WHEAT IN MISSOURI

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WHEAT IN MISSOURI[1]

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Wheat in the diversified agriculture of Missouri shows a strong earning power in proportion to its use of land and labor. This merit is supplemented by the steady performance of the crop, by the ease with which the yield may be increased, by wheat's favorable relation to soil conservation, and by its convenience in rotations.

STEADY YIELDS

Annual changes in wheat acreage usually are caused by wheat prices, though occasionally the failure of another crop, such as corn, leaves more land for fall-sown grains. The performance—acre yield—of the wheat plant itself, however, is very steady. Thus in its first 75-year statistical history, 1866-1940, Missouri wheat shows an average deviation of 13.5 per cent from the average yield of 13.4 bushels per acre. Oats and corn, by contrast, show average deviations over the same period of 17.7 per cent and 16.6 per cent, respectively. These differences covering such a long time are significant.

Because of these facts, and in view of the uncertain yields of grasses and many legumes, wheat stands out among Missouri crops for consistent returns.

The explanation of this superior stability of wheat is found in a comparison of the adversities met by corn, wheat and oats, and of the cultural treatments received by the three crops. The general decline in soil fertility has affected all of them, especially in the last two or three decades, when wastage by erosion has been accelerated. Corn, however, has suffered more than the others because it requires higher fertility and therefore was the first to be limited in growth by a steadily diminishing supply of soil nutrients. Oats also make a substantial draft upon the soil, and yields have been reduced by soil

[1]This is a revision of Missouri Agricultural Experiment Station Bulletin 398, "Wheat in Missouri" by W. C. Etheridge, C. A. Helm, B. M. King and J. M. Poehlman.

[2]Acknowledgment is here made to R. E. Langford, Instructor in Field Crops, and to Lloyd E. Cavanah and Wm. P. Sappenfield, Assistant Instructors in Field Crops, for assistance in conducting wheat yield tests at Sikeston, Elsberry, and Lathrop, respectively; to Arnold W. Klemme, Extension Professor of Soils. for the data used in Table 2; and to E. M. Brown and C. A. Helm, Professors of Field Crops, for the data used in Table 3.

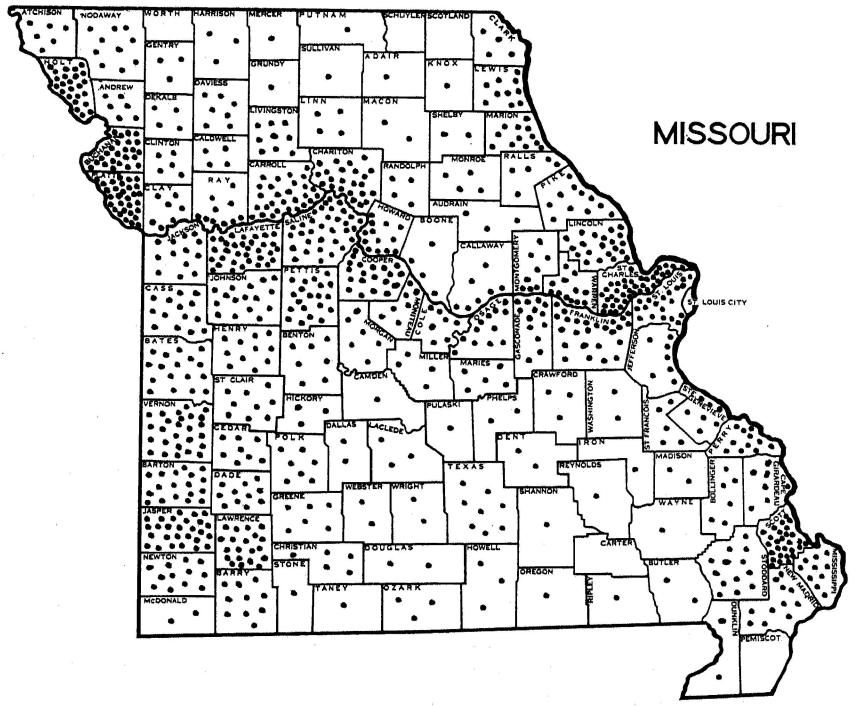

Fig. 1.—Distribution of the wheat acreages in Missouri. (Each dot represents 1,000 acres.) Wheat production in Missouri is concentrated along the rivers and on the level prairies of southwest Missouri. The average harvested acreage for the 10 year period, 1940-49, was 1,344,000 acres according to reports of the U. S. Department of Agriculture.

depletion but not so much as those of corn. On account of the exceedingly high water requirement of the oats plant, the nature of the season rather than the degree of fertility is the dominant factor in oats yields. Most Missouri oats are sown after corn in the crop rotation. In that position they are grown on land already strained by last year's corn crop, and in the haste to fill with oats a large part of the acreage left by corn, they are often planted on a seedbed poorly prepared.

Wheat, though actively responding to fertility, has been less affected than corn or oats by soil decline. There are two reasons for this difference. (1) In the past wheat has been extensively fertilized, whereas corn and oats, until recently, seldom received such treatment. (2) A better seedbed usually was prepared for wheat than for corn or oats. These benefits have mainly offset the effect of soil depletion on wheat yields.

Losses in yield from unfavorable weather are greater and more frequent in corn and oats than in wheat. Winter-killing takes a toll,

but hardy varieties like Clarkan and Vigo have reduced this loss to the extent that it is usually less than dry weather injury to corn in a normal summer, and rarely equals on a wide scale the devastation by intense drought. Nor do winter losses in wheat usually equal the effects of spring drouth and early summer heat upon the oats crop.

YIELDS EASILY INCREASED

In addition to its steadiness against unfavorable conditions, wheat is highly responsive to the means by which yields are increased. This fact is the basis of good returns from efficient practices.

Fertilizers invariably stimulate the growth of wheat and increase its production on Missouri uplands. Even on the more fertile bottomland soils fertilizers have greatly improved wheat yields. (See page 20.) Use of a mineral fertilizer containing phosphorus, or phosphorus and potassium, or, on most soils which require a balanced treatment, a complete fertilizer containing nitrogen in addition, will hasten the early growth, reduce winter injury, and aid the plant in recovery from devastating attacks of ever present root rotting fungi.

A well prepared, firm seedbed increases the rate at which the soil nutrients are made available to the plants, provides for the maximum contact between the young roots and the soil particles, and is

Fig. 2.—Among the major crops in Missouri, wheat is the safest and most responsive in which to invest money, labor, and skill for increased yields per acre.

favorable to root extension and the protection of the roots against various injuries from winter. Thus by excellent preparation of the soil itself a benefit similar to that from fertilizer—increased nutrition of the plant—is gained. However, the two practices—suitable preparation of the soil and the application of fertilizer—are not competitive but are supplementary, each raising the efficiency of the other.

A superior variety, suited to local conditions, is likely to yield several bushels more than an ordinary variety. Such a gain is made at little or no added cost, as there is not much difference between the cost of one lot of sound seed wheat and another.

Finally, in order to save the results of other good practices, a wheat crop must be protected from insects and diseases. Most of the injury by Hessian fly can be prevented. Injury by the chinch bug can be lessened. Preventive measures for stinking smut and scab are simple and effective. The control of loose smut, though difficult, is practical on a small scale. Damage by loose smut and rust may be escaped by the increasing use of smut and rust resistant varieties.

The foregoing measures—fertilizer treatments, good seedbed, productive variety, control of insects and diseases—are the principal means of improving the yield of wheat. Their details will be discussed later in this bulletin. They are briefly mentioned at this point for early emphasis of the important fact that *among the major crops grown in Missouri wheat is the safest and most responsive in which to invest money and labor and skill for increased yield per acre.*

RELATION OF WHEAT TO SOIL CONSERVATION

An area usually approximating 1½ to 2 million acres a year is covered by wheat from early fall through early summer, on 90 thousand to 100 thousand Missouri farms. Although this wheat acreage is distributed over the entire state, much of it is found on river hills and rolling prairies, where erosion control is greatly needed. Compared on equal areas, wheat is less effective than barley or rye in soil protection; aside from being planted later, its fall growth is not as rapid as theirs nor its winter turf as dense. But wheat is produced on a scale much broader than the combined acreage of the two other fall grains, and therefore it must be rated in practical terms as our most serviceable crop for saving the soil on the cultivated acreages through the whole period October to July.

Where wheat is the single crop of the year the loss by erosion is likely to be about half that which occurs where only corn is grown; but where wheat and a following growth of clover or lespedeza provide cover the year round, the probable erosion loss is only about

Fig. 3.—The wheat crop, from the view of its efficiency as a soil cover, its introduction of fertilizer into the soil, and its service to legumes and grasses is a highly important aid to soil conservation in Missouri.

one-tenth as large as that from the single-crop ground.* Perhaps as much as 90 per cent of the upland wheat acreage of Missouri receives a spring seeding of clover, or clover and grass, or lespedeza. Indirectly then wheat increases the acreage of these plants, themselves essential means of soil conservation.

