5-1-1952

An Analysis of Small Grain Performance in South Dakota, 1942-1951

J. E. Grafius

V. A. Dirks

BULLETIN 422
MAY 1952

AN ANALYSIS OF *Small Grain Performance* IN SOUTH DAKOTA 1942-1951

AGRONOMY DEPARTMENT
AGRICULTURAL EXPERIMENT STATION
SOUTH DAKOTA STATE COLLEGE
BROOKINGS

Table of Contents

AN ANALYSIS OF

Small Grain Performance

IN SOUTH DAKOTA 1942-1951

J. E. Grafius and V. A. Dirks[1]

The development of improved small grain varieties for South Dakota is primarily for the purpose of minimizing yearly fluctuations of yield and quality and increasing average yields. Average yield figures are cold and uninteresting in themselves, but when the reasons for the ups and downs of a particular variety are known it makes a fascinating story. An attempt will be made to tie in some of the extreme fluctuations in yield with phenomena observed during that particular season. Not all the reasons for low yields are known and many that are known are difficult to measure. Hence, only the more obvious ones will be mentioned here.

On cultivated land the climate is the determining factor in crop production, exerting its influence on the availability of soil nutrients, the prevalence of plant pathogens and insect pests, and on the performance of the crop plant itself. Temperature, rainfall, relative humidity, amount of light and wind velocity are all important and are all extremely variable in the Great Plains area.

Attempts at adapting varieties to the average conditions have met with some success. For example, the development of Richland to replace Swedish Select, a late maturing variety of oats, gave an average annual increase at Brookings and Highmore of 19 and 8 percent, respectively, for the years 1928 to 1932. This increase was due largely to the fact that Richland was an earlier variety which escaped the mid-summer heat and drouth, which is the expected average condition.

One speaks of a variety that fits the average as being an adapted variety. The best average performance is obtained from adapted varieties, but just being adapted is not enough. The mythical "average year" is the result of many seasons, with a wide range of climatic conditions. For example, at Brookings in 1949, Odessa barley was injured by drouth, while in 1951 excessive rainfall caused severe lodging and the yield of Odessa was again greatly reduced. During these same two years, Plains barley had acceptable yield averages because it was resistant to drouth and lodging. Going back in the records still further to 1946, Plains was injured by a late spring freeze while Odessa produced an excellent yield.

Climate also influences crop production indirectly by creating favorable or unfavorable environments for plant pathogens and insect pests. High temperatures and high relative humidity often lead to scab epi-

[1]Agronomist and Assistant Agronomist, respectively, South Dakota Agricultural Experiment Station.

demics in spring wheat; strong southerly winds in June frequently bring stem rust spores from fields farther south; high temperatures and low humidity are conducive to grasshopper outbreaks.

Time is a great leveler, and tends to draw the long-time average yields of adapted varieties together. A period of favorable years for one variety will be offset by an adverse year sooner or later. The job of those concerned with developing improved small grain varieties is to fill in the gaps, or guard the "Achilles heel" of a variety. The trouble with this is that with the diversified climate found in South Dakota a variety may have more "heels" than a centipede and the guarding takes a bit of doing.

The impact of environment on small grains, as shown by relative yields, has caused great shifts in the popularity of varieties. Some of the reasons for the extreme fluctuations in the individual yields are tied to the particular phenomena observed during that season.

Procedure and Location

The small grain performance tests were located at the State Experiment Station, Brookings, the Central Substation, Highmore, the Range Field Station, Cottonwood and the North Central Substation, Eureka.

In most cases the yields at the outlying stations were taken from nursery plots, with the exception of the winter wheat, rye and flax data which came from drill strip plots of approximately 1/50th acre in size. The yields at Brookings were taken from drill strip plots 1/40th acre in size.

Since yielding ability cannot be measured with absolute accuracy, small differences in yield are not important. Unless the difference exceeds the "least significant difference" given in the yield tables, little emphasis should be placed on the superiority in yield of one variety over another.

Barley

Average yield figures for barley varieties are given in Table 1. On the basis of the 10-year period from 1942 through 1951, it is apparent that the feed type barley varieties were superior throughout the state. South Dakota lies in a transition zone which can produce good malting barley but where the feed varieties with Mediterranean ancestry are generally more productive. Plant breeding and malt chemistry will eventually solve this problem, but it will take time. It is not expected that there will ever be a true dual purpose variety because a good feed barley should have high protein, whereas this is objectionable in a malting variety.

Another significant point found in Table 1 is the low yield of Spartan barley. In the previous five years from 1937 through 1941 it was one of the highest yielding varieties, exceeding Odessa at Brookings by 6 percent. The shift from drier to more humid seasons has apparently caused a shift in the relative yields of certain varieties such as Spartan.

Table 1. Average Yields of Barley in Bushels per Acre Grown at Four Locations in South Dakota, 1942—1951

Variety	Brookings 5-Yr. Av.	Brookings 10-Yr. Av.	Highmore* 5-Yr. Av.	Highmore* 9-Yr. Av.	Eureka 5-Yr. Av.	Eureka 10-Yr. Av.	Cottonwood† 5-Yr. Av.	Cottonwood† 9-Yr. Av.
Malting Types								
Odessa	47.4	45.0	31.3	30.7	38.4	34.2	23.6	20.2
Wisc. 38	50.5	43.3	28.2	29.4	36.5	34.3	22.4	17.4
Kindred	46.3	—	26.4	—	33.4	—	—	—
Moore‡	47.8	—	—	—	—	—	—	—
Montcalm	50.8	—	—	—	—	—	—	—
Manchuria	49.7	41.8	—	—	—	—	—	—
Feed Types								
Plains	51.6	44.9	31.4	33.6	36.6	—	27.0	23.3
Feebar	51.8	46.7	31.4	34.6	39.3	38.4	23.6	22.5
Spartan	46.3	38.8	27.4	28.4	34.1	28.3	20.4	16.4
Trebi	57.7	49.0	35.0	35.6	45.4	39.3	26.0	25.4
Velvon 11	55.5	—	37.4	—	42.6	—	29.7	—
Tregal	55.2	—	35.1	—	41.2	—	30.7	—
Mars	45.2	—	26.6	—	29.5	—	—	—
Campana	—	—	—	—	—	—	26.3	—
Least significant difference	2.5	1.6	3.0	2.3	3.8	2.5	3.4	2.4

*Crop destroyed by hail in 1946.
†No yields in 1951 due to soil blowing.
‡No longer acceptable as malting type.

