3-1-1933

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Bulletin 276 March, 1933

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ACKNOWLEDGEMENTS

The author wishes to express his indebtedness to the following persons for parts of the data used in this publication: Dr. A. N. Hume, Agronomist and Superintendent of Substations; Mr. C. F. Franzke, Assistant in Agronomy; Mr. S. W. Sussex, foreman of the Highmore Substation, and Mr. Walter Schronbrodt, foreman of the Eureka Substation.

Winter Wheat in South Dakota Agriculture

K. H. W. Klages

Three general classes of wheat are produced in South Dakota; namely, common spring, durum and hard red winter. Of these types of wheat the latter is, due to the geopraphical location of the state, of least importance. In some seasons as little as two per cent of the total wheat acreage of the state is given over to winter wheat production. During the seasons of 1931 and 1932, as may be observed from Tables 1 and 2, the winter wheat acreage of South Dakota has shown a material increase. In both of these seasons more than six per cent of the state's wheat acreage was taken up by winter wheat. In 1931 and 1932 winter wheat made up 7.0 and 9.1 per cent, respectively, of the total amount of wheat produced in the state. The relative importance of winter wheat during the past two seasons has increased, as may be observed from Table 1 and Fig. 1, at the expense of the durum wheat acreage of the state. The decrease in the relative importance of durum wheat in the state during the past three years is due not only to the increased interest in winter wheat production, but is to a large degree, due to economic conditions and the generally lower price offered for durum than for hard red spring wheat.

TABLE 1.—Variations in the Acreages Given Over to the Production of Each of the Three General Classes of Wheat Produced in South Dakota Expressed in Percentages of the Total Wheat Acregae of the State From 1925 to 1932 Inclusive.

	Per Cent of Total Wheat Acreage Devoted to Each Class		
Year	Common Spring	Durum	Winter
1925	62.0	33.3	4.6
1926	56.2	39.9	3.9
1927	64.3	32.2	3.5
1928	57.8	39.5	2.7
1929	56.9	41.0	2.1
1930	58.9	38.6	2.5
1931	63.4	29.9	6.6
1932	70.2	23.3	6.5

It is estimated that 403,000 acres of winter wheat were sown in South Dakota in the fall of 1932. This is by far the largest acreage of this crop ever planted in the state.

Table 2 and Fig. 2 show that the acreage devoted to the production of winter wheat in South Dakota has been subject to considerable fluctuations during the 20 year period from 1913 to 1932, inclusive. A close relationship between the acreage abandoned on May 1 of any one year and the acreage sown in September of that year is in evidence. This is especially brought out in a graphic presentation of these two factors in Fig. 2. Periods of high abandonment of acreage sown in the fall, which are more or less synonymous with periods with winter conditions unfavorable to the survival of the crop, have in all years with the exception of the season of 1931 led to significant curtailments of acreage sown to winter wheat. Likewise a succession of years, or even separate seasons, with a low

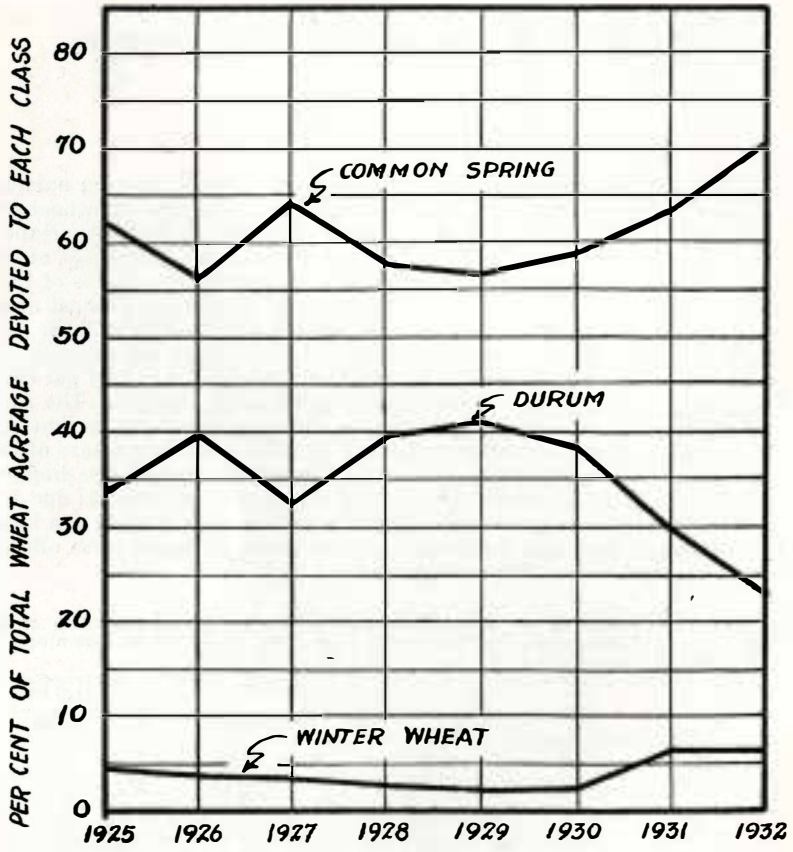

Fig. 1. Variations in the acreages given over to the production of each of the three classes of wheat produced in South Dakota expressed in percentages of the total wheat acreage of the state from 1925 to 1932, inclusive.

abandonment resulted invariably in marked increases in the winter wheat acreage of the state. The high abandonment of acreage in 1931 of the crop sown in the fall of 1930 was due primarily to drought and factors incident to it rather than to heavy winter-killing.

This points clearly to the main hazard encountered in winter wheat production, namely, winter-killing. Without doubt the main factor and obstacle to successful winter wheat production in South Dakota is the severity of the winters through which the fall sown plants must pass. All investigations relating to winter wheat production must center around the question of winter survival, either in the form of improving the immediate environment of the plants so as to provide for maximum protection or in the development and use of varieties sufficiently hardy to withstand the rigorous winter conditions encountered.

TABLE 2.—Winter Wheat Statistics for South Dakota.
(000 omited under acreage, production, and value)

Year	Acreage Sown in Preceeding Fall	Acreage Harvested	Acreage Abandoned		Production in Bushels	Price Per Bushel	Farm Value on Dec. 1 in dollars	Yield Per Acre Bushels
			Total Acres	Per Cent of Total				
1913	—	100	—	—	900	.71	639	9.0
1914	80	69	11	14.0	966	.94	908	14.0
1915	129	125	4	3.0	2562	.86	2203	20.5
1916	165	150	15	9.0	2775	1.50	4162	18.5
1917	182	120	62	34.0	1680	1.96	3293	14.0
1918	144	115	29	20.0	1955	1.99	3890	17.0
1919	79	75	4	5.0	975	2.40	2340	13.0
1920	66	56	10	15.0	812	1.15	934	14.5
1921	81	75	6	7.5	1050	.87	914	14.0
1922	102	96	6	6.0	1824	.92	1678	19.0
1923	128	77	51	40.0	924	.81	748	12.0
1924	89	80	9	10.7	1120	1.25	1400	14.0
1925	167	125	42	25.0	1428	1.27	1826	11.5
1926	94	75	19	20.0	638	1.15	733	7.0
1927	117	105	12	10.0	1890	1.06	2003	18.0
1928	163	98	65	40.0	1175	.85	999	12.0
1929	79	75	4	5.0	1065	.93	990	14.2
1930	101	96	5	5.0	1632	.46	751	17.0
1931	247	185	62	25.0	1166	.48	560	6.3
1932	288	259	29	10.1	4921	.28	1378	19.0
1933	403*							

* Estimated acreage.

The incorporation in the cropping program of a fall sown crop is desirable in all parts of South Dakota, not only from the standpoints of better diversification and spreading of risks but also to enable producers to make the best use of their labor and equipment. Most of South Dakota has, according to Spafford's (8)[1] outline of the principal types of cropping of the United States, a spring-summer type of cropping. The type of cropping common in the very southern portion of the state would according to Spafford's classification be designated as the summer-spring type. In the spring-summer type of cropping, crops sown in early spring, such as the spring sown cereals, are of primary importance in the cropping program, while crops planted in late spring and early summer, such as corn, are of secondary importance from the standpoint of acreage devoted to their production. In the summer-spring type of cropping the summer crops, that is, those planted in late spring and early summer, occupy most of the land given over to the production of annual crops, while the early spring sown types take a place of secondary importance. In either of these types of cropping found in the state, winter crops, such as winter wheat and rye sown in the fall and surviving the winter, are of relatively little importance. Crops seeded in the fall require no attention in the spring. This means less land to be prepared and to be seeded during the spring rush, and since such fall sown crops mature earlier than spring sown cereals, the harvest season is lengthened so that work at that time of the year may be better distributed. Not all parts of South Dakota are adapted to winter wheat production. In sections of the state with conditions too severe for the survival of winter wheat, winter rye may be grown in its place to advantage, and to the same end of placing a winter crop in the cropping program.

1. Reference by number is to "Literature Cited," p. 31.

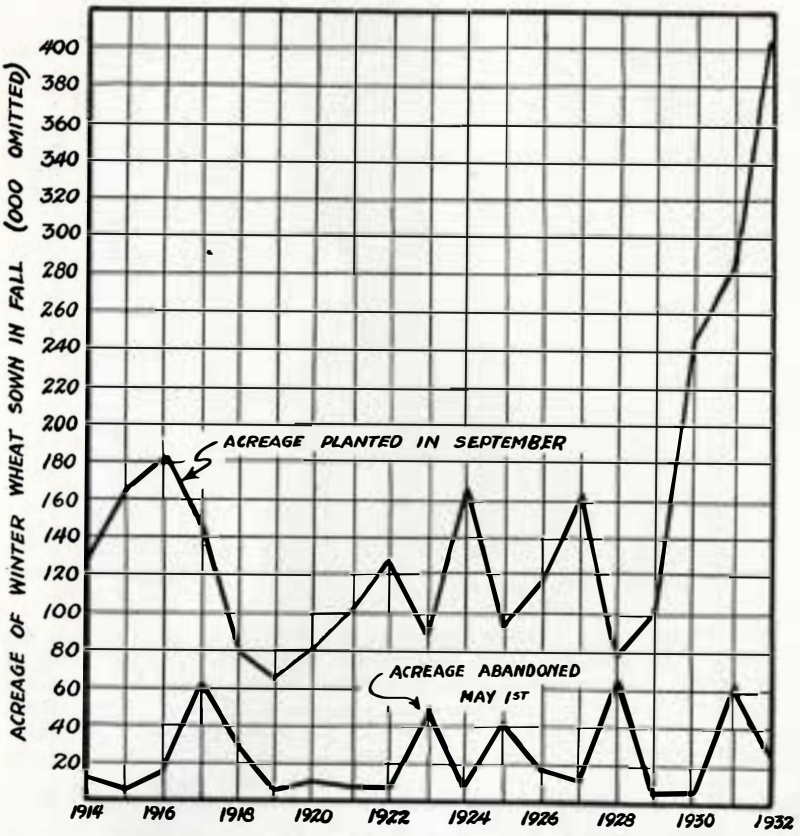

Fig. 2. Acreage of winter wheat in South Dakota abandoned on May 1 of any year and acreage sown in September of that year from 1914 to 1932.