Missouri wheat seeding annually carries into the soil many thousand tons of commercial fertilizer. The obvious result from its use has been a profitable increase in the yield of wheat. But beyond that, the annual addition of this great quantity of nutritive material to the soil has effectively aided soil conservation. For it has supplemented and helped to maintain the natural fertility of the soil, has increased the efficiency of wheat as a cover crop, and has stimulated —in many cases insured—the successful growth of the legumes and grasses sown in the wheat. Furthermore this fertilizer it not used on the same fields every year, but moves from field to field, as the wheat crop rotates through the cultivated land.

*Miller, M. F., "Cropping Systems in Relation to Erosion Control." Missouri Agricultural Experiment Station Bulletin 366.

The wheat crop, from the view of its efficiency as a soil cover, its introduction of fertilizer into the soil, and its service to legumes and grasses, is rightly appraised as a highly important practical means of soil conservation in Missouri.

VARIETIES FOR MISSOURI

The wheat crop is represented by many varietal forms. Over 450 varieties have been described* in this country in addition to the many thousand growing in foreign lands. These differ in the *visible features* by which crop varieties are identified as well as *unseen qualities* which can only be measured by plant performance. Some visible features widely associated with a variety have little relation

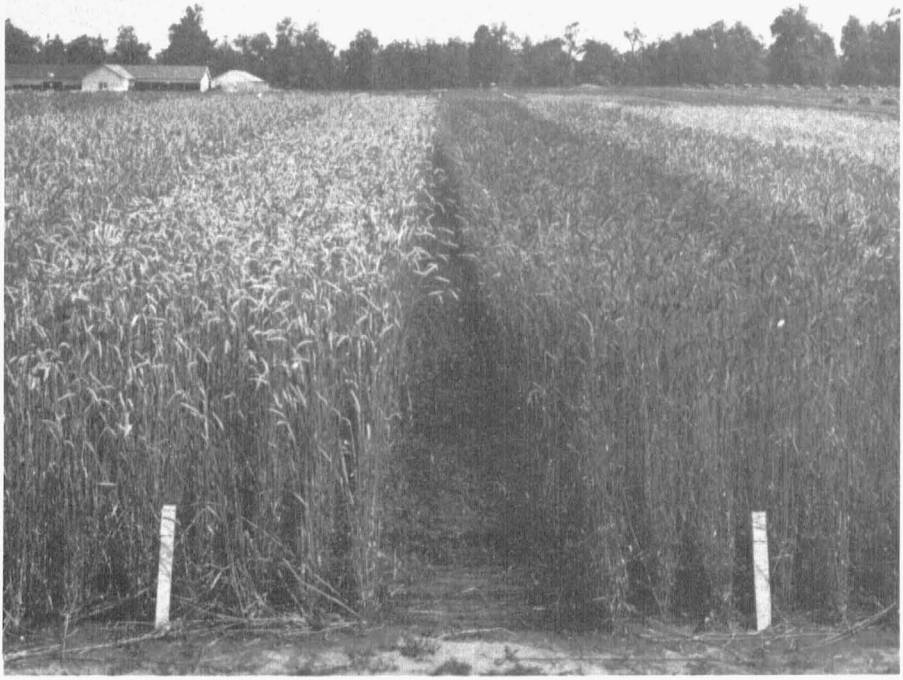

Fig. 4.—Many varieties of wheat are tested on the Experiment Station fields at Columbia. Vigo (left) and Clarkan, two leading soft wheat varieties, are being grown here in comparison with other varieties and new experimental strains.

*J. Allen Clark and B. B. Bayles, "Classification of wheat varieties grown in the United States in 1939." U. S. Dept. of Agriculture Technical Bulletin 795.

to performance and are useful only as a means of distinguishing one variety from another. Color of chaff and straw and presence or absence of awns are examples, although the relation of the latter to yield in soft wheats may still be questioned. Other visible features by which varieties differ are closely associated with performance. Examples are *maturity, winter hardiness, stiffness of straw, disease and insect resistance,* and *quality.* These latter features, together with the unseen qualities that influence vigor of growth and yield, are inherent in the variety itself. They determine the comparative performance and usefulness of a variety to the farmer. Thus the choice of a variety should be based upon its performance; measured by carefully conducted experimental yield trials and demonstrated through extensive use of the variety in the farmers' fields.

The Missouri Agricultural Experiment Station began testing wheat varieties as one of its earlier functions. Results were first published as an Experiment Station Bulletin in 1891.* Since that time many thousand strains and varieties have been compared for yield. Successively the high yields of Fultz, Fulcaster, Harvest Queen, Michigan Wonder, and Clarkan have been demonstrated and these in turn became leading varieties in Missouri. An early maturing variety, Early Premium, was developed and its high milling quality and usefulness as a companion crop with legumes demonstrated. With the increased emphasis on quality in marketing soft wheat, a wheat quality testing laboratory has been established in cooperation with the Department of Home Economics to aid in testing new improved strains for their milling and baking qualities.

These tests of wheat varieties, covering a 60-year period, have emphasized three qualities, above all others, necessary in a wheat variety if it is to be adapted and productive of high quality grain in Missouri's climate and soil. These qualities are: (1) Varieties need to be early to escape unfavorable heat and drought, and late attacks of rust. Early varieties also fit excellently into our cropping systems where wheat is used as a companion crop with lespedeza or clover, or where wheat is followed by a crop of soybeans. (2) Winter hardiness is necessary to enable a variety to escape severe winter injury either by extreme cold or by heaving. Both types of killing regularly cause damage to the Missouri wheat crop. (3) Long experience has demonstrated that in Missouri only soft wheat varieties with satisfactory grain characteristics can produce a quality of product that will consistently meet the present-day market standards for good

*H. J. Waters, "Wheat, Test of Varieties 1889-91." Missouri Agricultural Experiment Station Bulletin 15, 1891.

milling wheat. In addition, there is now recognized the need for varieties that will stand for the combine without lodging or shattering. And the increasing presence of disease and insect pests make it desirable that varieties be resistant to their ravishing attacks.

None of the present day varieties possesses all of these qualities. Neither is there a single variety that will be superior in yield and quality in Missouri in every season. So the search for new varieties goes on as a continuing process. And varieties recommended now may be supplanted by new ones two or three years hence.

TABLE 1--PERFORMANCE OF WHEAT VARIETIES IN COMBINE-HARVESTED TESTS IN MISSOURI IN 1948 AND 1949.*

Variety	Average Yield bu./acre	Test Weight lbs./bu.	Average Height inches	Strength of straw	Reaction to		Quality
					Leaf Rust	Loose Smut	
Soft wheat varieties							
Vigo	26.0	57.4	47	Strong	Resistant	Resistant	Excellent
Clarkan	25.5	58.5	46	Strong	Susceptible	Susceptible	Good
Royal	26.7	56.8	46	Weak-	Susceptible	Susceptible	Good
Fulcaster	23.3	57.7	46	Very Weak	Susceptible	Slightly Resistant	Good
Coker's Redhart**				Medium Strong	Susceptible	Susceptible	Good
Hard wheat varieties							
Pawnee	28.5	58.3	39	Medium Strong	Slightly Resistant	Resistant	Poor***
Triumph	26.4	58.8	34	Weak	Susceptible	Susceptible	Poor***

* Averages from 8 tests grown at four locations (Columbia, Lathrop, Elsberry, and Sikeston in each 1948 and 1949).

** Coker's Redhart was grown only at the Sikeston station where over a three year period (1947-1949) it yielded 18.9 bushels as compared to 22.2 bushels for Clarkan and 22.4 bushels for Vigo.

*** Pawnee and Triumph have good hard wheat quality when grown in areas where they develop high protein. Under Missouri conditions they are inferior both in hard and soft wheat qualities.

Soft wheat varieties currently recommended are Vigo, Clarkan, and Royal. Among the older soft wheat varieties, only Fulcaster still merits consideration. A hard wheat variety, Pawnee, early, with short straw and ability to produce a high yield, has become a leading variety in some areas of Missouri. Other varieties described here are Triumph and Coker Redhart. The latter is a soft wheat of special interest only in Southeast Missouri. Their comparative performance is shown in Table 1.

Superior soft wheat varieties:

Vigo.—Beardless, white chaff and straw, long heads, similar to Clarkan in height and maturity, stiff straw, does not hold the grain as tightly as Clarkan, moderate resistance to loose smut and leaf rust, excellent soft wheat quality. This is a new high-yielding variety developed in Indiana that is becoming popular in Missouri.

