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Manhattan, Kansas

WHEAT PRODUCTION IN KANSAS

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ROTATION OF CROPS, EARLY AND THOROUGH PREPARATION OF THE SEED BED, AND GOOD SEED GO FAR TOWARD PRODUCING FIELDS OF WHEAT SUCH AS THIS.

WHEAT PRODUCTION IN KANSAS[1]

S. C. SALMON AND R. I. THROCKMORTON

IMPORTANCE OF WHEAT PRODUCTION

Wheat is the most valuable grain crop of the world. The production in pounds exceeds that of any other grain and in many respects it is superior to any other for human food. It is adaptable to nearly all climates and soils and can be sown, cared for, harvested, threshed, and marketed with no handwork whatever. For these reasons it has from the earliest times played a leading part in the development of civilization. The important place which the United States occupies in the production of wheat is indicated in figure 1, which shows the average annual production for the principal wheat-growing countries of the world for the five-year period, 1922 to 1926.

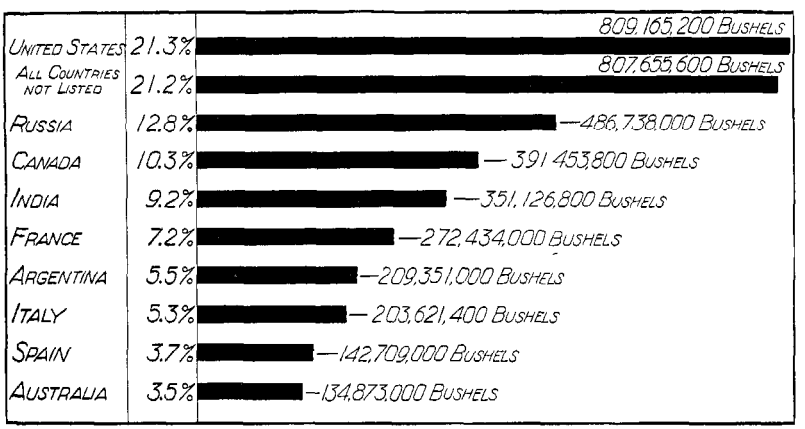


FIG. 1.—Average annual production and per cent of production of wheat for the principal wheat-producing countries of the world, 1922 to 1926.

WHEAT IN KANSAS

Kansas is the leading state in the United States in the production of wheat. (Table I.) The broad level plains which permit the use of power machinery, a rich soil, and a favorable climate are

Acknowledgment.--In the preparation of this bulletin the authors have drawn freely from the results of experimental work of the Kansas Agricultural Experiment Station and the various branch stations. The valuable assistance of the Office of Dry Land Agriculture and of the Office of Cereal Crops and Diseases, United States Department of Agriculture, in securing the experimental results reported herein is gratefully acknowledged.

1. Contribution No. 186 from the Department of Agronomy.

the chief factors responsible for the importance of wheat, in this state.

TABLE I.—THE TEN LEADING WHEAT-PRODUCING STATES OF THE UNITED STATES. AVERAGE PRODUCTION FOR THE FIVE-YEAR PERIOD, 1922 TO 1926.

STATE.	Bushels (a).
Kansas	118,820,000
North Dakota	104,187,000
Illinois	46,581,000
Montana	46,397,000
Oklahoma	45,426,000
Nebraska	44,796,000
Washington	40,170,000
Ohio	35,256,000
Indiana	30,379,000
South Dakota	29,419,000

(a) From yearbook, United States Department of Agriculture.

These, however, are of less concern to the producer and consumer than is the future of the wheat industry. High costs of production as compared with prevailing prices, depletion of the soil, increasing damage from insects and plant diseases, a possible or even probable decrease in quality of the wheat that is produced are all matters of vital concern to farmers, merchants, grain dealers, and consumers. These things must be carefully considered if the production of wheat is to remain on its present high plane of efficiency, not to mention further improvement.

NEED FOR STABLE PRODUCTION OF WHEAT

Although Kansas grows more wheat than any other state its production fluctuates greatly from year to year. Failures occur in some portions of the state nearly every year, and in some sections there are often three or four years of failure in succession. This is an unsatisfactory condition since it indicates large losses in growing wheat. Every acre that is seeded and not harvested adds to the average expense of growing that which is harvested. There are good reasons to believe that more attention to certain essentials in preparing the land, seeding, and care of the crop will materially reduce these losses and make wheat growing a more profitable business. One of the purposes of this bulletin is to bring these essentials

to the attention of Kansas farmers and to point the way to more profitable production rather than to the production of more wheat.

SOILS FOR WHEAT

Wheat may be grown on practically any soil found in Kansas except very sandy soils such as are found in river valleys and in certain areas in the southwestern counties. For such soils corn or the sorghums are usually more profitable. Wheat, like other small grains, tends to lodge on rich bottom lands in eastern Kansas. Corn is usually more profitable than wheat for such areas. In general it may be said that climate rather than soil limits the wheat area in Kansas.

CLIMATE FOR WHEAT

Wheat is grown most extensively in those parts of the world where the annual rainfall is more than 20 and less than 60 inches and where the temperatures for part of the year are cool. Winter wheat especially does not thrive in the tropics where warm weather prevails throughout the year.

The principal climatic factor that limits the production of wheat in Kansas is rainfall. In west central Kansas especially the rainfall often is not sufficient to grow wheat successfully. Deficient moisture for germination in the fall and dry winters as well as insufficient moisture during the growing season are serious difficulties. Hot winds and early summer drought also cause serious losses. For such conditions some of the sorghums, such as milo, feterita, and broom corn are usually more profitable than wheat. In eastern Kansas, especially on rich bottom land, other crops such as corn and alfalfa often prove more profitable than wheat.

WHERE WHEAT IS GROWN IN KANSAS

Wheat is grown most successfully on the broad level plains of central Kansas. Here it finds an almost ideal climate, a good soil, and a level to slightly rolling topography which permits the efficient use of labor-saving machinery. The distribution of wheat production in Kansas is shown in figure 2.

Only in recent years has wheat become a staple crop in southwestern Kansas. Higher prices, the advent of the combine, which has greatly reduced the cost of growing wheat, the use of tractors, and better methods of tillage are primarily responsible for this change.

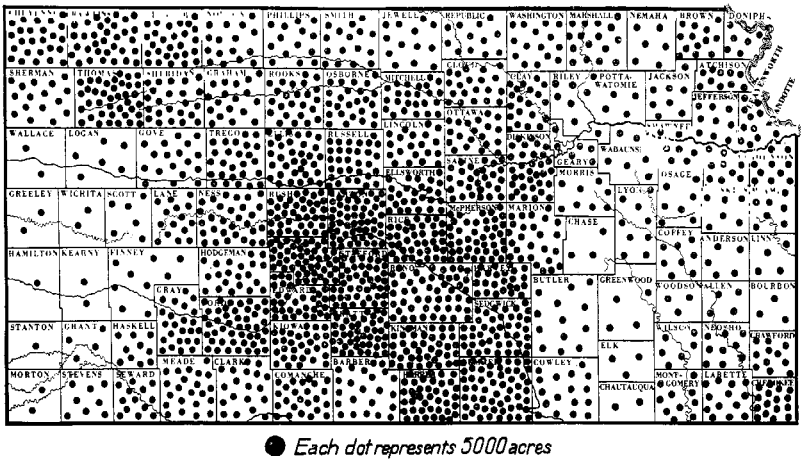


FIG. 2.—Average annual acreage of wheat in Kansas, 1917 to 1926.

PROFITS DEPEND ON HIGH YIELDS

The average yield of wheat in Kansas for the 10-year period, 1919 to 1928, was only 13.2 bushels per acre. This return is less than the cost of production, if labor at prevailing wages, interest, depreciation, and decrease in soil fertility be considered. Generally speaking, those who produce the highest yields secure the greatest profit as shown in figure 3. Intelligent soil management, timely culture, good seed, and control of wheat pests, it is believed, will bring about improvement in this respect.

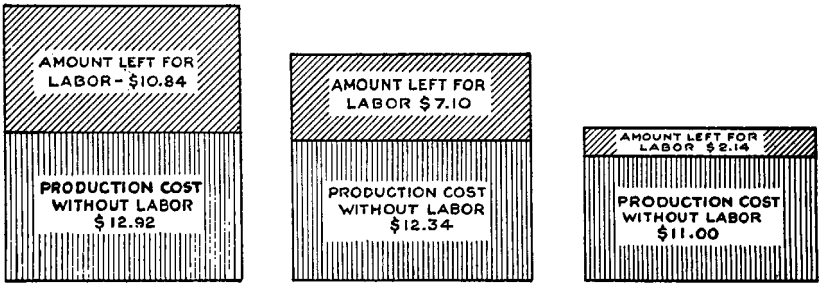


FIG. 3.—Cost of production and yield secured by three methods of preparing the seed bed for wheat at the Kansas Agricultural Experiment Station. More efficient methods will not only increase the yield per acre, but will make wheat raising more profitable. (Wheat valued at 90 cents a bushel.)

DIVERSIFIED FARMING AND WHEAT PRODUCTION

Experiments and farm experience agree in showing that a "one crop" system of farming cannot be continued for an indefinite period with profitable results. The thinking farmer will consider his system of farming rather than any single crop. That system is best which provides for the largest profit, the least risk, and the greatest safety. The wheat farmer who diversifies and produces feed crops on part of his acreage, handling this through live stock, and who produces some milk, butter, and eggs on the farm, is establishing a safe system. It is this kind of farming that gives employment the year around, brings in constant returns, and aids in keeping up the soil fertility.

ROTATION OF CROPS IS DESIRABLE

In general it is desirable to rotate wheat with other crops. At the Agricultural Experiment Station at Manhattan, the yields indicated in Table II have been secured from wheat grown in different ways.

Another experiment at Manhattan has given the results presented in Table III. In this case a rotation including alfalfa has given the highest yields and wheat every year the lowest yields.

TABLE II.—EFFECT OF ROTATION ON THE YIELD OF WHEAT AT THE AGRICULTURAL EXPERIMENT STATION, MANHATTAN, KANSAS.

PREPARATION OF THE GROUND.	Yield in bushels per acre. Average, 1913 to 1923.		
	Grown in rotation with corn and oats.	Grown without rotation.	Difference in favor of rotation.
Plowed July 15, 3 inches deep	26.8	15.0	11.8
Plowed July 15, 7 inches deep	26.7	19.0	7.7
Plowed August 15, 7 inches deep	23.2	17.0	6.2
Plowed September 15, 3 inches deep	17.0	11.4	5.6

TABLE III.—THE EFFECT OF ROTATION ON THE YIELD OF WHEAT IN EASTERN KANSAS.

ROTATION.	Average yield per acre for 17 years.
	Bus.
Sixteen-year rotation: Alfalfa, corn, and wheat	19.5
Three-year rotation: Corn, cowpeas, and wheat	17.0
Wheat every year	14.9

GENERAL ROTATIONS

As far as possible every rotation should include a leguminous crop such as alfalfa, red clover, sweet clover, soy beans, or cowpeas. It is usually desirable to include oats, barley, corn, kafir, milo, or sweet sorghums either singly or in combination, according to local requirements. Where none of the legumes mentioned is dependable, as in parts of western Kansas about the only successful crops that may be rotated with wheat are corn, kafir, milo, barley, feterita, and sorgo. In this region the fallow should be used as a part of the rotation.

It is usually desirable to rotate the crops according to a definite plan rather than hit or miss. It may not always be best to follow the plan as, for example, when weather conditions interfere or especially favor the planting of a certain crop, or a special condition of the market makes it desirable to change. Nevertheless a definite scheme enables one to make plans for years ahead and there is greater assurance that a worth-while plan will be followed.

ROTATIONS INCLUDING WHEAT FOR EASTERN KANSAS

Rotation of crops is especially desirable and profitable in eastern Kansas. Much of the land has been cropped to wheat or other grains almost continually since it was first broken up. The result is that it is low in organic matter and available plant food, especially nitrogen, and is in poor physical condition. Some of it has become so depleted that good crops can no longer be obtained without special soil treatments. Because of the relatively favorable climatic conditions of this region, good yields depend to a very large extent on the condition of the ground, and hence rotations which include legumes are very effective in increasing yields.

In northeastern Kansas where corn is a predominating crop, a popular rotation that includes wheat is clover, corn, corn, oats, and wheat. Red clover or sweet clover is sown with the wheat and is usually grown for hay or seed the following year, making a five-year rotation. The sweet clover is usually more successful when seeded in oats than when seeded in wheat. On poor land the clover may be plowed under for green manure the first fall or the following spring. Sweet clover should be plowed in the spring since it is not easily killed by fall plowing. The rotation may be further modified by growing two crops of wheat or by omitting one of the corn crops. Such change is advisable on land especially adapted to wheat.

The above rotations are also suited to good lands in southeastern

Kansas except that red clover is not so generally successful, and sweet clover, soy beans or cowpeas may often be grown to better advantage. On poor and droughty lands kafir or other sorghums may profitably be substituted for the corn or for one crop of corn. Soy beans or cowpeas for hay may be substituted for the oats where such a change seems desirable.

A good practice where alfalfa is dependable is to grow this crop for about four years, after which a rotation of grain crops may be followed for 10 to 12 years. The land may then be seeded to alfalfa

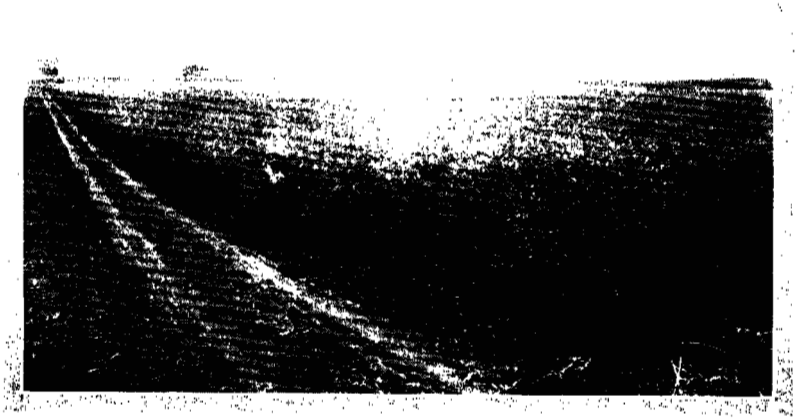


FIG. 4.—Sweet clover grown in rotation with wheat. Yields of wheat grown in rotation with this legume are greatly increased.

again. In the meantime alfalfa may be grown on other fields, later to be rotated with grain crops in a similar manner. The rotation after alfalfa may consist of corn, oats, and wheat, each one year, or any of the combinations mentioned above. On thin upland or in the drier portions, kafir may be partly or entirely substituted for the corn.

ROTATIONS INCLUDING WHEAT FOR CENTRAL KANSAS

Good rotations for central Kansas do not differ materially from those just described except that there are fewer crops to choose from and the greater weather hazard makes it more difficult to follow a definite rotation plan.

Perhaps the most satisfactory rotations are those including alfalfa. Those suggested for eastern Kansas are satisfactory on good

land. However, alfalfa leaves the subsoil dry and because of the unusual amount of available nitrogen left in the soil often induces an excessive vegetative growth, which is easily injured by hot winds and drought. The first crop after alfalfa should, therefore, be a crop well able to endure drought. The best crop for this purpose usually is an early-maturing sorghum such as Pink kafir, Dawn kafir, or Early Sumac sorgo. The sorghum may be followed by corn on the better lands and the corn by oats and then wheat. In many cases it is better to grow oats or barley after the sorghum and then wheat.

Sweet clover, as a combination pasture and soil-improvement crop, is being grown quite commonly in this region. Since the sweet clover usually fails when seeded in wheat in the spring, this practice cannot be recommended. When the wheat is thin and climatic conditions are favorable for the sweet clover, this method may be successful, but it is safer to seed with oats or alone. The sweet clover is seeded in the spring following the row crop. It is usually pastured during the summer and fall of that year and the following spring and is then plowed under in June in preparation for wheat. A field of sweet clover grown in rotation with wheat is shown in figure 4.

WHEAT AFTER ALFALFA

Wheat is sometimes grown with success immediately after alfalfa. The ground is plowed shallow soon after the second crop of hay is taken off and prepared for wheat in the usual way. Oats may also be sown following the alfalfa. The alfalfa ground is plowed in the late fall, seeded to oats the following spring, and wheat follows the oats.

In either case there is considerable danger of the small grains lodging and hence the practice cannot be recommended for rich soils. There is also danger in central Kansas of the small grain crops burning in dry years. In general it is best to follow alfalfa with one or two years of kafir or corn before seeding to wheat.

Lodging After Legumes.—One of the serious difficulties in growing wheat after a legume or in a rotation including legumes is lodging. This difficulty is especially serious on rich soils and in humid areas as in eastern Kansas and in wet seasons in central Kansas. Lodging is likely to take place whenever there is an excessive vegetative growth, which occurs only when there is an abundant supply of nitrates and soil moisture.

There is no certain way to prevent lodging. It can be reduced somewhat by plowing late, thus reducing the opportunity for nitri-

fication. Late seeding tends to have the same effect. Fall pasturing when the growth is excessive also tends to reduce lodging. In general it is better to grow corn or sorghums or alfalfa on rich land, where lodging generally takes place, rather than attempt, to grow wheat.

CROP ROTATION IN WESTERN KANSAS

Extensive experiments at the Fort Hays, Colby, and Garden City branch stations, all located in western Kansas, have failed to demonstrate any marked gain in the yield of wheat as a result of growing it in rotation with other crops, except in those cases where fallow is also included.

This is contrary to the results secured in eastern and central Kansas as just presented. It is perhaps explained by the fact that those diseases, weeds, and insects which tend to accumulate when wheat is grown on the same land year after year have largely been absent from this territory; by the fact that very little plant food is lost by leaching and the ground can be better prepared after a wheat crop than after many other crops; because yields in this region are limited by weather conditions much more frequently than by any deficiency of plant food; and because occasional crop failures frequently cause a change in the use of the land.

About all this means for the practical man is that wheat can be grown continually on the same land for a longer time in western Kansas without suffering those reverses which follow the same practice in the eastern part of the state. It also means that if the farmer so desires, he can grow wheat without rotation longer than has sometimes been thought possible. It does not mean that he can do so indefinitely without suffering losses in yield. Neither does it signify that it is usually desirable to grow wheat in this way. The occurrence of certain diseases and weeds in this region during the last few years indicates that it may soon be necessary to practice a rotation.

As brought out elsewhere in this bulletin no system of extensive farming is entirely satisfactory without live stock, and in order to grow live stock it is necessary to grow some feed crops. Such crops can often be rotated with wheat to advantage in a more or less systematic manner. This is especially so if fallow is included as one feature of the rotation.

Fallow in a Rotation for Western Kansas.—A cropping system which provides for a feed crop, and yet permits a large acreage of wheat, consists of one year each of an early kafir and of fallow fol-

lowed by two or three years of wheat. In southwestern Kansas milo may be substituted for kafir, and in northwestern Kansas an early variety of corn may likewise be substituted to advantage. The fallow coming immediately after the sorghum or the corn puts the ground in excellent shape for wheat. This eliminates one of the serious objections to sorghums, viz., its effect on the following crop. An outstanding advantage of this system is that it guards against total loss because (1) the fallow itself serves more or less as insurance against a total loss of the wheat crop, and (2) it is seldom that both sorghum and wheat fail in the same year.

