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CROP ROTATION AND CULTURAL METHODS AT EDGELEY, N. DAK.

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HISTORY OF THE INVESTIGATIONS.

The Edgeley substation of the North Dakota Agricultural Experiment Station is one unit in a group of 24 field stations at which the Office of Dry-Land Agriculture Investigations has established coordinated cooperative experiments in crop rotations and cultivation methods on the Great Plains.

The station at Edgeley is farther east than any of the other stations on the northern Great Plains. The rainfall is somewhat heavier and there is greater liability to damage from rust than at stations

[1] The Office of Dry-Land Agriculture was organized in 1905, with E. C. Chilcott as agriculturist in charge, who planned, outlined, and instituted these investigations and still has general supervision of them. This bulletin has been prepared under his direction. These investigations have had the active cooperation and support of the officials of the North Dakota Agricultural Experiment Station for the entire fifteen years. O. A. Thompson has been superintendent of the Edgeley substation since its establishment in 1903, and since 1918 he has had immediate charge of the cooperative investigations. The following assistants in Dry-Land Agriculture Investigations have been detailed by the United States Department of Agriculture to the station, in immediate charge of the cooperative work, during the years indicated: E. F. Chilcott, 1906 to 1908; C. H. Plath, 1909 to 1912; and R. S. Towle, 1913 to 1918.

in more typical dry-farming territory farther west. Though the results at Edgeley are in general agreement with those of the other stations, they differ from them in some respects in that they are expressive of conditions in a transition zone between the dry and the humid areas.

The first crops in these cooperative investigations at the Edgeley substation were planted in 1906. As more land became available the work was increased in 1907 and again in 1908. To check on deeper soil the results obtained at the station farm a 40-acre tract about 1 mile distant was leased and experimental work started on it in 1916. In the following pages this tract is referred to as section 9 and the plats on the station farm as the main field.

In interpreting the results of these investigations the writer has been greatly aided by his knowledge of the results obtained from the closely coordinated investigations conducted by the Office of Dry-Land Agriculture Investigations at 23 other stations on the Great Plains and by the reports, comments, and suggestions of the men in charge of such investigations at their respective stations. The following discussions and conclusions are therefore submitted with a higher degree of confidence than they would be were they based entirely upon investigations conducted at a single isolated station by an individual investigator.

SOIL.

The soil on which the main field is located is derived from the decomposition of shale. Shale in undecomposed particles is found very near the surface. In the third foot the shale, while broken and offering fairly free passage to water, is not broken down into soil. The depth of feeding of crops is practically limited to the first 2 feet. The first foot carries an exceptionally large proportion of water available to the crop and retains about 31 per cent of its dry weight of water, but about 14 per cent is nonavailable to the crop. The second foot retains about 28 per cent of its weight of water, but 18 per cent is nonavailable. The third foot retains about 32 per cent of water, but about 28 per cent is nonavailable. Thus it is possible to store in the first foot about 17 per cent of available water, in the second foot 10 per cent, and in the third foot about 4 per cent. Translated into inches of water, this amounts to a total of 4.76 inches, basing the calculation on an estimated soil weight of 80 pounds per cubic foot. While the amount of available water that can be stored in the first foot is exceptionally high, the shallowness of the soil reduces its total storage capacity to about one-half that of deeper soils.

The soil of section 9 (the tract used as a check in these investigations) is a deep clay loam of greater water-storage capacity.

PRECIPITATION.

The average annual precipitation at Edgeley for the 19 years from 1901 to 1919, inclusive, was 18.02 inches. The highest was 28.61 inches, in 1902, and the lowest 10.85 inches, in 1917. The highest precipitation recorded in any one year since the experiments began was 22.20 inches, in 1915.

The average precipitation by months is: January, 0.28; February, 0.33; March, 0.87; April, 1.92; May, 2.71; June, 3.38; July, 2.80; August, 2.27; September, 1.70; October, 1.01; November, 0.34; and December, 0.41.

The average seasonal precipitation for the five months of April, May, June, July, and August is 13.08 inches, or 72.5 per cent of the total annual precipitation.

EXTENT OF WORK AND CHARACTER OF THE SEASONS.[2]

In the 14 years from 1906 to 1919, inclusive, the following number of plat records have become available: Wheat, 485; oats, 415; barley, 123; corn, 505; flax, 14; alfalfa, 39; brome-grass, 52; red clover, 26; green manure, 98; fallow, 230; total, 1,987. Of this total number, 1,559 have been crop plats and 328 green-manure and fallow plats.

The average yields each year from all plats in the main field are shown in Table I. For wheat, oats, barley, and corn these averages are from a considerable number of plats, embracing a wide range of methods. They therefore give a fairly good indication of the effect of the season on yields and of the yields that may be expected with a wide range of methods, such as are likely to be practiced by farmers. The vital question, of course, is how much these averages may be increased or the poor years overcome by the choice of methods. This will be considered in its proper place.

The flax yield specified is not a fair showing for the flax crop, as it is from a single plat on brome-grass sod. The brome-grass yield is the average of two 1-year-old plats and two 2-year-old plats. The alfalfa yield is the average of one 1-year-old and one 2-year-old plat. The red-clover yield is from one plat in the second year after seeding.

The year 1906 was a good one, with some lodging and some rust.

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[2] Since this manuscript was prepared the 1920 crop results have become available. In the main field the average yields were: Wheat, 9.6 bushels; oats, 47.3 bushels; barley, 25.4 bushels; brome-grass, 2,075 pounds of hay; corn, 2,383 pounds of fodder; and the flax, alfalfa, and red clover were failures. The wheat crop was damaged by rust, lodging, and weeds. The damage was generally greatest and yields the lowest on those plats that had the greatest growth of straw and at one stage of growth the highest potential yield. Drought and hot weather after early grain harvest prevented the corn from earing. Flax was destroyed by wilt and dry weather. With all grain crops, disked corn ground produced the heaviest or one of the heaviest yields. Yields on fallow were especially poor for wheat and below the average for oats and barley. The data make no decisive contribution to the knowledge of the effect of manures.

TABLE I.—*Average annual yields from all plats in the main field at Edgeley, N. Dak., during the 14-year period from 1906 to 1919, inclusive.*

Year.	Wheat.	Oats.	Barley.	Corn (grain).	Corn stover.	Flax.	Brome-grass.	Alfalfa.	Red clover.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Pounds.*	*Bushels.*	*Pounds.*	*Pounds.*	*Pounds.*
1906	30.9	61.4	31.2	39.6	2,140	12.5	....	....	....
1907	9.1	24.9	12.9	0	2,420	4.4	3,000	....	....
1908	15.9	17.3	26.3	0	2,010	0	2,313	425	550
1909	27.6	56.0	29.2	30.4	5,042	13.2	4,288	1,000	....
1910	5.7	9.1	1.9	0	1,610	0	1,125	1,000	850
1911	1.9	4.4	0	0	4,630	0	1,238	975	....
1912	33.9	61.9	29.4	0	6,350	1.6	3,950	3,775	....
1913	22.8	40.7	24.2	20.9	4,268	0	2,588	1,650	500
1914	16.2	46.0	31.1	14.8	4,049	4.5	3,538	3,305	2,480
1915	36.0	79.7	41.5	0	5,900	4.1	2,800	4,760	2,300
1916	8.8	22.5	21.5	17.5	3,300	8.9	4,750	5,650	5,940
1917	14.0	16.4	10.3	0	1,840	1.4	1,713	1,575	1,300
1918	15.4	19.6	11.3	0	2,879	0	1,775	500	00
1919	2.2	16.2	13.8	0	4,382	0	2,663	0	
Average	17.2	34.0	20.3	8.8	3,623	3.6	2,749	2,051	1,160

General conditions for crops were not favorable in 1907. The spring was late and cold. During the growing season there was little rain. Just previous to ripening time, hot dry winds dried up the grain. A hailstorm on July 13 did some damage to small grains and hurt the corn very appreciably. No ears were matured on the corn.