Clarkan.—Beardless, white chaff and straw, tall, tends to be late, stiff straw, stands well for the combine without shattering, high test weight, susceptible to loose smut and leaf rust, good soft wheat quality. This has been the leading variety in acreage in Missouri.

Royal.—Bearded, white chaff, high yields, straw not so stiff as that of Clarkan or Vigo, high test weight, susceptible to rusts and to smut, acceptable milling quality. This is a new high yielding variety developed in Illinois, and may be recommended along with Vigo and Clarkan in Missouri.

Other soft wheat varieties:

Fulcaster.—Bearded, white chaff, purple straw, tall, stems weak and inclined to lodge, shatters if harvesting is delayed, good milling quality. This is the best of the old soft wheat varieties but is not satisfactory for combine harvesting.

Coker Redhart.—Beardless, white chaff, early, acceptable milling quality, grown on a limited acreage in Southeast Missouri but not recommended as it is less winter hardy and less productive than Vigo, Clarkan, or Royal.

Hard wheat varieties:

Pawnee.—Bearded, white chaff, short, early, stools heavily, medium stiff straw, will shatter if combining is delayed, resistant to loose smut, slight resistance to rust and Hessian fly. This is one of the highest yielding varieties of winter wheat and is popular with farmers in West and Central Missouri.

Triumph.—Bearded, white chaff, short, very early, does not stand as well as Pawnee, susceptible to rusts and smut, less productive than Pawnee.

Quality in Missouri Wheat

The importance of quality in Missouri wheat has been emphasized. In discussing quality we must consider it, first, from the standpoint of the farmers who grow the wheat, and second, from the standpoint of the millers and bakers who use the wheat in the manufacture of flour and baked products. We shall designate these as (1) *market quality,* and (2) *milling and baking quality.* For a better understanding of market quality a brief view of the grading system is desirable.

All wheat grown in the United States is grouped for commercial purposes into seven qualitative classes.* Most of the wheat grown in

*Handbook of Official Grain Standards of the United States, issued by the Grain Branch, Production and Marketing Administration, U. S. Department of Agriculture, gives full information on the classes, subclasses and grades of wheat in the United States.

Missouri is classed as Soft Red Winter and the remainder as Hard Red Winter, depending upon the variety grown. A class of wheat is next divided into subclasses and finally into grades. Soft red winter wheat has only two subclasses, Red Winter and Western Red; the latter is not found in the Missouri crop.

In each class of wheat there are five numbered grades, 1 to 5, the first representing wheat of the highest quality in the class, and the others in numerical order from No. 1 ranging downward in both quality and price. Each class contains also a sample grade, inferior to the lowest numbered grade. The presence in the grain of weevils, garlic, smut balls, ergot, too much moisture, or evidence of an objectionable treatment, causes the addition of a depreciative word to the grade designation. Thus a load of wheat might be graded and described as No. 3 Soft Red Winter, garlicky.

The factors (qualities) which determine the grades of wheat are weight per bushel, moisture content, damaged kernels, wheat of other classes, and all foreign material—any substance that is not wheat itself—contained in the lot of grain. Accordingly the meaning of market quality in wheat is apparent. It is *heavy, dry, sound grain, pure in class, and free from all foreign material.*

How can the Missouri wheat grower, one year with another, secure high *market quality* in his crop and thereby promote profitable returns? The factors of quality, as shown, are simple. All of them are compatible with the grower's natural desire for high yields. Actually the conditions which produce high yields also produce high quality.

Fertile land or the use of fertilizers to supplement natural soil fertility, is perhaps the first condition for good yields of well filled, heavy grain. Next a pure, productive variety, adapted to the locality, will make the best use of good soil. Thorough preparation of the seedbed will increase the availability of the soil properties and aid the plant in utilizing them. Seed that is naturally clean and healthy or seed that has been fanned and then treated for smut, will further contribute to both yield and quality. The control of insects will prevent losses in yield and quality, and thus will protect the gains made by productive factors. Finally, the ripe crop must be harvested without damage by unfavorable weather and stored without damage from mold or insects. With the use of the combine for harvesting wheat there are greater hazards from bleaching, weather damage, and loss in bushel weight and good storage is more difficult.

Milling and baking quality in wheat is determined by the performance of the wheat in the mill and during the baking procedures. These are measured by the granularity of the flour, its protein content,

chemical and physical properties of the dough which measure the gluten strength, and finally by the quality of the baked product. These, with the execption of protein content, are inherent in the variety.

Soft wheat varieties possess qualities in their gluten* that make them most suitable for milling into cake and pastry flours, while hard wheat varieties are better suited for making bread. But in turn a soft wheat variety may possess individual characteristics which make it undesirable to the milling trade. For example, the Kawvale variety, formerly grown in some areas of Missouri and marketed as a soft wheat, was found undesirable for making cake and pastry products. This was because it produced a flour that was granular and possessed gluten properties similar to those found in hard wheat varieties. This resulted in Kawvale being discounted below the price paid for satisfactory soft wheat of an equal market grade.

Growing the right variety of soft wheat is the most important step by which Missouri farmers can assure continued production of wheat high in milling and baking quality.

Soft Vs. Hard Wheat for Missouri

By soft wheats here are meant those varieties that are marketed under the classification "Soft Red Winter." By hard wheats are meant those varieties that are marketed under the classification "Hard Red Winter." This distinction is pointed out since the term soft wheat is sometimes used incorrectly with reference to all low protein wheat, and hard wheat with reference to all high protein wheat. Such usage of the terms "hard" and "soft" wheat has come about since most of the wheat grown in the Southern Great Plains area, a region which because of its climatic and soil conditions produces high protein wheat, is planted to hard wheat varieties, while soft wheat varieties are grown almost exclusively in the Eastern United States, a region whose climate and soil results in the production of low protein wheat.

Soft wheats differ from hard wheats primarily in their gluten characteristics. This may be easily observed by chewing a small handful of each. The soft wheat disintegrates rapidly when chewed, whereas the hard wheat is gritty and forms a rubbery wad which remains longer in the mouth in that form. These differences are carried over into the flour, adapting soft wheats to making cakes and pastries, and hard wheats for making light bread.

There are other differences between hard and soft wheat varieties. Most hard wheats are early, short, and have narrow leaves—char-

*Gluten refers to the proteins, peculiar only to wheat and to a less extent in rye, that makes possible the production of a risen loaf of bread.

acteristics associated with their adaptation to the dry Great Plains area. Soft wheats are generally taller, stiffer strawed, and wider leafed—characteristics associated with their adaptation in the more humid eastern states. In addition, the hard wheats have a hardiness which enables them to better withstand the dry cold of the plains states, while soft wheat varieties survive with less loss from heaving, a type of winterkilling more common in areas of higher rainfall.

Over a period of many years soft wheat varieties have been more productive than hard wheat varieties in Missouri, although hard wheats have been superior in occasional years, especially in northwest Missouri where the soft wheats have suffered more from winter killing. When hard and soft wheats sell at the same price per bushel, as they have in some parts of Missouri in recent years, due to the influence of the export trade on market price, there is an advantage to the farmer to grow the variety that will produce the greatest number of bushels per acre whether hard or soft. This is also true if the farmer is feeding his wheat, as there is no significant difference in the feeding value in hard and soft wheat varieties grown on the same farm. More recently, with the development of the high yielding Pawnee, there has been an increase in acreage of the hard class of wheat in Missouri.

It has long been known that hard wheat varieties grown in Missouri will produce wheat inferior for milling bread flours, because wheat grown in this climatic region will be low in protein. Also, hard wheat varieties, whether low or high in protein, make inferior cake flour because of the strong gluten, a characteristic inherent in hard wheat varieties. On the other hand, low protein is desirable for cake flour, and Missouri grown soft wheat has always produced superior flour for making cake and pastry products.

With the development of higher yielding soft wheat varieties there will no doubt be a return of this type to Missouri. Such a trend is desirable as it will again enable Missouri farmers to obtain the highest current market price through the marketing of a superior product—a goal they cannot reach while marketing hard wheats of inferior quality.

GOOD SEED WHEAT

The physical properties of good seed wheat coincide precisely with those of high quality market grain. To these are added freedom from disease and the power of high germination. The desired qualities of the variety—productivity, purity, adaptation—complete the requirements. Briefly then good seed wheat is heavy, clean, high in germination, free from disease, productive, pure, and adapted to local conditions.

It is a sound practice for growers to produce and maintain their own seed supply. Seed meeting the above requirements may easily be grown if good management practices are followed in the production of the wheat crop. Selection of the proper variety is necessary to insure having wheat that is inherently adapted and capable of producing highest yields. Purity of variety can be maintained if precautions are taken to grow seed wheat only on land where no volunteer wheat of another variety will be present and to clean thoroughly all machinery or bins in which the seed is handled or stored. Custom combines which move freely from farm to farm are a common source of variety mixtures.