During the last five years, the yields of two relatively new feed barleys, Tregal and Velvon 11, have been outstanding.

Among the known factors influencing the yield averages of barley since 1942 are: maturity class, drouth, test weight, freezing injury, lodging, plant diseases and insects. These topics will be discussed in relation to the average yields in the following paragraphs.

Maturity Class

Generally speaking, a late variety has a greater yield potential than an early one for the obvious reason that it has longer to make a crop. However, in years when the growing season ends in the latter part of June due to drouth and heat, lateness may be a distinct disadvantage. With the use of the new efficient controls for grasshoppers one of the major reasons for extreme earliness may have been removed. Nevertheless it is desirable to have some very early varieties around just in case. The heading dates and ripening dates given in Table 2 are an indication of relative maturity. It is interesting to note that in 1949 there was an 8-day spread at heading time between Moore and Plains, but only a 3-day spread at ripening. This simultaneous ripening is characteristic of South Dakota where heat, drouth and diseases frequently cut the growing season off all at once, resulting in low yield and poor quality of later varieties.

Drouth Resistance

In addition to the factor of earliness to escape drouth there appear to be genes or inherent factors for drouth resistance. One of the best illustrations of drouth resistance may be found in the 1949 yield figures. The exceptionally high yields re-

Table 2. Date of Heading, Date Ripe, Test Weight and Yield of Barley at Brookings For the Drouth Year of 1949

Variety	Date Headed 1949 June	Date Ripe 1949 July	Yield 1949 Bu./A.	Test Weight 1949 Lbs./Bu.	Av. Test Wt. 1947—1951* Lbs./Bu.
Malting Types					
Odessa	13	7	57.2	45	47
Wisc. 38	14	10	64.2	42	46
Kindred	10	6	59.5	43	46
Moore	16	9	52.5	40	46
Montcalm	15	9	62.8	46	47
Manchuria	12	7	62.4	43	47
Feed Types					
Plains	8	6	77.4	48	49
Feebar	11	7	58.6	44	44
Spartan	8	5	62.8	50	49
Trebi	13	7	66.1	41	45
Velvon 11	13	8	71.7	42	44
Tregal	13	7	65.6	44	46
Mars	9	6	58.6	50	48
Least significant difference			8.0		

*Not including 1949.

ported in Table 2 were obtained on 5.8 inches of rainfall for April through July 15 in a season of above normal temperatures. The two high yielding varieties were Plains and Velvon 11, an early and a moderately late variety, respectively.

Test Weight

The weights per bushel, shown in Table 2, reflect at least three factors: plumpness, shape of the grain, and ease of threshing. Certain varieties have the highly desirable characteristic of producing plump kernels and high test weights under a wide range of conditions—Spartan and Plains are examples of this. Others have a tendency to produce thin kernels under drouth conditions—Odessa and Wisc. 38 are examples of this. Plump kernels do not necessarily mean high test weights as the beards on some varieties are tough and hold fast and are not removed perfectly in threshing. To illustrate, the average weight of 1000 kernels of Feebar was 33.8 grams contrasted to 31.3 grams for Odessa and yet Odessa had a higher test weight. This characteristic of not threshing easily is objected to by many farmers. It is a fault that is found in Feebar, Trebi and Velvon 11.

Late Spring Freeze

An unusual environmental variation took place in 1946 at Brookings, when a severe freeze occurred on May 11 and 12 causing differential injury to barley. As can be seen in Table 3, Plains was hardest hit of any variety in the test and this is reflected in the low yield for this variety in 1946.

Resistance to Lodging and to Shattering

Many regard lodging mainly as an inconvenience in harvesting. Actually, lodging can cause large reductions in yield and quality. A

Table 3. Factors Affecting Yields of Barley Paired With the Yields in Bushels per Acre For a Given Year

	Brookings							Cottonwood	
	1944		1946		1951			1942—1945	
Variety	Spot* Blotch†	Yield	Frost Injury*	Yield	Net* Blotch‡	Lodging*	Yield	% Grasshopper Injury	Av. Yield
Malting Types									
Odessa	3	40.2	2	49.5	4	5	37.9	36§	16.0
Wisc. 38	5	20.7	1	38.5	2	3	47.9	60	11.2
Kindred	--	—	2	33.8	2	4	44.6	—	—
Moore	--	—	—	—	5	1	48.7	—	—
Montcalm	--	—		—	1	3	52.5	—	—
Manchuria	3	29.1	2	40.1	2	4	46.7	—	—
Feed Types									
Plains	2	42.5	5	28.6	1	1	49.2	15	18.6
Feebar	2	41.1	1	43.2	1	1	56.7	10	21.2
Spartan	4	20.3	1	34.4	2	1	45.0	33	11.4
Trebi	2	32.3	2	59.4	1	3	55.0	—	—
Velvon 11	--	—	2	52.1	3	1	52.0	—	—
Tregal	3	30.2	3	54.2	2	1	50.4	—	—
Mars	--	—	—	—	2	1	43.7	—	—
Least significant difference		1.5		3.6			4.3		3.4

*Where 1 is least severe and 5 is very severe.
†A disease caused by *Helminthosporium sativum.*
‡A disease caused by *Helminthosporium teres.*
§Percentage of barley heads clipped by grasshoppers.

striking example of this is found in the 1951 yield of Odessa, Table 3. This low yield was almost entirely caused by lodging, although net blotch was also a factor.