Yields in 1908 were about the average. The spring was cold, and stands, especially of oats, were rather poor and spotted. Corn was replanted in June. The growth in June was good, but high hot winds with little rainfall from heading until harvest time reduced the yield and flattened the differences between methods. Corn did not mature ears, and the yield of fodder was reduced by a hailstorm in August, which stripped the leaves and checked growth.

General conditions for crop production were very favorable in 1909. The prospective yield of small grains was decreased somewhat by hot dry winds at about the time they were in the milk stage. Corn was mature September 9.

The year 1910 was very unfavorable. Cold weather and heavy frosts after coming up checked and injured the crop. May, June, and July were very dry. The precipitation for April, May, June, and July was only 5.08 inches.

The poor crops of 1911 were due to drought with high temperatures and winds. The rainfall was poorly distributed, with particularly marked deficiency in June and July. The heavy rainfall of August made a fairly good crop of corn fodder.

An exceptionally good year, with high yields, was 1912. At no time did the crops suffer from a lack of water. Temperatures and evaporation were low. The season was too cool to mature corn.

On the whole, 1913 was fairly favorable to crop production. Small grain suffered from a lack of moisture in the first half of June and again preceding harvest. Corn matured on all the plats.

The growing season of 1914 was generally favorable for crops, but yields were reduced by drought, rust, and hail in the period immediately preceding harvest.

The year 1915 was exceptionally favorable. The spring was dry, but at no time after the 1st of May was there any suffering from lack of moisture. There was some lodging and rust in wheat and oats, but yields were higher than in any other year in the record. Corn eared well but did not mature.

Low yields of poor quality of small grains characterized 1916, but the yields of all forage crops were exceptionally high. At no time was there a lack of water. The prospects for all crops were of the best until July, when rust developed with warm humid weather. Many fields in the vicinity were not harvested.

The driest year yet recorded at Edgeley was 1917. As a consequence, the yields of all crops were comparatively low. The hay crop was especially short.

The comparatively low yields of 1918 were due to drought. There was a decided response on fallow and corn ground, but the yields were low where small grain followed small grain.

In 1919 there was some damage from drought, but rust was chiefly responsible for the low yields recorded.

The 14-year average yield of wheat with all methods in use was 17.2 bushels per acre. Maximum yields of over 34 bushels per acre have been recorded with all rotations and methods used except continuous cropping with fall plowing, which has attained a maximum of 29.5 bushels. The highest yield of wheat recorded in the 14 years was 41.9 bushels in 1915 from wheat on rye turned under for green manure.

The average yield of oats was 34 bushels per acre. With all rotations and methods maximum yields of 60 bushels or more have been produced. Three yields of over 100 bushels were obtained on fallow in 1915. The highest yield recorded was 106.9 bushels on fallow in rotation No. 19.

The average yield of barley was 20.3 bushels. With all rotations and methods maximums of over 32 bushels per acre have been reached. The highest yield of barley recorded was 50.8 bushels, in 1915, on spring-plowed oat ground in rotation No. 7.

The highest yields in every rotation were made in 1906, 1912, or 1915, with by far the most of them in 1915.

Expressed in pounds per acre, the average yield of wheat has been 1,032, oats 1,088, and barley 974. The absolute maximum yields recorded are: Wheat, 2,514 pounds; oats, 3,420 pounds; and barley, 2,438 pounds. In 1915, when the greater number of the rotations made their highest yields, the averages were: Wheat, 2,160 pounds; oats, 2,550 pounds; and barley, 1,992 pounds.

These figures are given to show the average production and maximum possibilities of these grain crops. Pound for pound they average practically the same, with the maximum possibilities rather in favor of oats. They suggest that the choice between these crops is determined by the price, and that the one commanding the highest price per pound is entitled to have the highest acreage. It may be stated as a result of similar work at other stations that this relation between spring wheat and oats has been found to hold true for the Great Plains as a whole.

In comparing the results of different methods in the following pages attention is called several times to the apparently greater response of oats than wheat to certain methods, such as fallow. This is probably due to the fact that wheat has on the average suffered more than oats from rust. The proportional damage from rust is nearly always greatest with those methods that have the heaviest and most luxuriant growth and previous to attack the greatest potential yield.

RESULTS OF FALL AND SPRING PLOWING COMPARED.

The work offers a number of comparisons of the relative merits of fall and spring plowing for the several crops. Fall plowing as a rule has been done comparatively early. It has been the endeavor, however, not to advance its date beyond practical limits. The average date of plowing grain stubble is September 12. In 9 of the 14 years the date has fallen between September 2 and September 13. In 2 years the plowing has been done in August and in 2 years it has been delayed until October.

When corn stubble is plowed in the fall it is generally necessary to delay it until a late date, as it can not be done until after the corn is removed. The average date of plowing corn stubble is October 1. Plowing has been done to a good depth, the maximum being 8 inches. The depth of spring plowing has been the same as that of fall plowing, with the exception of one plat, plat A, with each crop, which is continuously cropped and shallow spring plowed. When all the evidence on the subject is studied there is found in the average of a series of years little or no difference between fall and spring plowing for small grains in rotations of corn, wheat, and oats when the depth of the plowing has been the same. In continuous cropping to small grains shallow spring plowing has averaged from 1½ to 2½ bushels higher than deep fall plowing. This comparison at Edgeley is open to question on account of the fact that from time to time there has been an accumulation of blown soil in the stubble of the continuously spring-plowed plats, which has built them up several inches above their original level. Similar results, though, have been obtained since 1916 on section 9, where such building up has not taken place, and they are not out of keeping with results at other stations.

On the continuously cropped plats the years favoring fall plowing and those favoring spring plowing have been about equal in number. In rotations where spring plowing is deep the greater number of years have favored fall plowing. Some years have markedly favored fall plowing, and others have as markedly favored spring plowing. Measured in bushels per acre the greatest difference shown in any one year was in favor of spring plowing in 1915. This was the year of the heaviest yields in the history of the experiments. The winter and spring were dry until after the crop was up, and there was better germination on the spring-plowed than on the fall-plowed plats. The rains that made the crop did not begin until after the crop was started.

For corn the evidence is also contradictory, with little or no average difference where corn follows wheat or corn, but appearing to average in favor of spring plowing where corn follows oats. The evidence of section 9 shows an advantage of spring plowing for corn following wheat, oats, and corn.