Distribution of Winter Wheat and Winter Rye Production in South Dakota

The distribution by counties of the acreages given over to the production of winter grains in South Dakota for the year 1930 to 1931 are shown in Figs. 3 and 4 for winter wheat and winter rye, respectively.

There is, as would be expected, considerable overlapping of the producing areas of these two crops. Yet a comparison of the maps shows that the production of winter rye in South Dakota centers largely in the northeastern and northcentral portions of the state where winter conditions are generally too severe for the survival of winter wheat. A small acreage of winter wheat is reported from the northern and more from the central portions of South Dakota but the bulk of the winter wheat producing area is found in the south central and southern portions of the state. The great increase in the winter wheat acreage of the state during the past three seasons has been due largely to expansion in the south central area.

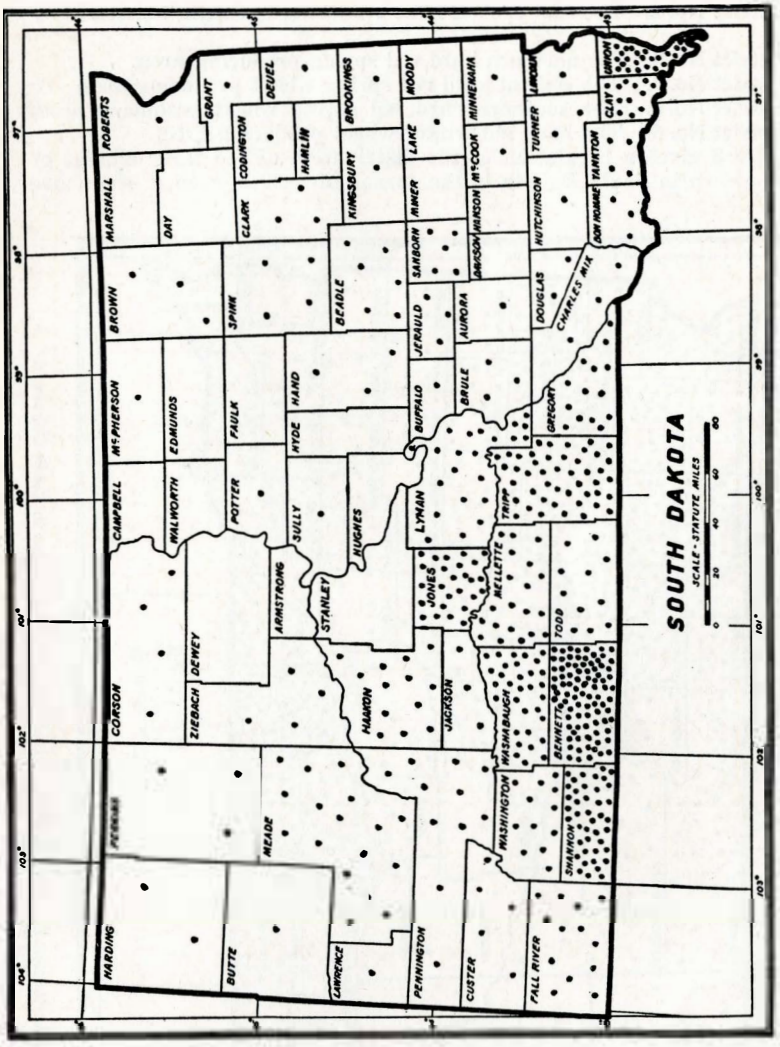

Fig. 3. Distribution by counties of the acreage sown to winter wheat in South Dakota in the fall of 1930. Each dot represents 500 acres.

Sections of South Dakota Adapted to Winter Wheat Production

Klages (7) divided South Dakota into six more or less well defined districts with regard to wheat production. These districts are given below and are shown on the map of the state in Fig. 5.

District No. 1. The northeastern area producing a high percentage of durum wheat.

District No. 2. The east central area producing but little wheat of any kind.

District No. 3 The northern hard red spring producing area.

District No. 4. The central hard red spring wheat producing area.

District No. 5. The southern hard red spring wheat producing area.

District No. 6. The hard red winter wheat producing area.

Table 3 gives a tabulation of the distribution of the three classes of wheat grown in South Dakota in the season of 1930 in each of the above

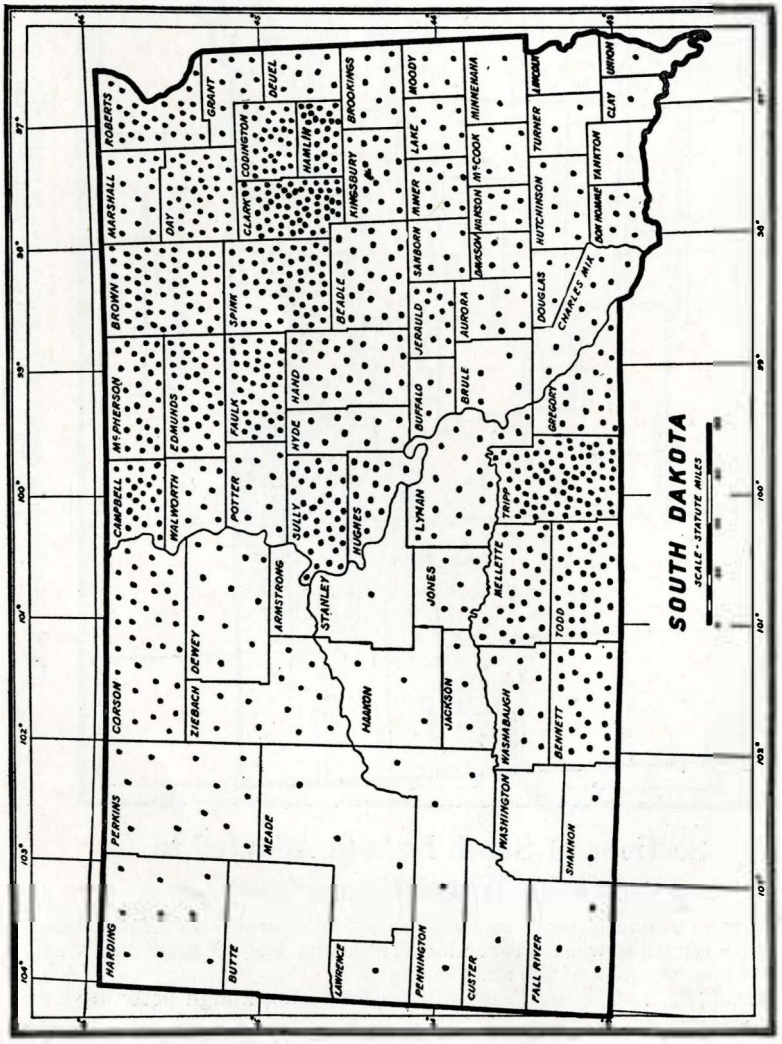

Fig. 4. Distribution by counties of the acreage sown to winter rye in South Dakota in the fall of 1930. Each dot represents 500 acres.

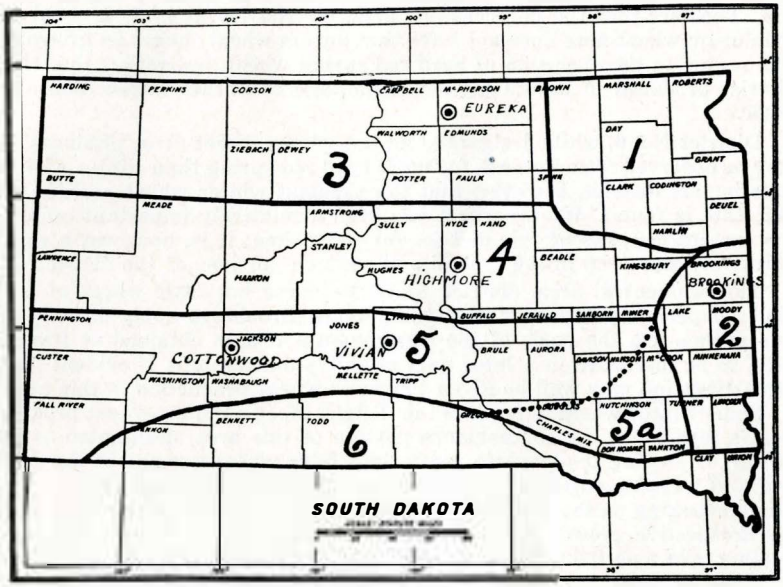

Fig. 5. Wheat producing districts of South Dakota as based on the distribution of different classes of wheat grown throughout the state. Districts 6, 2 and that portion of district 5 designated as 5a may be considered relatively safe for winter wheat production. Also showing the location of the main station and substations of the South Dakota Agricultural Experiment Station.

districts. It will be observed that no district grows only one class of wheat to the exclusion of the others, yet marked differences exist between the various districts. What is here being stated regarding the production of the various classes of wheat in the different districts refers to actual distribution, not to recommendations for the respective areas. Recommendations relative to classes of wheat and varieties for each district are fully

TABLE 3.—Distribution of Kinds of Wheat Produced in Each of the Six Districts of the State in 1930.