Weeds common to the wheat crop are wild onion or garlic, cheat and cockle. Since these are difficult to remove with ordinary cleaning equipment, care should be taken to use pure seed harvested from fields free of these pests. Likewise a field which contains volunteer rye should not be used for seed production since presence of rye lowers the market value of wheat.

To insure high germination, seed wheat should be stored with a low moisture content in a cool, dry place. Combined wheat which contains above 14 per cent moisture should be dried before storing in tight bins. In recent years there has been an increase in the number of insects which attack grain in storage. These should be controlled by sanitation and fumigation. For sanitation sweep the bin carefully and spray or dust the bin and sacks containing the seed thoroughly with DDT before storing seed. With proper precautions for control of insects and rodents, seed wheat stored in a cool, dry place may be safely kept from 1 to 3 years without appreciable loss in power of germination.

Heavy fanning of seed will remove light, broken, cracked, shriveled and diseased seed as well as impurities. Treatment with New Improved Ceresan will aid in control of bunt (stinking smut) and other surface fungi.

It is a common belief that wheat grown on the same farm a few years "runs out" and that new seed should be obtained. This is without doubt a mistaken idea. If the wheat has been kept pure of variety and free from weeds and disease, there is no evidence to support the belief that a change of seed will increase yields. One needs only to remember that the grower, from whom he is purchasing new seed, has used the practices described above for the maintenance of his seed supply.

Good seed wheat is easy to obtain, so if the grower suspects that his variety is not the best available, or if his wheat has become full of

weeds, rye, or smut, it would then be advisable to buy new seed. Official recommendation of a good variety for any local condition and of a reliable source of the seed, may be learned from the local County Extension Agent or by writing the Missouri Agricultural Experiment Station, Columbia, Missouri. A variety that is giving good yields and can be kept pure, healthy and free from weed seed need not be changed.

SEEDBED FOR WHEAT

A good seedbed is closely related to high yield in wheat. It is necessary for vigorous fall growth by which the crop is quickly established and strengthened against cold weather, and its good effect lasts in some degree until growth has ceased at maturity. The general methods of preparing the wheat seedbed are (1) plowing and fitting the land after oats, wheat, or barley, and (2) disking or otherwise fitting the land after soybeans, lespedeza or corn.

Wheat After a Small Grain Crop

The quality of the seedbed here produced ranges from excellent to poor, depending upon the time of preparation and the nature of the season. Land may be plowed for wheat as early in the summer as permitted by the removal of the previous grain crop and by the conditions of labor and the weather. Later it should be occasionally disked to keep down the weeds. These treatments produce a seedbed compact in the bottom, clean and pulverized on top.

Altogether the most productive seedbed for wheat can be made in this way, provided the plowing is done in July or early August and the land is later properly summer-tilled. But this method is unsafe on land which is subjected to serious summer erosion, for the soil losses it might cause there could over-balance the benefits.

This succession of crops also overlooks the opportunity for growing a legume crop—lespedeza or soybeans—in the interval between the summer grain harvest and the fall planting of wheat. While wheat yields may be slightly reduced by the latter practice, as compared to early plowing and summer fallowing, this reduction is more than offset by (1) the increased total production from the lespedeza or soybeans, (2) the economy in seedbed preparation for the wheat since only disking will be necessary, and (3) the reduction in soil erosion.

Wheat after Soybeans

It is a common practice in Missouri to plant wheat after soybeans that have been combined for seed. Here, two practical considerations are evident. *First,* where wheat is sown on soybean ground, without plowing or heavy tillage, the cost of producing the crop is materially

reduced. *Second,* soybeans should be followed by wheat or some other fall grain as a means of controlling soil erosion.

A soybean crop naturally leaves the soil loose and mellow, and as a rule little preparation of the soybean ground is needed to prepare a seedbed for wheat. When tillage is desirable it may best be performed with a disk. Wheat seeded after soybeans have been combined for seed will generally return a slightly smaller yield than wheat seeded on ground plowed and thoroughly tilled. This results from two factors. (1) The wheat generally is seeded at a later date. (2) The seed crop of soybeans, because it grows late, temporarily reduces until a late period the available soil nutrients and soil moisture, and so the wheat which follows may lose some yield by that cause, especially if the fall weather is dry.

Wheat After Lespedeza

Lespedeza sod, thoroughly disked and harrowed, is a good seedbed for wheat. Some special practices, however, are necessary in preparing the lespedeza ground for this purpose. *First,* the lespedeza seed must be ripe or nearly ripe when the sod is disked. If the seed is

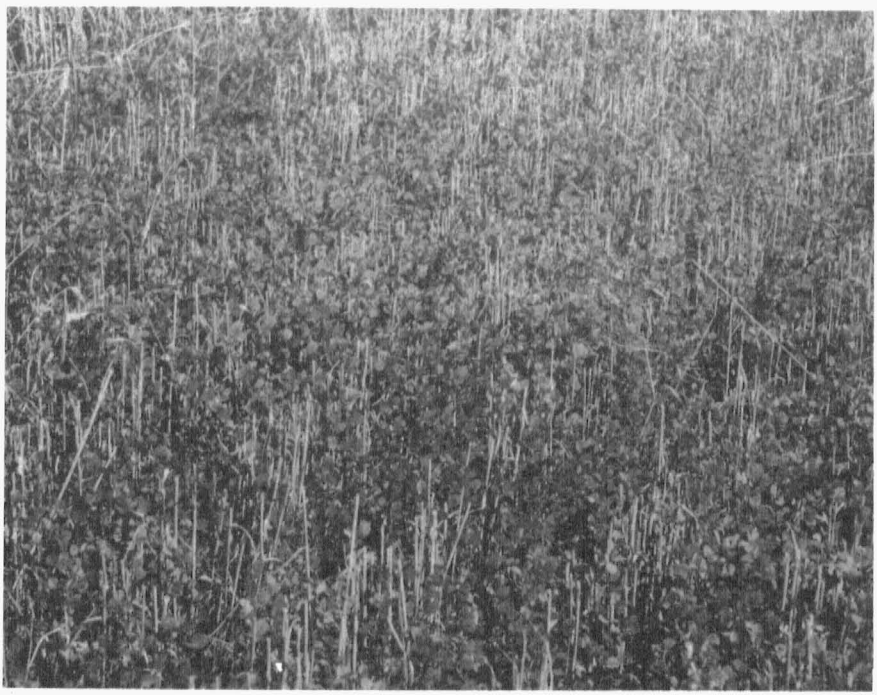

Fig. 5.—A good stand of lespedeza coming up in wheat stubble. After being grazed through midsummer, a good seedbed can be prepared for wheat by disking or with the field cultivator. The lespedeza will reseed itself in this succession of crops.

still green at that time, not enough may germinate next spring to renew the stand. *Second,* the lespedeza must have been grazed out or cut close, so that very little of the season's growth will be left. For if the usual dense lespedeza cover, 6 to 8 inches deep, is still on the ground. The preparation of a good seedbed by disking or by any other operation less than plowing, will be difficult and impractical. *Third,* if the sod is very dry and hard, a weighted and sharpened disk will be required for the job. If these three conditions are observed there will be no great difficulty in handling the sod, and a good seedbed at low cost may be formed.

The use of a field cultivator eliminates most of the difficulties frequently met in using the ordinary disk harrow. On stony land this implement is superior under all conditions. Elsewhere it is at least equal to the disk harrow. It can work the ground as shallow or as deep as desired, even where considerable vegetative growth has been left on the ground. Under normal conditions of moisture or where the soil is only slightly dry, the sweeps on the field cultivator will evenly pulverize the surface. Under such conditions the ground would need to be worked twice if shovels are used. However, where there is a lot of old growth on the land, or where the land is stony, or where it is extremely hard and dry, the shovels instead of the sweeps are necessary.

Where wheat is grown in a continuous rotation with lespedeza, an occasional plowing will be necessary to break up the sod and to destroy weeds that become established and are not killed by disking or field cultivation.

If large wheat yields are important to the grower, the lespedeza may be grazed out or cut for hay by early August. It is then possible to plow and prepare a seedbed as described for wheat after small grain. Since the lespedeza does not reseed it may be sowed during late winter at a 40 pound rate.

Wheat After Corn

The use of the corn picker, by speeding up the corn harvest, has made it possible to greatly increase the planting of wheat after corn. Prior to the mechanization of the corn harvest, it was necessary to cut and remove the corn crop or to plant wheat in the standing corn. Both operations were costly and difficult to perform. As with wheat after the soybean crop, soil erosion is reduced by this crop succession.