The work in hand is not designed to study the question of time of fall plowing. As noted above, there has been during the experiments considerable range in the time of fall plowing. It is not possible, however, to identify in the results any relation between the time the fall plowing has been done and the yield as compared with that from spring plowing.

In these experiments fall plowing and spring plowing are both seeded at the same time. Seeding is usually done comparatively early, the date depending upon the season. But when a large acreage is to be handled plowing in the spring necessarily delays seeding. It has been abundantly proved and is well recognized that delay in seeding in this section decreases yields. This is a section of large acreages. It is, therefore, highly desirable that as much as possible of the land to be seeded to small grains be plowed in the fall, so that seeding may not be delayed. There is, however, no disadvantage and there may even be some gain from spring plowing, provided it does not delay seeding beyond the critical date. The possibility of doing much spring plowing without incurring loss from late seeding depends very much upon the character of the spring.

The distribution of labor indicates spring plowing for corn, although little disadvantage in yield is experienced if the corn be planted on fall plowing.

All the evidence indicates that for the best results spring plowing should be shallow.

DISKING COMPARED WITH PLOWING CORN GROUND IN PREPARATION FOR WHEAT AND OATS.

When corn ground is to be sown to small grains it may be plowed in the fall or spring or it may be prepared for seeding without plowing. In the latter case it is generally disked. The work at Edgeley offers opportunity for several direct comparisons of the results of these methods.

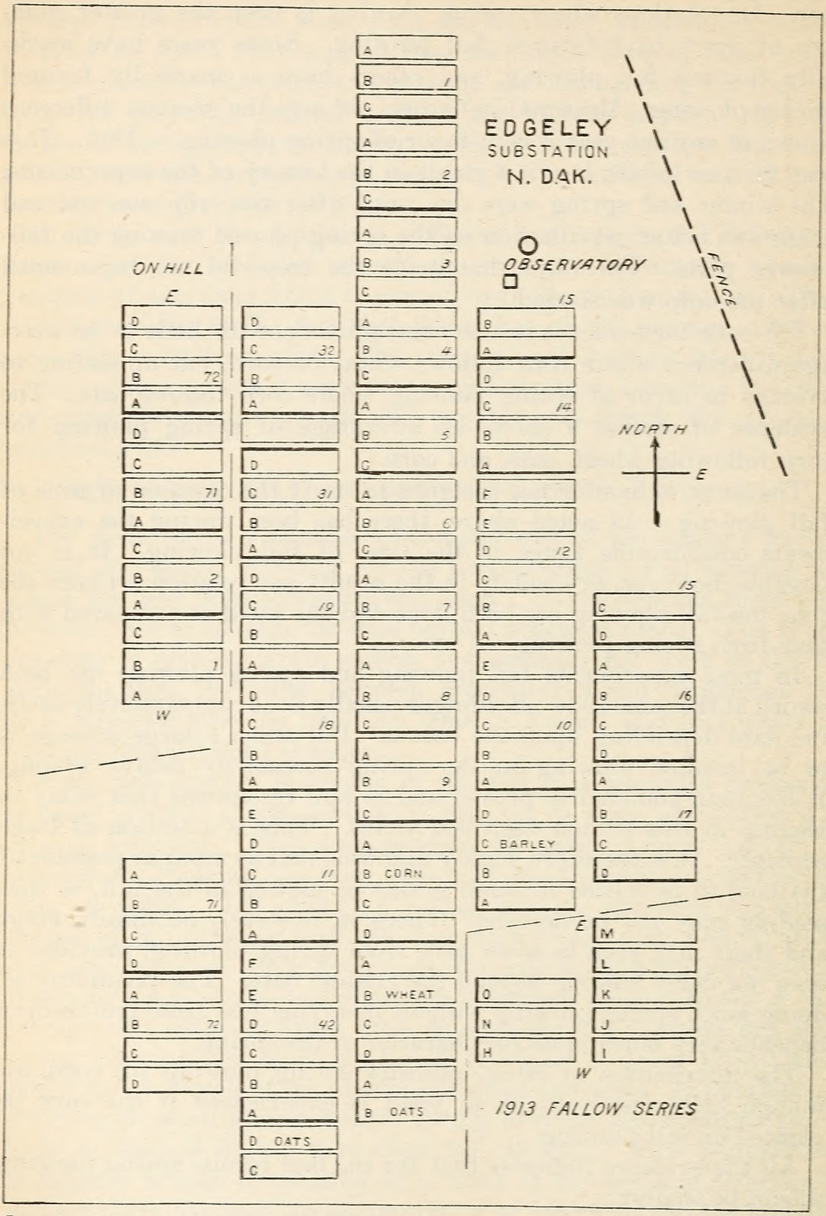

Fig. 1.—Diagram of the experimental plats in the main field at Edgeley, N. Dak., showing the location of the crop rotations with reference to each other.

The location of the rotations with reference to each other is shown in figure 1, which is a plat sheet of the main field. Each rotation is designated by a number and each plat in the rotation by a letter. The crop that is on plat C one year is on plat B the next, and so on until from A it moves to the letter marking the end of the rotation. The plats are 2 by 8 rods and are separated by 4-foot alleys and 20-foot roadways. In the diagram the separation of rotations is indicated by heavy lines. The four unnumbered blocks of four plats each are the continuous and alternate cropping plats devoted to the four crops designated.

Rotations Nos. 1, 2, 71, and 72, set off by a broken line and designated "on hill," are duplications described in the text as being on deeper soil. They do not occupy the position indicated on the diagram, but are detached. The eight plats, also set off by a broken line and designated "1913 fallow series," are also detached. They have been devoted to a study of four methods of fallow.

The circle and square designated "observatory" indicate the location of the instrument yard, in which the meteorological instruments are exposed.

Rotations Nos. 1 and 3 are exactly the same 3-year rotations of oats on fall-plowed wheat stubble, corn on fall-plowed oat stubble, and wheat on corn ground. In rotation No. 1 the corn ground is disked and in rotation No. 3 it is fall plowed in preparation for the wheat. The wheat on the disked corn ground has yielded more than on the fall-plowed corn ground in 11 out of 13 years, and for the 13 years it has averaged $2\frac{1}{2}$ bushels per acre more. The average yields of oats from the two rotations agree within a fraction of a bushel, but the corn has averaged slightly more in rotation No. 1. In 1906, when the treatment was the same, the yield was about the same, indicating no considerable natural advantage of rotation No. 1 over rotation No. 3.

Rotation No. 2 has the same crops, but the ground is spring plowed for each of them. The yield of wheat on disked corn ground in rotation No. 1 has exceeded that on spring-plowed corn ground in rotation No. 2 in 10 out of 13 years, and for the 13 years it has averaged 2.4 bushels more per acre.

The same rotations have been duplicated on deeper soil since 1908. In this duplication the disked corn ground has shown less advantage over the plowed land than in the original plat field, but its average increase for the 11-year period from 1909 to 1919, inclusive, has been three-tenths of a bushel per acre.

Rotation No. 4 is wheat on fall plowing, corn on fall plowing, and oats on disked corn ground. Rotation No. 9 has the same crops in the same order, but all on spring plowing. The oats on disked corn ground in rotation No. 4 has yielded more than the oats on spring plowing in rotation No. 9 in 10 out of 13 years. The average increase on disked corn for the 13 years is 1.1 bushels per acre.