A popular cropping system in which wheat is the only crop consists of one year fallow and two or three years of wheat. The principal advantages are the increased yields due to the fallow and the distribution of labor effected thereby. The latter comes about through the fact that the land to be fallowed may be prepared before harvest and therefore during a slack period of the year. A good plan where this method is followed is to fallow annually about one-third or one-fourth of the acreage intended for wheat. This is plowed or listed late in the spring, but before weeds have had an opportunity to rob the soil of moisture. The preparation of the wheat land fallowed the previous year may be left until the last since it should be in relatively good shape. This leaves only half the total land to be prepared early and thereby affords a better distribution of labor. Also as brought out elsewhere (Table XIII) the effect of the fallow lasts more than one year, and hence rapid inexpensive methods may be used to better advantage the second year after fallow than if no fallow is included.

The Partial Fallow in a Rotation for Western Kansas.—A system known as partial fallow or wide spacing has become quite common, especially in southwestern Kansas. The system consists of growing corn or one of the sorghums in wide rows, about two times the ordinary width, keeping the ground well cultivated during the summer and then drilling the wheat between the rows.

When this method is followed the yields of wheat are usually higher than with wheat every year, but lower than when a full fallow is practiced. In the western third of the state there is no loss on the average in the yield of corn or grain sorghums. It has the advantage of making possible the production of a crop each year and of leaving the corn or sorghum stalks on the ground to help prevent soil blowing and the drifting of snow during the winter.

The influence of wide spacing of kafir on the following yields of

wheat, is shown in Table IV, which gives the results secured at the Fort Hays Experiment Station.

TABLE IV.—YIELDS OF WHEAT AFTER FALLOW AND AFTER KAFIR AT THE FORT HAYS EXPERIMENT STATION.

Hays, Kan.

CROPPING METHOD.	Average yield per acre, 1916 to 1927.
	Bus.
Wheat on fallowed kafir ground	24.2
Wheat after kafir planted in rows of the usual width	12.2
Wheat after kafir planted in rows 80 inches apart	15.1
Wheat after corn in rows of usual width	16.2
Wheat after corn planted in rows 80 inches apart	17.8

SOIL TREATMENTS FOR WHEAT

The profitable use of fertilizers for wheat depends both on the soil and the location in the state. Thus in western Kansas fertilizers seldom pay even on poor soil for the reason that yields are so often limited by deficient rainfall. On the poorer types of soil in eastern Kansas fertilizers often pay large dividends on the investment. To secure these dividends, however it is necessary to know when and how to apply fertilizers and what kind to use.

BARNYARD MANURE FOR WHEAT

Barnyard manure is in general the most satisfactory material with which to increase wheat yields. If properly applied, it can be safely used in any section of the state. On poor upland farms in eastern Kansas a top dressing of manure may double the yield and make it much easier to get a stand of clover or grass sown in the wheat or of alfalfa following the wheat. Experiments at the Kansas Agricultural Experiment Station at Manhattan, as indicated in Table V and illustrated in figure 5, have shown an average gain of from 4 to 6 bushels per acre on reasonably fertile soil. Much greater increases are obtained on poor soils. Manure may safely be applied at the rate of 8 to 10 tons per acre every three or four years in eastern Kansas, but in central Kansas the rate of application should not exceed 5 or 6 tons per acre. Excessive applications may cause lodging during a wet year and burning during a dry year.

TABLE V.—EFFECT OF MANURE ON YIELD OF WHEAT.

Manhattan, Kan.

CROPPING SYSTEM.	Average yield per acre, 1911 to 1928.		Increase for manure.
	No manure.	Manure.	
	Bus.	*Bus.*	*Bus.*
Alfalfa, corn, wheat, wheat (*a*)	21.3	25.3	4.0
Corn, cowpeas, wheat (*b*)	17.7	22.0	4.3
Wheat continually (*c*)	15.4	22.2	6.8

(*a*) A 16-year rotation: alfalfa 4 years, corn, wheat, wheat repeated for 12 years. Manure, 5 tons per acre on third-year alfalfa and 5 tons per acre on ground to be planted to corn, except no manure is applied for first crop of corn following alfalfa. Thus 20 tons of manure per acre are applied each 16 years.

(*b*) Manure, 2½ tons per acre for corn; also 2½ tons per acre for wheat. Thus 5 tons of manure per acre are applied each 3 years.

(*c*) Manure applied as a top dressing in late fall or winter, 2½ tons per acre annually.

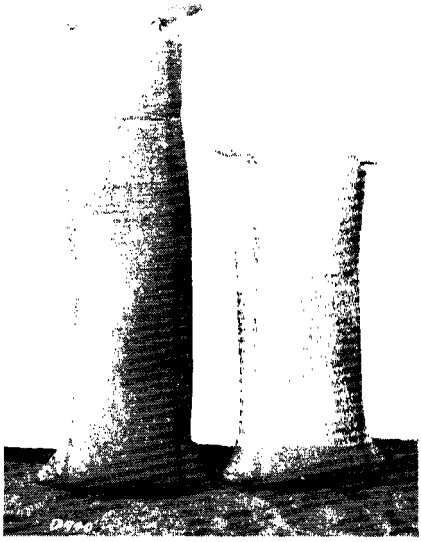


FIG. 5.—A top dressing of manure (2½ tons annually) on wheat at the Kansas Agricultural Experiment Station produced an average yield of 22.2 bushels per acre (indicated by the sack on the left) as compared with 15.4 bushels per acre (right) without manure.

In western Kansas manure has for the most part failed to give any marked increases in yield except on soils that have been eroded. In some cases a loss in yield has resulted from too heavy an application. A light top dressing applied during the winter will do no harm and may aid materially in reducing soil blowing and in maintaining the productivity of the soil.

COMMERCIAL FERTILIZERS FOR WHEAT

Whether or not it will pay to use commercial fertilizers for wheat depends largely on the soil and location. In central and western Kansas they have never paid. At Manhattan, some increases in the yield of wheat have been secured by using commercial fertilizers as shown in Table VI, but in general they have not been sufficient to prove profitable.

TABLE VI.—EFFECT OF COMMERCIAL FERTILIZERS ON THE YIELD OF WHEAT AT THE KANSAS AGRICULTURAL EXPERIMENT STATION.

Manhattan, Kan.

CROPPING SYSTEM.	Average yields in bushels per acre, 1911 to 1927.			
	Not fertilized.	80 pounds superphosphate per acre.	80 pounds superphosphate and 40 pounds muriate of potash per acre.	80 pounds superphosphate, 40 pounds muriate of potash, and 80 pounds nitrate of soda per acre.
Alfalfa, corn, wheat, wheat	19.5	22.2	23.7	26.0
Corn, cowpeas, wheat	17.0	18.8	20.0	24.2
Wheat continually	14.9	16.5	18.5	19.6

Much better results have been secured by farmers and in experiments on poorer types of soil farther east and especially in southeastern Kansas as shown in Table VII and illustrated in figure 6.

TABLE VII.—THE EFFECT OF FERTILIZERS ON THE YIELD OF WHEAT IN SOUTHEASTERN KANSAS.

TREATMENT.	Average yield per acre, 1912 to 1928.
	Bus.
None	16.9
Phosphorus	21.5
Phosphorus and nitrogen	21.5
Phosphorus, nitrogen, and potassium	22.1

SOILS ON WHICH TO APPLY FERTILIZERS

As previously stated, fertilizers cannot be used with profit on the wheat lands of central and western Kansas. Neither can they be used profitably on bottom land soils nor on the better upland soils

such as the glacial and limestone areas of eastern Kansas. However, the less fertile upland soils, such as those formed from sandstone and shale and others which have been eroded, respond very profitably to fertilizers. The white ashy lands, gray lands, and brown lands of southeastern Kansas are usually more in need of fertilizers than any other soils in the state, although there are areas as far west as Wichita that require fertilizers for maximum profits.

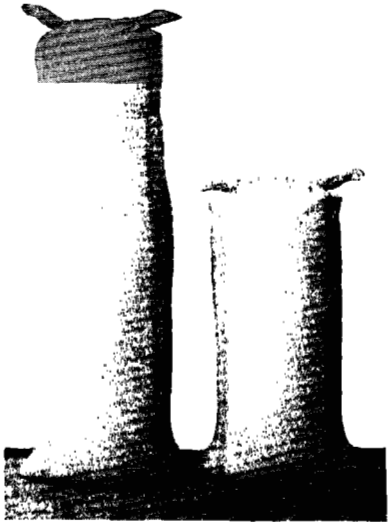


FIG. 6.—In experiments in eastern Kansas in 1922 an application of phosphorus produced 34.3 bushels per acre (left) as compared with 21.7 bushels (right) for unfertilized wheat.

KIND OF FERTILIZERS TO USE

Those soils which need fertilizer usually respond best to phosphorus or to phosphorus and nitrogen. Pratically all of the soils of Kansas are well supplied with potash and for this reason it is not usually necessary to purchase this plant food element as a fertilizer. The small increases sometimes resulting from the use of potash are not usually sufficient to justify the expenditure.

Phosphorus can be purchased in superphosphate (acid phosphate), rock phosphate, steamed bone meal, or in a mixed fertilizer containing a high per cent of phosphorus. Steamed bone meal and superphosphate have usually been found to be the cheapest sources of supply. The bone meal contains a small amount of nitrogen in addition to the phosphorus.

There are a number of different sources of nitrogen, but the most important at the present time are sodium nitrate, ammonium sulphate, and packing house by-products. A number of artificial nitrogen fertilizers are coming on to the market, but their use has not been common.

Since it has not been found practical to use nitrogen fertilizers alone they are used in combination with phosphorus as in bone meal or one of the mixed fertilizers. When a mixed fertilizer is to be used it should be of the approximate formula of 2-16-0 or 4-12-0 depending upon the amount of nitrogen needed.

When considering the use of nitrogenous fertilizers on a large scale, it should be remembered that in general the cheapest way to add nitrogen for most Kansas farmers is by the use of farm manure and the growing of legume crops.

APPLYING FERTILIZERS

The best rate to apply fertilizers will vary with the composition of the fertilizer and the condition of the soil. Under Kansas conditions, however, the rate must not be excessive because of the danger of the crop "firing" during hot, dry weather. Experiments conducted in cooperation with W. H. Shaffer, of Columbus, Kan., and the results secured by farmers, indicate that the most economical rate to apply bone meal is about 100 pounds per acre, except where it is used every year. when the amount may be reduced. Superphosphate (acid phosphate) and high-grade mixed fertilizers, as 2-16-0, should be applied at the rate of about 125 to 150 pounds per acre except where the application is made annually.

It is evident, from the data given in Table VIII, that applications

TABLE VIII.—EFFECT OF DIFFERENT RATES OF APPLYING SUPERPHOSPHATE ON THE YIELD OF WHEAT AT COLUMBUS, CHEROKEE COUNTY, KANSAS.

On the farm of W. H. Shaffer.

Pounds superphosphate applied per acre annually.	Yield in bushels per acre.									
	1920.	1921.	1922.	1923.	1924.	1925.	1926.	1927.	1928.	Av., 9 yrs.
None	11.8	13.6	15.8	21.7	18.1	18.6	20.8	7.8	21.9	16.7
50	13.8	17.9	19.2	28.2	22.5	32.6	25.7	10.0	32.0	22.4
100	12.9	14.8	17.0	28.3	23.6	24.9	29.5	16.5	26.3	21.5
150	10.8	17.5	16.2	25.6	24.7	28.6	26.5	12.1	26.4	20.9
200	11.7	15.4	17.3	28.8	20.9	28.3	31.6	12.1	27.3	21.5
250	12.4	14.7	16.6	25.7	22.4	29.0	28.8	9.5	26.8	20.7

of superphosphate (acid phosphate) at rates in excess of 150 pounds per acre will have little or no advantage over lighter applications. It must be remembered, however, that the results given above were secured on land that received the fertilizer every year.

Fertilizers can be applied most advantageously at the time of seeding with a combination grain and fertilizer drill. When this implement is not available, the fertilizer may be broadcast on the land and harrowed into the soil previous to seeding, but results secured from this method are not so satisfactory as those secured where the combination drill is used.

Spring applications of superphosphate to fall-seeded wheat have not given profitable returns. In extreme cases when the soil is very low in nitrogen and the wheat plants are yellow and retarded in the spring, it is profitable to use about 50 pounds of ammonium sulphate or sodium nitrate per acre as a surface dressing after spring growth has started. It is very doubtful, however, if this is a safe practice for central or western Kansas because of the limited rainfall in those regions.

APPLICATIONS OF STRAW FOR WHEAT

The common practice of burning stubble and straw is an undesirable one from the point of view of maintaining the soil in a productive condition. Thus in experiments conducted at Manhattan for four years, burning the stubble resulted in an average decrease of about 2 bushels of wheat per acre. The results of this experiment, which also included applying straw before and after plowing, are given in Table IX. It will be seen that applying straw before the ground was plowed and also after plowing, when the ground was plowed deep, gave profitable increases in yield. In these experiments the application was at the rate of about 3,000 pounds of straw per acre.

TABLE IX.—THE EFFECT OF APPLICATIONS OF STRAW AND OF BURNING STUBBLE ON YIELD OF WHEAT.

Manhattan, Kan.

	Average yield per acre.			
	No straw applied.		Straw applied.	
	Stubble not burned.	Stubble burned.	Before plowing.	After plowing.
	Bus.	*Bus.*	*Bus.*	*Bus.*
Plowed deep in July	27.6	25.2	28.8	28.8
Plowed shallow in July	27.2	26.0	28.0	25.7

Top dressings with straw during the winter are sometimes desirable for the purpose of preventing soil blowing and to protect the wheat from winter injury. However, such top dressings tend to retard growth in the spring and generally reduce yields except when coil blowing or winter injury would otherwise occur.

Unfortunately no experiments have been conducted to determine the effect of putting the straw back on the land in western Kansas as is done with the combine. Such experiments have been started and in time no doubt will supply valuable information. There are good reasons to believe that the effect will be beneficial except when there is a very heavy crop of straw. General experience indicates that turning under a heavy growth of straw causes the ground to dry out and results in a short crop the following year. In such cases it is advisable to leave most of the straw near the surface of the ground as when the ground is prepared with a one-way disk plow (p. 33) or a lister. In extreme cases it may be necessary to burn it, but this should be avoided as far as possible.

PREPARING THE GROUND FOR WHEAT

The preparation of the ground is perhaps the most expensive single item in growing wheat, and as shown by recent experiments, has a remarkable effect on the crop. The best method, however, varies greatly for different parts of the state, for different soils, and even for different seasons. For this reason no general rules can be given. Each farmer will do well to study his own conditions, keeping in mind especially what it is desirable to accomplish and follow those methods which will enable him to reach the desired end. In the following paragraphs an attempt is made to present some of the general principles involved rather than to give specific directions.

NITRATES IN RELATION TO PREPARATION OF THE GROUND

For many years it was thought that the conservation of water in the soil was the most important purpose of preparing the ground and hence that those methods should be used which would best accomplish this purpose. The importance of moisture is still recognized, but in recent years it has been clearly shown that in the eastern part of the hard wheat region and elsewhere, the development of nitrates in the soil is much more important.

Nitrogen, as is generally known, is one of the most important plant foods. The organic matter of the soil contains a high per cent of nitrogen, but until this organic matter has decayed the nitrogen cannot be absorbed by plants. The process by which it is made

available is called nitrification and the compounds containing the available nitrogen are called nitrates. A large quantity of nitrates in the soil when the wheat is seeded is usually necessary for a large crop.

TIME OF PLOWING AND NITRATES

One of the most certain ways to insure a large supply of nitrates in the soil is to plow, list, or otherwise cultivate the ground immediately after harvest. This especially is true in eastern and central Kansas. If stubble ground in this area is not cultivated soon after

FIG. 7.—An ideal seed bed for wheat. Note the cloddy surface which will reduce soil blowing and the compact subsurface which will hold moisture.

harvest, weeds and volunteer grain make a rapid growth and soon use up all the nitrates in the soil and the wheat must later get along with a limited supply until this vegetation has had time to decay.

THE VALUE OF GOOD TILTH

Another reason for preparing the ground is to get it into that condition where it is said to be in good tilth. (Fig. 7.) Ordinarily this means nothing more than that the soil is well pulverized and compact beneath the surface. Soil blowing must be considered and for this reason, as explained later, the surface soil must be left somewhat cloddy and rough. (Fig. 8.) Ground in this condition absorbs moisture readily and affords a favorable environment for bacteria and the liberation of plant food.

FIG. 8.—Rough ground that holds the snow and reduces the danger of soil blowing.

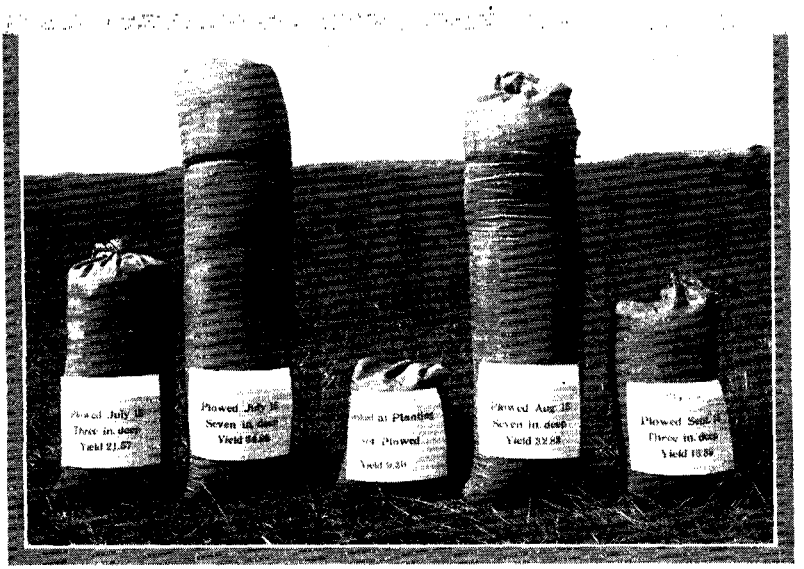


FIG. 9.—Sacks of wheat showing comparative yields of wheat secured from five different methods of preparing the seed bed. (Manhattan, Kan.)

PREPARING THE GROUND IN EASTERN KANSAS

The results of experiments at the Agricultural Experiment Station at Manhattan as shown in Table X and illustrated in figures 9 and 10 may be taken as fairly representative of what may be expected from different methods of preparing the ground for wheat in eastern Kansas. The experiments were conducted on upland soil of medium fertility.

TABLE X.—THE EFFECT OF DIFFERENT METHODS OF PREPARING THE GROUND ON THE YIELDS OF WHEAT.

Manhattan, Kan.

