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KANSAS STATE AGRICULTURAL COLLEGE

GROWING WHEAT IN KANSAS

MANHATTAN, KANSAS

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SUMMARY

Wheat is grown in every county in the state but most extensively in the central part. It is seldom a profitable crop in Southwestern Kansas.

Nearly all wheat grown in Kansas is sown in the fall. Less than one-tenth of 1 percent is spring wheat. In Northwestern Kansas only is spring wheat grown. In all sections of the state it is less productive than winter wheat when the latter germinates well in the fall and comes through the winter in good condition.

In general, oats or barley are more productive than spring wheat in Kansas. Where winter wheat fails to germinate or survive the winter, one or the other of these crops will give higher yields and, with the possible exception of Northwestern Kansas, will prove more profitable.

Hard wheats are best adapted to Central and Western Kansas, Soft wheats are better for the eastern part of the state.

Soft wheats are usually less able than hard wheats to endure drouth, hot winds, and severe winters. On the other hand, they are not so likely to lodge on rich soils and in wet seasons and, hence, give larger yields where these conditions prevail.

As far as known, there are no varieties of wheat suitable for growing in Kansas that are immune or markedly resistant to Hessian fly.

A new variety of hard winter wheat, known as Kanred, has been produced by the Agricultural Experiment Station at Manhattan, This variety has given an average yield of 4.5 bushels per acre more than Turkey and 4.7 bushels per acre more than Kharkof, the two varieties most generally grown in the state. It has also proved decidedly better than Turkey or Kharkof at the branch experiment stations and in cooperative tests with farmers.

A strain of Fulcaster, a soft wheat secured from the Missouri Experiment Station, has given the best yield of all varieties tested in Southeastern Kansas. In Northeastern Kansas, Harvest Queen, a soft wheat, has given practically as good yields as Fulcaster. Harvest Queen is a beardless wheat and is preferred to Fulcaster by many farmers because of this fact.

There is no evidence to show that wheat "runs out." If one has wheat of good quality, free from smut and mixtures, a change

of seed should not be made unless it is reasonably certain that a variety better adapted to the soil and climate where it is to be grown can be obtained.

Pure wheat should be grown. Mixtures usually yield less and sell at a discount, as compared with pure wheat. Mixtures of hard and soft wheat or of rye and wheat are particularly objectionable.

The best time to seed wheat depends on the prevalence of Hessian fly, the location in the state, the preparation of the ground, and local and seasonal conditions. No general rule can be given that will apply to all cases.

Experiments show that wheat sown in furrows somewhat deeper than those made with the common disk drill winterkills less and is less likely to be injured by the blowing of the soil. Good germination is also more certain. It is thought that seeding in deep furrows 10 to 12 inches apart will prove practical and profitable in the northern and western parts of the state where winter killing, blowing of the soil and dry falls often cause serious damage.

In Central Kansas, 4 to 5 pecks per acre of seed gives good results if sown reasonably early on well prepared ground. If sown late, 7 or 8 pecks per acre will give better yields than a smaller amount. About 6 pecks per acre should be sown in Eastern Kansas.

There is no experimental evidence to show that wheat is benefited by pasturing. Usually, a loss in yield occurs. Where wheat makes a good growth and is pastured judiciously, the value of the pasture overbalances the loss in the yield of grain.

Where injury from heaving occurs, as is sometimes the case in Eastern Kansas, rolling or harrowing in the spring is beneficial. Usually it is of little value and may cause injury by increasing the danger of blowing of the soil. Rolling is usually better than harrowing.

The preparation of the ground is one of the most expensive and one of the most important items in growing wheat. The best method depends on the character of the soil and the section of the state where one is farming.

Probably the most important point in preparing the ground for wheat is to work it early. At Manhattan, July or August plowing has given an average yield of 6 bushels per acre more than plowing September 15. Early plowing has given 4 bushels per acre more than late plowing at Hays, and nearly 6 bushels per acre more at Colby. Listing and summer fallow have given higher yields than any other method of preparation in the experiments at Hays.

In experiments conducted at Manhattan, disking immediately after harvest, followed by plowing in September, has given nearly as large yields as early plowing. Disking immediately after harvest has increased the yield 4.4 bushels per acre. Disking benefits the following crop by preventing the growth of weeds, by getting the soil in good condition to absorb water, and probably destroys some of the Hessian flies when these pests are numerous, It also aids in keeping the soil in condition to plow.

Plowed ground should be worked enough to keep down the weeds and get it in good condition for seeding. More work than is necessary to accomplish these results is not necessary. However, ground is not usually worked enough to secure the best yields. In Western Kansas too much working may actually be detrimental because of working the soil too fine and causing it to blow.

Where wheat has been grown continuously on the same land year after year at Manhattan, plowing 7 inches deep in July has given about 5 bushels per acre more than plowing 3 inches deep at the same time. When plowed in September, the difference is only 1.2 bushels. When grown in rotation with corn and oats, in which the ground is plowed fairly deep for these crops, 3 inch plowing has given practically as large yields as 7- and 12-inch plowing.

Listing, if done early, is a good method of preparing the ground for wheat. Late listing is poor practice. The principal advantages from listing are its cheapness and rapidity. A large acreage can be covered in a given period of time and more ground can be stirred early in the season by listing than by plowing.

Summer fallow can be used profitably in the western one-third of the state. It is particularly practical if used in rotation with other methods of preparing the ground or in a system of farming in which wheat is rotated with the sorghums or other crops.

Injury from blowing of the soil may be reduced or prevented by a light application of straw, which is pressed into the ground with a weighted disk, or by cultivating the ground at right angles to the direction of the wind.

Rotations for Eastern Kansas should contain a legume, such as red clover, sweet clover, alfalfa, or cowpeas. A good rotation where red clover is successfully grown and corn is a major crop is, (1) red clover, (2) corn, (3) corn, (4) oats or wheat, and (5) wheat with which clover is seeded in the spring. Cowpeas may be sub-

stituted for red clover and kafir for corn in Southeastern Kansas where red clover and corn are not so successfully grown.

Alfalfa should be included in the rotation where it can be successfully grown. A good rotation for Central Kansas is (1-8) alfalfa, (9) early kafir or Early Amber sorghum, (10) corn, (11) oats, barley, or winter wheat, (12) wheat on ground plowed early, (13-14) wheat, (15) kafir or sweet sorghum, (16) corn, and (17-24) alfalfa.

Barnyard manure is the most satisfactory fertilizer for wheat. In experiments at Manhattan, a top dressing of manure applied to wheat grown continuously on the same land has increased the average yield more than 7 bushels per acre. An application of 5 tons per acre once in three years has increased the average about 3 bushels per acre.

Commercial fertilizers never pay in Central and Western Kansas. On shale, sandstone, and thin glacial soils in Southeastern Kansas, applications of phosphorus in the form of steamed bone meal, acid phosphate, or raw bone meal usually pay well. Steamed bone meal and acid phosphate are usually the cheapest source of supply. For the most profitable results apply steamed bone meal at the rate of 100 to 125 pounds per acre or acid phosphate at the rate of 125 to 175 pounds per acre.

Damaged wheat and wheat mixed with rye or other kinds of wheat brings less on the market than pure wheat of quality. Because of difficulty in determining accurately the effect of damaged kernels and mixtures on the quality of flour, growers usually receive less for damaged and mixed wheat than it is actually worth.

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GROWING WHEAT IN KANSAS

L. E. CALL and S. C. SALMON

INTRODUCTION

Kansas ranks with the most important wheat growing states in the Union, producing during the five years 1913 to 1917 an average of 105,000,000 bushels annually, which is more than that produced by any other state. The quality of Kansas wheat is not surpassed by that of any other country, but the yield per acre (13.7 bushels) is not a record of which to boast.

A high yield per acre should not be the chief or only aim of the wheat grower. Perhaps the most important aim is to grow wheat economically and of the best quality. However, low acre yields, i.e., as low as the average secured in Kansas, indicate that much wheat is grown at a loss, when the cost of labor and machinery, depreciation of equipment, interest on the investment in land and equipment, and the fertility of the soil are taken into consideration.

Nearly every year many acres of wheat are sown which are not harvested. In many cases the yield is scarcely enough to pay the cost of harvesting. Such losses should be prevented as far as possible and practicable. In many cases a better variety or a little extra work at the right time would materially reduce such losses and increase the yield with little or no extra expense.

In the minds of many farmers, good farming means expensive farming—useless frills that make interesting reading for city folks, but of no value for practical men. This should not be true. If so-called good farming does not pay, it is not good farming.

The purpose of this bulletin is to point out practical methods that will make wheat growing more certain and so reduce the losses and the cost of production, and to suggest methods that will give maximum yields of the best quality at a reasonable cost.

The statements set forth are based largely on experimental evidence secured from the Experiment Station at Manhattan, the four branch experiment stations in the central and western parts of the state, numerous cooperative experimental tests with farmers throughout the state, the recorded history of nearly 60 years of wheat growing in Kansas, and the experience of practical farmers generally. It is believed the statements are as accurate as the present knowledge of wheat growing permits.

WHERE TO GROW WHEAT

Most of the wheat produced in Kansas is grown in the central part of the state—west of the eastern five tiers of counties, and east of the western three tiers. (Fig. 1.) However, some wheat is grown in every county.

In Southwestern Kansas wheat is an uncertain crop because of dry, hot winds, high winds in the spring, and summer drouth. Usually sorghum crops, such as early strains of kafir, milo, feterita, and broom corn, are more dependable and will prove more

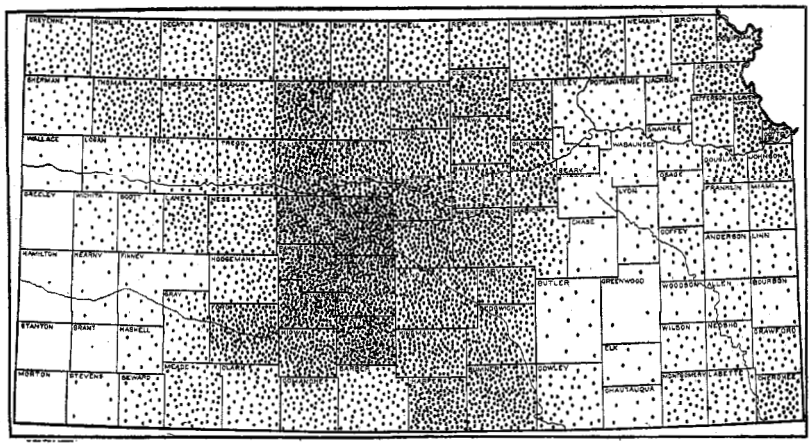

FIG. 1.—Average acreage of wheat, 1906-1915. Each dot represents 1,000 acres

profitable. In nine years experimental work on the upland near Garden City, only three crops of wheat large enough to pay expenses have been produced.