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Rotation No. 7 is barley, corn, and oats all on spring plowing. The oats on disked corn ground in rotation No. 4 have outyielded the oats on the plowed corn ground in this rotation in 6 out of 13 years, the average increase for the 13 years being 1.4 bushels per acre.

In all the comparisons of disked and plowed corn ground results in the year 1912 stand out as markedly unfavorable to the disking. In all but one of the comparisons the experience of 1915 is also unfavorable to the practice. These were both years of abundant rainfall and heavy production.

In the tests on section 9 the disked corn ground outyielded the plowed land in 1918 and 1919, but in 1917 the reverse was true.

The evidence seems quite conclusive that while individual years may favor either plowing or not plowing the corn ground, the average of a series of years is in favor of seeding without plowing. This means in practice a strong recommendation against plowing corn ground before seeding, on account of the cost and the time consumed in plowing.

The effect on the crops that follow is not considered in detail, as it appears to be negligible.

CORN GROUND COMPARED WITH SMALL-GRAIN STUBBLE FOR WHEAT AND OATS.

Three 3-year rotations, Nos. 1, 2, and 3, have wheat on corn ground and oats following wheat, while the 3-year rotations, Nos. 4 and 9, have the same crops, but with the oats on corn ground and the wheat following oats.

The average yield in these rotations of wheat following corn is 18.4 bushels, and following oats 14.5 bushels per acre, an advantage of 3.9 bushels per acre in favor of the corn ground. The yield on corn ground has exceeded that on oat stubble every year since the experiments were started.

The oats following corn in rotations, Nos. 4 and 9, show an average increase over the oats following wheat in rotations Nos. 1, 2, and 3 of only 1 bushel per acre. In six years the higher yield has been following corn, and in seven years it has been following wheat. On section 9 for the 3-year period, from 1917 to 1919, inclusive, the same rotations have shown an increase of 1.2 bushels for wheat on corn ground, and 5.3 bushels for oats on corn ground.

These results show a rather decided advantage of corn over small grain as a crop to precede small grain. They indicate very clearly that in a combination of wheat, oats, and corn the wheat should follow the corn and the oats follow the wheat.

GRAIN STUBBLE COMPARED WITH FALLOW.

Several closely and directly comparable experiments afford data for a study of the relative merits of fallow and cropped land as a preparation for a crop.

Rotation No. 5 is fallow, wheat, and oats. Rotation No. 8 is fallow, oats, and wheat. The wheat on fallow in rotation No. 5 in 1910

Fig. 2.—The fallow plat and wheat on fallowed land in rotation No. 5 at Edgeley, N. Dak., on July 26, 1910, showing an ideal condition of the fallow surface. The corn plat and wheat on disked corn ground in rotation No. 14 are in the immediate background.

is shown in figure 2. The fallow plat is shown in ideal condition, a coarse granular mulch free from weeds. The oat crop on fallow in rotation No. 8 on the same date is shown in figure 3.

Fig. 3.—General view of the plats at Edgeley, N. Dak., on July 26, 1910. The fallow plat and oats on fallow in rotation No. 8 are in the foreground, rotation No. 10 in the first series of plats in the background, and rotation No. 16 in the second one.

In 10 of the 13 years under study the wheat on fallow in rotation No. 5 has yielded more than the wheat in rotation No. 8, but in only four of these years has the yield been markedly better. In these four years the wheat on fallow averaged 26.1 bushels, and the wheat following oats 15.7 bushels per acre. In the other nine years the fallow averaged 14.2 bushels, and the oat stubble 13.4 bushels. The 13-year average is 17.8 bushels on fallow and 14.1 bushels following oats, a difference of 3.7 bushels in favor of the fallow.

The average yield of oats on fallow in rotation No. 8 has been 36 bushels, and on fall-plowed wheat stubble in rotation No. 5, 35.2 bushels per acre. The higher yield has been on fallow seven years and on the wheat land six years.

Other opportunities for comparisons are offered in the continuous cropping series. In this series each crop—wheat, oats, barley, and corn—occupies four plats. Plat A bears the same crop continuously, the preparation being shallow spring plowing. Plat B is continuously cropped under a system of deep (8-inch) fall plowing. Plats C and D are alternately cropped and fallowed, plat C being in crop in the even years and plat D in the odd years.

The wheat on fallow has averaged 1.4 bushels more than on spring plowing and 3 bushels more than on fall plowing. In 9 of the 13 years under study the yield on fallow has been higher than on either of the other plats. In the duplication of these plats on section 9 for the three years 1917 to 1919, inclusive, the yield on fallow has been 6.1 bushels more than on spring plowing and 8.1 bushels more than on fall plowing.

Oats in this series show a stronger response to fallow than wheat, or than oats did in rotation No. 8 as compared with rotation No. 5. Not only is the yield on fallow a little higher, but the yields of oats in continuous cropping with which it is compared are much lower than those in rotations. The yield on fallow in this series is 40.3 bushels; on spring-plowed oat stubble, 25.2 bushels; and on fall-plowed oat stubble, 23.7 bushels. The increase in favor of fallow in this case is 15.8 bushels over the average of the two other methods.

In the same series barley on fallow has yielded 19.8 bushels; on spring-plowed barley stubble, 17.8 bushels; and on fall-plowed barley stubble, 15.4 bushels. The increase due to fallow is 2 bushels over spring plowing, and 4.4 bushels over fall plowing, or 3.1 bushels over the average of the two.

With corn, there is practically no difference in the average yields of the different plats in this series, although there have been some years strongly in favor of and some as strongly against fallow. The corn plats are duplicated on section 9, and there also no difference in yield is observed.

CORN GROUND COMPARED WITH FALLOW AS A PREPARATION FOR SMALL GRAINS.

The experiments offer a number of direct comparisons of fallow and corn ground as preparations for wheat and oats. Rotation No. 5 is fallow, wheat, and oats, and rotation No. 3 is corn, wheat, and oats. The heavier yield of wheat has been on the corn ground seven years and on the fallow six years. The fallow has had somewhat the heavier yield of straw, but the grain has averaged only three-tenths of a bushel more than on the corn ground. There is some evidence of a carry-over effect of the fallow, as the oats following wheat in the fallow rotation have outyielded the oats in the corn rotation in 8 of the 13 years. The average increase for the 13 years is 5 bushels per acre of grain and nearly 200 pounds of straw. The average yield of corn, which occupies in rotation No. 3 the place of the bare fallow in rotation No. 8, has been 6.4 bushels of grain and 3,432 pounds of stover per acre.

Rotation No. 8 is fallow, oats, and wheat, and rotation No. 4 is corn, oats, and wheat. The heavier yield of oats has been on fallow eight years, and on corn five years. The 13-year average increase on fallow has been 4.2 bushels of grain, but less than 100 pounds of straw per acre. There apparently has been in this case no carry-over effect of the fallow, as the yield of wheat in these rotations differs only by one-tenth of a bushel.

The yield of corn has averaged 6.3 bushels of grain and 3,344 pounds of stover, being practically the same as in rotation No. 3.