METHOD OF PREPARING THE GROUND.	Yield per acre, average for 10 years, 1911 to 1920.
	Bus.
Double disked at seeding time, no other treatment	7.8
Plowed September 15, 3 inches deep	12.3
Double disked July 15. Plowed September 15, 7 inches deep	17.4
Double disked July 15. Plowed August 15, 7 inches deep	17.8
Listed July 15; ridges worked down	18.0
Listed July 15; ridges split August 15	18.3
Plowed July 15; 7 inches deep	20.7
Plowed August 15, 7 inches deep	19.1
Plowed August 15, 7 inches deep. Not worked till September 15	16.8
Plowed September 15, 7 inches deep	11.7
Plowed July 15, 3 inches deep	15.0

Early Plowing.—As shown in these experiments the most uniformly successful method of preparation is plowing early and to a reasonable depth. If the previous crop is oats or wheat an ideal method is to plow in July or early August to a depth of 6 or 7 inches, turning under all stubble and weeds. About a month later or as soon as the weeds and volunteer grain become well started the ground should be double disked and cultivation should be practiced thereafter as often as necessary to control weeds and keep the soil in good condition. If the ground is moist when plowed, it is a good plan to disk or harrow immediately after the plow; otherwise it dries out hard and cloddy. Nothing is gained by disking or harrowing after the plow if the ground is dry. When it is not possible to plow immediately after harvest it is advisable to disk the ground and then plow as soon as conditions will permit.

FIG. 10.—The result of preparing the ground in the usual way (right) as compared with a method (left) followed by many progressive farmers.

In these experiments, the results of which are given in Table X, wheat was grown on the same land every year. A much better way is to grow it in rotation with other crops as explained on pages 11 to 16. An experiment in which wheat is rotated with corn and oats has given the results presented in Table XI. Here also early plowing has greatly increased the yields.

TABLE XI.—THE EFFECT OF DIFFERENT METHODS OF PREPARING THE GROUND ON THE YIELDS OF WHEAT WHEN THE CROP IS GROWN IN ROTATION.

METHOD OF PREPARING THE GROUND.	Average yield per acre, 1913 to 1927.
	Bus.
Plowed July 15, 12 inches deep	25.7
Plowed July 15, 7 inches deep	26.7
Plowed July 15, 3 inches deep	26.8
Plowed August 15, 7 inches deep	23.2
Plowed September 15, 3 inches deep	17.0

In the experiment cited above, the ground in each case was prepared for corn by fall plowing to a depth of about 7 inches. It was also prepared uniformly for oats. The results secured emphasize the value of early plowing. They also show, as will be pointed out later, that when wheat is grown in rotation and the land is well prepared for the other crop, shallow plowing in July gives as good results as deep plowing.

Disking After Harvest.—If it is impossible because of other work to plow all land early a good plan is to disk the stubble immediately after the grain is harvested. The ground can be covered quickly in this way, weeds are killed, and moisture is conserved, making it possible to plow to better advantage at any time thereafter. Experiments at Manhattan (Table X) show that July disking followed by early September plowing has produced nearly 6 bushels more per acre than plowing at the same time without the early disking.

In these experiments early listing has given nearly as large yields as has early plowing. It has the advantage of covering the ground rapidly and where there is a large acreage to be prepared is a method that may well receive serious consideration. Late listing is seldom satisfactory; when the work is delayed, plowing is likely to be much better. Listing does not turn the stubble under so thoroughly as does plowing, and where Hessian flies are prevalent they are not so completely killed.

Depth of Plowing.—Table XI, giving the results of experiments at Manhattan, indicates there is little to be gained by plowing land for wheat deeper than is necessary to turn under stubble, trash, and weeds and to get the land in good condition. Similar results have been secured elsewhere. The depth necessary to secure these results will vary with conditions but is seldom more than 6 or 7 inches. On land rotated with other crops and occasionally plowed rather deep for them, a depth of 4 or 5 inches will often produce as large yields of wheat as will deeper plowing.

Plowing Dry Ground.—Some farmers hesitate to plow when it is very dry because of fear that the ground will be injured. There seems to be no basis for this fear so far as Kansas is concerned. Plowing under such conditions is of course very difficult and expensive and in some cases does not pay. Also the ground may come up in large clods or lumps which may be difficult or impossible to work down in time for seeding. It is, however, extremely desirable

to have the ground plowed early, even if it is dry, in order to take full advantage of rains that may come later, and this advantage is often sufficient to more than offset the objections. This applies especially to eastern and central Kansas.

On the other hand, ground should never be plowed when it is so wet that it turns up slick on the moldboard and runs together. Such land dries out, cloddy and lumpy and may not produce satisfactory yields for two or three years.

Cultivation After Plowing.—If the ground is dry when plowed thereis seldom any advantage in working it immediately after. It should, however, be disked or harrowed sufficiently to keep down all weeds and volunteer grain. Cultivation in excess of what is necessary to accomplish this result seldom pays; or rather if the early-plowed ground is cultivated sufficiently to keep down weeds and volunteer grain, the cultivation will be sufficient to get it into good condition.

PREPARING THE GROUND IN CENTRAL AND WESTERN KANSAS

In central and western Kansas, where wheat yields are usually limited by the moisture available for the crop, it is necessary to practice those methods which will aid as far as possible in storing soil moisture. The results of certain experiments at the Fort Hays, Colby, and Garden City branch stations, relating to time and methods of preparing the ground in central and western Kansas, are

TABLE XII.—RELATION OF METHOD OF PREPARATION TO THE YIELDS OF WHEAT IN WESTERN KANSAS.

METHOD OF PREPARATION.	Hays.		Colby.	Garden City.
	Average yield per acre, 1907 to 1927.	Number of failures in 21 years.	Average yield per acre.	
			1914 to 1927.	1918 to 1927.
	Bus.		*Bus.*	*Bus.*
Late fall plowing	10.1	11	10.0	4.1
Early fall plowing	15.7	6	8.2	5.3
Early listing	19.1	4	.....	7.5
Summer fallow	23.9	3	15.7	9.4

Early Versus Late Plowing—The results at Hays show a decided advantage for early as compared with late plowing, but the difference is not great at Garden City, and at Colby late plowing

has produced slightly better yields. It appears that in extreme western Kansas there is no great advantage in plowing immediately after harvest as compared with later plowing except in years of heavy summer rainfall, since there is little or no rain during the summer and usually no weeds. Early plowing therefore accomplishes nothing that is not done almost as well by late plowing. As pointed out later it may be advisable in some cases not to plow at all.

Listing in Western Kansas.—Early listing has given results second only to fallow as a method of preparing the land for wheat in the experiments referred to above. Late listing has not been included in these experiments, but is known not to be generally satisfactory because of the difficulty in getting a good seed bed in dry seasons. The principal advantages of early listing are the rapidity with which the ground can be covered, and the low cost as compared with plowing. Leaving the stubble on and near the surface of the ground is also an advantage in that it tends to prevent soil blowing and to leave the soil in better condition to absorb moisture. Covering a heavy growth of stubble as by plowing sometimes leaves the ground too loose.

Summer Fallow for Wheat.—Summer fallow has produced the highest average yield of any method used in these experiments. Also the number of failures as shown by the results at Hays have been materially fewer than for other methods. It must be remembered that the high average yield is secured at considerable extra expense such, for example, as the use of the land for an extra year and some extra cultivations. Nevertheless, the gain is believed to be sufficient to justify growing a portion of the wheat on fallow as outlined on pages 15 to 17. The farther west one is located the greater will be the advantage in using the fallow.

In considering the use of fallow the residual effect should not be overlooked. There is considerable evidence to show that fallow favorably affects the yield of wheat for two or even three years after

that which may reasonably be expected. The residual effect of the fallow is well illustrated by the yields of wheat secured in a fallow, wheat, wheat, wheat cropping system as given in Table XIII.

Methods of Summer Fallow.—Successful summer fallowing consists of handling the land in such a way as to conserve moisture, prevent weed growth, and to have the ground firm and not too finely

TABLE XIII.—EFFECT OF FALLOW ON THE YIELD OF WHEAT AT THE FORT HAYS EXPERIMENT STATION.

Hays, Kan.

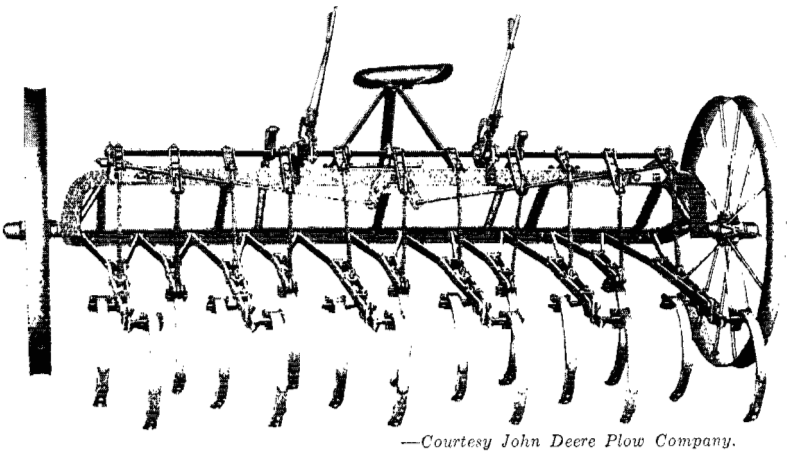
CROPPING SYSTEM.	Average yield per acre, 1918 to 1927.
	Bus.
Wheat after fallow	26.9
Wheat every year	20.1
Wheat second year after fallow	22.5
Wheat third year after fallow	22.8

pulverized at seeding time in the fall. One of the best methods is to double disk in the spring at a time that will best kill the first crops of weeds. The ground should then be plowed or listed in late May or June in time to plow under the second growth of weeds and to have the plowing completed before wheat harvest. The spring disking may be dispensed with if the plowing can be done in May. During the summer the ground should be cultivated (figs. 11 and 12) just frequently enough to keep down weed growth. A shovel type of cultivator or a spring-tooth harrow are good implements to use for the summer cultivation because they leave the land rough and do not pulverize the soil. If fallowed land is worked during the summer with a disk or smoothing harrow the work should be done when the soil is moist. Sandy types of soil or other land which is inclined to blow should be prepared for summer fallow with the

FIG. 11.—Cultivating a fallow for wheat at the Fort Hays Branch Experiment Station. (Hays, Kan.) The ground is left rough for most of the summer, thereby absorbing moisture and preventing soil blowing.

lister. The lister furrows should be worked down early enough that the ground will be packed uniformly.

Disking and Stubbling-in Wheat.—A practice fairly common in western Kansas is that of seeding wheat in small-grain stubble with no previous preparation, or at best with early disking. Frowned upon at first as a careless and not to be recommended practice, it has come to be recognized as a safe and dependable method for certain conditions. The principal advantages are economy in preparation and prevention of damage from soil blowing. In this area there is ordinarily very little weed growth between harvest and



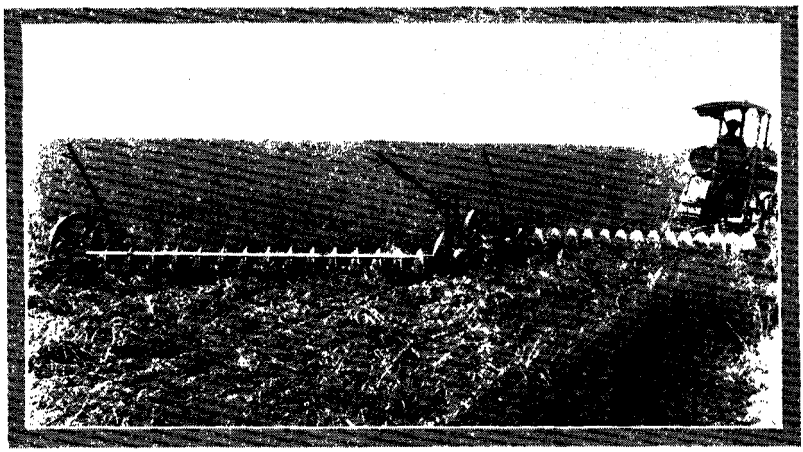
—Courtesy John Deere Plow Company.

FIG. 12.—A spring-tooth cultivator, an excellent tool for cultivating fallow or other ground to be left rough.

seeding, and the soil often does not become hard as it dries out. If the ground has been well prepared for the preceding crop, as by early plowing or fallow, and is free of weeds and not compact, it may be in excellent condition for the second crop with no further preparation. For such conditions stubbling-in can be recommended.

There is great danger, however, that the limitations of this method will not be realized and that it will be used too generally for satisfactory results. Perhaps the most serious objection is the tendency to follow this practice year after year on the same land. If used it should be rotated with other methods. While stubbling-in has been found successful in many cases in western Kansas, similar methods at Manhattan in eastern Kansas have produced the poorest yields of any method that has been tried.

The One-way Disk Plow.—Recently there has come into quite general use the one-way disk plow, commonly called the one-way plow. (Fig. 13.) Essentially, this implement is nothing more than a heavy disk harrow with all the disks set one way. The disks are considerably larger than those commonly found on disk harrows. It therefore cuts deeper, covers stubble more completely, and because of the one-way feature, leaves a smoother field than the ordinary disk harrow.



—*Courtesy Caterpillar Tractor Company.*

FIG. 13.—The one-way disk plow in operation in a Kansas wheat field.

The one-way plow seems to have a place in western Kansas agriculture. It does a better job than the disk harrow and hence is to be preferred, where disking is the only preparation. It can also be used to advantage immediately after the combine or header on land to be listed or plowed later.

Preparing the Ground After the Combine.—The advent of the combine has introduced a new problem in preparing wheat ground, viz., the question of what shall be done with the large amount of straw left on the land. Many farmers feel that it is necessary to burn this straw since turning it under frequently leaves the ground loose and in poor physical condition.

Whatever may be said as to the immediate effects it seems probable that burning this straw will ultimately prove injurious. On the other hand turning the straw back to the land, as done with the

combine, will undoubtedly help to maintain the organic matter supply of the soil and should prove advantageous.

The problem therefore has to do with handling the land without burning the straw and at the same time avoiding the ill effects of turning under at one time so much straw. Although there are no direct experimental data on the subject there are good reasons for believing that the use of the lister, the disk harrow, or the one-way disk plow, all of which leave a considerable portion of the straw at or near the surface, will largely avoid these difficulties and make it generally unnecessary to burn the straw and stubble.

Control of Soil Blowing.—One of the most serious difficulties in growing wheat in central and western Kansas is the control of soil blowing. Damage most frequently occurs where wheat has been planted on summer-fallowed or corn-stubble land. As a rule, cultivation in excess of that necessary to control weeds and settle the ground is favorable to soil blowing. Working ground too dry also tends to pulverize it too much, making it more likely to blow. An ideal condition is reached when the surface is left cloddy but with a firm, moist seed bed beneath, as shown in figure 7.

Much of the trouble from soil blowing can be overcome by keeping the surface rough as by listing; by working the surface when it is moist with a duck-foot cultivator or spring-tooth harrow; by leaving stubble and trash near the surface of the ground; by spreading straw and disking it enough to make it hold; and by cultivating and planting at right angles to prevailing winds. (Fig. 11.) The excessive use of the disk and smoothing harrow makes the soil fine and subject to blowing. If the soil in a wheat field begins to blow the ground should be cultivated at once in strips with some implement that will leave it in a very rough condition. In severe cases it may be necessary to make a series of four or six lister furrows across the field about two rods apart at right angles to the direction of the wind.

KINDS OF WHEAT IN KANSAS

Practically all wheat grown in Kansas is winter wheat, less than one-tenth of 1 per cent of the crop being sown in the spring. The principal reason for this is the small yields of the latter as compared with winter wheat. Thus at Manhattan, as shown in Table XIV, winter wheat yields several times as much as spring wheat, and at the branch stations in western Kansas, from two to three times as much. The small amount of spring wheat that is grown is confined to extreme northwestern Kansas. Even in this area winter wheat

on the average is more profitable, and spring wheat is sown only when winter wheat fails to germinate or is killed during the winter. Even then barley rather than spring wheat should usually be grown.

TABLE XIV.—WINTER WHEAT VERSUS SPRING WHEAT VERSUS BARLEY.

CROP.	Manhattan.	Hays.	Colby.	Garden City.
	Average yield in bushels per acre.			
	10 years.			8 years.
Winter wheat	35.0	16.8	25.9	15.6
Spring wheat	5.2	6.6	7.9	8.1
Spring barley	19.2	24.2	19.9	22.6

SPRING WHEAT

For those cases where spring wheat is desired Marquis is the most satisfactory variety. An earlier variety known as Prelude has given promising yields but has not been generally grown. It shatters rather badly. Spring wheat should be sown as early in the spring as practical. Four to five pecks per acre is usually a satisfactory rate of seeding.

HARD AND SOFT WINTER WHEATS

Both hard and soft winter wheat varieties are grown in Kansas. All the hard wheats are bearded, have smooth chaff and a relatively small, hard, red grain. All except Blackhull and selections from Blackhull have white chaff. Many attempts to produce a beardless hard wheat have been made, but unfortunately no such variety has ever been found that equals the bearded varieties in yield.

Soft wheats may be bearded or beardless and have smooth or velvet chaff. The chaff and beards may be of various colors, ranging from white to a dark reddish brown or almost black. The grain may be red or white, but no white-grained varieties are grown in Kansas.

Soft wheat, as the name implies, has rather soft grain. The flour has less "strength," meaning generally that an equal amount will not produce so large a loaf or stand such severe treatment in mechanical mixers. For these reasons, it is considered less desirable than hard wheat for bread, but more desirable for hot biscuits, crackers, and pastries.

The relative price of hard wheat and soft wheat varies with the

supply and demand. Hard wheat usually commands a premium, but when the supply of soft wheat is short, the reverse may be true.

Where to Grow Soft Winter Wheat.—Soft winter wheat is grown in the eastern part of the state only. It is less resistant to drought, hot winds, and cold than is hard wheat On the other hand, most varieties have a stiffer, stronger straw and consequently, are less likely to lodge in wet seasons and humid climates.

The map (fig. 14) shows the areas where hard wheat and soft wheat predominate. It should be understood that some hard wheat is grown in the soft-wheat belt, especially on upland, and, con-

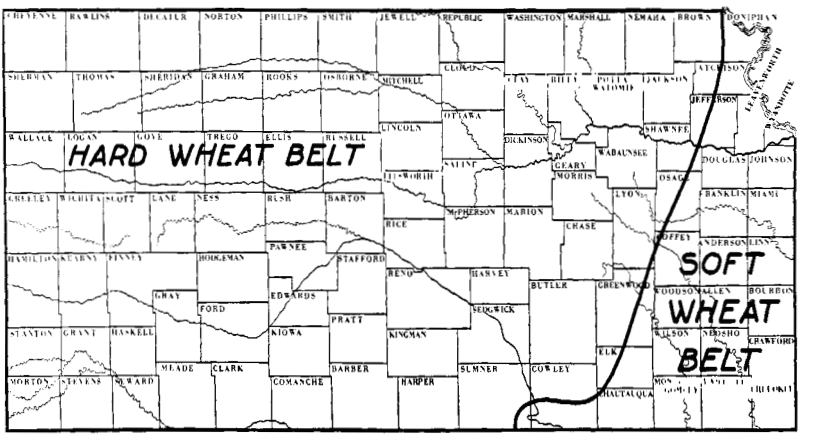


FIG. 14.—The hard- and soft-wheat belts of Kansas.

versely, some soft wheat in the hard-wheat belt, particularly along creek and river bottoms.

