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Winter Wheat In South Dakota

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WINTER WHEAT IN SOUTH DAKOTA

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Brookings, South Dakota

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WINTER WHEAT IN SOUTH DAKOTA

Arthur T. Evans, Associate Agronomist, and George Janssen, Assistant Agronomist.

Winter wheat production in South Dakota has been constantly on the decline since 1916. In that year 2,775,000 bushels were produced. The crop reporter reports the 1920 production at a figure of 1,325,000 bushels less. At the same time the acreage decreased by 75,000 acres. Spring wheat also shows a steady decrease in production since 1918. The yield in 1916 was low. The decrease in spring wheat production based upon the highest year's average is 63.2 per cent, while, basing our calculation upon the highest year's production on winter wheat we have a decrease of only 47.7 per cent. This in encouraging for the winter wheat growers of South Dakota when compared with that of spring wheat.

WINTER WHEAT
SOUTH DAKOTA

Year	Acreage	Yield	Production	Av. Farm Price
1921	75,000	14.0	1,050,000	.87
1920	56,000	14.5	812,000	1.15
1919	75,000	13.0	975,000	2.40
1918	115,000	17.0	1,955,000	1.99
1917	120,000	14.0	1,680,000	1.96
1916	150,000	18.5	2,775,000	1.50
1915	125,000	20.5	2,562,000	.86
1914	69,000	14.0	966,000	.94
1913	100,000	9.0	900,000	.71

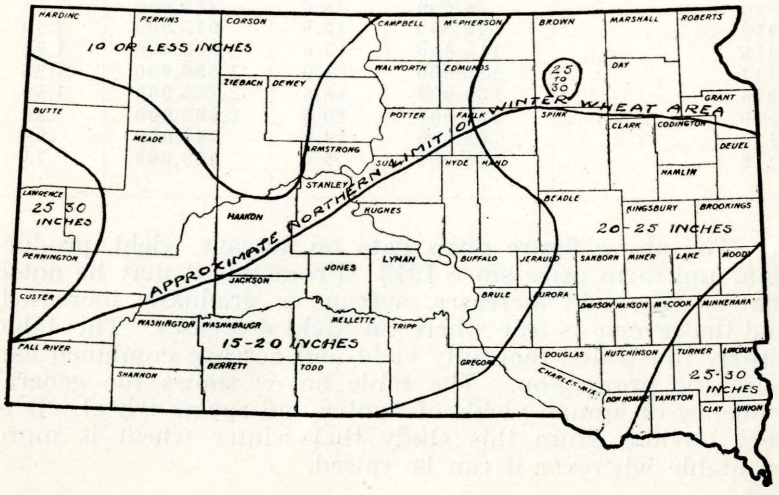
The above figure gives data on acreage, yield, production, and farm price since 1912. From this it may be noted that as the yield increases, acreage is gradually increased, and the reverse is true where the yield decreases. This table clearly illustrated that only yield and acreage combined can raise the production. The table below shows the general tendency of annual yields of winter and spring wheat. It is very obvious from this study that winter wheat is more profitable wherever it can be raised.

TABLE I-A

	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	Ave.
Winter....	No report	9.0	14.0	20.5	18 5	14.0	17.0	13.0	14.5	14.0	13.45
Spring....	14.2	9.0	9.0	17.0	6.3	14 0	19.0	8.0	9.0	9.0	11.45

Winter wheat in South Dakota perhaps has aroused as many questions in the minds of the people of this state as any cereal crop here produced. It is not an easy matter to answer questions on winter wheat in South Dakota. South Dakota is a varied state, in physiography as well as climatic characteristics. The variability in precipitation can be readily noted by studying the rainfall map. Rainfall and soil type have presumably been the biggest factors to contend with, in the production of winter wheat, up to the present time. Another factor of no less importance is the severe winters in this state. However, this latter would not play so great a role as might be expected, were there enough moisture present in the soil. Moisture seems to be the limiting factor in the production of winter grain. This in conjunction with our severe winters is frequently disastrous to the crop.

According to the map, South Dakota is divided into four divisions, according to physiographic and climatic conditions. Roughly speaking, winter wheat production in South Dakota may also be divided into these sections. According to available data, winter wheat has never been a complete failure at the experiment station at Brookings.



On observing the map it will be found that Brookings is located immediately on the border line of the 25 inches of rainfall. It is possible that winter wheat may be grown through the entire section having a precipitation of 20-25 inches of rain. Eureka, lying next to the border line of 20 inches of rain, has had no success with winter wheat. The question remains, is Eureka radically different in rainfall and soil conditions than that area designated as having 20 inches of rain? If not, the possibilities are that winter wheat may still be raised with success in the northeastern part of South Dakota. At the present time it is doubtful if winter wheat may be raised north of counties: Spink, Clark, Codington, and Deuel. Some precaution must be taken in this area, and the suggestion will be "go easy" until further data is obtained.

Cottonwood substation is located in a section having approximately the same rainfall as Eureka, a little less, perhaps. On summer fallow soil Cottonwood in a 5 year test produced 10 and 12 bushels respectively. This shows that there may be hope for it out in this area. Highmore, located in Hyde county, also in the 15-20 inch rainfall section, produced 11-12 bushels per acre in a 9 year test. Winter wheat killed out totally in 1917 and 1920—this makes the average low, yet the results are encouraging.

As an arbitrary division for the growing of winter wheat, it may be said that it can be raised with a minimum of failures where the rainfall is more than 25 inches. This division line would be south of Grant to the corner of Faulk, making an oblique cut across north of Hyde to Pierre, then via Cottonwood to Fall River county. See rainfall map. Reports from students and farmers from Mellette, Washabaugh, and the surrounding counties state that winter wheat was never known to be a failure in these sections. It should be borne in mind that the nearer to the arbitrary line indicated, and away to the north and west of the 20-25 inch rainfall line, the less assured will be the success with winter wheat.

The yields and experiments will be discussed at some length at each station.

