the most effective control. A definite break of 3 years or more between wheat crops is advisable. The disease reduces both quantity and quality of the grain.</p>

TABLE 3—Concluded

Disease and symptoms	Methods of transmission and time of occurrence	Control measure and remarks
<p>SCAB—Fungus (<i>Gibberella saubinetii</i>) May occur as a seedling and/or a head blight. Blighted seedlings have light brown to reddish brown water-soaked rot and blight before or after emergence. Head infection occurs as soon as the head emerges from the boot. Entire heads or only portions of a head may be bleached or lighter colored than normal. Dead tissue has a pinkish white fungus growth on or around it. Infected grain is shriveled, white or pinkish white, and scabby in appearance.</p>	<p>Carried on the seed and in crop residues of wheat and corn. May occur before or after emergence of the seedling. Head blight is conspicuous after heading until maturity.</p>	<p>Crop rotation is effective, with some crop other than barley, corn, or wheat to precede wheat in the rotation. Clean, healthy seed, free from scab, is effective as a preventive. Seed treatment is effective in controlling seedling blight. See page 10 for suggested fungicides.</p>
<p>STEM RUST—Fungus (<i>Puccinia graminis tritici</i>) Occurs in two stages, red and black spores. Red rust stage occurs first as spores of red brick color on leaves and stems in pustules, oblong in shape, and the epidermis of leaves and stems are ruptured and pushed back around the pustule. The black spore stage shows at near maturity of the wheat.</p>	<p>In the Southern United States and Mexico the red stage of the rust organism lives over winter and moves north by wind and air current. Infection occurs in early summer in Michigan. The disease can overwinter in the North in the black spore stage on straw, infect barberry plants in the spring, and infect the wheat late in the spring. However, the main source of infection is air-borne spores from the South.</p>	<p>Barberry control has almost completely eliminated infection from spores which over-winter in Michigan. Resistant varieties are the most practical means of control, but varieties are not available now. Disease can cause serious reductions in yield and test weight. However, it usually infects wheat too late to cause serious trouble, except late maturing fields.</p>
<p>SNOW MOLD—Fungus (<i>Caionectria graminicola</i>) Fungus is recognized by the white mycelium on the leaf and crown tissues in early spring. Frequently occurs in spots with healthy plants adjoining affected plants.</p>	<p>Soil-borne. Occurs most frequently where snow covering is heavy and soil temperatures are mild. White mycelium development is abundant under moist conditions. More common in lower, poorly drained areas.</p>	<p>No special means of control. Good soil drainage may be helpful. Serious losses are infrequent.</p>

FACTS REGARDING WHEAT

Total United States wheat crop (1959-60)

Acres—52,654,000

Bushels—1,245,000,000

Michigan wheat crop (1959-60)

Acres—1,099,000

Bushels—34,915,000

Main classes of wheat produced in the United States

Hard red winter Soft red winter Durum

Hard red spring Soft white winter

Approximate seeds per pound—12,000 (varies for the Class)

Weight per bushel in pounds—60

Market requirements for No. 2 grade of soft white and soft red wheats:

Test weight per bushel —58 pounds (minimum)

Moisture —14 percent (maximum)

Total damaged kernels — 4 percent (maximum)

Foreign material — 1 percent (maximum)

Wheat of other classes — 5 percent (maximum)

Shrunken and broken kernels — 5 percent (maximum)

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