Wheat is not as extensively grown in Eastern Kansas as in Central Kansas because farming is more diversified. However, conditions for growing wheat in Eastern Kansas are usually quite favorable. The principal difficulties met with are rust, chinch bugs, and Hessian fly. Lodging occurs on rich soils in wet seasons.

On thin uplands, wheat is often more profitable than corn, especially if grown after oats and the ground is plowed early. Where this can be done, wheat could be profitably substituted for some of the corn that is usually grown. Where corn is a major crop, as on many Eastern Kansas bottom land farms, wheat is grown in the rotation chiefly as a nurse crop for alfalfa or clover.

THE KIND OF WHEAT TO GROW

Practically all wheat grown in Kansas is sown in the fall. Less than one-tenth of 1 percent is spring wheat, all, or practically all, of which is grown in the extreme northwestern corner of the state. (Fig. 2.) In this section more winter than spring wheat is grown, and it is more productive except when conditions are very unfavorable, as when there is not sufficient moisture in the fall to germinate the grain, or the wheat is killed during the winter or early spring.

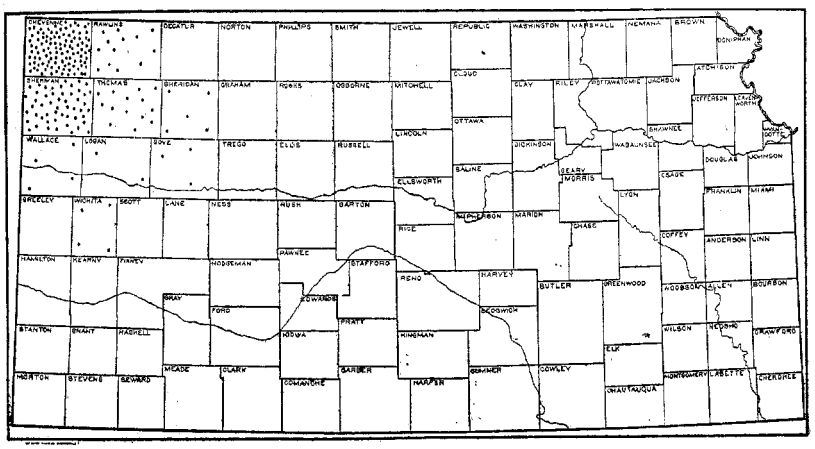

FIG. 2.—Average acreage of spring wheat, 1911-1915. Each dot represents 250 acres

SPRING WHEAT IN KANSAS

It is never advisable to attempt to grow spring wheat except in the extreme northwestern part of the state. Spring wheat matures. later than winter wheat, does not root so deeply, and is more likely to be injured by rust, hot winds, chinch bugs, and drouth. The quality is usually poor, and good yields are obtained only occasionally. If winter wheat fails, it is usually better to grow barley or oats. If a small grain is wanted; otherwise, corn, kafir, or other sorghum crops, depending on the part of the state and the use to be made of the crop.

The yields of spring wheat as compared with other small grain crops in experimental tests in various parts of the state are given in Table I. Data from the Experiment Station of the United States Department of Agriculture at Akron, Colo., are also included. This station is located about 60 miles directly west of the northwestern corner of Kansas. The results are applicable to Northwestern Kansas conditions.

TABLE I.—AVERAGE ANNUAL YIELD OF BARLEY, SPRING WHEAT AND OATS IN EXPERIMENTAL TESTS

PLACE OF EXPERIMENT	Number of tests	Yield per acre		
		Spring wheat	Oats	Barley
		Pounds	*Pounds*	*Pounds*
Manhattan, Kan.	11	468	1,507	1,501
McPherson, Kan.	4	806	1,203	1,454
Garden City, Kan.	10	270	292	386
Hays, Kan. (*a*)	12	238	538	626
Colby, Kan. (*a*)	2	960	856	1,459
Akron, Colo.	6	658	704	893

(*a*) The experiments at Hays and Colby, Kan., have been conducted in cooperation with the Office of Dry-Land Agriculture, United States Department of Agriculture. The Office of Cereal Investigations, United States Department of Agriculture, has cooperated in determining the best varieties and the best time and rate to seed at Hays, Kan.

It will be seen that in all tests barley or oats have produced more pounds of grain per acre than spring wheat and this difference is more than enough to balance the difference in price or the difference in feeding value because of the hulls on oats and barley.

In the two-year test at Colby, spring wheat has been decidedly more profitable than oats, but less profitable than barley. In the six-year test at Akron, Colo., spring wheat has proved more profitable than oats but there is little or no advantage as compared with barley. At Manhattan, barley and oats have produced more than three times as many pounds of grain as spring wheat. At McPherson, oats have produced about 50 percent more than spring wheat, and barley about 75 percent more than spring wheat. In the 12-year test at Hays, the yield of oats and barley is more than double that of spring wheat. Also at Garden City spring wheat has produced decidedly less grain than either oats or barley, although none of these grains have given profitable yields.

The experiments show conclusively that where winter wheat fails, oats or barley, or some other spring crop, will give more profitable yields than spring wheat, except possibly in extreme Northwestern Kansas. Even in this section barley is a more certain crop and, on the average, will usually prove more profitable than spring wheat.

HARD AND SOFT WINTER WHEATS

Both hard and soft minter wheat varieties are grown in Kansas. (Fig. 3.) The hard wheats are bearded, have smooth, white chaff and a relatively small, hard,slender, red grain. A semi-hard or hard wheat, known as Ghirka, is beardless. It is distinctly inferior to other varieties and is little grown.

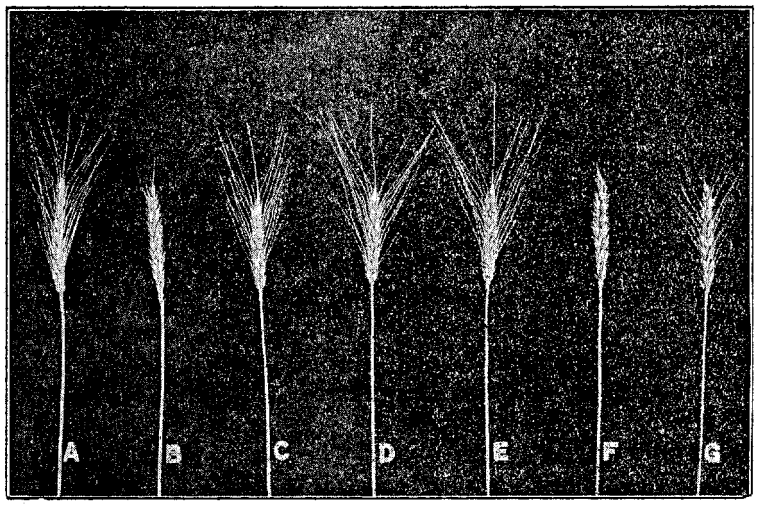

FIG. 3.—Varieties of winter wheat: A, Fulcaster; B, Zimmerman; C. Turkey; D, Kanred; E, Kharkof; F, Harvest Queen; G, Miracle

Soft wheats may be bearded or beardless, have smooth or velvet chaff, the chaff and beards being of various colors, ranging from white to a dark reddish brown, almost black. The grain may be red or white. Red-grained varieties are grown almost exclusively in Kansas.

Soft wheat has a lower protein and gluten content than hard wheat. The flour has less "strength," meaning that an equal amount will not produce so large a loaf. 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 of each. 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 drouth and usually less cold resistant than hard wheat, and more easily injured by hot winds. On the other hand, most varieties have a stiffer, stronger straw than hard wheat and, consequently, are less likely to lodge in wet seasons and humid climates.

The map (fig. 4) 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, conversely, some soft wheat in the hard wheat belt, particularly along creek and river bottoms.

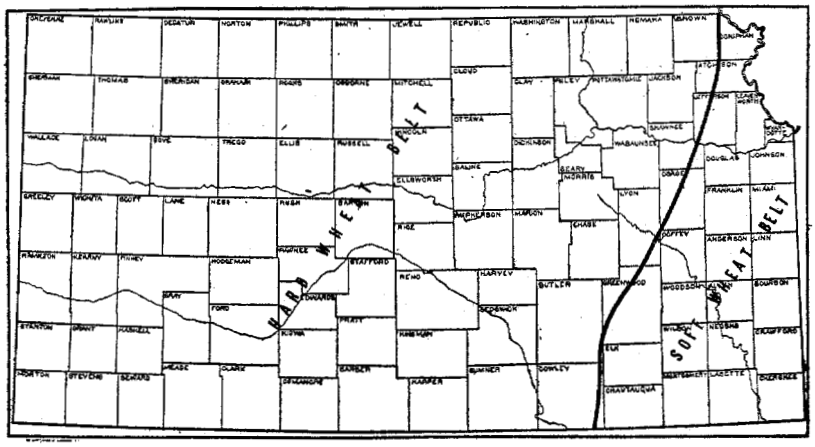

FIG. 4.—Areas where hard winter and soft winter wheats are grown. The heavy line marks approximately the division between the two areas

In experiments conducted in cooperation with farmers in Marshall, Nemaha, Lyon, and Cowley counties, the better varieties of hard and of soft wheats have given practically identical yields. In tests 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 almost always give the best yields.

WINTER KILLING OF HARD AND OF SOFT WHEATS

One of the principal advantages of growing hard winter wheat in Central and Northern Kansas is its ability to survive cold winters. Some varieties of soft winter wheat are almost as cold

resistant as the hard winter varieties. In fact, instances are known where soft wheats have survived the best. However, in the severe winter of 1916-17 at Manhattan, none proved as hardy as Kanred and Kharkof, and many were completely winter killed. This agrees with general farm experience in growing these two classes of wheats.

"FLY PROOF WHEAT"

Many farmers have observed that soft wheat is injured less than hard wheat by Hessian fly, where both are grown in the same neighborhood. In seasons when fly causes considerable damage, farmers are encouraged to grow soft wheat for this reason. In this connection it should be remembered that in the Eastern United States and in some parts of Eastern Kansas, where soft wheats are grown exclusively, wheat is frequently entirely destroyed by Hessian fly. In other words, it seems that although the Hessian fly prefers hard wheat, soft wheat may be injured just as badly if no hard wheat is grown.

As far as known, there are no varieties of wheat suitable for growing in Kansas that are immune or markedly resistant to fly.

In experimental tests conducted for one year only by the Agronomy and Entomology departments cooperating, certain varieties were found to be much more resistant than others. However, the varieties that appeared to be most resistant are, for various reasons, not adapted in general for growing in Kansas.