A variety of corn that will mature early is an aid to the timely sowing of wheat. Clean and level cultivation of the corn crop during the season leaves the land ready for easy disking after the corn has been harvested. The disking should be thorough, though not neces-

sarily deep, to make the soil fully receptive to the seed wheat. The physical condition of such a seedbed is usually as good as that prepared by the expensive method of early plowing and summer tillage, but the soil is temporarily reduced in readily available fertility, because it has just grown a corn crop. This deficiency increases the need for a heavy fertilizer treatment with the wheat.

Where wheat follows corn too frequently, the soil may become extensively infected by a disease which causes rots in corn and scab in wheat. Neither is this succession of wheat after corn desirable where the European corn borer is present as it leaves the corn stalks on the surface of the soil. Danger from corn borer is decreased where the corn is cut and ensiled.

DATE, RATE AND MANNER OF SEEDING

The date of seeding wheat will be influenced by the previous crop, seasonal conditions affecting the operations necessary for preparation of the seedbed, and the need for waiting until after the fly-free date.

Wheat grown in succession with other grain crops, where the ground has been plowed early, is ready for planting when soil and seasonal conditions permit. But it is always advisable to wait until after the fly-free date to prevent damage and loss by this insect pest. (See map on page 27.) This delay in seeding is imperative if surveys have shown a large carry over of fly from the preceding crop. In a date of seeding test at Columbia over an 8-year period (1931-1939), yields of wheat seeded one week before the fly-free date averagd 1.2 bushels below the yields of wheat seeded 1 to 4 days after the fly-free date. When there was no fly present, the early seeded wheat exceeded the yield of that seeded after the fly-free date by an average of 1.3 bushels. But when fly was present, the late wheats exceeded the early wheat by 9.9 bushels per acre.

Wheat seeded after harvesting soybeans or corn, or after lespedeza has matured seed, will generally go in after the fly-free date. Here the date of seeding will be determined by the influence of the season in ripening early the crop of soybeans and corn and the speed with which the seedbed can be prepared and the wheat drilled after harvesting the soybeans or corn. The quick turn from soybeans or corn to wheat has only been made possible by the mechanization of these two operations—combining the soybeans or picking the corn and the subsequent disking for wheat. Use of early maturing varieties of soybeans or corn moves forward the harvesting operation and increases the margin of safety for this succession of crops. This is especially necessary in northern Missouri where the fall is shortest. In southern Missouri wheat after these crops is a safer and more

successful procedure since the harvest season is longer and wheat may be profitably seeded at a later date.

The rate of seeding wheat varies in practice from 4 to 6 pecks, but 5 pecks is the generally accepted rate. Wheat seeded late might well be increased to the 6 peck rate since there will be less opportunity for stooling before cold weather. Late planted and thinly planted wheat are subject to greater winter injury, especially heaving.

Wheat is best seeded with a grain drill to insure planting the seed at a uniform rate and depth. With the greatly increased need and use of fertilizers with all small grains, a fertilizer attachment is an essential part of any grain drill.

FERTILIZERS FOR WHEAT

On all Missouri soils the sound use of fertilizer is an essential practice in the production of a profitable wheat crop. No other farm practice will pay better financial return, dollar for dollar invested. The wheat farmer of today who does not employ the power of fertilizer is losing an important aid for increasing the yield of the wheat crop. This has been discussed on page 5.

Recommendations by the Department of Soils, Missouri College of Agriculture, for the use of fertilizer in wheat production are based upon two general practices: (1) the use of a complete or mineral fertilizer applied with a fertilizer drill in the fall at the time the wheat is seeded, and (2) top-dressing of wheat in early spring with a nitrogen fertilizer.

Application of a complete or mineral fertilizer with a fertilizer drill, when the wheat is being seeded has long been a recommended practice on almost all soils in Missouri. Its use and the benefits derived through increased yields are recognized by all good wheat growers. Fertilizer applied at this stage speeds the early growth of the plant, promotes development of a vigorous root system, and reduces loss from winter killing and disease. Its effects carry over into the following spring stimulating early growth and finally results in increased harvest of grain. The effects of heavy applications of mineral fertilizer at this stage are not only beneficial to the wheat, but they increase the early growth and safety of the legume seeded therein.

The amount and kind of fertilizer applied here should vary with the amounts of nutrient elements that the soil will supply to the wheat plant. For example, a 30 bushel wheat crop will remove from the soil, on the average, 63 pounds of nitrogen, 22 pounds of phosphorus (P_2O_5) and 34 pounds of potassium (K_2O). Generally speaking, the fertilizer should supply the difference between what the soil can deliver

Unfertilized **Fertilized**

Fig. 6.—The sound use of fertilizer is an essential practice for the production of a wheat crop in Missouri. Use of a mineral fertilizer in the fall at time of planting, and top-dressing with a nitrogen fertilizer in the spring, are important aids to the farmer in increasing the returns from his soil and labor.

and the amount removed by a satisfactory harvest of wheat. Where a soil testing laboratory is not readily available so that soil may be analyzed from individual fields and specific recommendations made for fertilizing wheat, the following are good general rules to follow: (1) Use a complete* fertilizer in amounts of 200-300 pounds per acre on land low in organic matter, or if seeded late following lespedeza or corn on a trashy and poorly prepared seedbed. (2) Use only phosphate or phosphate and potash in similar amounts on fertile land, where legumes have been grown regularly and the organic matter has been kept at a high level.

*"Complete" fertilizer as used here refers to one which contains three elements generally deficient in the soil: nitrogen, phosphorus and potassium. A 4-24-12 formula mans that the fertilizer contains 4 parts nitrogen, 24 parts phosphorus (P_2O_5), and 12 parts potash (K_2O), per 100 pounds fertilizer.

Top-dressing wheat with a nitrogen fertilizer is performed in early spring, after the ground has begun to thaw, and before the wheat has made any appreciable growth. The fertilizer may be applied at a rate of 20 to 30 pounds nitrogen per acre with a grain drill, pressing the disks firmly against the soil, or by using a fertilizer distributor. In either case the foliage of the wheat should be dry when the nitrogen is applied to prevent burning.

TABLE 2--INCREASE IN YIELD OF WHEAT WHEN TOP-DRESSED WITH NITROGEN FERTILIZER IN EARLY SPRING. TESTS WERE GROWN ON VARIOUS SOIL GROUPS DURING 1946-48.*

Soil Group	Years	No. Tests	Average increase from nitrogen	
			Bu./Acre	Per Cent
Dark Soils, Northwest Mo.	1946-'48	5	11.0	38.8
Well drained bottomland soils	1947-'48	3	9.4	50.4
Heavy bottomland soils	1946-'48	9	9.8	95.1
Timbered soils, Northeast Mo.	1947-'48	6	13.1	70.5
Gray Prairie Soils, Northeast Mo.	1946-'48	8	7.4	33.9
Gray Prairie Soils, Southwest Mo.	1946-'47	5	8.8	63.8

* These are results from demonstration plots on farmers' fields conducted by the Department of Soils.

With an apparent increase in the availability of cheap nitrogen fertilizers in the years ahead, a top-dressing with this element, as outlined above, appears to be the single practice that will result in the greatest increase in yield of the wheat crop. Top-dressing with nitrogen in farmers' fields in a large number of tests during the years 1946-49 under the supervision of the Department of Soils, has resulted in yield increases of 34 to 95 per cent. (See Table 2.) Benefits from early applications of nitrogen are greatest in wet springs when the nitrification process in the soil is retarded by poor aeration. Under these conditions the lower leaves and tillers turn yellow and die as the wheat plant makes the necessary adjustment to the diminishing supply of nitrogen. Farmers noting the reduced vigor and unthrifty appearance of their crop at this stage frequently speak of their wheat as "going down hill" and sometimes attribute the results to disease. While several fungous diseases produce somewhat similar symptoms, this unthrifty appearance in early spring is commonly due to reduced nitrogen nutrition.

Unless the nitrogen is applied early, preferably before growth

starts in the spring, full benefits from its use will not be realized. Nitrogen put on after the wheat has reached the jointing stage will not give the large yield increases, but instead, may result in slightly increased content of protein in the grain. On soils high in organic matter, heavy applications of a nitrogen fertilizer may result in excessive lodging.

Top dressings of wheat with nitrogen does not replace, but should only be made in conjunction with the application of a complete fertilizer at the time of planting; both must be made to achieve the proper balance. Other good crop management practices—use of lime, seeding of legumes in the wheat crop and incorporation of large amounts of organic matter into the soil—must be maintained if wheat is to achieve its proper place as a soil conserving crop.

HARVESTING THE WHEAT CROP FOR GRAIN

The combine harvester has largely replaced the binder and thresher as a means of harvesting wheat. As a result of this change, the harvest operation may be performed with greater economy and timeliness, since both labor and money are saved. But this shift to labor saving machinery is not without its shortcomings in the more humid areas. Inproper harvesting and storage of combined wheat may result in increased spoilage of grain on the farms, the marketing of grain reduced in market quality, and extra expense in conditioning grain in the elevator.