TABLE I

VARIETY YIELDS OF WINTER WHEAT, BROOKINGS
BUSHELS PER ACRE

Name of Variety	S. D. No.	C. I. No.	Yield in Given Years							AVE.
			1916	1917	1918	1919	1920	1921	1922	
Turkey	144	.....	26.1	12.5	44.2	18.02	24.2	21.7	37.91	26.4
Kharkof	191	.....	24.1	0.0	45.0	12.5	6.7	25.8	45.83	22.8
Turkey	144	.....	.....	.....	44.2	18 0	24.2	21.7	37.91	29.2
Kharkof	191	.....	.....	.....	45.0	12.5	6.7	25.8	22.91	22.6
Turkey	1137	.....	.....	.....	22.5	13.3	8.3	31.7	36.24	22.4
Turkey	1138	.....	.....	.....	20.0	13.3	5.0	24.2	41.66	20.8
Kanred	1178	.....	.....	.....	.....	20.0	16 7	29.2	37.5	25.9
Kanred	1098	.....	.....	.....	.....	22.5	23.3	31.7	25.83	25.8
Kanred	1177	.....	.....	.....	.....	20.0	15.8	34.2	33.33	25.8
Turkey	144	.....	.....	.....	.....	18.0	24.2	21.7	37.91	25.5
Turkey	1137	.....	.....	.....	.....	13.3	8.3	31.7	36.24	22 4
Turkey	1138	.....	.....	.....	.....	13.3	5.0	24.2	41.66	21.0
Kharkof	191	.....	.....	.....	.....	12.5	6.7	25.8	22.91	17.0
Red Rock	1176	5976	.....	.....	.....	7.5	0 0	0.0	23.33	7.7
Turkey	144	.....	.....	.....	.....	.....	24.2	21.7	37.91	27.9
Kanred	1177	.....	.....	.....	.....	.....	15.8	34.2	33.33	27.8
Kanred	1098	.....	.....	.....	.....	.....	23.3	31.7	25.83	26.9
Kanred	1178	.....	.....	.....	.....	.....	16.7	29.2	37.5	27.8
Turkey	1137	.....	.....	.....	.....	.....	8.3	31.7	36.24	25 4
Turkey	1138	.....	.....	.....	.....	.....	5.0	24.2	41.66	23.6
Minturki	1182	6155	.....	.....	.....	.....	20.0	18.3	29.16	22.5
Kharkof	191	.....	.....	.....	.....	.....	6.7	25.8	22.91	18.5
Minhardi	1189	5149	.....	.....	.....	.....	0.0	5.4	22.5	9.3
Red Rock	1176	5976	.....	.....	.....	.....	0.0	0 0	23.33	7.8

VARIETY TEST AT BROOKINGS

The results of variety experiments at Brookings are given in Table I. Kharkof S. D. 191 and Turkey S. D. 144 have a continuous record since 1916. A very complete experiment was not started until 1919-1920.

The results as given indicate that in a 4 year test Kanred S. D. 1178 leads with a yield of 25.9 bushels. Its nearest competitor, Kanred S. D. 1098 and 1177, yielding .1 bushel less; Turkey S. D. 144 ranks fourth with 25.5; Turkey S. D. 1137 and 1138 follow in order. For similar data obtained from a 3 year test, one may examine the lower part of the table.

It will be noted that Kharkof on a 4 year basis was very inferior when compared with Kanred or Turkey. In the year 1920, there was only a stand of 85 per cent. Looking back to 1917 of the table, we find that Kharkof killed out entirely. It would seem from these data that Kharkof is probably not sufficiently hardy to withstand the climatic conditions at Brookings.

Red Rock from the Michigan station has been grown 4 years in succession. The first year it partially winter killed, the next two there was complete winter-killing. Last year its yield of 23.33 bushels was quite satisfactory.

Minhardi from the Minnesota station has a very low record. The wheat did not winterkill, but rusted badly. In 1920 the field had an excellent stand, heading out in fine shape, but at harvest it was impossible to find a grain in any of the heads. This was due largely to rusts and scab. In 1921, the results were not much better. In 1922 it did much better.

WINTER WHEAT VARIETIES AT HIGHMORE

Winter wheat variety tests have been conducted since 1913. Of the four varieties on trial since that period Kharkof S. D. 76 has proven best, yielding an average of 16.15 bushels.

Table II presents all data for these varieties, while Table III is a summary of the latter dealing only with the most important varieties.

The first part of Table III gives a 10 year average. Kharkof with 16.15 bushels leads in production. The other wheats have not proven as good over this period of years.

In a second comparison, an 8 year average is given for years 1915-1922, inclusive. Kharkof S. D. 76 again leads with a yield of 19.91 bushels, followed closely by Turkey S. D. 144, yielding 18.32 or 1.59 bushels less.

The third division gives varieties with an average of 6 years. New varieties were introduced in the later years—consequently could not be compared in the long test. Kanred S. D. 1098 in this comparison leads with a yield of 17.86 bushels. Theiss S. D. 352 and Kharkof S. D. 76 and 191 are next with good comparative yields of 17.18 bushels and 16.91 and 16.46 bushels respectively, followed by Turkey S. D. 635 and 144 in order, yielding 16.39 and 15.65 bushels respectively. From these figures it seems quite evident that Kanred S. D. 1098 will become the promising winter wheat for South Dakota.

TABLE II

ANNUAL YIELD OF WINTER WHEAT VARIETIES IN 50TH ACRE PLATS AT HIGHMORE

Variety	C. I. No.	S. D. No.	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	AVE.
Kharkof	1442	191	.....	.....	.....	5.5	39.2	winter killed	20.0	21 7	winter killed	8.74	48.33	17.93
Kharkof	1583	76	.....	1.1	1.1	11.0	45.8	"	20.0	21.7	"	7.50	53.3	16.15
Kharkof	4207	59	3.7	2.1	1.7	11.9	37.5	"	22.5	24.4	"	.....	.....	12.97
Turkey	1558	58	.....	.....	.....	5.5	33.3	"	16.2	22.9	"	7.5	46.66	16.507
Turkey	3055	635	.....	.....	.....	7.3	32.5	"	24.0	21.0	"	8.33	44 99	17.26
Turkey	3689	144	.....	.....	.....	14.6	38.3	"	17.5	23.5	"	7.91	44.99	18.35
Utah Turkey	2998	57	0.0	0 4	0.0	.....	.....	"	.....	.....	"	.....	.....	.13
Crimean	2943	353	.....	1.1	1.7	4.6	30.8	"	14.1	21 9	"	6.66	46.66	12 75
Theiss	1561	352	.....	0.5	0.6	9.1	30.0	"	23.3	23.1	"	8.33	48.33	14.32
Turkey	6249	1137	.....	.....	.....	.....	.....	"	.....	21.7	"	6.66	50.0	19.59
Turkey	6250	1138	.....	.....	.....	.....	.....	"	.....	20.8	"	5 83	49.16	18.94
Kanred	5146	1098	.....	.....	.....	.....	.....	"	27.1	27.8	"	6.45	45.83	21.43
Red Beardless hybrid	3130	311	.....	1.1	0.6	3.7	.....	"	.....	.....	"	.....	.....	1.8
Buffon	3330	354	0.0	2.2	1.1	11.0	13.3	"	27.5	.....	"	.....	.....	7.87
Red Rock	5976	1176	.....	.....	.....	.....	.....	"	.....	20.2	"	1.24	39.16	15.15
Neb. Hyb. 28	5147	1097	.....	.....	.....	.....	.....	"	13.3	19.5	"	4 16	27.77	12.94

TABLE III

WINTER WHEAT VARIETIES AT HIGHMORE, S. D.