In the same four rotations on section 9 for the three years, 1917 to 1919, inclusive, the wheat on fallow has outyielded that on corn ground each year, the average increase being 1.9 bushels. No carry-over effect has been apparent, however, as the average yield of the oats following wheat is a fraction of a bushel less in the fallow than it is in the corn rotation. The oats on fallow have outyielded the oats on corn ground each year, the average increase being 14.3 bushels. The wheat following the oats on fallow yielded 1.1 bushels more than the wheat on oats following corn.

Summing up the evidence from the four rotations on both the main field and section 9, it appears that in a comparison of fallow and corn ground there has been a small advantage in favor of the fallow. The response of oats to the fallow is apparently somewhat greater than that of wheat. Whatever advantage there may be from the fallow is practically exhausted by the first crop. There is some tendency to show a small carry-over effect of fallow on the second crop, but it is so small that the evidence is not very clear. It would appear from the direct comparison of these rotations that the difference in yielding power between fallow and corn ground is so small that a choice between them is really to be determined by the choice between either conducting a bare fallow or raising a crop of corn averaging for 13 years about 6½ bushels of grain and more than 1½ tons of stover per acre.

Two other rotations in the main field for the period from 1908 to 1919 and in section 9 from 1917 to 1919 bear evidence on this subject and lead to the same conclusions. Rotation No. 18 is corn on spring plowing, oats on disked corn ground, fallow, and wheat on fallow. Rotation No. 19 is the same, but with the wheat on disked corn ground and the oats on fallow.

In the main field the average yield for 12 years of oats on fallow has been 6.1 bushels more than on disked corn ground, but the yield of wheat has been four-tenths of a bushel less on fallow than on disked corn ground. The yield of corn in rotation No. 19, which shows the greater yield of both oats and wheat, is also slightly higher than in rotation No. 18.

In section 9 the oats on fallow have averaged 2.7 bushels more than on corn ground, and the wheat 3.4 bushels more.

MANURED COMPARED WITH UNMANURED FALLOW.

Nos. 18, 19, 71, and 72 are 4-year rotations. The first two were started in 1907 and the others in 1908. Nos. 18 and 72 are fallow, wheat, corn, and oats. Nos. 19 and 71 are fallow, oats, corn, and wheat. The fallow in Nos. 71 and 72 receives 10 tons of rotted barnyard manure per acre before plowing. In the 11 years from 1909 to 1919 each crop in the manured rotations has averaged higher yields of both grain and straw than the corresponding crop in the unmanured rotations. The average increases, however, have been small, the highest being 1½ bushels for wheat on fallow.

What appears to be the true significance of the value of manure in a rotation is shown when the results are studied in another way.

The crops are now being grown on land that has been manured the third time. When the results are studied in detail from year to year or grouped and studied in periods of no manure in the first years, manured once, manured twice, and manured three times, it is shown rather clearly that the use of manure on fallow once in four years not only increases the yields of the three crops in the rotation but has a cumulative effect, the increase becoming greater with each round of the rotation. Before the corn came on the manured land in rotations Nos. 71 and 72 the total weight of corn from these rotations averaged only 151 pounds per acre more than in rotations Nos. 18 and 19. When the land had been manured once the increase was 750 pounds; manured twice, 983 pounds; and manured three times, 1,438 pounds per acre.

The yields of wheat and oats are affected by the fact that in very favorable seasons the manure increases the tendency to lodge and to rust, but in the second and third rounds of manuring these crops show decided increases on the manured land.

It is a difficult question to study, but all evidence points to the belief that the observed differences are due to an increase in the manured rotations rather than to any deterioration or reduction in the original yielding power of the unmanured rotations.

These rotations are duplicated on section 9, but the rotations have only been one round in this location. The differences in any exhibition of yields are not as yet great enough to be distinguished from or among the natural differences due to soil variation.

GREEN MANURE COMPARED WITH BARE FALLOW.

At the time these experiments began it was thought that green manures might possibly offer a means of increasing or maintaining the humus content of dry-land soils, thus increasing the yields. It was argued that they could be used in extensive or exclusive grain farming where barnyard manure was not available in adequate quantity.

Experiments were instituted to determine the effect of using winter rye, field peas, and sweet clover for green manures. At the Edgeley station this group of experiments was confined to 4-year rotations in which the land is green manured once every four years. The crops in the other three years are wheat, oats, and corn. Each green manure is used in two rotations. In one rotation oats follow the green manure and the wheat is after corn, which follows the oats. In the other the wheat follows the green manure and the oats are on corn ground.

Rotation No. 14 is rye for green manure, oats, corn, and wheat; rotation No. 15 is rye for green manure, wheat, corn, and oats; rotation No. 16 is peas for green manure, oats, corn, and wheat; rotation No. 17 is peas for green manure, wheat, corn, and oats; rotation No. 32 is sweet clover for green manure, oats, corn, and wheat; and rotation No. 31, is sweet clover for green manure, wheat, corn, and oats. The sweet clover in these rotations is sown with the preceding wheat or oats and plowed under when in blossom in its second year.

For comparison with these green-manure rotations are two similar ones having bare fallow in place of the green manure. These are rotations Nos. 18 and 19, already described. In rotation No. 18 the wheat is on fallow and the oats on corn ground, and in rotation No. 19 the oats are on fallow and the wheat on corn ground.

The green-manure rotations are fairly comparable with the fallow rotations in that each of them involves the loss of the use of the land for one year in four. After the green-manure crop is turned under the plats are treated as fallow for the remainder of the season. They are essentially modified fallows, requiring the extra expense of seed and seeding.

Rotations Nos. 14, 15, 16, and 17 were started in 1906 and the other four in 1907.

The results are difficult to determine in all their relations, on account of the natural variations in plat yields. The study at the present time is further complicated by the fact that the last period of four years has been one of low yields and two of the four have been bad rust years. With all their discrepancies and apparent contradictions, however, they point to a general conclusion: The 12-year averages from 1908 to 1919, inclusive, afford no basis of hope to increase yields by the use of green manures. One possible exception to this will be considered farther on. The expense of the green manures precludes all possibility of their profitable employment. Further, when a crop is grown there is no basis of justification for plowing it under in the hope of increasing the yield of succeeding crops.

Possible differences in soil condition and natural yielding power may be largely eliminated by comparing the relative yielding power of the crops in the several rotations in succeeding periods. The 12-year period can be divided into three periods of four years each, corresponding to the length of the rotations. When so studied it is found that the yields of all crops in rotations Nos. 14, 15, 16, and 17 have been decreasing instead of increasing, as compared with the yields of the same crops in the corresponding fallow rotations, Nos. 18 and 19. The possibility that the later seasons may have been relatively more favorable to bare fallow than the earlier ones might be advanced in explanation of the behavior of the first crop following fallow or green manure; but such an explanation could hardly account for the behavior of the corn following this crop, and certainly not for the crop of wheat or oats which follows the corn and has two crops intervening between it and the fallow.

An exception has been mentioned above. This is noted in the sweet-clover rotations, Nos. 31 and 32. In these rotations the total yield of corn, which is the second crop after the sweet clover is plowed under, has been increasing in comparison with the yield of corn in the other rotations of this series.