Wheat harvested with the combine requires a delay of 5-10 days after it may be cut with a binder in order that the grain will be sufficiently dry to separate completely from the chaff and to store without danger of spoilage. Wheat normally contains from 20-30 per cent moisture when cut with a binder, but this moisture content must be reduced to around 14 per cent before it can be safely stored after combining. Even though it may have once reached this low level, grain will take up moisture from a rain or even a heavy dew and combining must again wait until the moisture content is down to a safe storage level. Research at the Pennsylvania Station* indicates that a safe moisture content of wheat for combining is indicated when the grain can no longer be creased with the thumb nail. Their observations also indicate that 2 to 3 hours of sunshine are required for grain to become dry enough to combine after a heavy dew, and grain that has received a half-inch of rain requires approximately one whole day of good weather to dry to a condition where it can be combined and stored with safety.

*Cromer, C. Otis, "Moisture Problems in Combining Grain." Pennsylvania Agricultural Experiment Station Bulletin 445, 1943.

Fig. 7.—Replacement of the binder by the combine has resulted in more timely and economical harvesting; but this change has emphasized the need for varieties with better straw and which will not shatter. Also careful consideration must be given to the moisture content of combined wheat to prevent spoilage losses in storage.

Market quality of combined wheat is usually below that of grain cut with a binder and threshed. This results from the wetting by rain while standing uncut in the field. Wheat taking up water in this manner and then dried back is bleached in appearance and lower in test weight. The latter reduces the market grade, but apparently does not reduce the percentage of flour yield or injure its baking value* In extreme cases, where wheat is lodged or stands for long periods under conditions of high humidity, the kernels may also sprout. Such damage materially reduces both market and milling value as well as its value for seed.

Windrowing before combining is practiced less with wheat than with other small grains, such as oats or barley, since wheat stands better without lodging and less grain is lost by shattering. If a heavy crop of weeds is present, it may be desirable to windrow the wheat as the presence of the green weeds in the combined grain will result in a high moisture content.

*Swanson, C. O., "Effects of rain on wheat during harvest." Kansas Agriculture Experiment Station Bulletin 60. 1946.

Harvesting of wheat with the combine, creates a new problem in disposing of the straw. Where the straw is not needed it may be left in the field to add organic matter to the soil. If large quantities of straw are plowed under, it is often advisable to use a nitrogen fertilizer, or the decomposition of the straw may have a temporary deleterious effect upon the following crop. Where a legume is seeded in the wheat, large quantities of straw left on the ground after the wheat has been combined may prove injurious to the stand of legume and reduce the quality of the legume hay. Observations at the Ohio Agricultural Experiment Station† have borne this out. They suggest removal of the straw immediately on livestock farms where it may be used as bedding. On grain farms where it is not profitable or feasible to remove the straw, mowing the stubble at once after combining will reduce the damage from the straw. Where straw is baled and used elsewhere or sold, phosphorous and potash thus removed should be added in the form of fertilizer. Results in Ohio indicate that the increased growth of clover or alfalfa roots will add more organic matter than the straw removed.

PROTECTION AGAINST INSECTS

The principal insect enemies of wheat in Missouri are the Hessian fly and the chinch bug. To these two pests may be charged nearly all insect damage to the crop, except that from an occasional invasion of army worms or green bugs. The means of protecting wheat from Hessian fly and chinch bug ravages are summarized here.

Hessian Fly Control

The effective control of Hessian fly is based on three simple practices.* (1) Late summer plowing in preparation for the next wheat crop, particularly if the ground is in wheat stubble, will bury and destroy large numbers of the flies then in the flaxseed stage. (2) Disking the plowed ground or even disking wheat stubble without plowing, will prevent the growth of a food supply of volunteer wheat for the flies that remain. (3) Delaying the seeding of the crop until after the fall brood has gone (fly-free date) will avoid fall damage. The latter is by far the most important single practice in Hessian fly control. The wheat-lespedeza rotation is naturally favorable to fly control, since it delays the fall seeding of the wheat and tends to keep

†Willard, C. I. and Lewis, R. D., "Reduction of stands and yields of clover and alfalfa after combined wheat." Ohio Agriculture Bimonthly Bulletin 32: Mar.-Apr., 1947.

*Taken from Missouri Agricultural Experiment Station Circular 212, "The Hessian Fly," by Leonard Haseman.

Fig. 8.—Infestation of wheat with Hessian fly results in the failure of many tillers to head and produce seed (left), and in the breaking of the straw as the plant matures (right).

down the summer volunteer growth of wheat where the lespedeza is grazed.

A map of Missouri showing the safe fly-free dates for seeding wheat is shown in Figure 9.

Chinch Bug Control

The clean-up of trash in the field will leave fewer places for the chinch bugs to live during the winter, and so will lessen the number of bugs that survive until spring. The dense shade of lespedeza in a wheat-lespedeza rotation is not a favorable condition for these insects. Since the chinch bug does not like shade, it will cause more injury to a thin weak growth of wheat than to a thick strong growth. This means that a crop stimulated by a good seedbed and fertilizer is likely to suffer less damage than a crop poorly treated. An early maturing variety will escape serious damage from this insect.

PROTECTION AGAINST DISEASES

The most prevalent diseases of wheat in Misouri are *loose smut* and *leaf rust*. *Stinking smut* or *bunt*, often causes serious damage to

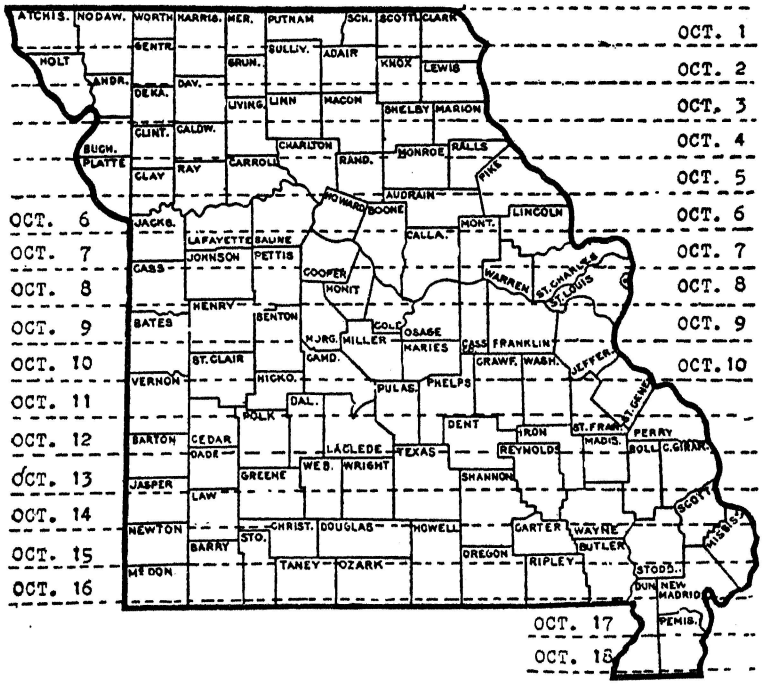

Fig. 9.—Map showing fly-free dates for Missouri. Wheat seeded on or after these dates should escape fall fly injury. (Taken from Missouri Agricultural Experiment Station Circular 212.)

individual fields, and *stem rust* greatly reduces yields in occasional years. Less important diseases are *scab* and *mosaic*. These are briefly described and practical means for their control are given in the paragraphs immediatly following.

Loose Smut

A head of wheat infected with loose smut soon becomes a black smutty mass. The spores are blown like dust and fall into the blooms of healthy heads. The ripe grains from these heads appear sound but they may contain the germ of the disease. If they are sown the disease is spread to come again in the next crop. Because the loose smut fungus is carried *inside* the kernels, it cannot be destroyed except by internal disinfection. The treatment is (1) to soak the seed in cool water for four hours, (2) to drain off the cool water and immediately immerse the seed for exactly ten minutes in water at 129° Fahrenheit, and (3) to dry the seed so rapidly that it will not sprout or mold. This treatment is difficult to manage and under ordinary farm conditions is not practical, except for a small lot of seed that is to be used to produce a larger supply temporarily free from loose smut.

Fig. 10.—Loose smut is a common disease of wheat in Missouri. It is controlled by the hot water seed treatment (a practical method for small lots of seed only) or by breeding resistant varieties.