Variety	C. I. No.	S. D. No.	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	AVE.
Kharkof	1583	76	.....	1.1	1.1	11.0	45.8	winter killed	20.0	21.7	winter killed	7.5	53.3	16.15
Theiss	1561	352	.....	0.5	0.6	9.1	30.0	"	23.3	23.1	"	8.33	48.33	14.32
Crimean	2943	353	.....	1.1	1.7	4.6	30.8	"	14.1	21.9	"	6.66	46.66	12.75
Kharkof	4207	59	3.7	2.1	1.7	11.9	37.5	"	22.5	24.4	"	None	.....	12.97
Kharkof	1583	76	.....	.....	.....	11.0	45.8	"	20.0	21.7	"	7.5	53.3	19.91
Turkey	3689	144	.....	.....	.....	14.4	38.3	"	17.5	23.5	"	7.91	44.99	18.32
Kharkof	1442	191	.....	.....	.....	5.5	39.2	"	20.0	21.7	"	8.74	48.33	17.93
Theiss	1561	352	.....	.....	.....	9.1	30.0	"	23.3	23.1	"	8.33	48.33	17.77
Turkey	3055	635	.....	.....	.....	7.3	32.5	"	24.0	21.0	"	8.33	44.99	17.26
Turkey	1558	58	.....	.....	.....	5.5	33.3	"	16.2	22.0	"	7.5	46.66	16.39
Crimean	2943	353	.....	.....	.....	4.6	30.8	"	14.1	21.9	"	6.66	46.66	15.59
Kanred	5146	1098	.....	.....	.....	.....	.....	"	27.1	27.8	"	6.45	45.83	17.86
Theiss	1561	352	.....	.....	.....	.....	.....	"	23.3	23.1	"	8.33	48.33	17.18
Kharkof	1583	76	.....	.....	.....	.....	.....	"	20.0	21.7	"	7.5	53.3	16.91
Kharkof	1442	191	.....	.....	.....	.....	.....	"	20.0	21.7	"	8.74	48.33	16.46
Turkey	3055	635	.....	.....	.....	.....	.....	"	24.0	21.0	"	8.33	44.99	16.39
Turkey	3689	144	.....	.....	.....	.....	.....	"	17.5	23.5	"	7.91	44.99	15.65
Turkey	1558	58	.....	.....	.....	.....	.....	"	16.2	22.9	"	7.5	46.66	15.54
Crimean	2943	353	.....	.....	.....	.....	.....	"	14.1	21.9	"	6.66	46.66	14.88
Neb. Hybrid	5147	1097	.....	.....	.....	.....	.....	"	13.3	19.5	"	4.16	27.77	10.79
Kanred	5146	1098	.....	.....	.....	.....	.....	"	.....	27.8	"	8.33	45.83	20.49
Turkey	6249	1137	.....	.....	.....	.....	.....	"	.....	21.7	"	6.66	50.00	19.59
Turkey	6250	1138	.....	.....	.....	.....	.....	"	.....	20.8	"	5.83	49.16	18.94

It will be noted that winter wheat varieties were completely killed in 1917 and 1920 without exception, where no special treatment was given. These missing years were included in the averages, and for this reason the yield is low.

TURKEY S. D. 144

History—In 1783 Crimea and provinces adjoining were ceded to Russia by the Turkish government, as conquered territory. Catherine II invited thither the people known as Mennonites, then inhabitants of Western Prussia, though formerly from the Netherlands. They were a thrifty and industrious people—they were accounted among Prussia's better class of agriculturists. Inducements were offered to them, among them religious freedom, immunity from military service, and a land grant of 160 acres to each family. Many Mennonites accepted the offer and went to Russia, settling just north of Crimea in what is known as the Melotschna (Milk River Colonies). In their agricultural industry they raised wheat—mostly soft spring. About 1860 hard wheat was introduced from Crimea through efforts of Mr. Warkentin.

During the Franco-Prussian war in 1870-71 a treaty was entered into with Germany whereby Russia remained neutral during the war, thus providing Germany the political guardianship it had exercised over 3,000,000 or more of German colonists in Russia. The terms were accepted by Germany with the proviso that they should be allowed 10 years to emigrate if they saw fit, rather than become Russian subjects.

At this time (1872) the Atchison, Topeka and Santa Fe Railroad company had completed its line through Kansas, thus claiming 3,000,000 acres of land. The land department of the railroad, knowing of these conditions, desired this immigration. Previous to this, five Mennonite leaders had visited the United States, and after searching through Nebraska, Minnesota, and the Dakotas, decided to settle in Kansas. It happened that Bernard Warkentin, son of Mr. Warkentin who imported the Crimean wheat into Southern Russia, was stationed in New York to direct his countrymen to Kansas. This first party that came brought with them all told not more than 20 to 30 bushels of seed of Turkey variety which had been popular in their Russian home.

The first importation made by Mr. Warkentin was in 1885 or 1886 for general distribution.

Description—Turkey wheat has very spreading awns and open spikelets. Chaff glabrous or yellow. Kernels red,

frequently mottled in appearance. It is difficult to distinguish a Turkey spike from a Kharkof spike. The heads are nearly square at the center and somewhat tapering towards the tip. Beaks 2 mm. to 10 mm. long. Frequently beards are very short at base of spike, lengthening as they near the middle and shortening again at the apex.

KANRED S. D. 1098

History—Kanred is the selection of a single head made in 1906 from the hard winter variety Crimean, C. I. 1435, that had been introduced into the United States by the Department of Agriculture. As the name indicates, it is a product of the Kansas Agricultural College. Kanred seems to be one out of 554 selections. Since that time various other selections have been made; however, S. D. 1098 has proven the most satisfactory in South Dakota.