In central and western Kansas hard winter wheat, such as Kanred, Turkey and Blackhull almost invariably yields more than the best soft wheats. The chief reason appears to be their greater resistance to winterkilling and drought. Thus at Manhattan, the best varieties of hard wheats have yielded about 4 bushels per acre more than the best soft wheats when grown on low upland. On the other hand, tests in eastern and southeastern Kansas show that soft wheat varieties generally give the best yields.

VARIETIES OF WHEAT FOR KANSAS

Everyone recognizes the value of good varieties of wheat, but not everyone knows how easy it is to get poor varieties nor how difficult it sometimes is to get a really superior variety.

Characteristics of a Good Variety.—Many farmers choose a variety because it has extra long heads, because it has three grains or more to each mesh or spikelet, or because the heads are well filled at the base. Still others choose those which have the largest grain. Such choices are based on the belief that these characters are associated with high yield, and hence if those varieties with long heads, well-filled meshes, etc., are chosen, the highest-yielding varieties will necessarily be secured.

Nine times out of ten this is a mistake. There are two reasons for this. The most important is the fact that yields really depend a great deal more on other things such as winterhardiness, early ripening, nonlodging, and ability to resist plant diseases, insects, and unfavorable weather. The other reason is the fact that if a variety has a short head or few grains to the mesh it may compensate for this deficiency by producing a larger number of heads per acre, by producing plumper, better-filled grain, or in other similar ways.

The important points to look for, then, are such things as winterhardiness, early maturity (in order to avoid hot winds, drought, rust, etc.), stiff straw, resistance to plant diseases and insects, and quality.

Winterhardiness and Yield.—The importance of winterhardiness depends largely upon the location in the state. Thus the winter temperatures are much lower in northwestern than in southeastern Kansas, and hence a hardier variety is required. Currell, a soft wheat seems to be hardy enough for average conditions in the latter area, but is not sufficiently hardy for northeastern Kansas. Even in southeastern Kansas it winterkills rather too frequently and a hardier variety would be desirable. Blackhull appears to be sufficiently hardy for most winters in south central Kansas but certainly is not for the northwestern corner of the state. The need for considering winterkilling in choosing varieties is illustrated in figure 15.

Winterkilling has not been an important factor in Kansas since the crop year of 1917. This does not mean that the climate is changing or that winterkilling will be less important in the future. There is every reason to believe that severe winters will come again and that severe losses from winterkilling will again occur. When they do those growing winter-hardy varieties will suffer the least.

Early Maturity and Yield.--There is certainly an important relation between time of maturity and yield. An early-maturing wheat

is more likely to escape damage from hot winds, drought, and rust. On the other hand, a late-maturing variety may be in a position to take advantage of a late rain and because of a larger, more vigorous growth will almost always produce a larger yield when conditions generally are favorable.

In a general way it may be said that there are not enough early varieties in Kansas to choose from. It is almost certain that an earlier variety than those now available would produce larger yields in many parts of the state. Also it would often be advantageous to

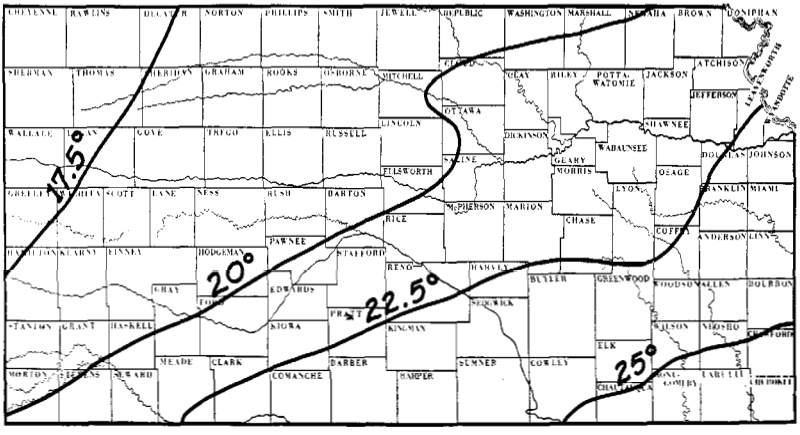


FIG. 15.—Mean minimum winter temperatures in Kansas. Note the change in winter temperature from southeastern to northwestern Kansas; also that the winter temperature in southwestern Kansas is about the same as in northeastern Kansas.

grow two varieties on the same farm, one early and the other late, so that all wheat would not ripen at the same time.

There are early maturing varieties, but unfortunately they are seriously defective in other respects. Plant breeders of the Agricultural Experiment Station and others are endeavoring to correct these defects by crossing with other varieties. Until success crowns their efforts the practical farmer must content himself with what is available.

Bearded Versus Beardless Wheat.—As is well known most of the wheat grown in Kansas is bearded or awned. Many farmers object to the beards or awns and would much prefer varieties without them. Many efforts have been made in Kansas and elsewhere to produce such varieties. So far as hard winter wheat is concerned these efforts have been fruitless. It is now believed that the awns

perform a useful (but for the most part unknown) function which enables a variety possessing them to produce better yields than awnless varieties. This seems to be especially true on poor land and in dry climates. Beardless varieties on good land in the eastern United States appear to yield as well as the bearded.

Shattering and Lodging.—The use of the combine has made it increasingly important that so far as possible those varieties be grown which will stand with little or no loss after they are ripe. Lodging of the straw and shattering of the grain are the principal sources of loss. Fortunately Kansas suffers very little from shattering, due to the fact that most of the widely grown varieties hold the grain with great tenacity. On the other hand, lodging frequently occurs, especially when wheat is grown on rich land. Lodging is especially serious if it occurs before the grain is ripe since it then prevents proper filling of the grain as well as makes it difficult to harvest.

Unfortunately there are no varieties that successfully resist lodging under all conditions. There are marked differences in this respect, however, and hence a marked tendency to lodge is one of the defects that must be considered in choosing a new untried variety.

Resistance to Insects and Plant Diseases.—Insects and plant diseases exact a heavy toll from the wheat grower. Smut, foot rot, several kinds of rust, black chaff disease, chinch bugs, and Hessian fly are a few of the more important. It is obvious that a variety that is resistant to any of these pests and at the same time not markedly defective in other respects would be worth considering. Some important differences are known to exist but as yet none of these pests can be controlled by the use of resistant varieties. Thus soft wheats are known to be attacked less by Hessian fly than are the hard wheats and Blackhull is more resistant than Turkey or Kanred, but all of them will be destroyed if Hessian flies are numerous.

Also varieties are known which show high resistance or immunity to smut, but unfortunately those so far studied mature too late, are too easily killed in severe winters, or for other reasons are not adapted to Kansas conditions.

Quality and the Choice of Varieties.—Kansas owes its reputation as a wheat state very largely to the uniformly high-grade wheat that is produced. Kansas flour is recognized as among the best wherever flour is used. A premium is usually paid for Kansas wheat for this reason. It would, therefore, be highly unfortunate if va-

rieties that are markedly inferior in quality should be grown, The quality of the wheat and the flour is an important consideration in choosing varieties.

How to Know a Good Variety.—A serious difficulty in choosing varieties lies in the fact that no one variety possesses all the desirable features. Thus Turkey and Kanred are drought and cold resistant, but they have weak straw. Currell has a very stiff straw and is early, but is not winterhardy. Harvest Queen has a stiff straw but it is a soft wheat and often matures too late for central

FIG. 16.—A variety test of wheat at the Agricultural Experiment Station, rate, and on ground all

and western Kansas. Other varieties are resistant to Hessian fly but are not winterhardy, and still others are resistant to rust and resistant or immune to smut, but for various reasons do not produce satisfactory yields. Every variety that can be mentioned has some weakness or defect. This means that in choosing a variety, one should not base his choice on a single desirable character. It also means that determining the value of varieties is not a simple matter and that one should be extremely cautious in growing varieties which he knows very little about.

New Varieties.—Experienced farmers are justly conservative about growing new, untried, or inadequately tried varieties. Usually they attract attention because of an unusual appearance or an exceptionally high yield. Sometimes the high yield is due to planting on extra good ground, very early plowing, or other favorable con-

ditions which are overlooked. Often the season is peculiarly favorable for the new variety and not for others with which it is compared. Also, serious defects of the new variety may not be apparent. Thus if the winter is a mild one it may survive and make a good yield and yet kill badly in the average winter. Some examples of varieties that have misled Kansas farmers are Miracle or Marvelous wheat, also known as half-bushel or peek wheat, extensively distributed in southeastern Kansas about 12 years ago, and Burbank wheat which is still sparingly grown in the south central part of

Manhattan, Kan. All varieties were planted on the same day, at the same prepared in a similar way.

the state. Accurate tests under controlled conditions (fig. 16) are very helpful in choosing varieties.

Varieties of Soft Wheat.—The principal varieties of soft wheat grown in Kansas are Fulcaster, Harvest Queen, and Currell.

Fulcaster.—Fulcaster was produced in 1836 by S. M. Schindel, of Hagerstown, Md., and is a cross between Fultz and Lancaster, both eastern varieties. It is a bearded soft wheat and is the leading variety in southeastern Kansas. In general it yields better than the beardless varieties, especially on the thin soils of that section. It is somewhat less winterhardy than Harvest Queen and considerably less so than Turkey and Kanred. It is recommended for southeastern Kansas as far north as Franklin and Miami counties.

Fulcaster is grown throughout the United States under at least

45 different names, some of these being: Acme, Bluestem, Dietz, Ebersole, Egyptian, Amber, Farmer's Friend, Georgia Red, Golden Chaff, Ironclad, Kansas Mortgage Lifter, Lincoln, Red Wonder, Stoner, Miracle, Wonderful, and Rattlejacket.

Harvest Queen.—The leading beardless soft wheat in Kansas is Harvest Queen. (Fig. 17.) It was produced between 1895 and 1897 by E. S. Marshall of De Soto, Kan. Mr. Marshall propagated it

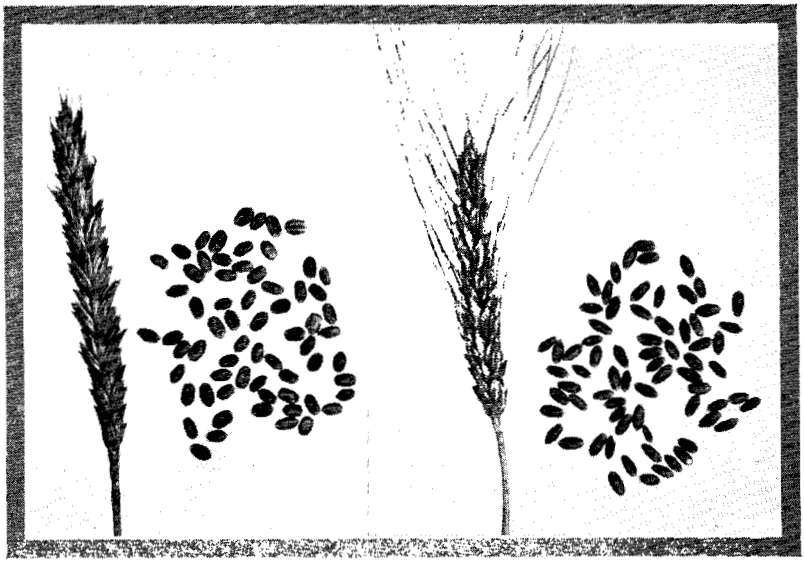


FIG. 17.—Heads and threshed grain of Harvest Queen (left), a popular variety of soft wheat in eastern Kansas, and of Kanred wheat (right). This latter variety is a selection from Turkey which has proved more winterhardy, resistant to rust, and high yielding.

from a promising plant selected in a field of wheat of unknown origin. This variety is the most winterhardy of any of the soft wheats grown in Kansas, but is less winterhardy than Kanred or Turkey. It has a stiff straw and is well adapted to the bottom lands of northeastern and east central Kansas. It is grown as far west as Clay and Cloud counties, but it is doubtful if it is as productive in this area as the better varieties of hard wheat.

Harvest Queen is also known by the names Kansas Queen, May Queen, Prairie Queen, Winter Queen, Red Cross, and Virginia Reel.

Currell.—The leading wheat in southeastern Kansas is Currell. It appears to be the least winter hardy of any variety grown on a

commercial scale in Kansas. It should therefore be confined to a few counties in southeastern Kansas. Its early maturit,y is a popular feature in that section.

Currell was originated by W. E. Currell, of Virginia, in 1881 as a selection from a field of Fultz wheat. The strain now grown in Kansas was selected by David Dunbar, of Hallowell, Kan., and often goes by the name of Dunbar-Currell. Currell is also known as Gill, Pearl Prolific, Perfection, Red Odessa, and by several other names.

Varieties of Hard Wheat.—Three important varieties or strains of hard wheat are grown in Kansas. They are Turkey, Kanred, and Blackhull. Kharkof wheat is for all practical purposes identical with Turkey.

Turkey.—Turkey wheat was brought to Kansas by Mennonites in 1873, and since that time has become the leading variety of the state.

Kanred.—Kanred wheat (fig. 17) was produced by the Kansas Agricultural Experiment Station by selecting and propagating the best single plant of several hundred selected from Turkey wheat in 1906. It has proved to be somewhat more winterhardy and slightly earlier than Turkey, and it resists certain kinds of stem rust better than any other known hard winter wheat. It is superior to Turkey in yield (Table XVI) and is a close competitor in every other respect.

Blackhull.—Blackhull wheat was originated by selection from Turkey by Earl G. Clark, of Sedgwick, Kan., in 1912. It has a slightly coarser, stiffer straw than other hard wheats, ripens a little earlier, has a higher test weight, and somewhat softer grain. The millers have objected to it because of its quality. It has produced higher yields than other varieties in all parts of Kansas, except the western and northwestern parts, but is definitely known to be less winterhardy than Turkey or Kanred.

Turkey Versus Blackhull Wheat.—Since about four million acres of Blackhull are grown in Kansas it is of much interest and importance to determine whether this variety is really a better yielder than Turkey and Kanred. Comparative yields with these varieties have been secured for nine years at the Agricultural Experiment Station at Manhattan, for seven years each at the Colby and the Fort Hays branch stations, for five years at the branch station at Tribune, for four years at the branch station at Garden City, and

for nine years in cooperative tests with farmers in various parts of the state. The cooperative tests with farmers number more than four hundred. The results of these tests are given in Table XV.

TABLE XV.—YIELDS OF BLACKHULL, TURKEY, AND KANRED ON THE AGRICULTURAL EXPERIMENT STATION FIELDS AT MANHATTAN, HAYS, COLBY, TRIBUNE, AND GARDEN CITY, AND IN COÖPERATIVE TESTS WITH FARMERS.

LOCATION OF TESTS.	Number of years tested.	Average yield per acre.		
		Blackhull.	Turkey.	Kanred.
		Bus.	*Bus.*	*Bus.*
Manhattan	10	36.6	33.3	34.8
Hays	7	24.2	19.2	22.3
Colby	10	27.4	25.2	29.3
Tribune	5	9.9	11.5	12.4
Garden City	4	25.7	19.0	25.0
Coöperative tests with farmers	9	22.9	20.1	21.3

It will be seen that on the average Blackhull has given somewhat better yields than Turkey except at Tribune, and better than Kanred except at Tribune and Colby. At these places, which are located in northwestern and extreme western Kansas, Blackhull has winterkilled to a greater extent than the other varieties, thus resulting in lower yields.

In considering the value of Blackhull for other sections of the state, the possibility of damage from winterkilling (fig. 18) should not be forgotten. The past nine winters have been milder than may normally be expected, and when severe winters again occur there is reason to believe Blackhull will yield even less than Turkey and Kanred. For further information regarding Blackhull the reader is referred to Kansas station bulletin 241.

Kandred Versus Turkey.—Kandred and Turkey have been grown in comparative yield trials at Manhattan for a period of 17 years and for various periods of time ranging from 6 to 12 years at the various branch stations. In addition they have been grown in 634 cooperative tests with farmers during a period of 15 years. The data are presented in Table XVI.

These are very extensive tests and would seem to show in the best possible way the relative value of these two varieties. It is significant to note that at Manhattan and at each of the branch stations Kanred has outyielded Turkey from 1.8 to 5.8 bushels, and in

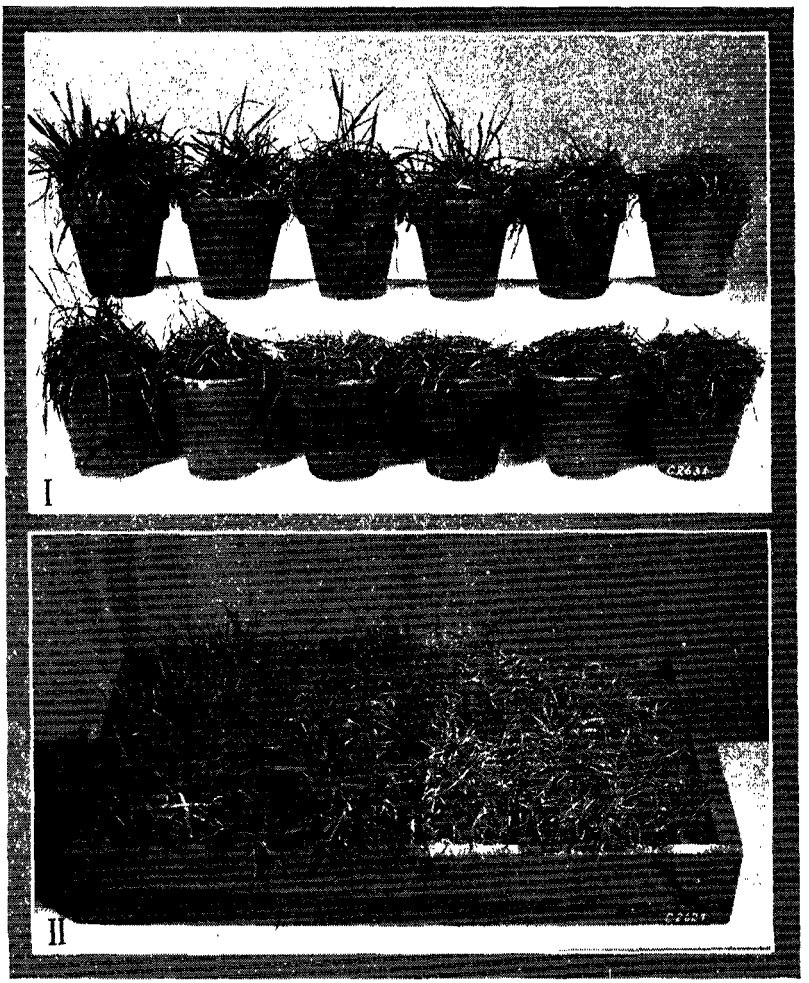


FIG. 18.—Freezing tests with Kanred and Blackhull wheat.

I. Top row, Kanred; bottom row, Blackhull; frozen at an approximate temperature of —10° F. for different periods of time. From left to right the pairs of pots were frozen 6, 12, 15, 18, 21, and 24 hours, respectively.

II. Left half, Kanred; right half, Blackhull; frozen 15 hours at an approximate temperature of —10° F.

It will be noted that all Blackhull plants were killed when frozen for more than 12 hours, whereas Kanred survived when frozen for 18 to 21 hours.

the 634 cooperative tests with farmers has produced an average gain of 2.1 bushels as compared with Turkey. The data seem to show beyond doubt that Kanred tends to produce higher yields than Turkey.