District	CLASSES OF WHEAT GROWN					
	Hard Red Spring		Durum		Winter	
	Acreage 1000 Acres	Percentage of Total Wheat Acreage	Acreage 1000 Acres	Percentage of Total Wheat Acreage	Acreage 1000 Acres	Percentage of Total Wheat Acreage
1. Durum wheat area	272	26.1	766	73.5	4	0.4
2. East central	6	43.0	6	43.0	2	14.0
3. Northern hard red spring	841	78.0	227	21.1	10	0.9
4. Central hard red spring	285	61.2	168	36.1	13	2.7
5. Southern hard red spring	443	68.8	163	25.3	38	5.9
6. Winter wheat area	170	59.4	53	18.5	63	22.1

discussed in South Dakota Agricultural Experiment Station bulletin No. 268. The fact that the northeastern area, district No. 1, is designated as the durum wheat area does not infer that durum wheat should be grown in this region to the exclusion of hard red spring wheat, but rather that this district produced in 1930 a higher percentage of durum wheat than any other.

District No. 6, while designated as the winter wheat area, produces as may be observed from Table 3, far more hard red spring than winter wheat. It is in this district, however, that the greatest winter wheat acreage of the state is found. Winter wheat has been a relatively important crop in the eastern counties of this district for some time; it is, however, a comparatively new crop in the central and western portions of the district.

The eastcentral area, district No. 2, produces but little wheat of any kind. Experimental results from the plots at Brookings apply directly to this region. On the basis of the experimental results obtained at Brookings, to be discussed in a later part of this publication, it is evident that more attention may well be given to winter wheat production in this area.

Some winter wheat is produced in district No. 5. Winter wheat production is feasible in the southeastern portion of this area, designated as 5a in Fig. 5. During the last two years the winter wheat acreage of the central and western portions of district No. 5 has increased materially. Before embarking on the growing of winter wheat in this area, it will be well for prospective growers to regard the yield data obtained from tests extending over a period of 19 years from 1913 to 1931, inclusive, at Highmore as given in Table 18. In nine of the 19 years over which yield data are available at Highmore, the crop failed; that is, it yielded either nothing or less than five bushels per acre. The graphic presentation of the ups and downs of winter wheat production in South Dakota given in Fig. 2 also serves to illustrate the risks to be assumed in the production of this crop. The hazards from winter-killing increase materially in going from the southern portions of the state to the central and northern districts.

It is difficult to draw a line across the map of South Dakota depicting the section south of which winter wheat may be considered a relatively safe crop and north of which the growing of the crop should not be attempted. Local conditions, such as variations in soil types, protection resulting from the lie of the land to be sown to the crop and other factors, may serve to reduce the hazards encountered in any given area. Winter injury and possible entire killing are always factors to be considered in the production of winter wheat. As yet no variety of winter wheat as hardy as winter rye has been produced. With these factors in mind, the statement can be made that winter wheat is a relatively safe crop to grow in the eastcentral and southern portions of South Dakota or in districts No. 6, 2, and that portion of district No. 5 designated in Fig. 5 as 5a. The production of winter wheat in the central and western portions of district No. 5 is a hazardous undertaking except where the acreage to be devoted to the crop may have the benefits of natural protection. This same statement may be made for the very eastern portions of district No. 4. Winter wheat production cannot be recommended in districts Nos. 1, 3, and 4. In these areas winter rye should be substituted for winter wheat. Due to generally more favorable moisture relationships the successful production of winter wheat is possible farther north in the eastern than in the central portion of the state.

Average Yields of Winter, Common Spring, and Durum Wheats at Brookings and Highmore

Table 4, taken from a paper by Klages (6) gives the average comparative yields of winter, common spring and durum wheats at Brookings and Highmore for a 23 year period from 1905 to 1929, inclusive, with the exception of two seasons. Winter wheat was not grown at Highmore in 1909 and 1910 nor at Brookings in 1910 and 1911.

TABLE 4.—Average Yields and Degrees of Variability of the Seasonal Yields of Winter, Durum, and Common Spring Wheats at Brookings and Highmore.

and Varieties Classes of Wheat	BROOKINGS		HIGHMORE	
	Average Yield in Bushels Per Acre	Coefficient of Variability of Yields	Average Yield in Bushels Per Acre	Coefficient of Variability of Yields
Winter, Turkey	25.2±1.64	48.45±5.61	13.8±2.05	110.13±19.44
Durum, Kubanka	17.0±1.20	52.12±6.17	15.8±1.33	62.45± 7.95
Common Spring *	15.6±1.06	50.71±5.95	12.9±1.09	62.88± 8.03

* Brookings Preston 1905-1912; Marquis 1913-1929.
Highmore Preston 1905-1929.

At Brookings winter wheat yielded significantly more than either durum or common spring wheat. It is of interest to compare the yields of winter wheat with the average yields of other cereals for the same period of years. Winter wheat for the period from 1905 to 1929 yielded 25.2 bushels as compared with yields of 54.8 and 44.1 bushels per acre from early oats and barley respectively. These yields expressed in common units such as pounds produced per acre would be 1512, 1753, and 2117, for Turkey S. D. 144 winter wheat, Sixty Day oats and Odessa barley, respectively. No allowances are made in these figures for the hull content of the oats and barley. Average figures for the percentages of hull in these two crops are 30 and 15 per cent, respectively, for oats and barley. According to Hunt (5) the hull content of these two crops varies from 20 to 45 per cent for oats and from 10 to 25 per cent for barley, depending on the variety and conditions under which the crops are produced.

At Highmore the three classes of wheats yielded much alike. However, the variations in the yields from season to season were considerably higher for the winter wheat than for either of the two spring wheats. Over the 23 year period of comparison the winter wheat crop failed in nine of these years as compared to five and six failures for the durum and the common spring wheats, respectively. Yields of less than five bushels per acre were considered failures. At Brookings only one complete failure of the winter wheat crop is on record for the same period of years.

Comparative yield data from Brookings and Highmore show that winter wheat may be considered a good crop for the eastcentral portion of South Dakota but that it cannot, due to the frequency of crop failures, be recommended in the central portion of the state, except, as has been pointed out, under very favorable conditions.

Effects of Preceding Crops on the Yield of Winter Wheat

Winter wheat in the northern Great Plains area is exposed to extreme conditions. Fields are frequently without protection of any kind during cold, dry periods. The effects of the preceding crops on the yields to be obtained from winter wheat are dependent primarily on the amount of protection that the remains of such crops can offer to the plants during the winter months. Standing cornstalks, or even stalks cut fairly high, and stubble of cereal crops serve to check the velocity of the wind and help hold the snow cover. The effects the remains of the previous crops have on the yields of winter wheat are clearly evident from Tables 5, 6 and 7.

TABLE 5.—Comparative Yields at Brookings From 1915 to 1932 Inclusive of Winter Wheat, Turkey S. D. 144, Planted in Checked Corn and Following Oats After Late Summer Plowing.

Year	Yield in Bushels Per Acre	
	Planted in Checked Corn	Following Oats After Late Summer Plowing
1915	37.7	37.6
1916	37.7	15.2
1917	0.0	0.0
1918	20.3	0.0
1919	9.7	6.0
1920	9.8	3.5
1921	16.9	6.6
1922	32.0	15.9
1923	12.3	8.6
1924	50.1	36.1
1925	13.8	7.1
1926	8.6	1.2
1927	23.2	16.1
1928	9.6	0.0
1929	28.0	26.2
1930	30.2	24.9
1931	13.3	8.1
1932	34.1	23.0
18 year average	21.5	13.1
Number of years of crop failure*	1	5

* Yield per acre less than 5 bushels.

Table 5 gives the results of 18 years of work at Brookings, from 1915 to 1932, inclusive. The yields reported were obtained from one-tenth acre plots replicated two times; that is, the yields of three plots were averaged. Winter wheat sown in standing corn in a corn, wheat, oats, legume rotation and having the protection of the stalks, cut at the time the corn was mature at a height of approximately 10 inches gave an average yield of 21.5 bushels per acre. Winter wheat grown in a similar rotation but following oats and seeded on land plowed after the cutting of the oats crop, consequently grown without protection of any kind, yielded only 13.1 bushels per acre over the same period of years. Only one complete failure resulted on the plots following corn during the 18 year period of the experiment as against five complete failures on the plots following oats. In part the low yields and possibly some of the failures of the winter wheat following the oats after late summer plowing may have been due to the looser seedbed resulting from that form of soil preparation. A firm seedbed is essential to successful winter wheat production.

At Eureka winter wheat was seeded on one-tenth acre plots after fa[1]-

TABLE 6.—Comparative Annual and Average Yields of Kharkof Winter Wheat at Eureka After Fallow and After Checked, Drilled, and Listed Corn From 1920 to 1932 Inclusive.

Year	Yield in Bushels Per Acre Following			
	Fallow	Checked Corn	Drilled Corn	Listed Corn
1920	0.0	0.0	4.8	0.0
1921	3.8	10.8	18.0	18.1
1922	17.5	21.0	28.6	34.0
1923	0.0	7.8	7.8	9.0
1924	17.4	17.8	21.5	25.8
1925	0.0	9.5	22.6	24.6
1926	0.0	1.0	0.3	0.5
1927	0.0	13.2	21.0	10.8
1928	0.0	0.0	0.0	0.0
1929	0.0	17.0	16.5	14.2
1930	0.0	14.8	8.3	14.7
1931	7.3	15.5	4.0	8.3
1932	1.4	17.3	18.2	1.7
13 year average	3.6	11.2	13.2	12.4
Number of years of crop failure*	10	3	4	4

* Yield per acre less than 5 bushels.

low and after checked, drilled and listed corn. The corn on these plots was cut after maturity. Annual and average yields of winter wheat following each treatment are presented in Table 6. Very striking differences were obtained. Winter wheat following drilled corn yielded 13.2 while the crop grown after fallow, that is, without protection, yielded only 3.2 bushels per acre. The crop after fallow showed 10 failures as compared to three and four failures during the 13 years of the test for the winter wheat on the land having the protection of the cut cornstalks. The differences in the yields following corn planted by the three different methods are not great. The somewhat higher yields of the wheat following the drilled and listed corn may possibly be accounted for as being due to the better protection resulting from these methods of planting insofar as they provide for a larger number and better distribution of stalks than result in the case of checked corn.