Unfortunately, there is no rotation to determine what the effect would have been had the sweet clover been harvested for hay or seed instead of being plowed under. Rotations to test this have been incorporated in the newer work on section 9, but are not yet advanced enough to furnish the desired data.

As to the relative values of rye and peas for green manure, the evidence is somewhat contradictory. Rotation No. 14 with rye has yielded heavier than No. 16 with peas. In these rotations wheat follows the green manure. The corn in rotation No. 15 with rye has outyielded the corn in No. 17 with peas, but the other crops have yielded more in No. 17. In these two rotations the green manure is followed by oats. The differences are small and probably well within the limits of experimental error.

In view of the fact that in more humid sections increases are usually expected from the use of legumes as green manure, it might be fair to state that one of the most interesting results of these experiments is the failure of peas as green manure to increase yields in comparison with those obtained on either fallow or nonleguminous green manures.

A result from these experiments more important than the differences between green manures or fallow is that on disked corn ground the wheat has averaged 1.3 bushels per acre more and the oats 4 bushels per acre more than the same crops on green manures and fallows. The corn following wheat in four rotations has averaged 6.8 bushels of grain and 3,065 pounds of stover per acre, and following oats in four similar rotations it has averaged 6.9 bushels of grain and 3,407 pounds of stover per acre.

SOD CROPS.

In humid sections sod-forming crops occupy an important place in crop rotations. Three such crops were incorporated in the experiments at Edgeley. These are brome-grass, alfalfa, and red clover. Brome-grass is included in two rotations and alfalfa and red clover in one each. The several rotations are all similar in that the other crops are oats on sod, corn on fall-plowed oat stubble, and wheat on disked corn ground. The two brome-grass rotations differ from each other in only one respect. No. 12 is lengthened one year over No. 10 by introducing a crop of flax on the brome-grass sod and raising the oats on fall-plowed flax stubble.

In the brome-grass rotations the brome-grass is seeded with the wheat. Both the alfalfa and the clover are spring seeded without a nurse crop on fall plowing. In the rotations containing these crops there is consequently one year in which there is no production. This loss of the use of the land is avoided in the brome-grass rotations, which produce a crop each year. The brome-grass stands two years, the alfalfa two years in addition to the seeding year, and the red clover one year in addition to the seeding year. The experiments were not intended to study brome-grass or alfalfa to determine how long they would remain productive. Neither was the length of the rotations fixed by a consideration of what might be the most profitable practice. They were purposely made short to meet the exigencies of experimentation and to determine as quickly as possible the effect of seeding and breaking up these crops. It was thought that a full sod would be formed and the effect on succeeding crops determined as well by standing for two years as for longer periods.

No. 10 is a 5-year rotation of oats, corn, wheat with brome-grass seed, and two years of brome-grass meadow. The oats are seeded on brome-grass sod broken in midsummer of the preceding season. The average date of harvesting the hay crop is July 12, or about three weeks before grain harvest. The instructions are to break the sod as early as convenient and possible after the hay crop for the year has been secured. Generally the sod has been backset late in the fall. The average yield of oats for the 12-year period from 1908 to 1919 has been 27.7 bushels. This yield might be compared with an average yield of 30.5 bushels per acre of oats following wheat in three 3-year rotations of corn, wheat, and oats. The yield of corn on spring plowing following the oats has been slightly more than when following oats in 4-year rotations containing fallow and green manures and slightly less than following oats in 3-year rotations of corn, wheat, and oats. It can not be stated positively that the introduction of brome-grass sod into the rotation has had a significant effect on the yield of corn grown the second year after breaking the sod. The yield of wheat following the corn has been practically the same as that of wheat following corn in 3-year and 4-year rotations.

No. 12 is the same rotation lengthened one year by raising a flax crop on the brome-grass sod. The sod has been broken in the spring immediately before seeding to flax. This has usually been about the middle of May, the actual dates ranging from May 7 to June 2. This practice can not be considered a success from the standpoint of flax production. In some years the sod has been too dry to germinate and grow the flax, in some of the wetter years the flax has been choked out by the brome-grass, and in some years there has been loss from flax wilt. The highest yield was 13.2 bushels in 1909. In 6 of the 13 years the crop has been a total failure, reducing the 13-year average yield to 2.9 bushels per acre. Data from other stations indicate that better results might be obtained by breaking the sod the preceding summer, the same as is done for oats in rotation No. 10.

The flax ground is fall plowed for oats. The oats in this rotation have averaged about 4 bushels of grain and 500 pounds of straw per acre more than the oats in rotation No. 10, where they are the first crop following the brome-grass. The corn following the oats seems to have been increased about 500 pounds per acre in total yield by the introduction of the flax crop, but the wheat following the corn shows little or no effect from it.

The brome-grass in rotation No. 12 has yielded heavier than in rotation No. 10. As there is no good reason for this in the rotations themselves, it seems that it should be attributed to a difference in the soil, which might also account for the heavier corn yields in rotation No. 12.

For the 13 years, 1907 to 1919, the first-year yield of hay has averaged 2,332 pounds in No. 10 and 2,868 pounds in No. 12. The second-year yield has been 2,714 pounds in No. 10 and 3,083 pounds in No. 12.

No. 42 is a 6-year rotation consisting of oats on alfalfa sod broken the previous fall, corn on fall-plowed oat stubble, wheat on disked corn ground, one year for seeding to alfalfa on fall-plowed wheat stubble, and two years of alfalfa meadow.

In only two years, 1915 and 1916, have the oats following the alfalfa outyielded the oats following brome-grass in rotations Nos. 10 and 12. The 12-year average yield is about 3 bushels per acre greater on the brome-grass sod of rotation No. 10 than it is on the alfalfa sod of No. 42. The only oat plat in the field that has averaged less than the one on alfalfa sod is the plat continuously cropped to oats on fall plowing.

The yield of corn following oats in the alfalfa rotation is also less than in the brome-grass rotations. It is also less than following oats in either 3-year or 4-year rotations.

The yield of wheat is about 3 bushels less in the alfalfa rotation than in the brome-grass rotations; rotation No. 42 is somewhat separated from rotations Nos. 10 and 12 in the field, and its apparent inferiority may be due to a difference in soil. When the results are separated into 4-year periods and studied it is seen, however, that the brome-grass and alfalfa rotations have not been undergoing any changes in their relative yielding powers.

The manured rotation No. 71 adjoins rotation No. 42. The corn following oats and the wheat on disked corn ground in this rotation exceed in yield the corresponding crops in rotation No. 42.

No crop is harvested the year the alfalfa is seeded. In 1909 and again in 1918 the 1-year-old alfalfa winterkilled, while the new seeding did not. In 1919 both plats winterkilled. Aside from these failures there has been a crop each year. Three years it has amounted to over 2 tons per acre, but the 12-year average yield from each plat has been slightly in excess of 1 ton. Two crops have been cut in only 4 of the 12 years. In 1916 a third cutting was made on the older plat.

It is fairly evident from these results that alfalfa in this section must stand on its own merits as a crop, as its introduction into a rotation decreases rather than increases the yields of following crops. It appears that alfalfa fields should stand as long as they are satisfactorily productive, rather than be broken up for the sake of rotation.