Kanred in a few cases has been observed to lodge more than Turkey, but with conditions that cause lodging both Turkey and Kanred are likely to go down. The slight difference between these varieties in this respect is not believed to be sufficient to justify any discrimination against Kanred in central and western Kansas. On the average Kanred has ripened about one day earlier than Turkey in these tests, and in milling tests has yielded somewhat more flour. No difference in protein content, quality, or other characteristics has been observed.

TABLE XVI.—COMPARATIVE YIELDS OF TURKEY AND KANRED, 1911 TO 1927.

LOCATION OF TESTS.	Number of years tested.	Average yield in bushels per acre.		
		Turkey.	Kanred.	Gain of Kanred over Turkey.
Agricultural Experiment Stations				
Manhattan	17	28.0	31.1	3.1
Hays	12	20.0	21.8	1.8
Colby	14	23.2	27.5	4.3
Tribune	8	9.8	12.6	2.8
Garden City	6	17.5	22.1	4.6
Coöperative Tests with Farmers				
634 farm tests	15	22.1	24.2	(a) 2 1

(a) Those familiar with statistical interpretation of experimental results will be interested to know that this difference is about 14 times the probable error, and hence by no reasonable possibility is it due to chance location of the plats or other similar experimental errors.

Superhard Blackhull.—Superhard Blackhull as it grows in the field is very similar to the ordinary Blackhull. The grain is harder, heavier, and of a finer appearance. It is claimed to be more productive and better than Blackhull in several respects. Rather extensive tests by the Agricultural Experiment Station have entirely failed to verify these claims, and on the other hand have indicated that the quality may even be inferior to that of Blackhull. Certainly it is inferior as compared with Turkey and Kanred, and decidedly less desirable than its appearance would indicate.

SEED WHEAT

Good seed is one of the prime essentials in wheat growing. To insure best yields of the highest quality nothing but adapted varie-

ties of clean, unmixed seed, free from rye, weed seed and smut should be sown.

PURE SEED

Experiments and practical experience show that it pays to use reasonably pure seed. Otherwise the grain may ripen unevenly or the crop may be docked in price because of mixture. The simplest and usually the most satisfactory way to secure pure seed is to purchase it from an agricultural experiment station or a dependable grower. Considerable extra expense is involved in producing pure seed, and no grower needing seed should hesitate to pay 50 to 100 per cent above the regular market price, or even more, for good, dependable seed.

HOW TO PURIFY SEED WHEAT

If the variety one is growing becomes mixed with other kinds of wheat or with rye, most of the mixtures can be eliminated by going through the field about heading time or just before harvest and pulling them out. It is practically impossible, however, to entirely remove all mixtures in a badly mixed field in this way. Usually it will pay in such cases either to buy new seed or to rouge with extra care only a small portion of the field from which seed is saved for general planting the following year. Rye mixtures cannot be entirely eliminated if wheat is grown continually on the same land. Some rye seed always shatters and grows with the next crop of wheat. To secure rye-free fields once they are contaminated it is practically necessary to rotate the wheat with other crops as well as to use rye-free seed.

CHANGING SEED

One of the most commonly suggested ways of increasing the yield of wheat is to change seed. If the grain is shrunken, affected with yellow berry, or if the yield is poor, many farmers believe that the seed is "running out." This is, without doubt, a mistaken idea. There is no evidence to show that wheat runs out, or that a change of seed increases the yield, while, on the other hand, numerous instances are known where farmers have grown the same variety for 20 or 30 years without ill effects.

In one sense, wheat does run out when neglected. Weeds get in and foul the land, and mature seed with the wheat. If not cleaned, the weed seeds are resown with the wheat and reduce the yield. Or smut gets in the wheat, and if not treated may increase from year to year. Also, small mixtures of rye or of other kinds of wheat may increase to a large per cent. This, however, is very different from

actual "running out," or deterioration in the variety, and can be corrected by treating for smut or cleaning or purifying the seed according to the circumstances.

If one is growing a good variety of wheat that is well adapted to the farm where it is grown, no change should be made unless it is certain that a better variety will be obtained.

YELLOW BERRY WHEAT FOR SEED

Yellow- berry in Kansas hard wheat is due mainly to wet seasons and to poor soils, especially soils deficient in nitrogen. The amount of yellow berry varies to some extent with the variety, but there is no variety that is not affected. It seems then that if one is growing a variety which experience has shown to be a good yielder and well adapted to the locality where it is grown, it should not be discarded because it contains yellow berry.

There is good evidence to show that yellow berry in wheat can be prevented or reduced by keeping up the fertility of the soil. There will usually be less yellow berry in wheat that is grown in rotation with legume crops, on fallow, or on early plowed ground than where no rotation is practiced or the ground is poorly prepared. Any practice that makes nitrogen available for the wheat is likely to reduce the amount of yellow berry and at the same time increase the yield.

CLEANING SEED

A much disputed question is whether it pays to use the fanning mill to clean and grade wheat for seed. Numerous experiments have been conducted, which for the most part, have given conflicting results. The following facts, however, appear to be definitely proved:

It pays to clean wheat that contains weed seeds, chaff, straw, and dirt, or diseased or shrunken kernels. Weeds rob the soil of food and moisture, and if present in the wheat are practically certain to reduce the yield. Chaff, straw, and dirt clog the drill and prevent uniform seeding. Diseased and badly shrunken kernels often do not germinate, and if they do, they produce small, weak plants that add little or nothing to the yield of the crop. If removed, the value of the screenings for chicken feed will pay for the cost of cleaning.

If wheat is well cleaned at the threshing machine, and is plump, free from weed seeds, dirt, and smut, and of general good quality, there is likely to be a small gain for cleaning. Thus as an average for a large number of experiments conducted in various parts of the winter-wheat, belt well cleaned seed has produced about one-half bushel more per acre than the uncleaned but otherwise good seed.

While this is a very small difference, it is more than enough to pay the cost of the cleaning.

It may be concluded that it is always worth while to use the fanning mill if the wheat contains weed seeds, chaff, dirt, smut balls, or shrunken kernels; and also that a small gain in yield may be expected merely as a result of eliminating all but the plumpest and heaviest kernels.

TREATING SEED FOR SMUT

If wheat contains stinking smut or bunt, it should be treated. Treatment is inexpensive, and if well done should not need to be repeated for several years.

Directions for treating seed for smut may be obtained from county agricultural agents or from the Agricultural Experiment Station, Manhattan, Kan.

THE TIME TO SEED WHEAT

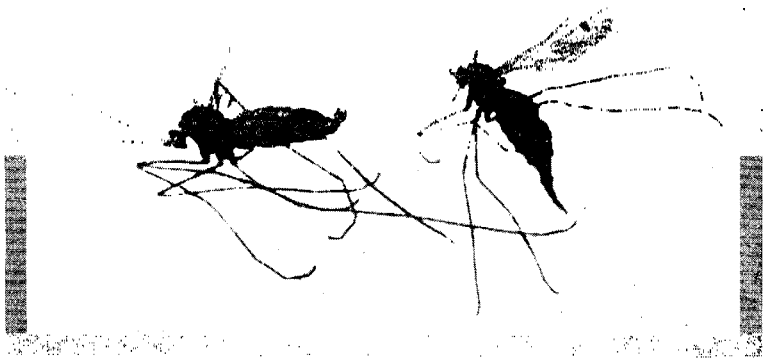
The best time to seed wheat in Kansas is not an easy question to settle. Wheat that is sown late usually winterkills badly; the roots do not penetrate the ground so deeply as when it is sown early; and it is more subject to injury from drouth and hot winds. Late-sown wheat tillers very little and usually produces a thin stand. It ripens late and is more likely to be injured by rust than wheat that is sown somewhat earlier. The quality is likely to be poor.

On the other hand, wheat sown too early is practically certain to be injured by Hessian fly if these insects are present in the neighborhood. In western Kansas very early seeding is often detrimental because the heavy growth uses all the moisture stored in the soil and leaves the crop entirely dependent on seasonal rains.

The best time to seed varies with different sections of the state, with different seasons, and with different conditions. For these reasons no definite date for planting can be given. The proper time must be settled according to the locality and local seasonal conditions.

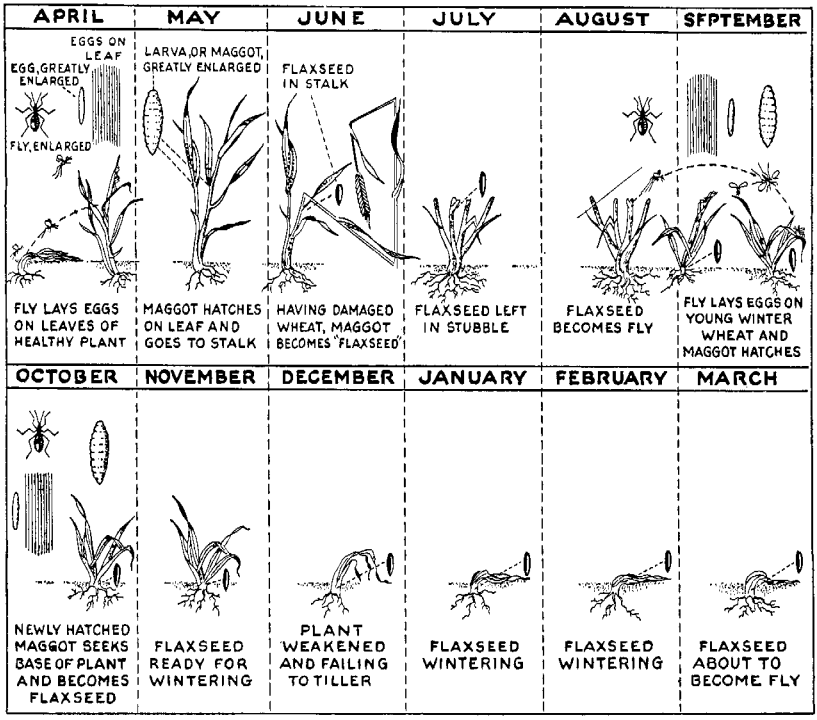
THE INFLUENCE OF THE HESSIAN FLY ON TIME OF SEEDING

The best time to seed wheat in central and eastern Kansas is often determined by the Hessian fly. (Fig. 19.) The presence of this insect can easily be detected by examining the wheat stubble. (Fig. 20.) If present in abundance, damage to the following crop is almost certain to occur unless measures are taken to avoid it.



After Headlee and Parker.

FIG. 19.—Adult Hessian flies. Left, male; right, female. (Enlarged about 8 times.)



—*Courtesy U. S. D. A.*

FIG. 20.—The life history of the Hessian fly from April to March. Note what it is doing each month.

Fly-safe Dates.—Late-sown wheat usually escapes injury from fly in the fall, and hence late sowing may be practiced as a means of preventing or reducing the damage from Hessian fly. It is usually advisable in such cases to seed as early as possible and yet escape damage, and hence it is desirable to know how early one can seed and yet escape injury. The so-called fly-safe dates, i.e., the earliest dates when wheat may be sown with a small chance of injury, vary for different parts of the state, and are shown in figure 21.

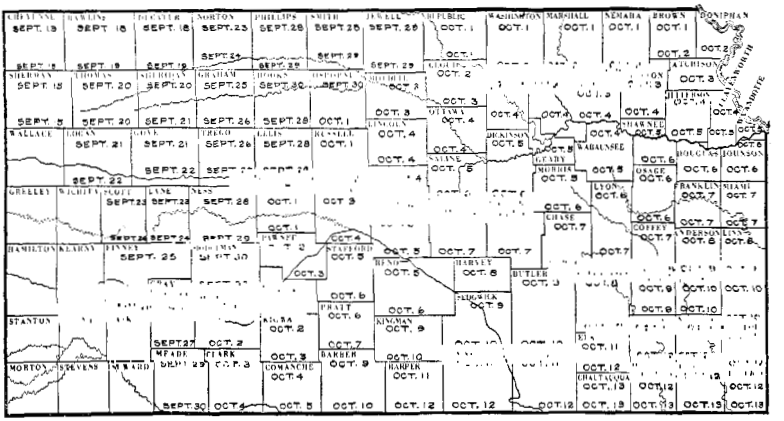


FIG. 21.—Map of Kansas showing the approximate safe dates of seeding wheat to avoid Hessian fly injury.

Relation of Fly-safe Dates to Time of Seeding.—Considerable misunderstanding has arisen as to the meaning and significance of fly-safe dates. The Agricultural Experiment Station does not recommend delaying the beginning of seeding until the fly-safe dates except in those places where the threatened damage from Hessian fly is more important than anything else. In general it is desirable to begin seeding a week to ten days earlier than the fly-safe date if no Hessian fly threatens and other conditions are favorable. This especially is true if one has a large acreage to seed and has reason to fear delays because of bad weather.

THE TIME TO SEED IN WESTERN KANSAS

Western Kansas differs markedly from the rest of the state with respect to the best time to seed. In the first place, Hessian fly is not so prevalent as in central Kansas, and if present is more likely to be killed by unfavorable weather. In the second place, the farmer has less choice with respect to time of seeding because of

dry falls. It is usually not advisable to seed in dry ground, expecting a rain later to germinate the wheat. The false wireworm may destroy the kernels. A light rainfall may be sufficient to cause germination and then lack of further moisture may kill the young plants, or there may be enough moisture to allow fungi to grow on the wheat kernels and destroy them and yet not enough to cause germination. In all such cases the seed is lost.

On the other hand, there is less danger of late seeding being the cause of winterkilling in western Kansas than in the eastern part of the state. It frequently happens that grain sown as late as November makes a fair yield. While it is not ordinarily advisable to seed so late, such late seeding with favorable conditions is usually better than early seeding with poor conditions, and better than seeding spring wheat.

Usually the best thing to do in this area is to prepare the ground early, clean the seed, treat it for smut if this is necessary, and be ready to seed when conditions are most favorable. The grain should then be sown as rapidly as possible.

Probably the best date to begin seeding in this area, when all conditions are favorable, is from September 10 to 15 in northwestern Kansas, and from September 20 to 25 in southwestern Kansas.

Extremely early seeding should be avoided even if conditions for germination are favorable, since a heavy growth takes the moisture from the ground, leaving the wheat entirely dependent on seasonal rains to complete its growth. Wheat sown too early sometimes makes so thick a growth in the spring that it is more likely to be injured by hot winds and drouth than if sown somewhat later.

SEEDING WINTER WHEAT IN THE SPRING

There are certain varieties of wheat which, in mild climates, may be sown either in the fall or in the spring. No such varieties suitable for Kansas are known. Usually when winter wheat is sown in the spring it will not head during the summer, or will produce so few heads that it will not be profitable. The reason for this appears to be the fact that winter wheat requires rather cool temperatures during the early stages of growth. It is not necessary that it be frozen as some think. Instances are known where winter wheat sown as late as February has made a normal growth and a fair crop. This seldom occurs, however, and is not recommended.

It is not uncommon for winter wheat sown in dry soil to germinate in the spring and make a fair crop. In such cases it is important

to know early in the spring whether a crop will be made or whether the land should be replanted to another crop.

There is no certain way of settling this point. If the weather turns off warm immediately after the wheat germinates and remains so, no grain will be produced. The plants tiller excessively but no heads are formed, giving the plants a grasslike appearance, When this occurs the wheat may as well be plowed up. If, however, the weather remains cool for three or four weeks the wheat may produce

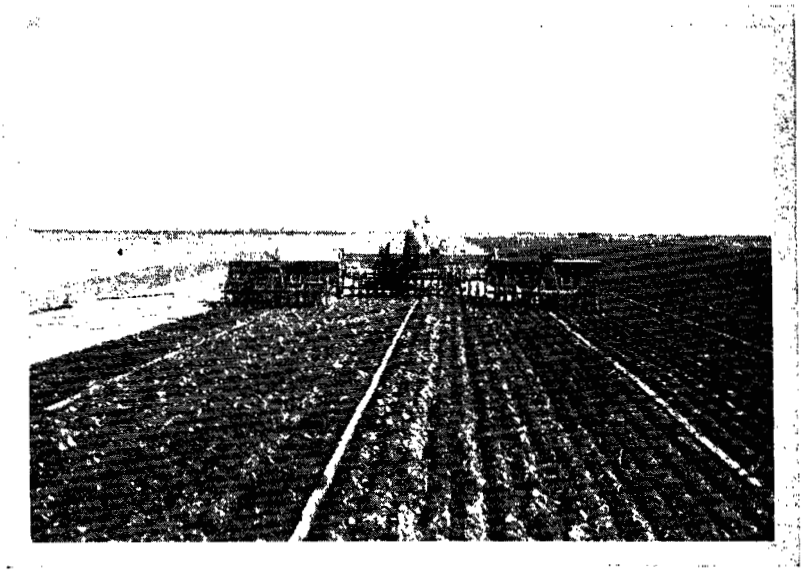


FIG. 22.—Drilling 100 acres a day in a Kansas wheat field.

heads in the normal way and make a fair crop. Usually one can tell by the character of the plants three or four weeks after growth starts in the spring whether heads will be produced.

THE DEPTH TO SEED WHEAT

In eastern Kansas there is no advantage to be gained in seeding wheat deeper than necessary to place it in moist soil and insure germination. Seeding too deeply delays germination and is therefore objectionable. An inch to one and one-half inches of soil over the seed is usually sufficient.

In western Kansas, it is usually desirable to "put the grain down to moisture" if possible. It is also desirable to cover the grain somewhat deeper than in other sections because of the danger of drying

out after seeding and before it can germinate even when planted in moist soil. Seed sown in dry soil should be drilled from two to three inches deep. At this depth light showers will not cause it to sprout, and when enough rain comes to reach the seed there will be sufficient moisture to keep it growing.

METHODS OF SEEDING

Practically all Kansas wheat is sown with a drill (fig. 22) and in general there appears to be no good reason for using other methods. Disk drills are generally favored because of light draft and their ability to cut through trash and weeds.

In recent years furrow drills, or lister drills as they are called, have been used extensively in Montana, Wyoming, northeastern Colorado, and to some extent in western Kansas. These drills place the seed in furrows 12 to 14 inches apart and somewhat deeper than those made by the ordinary drill. Wheat sown in this way is protected during the winter by snow in the furrows (fig. 23) and also to some extent against soil blowing. Also, it is sometimes possible to get the wheat in moister soil, thereby insuring better germination. Some of the objections are heavier draft of the drills, covering the grain or the plants too deeply by soil drifting, and weeds growing between the rows.

Extensive experiments relating to this method of seeding have been conducted at the Colby, Tribune, and Fort Hays branch stations. The average yields for the two methods of seeding at the Colby branch station are given in Table XVII.

TABLE XVII.—FURROW VERSUS COMMON DRILL FOR WINTER WHEAT AT THE COLBY BRANCH STATION.

Rate of seeding: Pecks per acre.	Average yield per acre for nine years.		
	Common drill.	Furrow drill.	Difference in favor of furrow drill.
	Bus.	*Bus.*	*Bus.*
4	23.2	25.6	2.4
3	23.7	26.9	3.2
2	23.9	24.9	1.0
1	24.7	22.2	—2.5
Average	23.9	24.9	1.0
Average, excluding the one-peck rate	23.6	25.8	2.2

The average yields are distinctly in favor of the furrow method if the one-peck rate is excluded, as it probably should be, since little or no wheat, is sown at this rate. A slight gain in yield for the furrow method has been recorded at the Tribune branch station. No gain at all or a slight loss was found at the Fort Hays branch station. In the latter case no winterkilling occurred during the course of the experiment. It is possible that a longer test, including seasons in which winterkilling occurred, would show some gains. However, it does not seem likely that this method will be permanently used outside of the northwestern and extreme western parts of the state.