VARIETIES OF HARD WINTER WHEAT

All good varieties of hard winter wheat are bearded, have red grain and smooth white chaff. Turkey and Kharkof are the two varieties most generally grown. Other varieties are Theiss, Beloglina, Malakoff, Crimean, and Kanred. All hard wheat varieties are very similar. In fact, they cannot usually be distinguished one from another.

All of these varieties except Kanred were imported from various parts of Asia, chiefly Southern Russia. Turkey was brought into Kansas about 1873 by Mennonite colonists who settled in McPherson and Harvey counties. Kharkof was brought directly from Russia in 1900 by the United States Department of Agriculture.

These original varieties have been improved by selection, and the strains produced in this way have been widely distributed over the state so that most of the hard wheat now grown in Kansas consists of improved strains of Turkey and Kharkof.

NEW VARIETIES OF WHEAT

One of the most important lines of work of the Experiment Station is the improvement of varieties of wheat by selection and breeding. (Fig. 5.) This consists essentially of selecting a large number of the best heads from fields or plots of the better varieties. Each head is thrashed separately, planted in a row by itself, and

FIG. 5.—View of the Cereal Crop Nursery, Manhattan, Kan.

FIG. 6.—New and improved varieties of wheat in the Cereal Crop Nursery, Manhattan, Kan. Each row is a different variety

harvested. The poorest are discarded and the best are grown in longer rows the second year. (Fig. 6.) This process is repeated the third year, and again the fourth year, or until only a few of the very best remain. These are then grown in field plots for several years. In these plots they are tested for yield, milling value, and resistance to cold, drouth, heat, and rust. A few of the best are given a further test for three or four years, or even longer, at the branch experiment stations in different parts of the state, and in cooperative tests with farmers throughout the wheat belt of the state. The varieties having the best quality and producing the best yields are then distributed to farmers for general planting.

Occasionally it may seem desirable to cross two varieties in order to combine in one the good qualities of both. After crossing, selection and thorough testing of the different types that are produced is necessary. This is carried out in approximately the manner already described.

Kanred—A New Variety for Kansas

As a result of work of this kind, a new variety of hard winter wheat has recently been secured which in all respects appears to be superior o any heretofore grown. This variety has been named Kanred from Kan(sas)-red.

Table II gives the yields of Kanred as compared with Turkey and Kharkof, the two varieties of hard winter wheat most generally grown.

TABLE II.—YIELDS OF KANRED, TURKEY, AND KHARKOF AT MANHATTAN, KAN.

VARIETY	Bushels per acre							
	1911	1912	1913	1914	1915	1916	1917	Average
Kanred	34.6	19.8	37.1	35.2	26.0	33.6	16.6	29.0
Turkey	31.1	13.2	33.6	36.1	23.0	22.2	12.7	24.5
Kharkof	26.1	11.9	33.8	36.0	22.9	24.6	14.6	24.3

Table III gives the yields as grown at three branch experiment stations in Central and Western Kansas, and Table IV, as grown in cooperative tests with farmers in the hard wheat belt of the state. In all tests conducted in cooperation with farmers, the variety being grown by each farmer was also included in his test. This variety is called "local" in Table IV, the yields being given to compare with the other varieties.

TABLE III.—YIELDS OF KANRED, TURKEY, AND KHARKOF AT KANSAS BRANCH EXPERIMENT STATIONS, 1914 TO 1917

STATION AND VARIETY	Yield in bushels per acre				
	1914	1915	1916	1917	Average
Fort Hays—					
Kanred	25.6	.....	36.4	20.6	27.5
Turkey	23.3	.....	32.7	19.8	25.3
Garden City—					
Kanred	.....	15.4	17.2	0.0	10.9
Turkey	.....	13.8	15.3	0.0	9.7
Kharkof	.....	15.5	13.3	0.0	9.6
Colby—					
Kanred	.....	34.8	42.6	0.0	25.9
Turkey	.....	33.8	28.8	0.0	20.9

TABLE IV.—AVERAGE YIELDS OF KANRED, TURKEY, AND KHARKOF IN COOPERATIVE TESTS WITH FARMERS

	Yield in bushels per acre				
	1914	1915	1916	1917	Average
Number of tests	10	25	21	11	.....
Kanred	28.9	25.2	26.3	23.7	26.0
Turkey	26.4	23.2	20.4	21.9	23.0
Kharkof	25.7	20.7	19.8	20.5	21.7
Local	26.4	21.6	20.4	20.8	22.3

It will be seen that at Manhattan, the average production of Kanred has been 4.5 bushels per acre more than Turkey, and 4.7 bushels more than Kharkof. It has outyielded these varieties in every season but one and in that season (1914) practically equalled the others. At the branch stations, it has exceeded in yield the varieties grown with it in nearly every test.

In cooperative tests with farmers the average production of Kanred has been 3 bushels per acre more than Turkey, 4.3 bushels more than Kharkof, and 3.7 bushels more than the local variety grown by each farmer. (Fig. 7.) Kanred exceeded Turkey in 59 times out of a possible 66, Kharkof 51 times out of a possible 58, and the local variety 49 out of a possible 54. This is for all tests prior to 1917.

Kanred Ripens Early.—Probably one of the reasons for the greater yield of Kanred as compared with Turkey and Kharkof is the fact that it usually matures somewhat earlier. The average

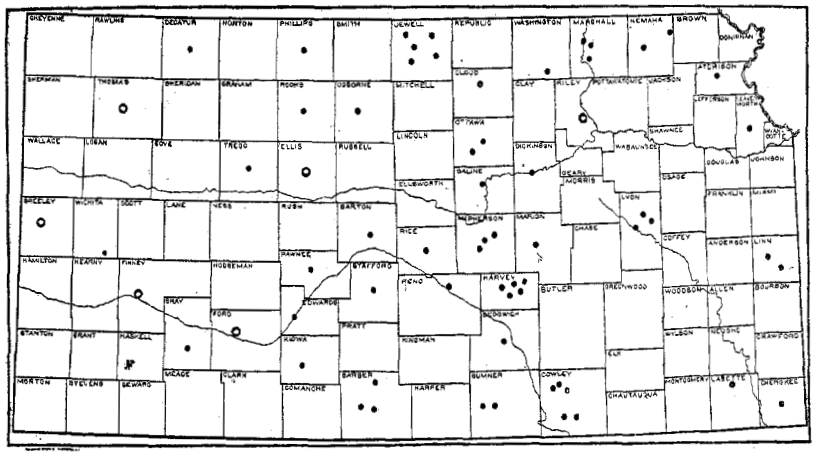

FIG. 7.—Location of Experimental tests with Kanred wheat. The circles represent tests on State Experiment Stations, and the dots cooperative tests with farmers

time of the heading of Kanred at Manhattan has been one day earlier than Turkey and Kharkof; the average time of ripening has been two days earlier. Similar differences have been observed at the branch stations and in cooperative tests with farmers.

Cold Resistance of Kanred.—In a considerable number of tests, it has been observed that Kanred was markedly resistant to winter killing as compared with other hard wheats. As an example, in tests conducted on the farm of Mr. Frank Carlson, in Cloud County, in 1915-16, Kanred survived almost perfectly, while at least 50 percent of Turkey and Kharkof on adjoining plots on either side was killed. No exact determinations of winter killing were made, but the yields in that season were 27 bushels for Kanred, 17.2 bushels for Turkey, and 16 bushels for Kharkof. Similar results were secured in other tests in Northern and Northeastern Kansas in that season.

Winter killing in the winter and spring of 1915-16 was mainly attributed to an ice sheet which covered the ground in late February and early March and to alternate thawing and freezing in the spring. A heavy ice sheet covered the ground at Manhattan and, although no winter killing occurred, it appeared that the wheat was somewhat injured. Kanred was distinctly more vigorous and thrifty in the spring than other varieties and yielded, in that season, 11.4 bushels more than Turkey and 9 bushels more than Kharkof. (Table 11.)

In certain other tests in which winter killing has occurred, Kan-

red has showed no superiority in this respect as compared with other varieties, but the yields have, in all such cases, been decidedly in favor of Kanred.

No doubt there is more than one cause of winter killing. It is probable that Kanred is more resistant than other varieties when certain causes predominate, but no more resistant, or conceivably even less resistant, when other factors cause injury. It seems reasonable to conclude that, for the hard wheat belt of Kansas, Kanred is one of the best varieties, if not the best.

Rust Resistance of Kanred.—Careful tests at Manhattan and elsewhere, conducted by Professor L. E. Melchers of the Department of Botany and Professor J. H. Parker of the United States Department of Agriculture show that Kanred is markedly resistant or immune to certain kinds of black stem rust. Also, it has frequently been observed in the fields at Manhattan and in cooperative tests with farmers that Kanred wheat has been injured much less than other varieties when orange leaf rust was prevalent. Black stem rust is seldom injurious in Kansas except in the eastern part of the state and in very wet seasons elsewhere. While rust does not damage wheat in Kansas to the extent that it does in other states, the fact that a good variety that is rust resistant is available for planting may be very important in some seasons.

VARIETIES OF SOFT WHEAT

Experiments to determine the best varieties of soft wheat have been conducted in Southeastern Kansas for four years and in Northeastern Kansas for five years. In all, about 60 trials have been made. Table V shows the results obtained in Northeastern Kansas and Table VI, those in Southeastern Kansas.

TABLE V.—VARIETY TESTS OF SOFT WINTER WHEAT IN NORTHEASTERN KANSAS

YEAR	1913	1914	1915	1916	1917	Average 1913–1917	Average 1915–1917
Number of tests	3	5	5	8	4		
VARIETY	Average yield in bushels per acre						
Fulcaster	.....	.....	21.4	26.0	22.6	.....	23.3
Harvest Queen	.....	27.5	18.0	25.2	23.7	.....	22.3
Currell	32.8	31.8	18.5	24.6	16.8	24.9	20 0
Turkey	33.9	26.6	12.9	22.4	22.2	23.6	19.2
Miracle	.....	.....	.....	19.7	17.9	.....	.....

1. Now of the Department of Agronomy, Kansas Agricultural Experiment Station.

TABLE VI.—VARIETY TESTS OF SOFT WINTER WHEAT IN SOUTHEASTERN KANSAS

YEAR	1914	1915	1916	1917	Average 1915–1917
Number of tests	6	7	10	12	
VARIETY	Average yield in bushels per acre				
Fulcaster	.....	16.8	16.9	31.0	21.6
Currell	27.1	15.3	15.9	27.6	19.6
Harvest Queen	26.3	13.8	13.4	30.1	19.1
Red Sea	.....	15.9	16.4	27.5	19.9
Fultz	.....	13.2	16.3	.....	.....
Miracle	.....	18.0	14.9	27.6	20 2

It will be seen that in both sections Fulcaster has given the best yields. Fulcaster has a red grain and is bearded. Many farmers object to it because of the beards. In Northeastern Kansas, Harvest Queen has given nearly as good yields as Fulcaster and has been more winter hardy. This variety is beardless. As the yields are practically equal to Fulcaster, it may be recommended for this section of the state.