No. 11 is a 5-year rotation of oats, corn, wheat, and two years of clover. One of the clover years is devoted to seeding down, and the second is the crop year. After the crop is harvested the sod is fall broken for oats. This rotation can be considered a failure, because the red clover so frequently fails to survive the winter. It has been a total failure in 5 out of 12 years and in 3 other years has produced less than 1,000 pounds of hay per acre. Its 12-year average is 1,160 pounds, or only a little more than one-half that of alfalfa and less than half that of brome-grass. The growth of clover has not increased the yields of the other crops in the rotations.

THE EFFECT OF THE SEASON ON YIELDS.

In the preceding pages the effects of diverse cultural practices on yields have been considered. It has been shown that in the average of a series of years the differences resulting from wide divergence of methods are very modest and in some cases not measurable by the methods of investigation employed. When the results are studied in detail year by year it is immediately seen that differences in yield resulting from differences in soil treatment are of minor importance when compared with the results of differences in seasons.

The effect of seasonal conditions is shown clearly enough in the average yields given in Table I, but it can be more effectively illustrated by the use of yields from individual plats representing widely contrasting methods. It matters little which are selected for this purpose, as all show much the same thing, as evidenced in the general averages presented in Table I. Typical illustrations are offered in rotations Nos. 5 and 8, which were described in considering the subject of small-grain stubble compared with fallow. Bare fallow might reasonably be expected to overcome the effect of the seasonal conditions as fully as any cultural method. There should at least be offered as wide a contrast between fallow and cropped land in their control by seasonal conditions as between any methods that might be selected.

In rotation No. 5 wheat is on fallow, and in rotation No. 8 it follows oats. In rotation No. 8 the oat crop is on fallow and in No. 5 it follows wheat. The yields of these two crops in these rotations are given in Table II for each year of the 14-year period from 1906 to 1919. In 1906, the first year, neither plat was on fallow, but all were on land in variety tests of small grain in 1905. The yields from 1907 to 1919 are shown graphically in figure 4. The upper portion of this diagram gives the yields of oats and the lower portion the yields of wheat. The yields on fallow are shown by circles connected by a solid line and the yields on land producing a crop the year before by crosses connected with a broken line. Both the figures of yield and the diagram are so clear as to need little comment. The yields of both methods go up or down with the seasons to a degree altogether disproportionate to any differences between the methods themselves.

TABLE II.—*Annual yields of wheat on fallow in rotation No. 5 and following oats in rotation No. 8, and of oats on fallow in rotation No. 8 and following wheat in rotation No. 5, showing the controlling effect of seasonal conditions at Edgeley, N. Dak., during the 14-year period from 1906 to 1919, inclusive.*

Year.	Yields per acre.			
	Wheat.		Oats.	
	Rotation No. 5.	Rotation No. 8.	Rotation No. 8.	Rotation No. 5.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*
1906	15.8	15.0	50.0	55.6
1907	30.3	27.5	63.8	57.5
1908	11.8	8.5	30.9	27.5
1909	19.5	10.3	20.9	33.4
1910	29.8	26.6	56.2	63.7
1911	7.8	6.3	10.0	13.7
1912	2.7	.7	6.1	4.4
1913	39.0	28.2	72.5	65.9
1914	25.3	17.1	46.2	36.2
1915	38.7	37.0	100.7	82.2
1916	9.2	10.5	26.9	19.1
1917	10.0	13.3	8.1	16.9
1918	20.5	7.0	27.8	15.6
1919	1.7	2.8	11.6	22.8
Average, 1907–1919	17.8	14.1	36.0	35.2

Several causes conspire to make this so, or there are several reasons why it is so. The season may be so dry, as in 1910 and 1911, that both methods are more or less complete failures, or the season may be so wet that both methods produce heavily, as in 1912 and 1915. The fallow season may be so dry that it is impossible to store water in the fallow, in which case it possesses no advantage in this respect over a cropped plat, or the rainfall between harvest and seeding may be so abundant that the cropped as well as the fallow plat is filled with water, in which case again the fallow would have no advantage so far as water supply is concerned. This is an especially common occurrence in a shallow soil of limited water-storage capacity and with a rainfall as high as that at Edgeley. Another factor that equalizes yields by reducing all to a common

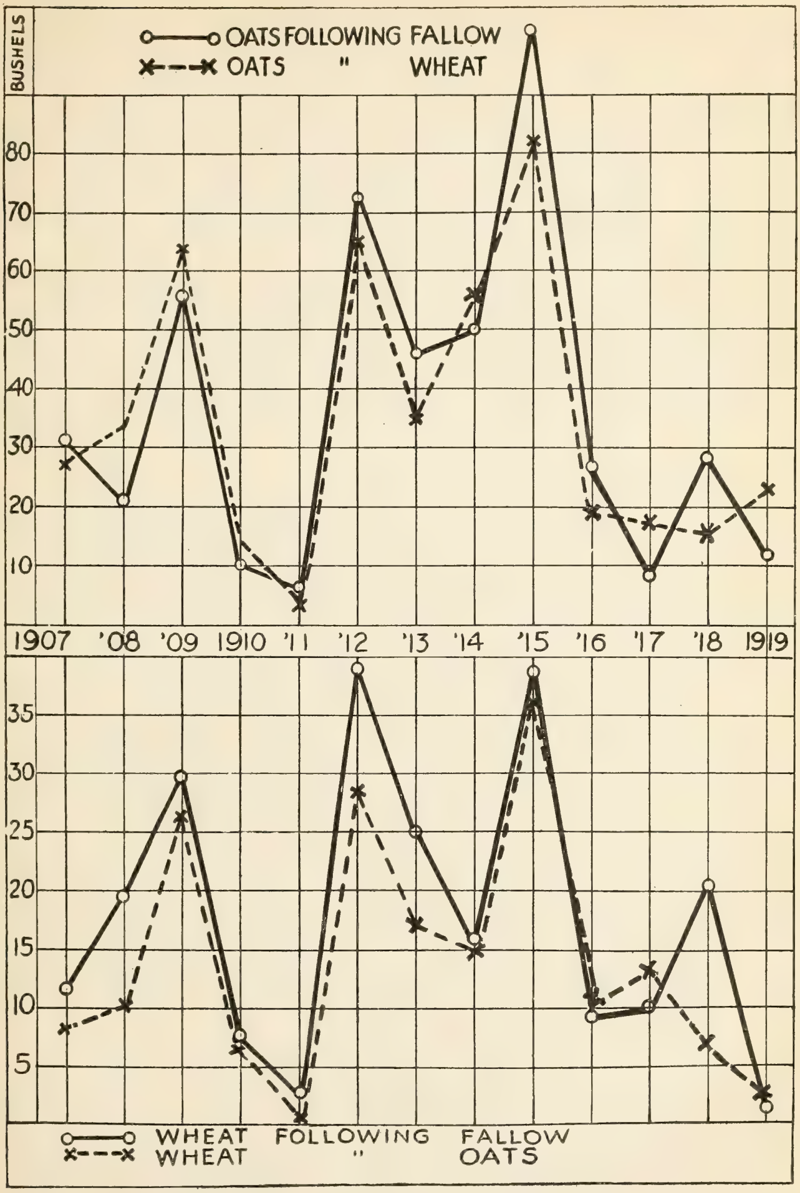

FIG. 4.—Diagram showing the data presented in Table II. The upper part of the figure gives the yield of oats on fallow in rotation No. 8 and following wheat in rotation No. 5 for the years 1907 to 1919. The lower portion shows the yield of wheat on fallow in rotation No. 5 and following oats in rotation No. 8. In each part of the diagram the yields on fallow are shown by circles connected by a solid line and the yields following a grain crop by crosses connected by a broken line.

low level is disease, of which the most important at Edgeley is rust. This generally occurs in wet years when yields would otherwise be relatively high. It was the cause of the low yields in 1916 and 1919.