Description—The wheat is a hard winter variety quite similar to Turkey S. D. 144, but distinguished from the presence generally of a much longer tooth on the outer or sterile glume. In Turkey S. D. 144 this outer glume is generally only toothed. In Kanred the tooth really becomes a short awn. Ordinarily Kanred will ripen a few days earlier in South Dakota. With us the survival of winter is no greater apparently than Turkey S. D. 144. In 1921 the stand of Kanred S. D. 1098 was 80 per cent while that of Turkey S. D. 144 was 100. Other years the stand has been recorded as the same. There is apparently no question as to the good milling and baking qualities of this wheat.

KHARKOF S. D. 191

History—Wheat was introduced directly from Russia in 1900 by the Department of Agriculture. This original wheat has subsequently been selected and various strains are grown through the states.

Description—Kharkof is very similar to Turkey. The spikes are very hard to distinguish one from the other. In South Dakota the grain of Kharkof is a little larger and of a darker color. This varies with the season. The spikelets are not as spreading as the Turkey. Awns run more parallel to the spike. Glumes seem to hold berry more firmly. This wheat is of good milling and baking qualities and is one of the promising winter wheats for South Dakota.

RATE OF SEEDING

A rate of seeding test on winter wheat is conducted at the Brookings station on the same soil as the variety tests. The object is to find if possible the best rates of seeding under conditions such as at Brookings. Since 1913, six rates have been used. In 1916 the wheat lodged badly and necessitated cutting all plots as one. The plots are approximately 2½ feet apart, and through the lodging it was impossible to keep them separate—hence that year (1916) was not used to average the yield. In 1917, the 3-4-5 rate of seeding killed out. The two pecks produced 7.5 bushels; and 6 and 7 pecks 12.5 each. All rates are figured into the results.

The averages from the 9 years' results are given in Table IV. The yield increases consistently until the 6 peck rate of seeding is reached and then drops. A difference of 2.9 bushels is obtained in favor of the 6 peck over 4 and 5 peck rate of seeding, and .8 bushel in favor of 6 peck over the 7 peck rate of seeding.

From these figures it is evident that the 6 peck rate of seeding winter wheat at Brookings proves most satisfactory.

DATE OF SEEDING AT HIGHMORE

Date of seeding winter wheat at Highmore on cornstalk land cut high reveals the fact that September 2-3 seeding is the best in so far as the results indicate up to the present time. The September 2-3 has an average of 21.38 bushels on 5 years' trial—this is 2.02 bushels greater than the July 15-28 seeding, which is an impossible date. The average of the July seeding is for 4 years, the September for five.

Averages for the years 1919 to 1922 inclusive for the September date shows a yield of 21.29 bushels, which is 1.93 more than the July average. The September 14-18 date of seeding for 8 years is 18.27. The average for 1918-1922 inclusive is 22.4. This is an increase of 1.02 bushels, which is significant. Our belief is that the September 10-15 date represents rather accurately the optimum time for seeding winter wheat. Ordinarily our grains are planted between these dates regardless of apparent existing conditions. This fall (1922) our grains were planted between these dates and our stand appears good. It is our belief that for the Highmore substation the greatest degree of success will be attendant upon plantings made between September 1 and 20. We would not advise planting thereafter, even though occasionally such late plantings with us have resulted in good yields.

TABLE IV

ANNUAL AND AVERAGE YIELD OF RATE OF SEEDING TESTS ON WINTER WHEAT, BROOKINGS, 1913-1922

Rate	S. D. No.	C. I. No.	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	AVE.
Turkey	144	3689				(1)							
2 pecks			20.8	26.7	43.3	0.0*	7.5	30.0	10.8	22.5	8.3	27.5	21.9
3 pecks			26.5	28.3	42.5	0.0	**	40.0	12.5	21.7	12.5	31.25	23.9
4 pecks			27.7	30.8	43.3	0.0	**	36.7	15.0	26.0	13.3	36 66	25.9
5 pecks			30.0	30.8	40.0	0.0	**	44.2	18.0	25.0	17.5	37.91	25.9
6 pecks			34.2	28.3	35.0	0.0	12.5	46.7	18.3	27.5	19.6	37.08	28.8
7 pecks			32.7	28.3	27.5	0.0	12.5	48.3	16.6	27.5	20.8	37.91	28.0
8 pecks			.....	.....	.....	.....	.....	.....	.....	.....	.....	35.41	.....

(1) Not included in average.
* Lodged so badly that all plots were harvested together. 1916 not included in average.
** Winter killed.

TABLE V

ANNUAL AND AVERAGE YIELDS OF WINTER WHEAT IN A DATE OF SEEDING TEST AT HIGHMORE WITH TURKEY S. D. 144; C. I. 3689.

DATE OF SEEDING	On corn stalks cut high								
	1915	1916	1917	1918	1919	1920	1921	1922	Average
July 15-28	.....	.....	.....	.....	29.2	—	1.66	46.6	19.36
August 2-3	.....	.....	.....	(1) 25.1	*	—	6.66	57.5	17.85
August 15-16	.....	.....	.....	—	—	—	9.58	55.8	13.11
September 2-3	.....	.....	.....	15.8	24.5	—	9.17	57.5	21.38
September 14-18	34.2	—	—	16.2	29.6	—	11.2	55.0	18.27
October 1-5	28.3	23.3	—	18.3	21.7	—	6.66	40.8	17.28
October 15-23	25.8	5.8	—	(1) 34.3	17.5	—	5.83	31.7	15.11
November 1-2	33.3	5.8	—	—	15.0	—	5.83	31.7	11.45
November 15-16	3.3	1.7	—	—	4.8	—	5.83	27.5	5.39
December 1-2	3.3	failed	—	—	—	—	3.33	9.2	1.97
December 15	0.0	0.0	—	—	—	—	.....	.....	0.0

— Failed.
* Kharkof instead of Turkey in 1919.
(1) Was seeded to oats, 25% oats.

TABLE VI

DATE OF SEEDING ON SUMMER FALLOW at HIGHMORE WITH TURKEY S. D. 635, C. I. 3055.

Date	1914	1915	1916	1917	Average 1914–1917
September 1-6	1.7	0.0	30.8	*	
September 14-18	1.1	13.3	31.7	*	11.5
October 1-4	2.2	23 2	20.0	*	11.4
October 15-23	?	10.0	10.0	*	
November 1-2	0.3	10.0	5.8	7.0	5.8
November 15-16		5.8	2.5	15 0	
December 1-2		6.7	2.5	8.2	
March 16	failed		7.5		

* All seedings from July 19 to November 1 killed.