In this day of the combine the ability of a variety to resist shattering is of great importance. The experimental plots are harvested with a great deal of care at the proper time, so that the yields do not reflect losses due to shattering. However, the farmer is often unable to harvest at the exact time of ripening and then resistance to shattering assumes great importance. Among the better varieties in this respect are Feebar, Plains, Mars and Spartan. One of the poorest is Kindred.

Resistance to Disease

Plant pathogens take a yearly toll of the potential plant yield. The effects of some pathogens such as the one causing loose smut are easily estimated, while others are not so easily dealt with.

Varietal response to two pathogens, *Helminthosporium sativum* and *H. teres,* has been observed at the State Experiment Station, Brookings. Spot blotch caused by *H. sativum* was severe in the years 1942 to 1944. While all yields were cut by this pathogen, Wisc. 38, and Spartan, the two most susceptible varieties in the test, showed very low yields. This relationship shows up very well in 1944 (Table 3).

In 1951, conditions were apparently right for the development of *H. teres,* which causes net blotch. Moore proved to be the most susceptible variety. The loss due to this pathogen was partly compensated for by the fact that Moore had no

Table 4. Average Yields of Rye in Bushels per Acre and Average Percent Survival at Three Locations in South Dakota

	Brookings				Highmore		Eureka			
	% Survival*		Yield†		% Survival	Yield‡	% Survival		Yield	
Variety	'46-'51	'48-'51	'46-'51	'48-'51	'47-'51	'47-'51	'47-'51	'49-'51	'47-'51	'49-'51
Pierre	98	99	41.5	40.7	94	23.0	84	96	19.3	20.7
Dakold	94	96	38.8	38.7	89	22.6	79	92	14.0	15.4
Emerald	90	92	39.8	39.4	80	22.7	65	80	15.5	15.8
White Soviet		94	—	39.8	—	—	—	84	—	16.5
Least significant difference			1.5	1.6	Not significant				1.9	2.7

*Percentage estimates of the plants surviving the winter.
†No yield for 1947 as crop destroyed by hail.
‡No yield recorded for 1949 due to fall drouth.

yield reduction due to lodging, (Table 3).

Grasshopper Resistance

In looking at the 9-year average yields for Cottonwood one is likely to jump to the conclusion that the low yield for Wisc. 38 is due to the lateness of this variety for the Cottonwood area and to its susceptibility to heat and drouth. Wisc. 38 is susceptible to heat and drouth, but the major reason for the low relative yield at Cottonwood has been grasshopper injury. Observation of Cottonwood data in Table 3 confirms this statement.

With the advent of better grasshopper controls, these insects may no longer be a problem, but it is perhaps unnecessary to try to grow varieties such as Wisc. 38 in western South Dakota when there are highly productive, drouth and grasshopper resistant feed barleys.

Rye

The average yields given in Table 4 are in part a reflection of winter hardiness. Pierre rye significantly outyielded other varieties at Brookings and Eureka. In the absence of differential winter killing Pierre has not outyielded Emerald.

It should be mentioned that the Dakold used in these comparisons is of unknown origin, since the original strain has become mixed with other varieties through cross pollination.

Other rye varieties have been tested for grain production. Imperial, Rosen and Balbo have been found too winter-tender for South Dakota conditions. There may be a place for Balbo in southeastern South Dakota where some farmers are using this variety for pasture.

Other performance data are given in Table 5. It will be noted that Pierre is the earliest of the four varieties and that it has the highest test weight.

Table 5. Average Heading Date, Height, and Test Weight for Rye Varieties at Brookings, 1947—1951

Variety	Date Headed June	Height Inches	Test Weight Lbs./Bu.
Pierre	5	43	56
Dakold	7	42	54
Emerald	8	43	54
White Soviet	9	45	54

Table 6. Performance Data for Winter Wheat Varieties Grown at Brookings, 1946—1950

Variety	Yield '46-'50 Bu./A.	Yield '47-'50 Bu./A.	Test Wt. '47-'50 Lbs./Bu.	Winter Survival '47-'50 %	Date Headed June	Stem Rust 1948 %	Leaf Rust 1949 %	Height '47-'50 Inches
Nebred	27.6	29.3	58	56	17	20	80	27
Minturki	27.5	29.4	57	70	19	10	60	32
Minter	31.9	32.9	59	72	18	Tr	50	33
Pawnee	—	13.2	57	25	15	—	20	28
Iowin	—	26.2	59	55	18	5	40	32
Marmin	—	27.9	57	72	18	20	50	32
Least significant difference	2.0	2.2						

Winter Wheat

South Dakota is on the northern edge of the winter wheat belt. Winter wheat is a highly productive crop when winter killing is not a factor. While other things affect the yields of winter wheat such as drouth, rust, and insects, all are of secondary importance compared to winterhardiness in South Dakota. Needless to say, these other hazards will not be ignored in the breeding program, but the main emphasis will be placed on winterhardiness.

Average yields and winter survival data are presented in Table 6. It will be noted that Minter is one of the highest in yield and also one of the most winter-hardy. Pawnee is too winter-tender and should not be grown in South Dakota.

Certain years have been chosen to show the stem rust *Puccinia graminis tritici* and leaf rust *P. rubigo-vera* reaction of these varieties. Minter carries the Hope gene for stem rust resistance and this shows up in the 1948 readings. Since then a new race of stem rust has become prevalent and all of these varieties are susceptible to it.

The story is similar with leaf rust. The Hope genes for leaf rust resistance were formerly good enough, but this is no longer true. However, the leaf rust resistance of Minter is still better than that of Nebred even though readings taken at a later date would have given both varieties a reading of 80 percent. Pawnee, Iowin and Marmin have shown less suceptibility to leaf rust in the field than has Nebred.