Extensive experiments on the effects of the preceding crop on winter wheat yields at Highmore are presented in Table 7. These results were obtained on one-tenth acre plots. For an 18 year period of comparison winter wheat following corn averaged 11.2 bushels as compared to an average yield of 8.9 bushels per acre after fallow. Winter wheat grown in a corn, wheat, sweet clover rotation for a 17 year period of comparison, from 1916 to 1932, inclusive, yielded slightly more than wheat in a corn, winter wheat sequence of cropping. For a 16 year period of comparison the lowest yields are again in evidence in the case of the winter wheat after fallow. Wheat following cultivated millet gave the highest yields for this period of comparison. The millet in question was planted in 36 inch rows and cut for seed; the stubble was left as high as possible so as to offer a maximum of protection. Wheat seeded in oats stubble even without the possible benefits of a straw mulch slightly outyielded the crop after fallow. More will be said regarding the effects of straw mulches on yields in a later part of this publication. No great differences were found in the number of crop failures with all the various methods of seeding. The winter wheat crop failed in seven to nine years out of the 16 years of the test.

The various rotations and sequences of cropping here referred to are

TABLE 7.—Annual and Average Yields at Highmore of Kharkof Winter Wheat After Fallow; After Corn, in a Corn, Winter Wheat Rotation; After Corn, in a Corn, Winter Wheat, Sweet Clover Rotation; After Millet in Cultivated Rows and Planted in Oats Stubble With and Without a Straw Mulch in a Corn, Oats, Winter Wheat Rotation From 1915 to 1932 Inclusive.

	Yields in Bushels Per Acre Following the Given Crop					
					Seeded in Oats Stubble in a Corn, Oats, W. Wheat Rot.	
Yead	Fallow in a Winter Wheat Fallow Rotation	Corn in a Corn, Winter Wheat Rotation	Corn in a Winter Wheat Sweet Clover Rotation	Millet in 36-inch Cultivated Rows	With a Straw Mulch	Without a Straw Mulch
1915	0.0	19.0	----	----	----	----
1916	19.2	30.0	25.8	----	----	----
1917	0.0	0.0	0.0	0.0	0.0	0.0
1918	0.0	0.0	0.0	0.0	15.1	10.8
1919	24.8	20.6	20.5	28.1	8.1	7.1
1920	0.0	0.0	0.0	0.0	0.0	0.0
1921	9.3	12.0	11.2	11.8	9.7	8.5
1922	36.5	35.7	48.2	42.7	23.0	15.8
1923	7.1	0.0	0.0	7.5	0.0	0.0
1924	28.1	31.3	42.2	53.2	39.3	28.8
1925	1.3	7.0	2.7	21.0	3.8	4.9
1926	0.9	2.3	3.7	1.3	0.7	1.1
1927	15.0	3.8	0.8	24.2	26.2	26.0
1928	0.0	15.4	13.2	10.7	0.7	0.7
1929	8.8	13.8	20.2	13.8	10.8	9.7
1930	0.0	0.0	0.0	0.0	12.3	11.0
1931	9.7	4.7	2.9	3.2	2.5	2.2
1932	0.0	6.3	8.3	2.3	28.2	24.7
18 yr. av. 1915–1932	8.9	11.2				
17 yr. av. 1916–1931	9.5	10.8	11.7			
16 yr. av. 1917–1932	8.8	9.6	10.9	13.7	11.3	9.5
Number of failures during the 16 year period*	8	8	9	7	7	7

* Yield less than 5 bushels per acre.

discussed in detail by Hume (4) in South Dakota Agricultural Experiment Station bulletin 272.

Where winter wheat is to be sown in the stubble of spring sown cereal crops, such stubble should not be disturbed more than is necessary to cover the seed properly at planting. In some seasons considerable difficulty was encountered in the proper covering of the seed in a manner so that the major portion of the stubble would remain standing. Stubble disturbed to the extent of being pulled out of the soil offers but little protection to the wheat plants during the winter months.

Since mixtures of wheat and rye are objectionable and since rye volunteers readily, winter wheat should not be sown in the stubble of winter rye.

Yield data on winter wheat for a four year period, from 1929 to 1932, inclusive, are available from Cottonwood. Kharkof on one-tenth acre plots following corn yielded 9.8 bushels as compared with an average yield of 8.5 bushels per acre following sorghums.

In the experiments here reported the winter wheat following corn was sown in standing corn with a one-horse disk drill of a width to seed one row. This system necessitates a fairly clean corn field. Corn will of course

offer the greatest amount of protection if the stalks are left standing after husking. The standing stalks may then be harrowed down the following spring without damage to the winter wheat. Where the prospective winter wheat producer does not feel justified to invest in a one-horse inter-row drill the corn may first be cut and the wheat sown with a standard drill. This necessitates early cutting of the corn or a slight deferment of the date of seeding. In any form of seeding decided upon every thought should be given to provide a maximum of protection to the plants to survive the rigor of the winter months.

Date of Seeding Winter Wheat

Winter wheat must be sown early enough in the season to give the plants an opportunity to establish themselves thoroughly before the advent of low temperatures with the approach of winter. Yet the seeding of the crop earlier than is required for this will lead to decreased rather than to increased yields. Yield data from date of seeding experiments conduct-

TABLE 8.—Annual and Average Yields in Bushels Per Acre at Brookings From 1922 to 1930 Inclusive of Winter Wheat, Turkey S. D. 144 Seeded at the Dates Indicated.

Year	Aug. 1	Aug. 15	Sept. 1	Sept. 15	Oct. 1	Oct. 15	Nov. 1	Nov. 15
1922	----	40.4	30.8	29.6	21.2	26.2	16.7	
1923	23.7	21.7	24.5	20.0	20.0	16.7	11.7	
1924	----	----	66.7	50.9	26.7	16.7	18.3	
1925	----	30.9	32.9	40.0	44.2	30.9	24.2	20.9
1926		Fall and spring dry, not considered in average						
1927	----	20.0	35.0	25.0	13.3	6.7	6.7	
1928	----	0.0	0.0	10.0	0.0	0.0	0.0	
1929	----	34.2	42.5	42.5	37.5	25.0	25.0	25.8
1930	----	25.8	31.7	30.0	24.2	6.7	20.8	18.3
8 yr. av. yields 1922–1930 (not including 1926)	----	----	33.0	31.0	23.4	16.1	15.4	
7 yr. av. yields 1922–1930 (not including 1924 and 1926)	----	24.7	28.2	28.2	22.9	16.0	15.0	

TABLE 9.—Annual and Average Yields in Bushels Per Acre at Highmore From 1917 to 1932 Inclusive, of Winter Wheat Seeded at the Dates Indicated

Year	July 15	Aug. 1	Aug. 15	Sept. 1	Sept. 15	Oct. 1	Oct. 15	Nov. 1	Nov. 15	Dec. 1
1917	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	15.0	8.2
1918	0.0	0.0	0.0	15.8	16.2	18.3	34.3	----	----	----
1919	29.5	0.0	0.0	24.3	29.6	21.7	17.6	15.0	4.8	----
1920	0.0	0.0	0.0	0.0	0.0	0.0	0.0	----	----	----
1921	1.7	6.7	9.6	9.2	11.3	6.7	5.8	5.8	5.8	3.3
1922	46.6	57.5	55.8	57.5	55.0	40.8	31.7	31.7	27.5	9.2
1923	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1924	45.8	47.5	51.6	53.4	48.4	47.5	29.1	25.0	17.5	9.2
1925	4.2	7.1	4.2	12.9	12.9	7.5	3.3	5.0	5.0	2.1
1926	0.0	0.0	0.0	0.0	1.3	1.3	2.3	2.3	1.9	4.0
1927	12.6	19.3	17.5	22.4	9.2	9.2	6.7	15.1	8.3	----
1928	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1929	10.8	18.8	21.7	18.3	15.0	10.4	11.0	11.7	2.9	5.4
1930	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1931	15.8	3.2	4.2	3.0	4.4	4.5	3.7	2.7	1.2	----
1932	10.4	17.1	10.0	11.7	8.3	12.0	4.6	1.7	4.2	----
16 yr. av. 1917-1932	11.1	11.1	10.9	14.3	13.2	11.2	9.4	----	----	----
12 yr. av. 1921-1932	12.3	14.8	14.6	15.7	13.8	11.7	8.2	8.4	6.2	----

ed at Brookings and Highmore, presented in Tables 8 and 9, serve to substantiate these facts.

At Brookings higher yields were obtained from September 1 seedings than from plots sown on August 15. Likewise materially higher average yields were obtained from the September 15 plantings than where the dates of seeding were delayed until October 1. Yield data from date-of-seeding experiments are available at Brookings for a seven and eight year period; one-fiftieth acre plots following corn were used. The same sequence of cropping and size of plots were also used at Highmore.

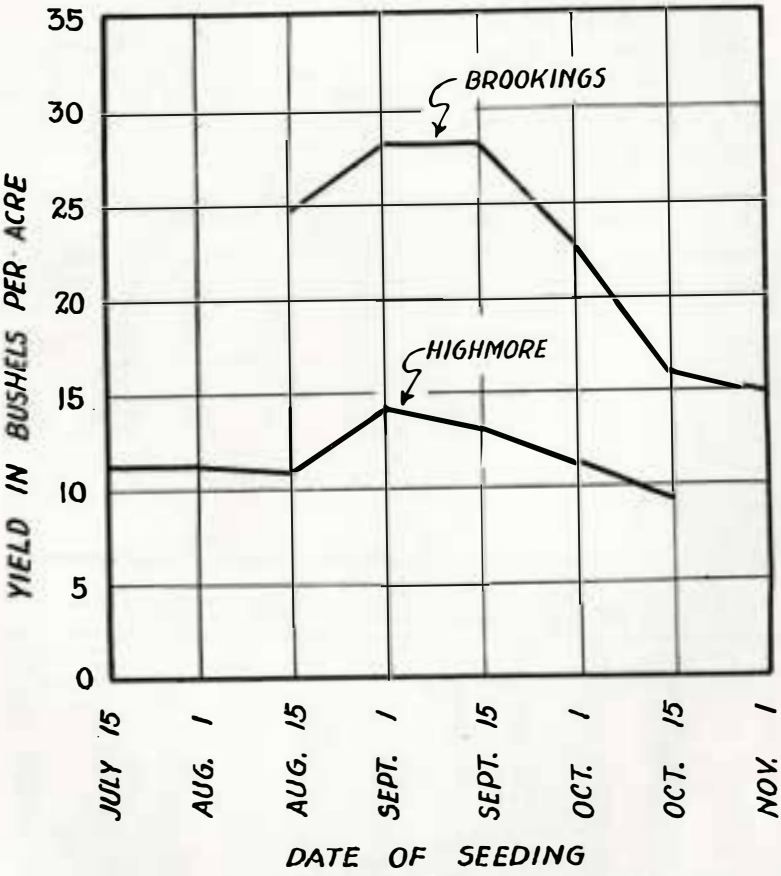

Fig. 6. Results of the date of seeding tests at Brookings and Highmore.