TABLE VII

DATE OF SEEDING ON SUMMER FALLOW AT HIGHMORE WITH TURKEY S. D. 635, C. I. 3055.

Date	1914	1915	1916	1917	Average
September 14-18	1.1	13.3	31.7		11.5
October 1-4	2.2	23.3	20.0		11.4
November 1-2	0.3	10.0	5.8		4.0
September 14-18		13.3	31.7	0.0	15.0
October 1-4		23.3	20 0	0.0	14.4
October 15-23		10.0	10.0	0.0	6.6
November 1-2		10.0	5.8	7.0	7.6
November 15-16		5.8	2.5	15.0	7.7
December 1-2		6.7	2.5	8.2	5.8
September 14-18		13.3	31.7		22.5
October 1-4		23.3	20.0		21.6
October 15-23		10.0	10.0		10.0
November 1-2		10.0	5.8		7.9
November 15-16		5.8	2.5		4.1
December 1-2		6.7	2.5		4.6
March 16			7.5		7.5

DATE OF SEEDING ON SUMMER FALLOW

Although there is but a short test on the date of seeding winter wheat on summer fallow at Highmore, the figures conform with the longer period. In all trials in Table VI it will be recognized at a glance that September 14-18 seeding is the best. No comment is necessary on this table,

except to say that the wheat was seeded on soil that was greatly infested with field bindweed. It was supposed that through the summer fallowing of the land and seeding the same with winter grain, the weed would be eradicated. This was not the case. It was impossible to eradicate the bindweed thus, and consequently it was necessary to devote an entire year to its eradication.

For convenience of comparison Table VII was compiled. This allows the comparison of same years and same number of years. It will be noted that the averages are different in each trial—however, the deductions as made above, namely, that yields tend to decrease from September 14-18, holds true in every case.

DATE OF SEEDING WINTER WHEAT ON ANNUAL LEGUME GROUND AT HIGHMORE

In Table VIII, yields are put down from winter wheat sown at successive dates on "annual legume ground." These results, though inconclusive in themselves, indicate that winter wheat in Highmore area should certainly be seeded not later than September.

TABLE VIII

TURKEY WHEAT AT HIGHMORE

Date	On annual legume ground				Average
	1914	1915	1916	1917	1915–1916
September 14		20.0			
October 3-5		16.7	20.0	*	18.3
October 16-23		14.2	14.2		14.2
November 2		26.7	10.0		18.3
November 15-16		3.3	10.0		6.6

* Not grown on this preparation.

MULCHING OF WINTER WHEAT AT HIGHMORE AND EUREKA

Because of the fact of severe winter killing of winter wheat in the drier areas of South Dakota and because of frequent drifting of soil and fine sand, mulching experiments have been conducted at both Highmore and Eureka. Various tests are conducted at Highmore as will be explained in the following discussion.

Mulching with Six Tons of Rotten Manure

Table IX gives data concerning the mulching of winter wheat with manure. In spite of the mulch the wheat killed in 1917, proving less effective in this respect than the straw

TABLE IX

MULCHING AT HIGHMORE, ROTATION 16

Six tons manure used as mulch, Rotation 16							No mulch						
Year	Plot number					Ave.	Year	Plot number					Ave.
	1	2	3	4	5			6	7	8	9	10	
1916							1916	18.1	18.1	18.1	18.1	18.1	18.1
1917	Winter killed; then seeded to Marquis						1917	Winter killed; then seeded to Marquis					
1918	9.2	10.8	15.1	16.1	14.3	13.10	1918	8.6	10.8	12.0	15.0	13.8	12.04
1919	6.5	13.0	8.1	11.8	9.0	9.68	1919	11.0	7.1	7.5	4.7	4.0	6.86
1920	6.0	5.66	4.33	4.50	5.33	5.16	1920	5.66	5.50	5.33	3.83	4.16	4.89
1921	6.16	8.83	9.66	10.16	9.66	8.89	1921	4.16	8.5	8.0	8.0	9.66	7.66
1922	25.16	24.5	24.0	24.5	24.0	24.23	1922	16.16	15.83	12.5	12.83	12.83	14.03
Average						12.21	Average						9.09

mulch. See Table X. This last should not receive as great a weight as might be deducted on first thought. Perhaps the greatest difference between the fact why winter wheat killed out with manure and not with straw is that the straw mulch was on corn stubble, and the manure was on disced wheat stubble—the wheat having been grown in the 3 row group system and cultivated. Whether this explains it or not, the fact remains that winter wheat on disced wheat stubble killed out having a manure mulch and wheat on corn stubble having a straw mulch did not kill out in 1917.

The average for 5 years, 1918-1922 inclusive, gives a yield of wheat on the manure mulched land of 12.21 bushels; that receiving no mulch a yield of 9.09 bushels, or 3.12 bushels in favor of the mulch.

Winter Wheat Mulched with Straw

Table X gives yearly and average yields of winter wheat with straw mulch. The results are encouraging, as will be noted. In 1917 winter wheat mulched at the rate of three tons per acre gave a very good yield, while other plots the same year receiving no mulch were failures.

In 1920 the mulched winter wheat again survived, other plots proving a failure. Table X gives the results since 1918 of two plots, one receiving two and the other receiving three tons per acre. Previous to 1918 only one rate of mulching was used, namely, three tons. This rate proved too heavy in 1918, and as a result winter wheat smothered. Combined with this experiment is an additional rate of seeding test. Five pecks proved to be the best rate over a period of 6 years.

Table XI gives the results of a rate of seeding test mulched with straw at a three ton and a two ton per acre rate. In every case since 1919, when the experiment was started, the two ton rate of mulching has given better results. With the exception of the two and three peck rates in 1922, the two ton rate of mulching has outyielded in every instance. It is also of interest to note that the lowest rate of seeding in the two ton rate of mulching has yielded nearly as much as the highest rate of seeding in the three ton rate of mulching.

In Table X the 1918 grain smothered under a three ton rate, it apparently being too heavy. The smothering of weaker or less sturdy plants may account for the smaller yield in the case of the three ton mulch.

From this experiment the 6 peck rate of seeding seems to be the best with mulch. Without mulch we prefer the 5 peck rate.

TABLE X

ANNUAL AND AVERAGE RATE OF SEEDING RESULTS WITH WINTER WHEAT AT HIGHMORE STATION—AVERAGE OF TWO PLATS MULCHED WITH TWO AND THREE TONS STRAW PER ACRE.