FIG. 23.—A wheat field sown with a furrow or lister drill at the Colby Branch Experiment Station. Snow in the furrows protects the wheat during the winter.

THE RATE TO SEED WHEAT

In eastern Kansas the rate to seed wheat bears a very definite relation to the time of seeding. Experiments at Manhattan indicate that when sown reasonably early, i.e., from September 20 to October 1, from 4 to 6 pecks per acre will give the best yields. Eight pecks per acre have proved better than a less amount when sown after October 1. In central Kansas four pecks for early seeding on well-prepared ground is sufficient, whereas in extreme western Kansas two to three pecks will often prove adequate. However, there is generally no loss in using a larger amount, and this sometimes is advisable to allow for poor germination, winterkilling, etc.

On thin land less seed is required than on rich bottom land. This fact may well be considered in deciding as to the best rate.

VOLUNTEER WHEAT

Good yields have been secured from volunteer wheat, i.e., from seed shattered before and during harvest with no further seeding. Yields of 30 bushels per acre and more from such fields were not uncommon in western Kansas in 1921. This seldom occurs, however, and one may well be conservative when it comes to depending on a volunteer seeding for a crop.

FIG. 24.—In eastern Kansas a cultipacker or corrugated roller on the wheat early in the spring is often beneficial.

In eastern Kansas it is always desirable to plow fields early and thoroughly destroy all volunteer plants before they have an opportunity to sap the ground of moisture or harbor Hessian fly.

PASTURING WHEAT

Wheat makes excellent fall pasture, and is frequently used for this purpose. Experiments so far conducted show that in general pasturing does not benefit the wheat and often reduces the yield. The yield is greatly reduced if the grain is pastured too soon, too closely, too late in the spring, or when the ground is wet. An exception to this is when wheat grows very rank and lodges. In such cases pasturing might have reduced the lodging and thereby increased the yield. One of the most serious objections to pasturing is that wheat sown early for pasture often harbors Hessian fly which may injure other fields as well as the pastured field.

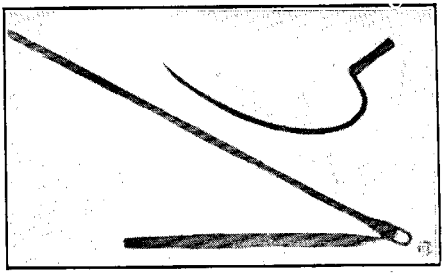
ROLLING AND HARROWING WHEAT

Rolling (fig. 24) or harrowing wheat in the spring is often beneficial. The Nebraska Agricultural Experiment Station found that wheat which had been injured by alternate thawing and freezing was greatly benefited by rolling with a corrugated roller. Rolling pressed the soil back around the roots of the plants and seemed to prevent much of the injury that would otherwise have occurred. Most experiments have shown that harrowing reduces the yield rather than increases it.

Rolling or harrowing wheat in the spring may increase the damage from soil blowing in western and central Kansas and for that reason is seldom advisable.

HARVESTING WHEAT

Perhaps there is no phase of modern wheat production that shows such a contrast with ancient methods as the harvesting. This is illustrated in figures 25 to 31, inclusive.



—Courtesy U. S. D. A.

FIG. 25.—The sickle and the flail were among the earliest implements used for harvesting and threshing wheat.

—Courtesy U. S. D. A.

FIG. 26.—The cradle was used almost exclusively for harvesting wheat in the United States during the early part of the 19th century.

—*Courtesy U. S. D. A.*

FIG. 27.—The hand rake reaper was first used for harvesting wheat about 1830. It was the forerunner of the modern self-binder.

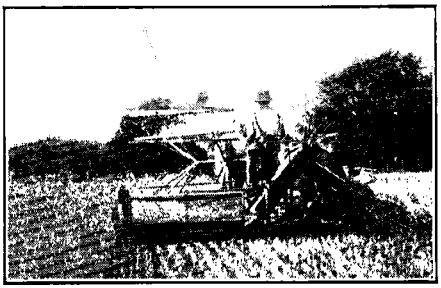


FIG. 28.—The modern self-binder in an eastern Kansas wheat field.

—*Courtesy Nebr. Agr. Expt. Sta.*

FIG. 29.—A header at work in a Great Plains wheat field.

FIG. 30.—A typical threshing scene.

Three different methods are generally employed in harvesting wheat in Kansas; viz., binding, heading, and harvesting with a combine. The grain binder is used mostly in eastern Kansas where the acreage of wheat on any one farm is usually small and where the rain often interferes with other methods.

Headers and combines are used mostly in central and western Kansas. In recent years there has been a very marked increase in the use of combines, largely because of the greatly reduced cost of harvesting and threshing by this method.

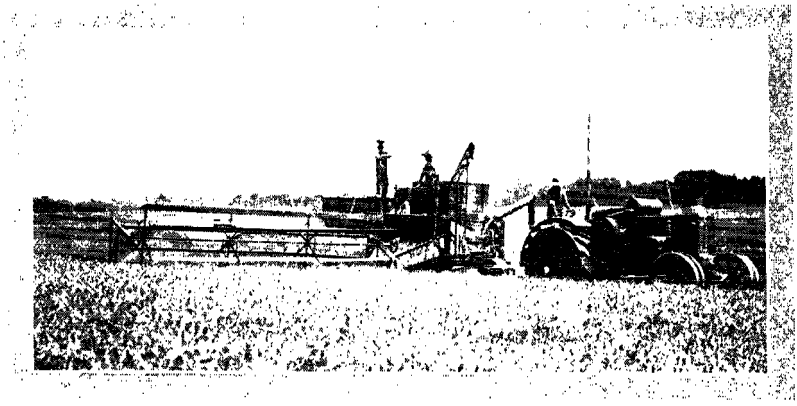


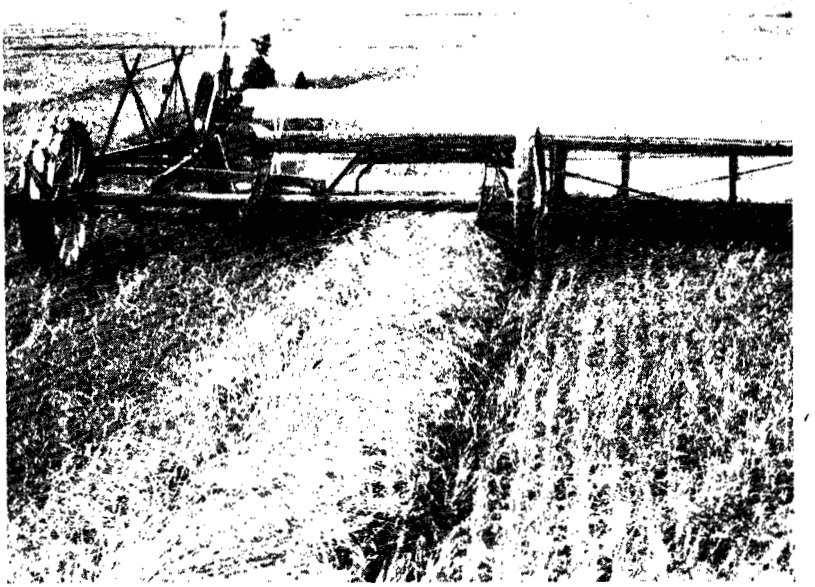
FIG. 31.—A modern combine (harvester-thresher) in a Kansas wheat field.

Perhaps the most serious objection to the combine method is the tendency to begin harvesting before the wheat is thoroughly ripe or to harvest when the grain is damp from dew or rain. Green spots in the fields and along the edges which are later in maturing than the center often cause trouble. Excessive moisture in the grain from any cause is almost. certain to result in heat-damage. Other objections are the high first cost, risks of wet weather and hail while the grain is waiting to be cut, and bleaching of the standing grain, causing it to lose weight and quality.

Much of the damage from damp grain can be prevented by cutting only when the grain is dry and by sacking any damp grain (as from green spots in the field) that may be harvested. Sacking is especially effective if the grain is piled so there is free circulation of air between the sacks.

A recent innovation which promises to remedy some of the difficulties in using the combine is the swather method of harvesting. This consists of laying the cut grain in a swath on top of the stubble

(fig. 32) and when thoroughly dry picking it up and threshing it with the combine by means of special attachments. (Fig. 33.) In this way, harvesting may begin as early as it would if the grain were cut with a binder, the cut grain being allowed to cure in the swath until the remainder of the field is harvested. The method is still in the experimental stage so far as Kansas is concerned, and just what objections to its use may arise or what precautions must be observed are yet to be determined.



—Courtesy Weekly Kansas City Star.

FIG. 32.—A swather in a Kansas wheat field. The wheat is dumped in windrows to cure, after which it is threshed as shown in figure 33.

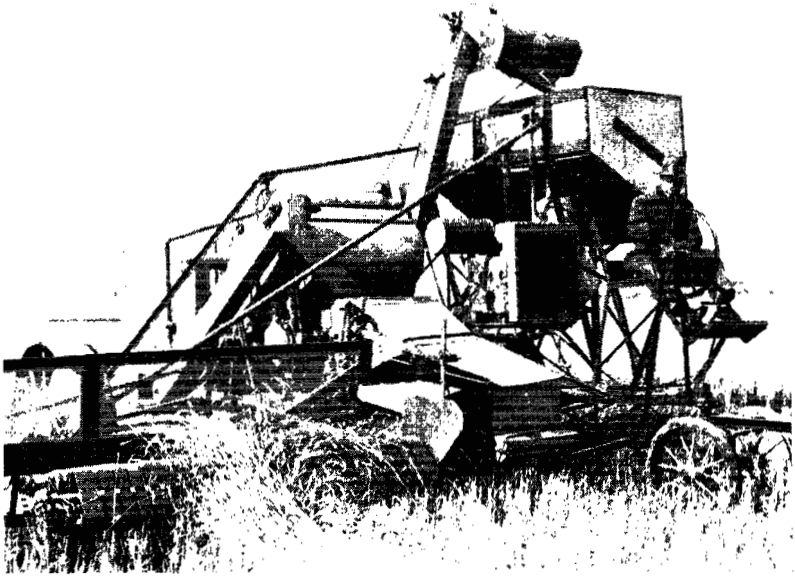
TIME OF HARVESTING

In general wheat may be harvested with a combine or header as soon as it is ripe enough to be safely stored in the bin or stack. Wheat may be cut with a binder as soon as the grain has reached the hard dough stage. There is ordinarily no appreciable gain by permitting it to stand until "dead" ripe. It is, of course, advisable to harvest as promptly as possible after the grain is ready to cut, in order to avoid possible losses from shattering, hail, or storms.

MARKETING THE WHEAT CROP[2]

There are few problems of greater importance or interest to wheat growers than those relating to marketing the crop. The fact that profits depend on prices is so obvious as to require no comment or discussion. How to get the best price, however, is the grower's real problem.

A common practice is to haul wheat to the nearest market or to the market offering the best flat rate, and take whatever price the buyer is willing to pay. Unless there is a marked difference in



—*Courtesy Weekly Kansas City Star.*

FIG. 33.—A combine fitted with a "pickup" for threshing wheat dumped in windrows by a swather.

quality, the wheat sells largely according to the test weight per bushel. The time of marketing is determined largely by credit and storage facilities and belief in the future trend of the market. The latter often is based on nothing better than prices during the past year.

This system is simple and convenient, but it often fails to give the producer the real value of his product. Possibly the most serious objection is that the good wheat sells for about the same price as the poor wheat, and hence there is but little inducement to produce high-quality wheat.

2. The price data included in this section were supplied by Prof. R. M. Green, in charge of marketing investigations, Department of Agricultural Economics.

Many remedies have been suggested, some of which no doubt have merit. But all of them in one way or another depend for their successful outcome on a knowledge by the grower of the quality of the wheat to be marketed and of some of the factors which determine prices. In the following pages an attempt is made to call attention to some of these factors and their relation to prices.

MARKET CLASSES AND GRADES

Every farmer knows that the value of wheat depends on the kind and the quality. Thus Durum wheat is worth less for bread than is common wheat, and badly smutted wheat is less valuable than sound wheat free of smut. In order to classify wheat so that buyers can more easily and surely get the kind they want, that which reaches the terminal markets is grouped into classes and grades. The classes are designed to indicate the kind of wheat, whereas the grade is for the purpose of showing the quality.

Classes.—Altogether there are five principal classes of wheat for the United States: Hard Red winter, Soft Red winter, Hard Red spring, Durum, and Common White. Kansas farmers are interested only in Hard Red winter and Soft Red winter, principally the former. The grain of such varieties as Harvest Queen, Fulcaster, Currell, etc., is classified as Soft Red winter, whereas that of Kanred, Turkey, Blackhull, etc., is classed as Hard Red winter.

Subclasses.—The Hard Red winter class is further subdivided into what are known as subclasses; viz., Dark Hard winter, Hard winter, and Yellow Hard winter. This subdivision gives the prospective buyer some information as to the amount of yellow berry (page 48) in the wheat. Thus Dark Hard winter wheat contains not to exceed 20 per cent of yellow or mottled kernels, and Yellow Hard winter contains 75 per cent or more of yellow or mottled kernels. This information is very useful, especially when the protein content has not been determined, since the protein content is known to be somewhat related to the amount of yellow berry.

Grades.—Each subclass of wheat is divided into six grades: 1, 2, 3, 4, 5, and sample. The accurate grading of wheat is too complicated to permit a complete presentation here, but a few of the more important items that determine the grades, such as test weight per bushel, moisture content, presence of damaged kernels, purity, cleanliness and condition may be briefly discussed.[3]

3. Interested farmers may secure more complete information from the Kanas State Grain Inspection Department, Board of Trade Building, Kansas City, Mo.

Damaged Wheat.—The presence of a material amount of damaged kernels always reduces the grade because of its effect on the quality of the flour and bread and the fact that they cannot be removed. The most serious damages of this kind are "heat damage," musty wheat, and sprouted wheat. Heat damage, when present even in quantities of 1 per cent or less, imparts a bitter taste and a dark color to the flour. It is caused by stacking wheat too wet, or putting it into a bin in a damp condition. Only one-tenth of 1 per cent of heat-damaged kernels is allowed in No. 1 wheat, two-tenths of 1 per cent in No. 2, five-tenths of 1 per cent in No. 3, 1 per cent in No. 4, and 3 per cent in No. 5. It is obvious that any material amount of heat-damaged kernels greatly reduces the price.

Musty wheat is very objectionable because of the bad odor it gives to the flour. A small amount of sprouted wheat is not a serious objection. In fact a small per cent usually improves the quality of the bread. If in excess of about 3 per cent, the quality of the flour is injured materially. Bleaching, such as occurs when harvesting is delayed or when wheat in the shock is exposed to rain and sun, ordinarily does not seriously injure the quality. If excessive, the bran may be brittle and impossible to separate properly, thus making a darker flour. Bleached wheat usually sells for less money than wheat that is not bleached, and hence bleaching should be avoided as far as possible.

Moisture Content.—Wheat containing too much moisture is graded down because of excessive weight, and especially because of the danger of becoming musty, sour, or heat damaged. Wheat containing less than 13.5 per cent moisture will not heat or become musty under ordinary conditions, whereas an excess of 14 per cent is likely to cause trouble.

Rye in Wheat.—The presence of rye in wheat reduces the grade and the price. Thus No. 1 wheat may not contain more than 1 per cent of rye, No. 2 not more than 2 per cent, No. 3 not more than 3 per cent, No. 4 not more than 5 per cent, and No. 5 not more than 7 per cent. The permissible amount is less if at the same time the wheat contains other foreign material.

Millers object to admixtures of rye because rye darkens the bread and, if present in large amounts, produces a heavy, coarse texture that is not wanted in this country.

Mixed Wheat.—A mixture of different kinds of wheat such as Durum and Hard spring or of Hard Red winter and Soft Red win-

ter is usually objectionable as it is impossible to make a flour of uniform quality from it. Fortunately such mixtures are not of great concern to most Kansas farmers. It does influence the price in those sections of eastern and central Kansas where both Hard Red winter and Soft Red winter varieties are grown. In these areas the two classes should be marketed separately.

Foreign Material.—Foreign material includes sand, dirt, weed seed, stems, chaff, straw, etc. Foreign material reduces the yield of flour, and such part as cannot be removed before milling may

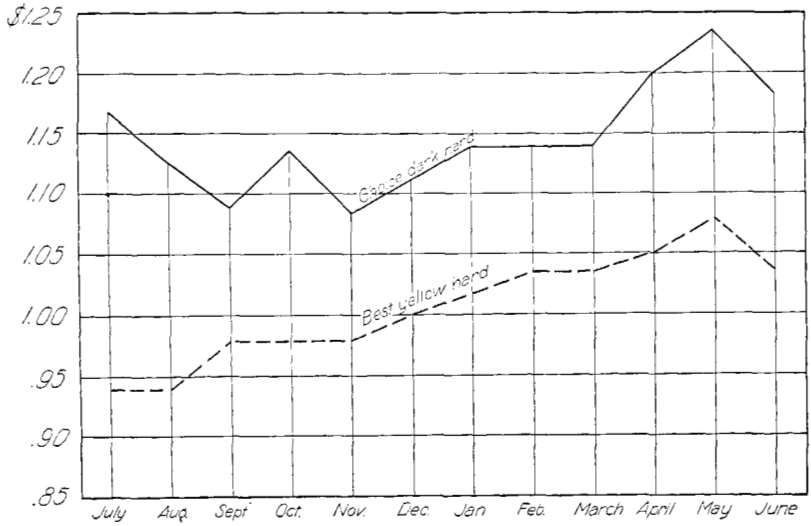


FIG. 34.—Average monthly high and low prices of No. 2 Hard Winter wheat for 31 years at Kansas City, showing the spread in prices between choice Dark Hard (high in protein) and best Yellow Hard (low in protein).

seriously injure the quality. The effect on the grade and the price depends on the kind of foreign material that is present as well as the quantity.

PROTEIN AND THE PRICE OF WHEAT

High-protein wheat usually brings a premium on the market, as shown in figure 34, which gives the average monthly prices of choice Dark Hard and best Yellow Hard wheat for a period of 31 years at Kansas City, Mo.

The principal reason for half or more of the spread in prices as shown in this figure is the difference in protein content, Dark Hard wheat usually being higher in protein than Yellow Hard wheat of the same variety.

Determining the Protein Content of Wheat.--Until recent years protein content has been estimated, buyers paying a premium for what they thought to be high-protein wheat. The best and the only really satisfactory method is to have the actual amount determined by chemical analysis. Kansas farmers are fortunate in having at their disposal state-operated chemical laboratories where samples of wheat may be sent and protein determinations obtained. Such laboratories are located at Wichita, Hutchinson, and Kansas City. During the summer and early fall laboratories are also maintained at Hays and Colby. Farmers wishing such determinations should take a half-pound sample of their wheat and mail it to the Kansas State Grain Inspection Department at any one of the addresses given above. The sample should be marked on the outside, "For protein test." The package should also show the sender's name and address.