Flax

The yield averages of flax varieties are reported in Table 7. A much higher yield level is indicated at Brookings, located in the main flax area of South Dakota, as compared to the substations, located outside that area. The yield averages at Brookings emphasize the gains made by plant breeding, since both the 10-year and the 4-year averages indicate the superiority of the recently developed varieties as compared to the older ones. Thus, for the 10-year period, Dakota and Crystal are high, while for the 4-year period, Marine, Redwood, B-5128 and Crystal are superior in yield.

The yields produced by any crop

Table 7. Average Yield of Flax in Bushels per Acre Grown at Three Locations in South Dakota, 1942—1951

	Brookings		Highmore		Eureka	
Variety*	4-Yr. Av.	10-Yr. Av.	2-Yr. Av.	4-Yr. Av.	2-Yr. Av.	4-Yr. Av.
Redwing	16.1	15.9	13.8	9.8	13.6	12.2
Sheyenne	18.4	—	14.6	10.4	15.0	13.7
Marine	21.2	—	15.8	—	14.7	—
Koto	17.4	16.9	14.7	10.3	15.6	14.2
Dakota	20.0	18.0	15.4	10.6	15.7	14.7
Arrow	20.6	—	14.6	10.8	13.8	12.4
Bison	15.5	14.9	13.8	10.2	9.2	10.5
Redwood	22.5	—	15.4	—	14.8	—
Royal	20.6	—	—	—	—	—
B-5128	21.6	—	—	—	—	—
Minerva	21.4	—	—	—	—	—
Crystal	21.5	18.0	—	—	—	—
Least significant difference	1.1	0.7	Not significant		3.0	2.1

*Listed in order of maturity, Redwing earliest.

variety are the result of the interaction of its hereditary makeup with the environmental factors present. Among the factors that have influenced flax yields during the last ten years are maturity, drouth, high temperatures, lodging, weathering, weeds and plant diseases. The importance of these will be discussed in terms of their effects on varietal yield differences.

Maturity

The maturity range of the flax varieties tested is as much as 10 days. In Table 7, the varieties are listed in order of maturity, and the average yields at Brookings indicate that the relationship of yield and maturity is not clear cut. Apparently moderately late varieties, such as Redwood and B-5128, make maximum use of the growing season in eastern South Dakota, without exceeding the safe limit of maturity. Farther west, where flax yields are less dependable, the later varieties show no yield advantage, as seen from the Highmore and Eureka results. Under such circumstances, the choice of an early variety to minimize the risk of heat, hail, storms, disease, drouth and insects, would involve no sacrifice in yield prospects. In the northeastern area, however, such a program of crop insurance may involve a definite sacrifice. For example, at Brookings the early variety Sheyenne yielded an average of three bushels per acre less than the equally rust-resistant, but very much later, variety Crystal, during the period 1948 to 1951.

Drouth

Moisture deficiency can greatly reduce flax yields. Table 8 shows the yields of six flax varieties at Highmore in the dry year 1949, in comparison with those of 1951, when moisture was plentiful. The yield spread between varieties narrows under drouth conditions. The 4-year yield averages at both substations (Table 7) reflect the effect of moisture deficiency in 1949 and 1950. In

Table 8. Paired Comparisons of Flax Yields in Bushels per Acre to Illustrate Varietal Response to Yield Limiting Factors

	Summer Temperature		Moisture and Temperature		Weeds	
	Brookings		Highmore		Brookings 1944	
Variety	Warm '48-'49	Cool '50-'51	Drouth 1949	Good 1951	Hand Weeded	Not Weeded
Redwing	15.5	16.7	4.7	21.6	17.8	16.0
Sheyenne	16.9	20.0	5.1	23.5	—	—
Marine	17.8	24.6	—	—	—	—
Koto	16.7	18.2	4.3	22.4	19.9	16.8
Dakota	18.5	21.4	4.3	24.6	17.0	15.1
Arrow	18.2	23.1	1.7	21.6	—	—
Bison	16.7	14.2	3.8	19.4	15.8	15.0
Redwood	19.9	25.1	—	—	—	—
Royal	18.5	22.7	—	—	—	—
B-5128	18.8	24.4	—	—	—	—
Minerva	17.8	25.1	—	—	—	—
Crystal	16.4	26.6	—	—	13.7	9.1

the absence of heat, no definite differential response of varieties to drouth can be demonstrated.

High Temperatures

High summer temperatures cause marked reductions in flax yields, even when moisture is abundant. When heat is coupled with drouth, extreme reduction in yield may be effected. This was the case at Highmore in 1949, where the average yield of six varieties was 4 bushels per acre (Table 8). Heat injury was noted at Brookings in the same year; Table 9 shows that heat damage was most severe on the late varieties so that the yield potential of these varieties was not realized. A comparison of average yields at Brookings in two years of high midsummer temperature with those of two years of cool temperatures is made in Table 8. Both averages contain one dry and one humid year. It is obvious that cool summer temperatures favored the yield of all varieties. The one exception, Bison, was severely injured by rust in the cool years. Assuming that cool weather is the optimum condition for flax, high summer temperatures are much more injurious to late varieties than to the early strains. These apparently escape much heat injury because their bolls are more nearly mature than those of late varieties at the onset of high temperatures. The nature of heat injury is a burning or drying of immature bolls.