Rate of Seeding with Kharkof	S. D. No.	C. I. No.	1916	1917	1918	1919	1920	1921	1922	Average
ROTATION 14—										
Kharkof	191	1 442								
2 pecks			20.8	5.8	0.0	9.2	5.33	10.41	37.5	12.72
3 pecks			23.0	14.2	*	11.5	6.33	11.75	40.08	15.26
4 pecks			28.3	25.8		11.6	6.33	13.08	37.08	17.45
5 pecks			32.2	28.0		11.3	8.16	14.08	38.49	18.89
6 pecks			31.8	15.5		13.0	10.08	14.16	39.41	17.7

* Wheat smothered.

TABLE XI

ANNUAL AND AVERAGE RATE OF SEEDING MULCHED WITH STRAW

Three ton mulch						Two ton mulch					
Rate	1919	1920	1921	1922	Ave.	Rate	1919	1920	1921	1922	Ave.
2 pecks	8.3	3.66	9.66	38.0	14.90	2 pecks	10.0	7.0	11.16	37.0	16 29
3 pecks	9 0	4.66	11.0	42.16	16.70	3 pecks	14.0	8.0	12.50	38.0	18.12
4 pecks	7.8	4.50	11.83	36.83	15.24	4 pecks	11.8	8.66	14.33	37.33	18.03
5 pecks	7.1	7.33	12.50	35.66	15.64	5 pecks	11.8	9.00	15.66	41.33	19.44
6 pecks	12.7	8.16	12.50	34.0	16.84	6 pecks	13.1	12 00	15.83	44.83	21.44

ROTATION AT BROOKINGS

Turkey S. D. 144 has been grown in two 4-year rotations consisting of corn, wheat, oats, clover; and corn, oats, wheat, clover. It will be seen from Table XII that the former rotation exceeds the latter by 5.71 bushels per acre in an 8-year average.

The yield in rotation 2 is partly due to two successive winterkillings. In 1918 this rotation winterkilled while Rotation 1 produced 20.26 bushels.

Winter wheat in Rotation 1 was seeded on early fall plowing before 1918, and this undoubtedly caused it to winterkill. There was no protection for the young plants. Since 1918 the wheat was drilled into disced oat stubble and only fair results have been obtained. The chief difficulty experienced on these fields is the enormous amount of weeds and rubbish in the form of straw stubble which prevented a perfect working of the soil. As a result the drill frequently did not cover the seed sufficiently to germinate, and consequently poor germination and a poor stand resulted. It undoubtedly is a fact that the stubble will protect the young plant and prevent it from winterkilling. See Fig. 4. Snow must lodge in the stubble if success is to be assured. The stubble must be disced immediately after harvesting and again shortly before seeding. No harrowing is necessary. The ground should be double disced each time by means of lapping one-half of the disc swath—this will prevent ridging. The first discing will kill the young weeds that are coming on and also start others to grow. These latter will be killed by the second discing. From the evidence thus far at hand we may expect that if a stand of winter wheat is obtained on such ground it will not winterkill.

In Rotation 2, winter wheat is seeded in the corn stalks about September 15th without any preparation. The seeding is done with a one-horse disc drill that will just seed the width of one row. This system necessitates a fairly clean and even corn field. It is impossible to seed and harvest wheat from a field that has been greatly ridged by a disc cultivator. The corn may be either cut with a corn binder and shocked, as is the usual practice, or it may be picked and the stalks left in the field. A little greater difficulty in harvesting is experienced where the stalks remain in the field. If a farmer does not care to invest in a one-horse drill he may still drill his wheat into corn land. This necessitates early cutting of corn or seeding the wheat a little later than the specified time. The corn shocks may be placed in a straight line so the man operating the drill will have

TABLE XII

WINTER WHEAT ROTATIONS AT BROOKINGS

Rotation	1915	1916	1917	1918	1919	1920	1921	1922	Average
Corn, wheat, oats, legume..... Rotation 1	37.0	37.66	failed	20.26	9.77	9.80	16.83	15.94	18.41
Corn, oats, wheat, legume..... Rotation 2	37.63	15.23	failed	failed	6.60	3.53	6.66	31.99	12.70

less difficulty in seeding. There will be a small space, of course, unoccupied by the wheat where the shocks stood, but this is small indeed. This is not so great but that it can be seeded by hand after shocks are removed. If the corn is cut for silage this latter difficulty of seeding is eliminated.

WINTER WHEAT AT COTTONWOOD

Two varieties have been tested side by side at Cottonwood on summer fallow soil since 1916. The results are given in Table XIII. Kharkof has a slightly greater yield than Turkey—Kharkof yielding 11.69 bushels, or .06 bushel in its favor. It is a general opinion that if a stand is obtained of winter grains in the fall that it will live over. This is not the case. In every instance where winter wheat was sown on summer fallow there was a 90-95 per cent stand in the fall but little or none in the spring. It will be noted that the table shows generally a poor stand even in spite of care in seeding.

In Table XIV is given the results of a 6-year test on a 4-year rotation of sorghum, rye, corn, and wheat. This experiment is conducted on acre fields—one plowed 10 inches and the other 5 inches. Both acres are mulched. The 5-inch plowing is favored by 4.7 bushels greater yield. What is more significant is that the stand is generally better.

The straw mulch for 1916 crop mostly blew off the land because there was no stubble to furnish a catch for same. The ground was smooth and when the high winds came on in the fall months, all protection was taken off. Hence, if a straw mulch is to be used some obstruction must be afforded it. This may be done by cutting the sorghum or corn high or else to leave the stalks in the field and pick the corn. This latter will provide an added protection.

Results are shown in Table XV, where no means of protection was offered aside from the corn stubble left in the field. In 1915 the crop was considerably reduced by hail, however, it is included in the average. This wheat is grown on a 6-year rotation of corn, wheat, sweet clover, sorghum, oats, and another crop of sweet clover. This latter is plowed under for green manure some time in June when the blossoms are forming.

From the results obtained on this rotation it would indicate (See Table XV) that the 5 peck rate of seeding has the highest average yield, namely, 4.90 bushels, followed by 4 pecks with 4.48 bushels, and 3 pecks with 3.78 bushels, or 0.42 bushel and 1.12 bushels less respectively than the 5 peck rate of seeding.