Winter wheat at Highmore was seeded at intervals of 15 days from July 15 to December 1, in seasons permitting such late seedings. The highest average yields were obtained with the September 1 plantings. In a few isolated seasons winter wheat seeded as late as November 1 and

even November 15 gave fair to good yields. These seasons were, however, very much the exception. Occasionally seed sown late in the fall will not germinate until the following spring and may then produce a crop; more frequently, however, a complete failure or only a partial crop results from such late seedings.

Results of the date of seeding tests at Brookings and Highmore are shown graphically in Fig. 6.

To obtain maximum yields, winter wheat should be planted during the first week of September; it should by all means be in the ground by the middle of the month. This statement is based on the results obtained from the date of seeding tests at Brookings and Highmore. In the very southern portions of the state the crop may be sown somewhat later than indicated here. But even there seeding operations should be completed by the twentieth of September. Since the Hessian fly does not occur in South Dakota in numbers sufficient to do any material damage to fall sown wheat, the seeding of winter wheat need not be delayed on account of this insect as in wheat producing sections where this pest is encountered.

Rate of Seeding Winter Wheat

Yield data from rate of seeding tests are available from Brookings, Highmore and Eureka.

Table 10 shows the annual and average yields from two periods of comparison at Brookings. From two to seven pecks were sown over a period of 12 years and from two to eight pecks for a period of four years. For both of these periods the highest average yields were obtained with the use of five pecks of seed per acre.

Yield data from two separate sets of plots are available from Highmore. Table 11 gives the annual and average yields with the use of from two to six pecks of seed per acre on plots following corn. The highest yields were obtained with the use of five pecks of seed. When allowances

TABLE 10.—Annual and Average Yields in Bushels Per Acre of Winter Wheat Seeded at the Rates Indicated, at Brookings, From 1913 to 1925 Inclusive

	Rates of Seeding in Pecks Per Acre						
Year	2	3	4	5	6	7	8
1913	20.8	26.5	27.7	30.0	34.2	32.7	
1915	43.3	42.5	43.3	40.0	35.0	37.5	
1915	43.2	42.5	43.3	40.0	35.0	37.5	
1916	Average yields of all plots 26.1, not considered in avs.						
1917	15.0	18.3	19.1	18.3	12.5	12.5	
1918	30.0	40.0	36.7	42.2	40.7	48.3	
1919	10.8	12.5	15.0	18.0	18.3	16.6	
1920	22.5	21.7	25.8	25.0	27.5	27.5	
1921	8.5	12.5	13.3	17.5	19.2	12.8	
1922	27.5	31.3	36.7	37.9	37.1	37.9	34.6
1923	5.0	7.5	9.2	13.7	16.7	15.8	12.1
1924	33.7	36.7	35.0	35.9	35.9	33.7	34.2
1925	35.0	36.7	41.7	41.7	39.2	41.7	40.9
12 yr. av. yields, 1913 to 1925, not including 1926	23.2	26.2	27.9	29.4	28.7	29.4	
Corrections for seed used	+.8	+.5	+.3	0.0	—.3	—.5	
Corrected 12 yr. av. yields	24.0	26.7	28.2	29.4	28.4	28.9	
4 yr. av. yields, 1922 to 1925 inclusive	25.3	28.1	30.7	32.3	32.2	32.3	30.5
Corrections for seed used	+.8	+.5	+.3	0.0	—.3	—.5	—.8
Corrected 4 yr. av. yields	26.1	28.6	31.0	32.3	31.9	31.8	29.7

TABLE 11.—Annual and Average Yields in Bushels Per Acre of Kharkof Winter Wheat Seeded at the Rates indicated at Highmore from 1917 to 1925 Inclusive

	Rates of Seeding in Pecks Per Acre				
Year	2	3	4	5	6
1917	5.8	14.2	25.8	28.0	15.5
1918	0.0	0.0	0.0	0.0	0.0
1919	9.1	11.5	9.8	9.5	12.9
1920	5.3	6.3	6.5	8.2	10.0
1921	10.4	11.7	13.1	14.1	14.2
1922	37.5	40.1	37.1	38.5	39.4
1923	5.7	6.3	6.0	6.1	6.1
1924	37.1	39.1	40.2	38.7	39.4
1925	5.5	7.1	7.4	7.7	8.9
9 yr. av. yields, 1917-1925	12.9	15.1	16.2	16.8	16.3
Correction for seed used	+.8	+.5	+.3	0.0	—.3
Corrected 9 yr. av. yields	13.7	15.6	16.5	16.8	16.0

TABLE 12.—Annual and Average Yields in Bushels Per Acre of Kharkof Winter Wheat Seeded at the Rates Per Acre Indicated at Highmore From 1919 to 1932 Inclusive, With a 2 Ton and a 3 Ton Per Acre Straw Mulch

	2 Ton Straw Mulch Rates of Seeding in Pecks					3 Ton Straw Mulch Rates of Seeding in Pecks				
Year	2	3	4	5	6	2	3	4	5	6
1919	10.0	14.0	11.8	11.8	13.1	8.3	9.0	7.8	7.1	12.7
1920	7.0	8.0	8.7	9.0	12.0	3.7	4.7	4.5	7.3	8.2
1921	11.2	12.5	14.3	15.7	15.8	9.7	11.0	11.8	12.5	12.5
1922	37.0	38.0	37.3	41.3	44.8	38.0	42.2	36.8	35.7	34.0
1923	6.0	6.7	5.8	6.0	6.3	5.5	5.8	6.2	6.2	6.0
1924	35.0	37.0	39.3	41.3	43.2	39.2	41.2	41.2	36.2	35.7
1925	8.5	8.8	8.7	9.2	9.0	2.5	5.3	6.0	6.2	8.7
1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1927	21.2	23.8	23.5	23.3	22.7	18.3	20.6	23.9	24.7	26.5
1928	12.2	11.2	12.3	12.6	12.3	5.2	7.3	7.6	8.5	9.2
1929	18.0	17.2	17.2	19.5	20.5	11.7	16.2	17.7	18.0	20.5
1930	2.3	8.3	7.0	4.6	6.4	2.2	8.2	11.2	12.5	13.2
1931	5.3	5.3	4.8	4.2	3.7	3.8	5.0	4.5	4.5	4.3
1932	10.0	6.2	3.4	5.3	7.9	14.1	13.0	10.6	7.8	7.7
14 yr. av. 1919-1932	13.1	14.1	13.9	14.6	15.6	11.6	13.5	13.6	13.4	14.2
Correct'n*	+1.0	+.8	+.5	+.3	0.0	+1.0	+.8	+.5	+.3	0.0
Yields†	14.1	14.9	14.4	14.9	15.6	12.6	14.3	14.1	13.7	14.2

* Correction for seed used, the six peck per acre rate being taken as standard.
† Yields corrected for variable amounts of seed used per acre.

TABLE 13.—Annual and Average Yields in Bushels Per Acre of Kharkof Winter Wheat Seeded at the Rates Indicated, at Eureka, From 1920 to 1932 Inclusive

	Rates of Seeding in Pecks Per Acre			
Year	3	4	5	6
1920	0.0	0.0	0.0	0.0
1921	23.5	20.5	10.7	11.0
1922	38.6	37.1	44.5	40.3
1923	0.0	0.0	0.0	0.0
1924	29.1	36.5	20.1	33.0
1925	15.0	19.8	26.0	24.0
1926	0.0	0.5	0.0	0.0
1927	10.0	4.2	5.0	0.0
1928	0.0	0.0	0.0	0.0
1929	11.8	11.0	20.7	15.3
1930	9.2	9.0	11.0	11.7
1931	23.8	29.7	27.8	27.2
1932	18.5	18.5	16.8	18.2
13 yr. average yields 1920 to 1932	13.8	14.4	14.0	13.9
Corrections for seed used	+.3	0.0	—.3	—.5
Corrected 13 yr. av. yields	14.1	14.4	13.7	13.4

were made for the extra amount of seed sown, the four peck rate gave practically as high returns as were obtained with the use of an extra peck of seed. In 1919 a second series of rate of seeding tests was started. The yield data from these plots are given in Table 12. Kharkof winter wheat was grown on one-tenth acre plots following corn. One set of these plots received a two ton and the other a three ton per acre straw mulch. The six peck rate of seeding gave the highest average yields on the plots mulched with two tons of straw per acre. The yields obtained with the six peck rate of planting were, however, only 0.7 bushels per acre higher than those obtained with the use of only three pecks of seed after making allowances

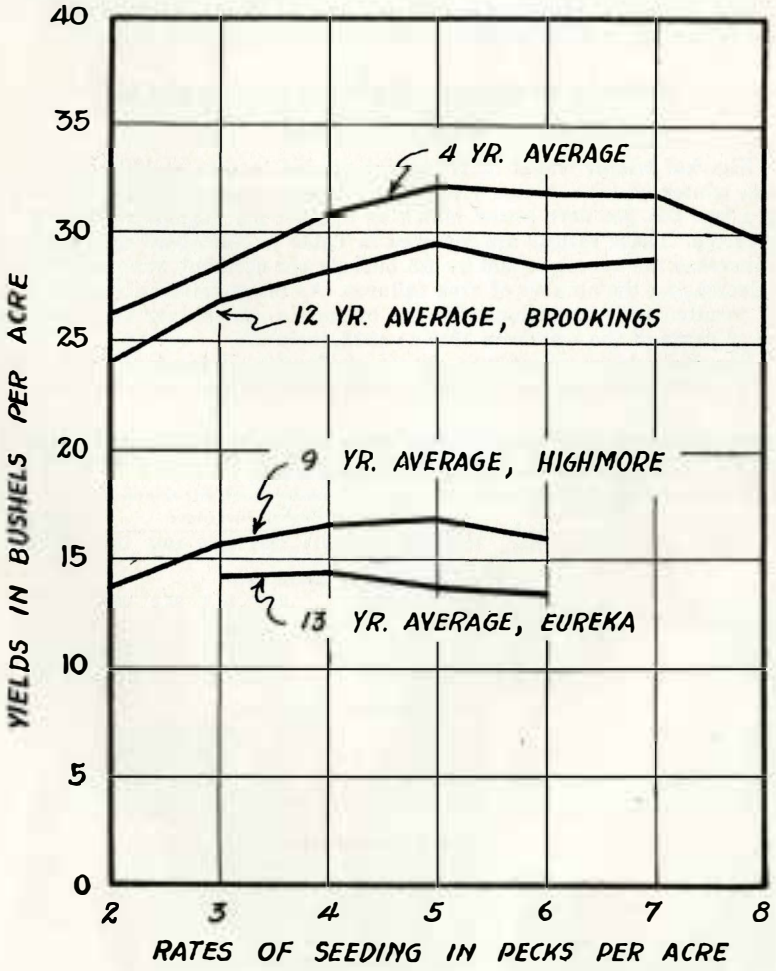

Fig. 7. Results of the rate of seeding tests at Brookings, Highmore and Eureka.

for the extra seed planted. On those plots mulched with three tons of straw, the three and four peck rates gave the highest average yields.