The Miracle variety, which has been widely advertised, was included in some of the tests. In nearly all cases it produced less than other varieties. Milling tests have shown that it is somewhat inferior to other soft wheats for milling. Also, it appears to be among the least hardy of any of the soft winter wheats, as shown by tests at Manhattan and by tests conducted in cooperation with farmers throughout Central and Northern Kansas. In the winter of 1916-17, it killed out completely when other soft varieties made fair yields and in other seasons it has shown marked injury where others escaped entirely.

Fultz and Zimmerman are often grown in the soft wheat belt. Zimmerman is very early and gives satisfactory results where an early maturing wheat is desired. On good land and in favorable seasons, it does not yield as much as later maturing varieties, such as Harvest Queen. Neither the Fultz nor the Zimmerman have proved unusually productive in experimental tests.

Currell has given good results on wet lands in Southeastern Kansas. General observation appears to show that it will stand up longer than many other varieties after it is ripe. It is a beardless variety.

CHANGING SEED

One of the most commonly suggested ways of increasing the yield of wheat is to change seed. If the grain is shrunken, smutty, 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 percentage. 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 reasonably certain that a better variety will be obtained.

PURE SEED

In general, it is better to use to pure variety of wheat than a mixture of two or more varieties. All kinds in a mixture will likely not ripen at the same time; hence, some may ripen and shatter out, or others may be green when the field is cut. Also, they are quite likely to differ in ability to yield. Pure wheat will often bring a premium for seed, where a mixed wheat must always be sold at market price or, if badly mixed, at a discount.

A mixture of soft wheat in hard wheat, or of rye in either soft or hard winter wheat, is particularly objectionable. According to the rules of the United States Department of Agriculture for grading wheat in force after July 15, 1918, No. 1 wheat must not contain more than 1 percent of rye; No. 2, more than 2 percent; or No, 3, more than 3 percent. Mixtures of different kinds and varietie of wheat also lower the grade if present in sufficient amounts.

HOW TO PURIFY SEED WHEAT

If the variety one is growing becomes mixed with other kinds of wheat or with rye, it can be purified only by going through the field about heading time or just before harvest and pulling out the mixtures. A field can be quite easily freed of rye in this way, if not badly mixed. If badly mixed, whether with rye or other kinds of wheat, it will usually pay either to buy new seed or to rogue only a small portion of the field from which seed is saved for general planting the following year.

YELLOW BERRY WHEAT FOR SEED

Many farmers in Eastern and Central Kansas hesitate to use yellow berry wheat for seed, believing it to be an indication of "running out" or deterioration of the wheat. Yellow berry in Kansas hard wheat is due mainly to wet seasons. Another contributory cause is poor soil, especially a soil deficient in nitrogen. The percent of yellow berry varies also with the variety, some varieties having more yellow berry than others in wet seasons.

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. All the better varieties of hard wheat, as far as known, have yellow berry when weather and soil conditions are favorable for it.

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 or on early plowed ground than where no rotation is practiced or the ground is plowed late or poorly prepared. Any practice that makes nitrogen available for the wheat will likely reduce the amount of yellow berry and at the same time increase the yield of wheat.

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 appear, to be definitely proven:

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, weakly 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 thrashing machine, and is reasonably plump, free from weed seeds, dirt, and smut, and of general good quality, there is little to be gained by cleaning and grading. It appears that for the average farm conditions, small, plump kernels will yield just as well as equally plump but larger kernels.

TREATING SEED FOR SMUT

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

County agents will supply directions for treating or they may be obtained by application to the Agricultural Experiment Station at Manhattan. Bulletin 210 gives full directions.

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 as deeply as when it is sown early, and it is more subject to injury from drouth and hot winds. Late sown wheat tillers vary little and usually gives a thin stand. It ripens late, and in the eastern part of the state is more likely to be injured by rust than wheat that is sown somewhat earlier. The quality is usually poor as compared with wheat planted early.

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 dry seasons, 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. This happens frequently in Central and Western Kansas.

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 for seeding 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. The presence of Hessian fly can be easily detected by examining the wheat stubble. If present in abundance, damage to the following crop is almost certain to occur unless measures are taken to control or avoid it.

HOW TO PREVENT INJURY FROM HESSIAN FLY

There are two effective and practical ways to avoid injury from Hessian fly. One is to kill the flies in the stubble and in volunteer wheat before they can hatch and lay their eggs on the grain. The other is to destroy the volunteer wheat and delay seeding so that most of the flies will have ceased laying eggs by the time the wheat is up.

The best way to kill the Hessian fly in infested stubble, where it exists in the "flax-seed" stage, is to plow early and at least 4 or 5 inches deep. If the ground is then worked with a disk, the flies will be buried so deep and the ground above packed so firmly that very few will be able to get to the surface.

Burning the stubble also kills the few Hessian flies above the ground but does not kill the majority, which are below the surface. Since burning destroys the organic matter in the stubble, which is badly needed in most Kansas soils, and does not destroy a very large percent of the Hessian flies, it cannot be recommended as a general practice.

Early deep plowing, to be fully effective, must be practiced by the entire neighborhood and must include all infested fields, since the flies frequently migrate considerable distances. As it is usually impractical to plow all fields in a neighborhood early and deep, the only way to insure safety from the fly is to avoid early seeding. It is also necessary to destroy the volunteer wheat, since it may become infested, carry the flies through the winter, and contaminate the fields in the spring.

Fly Free Dates

Late sown wheat usually escapes injury from fly in the fall but may be injured in the spring by flies migrating from nearby early sown fields. If sown too late, there is danger of winter killing.

The so-called fly free date, i.e., the date when wheat may be sown with a small chance of injury, varies for different parts of the state. In Northeastern Kansas, it varies from about October 1 to October 5 or 6; in Southeastern Kansas, from October 12 to 14;

in North-Central Kansas, from September 25 to September 28; and in South-Central Kansas, from October 10 to 12. If wheat is sown on or about the fly free dates on early plowed and well prepared ground, there will usually be no injury from fly or from winter killing, and the yields will be as large as for earlier seeding even when no fly is present.

If, however, the ground is plowed late and poorly prepared, wheat sown on these dates will often not make sufficient growth to carry it through the winter. In such cases it is best to seed somewhat earlier than the dates mentioned. Also, if one has a large acreage, it is necessary to begin early in order to finish by a safe date.

When to Seed in Eastern Kansas.— When Hessian flies are present in damaging numbers, wheat should not be sown before about September 25 to September 28 in Northeastern Kansas or before October 3 to 5 in Southeastern Kansas. Even when sown this late some damage from the fly may be expected. If the fields are small and the wheat can be sown promptly, it may be advisable often, where fly is unusually bad, to delay seeding until October 1 to 5 in Northeastern Kansas and until October 10 to 15 in Southeastern Kansas.

When there are no Hessian flies, much earlier seeding may be practiced. However, it is seldom advisable to seed before September 20 in Northeastern Kansas or September 25 in Southeastern Kansas, except when sowing mainly for pasture.

When to Seed in South-Central Kansas.— Hessian flies cause serious damage in South-Central Kansas, sometimes entirely destroying wheat that is sown early. When they are present in damaging numbers, seeding should not begin before October 1 on poor soil or on poorly prepared land, nor before October 6 to 7 on fertile soil or on well prepared land. If no flies are present, seeding may begin as early as September 15 if conditions are favorable for seeding at that time.

When to Seed in North-Central Kansas.— Somewhat earlier seeding is desirable for North-Central Kansas than for points east or south. This is because the elevation and latitude shorten the season and grain must be sown earlier to get the same start before winter. The Hessian fly seldom causes serious damage and disappears earlier in the fall so there is not so much danger from this source.

Experiments conducted in this part of the state show that the best yields are usually secured from seeding about September 20

to 25. As elsewhere, the best time to seed will depend not only on the prevalence of fly but also on other local conditions, especially the condition of the land and the acreage to be seeded. If a large acreage is to be seeded, it is advisable to begin seeding reasonably early, even as early as September 10 to 15, since unfavorable weather may delay seeding until too late for good results. If, on the other hand, a small acreage only is to be sown and flies are present in abundance, seeding should be delayed until near the end of September.

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, flies are seldom found west of the eastern border of Norton, Graham, Trego, Ness, Hodgeman, Ford, and Clark counties—hence the question of damage from fly need not be considered in the average season. 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. There may be just enough moisture in the ground to germinate the wheat, but not enough to keep it growing. It may then start to grow and die for lack of moisture. 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 either case the seed is lost.

On the other hand, there is less danger of late seeding being the cause of winter killing in Western Kansas than in the eastern part of the state. It quite 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.

The best thing to do in this area is 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.

The common practice of delaying the preparation of the gound until sufficient rain comes to germinate the seed should be discouraged. By the time the ground is prepared, the moisture may all have evaporated, and the grain must be sown in dry ground or seeding delayed until another rain comes.

Probably the best date for seeding in Western Kansas, when all conditions are favorable, is about the middle of September.

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 or when sown in dry soil in the fall and it fails to germinate before spring, it will not head during the summer (fig. 8.) 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 in February has made a normal growth and produced a fair yield. This seldom occurs, however, and the practice cannot be recommended.

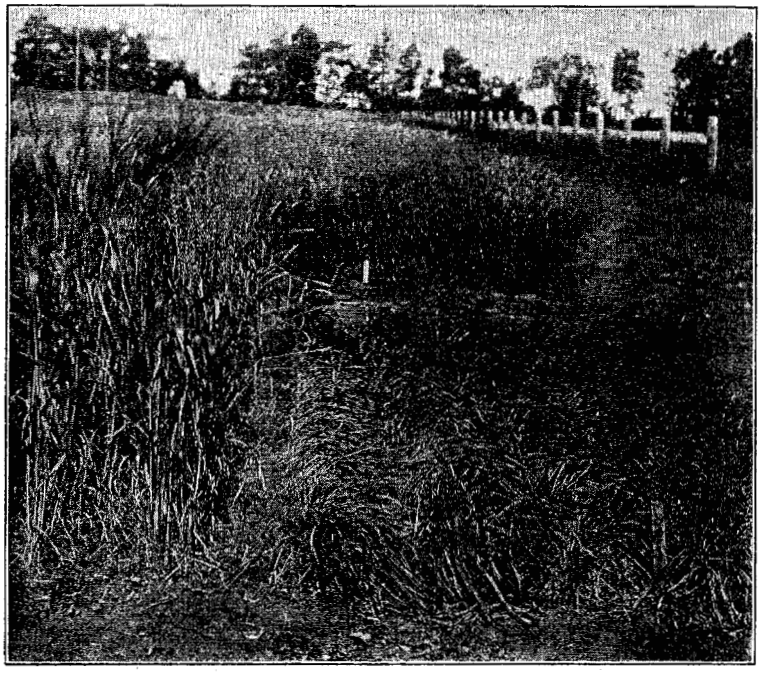

FIG. 8.—Winter wheat sown in the spring (right) compared with the same varieties sown in the fall (left). Oats in the background

METHODS OF SEEDING

Practically all wheat in Kansas is sown with a drill. Winter wheat cannot be successfully grown if sown broadcast either because of difficulty in getting the wheat in moist soil or because of winter killing. The slight ridges left by the drill catch snow during the winter, and these protect the wheat to some extent. Also, damage from heaving is greatly reduced where such injury occurs as a result of alternate freezing and thawing in the spring.