TABLE XIII

VARIETY TEST AT COTTONWOOD, WINTER WHEAT ON ACRE PLOTS

Variety	1916		1917		1918		1919	
	Stand	Grain	Stand	Grain	Stand	Grain	Stand	Grain
Kharkof S. D. 191	50	21.3	0	0	0	0	85	23.75
Turkey S. D. 144	35	11.0	0	0	0	0	80	19.2

Variety	1920		1921		1922		Average
	Stand	Grain	Stand	Grain	Stand	Grain	
Kharkof S. D. 191	75	21.66	65	10.0	35	5.03	11.69
Turkey S. D. 144	70	31.08	75	12.16	40	8.0	11.63

TABLE XIV

SIX YEAR RESULTS ON FOUR YEAR ROTATION (SORGHUM, RYE, CORN, WHEAT) ON ACRE FIELDS. PLOWING 5 AND 10 INCHES. TURKEY S. D. 144, MULCHED WITH SIX TONS MANURE.

Depth Plowing	1916		1917		1918		1919	
	Stand	Grain	Stand	Grain	Stand	Grain	Stand	Grain
10 inch, mulched	0	0	0	0	0	0	55	11.41
5 inch, mulched	0	0	0	0	0	0	65	11.2

Variety	1920		1921		1922		Average
	Stand	Grain	Stand	Grain	Stand	Grain	
10 inch, mulched	50	12.5	35	2.85	55	8.9	5.13
5 inch, mulched	70	17.66	60	5.18	50	5.2	5.60

TABLE XV

RATE OF SEEDING WINTER WHEAT AT COTTONWOOD. NO WINTER PROTECTION.
KHARKOF S. D. 191.

Rate of Seeding	1913		1914		1915		1916		1917		1918	
	Stand	Yield	Stand	Yield	Stand	Yield	Stand	Yield	Stand	Yield	Stand	Yield
3 pecks	25	1.00	(1) 0	0	** 80	3.0	(1) 0	0	0	0	0	0
4 pecks	25	0.20	(1) 0	0	** 80	4.7	(1) 0	0	0	0	0	0
5 pecks	25	0.10	(1) 0	0	** 80	4.7	(1) 0	0	0	0	0	0

Rate of Seeding	1919		1920		1921		1922		
	Stand	Yield	Stand	Yield	Stand	Yield	Stand	Yield	Average
3 pecks	100	20.0	90	13.83	90	* 0	Killed out		3.78
4 pecks	95	22.7	90	17.25	90	0	Killed out		4.48
5 pecks	95	27.0	95	17.16	95	0	Killed out		4.90

* Drought in summer.
** Struck by hail.
(1) Injured by jack rabbits.

Comparing Table XV with Table XIV, it would appear that there was some difference caused by either deep plowing or mulch, or both. The results of 1922 would indicate that mulching was effective although the stand figures of 1920 and 1921 confuse such a conclusion.

WINTER WHEAT AT EUREKA

Winter wheat has been grown on summer fallow at Eureka since 1913. This gives us an 11 year average with an average yield of 1.08 bushels. See Table XVI. This seems to indicate that winter wheat may be excluded from the area. Mention may be made here of the fact that in 1913 while winter wheat killed out on summer fallow, it lived through on corn stubble on the same acre and ground. This latter was undoubtedly due to the added protection of the stubble.

Table XVII gives the rate of seeding test as conducted on a 7-year rotation following corn. The rotation is as follows: Corn, wheat, sweet clover, millet, grain, potatoes, flax. The crop is mulched in the fall with two tons of straw. In spite of this it killed in 1914-18-19-20. The rate of seeding was 5 pecks up to 1921, when the rate was increased to 6 pecks.

From this test the 5 peck rate of seeding over an 8-year period has outyielded all others. This heavier rate produced .95 of a bushel more than the 4 peck rate of seeding. The 4 and 5 peck rates are noticeably better yielders than the 2 peck, slightly better than the 3 peck, which have been widely advocated. The 2-year average for the 6 peck rate of seeding is interesting, although over too short a period for any definite conclusions. The 5 peck rate would have been better were it not for an unaccountably low yield in 1921. No explanation can be given for this low yield.

Table XVIII gives results of winter wheat as grown on a 2-year rotation, corn, wheat. It may be noted that wheat after listed corn produced the best results. This, however, may be an error through lack of uniformity in the soil type, and should not be taken as conclusive. Additional data is necessary to demonstrate this fact.

It is almost impossible to formulate an opinion on the data at hand on winter wheat at Eureka. A great deal of the variations are caused by winterkilling—however, from the above data we may conclude that winter wheat cannot be recommended with safety in the Eureka district, though the future may change results through hardy varieties.

TABLE XVI

WINTER GRAINS, WHEAT AND RYE, EUREKA, SOUTH DAKOTA.
TURKEY S. D. 144, 1912-1919; KHARKOF S. D. 191, 1920-1921.

Summer Fallow Rotation 3	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average
	Red Fife	(1) 4.30	0	0	0	(1) 3.8	0	0	0	(1) 3.75	Killed	1.08

(1) Average of two plots.

TABLE XVII

WINTER GRAINS, WHEAT AND RYE, EUREKA, SOUTH DAKOTA
TURKEY S. D. 144, 1912-19; KHARKOF S. D. 191, 1920-21

Mulched Rotation 7	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	Average
2 pecks	7.8	**	36.0	14.5	1.5	**	**	**	None	Not seeded	8.6 (6 yrs.)
3 pecks	5.4	**	26.8	15.2	7.8	**	**	**	23.5	38.6	15.2 (8 yrs.)
4 pecks	*	**	34.3	22.2	7.1	**	**	**	20.5	37.1	15.15 (8 yrs.)
5 pecks	*	**	36.3	25.2	12.2	**	**	**	10.7	44.5	16.1 (8 yrs.)
6 pecks									11.0	40.3	25.6 (2 yrs.)

* Heavy seeding killed out in 1913, mulched. Turkey from 1913-19; Kharkof from 1920-21.
** Winter killed.

TABLE XVIII

WINTER GRAINS, WHEAT AND RYE, EUREKA, S. D.
TURKEY S. D. 144, 1912-19; KHARKOF S. D. 191, 1920-21.

Rotation of Corn	1918	1919	1920	1921	1922	Average
	(1)	(1)	(1)	(1)	Killed	
Rot. 9, check	0	0	0	10.8		2.16
	(1)	(1)	(2)	(1)		
9-B drilled	0	0	5.2	17.5	26.8	9.9
	(1)	(1)	(1)	(1)		
9-A listed	0	0	0	18 2	34.0	10.4

(1) Average of two plots.
(2) Seeded in spring.