Lodging

Flax varieties generally have sufficient stiffness and resilience of straw to stand in the field for long periods after maturity. Summer storms on green flax may induce lodging earlier in the season and cause serious yield losses. Table 9 shows the effect of lodging on 1951 yields at Brookings. The low yield of the rust-resistant Sheyenne may be ascribed to lodging. This variety actually yielded less than Bison and Redwing, which stood up despite severe rust injury. Where lodging and rust

Table 9. Factors Affecting Yields of Flax Paired With the Yield in Bushels per Acre in Specified Years at Brookings

	1951			1946			1949		
Variety	Rust*	Lodging*	Yield	Pasmo*	Test Weight Lbs./Bu.	Yield	Ripe, July	Heat Injury*	Yield
Redwing	3	1	13.1	5	57	10.9	18	1	12.6
Sheyenne	0	5	9.6	—	—	—	19	1	13.8
Marine	0	1	13.6	—	—	—	20	2	16.6
Koto	3	3	10.1	3	60	10.7	21	2	13.4
Dakota	5	3	7.9	5	55	13.6	22	2	16.6
Arrow	3	3	8.4	—	—	—	22	2	15.8
Bison	5	1	11.0	3	58	9.6	21	3	13.0
Redwood	0	1	15.5	—	—	—	23	2	17.4
Royal	1	4	11.6	2	58	15.8	23	4	15.2
B-5128	0	1	13.9	—	—	—	24	3	16.2
Minerva	2	1	18.0	—	—	—	24	4	15.0
Crystal	0	2	14.3	3	58	19.0	25	4	15.8

*Where 1 is least severe and 5 is very severe.

injury both affected a variety, as in Dakota and Arrow, very low yields were obtained.

Weathering

Flax in the swath is often subject to damage by heavy fall rains in eastern South Dakota. This was the case in 1951. The test plots were harvested by binder and shocked, so that such injury was not reflected in yields. However, the earlier varieties were definitely superior to the later ones in appearance of the harvested grain.

Weeds

Flax varieties differ considerably in growth habit during the early part of the season. Sheyenne, Marine and Koto make rapid early growth and shade the ground while Crystal makes slow, rather sparse growth. The latter variety often suffers from weed competition. In 1944, part of the flax plots at Brookings was hand weeded. Table 8 shows the effect of removing weeds on varietal yields. The inability of Crystal to compete with weeds is illustrated by its yield response to removal of weeds by hand cultivation.

Plant Diseases

Rust has already been mentioned in connection with lodging. This disease, caused by *Melampsora lini*, has been very important in establishing differences in varietal yields. The low yields of Bison at Brookings (Table 7) are largely due to rust injury. The rise of new physiologic races of the rust organism has resulted in the recent "loss" of resistance by Dakota and Arrow, which derived their resistance from Newland. This has resulted in a lowering of yields of these varieties in the eastern area in the past two years. At the substations in the drier areas in the state, rust has not yet been found on these two varieties and so their yields through 1951 have remained high. The varieties Sheyenne, B-5128, Marine, Redwood and Crystal derive their rust resistance

Table 10. Average Yields of Oats in Bushels per Acre as Grown at Four Locations in South Dakota, 1942—1951

	Brookings			Highmore†		Eureka		Cottonwood‡	
Variety*	4-Yr. Av.	6-Yr. Av.	10-Yr. Av.	4-Yr. Av.	9-Yr. Av.	4-Yr. Av.	10-Yr. Av.	3-Yr. Av.	8-Yr. Av.
Brunker	77.6	73.0	62.9	51.9	56.6	40.0	41.4	35.1	36.2
Trojan	81.7	74.1	64.6	49.7	56.1	44.7	42.0	30.9	35.9
Andrew	82.4	—	—	55.6	—	41.4	—	34.1	—
Mindo	82.7	85.5	—	58.2	—	46.8	—	34.2	—
Osage	77.8	—	—	52.8	—	48.8	—	37.5	—
Cherokee	81.2	—	—	57.2	—	42.5	—	31.7	—
Nemaha	78.1	—	—	51.0	—	44.0	—	31.5	—
Vikota	82.2	78.1	78.8	58.4	62.8	47.1	49.7	31.4	34.8
Tama	81.8	78.5	79.3	48.9	57.0	51.4	54.2	31.4	35.2
Richland	84.4	77.9	66.8	54.7	57.7	51.3	52.5	31.5	31.6
Clinton	80.0	84.0	—	54.4	—	47.6	—	31.4	—
Marion	—	—	—	59.3	—	50.5	—	—	—
Bonda	75.4	79.2	—	—	—	—	—	—	—
James§	88.6	—	—	74.7	—	59.0	—	33.1	—
Shelby	82.6	—	—	—	—	—	—	—	—
Zephyr	81.4	—	—	54.8	—	44.2	—	—	—
Ajax	—	—	—	58.7	—	50.4	—	31.6	—
Least significant difference	4.4	3.3	2.6	4.2	3.2	4.3	3.2	3.9	3.9

*Listed in order of maturity, Brunker earliest.

†1946 crop hailed out.

‡No yields in 1944 and 1951, due to grasshoppers and soil blowing, respectively.

§Hulless, yields adjusted.

from other sources, and have been resistant to all races of flax rust found in the Northwest so far. Table 9 shows the effect of rust on the yield of flax varieties at Brookings. The susceptible variety Bison yielded 30 percent less than the resistant Redwood. Dakota yielded 48 percent less, but lodging combined with rust to produce this extreme case of yield reduction.

Pasmo, caused by *Sphaerella linorum,* has been observed on flax varieties at Brookings in most years. Generally, it has occurred late in the season, and its effects have been primarily those of an old age disease. The yield of the extremely susceptible variety Bolley Golden was reduced to 5.8 bushels in 1946, as compared to 19.0 bushels for Crystal. The effect of pasmo on varietal yields in 1946 may be seen in Table 9. The highest pasmo readings were obtained on the early strains. Crystal and Royal, the two latest varieties grown that year, were not severely affected. (The yields reflect the degree of pasmo injury.) Of the recently developed varieties, Marine has shown considerable pasmo resistance and Redwood and B-5128 appear to have some tolerance.