It is very important that the sample submitted be representative of the entire bin or lot. This may be accomplished by taking several samples, each from a different portion, and thoroughly mixing them. This large sample may then be halved and quartered and further subdivided until a sample of the desired size is obtained.

ORDERLY MARKETING

Kansas farmers on the average sell about 40 per cent of their crop in July and August. This period coincides with heavy movements from other portions of the Southwest, with the frequent result that railroads are unable to haul it promptly to market, and both primary and terminal elevators are congested. Under such conditions prices decline and the opportunities for careful examination and grading of the wheat are wanting.

Prompt selling after threshing is of course often advisable or necessary, as when money is needed, when storage space is not available on the farm, or when the wheat is wet and no facilities for conditioning it are at hand. Sometimes, also, prices at threshing time are better than later in the year. On the contrary, much wheat could often be withheld from market for several months to good advantage.

SEASONAL PRICE CHANGES

As an average, Hard Winter wheat sells from 3 to 6 cents per bushel more in the winter and from 10 to 15 cents more in the spring than during the late summer months. This is illustrated in figure 34, which gives the average of the highest prices for No. 2

Hard Winter wheat at Kansas City for the past 31 years. This difference is usually more than enough to pay storage and carrying charges and shrinkage. The latter is generally so small as to be negligible as related to dry wheat stored in tight bins. This means that on the average wheat may be expected to earn storage costs if held for the winter or spring market. Any additional profit comes only from a careful study of the situation each year in order to determine whether prices are likely to improve or decline that particular year. Of course there is no way to accurately predict price changes, but nevertheless predictions based on careful study are always better than depending on "hunches" or judgment based only on limited personal experience.

Factors Influencing Monthly Price Changes.—The principal factors that should be considered in judging probable trends of the market after harvest are (1) the probable world's crop of wheat, (2) the carry-over from the preceding year, and (3) the crop in the Southwest, i.e., in Kansas, Oklahoma, and Texas. The demand for wheat must also be considered, but since this is fairly constant from month to month and from year to year it need not be discussed here.

The average world crop of wheat is about 3½ billion bushels and the average carry-over from one season to the next, i.e., the amount on hand July 1 is about 200 million, making a total of 3,700,000,000 bushels available for consumption and subsequent carry-over. Any marked deficiency or surplus in this amount is the most important and fundamental factor affecting the level of prices for the year.

The size of the crop in the Southwest is of special concern to Kansas farmers because of its effect on the price level immediately after harvest when the bulk of the Kansas crop is going to market. That is to say, a large Kansas crop usually depresses the price while the bulk of it is going to market, i.e., during July and August. It may not affect the price level for the year if offset by a small crop in some other part of the world.

July, August, and September Prices.—The decline in prices after July is large or small, depending largely on whether July prices are out of line with general conditions and on the size of the crop in the Southwest. Thus a large crop in this region following a season of small supplies (which usually means relatively high July prices) is likely to produce a very rapid decline as new wheat moves to market. On the other hand a large crop in the Southwest of itself is not likely to produce a marked decline in prices after July.

As a rule wheat at Kansas City is cheaper in August than in

July. Thus August prices have been higher than July prices in only 10 of the 35 years in which this relation has been studied. Usually there is a slight improvement in September following a slowing up of deliveries of winter wheat and before spring wheat comes on the market in large volume.

These relations suggest that a farmer who must sell his wheat within a month or two after harvest will on the average do better to sell as soon as it is threshed rather than later. Assuming conditions like those of the past, he will hit the high market approximately three-fourths of the time. He can improve this somewhat by studying market conditions and holding his wheat when there is a short crop in the Southwest, especially if the world's crop for the preceding year has been a large one, but selling early when these conditions are reversed.

Winter and Spring Prices.—The farmer who is in a position to hold wheat as long as he wishes will be interested especially in prospective prices during the winter and spring.

Studies that have been made indicate that the seasonal trend of the market can be predicted with a fair degree of accuracy by the ratio between July and September-October prices.

This is because July prices are determined very largely by demand from domestic mills and speculators, whereas fall prices are determined very largely by the demand from foreign countries. If prices in September and early October are higher than in July one may be sure that there is a strong demand in foreign countries and that prices will probably remain firm or possibly advance during the winter and spring. On the other hand, if September-October prices are below those of July the foreign market is probably weak and prices will likely continue low throughout the year.

In the past 34 years there have been only 13 in which September-October prices have been above those of the preceding July. The trend of the market during the season as an average for these years is shown in figure 35. It will be seen that in these 13 years January prices have averaged 25 cents above the preceding July price and from 9 to 14 cents above the September-October price. Furthermore, the market remained fairly strong throughout the year.

In a similar way figure 36 shows the seasonal trend of the market for the 21 years in which September-October prices at Kansas City have been below July prices. It will be noted that on the average the market has remained relatively weak throughout the winter.

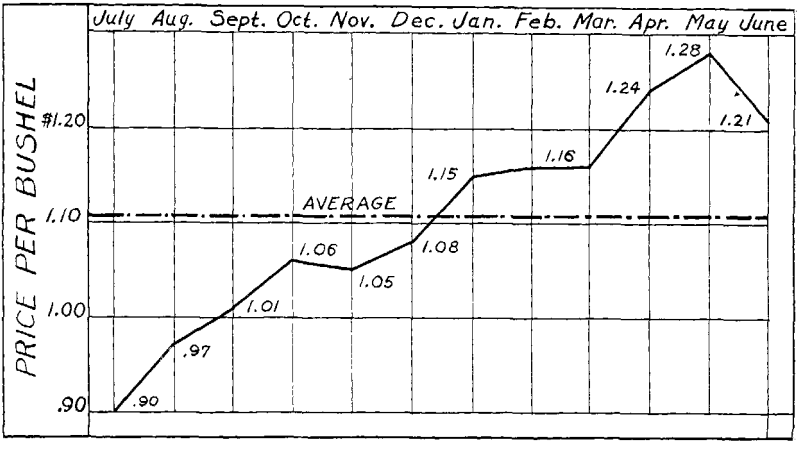


FIG. 35.—Average prices for No. 2 Hard Winter wheat at Kansas City for the 13 years when September or October prices were above prices for the preceding July.

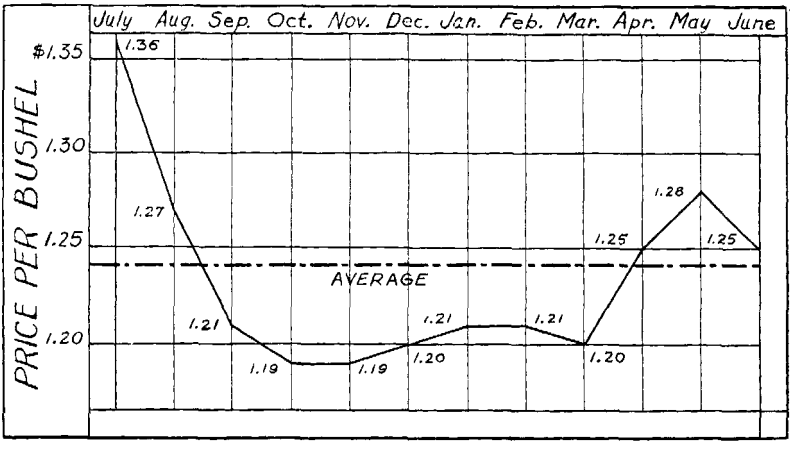


FIG. 36.—Average monthly prices for No. 2 Hard Winter wheat at Kansas City for the 21 years when September or October prices were below those of the preceding July.

Disturbing Factors.—Anyone familiar with markets knows there are numerous factors that greatly influence any general rule. The relations just discussed are no exception. The principal disturbing factors are (1) the new crop prospects based on conditions of the growing crop in the United States, and (2) especially the size of the Argentine and Australian crops. Poor prospects in the United States or poor crops in Argentina and Australia tend to strengthen the market, whereas good prospects and good crops have the reverse

effect. The Canadian crop must also be considered, but its effect on price levels is usually discounted before September.

Strong and Weak Spots in the Market.—Besides the factors mentioned above which have to do largely with price levels during the year, there are strong and weak spots in the market which depend very largely on the rate of export of wheat from surplus-producing countries. Thus, as pointed out above, a large movement of winter wheat tends to depress the market in July and August. A similar depression occurs in November and December when the Canadian crop is moving, and another in March and April coinciding with the movement of the Argentine crop. These periods may be referred to as weak spots in the market. The exports by months for the principal countries of the world which export wheat in competition with the United States are shown in figure 37.

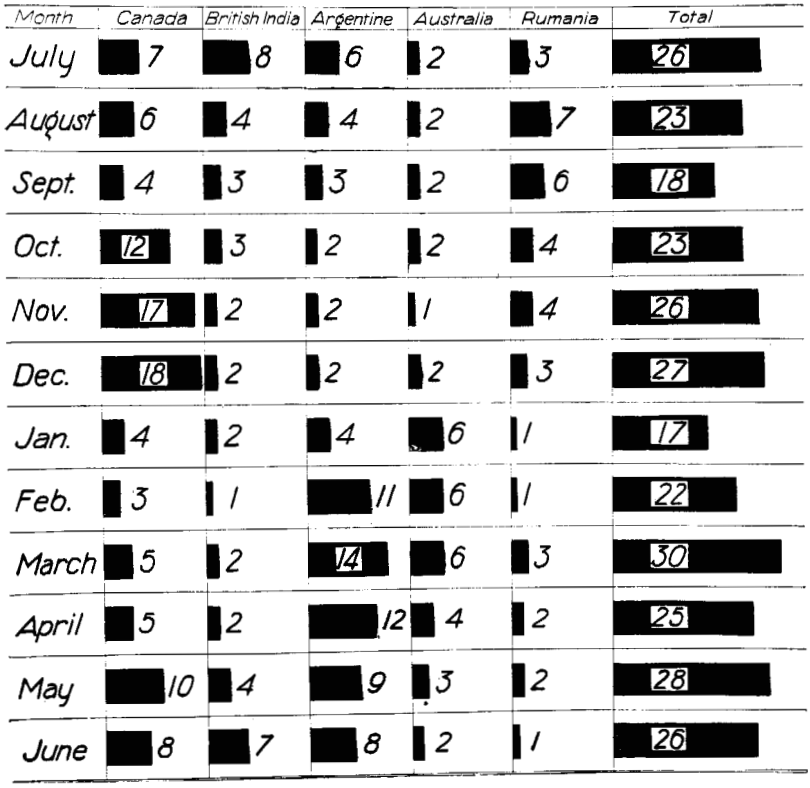


FIG. 37.—Average monthly exports of wheat (1908-'09 to 1917-'18) from countries competing with the United States. (Figures indicate millions of bushels.)

On the other hand, there is a tendency for the market to strengthen when exports from all countries are small. These periods may be referred to as strong spots. They occur usually in late September or early October, in January, and again late in April or May.

The late September or early October market coincides with the falling off of hard winter wheat marketing and before the Canadian crop comes on in large volume. The increase in price in January (sometimes in late December) occurs when the Great Lakes freeze, thus cutting off water transportation from Canada, and the spring market coincides with the exhaustion of the Argentine and Australian surpluses. Obviously any material shortage of the crop in these countries will have an influence on these strong and weak spots.

Holding High-quality Wheat.—Farmers having wheat differing in quality will usually benefit most from holding the better rather than the poorer grades. This is because when a large volume of wheat is going to market, facilities for taking care of it are taxed to capacity and there is little opportunity to give careful attention to protein content, mixtures, smut, damage, etc. The tendency then is to establish a margin wide enough to take care of the usual fluctuations in quality and buy all wheat at approximately the same price. Thus during the heavy movement of the 1928 crop, examples are known of top prices being paid for wheat containing as much as 20 per cent rye.

Holding high-quality wheat gives an opportunity to study the grade, obtain a protein analysis, and prevail upon dealers to give due consideration to quality. Many farmers also find it to their advantage to segregate their wheat, marketing the best grades together and the low grades together. Mixing low-grade and high-grade wheat will of course improve the quality of the former, but usually not enough to compensate for the loss in quality of the latter.

PRODUCING HIGH-PROTEIN WHEAT

Kansas wheat commands a premium as compared with that from most other states because of its uniformly high quality. It is important that this quality at least be maintained, and so far as possible improved. As has already been mentioned, much can be done by eliminating smut, rye, and mixtures with other varieties; also by care in harvesting and storing, so that, a minimum of damage to the threshed grain occurs.

Another point that may well receive more consideration is the possibility of increasing the protein content.

The protein content of wheat varies with several factors, such as variety, climate, and soil. There is no marked difference in the protein content of the different varieties of wheat generally grown in Kansas, hence it seems that any improvement in this respect must be secured mainly by attention to the soil.

The Relation of Protein Content to the Soil.—Perhaps the most important constituent of protein is the nitrogen; at least protein cannot be produced by the wheat plant without an adequate supply of this element in the soil. It is therefore not surprising to find a close relation between the nitrogen content of the soil and the protein content of the wheat.

Growing wheat in rotation with alfalfa tends to increase the protein content, since alfalfa leaves the ground richer in nitrogen. Sweet clover has a similar effect. Also early plowing and summer fallow tend to produce a wheat of better quality because of the larger amount of nitrates made available for the plant. In neither case, however, is this result always secured, since there is a tendency for high protein to be associated with low yields and *vice versa*. Since alfalfa and early plowing tend to increase yields, this effect may offset the tendency toward higher protein content. It is particularly fortunate, nevertheless, that early plowing and legumes tend to increase both the yield and the protein content of wheat.

INJURIOUS INSECTS[4]

Insects are responsible for large losses to wheat growers every year. Much of the damage is easily prevented. The most destructive insects are the Hessian fly, chinch bug, false wireworm, and wheat white grub. Others of less importance are the grasshopper and wheat strawworm. Still others which damage stored grain are weevil, Angoumois moth, and the Cadelle.

THE HESSIAN FLY

Damage from Hessian fly (fig. 19) occurs both in the fall and spring. The pupae which live during the early summer in wheat stubble emerge soon after harvest and find their way to volunteer or early sown wheat. (Fig. 20.) They cannot be killed by any practical method after the wheat is infested without also killing the

4. Contributed by Prof. J. W. McColloch, in charge of staple crop insect investigation, Department of Entomology, Kansas Agricultural Experiment Station.

wheat. Infestations of the Hessian fly come from the stubble of the previous crop or from volunteer and early-sown wheat. Hence all control measures aim at the destruction of the fly between the time of harvesting one crop and the sowing of the next.

The most effective means for destroying the fly in infested stubble is to plow 5 to 7 inches deep immediately after harvest and work the ground soon after with a disk and harrow. When this is done the pupae are buried so deep that the adults (fig. 19) cannot get out. Listing the ground as discussed on page 30 kills many, but it is not so effective as the plowing. Burning the stubble has frequently been recommended. However, this method is not very effective as it does not kill those which are below the surface of the ground.

In practice it is also necessary to destroy all volunteer wheat after plowing for the reason that such wheat is likely to become infested from surrounding stubble fields which have not been plowed. In fighting the Hessian fly community organization is highly desirable. The most seriously infested fields may often be plowed first and the sources of infection removed before the fly becomes widely distributed.

Time of Seeding and the Hessian Fly.—Late seeding has often been recommended as a means of controlling Hessian fly, and experiments have shown very conclusively that late-sown wheat is less likely to be injured. The reason for this is that eggs laid on the wheat in the late fall will be killed by frosts and cold weather. The earliest date at which wheat may be sown and still escape material damage is known as the safe-seeding date. Such dates have been determined for different parts of the state, as shown in figure 21. There is considerable variation in seasons, and of course late seeding does not prevent infestation in the spring. Hence seeding on or after the safe-seeding dates does not guarantee freedom from Hessian fly. Unfortunately the safe-seeding dates are too late for best results under all conditions; hence somewhat earlier seeding is usually advisable if no Hessian fly are present. This is especially true if early seed-bed preparation has been practiced and the volunteer wheat destroyed. This point is discussed more fully on page 49.

THE CHINCH BUG

The chinch bug is more destructive to corn and sorghums: but also seriously damages wheat, especially if for any reason the stand is thin. The only effective means for keeping chinch bugs out of wheat is to burn them in their winter quarters. After they have once reached the wheat, fields there is no practical method by which injury can be prevented.

FIG. 38.—Adult chinch bug. (Enlarged about 4 times.)

Chinch bugs (fig. 38) hibernate during the winter in bunch grass growing in fence corners, sloughs, and other waste places. If this grass is burned early in the winter, those bugs not killed by the fire will be left exposed to winter freezes. Burning should include rubbish and weeds in fence corners as well as grass. The bugs may also be destroyed as they migrate from wheat fields to corn or sorghum fields in the early summer. The method is fully described in circular 113 of the Kansas Agricultural Experiment Station.

THE FALSE WIREWORM

The false Wireworm (fig. 39) in recent years has caused much loss to wheat growers in the western half of Kansas. These insects are especially destructive in dry falls, eating the wheat kernels before they germinate, thus causing a very thin stand or even complete failure. One of the best methods of preventing injury is not to plant wheat, in dry soil. The damage is likely to be greatest in those fields cropped to wheat year after year. Since the worms migrate very slowly, damage can be greatly reduced by growing wheat in rotation with row crops and summer fallow. Early spring plowing or listing, which destroys the hibernating pupae, is advisable for wheat fields in which the wheat has been killed.

WHEAT STRAWWORM

The wheat strawworm is becoming a greater menace, especially in central and western Kansas, possibly as a result of the combine method of harvesting and the one-way plow which leave infested stubble on the surface of the ground, thereby favoring the propagation of the worm.

Injury by the wheat strawworm is usually not observed until near

harvest. At that time the affected heads turn white and the straws may break over. Examination reveals the small larva (about ¼ inch long) inside the straw, usually near the first or second joint below the head.

Plowing immediately after harvest, covering all stubble, and cultivating, as necessary to control volunteer wheat, holds the insect in

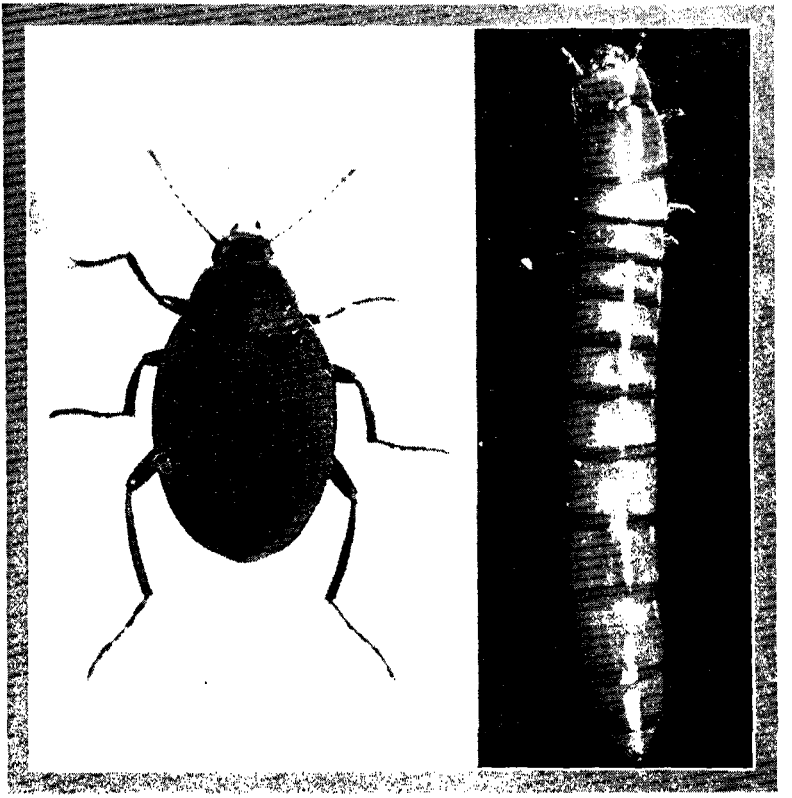


FIG. 39.—False wireworm. Left, adult; right, larva. (Enlarged about 4 times.)

check. Burning the stubble may be recommended as an emergency measure when serious losses have occurred.