Disc drills are generally used as they catch less trash and have a lighter draft than hoe drills and shoe drills. Double disc drills seldom prove satisfactory because of the ridge left between the discs, heavy draft, clogging in trashy ground, and short life.

Press wheels are used in Western Kansas to press the dirt around the grain and so insure better germination.

For seeding in Central and Western Kansas, the discs are usually spaced 7 to 8 inches apart, while in Eastern Kansas 6- or 7-inch spacing is more common. Drills which space the rows 3½ to 4 inches apart have not been tried at the Kansas Experiment Station. It is not probable that they will prove in any way superior to those which space the drill rows 6 to 8 inches apart. Where the rows are close together the ground is left very smooth with practically no ridge between the rows and hence the grain receives very little protection as compared to the wider spaced rows with the higher ridges.

SEEDING IN FURROWS

Listing or seeding in furrows has been tried out quite extensively at the experiment stations at Manhattan, Hays, Garden City, and Tribune. By this method the wheat is placed in the bottom of furrows about 3 to 5 inches deep and from 10 to 16 inches apart. Some of the advantages are as follows: The wheat is more likely to be placed in moist soil and good germination is more certain. The furrows catch snow which protects the wheat during the winter. (Fig. 9.) Blowing of the soil in the spring is less likely to occur, and if it does, the wheat being somewhat below the level surface is not so likely to be blown out. In Eastern Kansas where wheat is frequently killed by thawing and freezing, winter killing is greatly reduced. It is probable, however, that in very favorable seasons, when germination is good and when no injury from winter killing or blowing occurs, wheat in furrows will yield no better than that sown in the usual way.

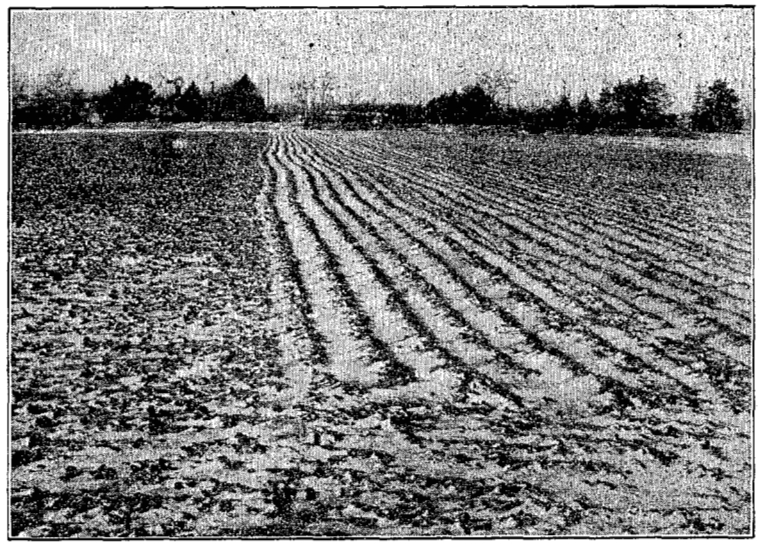

FIG. 9.—Effect of 4- to 5-inch furrows, 12 inches apart, on holding snow.

In experiments being conducted at the present time, drills are used which make the furrows about 4 inches deep and 12 inches apart. There appears to be no material reduction in yield due to this spacing, though the protection afforded the wheat is considerably greater than when sown in the usual way. There is good reason to believe that this method of seeding will prove of practical value, especially in the northern and western parts of the state where wheat often fails to germinate well in the fall, and where injury from blowing of the soil or winter killing frequently occurs.

In experiments so far conducted at Manhattan and at Hays, seeding in furrows north and south has given larger yields than seeding east and west. This is contrary to what might be expected. It appears to be explained by the fact that the wheat is protected during the winter practically as much as that in east and west furrows, that it often grows faster in the early spring and makes a more vigorous and larger growth and hence produces larger yields.

THE RATE TO SEED WHEAT

The rate to seed wheat bears a very definite relation to the time of seeding. Wheat that is planted early tillers abundantly and produces many heads from a single grain. On the other hand, late sown wheat often germinates poorly and produces but one or two heads per plant.

The rate of seeding varies also according to the variety and the condition of the ground. In Eastern Kansas soft wheat is often sown about 1 peck per acre heavier than hard wheat. This is because the grains are usually larger and because soft wheats usually tiller less than hard wheat. Less seed is required on well prepared ground than on poorly prepared ground. Germination on the former is better and the grain tillers more.

Experiments to determine the best rate to seed hard wheat at different times of seeding have been conducted at the Experiment Station at Manhattan for five years. The results show that when sown reasonably early, i. e., from September 20 to October 1, from 4 to 6 pecks per acre have given the best yields. Eight pecks per acre have proved better than a less amount when sown after October 1.

In Central and Western Kansas lighter seeding is the common rule. The rainfall, is less and the soil is not capable of supporting so many plants. In Central Kansas, 4 to 5 pecks for early seeding is sufficient, while in Western Kansas, 3 pecks or even less will usually give better yields than heavier seeding.

PASTURING WHEAT

Wheat makes excellent fall pasture, and where it makes a good growth in the fall is frequently used for this purpose. There is considerable difference of opinion as to the advisability of this practice.

Experiments so far conducted show that pasturing does not benefit the wheat and usually reduces the yield somewhat. The yield is greatly reduced if the grain is pastured too soon, i. e., before it gets a good start; if it is pastured too close; if it is pastured when the ground is wet; or if it is pastured late in the spring.

It seems that when judiciously pastured the reduction in yield is seldom more than 1 or 2 bushels per acre. Often the value of the pasture is more than enough to make up this loss.

It is thought by many farmers that pasturing is beneficial if the

wheat makes too much growth in the fall. This is probably true, but so far is not supported by experimental evidence.

As far as known, pasturing does not greatly reduce injury from Hessian fly as is sometimes thought.

HARROWING AND ROLLING WHEAT

It is believed that rolling or harrowing wheat in the spring is sometimes beneficial. The Nebraska Agricultural Experiment Station found that rolling wheat that had been injured by alternate thawing and freezing increased the yield about 5 bushels per acre. Harrowing was beneficial but not so much so as rolling. Rolling pressed the soil back around the roots of the plants and probably prevented much of the injury that would otherwise have occurred, Most other experiments have shown that harrowing wheat usually reduces the yield rather than increases it.

In Central and Western Kansas rolling or harrowing increases blowing of the soil and hence causes more injury than benefit. Neither practice is considered advisable in this section of the state.

Winter wheat should not be harrowed in the fall after seeding. The small ridges left by the drill protect the wheat during the winter. If leveled down, the wheat is more likely to be injured.

Spring wheat may be harrowed after seeding if the condition of the ground appears to make harrowing desirable.

PREPARATION OF THE GROUND FOR WHEAT

The preparation of the ground is usually the most expensive single item in growing wheat, and it is one of the most important within the farmer's control. A fair yield will sometimes be secured with indifferent or poor farming and occasionally good farming will not offset an unusually bad season. But, as a rule, good preparation of the ground pays.

The kind of preparation that pays best, i. e., the time, depth, and manner of plowing, listing, or disking depends on the character of the soil and the section of the state where one is farming.

EXPERIMENTS AT MANHATTAN, HAYS, AND COLBY

The most extensive experiments to determine the best way to prepare ground for wheat are those at the Experiment Station at Manhattan, on the eastern edge of the wheat belt.

Two sets of experiments have been conducted—one in which

the wheat is grown continuously on the same land year after year, and the other in which the wheat is grown in rotation with corn and oats. Fifteen different methods have been compared. In all cases the method, time of seeding, rate of seeding, and variety have been exactly the same for all plots. Except as otherwise stated, the ground has been worked after plowing as seemed to be most desirable to get it into good condition for a crop.

The yield for each year and the average for all years tested are given in Table VII.

Similar experiments have also been conducted at the Fort Hays Experiment Station at Hays, Kan., and the Colby Experiment Station at Colby, Kan. The results secured at these two stations are presented in Tables VIII and IX.

TABLE VII.—METHODS OF PREPARING THE GROUND FOR WHEAT AT MANHATTAN, KAN., 1911-1917

PREPARATION OF THE GROUND	Yield—bushels per acre								
	1911	1912	1913	1914	1915	1916	1917	Average 1911–1917	Average 1913–1917
Cropped to wheat continuously—									
Disked at seeding time	4.29	6.20	9.39	22.41	3.61	2.14	6.37	7.8	8.8
Plowed Sept. 15, 3″ deep	13.46	8.86	16.39	23.91	14.89	5.29	12.09	13.6	14.6
Disked July 15, plowed Sept. 15, 7″ deep	23.57	8.03	27.53	26.96	22.22	6.58	19.64	19.2	20.6
Listed July 15, ridges worked down	35.07	5.44	27.81	23.58	14.14	8.25	15.70	18.6	17.9
Listed July 15, ridges split August 15	34.55	4.95	29.40	25.24	16.94	6.16	10.80	18.3	17.7
Plowed July 15, 7″ deep	38.36	8.01	34.95	22.82	22.77	7.20	20.32	22.1	21.6
Plowed Aug. 15, 7″ deep	27.74	12.56	32.83	23.57	23.07	7.41	18.05	20.7	21.0
Plowed Aug. 15, 7″ deep, not worked until Sept. 15	23.62	9.03	28.80	26.14	22.94	5.79	17.78	19.2	20.5
Plowed Sept. 15, 7″ deep	15.79	9.12	17.55	24.31	17.31	6.54	13.28	14.8	15.8
Plowed July 15, 3″ deep	33.46	7.29	21.57	23.09	13.13	7.50	13.75	17.1	15.8
Wheat grown in rotation with corn and oats—									
Plowed July 15, 12″ deep	.....	.....	44.00	28.08	24.65	16.16	17.50	.....	26.1
Plowed July 15, 7″ deep	.....	.....	44.66	25.67	23.78	14.41	18.90	.....	25.5
Plowed July 15, 3″ deep	.....	.....	44.08	31.17	24.43	14.16	18.16	.....	26.4
Plowed Aug. 15, 7″ deep	.....	.....	41.16	30.58	25.77	16.83	14.50	.....	25.8
Plowed Sept. 15, 3″ deep	.....	.....	25.50	30.50	25.60	12.66	10.16	.....	20.9