Oats

The changes in the varietal picture for oats in South Dakota during the past 10 years are evident in Table 10, which contains the average yields of oat varieties, listed in order of maturity. Of the 17 varieties listed, only 5 have been grown for the entire period. Of these, the two Victoria-Richland varieties, Vikota and Tama, have been superior at all locations, and at Cottonwood the record of Brunker and Trojan justifies the place they gained in the western area during the dry years. The shorter period of comparison permits an evaluation of the newer varieties with the standard strains. It is worth noting that at the three stations east of the Missouri River, only the hulless variety James has significantly outyielded Vikota during the last four years, while at Cottonwood during the three years 1948 to 1950, no new variety has established its superiority over Brunker. The high level of adaptation embodied in the varieties Vikota and Brunker for central and western South Dakota conditions, respectively, has apparently not been exceeded by more recently developed strains. The one exception, James, probably owes its superiority to its multiple florets, which enable it to take advantage of favorable climatic conditions by ripening three, four or even more kernels per floret. This was the case in 1951 at Highmore and Eureka, where James yielded 138 bushels per acre. It should be noted that since adjustment has been made for hulls, the yields of James reported in this bulletin are on an equivalent basis to common oat varieties.

The early varieties derived from Bond, which occupy most of the oat acreage in eastern South Dakota, have so far yielded well at the three stations east of the Missouri River. James, Andrew and Mindo seem to have the widest area of adaptation, with Clinton and Cherokee being favored in the more humid areas of the state.

Many factors have affected the yields of oat varieties during the 10 years covered by this report. Maturity, drouth, lodging, grasshopper injury, wind damage and plant diseases have affected yields. The yield differences seen in Table 10 have been established to the extent that varieties have differed in their reaction to these limiting factors, or in their ability to escape their effects. Individual varieties stand out in their resistance to one or more of these limiting factors. The fact that no one variety combines maximum resistance to all of them constitutes the challenge to oat breeding in South Dakota.

Maturity

The oat varieties listed in Table 10 are in order of their maturity. In Table 11, the heading and ripening dates of most of these varieties are given as recorded at Brookings in 1949. Most of the Bond derived varieties took a month after heading to mature, but Tama, Vikota and Osage required considerably less time. The ability of these varieties to ripen rapidly involves some loss of test weight in many seasons but is nevertheless a very valuable feature in the less humid areas of the state. The oat yields indicate no yield advantage for late varieties even at the most favorable location, Brookings. Even in so favorable a season as 1951 at Brookings the late varieties Shelby and Zephyr were unable to compete in yield with the earlier varieties Vikota and Mindo. Farther

Table 11. Performance of Oat Varieties Under Drouth Conditions in 1949 and 1950

	Brookings 1949					Substation Av. 1949		Substation Av. 1950	
Variety	Date Headed, June	Date Ripe, July	Heat Damage*	Test Weight Lbs./Bu.	Yield Bu./A.	Test Weight Lbs./Bu.	Yield Bu./A.	Test Weight Lbs./Bu.	Yield Bu./A.
Brunker	2	1	1	37	81.5	34	22.2	32	33.1
Trojan	3	1	1	35	74.6	34	16.5	29	33.4
Andrew	3	2	2	36	73.0	38	23.9	33	34.5
Mindo	4	2	2	38	73.0	38	22.8	33	35.0
Osage	5	2	2	36	65.9	35	22.1	31	34.8
Cherokee	4	3	4	36	69.4	40	22.9	34	31.9
Nemaha	5	4	4	36	66.3	39	21.2	33	34.3
Vikota	9	3	1	34	70.9	33	22.4	32	33.6
Tama	10	4	1	34	72.7	34	16.2	32	35.9
Richland	9	5	2	33	68.0	33	21.3	31	37.6
Clinton	9	7	3	38	71.6	38	19.8	35	35.2
Bonda	9	6	3	38	64.5	40	21.9	—	—
James†	10	9	3	43	79.5	42	20.2	46	38.0
Zephyr	12	12	5	36	66.6	—	—	—	—
Ajax	—	—	—	—	—	32	16.7	30	35.9

*Where 1 is least severe, 5 is very severe.
†Hulless, yields adjusted.

west the early varieties show a distinct yield superiority over the later varieties. Much of this yield advantage of the early strains must be attributed to the progressive intensity of various yield limiting factors as the season advances. They affect the later varieties at a more immature stage and consequently are more severe on them than on the early ones.

Drouth

Moisture shortages at various times, duration and intensity have affected the oat variety tests in most years at most locations. Table 11 shows the performance of oat varieties under dry conditions at Brookings in 1949. The hot, dry weather coupled with the absence of diseases resulted in the extremely early variety Brunker outyielding all the others; this explains the place Brunker has gained in the western area of the state.

Heat intensifies the effect of moisture deficiency. At Brookings in 1949, heat damage was most severe on late Bond type varieties, while the early Victoria-Richlands, Brunker and Trojan escaped. A comparison of the average yields of oats in 1949 at the three substations with those of 1950 gives further evidence of the role of heat in drouth years. Both years were extremely dry at all three locations. There was one difference: the mean growing season temperature in 1949 was 8 degrees higher than in 1950. The yields in the cool season are nearly twice those in the hot season. The lowered test weights in 1950 suggest that the moisture deficiency affected filling of the kernels formed under cool conditions. In 1949, tillering and size of panicles were reduced to such an extent that the kernels present could be filled despite drouth.