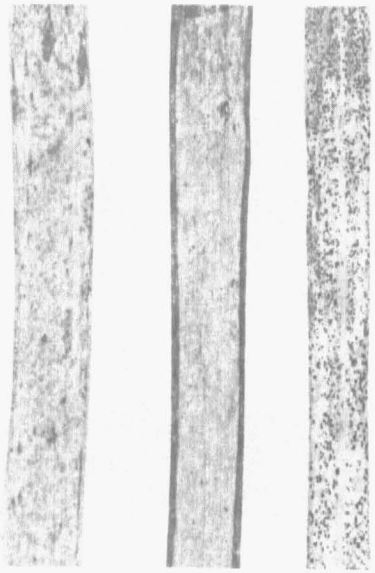

Fig. 11.—Leaf rust injures the wheat crop in Missouri nearly every year. It is recognized by small- orange-red pustules on the leaves, which become black as the wheat matures. (See leaf on right above.)

Varieties of wheat formerly grown in Missouri have been susceptible to this disease and it could be found in almost every field in amounts varying from 1 to 5 per cent. Some newer varieties, including Pawnee and Vigo are more resistant to loose smut.

Stinking Smut or Bunt

If a wheat plant is infected with stinking smut the disease consumes the kernels and forms smut balls in their places. The whole head becomes somewhat shrunken but not otherwise changed in outward appearance. When a smutted crop is threshed many of the smut balls are broken into dust-like spores, which lodge upon the surfaces of sound grains. If this re-smutted seed is sown, the smut spores germinate with the seed wheat and the fungus again grows up within the plant. Thus the disease is carried from one crop to the next.

The spores of this disease, being carried on the *outside* of the seed, can be destroyed by surface disinfection. Treatment of the seed is simple, effective and inexpensive. (1) New Improved Ceresan or Ceresan M is thoroughly mixed with the seed wheat at the rate of half an ounce of dry powder to each bushel of seed. Or (2) Ceresan M is applied as a slurry, according to rates recommended by the manufac-

turer. When used as a slurry, the Ceresan M is applied wet. This eliminates some of the hazard to the operator caused by breathing the dry dust. Special seed treaters are necessary for use of the slurry.

None of the varieties grown in Missouri is resistant to this disease.

Leaf Rust

This is the rust which covers the leaves of wheat with bright orange-red pustules filled with the spores. By harvest time the spores may be found on all parts of the plant. Wind blown spores carry the disease from plant to plant; initial infections in Missouri are started by spores blown in from the southwest. Where orange leaf rust is abundant it causes damage by preventing the leaves from forming food for the plant. It occurs in nearly all Missouri wheat every season, and the annual average loss from leaf rust in Missouri probably exceeds that of any other disease of wheat. No remedy for it is known. Resistance to this disease is found in Vigo and to a lesser extent in Pawnee varieties.

Black Stem Rust

Fig. 12.—Spores blown in from the southwest or disseminated from nearby barberry bushes produce infections of stem rust which weaken the straw and cause lodging, low yields, and shriveled grain.

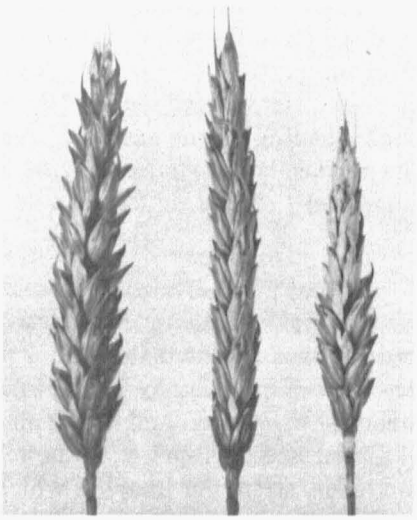

Fig. 13.—Scab (two heads at right in contrast to normal head at left) is common if there are rains during the heading period. The same disease organism also produces a root, stalk, and ear rot disease in corn.

Black stem-rust, if it appears in Missouri wheat, is first noticed in the red-spore stage on the stems and leaves, as the crop approaches maturity. Soon it reaches the black-spore stage, giving the stems a

black and roughened appearance. The disease at its worst extends into the head, shrivels the kernels, and ruins the crop. There was an unprecedented epidemic of black stem-rust in Missouri in 1937, although no serious damage has occurred here since that time.

There is no remedy or direct preventive for this disease. Elimination of the common barberry may reduce local infections, since the fungus spends part of its life cycle in this host. Most of the serious epidemics are caused by wind blown spores, and originate in the southwest. Resistant varieties of hard red spring wheat have been developed and are widely grown, but no resistant soft wheat varieties adapted to Missouri are available. Early maturing varieties will generally mature ahead of these wind blown infections and escape damage.

Scab

Wheat scab is shown by pinkish spots on the heads of the nearly mature plant. It shrivels or rots the kernels and causes light-weight grain. It occurs frequently in Missouri and is produced by the same fungus that causes a root and ear rot in corn.

There is no practical treatment for scab, although it may be cleansed from the soil by a rotation of crops that does not bring wheat after either wheat or corn. Scabby seed wheat of course should not be used. Heavy seed may safely be considered fairly scab-free. Thorough cleaning of the seed will remove most of the scabby grains and the surface borne spores may be killed by treating the seed with New Improved Ceresan or Ceresan M.

Mosaic

Wheat mosaic, a virus disease, has been found in several counties in Missouri. Little or no loss was noted in earlier observations, but damage was reported in limited areas in 1949. Badly diseased fields are uneven and patchy in appearance, with small circular to irregular areas of stunted and dying plants. Infected plants are most easily observed in early spring, as new leaves unfold; these bearing irregular yellow stripes or blotches which tend to run parallel with the length of the leaf, presenting a mottled appearance. The disease is generally restricted to small areas on individual farms. Damage has been most severe when susceptible varieties were grown on the same field in successive years.

The only control is through the use of resistant varieties. Many of the older soft wheat varieties, and Vigo and Royal among the newer, are somewhat resistant. Clarkan, Pawnee and Triumph are susceptible.

WHEAT AS A FEED CROP

Emphasis upon growing wheat for feed, instead of producing it as a cash crop, is receiving greater attention in Missouri agriculture. When grown to produce feed for livestock, wheat may be utilized (1) as a grain feed, or (2) for pasture. These will be discussed separately.

Wheat as a Grain Feed

The idea of using wheat as feed for livestock has been obstructed, in the past, by the fixed custom of selling the grain for cash. A relatively high price, arising from the special utility of wheat for bread has made wheat historically a market crop. Experimental results, however, readily demonstrate the possibility of excellent returns from growing and using wheat wholly as feed. Clearly the decision to feed wheat or sell it must rest upon the comparative market prices of wheat and corn, in relation to their comparative value as feed, and upon the need for additional grain feed on the farms where the wheat has been produced. In the upland soil areas of Missouri increased acreages of wheat may well be grown solely as a feed grain, there replacing corn on the more erosive soils.

As a feed, wheat is higher in protein than oats and considerably higher than corn. It is low in calcium, containing about one-third as much as oats, but more than corn. The phosphorus content is higher in wheat than in the other cereals.

The Missouri Experiment Station found ground wheat to be 10 to 15 per cent more efficient than corn-pound for pound-for fattening hogs* Wheat required less protein supplement and produced gains more rapidly than corn. Pork from wheat-fed hogs was equal in quality and superior in firmness to pork from corn-fed hogs. Other experiment stations have reached similar conclusions.

It was also found here that coarsely ground wheat, when composing not more than half the grain mixture for fattening cattle, was worth 5 to 15 per cent more than corn. † Such wheat used as a complete substitute for corn produced gains with 10 per cent less feed, but produced them less rapidly. Cattle fed wheat were more difficult to keep on feed, and they frequently lacked finish and sold for less than corn-fed cattle. Cattle should be put on wheat feed slowly, as bloat and scouring frequently result if the animals too rapidly reach a full feed of this grain. These results mean that wheat is better as a partial

*Weaver, L. A., "Various Grains and Other Corn Substitutes as Hog Feeds." Missouri Agricultural Extension Circular 321, 1935.

†Trowbridge, E. A. and Moffet, H. C., "Wheat as a Cattle Feed." Missouri Agricultural Experiment Station Bulletin 325, 1933.

substitute than as a complete substitute for corn in the ration for fattening cattle. Coarse grinding substantially increased the value of wheat as feed for cattle and was more effective than any other treatment for this purpose.

Wheat as Pasture

Young growing wheat is a nutritious pasture crop rich in protein and the essential minerals. While excellent for all classes of livestock, it is best utilized by cattle or sheep. It may be grazed early in the spring, usually before pasturage from bluegrass is available, thus shortening the winter period when it is necessary to feed livestock on dry forage. This spring grazing of wheat may be carried through the life of the wheat plant or the cattle may be removed when bluegrass pasture becomes available, and the wheat harvested as grain.