Table 13 gives the annual and average yields obtained with the use of from three to six pecks of seed per acre at Eureka. Kharkof winter wheat was grown on one-tenth acre plots following corn. The highest average yields resulted from the use of four pecks of seed. This stands in close agreement with the results obtained at Highmore.

The rate of seeding tests may be summarized with the statement that the seeding of five pecks per acre is likely to lead to maximum returns in the eastern more humid portions of South Dakota while the use of four pecks is sufficient for the central part of the state.

Fig. 7 gives a graphic presentation of the results obtained from the rate of seeding tests at Brookings, Highmore and Eureka.

Effects of Straw Mulches on Yields of Winter Wheat

Kharkof winter wheat at Highmore seeded in oats stubble in a corn, oats, winter wheat rotation yielded 11.3 bushels per acre when protected by a two ton per acre straw mulch as against 9.5 bushels where not so protected. These results are reported in Table 7. The straw mulch served to increase the average yield by 1.8 bushels per acre but was not effective in decreasing the number of crop failures. As many failures, namely, seven, resulted with as without the use of such a mulch over the course of the 16 years of the test from 1917 to 1932, inclusive.

Kharkof winter wheat was grown at Eureka on one-tenth acre plots following checked, drilled and listed corn with and without a two ton per

TABLE 14.—Annual and Average Yields of Winter Rye and Varieties of Winter Wheat at Eureka Following Checked, Drilled and Listed Corn From 1925 to 1932, Inclusive. Karkof is Grown With and Without a Two Ton Straw Mulch.

Variety	S. Dak. Acc. No.	C. I. No.	Yields in Bushels Per Acre								8 Yr. Av. Yield
			1925	1926	1927	1928	1929	1930	1931	1932	1925-32
Yields Following Checked Corn											
Swedish Rye			21.3	3.8	29.3		23.8	19.6	25.0	30.2	19.1
Nebraska No. 60	1138	6250	6.2	1.5	12.2		23.2	13.8	23.0	18.5	12.3
Turkey	144	3689	15.8	0.2	12.7	Hail	18.7	13.5	15.0	12.7	11.1
Kanred	1178	5880	6.8	0.3	18.8		17.5	12.3	14.2	11.7	10.2
Kharkof (1)	191	1442	9.5	1.0	13.2		17.0	14.8	15.5	17.3	9.7
Kharkof (2)	191	1442	14.6	0.0	10.2		19.3	0.0	13.7	19.3	9.6
Yields Following Drilled orn											
Swedish Rye			17.1	2.7	33.4		22.3	12.7	28.8	24.1	17.6
Turkey	144	3689	26.5	0.3	21.3		12.5	10.8	8.0	14.3	11.7
Kharkof (1)	191	1442	22.6	0.3	21.0	Hail	16.5	8.3	4.0	18.2	11.4
Nebraska No. 60	1138	6250	13.5	1.0	16.0		10.2	9.2	9.0	28.7	11.0
Kanred	1178	5880	20.0	0.3	23.3		16.5	7.5	4.7	11.7	10.5
Kharkof (2)	191	1442	20.6	0.0	16.3		13.5	7.2	2.7	9.0	8.7
Yields Following Listed Corn											
Swedish Rye			26.2	0.0	40.0		18.6	20.5	27.9	15.9	18.6
Turkey	144	3689	31.8	0.2	14.2		16.7	16.0	11.5	2.7	11.6
Kanred	1178	5880	18.3	0.1	16.2	Hail	17.2	14.8	10.8	2.0	9.9
Kharkof (1)	191	1442	24.6	0.5	10.8		14.2	14.7	8.3	1.7	9.4
Kharkof (2)	191	1442	26.8	0.7	13.7		14.5	9.0	8.0	1.5	9.3
Nebraska No. 60	1138	6250	16.8	0.1	14.2		16.2	17.7	6.8	2.2	9.3

(1) Without straw mulch.
(2) Mulched with rotted straw at the rate of two tons per acre.

acre straw mulch. Yield data on this experiment are presented in Table 14. Over a period of eight years from 1925 to 1932, inclusive, the average yields of the wheat on all plots following the corn planted in the various manners were 10.2 bushels for the unmulched and only 9.2 bushels per acre for the mulched plots, thus showing an actual decrease resulting from the straw cover.

Yield data from a rate of seeding test at Highmore with the use of two and three ton per acre straw mulches are reported in Table 12. In all instances higher average yields are in evidence for the lighter of the two straw applications. This indicates clearly that the three ton applications were too heavy. In certain seasons some smothering resulted from the application of three tons of straw per acre.

The straw mulching experiments did not give the results hoped for. At Highmore a slight increase in yield resulted from the spreading of straw on winter wheat in the fall. The increase was too small, however, to pay for the labor costs of applying the straw. At Eureka the yields were actually decreased. Where straw is applied, the applications should be light, not in excess of two tons per acre. The main objection to the use of straw mulches is that it is exceedingly difficult to keep the straw in place and to prevent it from drifting into banks and piles under which the wheat may be smothered. This is likely to take place especially where wheat is seeded on bare ground. Grain and corn stubble will be of help in keeping the straw in place.

Winter Wheat Variety Tests at Brookings

Table 15 gives the annual and average yields of varieties of winter wheat tested in the regular variety test plots at Brookings from 1916 to 1930, inclusive. Average yields for the varieties included in the tests for various lengths of time are given for 15, 13, 12 and 9 year periods of comparison. The wheat in these plots followed corn. The varieties were grown on single one-fiftieth acre plots.

The differences in the yields of Kharkof S. D. 191 and Turkey S. D. 144 for the 15 year period of comparison are not great enough to be significant. Nevertheless, Kharkof yielded more than any other variety included in the tests for the 15, 13 and 9 year periods of comparison.

Kharkof and Kanred are high yielding varieties for the 12 year period of comparison. Nebraska No. 60 gave rather low yields during this period.

No very great and significant differences in the yields of any of the eight varieties tested for the nine year period of comparison are in evidence. Kharkof, Turkey S. D. 144, Minturki and Kanred gave good yields. Varieties sufficiently hardy to survive the winters encountered yielded much alike. Such varieties as Red Rock and Blackhull are not winter hardy enough for South Dakota conditions. Blackhull was grown for a period of four years; it produced an average yield of only 12.5 bushels as compared to 20.4 bushels per acre for Kharkof for the same period. Red Rock gave an average yield of only 9.5 bushels as compared to 28.2 bushels per acre for Kharkof over a seven year period of comparison.

Results of Nursery Tests at Brookings

Table 16 gives the annual and average yields of standard varieties of winter wheat included, together with various hybrids, in the winter wheat nursery at Brookings. These tests were conducted on triplicate rod row

TABLE 15.—Annual and Average Yields of Varieties of Winter Wheat Grown on the Variety Test Plats at Brookings for One or More of 15 years From 1916 to 1930, Inclusive

Variety	C. I. No.	S. Dak. Acc. No.	Yields in Bushels Per Acre															15 yr. Av. 1916-1930	13 yr. Av. 1918-1930	12 yr. Av. 1919-1930	9 yr. Av. 1922-1930
			1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930				
1 Kharkof	1442	191	24.1	0.0	45.0	12.5	6.7	25.8	45.8	21.6	55.0	32.5	10.0	27.5	9.2	45.0	33.7	26.3	29.2	27.9	31.1
2 Turkey	3689	144	26.1	12.5	44.2	18.0	24.1	21.7	40.8	23.3	43.3	33.4	10.0	22.0	0.0	41.7	33.3	25.0	27.4	26.0	27.5
3 Nebraska 60	6250	1138			20.0	13.3	5.0	24.2	41.7	16.7	41.7	41.7	8.3	26.7	10.0	41.7	31.7		24.8	25.2	28.9
4 Kanred	5146	1098				22.5	23.3	31.7	25.8	13.3	60.9	25.0	10.8	34.4	9.2	45.0	33.3			27.9	28.6
5 Kanred	5879	1177				20.0	15.8	34.2	33.3	17.5	51.6	30.9	10.0	25.8	6.7	45.8	32.9			27.0	28.3
6 Kanred	5880	1178				20.0	16.7	29.2	37.5	15.0	49.5	32.5	10.0	24.2	0.0	42.5	31.7			25.7	26.9
7 Minturki	6155	1213					20.0	18.3	29.2	19.2	38.3	40.0	9.0	24.2	12.5	42.5	32.5				27.5
8 Station Red	----	1260							35.0	10.0	30.9	40.0	13.3	24.2	0.0	42.5	35.8				25.7
9 Nebraska 6	6249	1137			22.5	13.3	8.3	31.7	36.2	17.5	50.9	33.4									
10 Red Rock	5976	1176					0.0	0.0	23.3	1.7	33.3	7.1	1.1								
11 Minard	----	1276											8.3	10.6	11.7	39.2					
12 Blackhull	6251	1274											6.7	10.0	0.0	33.3					