WHEAT WHITE GRUB

The wheat white grub attacks the roots of young wheat plants in the fall. Damage usually occurs at first in small areas, which become larger year by year, finally including the entire field in extreme cases. The plants are injured or killed by cutting off the roots.

One of the most effective and at the same time the simplest control measure is rotation of crops. A rotation of wheat, corn, and oats has been found very effective. No doubt any rotation which would deprive the insects of food by keeping the ground free of all vegetation would be effective in preventing damage.

STORED GRAIN INSECTS

Insects of various kinds cause considerable losses in grain stored in bins. Weevil and Angoumois moth also damage wheat in the shock and stack. These insects appear to be especially destructive when grain is damp, as when threshed during rainy weather. They may cause not only a heavy shrinkage in weight but also a severe reduction in market value.

The most effective preventive measures are early threshing and storage in tight bins. For farm conditions the most effective treatment after these insects once become established is fumigation. Full directions for control may be secured free upon application to the Agricultural Experiment Station, Manhattan, Kan.

DISEASES OF WHEATS

Wheat, like all other crops, is attacked by a number of diseases, and a large annual loss is sustained in Kansas from this source. Both fungous and bacterial diseases occur, but the major diseases such as bunt, black stem rust, orange leaf rust,, and take-all are caused by fungi. Eradication or control is in some cases impossible, and in any case depends upon knowledge concerning the disease. The principal diseases that seem to be especially worthy of mention are bunt or stinking smut, loose smut, flag smut, black stem rust, orange leaf rust, take-all, foot-rot diseases, black chaff, and crinkle joint.

BUST OR STINKING SMUT

Bunt is the most destructive disease of wheat in Kansas due to its state-wide distribution and the regularity of its occurrence. The loss is two-fold in nature, a large direct loss being caused by the reduction in yield and a smaller loss by the dockage of smutty wheat on the market. Bunt is caused by a fungus which develops in the interior of the wheat plant and at heading time replaces the grains with false kernels containing a mass of black spores. (Fig. 40.) In threshing, the false kernels are broken up, releasing the spores, which are mixed throughout the grain. The disease is carried over summer on the outside of the seed. At sowing time the spores germinate

5. Contributed by C. O. Johnston, assistant pathologist, Department of Botany and Plant Pathology.

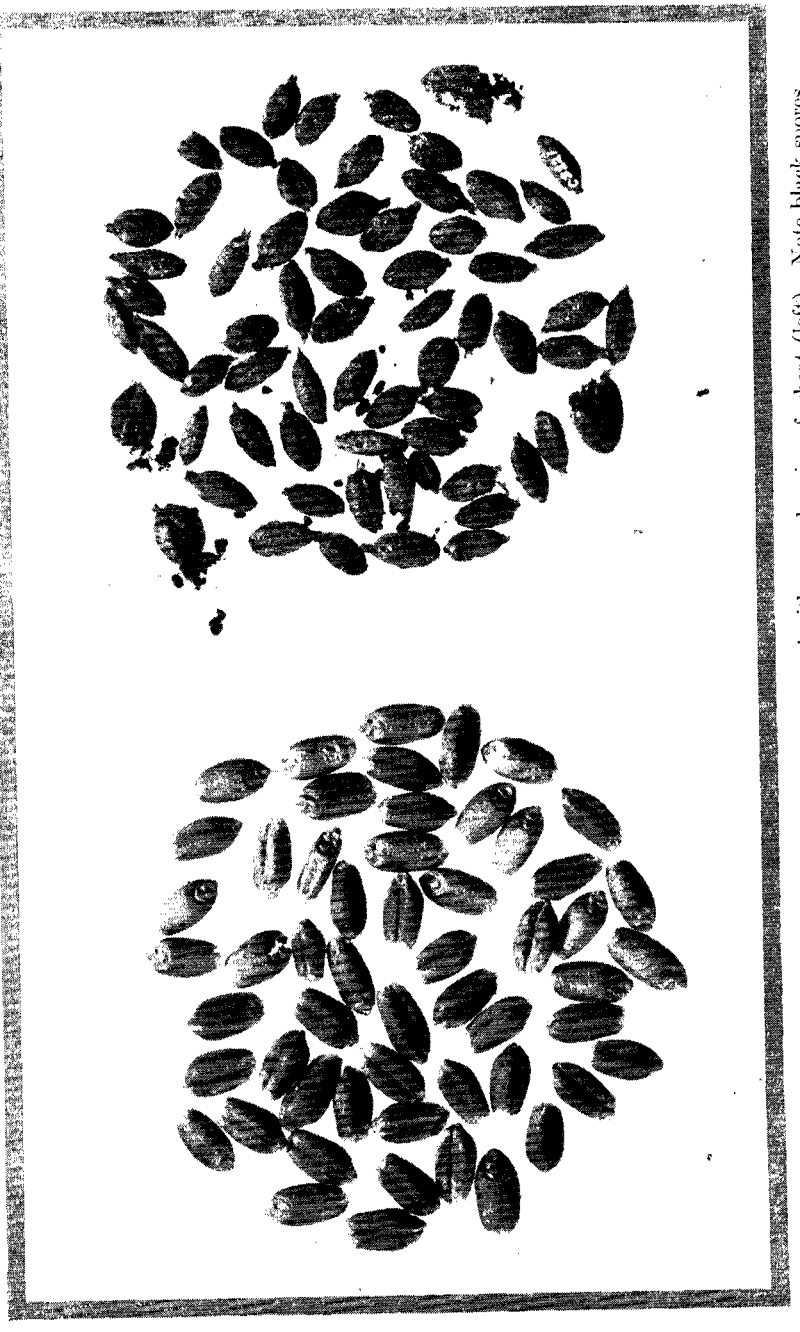


FIG. 40.—Bunt or stinking smut of wheat (right) compared with normal grains of wheat (left). Note black spores emerging from crushed grains of the former.

and the fungus penetrates the young wheat plant and lives there until heading time the following spring.

Heavy infection is favored by low temperatures and high moisture content of the soil at the time of sowing. Thus late sowing often results in high bunt infection as compared with earlier sowings of the same seed.

Smutty seed easily can be detected by the fetid odor, and in heavily smutted seed by the dark color of the grain caused by the clinging spores. Smutty plants cannot be detected in the field until heading time, and they are then rather inconspicuous because such plants often are shorter and the heads smaller than normal plants. They can be identified by their dark bluish green color and by the fact that they are less compact than normal heads, the glumes being forced apart by the false kernels. The kernels are bluish green at first, but dark brown when the wheat is mature. The amount of smut in a field is frequently underestimated on account of the inconspicuousness of the smutted plants.

Stinking smut can be satisfactorily controlled by treating the seed with copper carbonate before sowing. Two grades of this compound are on the market, one containing 50 to 55 per cent copper. and the other containing less than 25 per cent copper. Either gives satisfactory control when properly used. Those containing 50 to 55 per cent copper should be used at the rate of two ounces per bushel of seed, while those containing less than 25 per cent copper should be used at the rate of 3 to 4 ounces per bushel. Complete information on treating methods and machinery can be secured from the Kansas Agricultural Experiment Station.

LOOSE SMUT

Loose smut differs from the covered smut in appearance in that almost the entire head is destroyed by the fungus (fig. 41),the glumes and seeds being replaced by tufts of loose sooty-black fungous material. This is readily washed off by rain or blown off by winds leaving only the bare central stalk of the head. This disease is particularly severe in northeastern Kansas in certain seasons but usually is found in small amounts in all parts of the state. It is carried from season to season in the interior of the seed, and hence control by seed treatment is very difficult. Copper carbonate and other such treatments give no control, a special hot water treatment being necessary. This treatment is not recommended for general farm use. If seed becomes badly infested with loose smut, probably the best method of eradicating the disease is

to secure a new supply of seed from fields at some distance which are known to be free from the disease.

FLAG SMUT

Flag smut, which was apparently introduced from Australia, has been found in Kansas but rarely, and only in counties bordering on the Missouri river. It attacks the leaves and leaf sheaths of the

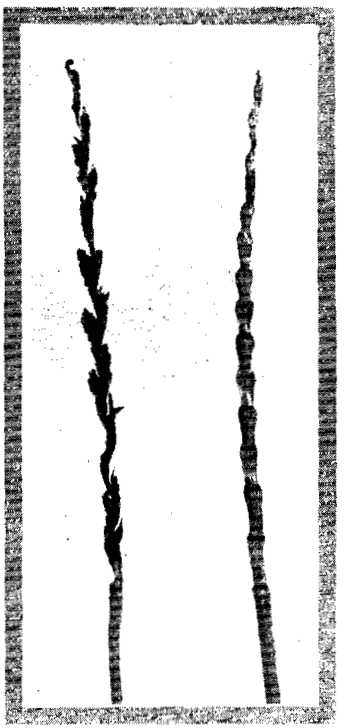


FIG. 41.—Loose smut of wheat with smut spores (left) and after spores have blown away (right).

wheat plants and badly infected plants dry up without producing heads. The disease seems to be particularly severe in the Harvest Queen variety of wheat, which is widely grown in northeastern Kansas. Fulcaster among the soft red winter wheats, and Kanred and Turkey among the hard red winter wheats, are relatively resistant to flag smut.

Treatment of the seed with copper carbonate at the same rate as that recommended for stinking smut gives satisfactory control pro-

vided the seed is sown on land free from flag-smut spores. Crop rotation seems necessary for complete control.

BLACK STEM RUST AND ORANGE LEAF RUST

There are two rusts which are common on wheat in Kansas These are the black stem rust and orange leaf rust. Considerable confusion exists in the minds of many people as to the difference between the two. They are often spoken of as "black rust" and "red rust." This itself is confusing, since both rusts have both red and black stages. There are several strains of each kind of rust, those of black stem rust being especially numerous.

Black stem rust is far more destructive than orange leaf rust, but fortunately it seldom gets started early enough in Kansas to cause serious damage. Orange leaf rust occurs nearly every year and especially in wet years. It no doubt causes considerable losses by using up foods manufactured by the leaves for the plant and by causing injury and premature drying of the leaves.

No control for either disease is known except that early maturing varieties often escape damage when other varieties are injured. Also, certain varieties are known to be resistant or partly resistant to certain strains of these rusts.

TAKE-ALL

Take-all is a disease probably introduced from Australia, which seems to be increasing in Kansas. Infected fields contain spots varying from a few feet square to several acres in extent in which most of the plants are killed early in the spring, while those remaining alive are very weak and have small heads. Such spots are particularly noticeable at heading time, the short dead plants standing out in sharp contrast to the tall normally green plants.

The take-all disease is caused by a fungus which attacks the roots and crowns of the plants. The attacked plants may be entirely killed or only portions of them injured. The disease can usually be identified by the fact that the first internode of the stem above the crown is a glistening black when the leaf sheath and soil are rubbed away.

This disease is carried over summer in the soil and may increase rapidly when wheat is grown continually on the same land. Its severity varies somewhat with the season, apparently being more severe the year following a cool, moist summer. At present, the most practical method of control seems to be rotation of crops in which wheat is not grown on infested land for a period of about five years.

FOOT-ROT DISEASES

There are a number of so-called "foot-rot" diseases which somewhat resemble take-all. Practically all of them cause rotting of the roots or crown tissues. The glossy black appearance on the lower internodes is absent, however. The roots and lower internodes may be brown but seldom black. These foot-rot diseases may kill plants in large areas or single plants scattered throughout the field, but small spots or areas in which the wheat is completely killed, so characteristic of take-all, are seldom found as a result of foot-rot diseases.

Foot-rot diseases are carried either wholly or partially in the soil and rotation of crops seems to be one of the most practical methods of control.

BLACK CHAFF

A bacterial disease of wheat known as black chaff is often prevalent in wet seasons, and particularly so if wheat is lodged or very thick. The leaves, stems, glumes, and awns are attacked, but the most characteristic symptoms are the purplish black blotches on the glumes and stems just below the head. These often appear in the form of stripes, especially on the stems. In severe cases the entire stem for some distance below the head turns a dull brownish-purple. The disease is not considered very serious, and its chief interest lies in the fact that it is often confused with black stem rust. No practical control measures are known.

CRINKLE JOINT

Crinkle joint, so called because the straw of affected plants frequently bends or breaks at the joint or node, has been common in Kansas wheat fields in recent years. Straws of affected plants are shown in figure 42. Very little is known regarding this condition, except that fungous organisms have been isolated from affected joints, and there is good reason to believe they are at least partially responsible for the disease.

Crinkle joint has sometimes been attributed to hail damage. This certainly is not the case, since it often has been observed in fields where there has been no hail and, moreover, hail-injured plants seldom or never break or bend at the joint. No remedy for the disease is known.

MISCELLANEOUS DISEASES

A number of other diseases of wheat, generally of minor importance but which merit attention are scab, basal glume rot, mildew, and septoria leaf spot.

Scab is a serious disease in the more humid portions of the United States and occasionally in Kansas in wet seasons. It is caused by a fungus which attacks the heads shortly after they emerge from the boot. Single spikelets or several spikelets may be killed or development of the grain prevented. The disease can easily be identified by the presence of a pinkish white fungous growth on and around the dead tissue. The grain usually is badly shriveled and

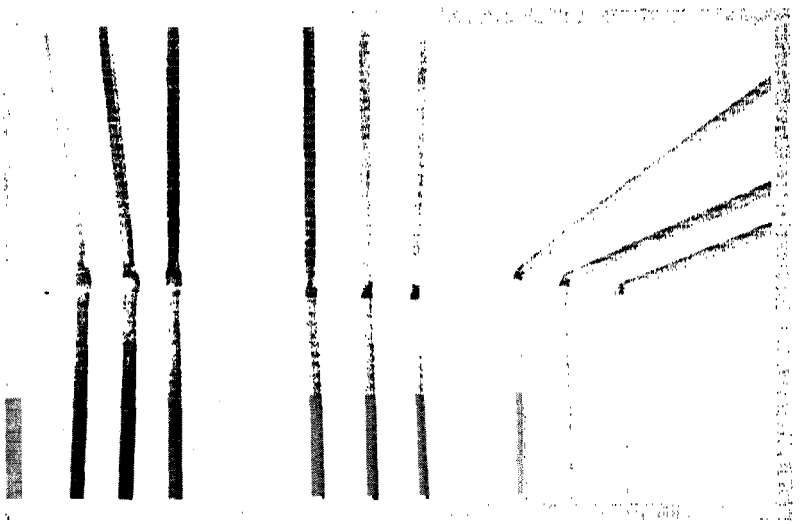


FIG. 42.—Crinkle joint of wheat (right and center) compared with normal straws (left). Note the shrunken, discolored, and sometimes bent or broken joints of the former. A healthy straw never breaks at the joints.

bleached and may be pinkish in color. Wheat grown on corn ground is especially likely to be infected.

Mildew appears on the leaves of wheat in wet seasons, but seldom reaches serious proportions. It is characterized by a white, fuzzy mass of fungous tissues growing over the surfaces of the leaves and stems. It is particularly severe in low fields and lodged spots and in fields having a dense, rank growth of wheat.

Basal glume rot is a bacterial disease which is prevalent only in wet seasons or on bottom land. It makes its presence known to the farmer by the blackened tip of the grain at the germ end. The grain may or may not be shriveled. The disease is of minor importance and control measures are not recommended.

Septoria spot disease attacks the leaves and glumes, usually mak-

ing its first appearance on the lowermost leaves early in the spring. At this time it is characterized by brown areas in the leaves containing many black dots. These are the fruiting bodies containing the spores (or seeds) of the fungus. These areas may also appear on the glumes. No control measures of a practical nature are

FIG. 43.—Three troublesome weeds in Kansas wheat fields: Goat grass or ægilops (left), June grass or wild barley (center), and cheat (right).

known, but fortunately the disease occurs only in wet seasons and seldom causes serious damage.

WEED PESTS

Fortunately Kansas wheat fields are relatively free of weeds. Bindweed is the most serious, especially in view of the fact that the plants live in the ground year after year and are very difficult to

eradicate. Cheat causes some difficulty in eastern Kansas. June grass or little barley and a relatively new weed known as goat grass, or ægilops, are troublesome in central and western Kansas. (Fig. 43.) All of these weeds, except bindweed, can be controlled by rotation of crops and good methods of farming.

CONTROL OF CHEAT AND SIMILAR WEEDS

Cheat, little barley *(Hordeum pusillum)*, and goat grass (*Ægilops)*, as mentioned above, seldom cause trouble when wheat is rotated with other crops. Hence rotation with alfalfa or a cultivated

FIG. 44.—Bindweed, the most serious weed pest Kansas farmers must contend with.

crop is one of the most effective methods of control. Summer fallow in western Kansas is also effective for little barley and goat grass.

It is very difficult to control these pests when wheat is grown continually on the same land. This is for the reason that they have the same growth habits as wheat, germinating in the fall and maturing their seed about the same time or before the wheat ripens. The seed therefore is scattered on the ground where it volunteers and grows in the succeeding crop.

Early plowing followed by clean cultivation is partially effective, but not entirely so, because many of the seeds do not germinate until fall, and hence there is no opportunity to kill the young plants before the wheat is sown. Wheat free from seeds of these weeds should of course be used for seeding.

BINDWEED

Bindweed (fig. 44) can be identified by the small white morning-glory-like flowers about an inch in diameter and the underground stems. The seeds are black, nearly round, and almost as large as wheat grain. It is spread in seed grain and by the underground stems which are carried on tillage implements to other parts of the field where they develop new plants. Small patches of bindweed can be eradicated by applying salt at the rate of about one pound per square foot. Salt should not be applied to bindweed around shade trees as the latter will also be killed.

Bindweed may also be killed by intensive cultivation, i.e., by destroying the stems every time they appear above the ground with a spring-tooth harrow, duck-foot cultivator, or other suitable implement. Such cultivation, if continued throughout one season, will greatly weaken the plants but will not kill them. It should be continued during the second season or at least until about July 1, when the ground may be sowed to drilled sorghum for hay. A few stray plants may survive this treatment and seedlings from seed buried in the soil may appear from time to time. They should be destroyed.

Recently marked success has been had by spraying bindweed plants with sodium chlorate. This method is to a considerable extent still in the experimental stages and moreover requires more extended discussion than can be given here. The reader is therefore referred to the Agricultural Experiment Station for further information.