There are fine possibilities in the use of wheat wholly for pasture, especially if wheat is followed with lespedeza, so that the two crops furnish heavy and continuous grazing through a long season. A wheat-lespedeza pasture is set up by the spring seeding of lespedeza in the wheat. Grazing of the wheat normally begins during April, and if regulated to a rate that keeps up with growth it will last until early or mid June, for a total of 50 to 60 days. By the time wheat is grazed out lespedeza usually is ready and will carry the stock through the summer and normally into early October. The lespedeza sod is then disked and the wheat resown, as described in the explanation of the wheat-lespedeza rotation, beginning on page 33.

The Missouri Experiment Station in 1933 began at Columbia a study of wheat-lespedeza pasture to learn the productivity and cost of this method of feed production. Records of the essential results are given in Table 3.

In addition to growing wheat and utilizing it wholly for pasture, as in the wheat-lespedeza rotation, wheat is sometimes used briefly for supplemental grazing and then later harvested for grain. The degree to which it may be grazed is sharply limited by the consideration of the yield of grain. Fall grazing will seldom be obtained, if seeding is delayed, as when we try to avoid the Hessian fly or wheat is seeded after lespedeza which has matured seed, or after soybeans or corn harvested for grain, or if the fall weather is so dry as to cause slow growth. If the seeding is very early a good deal of fall pasture may be obtained, but such a crop is likely to be severely injured by the fly and to yield grain poorly. Spring grazing, under suitable conditions can furnish considerable feed and if correctly regulated will not cause a material reduction in yield. The rules for this prac-

TABLE 3--COMPARISON OF POUNDS OF BEEF PRODUCED PER ACRE BY CATTLE GRAZING BLUEGRASS AND WHEAT-LESPEDEZA EXPERIMENTAL PASTURES AT COLUMBIA AND LATHROP, MISSOURI, 1937-1949.

	Columbia, Missouri		Lathrop, Missouri	
	Pounds beef per acre from		Pounds beef per acre from	
Year	Bluegrass*	Wheat & Lespedeza**	Bluegrass & Lespedeza	Wheat & Lespedeza**
1937	128	287		
1938	151	204		
1939	230	331		
1940	223	386	170	301
1941	273	281	138	207
1942	181	122	175	345
1943	145	270	90	316
1944	204	166	205	205
1945	273	197		
1946	281	238	207	308
1947	223	243	197	352
1948			217	290
1949			201	240
Average	210	248	145	233

* Bluegrass only during years 1937-42. Mixture of bluegrass and lespedeza, 1943-1947.

** Both Wheat and Lespedeza grazed out.

tice are these; do not graze the growth too close; do not graze after the growth has begun to joint; do not graze when the ground is too wet.

WHEAT-LESPEDEZA ROTATION

The one-year rotation of wheat and lespedeza, on the same field for long periods, is a matter of production in which Missouri growers have found important advantages. It is established by sowing lespedeza on wheat in winter or early spring. The operation thereafter is very simple. Soon after the wheat is harvested the lespedeza may be grazed for the remainder of the season, or it may be saved for a midsummer hay crop or a fall crop of seed. Grazing is the usual means of utilizing the legume growth. In the fall when the seed on the grazed lespedeza sod is ripe, or nearly ripe, the sod is worked with the field cultivator or is thoroughly disked and harrowed, and wheat is sown on it. There will be an abundance of seed left on the lespedeza ground, whether the crop was grazed or harvested, and it will produce a thick volunteer stand in the wheat next spring. Thus the legume, once established, will renew itself year after year. Wheat is sown on the lespedeza sod every fall.

Some points in the management of this rotation are to be observed for maximum returns.

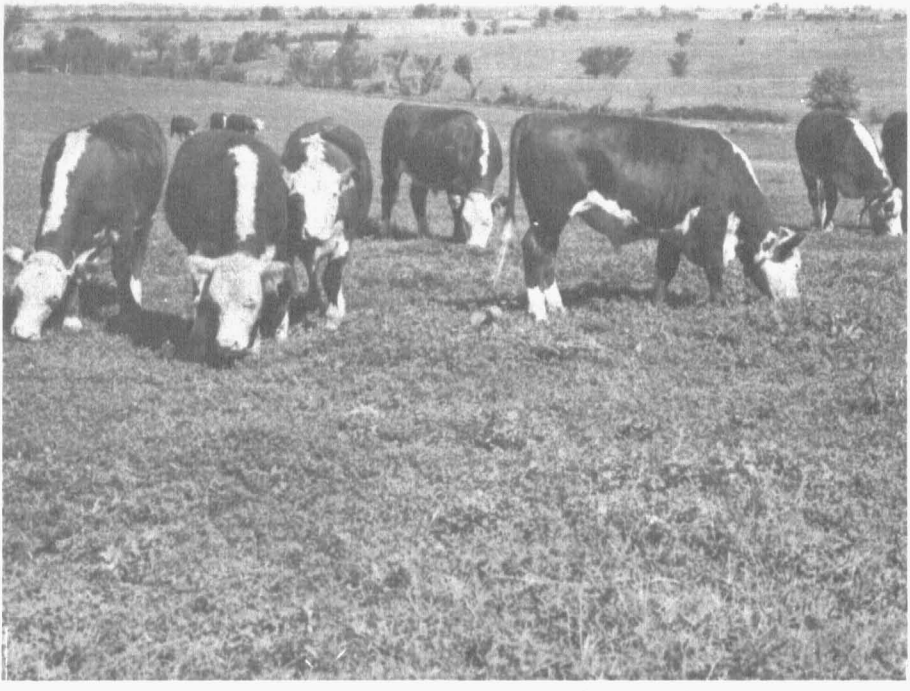

Fig. 14.—Livestock grazing lespedeza in a continuous wheat-lespedeza rotation on the University South Farms, Columbia. In this field the cattle were put on the wheat in early April, pasturing it until mid June, after which the lespedeza furnished pasture until killed by frost in the fall.

First, an early maturing variety of wheat will allow a strong early growth of lespedeza.

Second, the lespedeza should be grazed to its full carrying capacity all through the season, late June or early July to late September or early October. This will bring the highest returns from the legume and will not leave enough dry growth on the ground to interfere with disking for the wheat.

Third, if the lespedeza is cut for hay the harvesting should be done early to late July. The finest quality of hay may then be obtained, and the lespedeza will renew growth and produce seed. Later cutting will give less valuable hay and may not leave enough life in the stubble or enough time for the good renewal of growth. In that

case the stand may not volunteer next spring and so will require reseeding.

Fourth, if the stand is harvested for seed it should be cut to a short stubble, so that the ground may be readily disked.

Fifth, the lespedeza seed will be ripe enough by the last of September to October 20, to allow the sod to be disked for wheat. This will be high time, however, for putting in the wheat crop and a quick job of disking, harrowing and sowing will then be necessary. It is more readily done where the lespedeza has been grazed short all season, because the seed will ripen somewhat earlier and not much old growth will be left.

Sixth, the wheat crop should be fertilized year after year.

The merits of the wheat-lespedeza rotation may be stated in summary as high returns, low cost, soil conservation, safety, facility in crop management, and withal *profit.*

WHEAT-SOYBEAN ROTATION

This rotation, like the one-year rotation of wheat and lespedeza, offers high returns at a low cost of production. It embodies the growing of a crop of wheat and a crop of soybeans on the same land in one year. Following the combining of the wheat for grain, the land is thoroughly disked and quickly seeded to soybeans. The soybeans are either rowed or drilled, and an early maturing variety is used. As soon as ripe the soybeans are combined and the land again disked and seeded to wheat.

Successful operation of the rotation is based on several management practices.

First, use of an early variety of wheat to permit an early harvest.

Second, use of an early variety of soybeans to permit the more timely seeding of wheat in the fall.

Third, planting the soybeans in rows to speed their harvest, since the more thinly spaced plants will dry more quickly to a low moisture content and permit earlier combining. The quick turn from wheat to soybeans and from soybeans to wheat can only be made when power machinery is available to hasten the combining operation and make possible the thorough tillage of the soil. Also, favorable soil moisture conditions after the wheat has been combined is necessary to obtain quick germination of the soybeans.

This rotation is now successfully used on many farms in Southeast Missouri. There the fall season favors its operation, since there is a longer period of time in which the soybeans may be harvested

and the wheat safely planted. This rotation has also been successfully carried out on the bottomland experiment field at Elsberry, Missouri.

This field is located on heavy gumbo soil which is difficult to till, but which is favorable to the production of both soybeans and wheat. Its utilization on this type of soil opens up great possibilities for increased production on all of the heavy bottomland soils throughout central Missouri. Much of this land is already in wheat, lying idle through the summer after the wheat is harvested. These soils are high in organic matter and basic minerals. Return of all of the wheat straw in addition to the soybean straw, combined with the application of mineral fertilizers at the time of planting wheat should keep them in a highly productive state.