TABLE 16.—Annual and Average Yields of Standard Varieties included in the Winter Wheat Nursery at Brookings from 1929 to 1932, Inclusive

Rank	Variety	C. I. No.	Yields in Bushels Per Acre 1929	1930	1931	1932	Av. Yield 1929-1932
1	Minturki	6155	26.3	27.7	8.0	24.6	21.7
2	Beloglina	1543	26.8	27.7	9.3	20.9	21.2
3	Turkey S. D. 144	3689	26.2	26.8	7.9	20.2	20.3
4	Kanred	5146	23.5	26.3	7.1	17.9	18.7
5	Turkey	6152	21.1	28.6	7.1	17.8	18.7
6	Oro	8220	25.1	24.4	7.3	17.4	18.6
7	Turkey	1575	22.9	23.9	7.5	18.3	18.2
8	Wisconsin Ped No. 2	----	23.2	25.0	8.3	15.7	18.1
9	Kharkof S. D. 191	1442	21.2	18.3	13.7	18.8	18.0
10	Nebraska No. 60	6250	21.6	23.5	7.7	18.2	17.8
11	Kharkof	6939	22.3	21.0	7.1	18.4	17.2
12	Minhardi	5149	18.3	21.0	9.0	19.7	17.0
13	Kawvale	8180	28.2	12.3	6.1	19.4	16.5
14	Tenmarq	6936	23.7	15.3	9.8	12.3	15.3
15	Blackhull	6251	22.6	4.9	10.8	11.9	12.6
16	Fulcaster	6471	18.8	7.9	7.9	10.7	11.3
17	Buffum No. 17	3330	15.3	17.8	7.5	2.6	10.8
P. E. of experiment in per cent			7.2	10.7	15.9	16.2	

plots replicated three times on land plowed in early summer or in some seasons after fallow; consequently the plants survived the winters without the protection of stalks or stubble. Yield data are available for a four year period, from 1929 to 1932, inclusive. Yields were analyzed by the probable error method, using the following formula given by Hayes and Garber (2):

$$\text{P. E.} = \pm .6745\sqrt{\frac{\Sigma d^2}{N(n-1)}}$$

Minturki and Beloglina are high yielding varieties. The yields of these varieties are, however, in view of the rather large experimental errors

TABLE 17.—Annual and Average Survival in Spring of Standard Varieties Included in the Winter Wheat Nursery at Brookings From 1929 to 1932, Inclusive

Rank	Variety	C. I. No.	Spring Survival in Per Cent 1929	1930	1931	1932	Average Survival 1929-1932
1	Buffum No. 17	3330	100	99	100	69	92.0
2	Minhardi	5149	98	93	100	71	90.5
3	Minturki	6155	99	82	100	58	84.8
4	Turkey	6152	99	90	98	49	84.0
5	Kharkof	6939	100	89	98	49	84.0
6	Beloglina	1543	100	87	100	38	81.2
7	Turkey S. D. 144	.3689	98	64	100	40	75.5
8	Wisconsin Ped. No. 2		96	69	100	35	75.0
9	Oro	8220	98	72	100	28	74.5
10	Turkey	1575	98	54	97	40	72.3
11	Nebraska No. 60	6250	98	69	100	18	71.3
12	Kharkof S. D. 191	1442	97	43	98	38	69.0
13	Kanred	5146	100	49	94	30	68.3
14	Kawvale	8180	87	18	83	39	56.8
15	Blackhull	6251	85	1	53	23	40.5
16	Tenmarq	6936	95	10	46	4	38.8
17	Fulcaster	6471	45	2	68	11	31.5
P. E. of experiment in per cent				8.0	3.4	9.9	

encountered, not significantly different from those of Turkey S. D. 144, Kanred, Kharkof S. D. 191 or similar varieties.

Table 17 gives the annual and average survival in spring of standard varieties included in the winter wheat nursery at Brookings. Buffum and Minhardi showed the highest degrees of winter hardiness. Neither of these varieties have, however, given good account of themselves in comparative yield tests and can for that reason not be recommended for field production. Minturki proved itself quite winter hardy, also Kharkof C. I. No. 6939, Turkey C. I. No. 6152, and Bologlina. Turkey S. D. 144 and Kharkof S. D. 191 proved fairly hardy. Blackhull, Tenmarq and Fulcaster showed high percentages of winter-killing. The comparative spring survivals of Turkey S. D. 144 and Fulcaster during the season of 1928 to 1929 are shown in Fig. 8. Soft red winter wheats have no place in South Dakota; most of them are not sufficiently hardy to survive the winters.

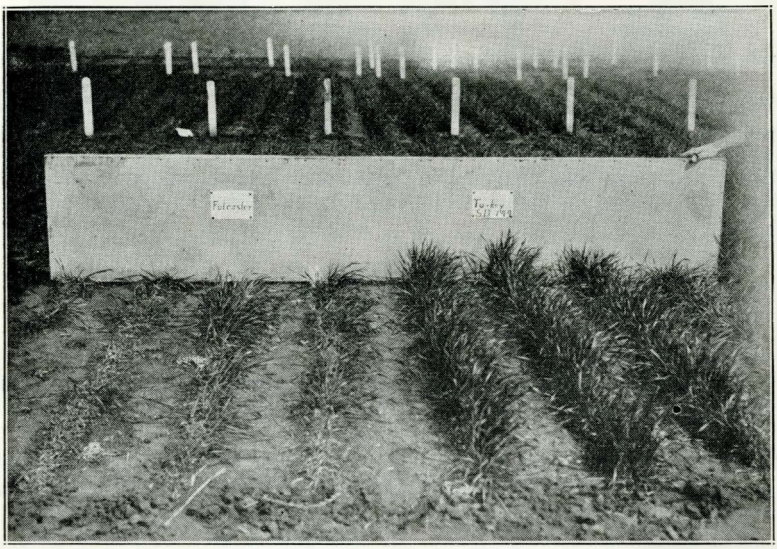

Fig. 8. Comparative winter survival of Turkey S. D. 144 and Fulcaster winter wheats in the spring of 1929 in the winter wheat nursery at Brookings.

Summary of Variety Tests at Brookings

On the basis of the yield and spring survival data presented from the regular variety test and nursery plots at Brookings, Minturki, Kharkof S. D. 191 and Turkey S. D. 144 stand out as leading varieties. Kanred gave good yields, but showed a somewhat higher percentage of winter-killing than the above varieties. These results stand in agreement with those obtained by the Minnesota Agricultural Experiment Station. Hodgson and Hayes (3) summarize the relative merits of Minturki and Kanred by stating that "Kanred has yielded as well as Minturki except in occasional years when winter-killing is a big factor. Kanred is equal in

TABLE 18.—Annual and Average Yields of Varieties of Winter Wheat Grown on the Variety Test Plat at the Highmore Substation for One or More of 19 Years From 1913 to 1931, Inclusive

Variety	C. I. No.	S. Dak. Acc. No.	Yields in Bushels Per Acre																			19 yr. Av. 1913-1931	15 yr. Av. 1917-1931	13 yr. Av. 1919-1931	8 yr. Av. 1924-1931
			1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931				
1 Karkof	1583	76	1.1	1.1	11.0	45.8	0.0	20.0	21.7	0.0	7.5	53.3	0.0	49.6	10.8	0.0	10.8	0.0	17.3	0.0	2.8	13.3	12.9	13.4	11.4
2 Turkey	3689	144	0.0	0.0	14.4	38.3	0.0	17.5	23.5	0.0	7.9	45.0	0.0	45.8	10.4	0.0	18.5	0.0	18.3	0.0	1.0	12.7	12.5	13.1	11.8
3 Theiss	1561	352	0.5	0.6	9.1	30.0	0.0	23.3	23.1	0.0	8.3	48.3	0.0	44.2	10.0	0.0	13.5	0.0	17.5	0.0	3.2	12.2	12.8	12.9	11.1
4 Kharkof	1442	191	4.0	3.2	5.5	39.2	0.0	20.0	21.7	0.0	8.7	48.3	0.0	42.8	5.8	0.0	10.7	0.0	16.7	0.0	2.1	12.0	11.8	12.1	9.8
5 Crimean	2943	353	1.1	1.7	4.6	30.8	0.0	14.1	21.9	0.0	6.7	46.7	0.0	43.7	8.3	0.0	6.7	0.0	10.7	0.0	1.7	10.5	10.7	11.3	8.9
6 Turkey	1558	58			5.5	33.3	0.0	16.2	22.0	0.0	7.5	46.6	0.0	43.3	8.7	0.0	8.4	0.0	15.8	0.0	3.0		11.4	11.9	9.9
7 Turkey	3055	635					0.0	24.0	21.0	0.0	8.3	45.0	0.0	43.7	12.1	0.0	15.5	0.0	18.3	0.0	1.7		12.6	12.7	11.4
8 Kanred	5146	1098					0.0	27.1	27.8	0.0	6.5	45.8	0.0	44.6	7.1	0.0	9.4	0.0	16.7	0.0	1.7		12.4	12.3	9.9
9 Nebr. 60	6250	1138							20.8	0.0	5.8	49.2	0.0	47.5	9.1	0.0	16.7	0.0	15.2	0.0	1.7			12.8	11.3
10 Nebr. 6	6249	1137							21.7	0.0	6.7	50.0	0.0	44.2	7.1	0.0	10.0	0.0	14.6	0.0	1.6			12.0	9.7
11 Minturki	6155	1213								0.0	2.9	44.2	0.0	45.7	12.5	0.0	22.7	0.0	16.2	0.0	1.7				12.4
12 Station Red														38.3	7.1	0.0	20.0	0.0	16.9	0.0	1.7				10.5
13 Red Cross														29.6	5.4	0.0	12.0	0.0	15.8	0.0	2.0				8.1
14 Minhardi	5149	1189								0.0	5.8	39.0	0.0	33.3	10.8										
15 Red Rock	5976	1176										39.2	0.0	35.8	2.5	0.0	0.0								

milling quality but, as a rule, Minturki is more rust-resistant. Kanred is immune to some forms of stem rust, but susceptible to others. Minturki is resistant to most forms. On heavy, rich soil Minturki shows a much greater ability to stand erect until harvest time." Minturki also shows a high degree of resistance to covered smut or bunt.