Aside from disease, the most important factor controlling yields at this station is the rainfall during the growing season.

The precipitation for the months of April, May, June, and July for the several years was as follows: 1906, 14.03; 1907, 6.44; 1908, 9.18; 1909, 10.50; 1910, 5.08; 1911, 7.09; 1912, 15.63; 1913, 9.53; 1914, 13.23; 1915, 13.81; 1916, 12.48; 1917, 7.54; 1918, 8.58; 1919, 13.45; average, 10.47 inches.

There is a close relation between these figures and those of yields shown in Table II, except in those cases where disease interferes with the production of a good crop by a sufficient rainfall.

It will be noted that, generally speaking, a rainfall of over 9 inches during the growing season is necessary to the production of a good crop.

CONTINUOUS CROPPING COMPARED WITH ROTATION.

Considerable study has been devoted to the subject of changes that may be taking place in the relative yields of crops grown continuously on the same plats and those grown in rotation with other crops. The great fluctuations due to seasons and the relative response to methods of cultivation in different seasons tend to obscure results in even as long a series of years as that under study. There are, however, rather marked indications of comparatively decreasing yields under continuous cropping to any one small grain. This observation is not confined to this station alone, but is more or less general. After the first few years, from four to seven, on new land there appears to come a break in the relative yields from land continuously cropped to one grain. The most obvious reason for this, and one that in some cases clearly accounts for it, is the development of weeds. Diseases that are propagated in the soil are probably another reason. It is not believed that it is due to any impairment of the soil. Another bumper crop year such as 1915 was will be very interesting on account of the evidence it will furnish on this subject.

CONCLUSIONS.

The results attending the use of barnyard manure, various green manures (leguminous and nonleguminous), sod crops, and a continued and rather extensive test of commercial fertilizers which has been conducted at the station but is not considered in the present paper, all show that soil fertility is not a limiting or controlling factor of major importance in crop production at Edgeley. On the other hand, the seasonal variation in yields shows that the chief controlling factor is the seasonal rainfall. The full operation of its control is interfered with by plant diseases, of which the chief one not under control is rust. The nature of the soil and the amount and distribution of the rainfall are such that attempts to overcome the controlling influence of rainfall by means of cultural methods designed to store water in the soil in advance of the growing season meet with only limited success.

Phrased in other words, 15 years of thorough investigation have failed to discover any one method or any royal road to the solution of the problems of crop production in this section. Success is to be attained rather through the application of many small details embraced under the general term of good husbandry. Work must be well and timely done. Good seed of the best varieties, free from disease, should be sown in good season in a well-prepared seed bed free from weeds.

Whether plowing is done in the fall or the spring may be of material effect in any one year, and so also may differences in the time of plowing in the fall, but in the average of a series of years these factors are of minor importance provided seeding is not unduly delayed.

Fallow may be usefully enlisted as an emergency measure for cleaning up land that is infested with weeds or in preparing for a crop the following season an excess acreage that for any reason it has been impossible to utilize for cropping in the current season or on which for any reason there may be an early crop failure. Fallow does not, however, increase the yield over that on cropped land sufficiently to warrant giving it any recognized place in a cropping system.

Green manuring is entirely unjustifiable, as it increases the expense without increasing the yields. Any crop produced should be harvested, as little or nothing is to be gained by plowing it under.

The effect of barnyard manure is comparatively small, but it appears to be cumulative. The results indicate that one would not be compensated for any considerable expense incurred in manuring land for field crops, but that he will be paid for disposing of the available manure by judiciously applying it to the fields in a systematic rotation. It should be applied in preparation for the corn crop.

Corn has not been a strong competitor of the grain crops. In 14 years it has matured only five good crops of grain, averaging for this period a little less than 9 bushels per acre. In addition, it has produced an average of about 3,600 pounds of stover or fodder per acre. It deserves, however, an important place in the rotation. The yields of small grain following it are materially increased over those following small grain and fully equal or even exceed those on fallow. When properly handled corn can take the place of fallow in cleaning the ground of most weeds. Its inclusion in the cropping system distributes labor and team requirements better than unmixed grain farming and by preparing the ground for small grain helps to prepare for the early seeding of a large acreage. As the most valuable part of the average crop is the fodder, it tends to diversification, as live stock is necessary in order to consume it on the farm where produced.

Brome-grass has been found to lend itself well to use in a rotation. It has been a sure and reliable hay crop. There is also an aftermath eminently suited for fall pasture, but its value has not been determined in these experiments.

Alfalfa has also proved a valuable sod crop. The only failures have been from rather infrequent winterkilling. Its average tonnage is not quite as heavy as that of brome-grass, but it is of higher value. It does not lend itself to short rotations as well as brome-grass, because it is not desirable here to attempt to establish it by seeding with another crop, a practice which for 14 years has proved entirely practicable with brome-grass.

The effect of alfalfa in a rotation has apparently been to depress the yield of the crops immediately following. Brome-grass has had a slightly depressing effect on the first crop following it, but succeeding crops have neither been increased nor decreased in yield. It may well be that these experiments do not show what may fairly be expected from sod crops in rotation on a farm. Generally speaking, in these experiments the crops have been allowed to meet the weeds that attend their growth under the several cultural methods under trial, but it is necessary in plat work to prevent pernicious weeds, such as the mustards, wild oats, quack-grass, and perennial thistles, from becoming established, as they could not well be confined to single plats or rotations. As one of the effects of sod crops is to clean the land of weeds, it can not be said with certainty that their full effect has been measured in these experiments.

The results indicate that the sod crops, while forming a part of the rotation, should enter into it only as it is necessary to make new seedings and break up the old, in order to maintain the maximum production of the brome-grass or alfalfa.

The remaining ground should be in a rotation of corn on spring plowing, followed by wheat on disked corn ground, and it by wheat, oats, or barley. To make early seeding possible, fall plowing for the small grain is desirable. There is no objection to spring plowing except as it delays seeding. If it can be done in time to permit early seeding, it may be even better than fall plowing.

If one-third the land not in sod were devoted to corn, there would be one crop of wheat on corn ground and one crop of small grain on wheat stubble. The relative production of corn and small grain probably does not justify planting so large a proportion of the land to corn. The adoption of such a rotation would mean a radical change in the agriculture of the section, which is now based chiefly on wheat. It would also mean a decreased total production of wheat, as the increased yield of wheat on the corn ground over wheat following wheat would not compensate for the reduced wheat acreage. The rotation may be lengthened to meet the requirements by reducing the acreage of corn and letting small grain follow small grain for a greater number of years.

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