TABLE VIII.—METHODS OF PREPARING THE GROUND FOR WINTER WHEAT, FORT HAYS EXPERIMENT STATION, HAYS, KAN., 1907-1917 (*a*)

METHOD OF PREPARATION	Yield of grain in bushels per acre											
	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	Average (*b*)
Late fall plowing (shallow)	11.7	25.6	(*c*)	20.3	0.0	2.3	0.8	20.6	9.3	8.7	0.0	10.9
Early fall plowing (6 inches deep)	18.2	23.2	(*c*)	27.8	0.3	13.8	2.3	24.8	13.1	22.7	2.0	14.8
Early fall plowing and subsoiling	13.6	30.5	(*c*)	39.9	0.3	20.1	4.1	25.3	14.9	27.6	2.6	17.9
Early fall listing	12.4	28.1	(*c*)	36.7	0.6	26.6	8.4	23.1	13.9	23.1	0.0	17.3
Summer fallow	11.2	32.3	(*c*)	42.5	2.6	29.2	10.3	21.6	11.3	33.8	7.1	20.2

(*a*) In cooperation with the Office of Dry-Land Agriculture, United States Department of Agriculture.
(*b*) The average does not include 1909. (*c*) Hailed out.

TABLE IX.—METHODS OF PREPARING THE GROUND FOR WINTER WHEAT, COLBY EXPERIMENT STATION, COLBY, KAN., 1915-1917 (*a*)

METHOD OF PREPARATION	Yield of grain in bushels per acre			
	1915	1916	1917	Average
Late fall plowing (shallow)	9.2	9.0	0.0	6.1
Early fall plowing (6 inches deep)	18.7	18.5	0.0	12.4
Summer fallow	19.5	26.5	0.0	15.3

(*a*) In cooperation with the Office of Dry-Land Agriculture, United States Department of Agriculture.

EARLY PLOWING

Perhaps the most important result of these experiments is the demonstration of the value of working the ground early. (Fig. 10.) At Manhattan, plowing 7 inches deep July 15 has given the

FIG. 10.—A good field of wheat, the result of early and thorough seedbed preparation

highest average yield of any method. The average yield for seven years is 22.1 bushels per acre as compared with 20.7 bushels for plowing 7 inches deep August 15, and 14.8 bushels for plowing 7 inches deep September 15. In other words, plowing in July or the first half of August, as compared with plowing September 15, has increased the average yield nearly 6 bushels per acre. The results in 1913 are shown in figure 11.

For those plots where the ground was plowed only 3 inches deep, the difference between early and late plowing is somewhat less, but still enough to demonstrate the value of early plowing.

In the experiments at Hays, the average yield per acre has been about 4 bushels more on early plowing than on late fall plowing, while at Colby, the difference in favor of early plowing is nearly

6 bushels per acre. At Hays, listing and summer fallow have given somewhat better yields than early plowing. Where it is not practicable to use these methods, as discussed later, early plowing can be expected to yield from 3 to 6 bushels per acre more than late plowing.

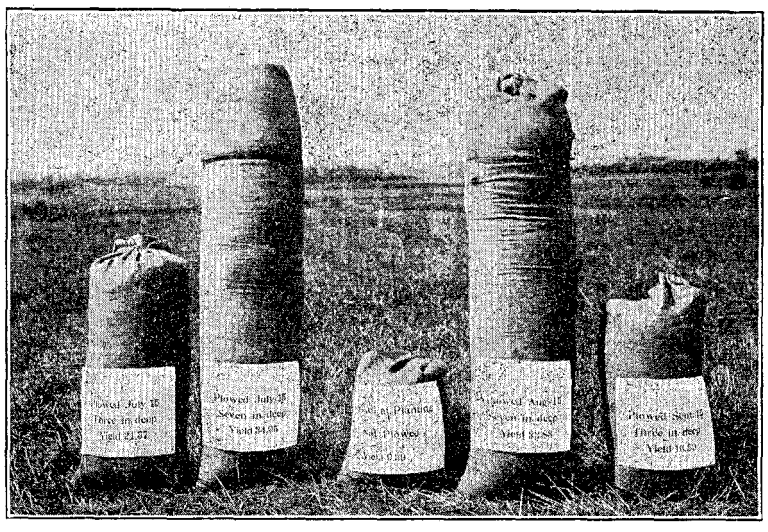

FIG. II.-Wheat grown on one-tenth acre in 1913, showing the effect of five different methods of seedbed preparation on ground cropped continuously in wheat. Plowing 7 inches deep in July pvoduced more than twice as much wheat as plowing 8 inches deep in September.

DISKING IMMEDIATELY AFTER HARVEST

Disking immediately after harvest (July 15 in the experiments), followed by plowing in August or September, has given practically as good results as plowing early. Comparing the plots plowed September 15 with those plowed at the same time but not disked immediately after harvest, disking has increased the yield 4.4 bushels per acre.

Disking is believed to benefit the crop mainly by preventing the growth of weeds, which exhaust the available moisture and plant food. It also aids in getting the soil in condition to absorb rain, and is beneficial in keeping the ground in condition to plow.

DISKING AFTER PLOWING

In the experiments at Manhattan the ground, in all plots but one, has been worked with a disk after plowing. One plot which has been regularly plowed 7 inches deep August 15 has not been

worked until a month later. This practice has resulted in a loss of 1.5 bushels per acre as an average for seven years.

Probably the principal object to keep in mind in working the ground after plowing is to control weeds and get the land in good condition for seeding. More work than is required to accomplish this is unnecessary. In fact, in Western Kansas too much work may actually be detrimental in getting the soil too fine and in a condition to blow in high winds.

DEPTH TO PLOW FOR WHEAT

In the experiments at Manhattan in which the wheat has been grown continuously on the same land, 7-inch plowing has given better yields than 3-inch plowing. When plowed in July, the average difference is 5 bushels per acre, but when plowed September 15, the difference in favor of the deeper plowing is only 1.2 bushels.

At average prices, the difference for the plots plowed in September is no more than enough to pay the extra cost of the deeper plowing.

In those experiments in which the wheat is grown in rotation with corn and oats, 3-inch, 7-inch, and 12-inch plowing have given practically the same yields. Thus, as an average for five years, 3-inch plowing has produced 26.4 bushels per acre, 7-inch plowing, 25.5 bushels, and 12-inch plowing 26.1 bushels. The differences are probably less than the experimental error.

As a whole, these experiments seem to show that deep plowing (i.e., 6 inches or deeper), is advisable only when the ground is plowed reasonably early and the wheat is grown continuously on the same land or after other small grain crops. When grown in rotation with an intertilled crop for which the ground is plowed reasonably deep, deep plowing for the wheat usually will not pay,

SUBSOILING FOR WHEAT

Early fall plowing with subsoiling once in three years at Hays has given an average gain of 3.1 bushels per acre as compared with early fall plowing without subsoiling. Subsoiling has not been included in the experiments at Manhattan and Colby. In other experiments in various part of the United States, subsoiling has seldom given enough larger yield to pay for the extra cost. Undoubtedly the value of this practice will vary with different crops and different methods of farming. Probably it will prove most

valuable on the heavier types of soil. Since there is some question as to the advisability of subsoiling, it should be tried out in a small way before being adopted as a general practice.

LISTING

Early listing in all tests has given better yields than late plowing and at Hays has given better yields than early plowing. The difference at Hays in favor of listing as compared with early fall plowing is 2.5 bushels, and as compared with late fall plowing 6.4 bushels per acre. The yield for listing is about 3 bushels per acre less than for summer fallow.

Usually the advantage for listing is not so great as shown in these experiments. On the large fields of the Fort Hays Experiment Station Farm, where wheat has been grown in rotation with other crops, listing has not given such large yields in comparison with other methods.

Listing is advantageous principally because it is a rapid and economical method of preparing the ground. A larger acreage can be covered in a given period of time, and hence more ground can be stirred earlier in the season than if plowed. This often permits one to stir all the ground when it is moist and in good condition, when, if it is plowed, some of it could not be worked until it had dried out.

Where one has a large acreage to put into wheat, listing is a good method to follow. However, the fact should be kept in mind that ground listed late makes a very poor seedbed.

Double listing, i.e., listing early and splitting the ridges a month later, has given no higher yields at Manhattan than single listing. It is a more expensive method, and in Central and Western Kansas, is likely to so dry out the ground that a good seedbed cannot be secured.

It is not advisable to list ground in the same direction year after year. In such cases the lister has a tendency to follow the old furrows. It is a good plan where listing is the common practice, to plow the ground occasionally.

STUBBLING IN WHEAT

In Western Kansas where the rainfall is light, it is not necessary to plow each season for wheat. Ground that has been well plowed in the past and is loose and mellow can often be prepared for wheat with a disk or may even be sown in the stubble without any preparation. The standing stubble protects the young grow-

ing wheat, catches and holds snow, prevents blowing, and frequently produces a crop when other so-called better methods fail.

This method of seeding is satisfactory only when the ground has been well prepared in preceding years. For this reason, it should not be followed many years in succession or on ground that is hard and weedy. Because of the ease and cheapness with which wheat can be seeded by this method, and because good crops are frequently produced by it, there is a tendency to follow the practice continuously, which gives unsatisfactory results.

SUMMER FALLOW

Summer fallow consists in cultivating the ground and permitting it to lie idle for a season in order to conserve moisture for a crop the following year.

At Hays this method has given an average yield of 10.7 bushels more per acre than late fall plowing, and 5.4 bushels more than early fall plowing. At Colby this difference has been 9.2 bushels and 2.9 bushels respectively in favor of summer fallow. (Table IX.)

The chief objection to fallow is the cost. The ground must lie idle a year, and somewhat more work is required to keep the weeds under control. If all ground that is sown to wheat could be plowed or listed early in the summer, i.e., before August 15, summer fallow probably would not pay. This, however, is usually not possible. When summer fallowing is practiced, a portion of the ground can be plowed in the spring or other convenient time, thus distributing the labor over a greater portion of the year.

If judiciously handled, summer fallow need be but slightly more expensive than other methods of preparing the ground except for the interest on the value of the land for the idle season. The yields secured on summer fallow in the western third of the state are usually enough larger than with usual methods of preparation to justify its use quite extensively.