The 1949 substation average

Table 12. Factors Affecting Yields of Oats Paired With the Yields in Bushels per Acre for a Given Year

	Brookings								Highmore	
	1951		1944			1948			1943-44	
Variety	Lodging*	Yield	Crown Rust†	Test Wt. Lbs./Bu.	Yield	Lodging*	Shattering*	Yield	Grasshopper Injury*	Av. Yield
Brunker	5	100.2	50	24	38.2	—	—	—	1	48.8
Trojan	--	—	50	24	39.7	—	—	—	1	52.4
Andrew	3	100.5	1	33	86.4	—	—	—	—	—
Mindo	1	111.8	2	33	74.5	—	—	—	5	29.5
Osage	--	—	T	30	69.3	—	—	—	—	—
Cherokee	3	109.2	—	—	—	—	—	—	—	—
Nemaha	3	109.0	—	—	—	—	—	—	—	—
Vikota	3	113.6	T	32	73.9	—	—	—	1	59.9
Tama	--	—	T	31	77.2	3	2	65.1	1	53.8
Richland	3	116.4	50	21	29.6	—	—	—	2	45.8
Clinton	1	110.8	T	28	88.9	0	5	35.8	3	47.8
Marion	4	101.4	40	29	55.0	—	—	—	4	42.3
Bonda	3	101.6	T	34	80.9	1	4	58.6	5	28.0
James‡	2	109.2	—	—	—	0	4	55.2	—	—
Shelby	5	103.7	—	—	—	2	1	75.8	—	—
Zephyr	5	104.2	—	—	—	3	1	81.2	—	—
Ajax	--	—	—	—	—	2	2	64.4	—	—

*Where 1 is least severe, 5 is very severe.
†Rust readings in percentages. Leaf and crown rust are the same.
‡Hulless, yields adjusted.

yields are less than one-third those of Brookings in the same year, despite drouth at all locations. At least some of this difference must be ascribed to soil fertility. At Brookings a high level of soil fertility has been maintained. At the substations, however, the soils were deficient in organic matter and especially nitrogen. Nitrogen deficiency appears to have increased the effect of drouth on all oat varieties.

Lodging

Lodging in oats always adds to the difficulties of harvesting. If it occurs shortly after heading, yields and test weight may be reduced. In 1951, Shelby, Zephyr and Brunker were severely lodged at Brookings. Clinton, Mindo and James stood very well. The effect of lodging on the yield may be seen in Table 12.

Grasshopper Injury

Clipping of heads and shelling of kernels were two ways in which grasshoppers reduced oat yields at Highmore in 1943 and 1944. Table 12 shows the extent of grasshopper injury and the resultant yields of varieties grown at the time. The fondness of grasshoppers for the succulent, heavy-strawed Bond type varieties (Clinton, Mindo and Bonda) is quite evident.

Wind Damage

High midsummer winds caused severe damage in one oat nursery at Brookings in 1948. Table 12 shows the extent of shattering on a few varieties, and the effect on yields. The degree of lodging on the same varieties appears to have an inverse relation to the shattering loss. Apparently damaging wind on ripe, standing oats shelled out the stiff strawed varieties and pushed over the weaker strawed ones which could still be harvested. Clinton appears especially susceptible to shattering.

Plant Diseases

In the 10-year period reported, relatively favorable moisture conditions have manifested the ability of plant diseases to affect oat varieties and yields.

Crown rust caused by *Puccinia coronata* was very severe on susceptible varieties during the mid-forties. Table 12 gives the effect of crown rust on the yield and test weight of oat varieties at Brookings in 1944. The yield of the four susceptible varieties Brunker, Trojan, Richland and Marion was greatly reduced, as was the test weight of the first three. Such severe injury led to the widespread adoption of the highly crown rust resistant Victoria-Richland varieties like Vikota and Tama. These proved susceptible to Victoria blight in 1946. This disease, caused by *Helminthosporium victoriae,* may have been responsible for a 20 percent yield loss of three susceptible varieties (Osage, Tama and Vikota) at Brookings in 1947, as compared to six resistant Bond type varieties. The occurrence of Victoria blight hastened the adoption of the Bond type varieties in eastern South Dakota. The latter are not resistant to all races of crown rust and their widespread use has been followed by a rapid increase of crown rust races capable of attacking them. In 1951, crown rust readings as high as 50 percent were obtained on late planted Clinton at Brookings.

Stem rust of oats has occurred during this decade and has lowered the yields of susceptible varieties like Brunker and Trojan, particularly at Brookings. All the other varieties listed here have partial stem rust resistance derived from either of two sources. The two forms of resistance are allelic[2] to each other, so that none of the present varieties is resistant to all races of stem rust. The ability of this disease to reduce yields is seen in the case of Andrew. A 30 percent infection reduced the yield of this variety 15 percent in 1947.

Spring Wheat

Bread and durum wheat yields for the period 1942 to 1951 are listed in Table 13. The varieties in each class are listed in order of maturity. The degree of varietal stability in spring wheat is indicated by the fact that 10 of the 11 varieties have been grown for the entire decade. The one exception, Lee, was produced to meet the leaf rust problems arising from the widespread occurrence of this disease on the Hope derivatives. Short-time averages are given to compare this variety with the others.

For the 10-year period, the variety Rushmore has been outstanding throughout the state. Mida has performed well in the central area of

[2]The term "allelic" implies that the two forms of resistance cannot be maintained in the same true breeding variety.