Winter Wheat Variety Tests at Highmore

Table 18 gives the annual and average yields of varieties of winter wheat tested on the regular variety test plots at Highmore from 1913 to 1931, inclusive. Average comparative yields for the varieties included in the tests for various lengths of time are given for 19, 15, 13 and 8 year periods. The wheat in these plots, like at Brookings, followed corn. Single one-fiftieth acre plots were used.

Kharkof S. D. 76 and Turkey S. D. 144 were high yielding varieties for the 19 year period of comparison. Theiss and Kharkof S. D. 191 gave yields slightly lower than those of the above named two varieties; the differences are, however, not great enough to be significant. Crimean yielded materially less than the other varieties tested for this period of comparison.

For the 15 year period of comparison Kharkof S. D. 76 again produced the highest average yields; it was followed in close succession by Theiss, Turkey S. D. 635, Turkey S. D. 144, Kanred, Kharkof S. D. 191 and Turkey S. D. 58. Crimean again gave somewhat lower yields than other varieties.

All varieties included in the tests for the 13 year period of comparison, with the exception of Crimean, yielded very much the same. Winter-hardiness is the prime requirement; those varieties able to survive the winter months did not give greatly differing yields. Nevertheless, Kharkof S. D. 76 and Turkey S. D. 144 again yielded slightly more than any of the eight varieties tested for this period.

Minturki was the high yielding variety for the last period of comparison, from 1924 to 1931. Red Rock and Red Cross did not prove winter-hardy.

Results of Nursery Tests at Highmore

Table 19 gives the annual and average yields of standard varieties included in the winter wheat nursery at Highmore for a three-year period from 1930 to 1932, inclusive. These plots were laid out following the rod row oats nursery. The winter wheat was sown in between the rows of stubble left by the preceding crop. The highest yielding varieties were Beloglina, Minhardi, Nebraska No. 60 and Minturki. Turkey S. D. 144 and Kharkof S. D. 191 produced good yields. Kanred yielded significantly less than these varieties.

Table 20 gives the annual and average survival in spring of varieties included in the winter wheat nursery at Highmore. Minhardi, Kharkof C. I. No. 6939, and Buffum showed high percentages of survival. Wisconsin Pedigree No. 2, Beloglina, Minturki, Turkey S. D. 144 and Turkey C. I. No. 6152 showed high degrees of hardiness in the order named. Kanred proved less winter-hardy than the above enumerated varieties.

TABLE 19.—Annual and Average Yields of Standard Varieties Included in the Winter Wheat Nursery at Highmore From 1930 to 1932, Inclusive

Rank	Variety	C. I. No.	Yields in Bushels Per Acre 1930	1931	1932	Av. Yield 1930-1932
1	Beloglina	1543	18.7	6.2	30.8	18.6
2	Minhardi	5149	23.8	4.3	24.2	17.4
3	Nebraska No. 60	6250	17.5	4.8	28.3	16.9
4	Minturki	6155	17.6	4.5	28.3	16.8
5	Turkey S. D. 144	3689	14.6	5.2	27.8	15.9
6	Kharkof	6939	22.0	5.2	19.3	15.5
7	Kharkof S. D. 191	1442	8.5	5.0	30.3	14.6
8	Turkey	6152	15.8	4.1	23.2	14.4
9	Buffum No. 17	3330	18.8	4.1	18.2	13.7
10	Kanred	5146	9.9	4.4	26.0	13.4
11	Wisconsin Ped. No. 2	———	16.4	2.6	20.3	13.1
12	Oro	8220	9.7	4.1	22.7	12.2
13	Turkey	1575	13.5	3.3	19.5	12.1
14	Fulcaster	6471	16.6	2.2	15.3	11.4
15	Kawvale	8180	10.4	4.5	17.5	10.8
16	Blackhull	6251	4.3	5.1	21.0	10.1
17	Tenmarq	6471	1.7	3.6	19.3	8.2
P. E. of experiment in per cent			17.4	11.9	14.3	

TABLE 20.—Annual and Average Survival in Spring of Standard Varieties Included in the Winter Wheat Nursery at Highmore, From 1930 to 1932, Inclusive

Rank	Variety	C. I. No.	Spring Survival in Per Cent 1930	1931	1932	Av. Survival 1930-1032
1	Minhardi	5149	30	100	100	76.7
2	Kharkof	6939	31	100	86	72.3
3	Buffum No. 17	3330	17	100	93	70.0
4	Wisconsin Ped. No .2		20	99	90	69.7
5	Beloglina	1543	17	100	87	68.0
6	Minturki	5149	8	98	95	67.0
7	Turkey S. D. 144	3689	22	99	75	65.3
8	Turkey	6152	12	83	97	64.0
9	Oro	8220	2	95	83	60.0
10	Turkey	1575	7	95	73	58.3
11	Kanred	5146	2	98	73	57.7
12	Kawvale	8180	1	92	80	57.7
13.	Kharkof S. D. 191	1442	1	87	83	57.0
14	Nebraska No. 60	6250	6	83	75	54.7
15	Blackhull	6251	1	73	75	48.0
16	Fulcaster	6471	2	60	65	42.3
17	Tenmarq	6936	1	47	68	38.7
P. E. of experiment in per cent			4.6	6.2	11.5	

Summary of Variety Tests at Highmore

An analysis of the yield data of the regular variety test plots and yield and survival data from the nursery at Highmore leads to the same conclusions derived at in the case of the Brookings tests. Considering both yield performances and degrees of spring survival, the outstanding varieties are Minturki, Kharkof and Turkey S. D. 144. Kharkof S. D. 76 gave a somewhat better account of itself in the regular variety test plots at Highmore than Kharkof S. D. 191; the differences in the yields of these two selections were not great. Kharkof C. I. No. 6939 gave good returns in the nursery tests from the standpoints of both yields and survival. This selection is very susceptible to stem rust. Kanred gave good yields but showed itself somewhat deficient in hardiness. Beloglina was grown in the nursery plots only. This variety gave good yields at Brookings and Highmore and showed good spring survival.

Winter Wheat Variety Tests at Eureka

Table 21 gives a summary of the average yields of winter rye and four varieties of winter wheat grown at Eureka following checked, drilled and listed corn for a period of eight years from 1925 to 1932, inclusive. As at Brookings and Highmore, all varieties able to survive the winters yielded very much alike. Turkey S. D. 144 gave the highest average yields. Minturki was not included in the Eureka tests.

It will be observed that winter rye yielded considerable more than any variety of winter wheat tested.

TABLE 21.—Summary of Yields of Winter Rye and Varieties of Winter Wheat at Eureka Following Checked, Drilled and Listed Corn From 1925 to 1932, Inclusive

Variety	S. Dak. Acc. No.	Yields in Bushels Per Acre: Following Checked Corn	Following Drilled Corn	Following Listed Corn	Av. Yields 1925-1932
Swedish Rye		19.1	17.6	18.6	18.4
Turkey	144	11.1	11.4	11.6	11.5
Nebraska No. 60	1138	12.3	11.0	9.3	10.9
Kanred	1178	10.2	10.5	9.9	10.2
Kharkof*	191	9.7	11.4	9.4	10.2
Kharkof†	191	9.6	8.7	9.3	9.2

* Grown without a straw mulch.
† Grown with a two ton per acre straw mulch.

Summary

The winter wheat acreage of South Dakota during the past three seasons has shown a material increase. In 1931 and 1932 winter wheat made up 7.0 and 9.1 per cent respectively, of the total amount of wheat produced in the state.

The incorporation in the cropping program of a fall sown crop is desirable in all parts of South Dakota. A combination of spring and fall sown crops makes for a greater diversification, a spreading of risks, and enables producers to make better use of their labor and equipment. Not all parts of South Dakota are adapted to winter wheat production. In sections of the state with conditions too severe for the survival of winter wheat, winter rye may be grown to advantage.

The greatest obstacle to successful winter wheat production in South Dakota is the severity of the winters through which the fall sown plants must pass. For that reason investigations here reported center mainly around the question of winter survival, either in the form of improving the immediate environment of the plants so as to provide for maximum protection or in the development and use of varieties and types sufficiently hardy to withstand the rigorous winter conditions encountered.

It is difficult to draw a line across the map of South Dakota depicting the section south of which winter wheat may be considered a relatively safe crop and north of which the growing of the crops should not be attempted. Local conditions such as variations in soil types, protection resulting from the lie of the land to be sown to the crop and other factors may serve to reduce the hazards encountered in any given area. Winter injury and possible entire killing of the crop are always factors to be considered in the production of winter wheat. Winter wheat is a relatively

safe crop to grow in the eastcentral and southern portions of South Dakota. The production of winter wheat in the central and northern parts of the state is a hazardous undertaking. This is indicated by the yield data from Highmore and Eureka. Over a period of twenty-three years winter wheat at Brookings yielded 25.2 bushels as compared to 17.0 and 15.6 for durum and hard red spring wheats respectively.

The effects of the preceding crops on the yield to be obtained from winter wheat are dependent primarily on the amount of protection that the remains of such crops can offer to the plants during the winter months. Winter wheat on fallow or on bare land yielded materially less than where protected by either corn stalks, even cut corn stalks or where sown in the stubble of cereal crops. At Brookings winter wheat sown in standing corn yielded 21.5 bushels as against 13.1 bushels per acre where the crop was grown without the protection of the cut cornstalks. At Eureka winter wheat on fallow yielded 3.2 bushels as against 13.2 bushels following drilled corn. At Highmore winter wheat following millet planted in rows yielded 13.7 bushels as against 8.8 bushels per acre when sown after fallow.

To obtain maximum yields, winter wheat should be planted during the first week in September. Material decreases may be expected when the date of seeding is delayed beyond the middle of September.

The seeding of five pecks per acre is recommended for the eastern portions of South Dakota; in the central and western areas of the state four pecks is sufficient.

The use of straw mulches did not prove effective either in reducing the number of crop failures or in increasing the yields of winter wheat.

On the basis of the yield and spring survival data from the regular variety test and nursery plots at Brookings and Highmore, Minturki, Kharkof and Turkey S. D. 144 stand out as leading varieties. Kanred gave good yields but showed a somewhat higher percentage of winter killing than the above varieties. Turkey S. D. 144 was the highest yielding variety in the comparative tests at Eureka.

Winter wheats are subject to smut, and so all seed should be treated before seeding.

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