BLOWING OF THE SOIL

One of the difficulties of growing wheat in Western Kansas is the blowing of the soil in late winter and early spring. The damage is caused (1) by the exposure of the roots to the air and (2) by the rapidly moving dirt particles cutting off or badly injuring the plants.

Damage most frequently occurs on summer fallow, in corn stub-

ble fields, and other fields that have been cultivated so much that the surface soil is very fine and dry.

The best way to prevent blowing is to keep the soil as rough and cloddy as possible consistent with a good seedbed. The use of the smoothing harrow should be avoided except immediately after plowing, when the ground is very rough. Also, the disk should be used sparingly on land that is inclined to blow.

Ordinarily, if land is worked enough to control weeds, no further cultivation is necessary. Recent experiments show that for Central and Western Kansas a dust mulch is not necessary to conserve moisture, as many think. If water once gets into the soil in this area it usually stays there until removed by plants—either weeds or a growing crop.

On fields that tend to blow regardless of the reparation of the ground, a top dressing of straw will prevent blowing, at least to some extent. It will also benefit the wheat by reducing the injury from winter killing. The straw may,be put on with a straw spreader at the rate of ½ of a ton to 1 ton per acre. If a disk set straight and weighted is then run over the ground, the straw will be partly forced into the ground. More than 1 ton per acre should not be spread or it will retard the wheat in the spring and reduce the yield.

Blowing can also be largely prevented by cultivating at right angles to the direction of the wind. A satisfactory way to do this is to use a corn cultivator, removing about two-thirds of the shovels. If a field starts to blow, cultivation should begin on the windward side. Such cultivation will kill some of the wheat, but the loss will be much less than if the blowing is allowed to go on unchecked.

In case blowing is excessive and cannot be stopped by the methods just described, lister furrows may be run at intervals at right angles to the direction of the wind. In unusually dry and windy seasons it may be necessary to renew the furrows from time to time.

There is good evidence to show that seeding wheat in furrows, as heretofore described, will prevent injury from blowing to a large extent. The wheat crowns are below the level of the surface and consequently the roots are less likely to be exposed by the removal of the soil, and the plants are not injured so much by the moving soil particles.

SUMMER FALLOW IN CROPPING SYSTEMS FOR WESTERN KANSAS

One of the principal reasons for small yields and partial crop failures in Western Kansas is the large acreage in wheat and the poor and late preparation of the ground. Undoubtedly, the situation could be greatly improved by introducing cropping systems in which other crops beside wheat are used, or even by using better methods of growing wheat alone.

A system of continous cropping to wheat that has been used with success consists of putting one-fourth of the land in fallow and three-fourths in wheat. The ground to be fallowed is plowed at the most convenient time in the spring and worked thereafter as necessary to control weeds. The ground should not be worked more than necessary after plowing. In fact, too much working may be injurious by getting the soil too fine and increasing the tendency to blow during the late winter or early spring.

Of the ground that is in wheat, one-third could be plowed or listed early in the summer; one-third could be prepared later, being plowed, listed or simply disked before seeding, as available labor, condition of the soil, and the season may indicate best; the other third could remain without cultivation until the following spring.

A farmer handling 400 acres in this way would divide his farm into four fields of approximately 100 acres each. Each season 100 acres would be fallowed and 300 acres would be sown to wheat. Of the wheat, one-third would be on fallow, one-third on early plowed or listed ground, and one-third on ground prepared later. Such a system would divide the work and distribute it throughout the year and at the same time would undoubtedly increase the certainty of a crop and the total average product of the farm.

SUMMER FALLOW IN A ROTATION

Successful farming in Western Kansas depends in a large measure on raising livestock, and the most profitable farms are those which combine a system of growing wheat and feed for stock.

The best feed crops for Western Kansas are the sorghums—kafir, feterita, milo, and the sweet sorghums. The best results are secured when these crops are grown in a rotation with wheat. But kafir and most other sorghums grow rather late in the fall and come off so late that wheat cannot be sown, or they leave the ground in such condition that wheat cannot be grown successfully the following season.

This difficulty may be overcome by using summer fallow. A good rotation is wheat for two years, kafir or other sorghum one year, and summer fallow one year. By this system one-half of the farm is in wheat each year, one-fourth in a sorghum crop for feed, and one-fourth fallow for the following wheat crop.

If this system does not supply sufficient feed, an additional crop of sorghum can be added to the rotation, making it first year wheat; second year wheat; third year sorghum; fourth year sorghum; and fifth year fallow.

ROTATIONS FOR WHEAT IN EASTERN KANSAS

Without doubt, one of the most important ways to increase the yield of wheat in Eastern Kansas is to rotate with other crops, Much of the Kansas wheat land has been cropped to wheat or other small grains almost continuously since it was first broken up. The result is that such land is poor in humus and plant food, and the soil is in poor physical condition—some of it so poor that a good crop can no longer be obtained.

The very best way to correct this condition is to grow wheat in rotation with other crops, especially legume or grass crops. The effect is especially marked if manure is added occasionally either as a top dressing on the wheat or for other crops in the rotation. This is well shown by experiments at Manhattan in which wheat is grown continuously on the same land year after year and in rotation with other crops. In 1916, wheat had been grown on the same field for 10 years in succession while on other fields wheat had been grown in a rotation with other crops. In some of the rotations manure was used. The yields of wheat for the season of 1916 on the various fields are shown in Table X.

TABLE X.—RELATION OF THE CROPPING SYSTEM TO THE YIELD OF WHEAT

CROPPING SYSTEM	Yield of wheat per acre, 1916
	Bushels
Continuously in wheat, 10 years	6.9
Continuously in wheat, 10 years (2½ tons manure annually)	18.4
Three-year rotation, corn, corn, wheat	16.3
Three-year rotation, corn, cowpeas, wheat	16.7
Three-year rotation, corn, cowpeas, wheat (5 tons manure on corn)	19.4
Three-year rotation, corn, cowpeas, wheat (2½ tons manure on corn) (2½ tons manure on wheat)	25.6
Sixteen-year rotation, alfalfa, corn, wheat	18.5
Sixteen-year rotation, alfalfa, corn, wheat (5 tons manure every third year)	28.3
Sixteen-year rotation, Brome grass, corn, wheat (5 tons manure every third year)	37.2

On the field where wheat had been grown continuously for 10 years without manure or fertilizers, the yield in 1916 was a little less than 7 bushels per acre. In the three-year rotation consisting of two crops of corn and one of wheat, the yield of wheat was a little more than 16 bushels. In a sixteen-year rotation with alfalfa, corn, and wheat, the yield was 18.5 bushels. Where manure had been applied in this rotation the yield was over 28 bushels, and in a similar rotation where Brome grass was substituted for alfalfa, and manure was applied, the yield of wheat was over 37 bushels per acre.

Good rotations for Eastern Kansas will always contain a leguminous crop, like red clover, sweet clover, alfalfa, or cowpeas. In the extreme eastern part of the state, where red clover is extensively grown, and where corn is the major crop, as in Northeastern Kansas, a good rotation is first year red clover, second year corn, third year corn, fourth year oats or wheat, and fifth year wheat with which red clover is seeded. Further south, kafir may be substituted for the first crop of corn in the above rotation. In the section of Southeastern Kansas where red clover is an unsatisfactory crop, cowpeas should be used. In this section of the state, a crop of cowpeas can be grown for hay or pasture, after harvesting a crop of wheat. The ground can then be planted to corn or kafir the following season.

ROTATIONS FOR WHEAT IN CENTRAL KANSAS

Good rotations for Central Kansas do not differ materially from those described except that alfalfa is grown. Where this crop is a success it should by all means be included in the rotation.

The increased yields of grain secured more than compensate for the cost of seeding an extra field of alfalfa occasionally.

Alfalfa leaves the ground very dry. As the soil is also left well supplied with available nitrogen, the following crop is likely to grow rank and succulent and be easily injured by hot winds and drouth. For these reasons the first crop after alfalfa is likely to be a small one.

Probably the best crop to grow after alfalfa in Central Kansas is an early maturing variety of sorghum such as Dwarf Kafir, Pink Kafir, or Early Amber sorghum. The sorghum may be followed by corn and the corn by oats or barley. On rich bottom lands, where the moisture supply is usually ample, corn may be planted directly after alfalfa. Usually, however, corn dries up after alfalfa and makes very small yields.

As soon as the first effects of the alfalfa have disappeared, which will be a year after it is broken, a rotation such as the following may be used: First year, corn; second year, oats, barley, or winter wheat; third year, wheat on ground plowed early; fourth and fifth years, wheat on ground plowed as early as possible; sixth year, kafir or sweet sorgo; and seventh year, again to corn. This makes a six year rotation after alfalfa containing four crops of small grain, one of sorghum, and one of corn.

This should run for about 18 years or through three courses, when the ground should again be sown to alfalfa. The alfalfa may be left six to eight years before it is again plowed up.

Taking this rotation as a whole, about one-fourth of the land will be in alfalfa each year, about one-half in wheat or other small grain, and about one-fourth in corn or the sorghums.

It is not necessary that these exact proportions be maintained. If kafir or sorgo is more profitable than corn, the corn may be entirely replaced by them. Unusual markets or other unforeseen conditions may make it desirable to modify any given plan that can be worked out. Nevertheless, it will be found advisable to have some definite plan of procedure, even though it cannot always be followed out in all details.

FERTILIZERS FOR WHEAT

Barnyard manure is the most satisfactory fertilizer for wheat. If properly applied, it can be safely and profitably used in any section of the state. It is usually best to apply it as a top dressing during the winter. Applied in this way, the manure serves as a protection to the crop and, to some extent, prevents winter killing. It also prevents injury from blowing in the spring and aids in retaining moisture as well as in supplying plant food. Also, as most of the manure is produced in the winter months and there is usually labor available at that season of the year to haul it, it is good practice to apply most of the manure to the wheat fields as a top dressing at this season of the year.

Manure produced during the summer months can be applied before seeding. It is usually best to apply it after the ground is plowed and work it into the soil with the disk and harrow as the seedbed is prepared. Manure does not decay as rapidly when plowed under as when applied as a top dressing and is, therefore, not as beneficial. Also where it is plowed under, there is danger of producing a loose, open seedbed, which may result in injury to the crop by winter killing and by drouth. Because of this danger,

it is never advisable to plow under manure for wheat in Central or Western Kansas. There is no danger of such injury if the manure is applied as a top dressing.

Manure applied as a top dressing should be spread evenly and lightly. A manure spreader is almost indispensable for this purpose although, with care, it can be spread by hand. Under no consideration should the manure be applied at a heavier rate than 10 tons to the acre and usually a lighter application is better. Where a spreader is used, it is good practice to set it to spread as lightly as possible and, in this way, cover a larger area of ground.