WINTER WHEAT IN ROTATION AT HIGHMORE

Winter wheat in various rotations at Highmore are given in Tables XIX, XX, and XXI. In Table XIX is given the total data for all years in all five rotations having winter wheat. In studying this table one becomes doubtful relative to the profitable raising of winter wheat for this district. The results and study of these experiments leads us to believe that protection must be provided for fall wheat. In every case where a field was favored by a slight depression in the soil or a draw the loss was not nearly so great as where this advantage was not present. Rotations 2 and 5 have results from a 10-year trial. The results are in favor of the former, namely, corn, wheat, having an average of 10.95 bushels, while summer fallow wheat shows an average of 8.14 bushels.

Much of the winter wheat raising experience in the central area of South Dakota is of the past 2 years, both of which have been rather profitable even on all of our own rotations. When one studies carefully the 11-year record for the years which we have experimented, he is likely to lose some of his optimism as to the surety of winter wheat. So far as possible we have planted and cared for our plantings in the same manner. It is our belief the rigorous vicissitudes of winter are quite responsible for the failure in many instances. There are instances of various factors at work in these results. Snow, soil, moisture, protection, and other things have been found to be of value to a wintering crop.

TABLE XIX

WINTER WHEAT, KHARKOF S. D. 191, IN ROTATION AT HIGHMORE

Rotation No.	1912		1913		1914		1915		1916		1917	
	Stand	Yield	Stand	Yield	Stand	Yield	Stand	Yield	Stand	Yield	Stand	Yield
Rotation 2— Corn, wheat	Killed out		Killed out			3.2	80	19.0	80	30.0	Killed out	
Rotation 3— Corn legume, wheat									80	25.8	Killed out	
Rotation 4— Corn, rye, legume, millet, wheat, peas, and rape												
Rotation 5— Fallow, wheat	(1) Killed out		Killed out		Killed	(2) out	Killed out		60	19.2	Killed out	
Rotation 9— Continuous wheat									70	16.7	Killed out	

(1) Low spots did not kill out.
(2) Destroyed by wind and jack rabbits.

TABLE XIX—Continued

Rotation No.	1918		1919		1920		1921		1922		Average
	Stand	Yield	Stand	Yield	Stand	Yield	Stand	Yield	Stand	Yield	Yield
Rotation 2— Corn, wheat	Killed out		90	20.6	Killed out		95	12.00	100	35.66	10.95
Rotation 3— Corn, legume, wheat	Killed out		80	20.5	Killed out		90	11.16	100	48.16	9.60
Rotation 4— Corn, rye, legume, millet, wheat, peas, and rape	80	9.6	100	28 9	Killed out		95	11.83	100	42.66	8.45
Rotation 5— Fallow, wheat	Killed out		80	24.8	Killed out		75	9.33	85	36.5	8.14
Rotation 9— Continuous wheat	Killed out		85	15.3	Killed out		100	8.83	95	17.33	5.28

TABLE XX

WINTER WHEAT, KHARKOF S. D. 191, IN ROTATION AT HIGHMORE

Rotation No.	1917		1918		1919		1920		1921		1922		Average
	Stand	Yield	Stand	Yield	Stand	Yield	Stand	Yield	Stand	Yield	Stand	Yield	Yield
Rotation 2....	Killed out		Killed out		90	20.6	Killed out		95	12.00	100	35.66	11.37
Rotation 3....	Killed out		Killed out		80	20.5	Killed out		90	11.16	100	48.16	13.30
Rotation 4....	Killed out		80	9.6	100	28.9	Killed out		95	11.83	100	42.66	15.49
Rotation 5....	Killed out		Killed out		80	24.8	Killed out		75	9.33	85	36.5	11.60
Rotation 9....	Killed out		Killed out		85	15.3	Killed out		100	8.83	95	17.33	6.07

TABLE XXI

WINTER WHEAT, KHARKOF S. D. 191, IN ROTATION AT HIGHMORE

Rotation No.	1916		1917		1918		1919	
	Stand	Yield	Stand	Yield	Stand	Yield	Stand	Yield
Rotation 2	80	30.0	Killed out		Killed out		90	20.6
Rotation 3	80	25.8	Killed out		Killed out		80	20.5
Rotation 5	60	19.2	Killed out		Killed out		80	24.8
Rotation 9	70	16.7	Killed out		Killed out		85	15.3

Rotation No.	1920		1921		1922		Average Yield
	Stand	Yield	Stand	Yield	Stand	Yield	
Rotation 2	Killed out		95	12.00	100	35.66	14.04
Rotation 3	Killed out		90	11.16	100	48.16	15.09
Rotation 5	Killed out		75	9.33	85	36.5	12.83
Rotation 9	Killed out		100	8.83	95	17.33	8.31

In Table XX the averages are given from 6 years on all rotations. Here is a direct comparison. Rotation 4, corn, rye, legume, millet, wheat, peas, and oats, leads with 15.49 bushels. Its nearest competitior is Rotation 3, with 13.30 bushels. Following in order comes Rotation 5, with 11.60 bushels; Rotation 2, with 11.37 bushels, etc.

In Table XXI is given a 7-year average of four rotations, namely, 2, 3, 5, and 9. In this section corn, wheat, legume, leads with 15.09 bushels. Following in order of rotation: 2 having 14.04 bushels, 5 with 12.83 bushels; and 9 with 8.31 bushels.

It will be noted that in 1918 all rotations killed out except 9. Here winter wheat is seeded on millet ground. The millet was seeded in the 3-row group system, i. e., three consecutive rows are seeded and then four skipped, leaving a distance of 30 inches between groups. These rows are cultivated as corn. They are harvested with an ordinary grain binder. The stubble makes an excellent snow retainer.

The 1922 yields were large and in most cases have determined the rotation which is the leader. The leading rotation in 1921 in most cases would be different. Too much weight, therefore, should not be given, we believe, to this very successful wheat year of 1922.

In conclusion it may be said that winter wheat is successful south of a line through Brookings and Huron. North of this line it seems to us to be problematic, probably depending very largely for success upon the type of winter weather which we experience. Fall and spring weather are really more critical on winter wheat than is frozen midwinter weather. So far as we are aware, no heaving has ever been experienced in South Dakota, a fact for which we should be appreciative, since usually slight heaving is sufficient to break enough roots to kill young plants. Heaving is caused by alternate freezing and thawing of the ground, sufficient to cause buckling of the frozen crust.

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