In Eastern Kansas, chinch bugs occasionally injure wheat that has been top dressed with manure. This injury is usually observed when only a portion of the field is covered. In such cases, the bugs congregate in the manured area in order to take advantage of the protection afforded by the manure during spells of cold weather in the early spring. In fact, less injury often results when the entire field is manured because the manure produces a ranker growth of wheat which is unfavorable for the bugs.

The value of barnyard manure applied as a light top dressing to wheat during the winter months is well shown in experiments conducted at Manhattan in which manure was applied to wheat grown continuously and to wheat grown in a rotation with corn and cowpeas. When the wheat was grown continuously, the manure was applied annually at the rate of 2½ tons per acre during the early winter. Where the wheat was grown in rotation, 5 tons of manure was applied once in three years. Two plots received

TABLE XI.—EFFECT OF MANURE ON THE YIELD OF WHEAT AT MANHATTAN

TREATMENT	Yield per acre—bushels							
	1911	1912	1913	1914	1915	1916	1917	Average
Wheat grown continuously								
No treatment	25.8	5.7	17.6	23.5	12.8	6.9	11.9	14.9
2½ tons of manure applied annually as a top dressing	29.4	6.7	28.4	29.5	21.9	18.4	20.5	22.1
Wheat grown in rotation with cowpeas and corn								
No treatment	15.8	9.0	10.0	29.8	15.3	16.7	13.6	15.8
5 tons of manure applied before the corn	18.5	9.5	13.7	32.0	26.7	19.5	13.8	19.1
2½ tons of manure before corn and 2½ tons dressing on wheat	14.9	10.5	11.1	32.8	21.3	25.6	12.5	18.4

manure. In one case all the manure was applied on the corn crop which was followed by wheat two years later; in the other case, 2½ tons of the manure were applied on the corn and the same amount as a winter top dressing on the wheat. The effect of the various applications is shown in Table XI.

It will be seen that in those experiments where wheat is grown continuously on the same land a top dressing of 2½ tons of manure annually has increased the average yield more than 7 bushels per acre. Where grown in rotation, the increase in the yield of wheat, due to the application of 5 tons of manure once in three years, has been about 3 bushels per acre. The yield of the corn and the cowpeas grown in rotation with the wheat has also been increased by the application of manure.

COMMERCIAL FERTILIZERS FOR WHEAT

Whether or not it will pay to use commercial fertilizers for wheat will depend entirely on the soil. In Central and Western Kansas, commercial fertilizers never pay. On many soils in Eastern Kansas, especially Southeastern Kansas, good results with wheat cannot be secured without them. This is especially true of the shale, sandstone and thin glacial soils. Limestone soil that has been properly handled seldom requires commercial fertilizers.

Those soils which need fertilizer respond best to phosphorus. In fact, it seldom pays to use a fertilizer supplying much of any other element of plant food. Phosphorus can be purchased as raw bone meal, steamed bone meal, acid phosphate, or in a mixed fertilizer containing a high percent of phosphorus. Steamed bone meal and acid phosphate have usually been found to be the cheapeast source of supply.

Experiments conducted in Atchison, Leavenworth, Miami, Linn, Anderson, Allen, Neosho, Crawford, Montgomery, Labette, and Cherokee counties show that commercial fertilizers containing phosphorus or phosphorus and nitrogen usually pay. The results of these experiments are given in Table XII.

TABLE XII.—EFFECT OF COMMERCIAL FERTILIZERS ON THE FIELD OF WHEAT

YEAR	1914	1915	1916	1917	Average 1914–1917
Number of tests	5	10	8	6	
TREATMENT	Average yield in bushels per acre				
Phosphorus (bone meal, 180 lbs.), and nitrogen (blood meal, 50 lbs.), and potash (17½ lbs.)	29.5	22.8	13.7	23.7	22.4
Phosphorus (bone meal, 180 lbs.), and nitrogen (blood meal, 50 lbs.)	28.4	22.5	13.8	22.9	21.9
Phosphorus (bone meal, 180 lbs.)	28.6	21.1	13.5	23.1	21.1
No fertilizer	23.3	13.3	8.4	16.7	15.4

As an average of all tests, an application of 180 pounds of steamed bone meal has given an increase in yield of 5.7 bushels per acre. Fertilizer mixtures containing nitrogen and potash in addition have given somewhat greater increases in yield but seldom enough to pay for the extra cost. Experiments conducted to determine the most profitable rate to apply commercial fertilizers on wheat in Southeastern Kansas have shown that an application of 100 to 125 pounds of steamed bone meal, or 125 to 175 pounds of acid phosphate usually give the most profitable results. A fuller discussion of the use of commercial fertilizers will be found in Bulletin 220 of this station.

MARKETING WHEAT

It is very important that every farmer who grows wheat understand the marketing of this important product and be able to determine with reasonable accuracy what any lot of wheat is worth.

The price a given lot of wheat will bring as compared with other wheat will depend on the class and the grade.

CLASSES OF WHEAT

There are two principal market classes of wheat grown in Kansas—Hard Red Winter wheat and Red Winter wheat, or, as it is more commonly known, Soft Red Winter wheat. Most of the wheat grown in Kansas is Hard Red Winter.

Subclasses of Hard Red Winter Wheat

Hard Red Winter wheat is subdivided into three subclasses; namely, Dark Hard Winter, Hard Winter, and Yellow Hard Winter.

Dark Hard Winter is hard red winter wheat which contains not more than 20 percent of yellow or mottled, i.e., '"yellow berry," kernels. Hard Winter is that which contains more than 20 percent of yellow or mottled kernels, but less than 75 percent. Yellow Hard Winter is that which contains more than 75 percent of yellow or mottled kernels.

Of these three subclasses, Dark Hard Winter wheat brings the highest price on the market and Yellow Hard, the lowest.

GRADING WHEAT

In each class and subclass there are five numerical grades and a sample grade. They are numbers 1, 2, 3, 4, 5, and sample. The grade of any lot depends on several things; viz., damage such as sprouted, bin burnt, musty, and frosted grain; the moisture content of the grain; mixtures with rye and other kinds of grain, including other varieties of wheat; mixtures of foreign material which cannot easily be separated from the grain; and the test weight per bushel.

Damaged Wheat

No other factor reduces the grade of wheat so much as the presence of damaged kernels. The most serious kinds of damage are "bin burnt," "stack burnt," and musty wheat. "Bin burnt" wheat is caused by fermentation which takes place when very damp or wet wheat is stored in a bin. Musty wheat also is caused by storing wheat that is damp or wet. A very small percent of "bin burnt'' or "stack burnt" kernels gives a bitter taste to bread made from it. Musty wheat is objectionable because of the odor which is imparted to the flour. Neither bin burnt, stack burnt, nor musty kernels can be removed from sound wheat, and the only way such wheat can be used is to mix with sound wheat in such quantitites that the percent of damaged grain will be so low that it will not be noticeable.

Sprouted wheat can be used for flour if mixed with sound wheat. Investigations have shown that 3 percent or more of sprouted wheat injured the quality of the flour materially.

"Stack burnt" wheat is similar to "bin burnt" except that it occurs in stacked grain. It occurs frequently in headed grain, especially in wet seasons when the grain is cut too green and when green weeds are harvested with the wheat. Usually "stack burnt" wheat is not damaged so seriously as "bin burnt" wheat.

Moisture Concent of the Grain

Wheat that contains much moisture is discriminated against on the market for two reasons: (1) The intrinsic value of the wheat, pound for pound, is less; and (2) such wheat is likely to become musty, sour, or bin burnt either in transit or in storage. If the moisture exceeds a certain percent, the wheat must be artificially dried before it can be stored or shipped long distances.

Mixtures with Rye and Other Kinds of Wheat

Rye in wheat is objectionable because it makes a dark flour. Also, rye contains less gluten than wheat and makes a coarser, heavier bread. If present in large amounts it reduces the commercial value of the flour made from it.

Mixtures of other kinds of wheat or other grain make it difficult or impossible for millers to make flour that is uniform in quality from time to time.

Foreign Material in Wheat

Foreign material in wheat reduces the yield of flour because most of it is removed before milling. That which can easily be removed is known as "dockage." Some foreign material such as barley, rye, and many weed seeds, cannot be removed, and is milled with the wheat. This foreign material always reduces the yield and injures the quality of the flour.

Weight per Bushel

The value of any lot of wheat is indicated in part by the weight per bushel. Wheat with a low test weight per bushel produces less flour and more feed than one which has a high test weight per bushel. Also wheat with a high test weight usually produces flour of better quality than wheat of the same kind but with a lower test weight.

Table XIII indicates the minimum test weight, the maximum percent of moisture, damaged kernels, foreign material, and of other kinds of wheat permitted in each of the numerical grades of Hard Red Winter wheat.

TABLE XIII.—MOISTURE, WEIGHT, SOUNDNESS, AND PURITY REQUIREMENTS FOR DIFFERENT GRADES OF HARD RED WINTER WHEAT

GRADE	Minimum test weight—pounds per bushel	Maximum percent of moisture	Maximum percent of damaged kernels		Maximum percent of foreign material other than dockage		Maximum percent of other kinds of wheat
			Total damage	Heat damage	Total	Other than cereal grains	
Number 1...	60	13.5	2	0.1	1	0.5	5.0
Number 2...	58	14.0	4	0.2	2	1.0	10.0
Number 3...	56	14.5	7	0.5	3	2.0	10.0
Number 4...	54	15.5	10	1.0	5	3.0	10.0
Number 5...	51	15.5	15	3.0	7	5.0	10.0
Sample (*a*)...							

(*a*) A sample grade is any wheat which does not come within the requirements of any of the grades from Number 1 to 5, inclusive, or which has any commercially objectionable foreign odor, or is very sour, is heating, hot, infested with live weevils or other insects injurious to stored grain, or is otherwise of distinctly low quality, or contains small inseparable stones or cinders.

Relation of Grade to Price

There is usually a spread of from one to several cents per bushel between different grades of the same class of wheat. The difference is greatest for the lower grade.

It always pays to market wheat in as good condition as possible and practicable. If wheat is bin burnt, musty, wet, or badly damaged in other ways, the price is always much lower than for good sound wheat.

Care in shocking and stacking will save much wheat that goes to market badly damaged. The practice of thrashing from the shock is responsible for much damaged wheat where such grain cannot be thrashed promptly. Stacking the grain would greatly reduce the damage.

Country dealers are frequently not well informed as to the actual value of damaged wheat. In order to protect themselves against loss, they usually will buy such wheat only at a price that is certainly lower than its actual value. The result is that the seller gets less than it is worth as compared with good sound wheat.