Table 13. Average Yields of Spring Wheat in Bushels per Acre Grown at Four Locations in South Dakota, 1942—1951

	Brookings		Highmore†		Eureka		Cottonwood‡	
Variety*	4-Yr. Av.	10-Yr. Av.	4-Yr. Av.	9-Yr. Av.	4-Yr. Av.	10-Yr. Av.	3-Yr. Av.	8-Yr. Av.
Bread wheats								
Lee	32.2	—	19.8	—	16.3	—	12.6	—
Rushmore	29.9	29.9	19.0	22.2	17.1	19.3	14.5	16.7
Thatcher	27.0	24.4	19.0	20.7	16.5	17.9	14.1	15.8
Mida	29.8	29.0	20.1	22.3	17.2	21.0	13.6	14.9
Ceres	27.8	24.5	19.2	20.0	16.1	19.2	14.5	15.9
Rival	29.1	28.9	17.0	20.0	16.2	19.6	12.6	15.8
Pilot	28.1	28.5	18.6	21.2	17.0	19.3	13.1	15.4
Cadet	25.2	26.2	17.8	17.2	16.6	19.3	14.7	—
Durum wheats§								
Vernum	30.4	28.5	17.4	18.7	16.7	18.1	10.8	11.0
Mindum	30.3	29.2	17.7	18.4	18.8	18.6	12.4	13.5
Stewart	28.6	30.6	20.6	20.3	17.7	17.9	13.7	13.8
Least significant difference	1.3	0.9	1.6	1.4	1.9	1.7	1.6	1.3

*Listed in order of maturity, Lee earliest.
†1946 crop hailed out.
‡1943 crop lost to grasshoppers; 1951 crop to soil blowing.
§Long-time average for durum wheat at Highmore do not include 1942 and 1946; at Eureka do not include 1942 and at Cottonwood, cover the 5-year period 1945, 1947-50.

the state, as measured at Highmore and Eureka. Of the durum wheats, Stewart has the best 10-year record. The leaf rust resistant variety Lee has been superior in yield to the older varieties at Brookings only. At the three western stations, where leaf rust is not so severe, it has not outyielded Rushmore or Mida.

The production of new wheat varieties is largely aimed at the removal of yield limitations affecting present varieties. These are "improved" by adding genetic factors for resistance to the various detrimental environmental conditions and plant pathogens. It is therefore of prime importance to examine some of the causes of reduced wheat yields in South Dakota during the decade. The causes include earliness of varieties themselves, drouth, spring frost injury, grasshoppers, lodging and plant diseases.

Earliness

The maturity range of the 11 spring wheat varieties may be seen in Table 14, where the heading dates are given for 1949. When growing conditions are favorable, the wheat variety with the longest growing season produces the highest yields. The excellent yield record of Stewart durum over the 10-year period is an illustration of the capacity of late varieties to achieve maximum yields. However, lateness is no guarantee of high yields in wheat, as may be seen in Table 13. The latest of the bread wheats, Cadet, has nowhere been superior to much earlier varieties of equal disease resistance. Lateness exposes wheat to added hazards of climate and disease. The low yield of Cadet at Brookings is probably due to the extent of injury by plant diseases during its extended growth period.

Table 14. Performance of Wheat Varieties Under Drouth Conditions

	Brookings 1949				Substations 1949		Substations 1950	
Variety	Date Headed	Heat Damage*	Test Weight Lbs./Bu.	Yield Bu./A.	Test Weight Lbs./Bu.	Yield Bu./A.	Test Weight Lbs./Bu.	Yield Bu./A.
Bread wheats	June							
Lee	7	1	57	26.8	56	10.7	59	12.2
Rushmore	12	1	57	24.2	56	11.5	59	15.2
Thatcher	12	2	54	19.6	53	10.4	59	13.8
Mida	13	2	59	24.6	56	11.0	61	14.8
Ceres	13	2	56	22.2	57	9.5	61	17.3
Rival	14	2	57	25.0	56	9.8	59	13.4
Pilot	14	2	57	22.0	54	8.9	60	14.7
Cadet	16	5	54	17.8	53	8.0	58	18.2
Durum wheats								
Vernum	13	2	59	23.0	58	8.4	63	13.9
Mindum	16	3	61	23.2	57	10.6	63	13.3
Stewart	17	3	60	20.8	56	11.2	63	13.8

*Where 1 is the least severe, 5 most severe.

Extreme earliness in wheat, on the other hand, may prevent the maximum utilization of favorable seasons. This happened to Lee and Thatcher at the substations in 1950. Midseason varieties like Mida and Ceres seem to have the maturity level best suited to South Dakota conditions. The high yield of Rushmore in comparison with Mida shows that the accumulation of yield genes in early varieties may make them highly competitive with later ones.

Drouth

Hot, dry conditions existed throughout South Dakota in 1949 and reduced wheat yields. Table 14 summarizes the performance of wheat varieties under those conditions. Visible heat injury was lightest on the early varieties, and most severe on the late ones at Brookings. The yields of the earlier and midseason varieties greatly exceeded those of the late variety Cadet. Since leaf rust was a factor at Brookings, the substation averages probably give a truer measure of the actual drouth resistance of varieties. It is evident that the early varieties Thatcher, Rushmore and Lee were superior to Cadet and Ceres which suffered considerable drouth injury. Of the durum wheats, the early Vernum showed most drouth tolerance.

The 1949 wheat yields at the three substations are quite low in comparison with those at Brookings. As in oats, part of this difference must be ascribed to the lower level of soil fertility that exists at the three western locations. The 1950 substation average yields show the effect of moisture deficiency under much lower summer temperatures. The yield increases due to cooler conditions are much smaller than in oats. The early variety Lee shows the least gain. The late variety Cadet, however, doubled its yield because it was able to grow to full maturity. The test weights in 1950 were much higher than those in 1949, indicating that cool conditions permitted better filling of the kernels than was possible under the hot dry condi-

Table 15. Factors Affecting Yields of Spring Wheat at Brookings Paired With the Yields in Bushels per Acre For a Given Year

Variety	1946		1949			1948 and 1951, Average		
	Frost Injury*	Yield	Leaf Rust†	Test Weight Lbs./Bu.	Yield	Scab Injury*	Test Weight Lbs./Bu.	Yield
Bread wheats								
Lee	1	----	0	57	26.8	5	58	34.7
Rushmore	1	39.6	50	57	24.2	3	57	33.8
Thatcher	2	38.3	70	54	19.6	3	57	30.8
Mida	4	30.2	40	59	24.6	5	57	32.0
Ceres	5	39.4	50	56	22.2	2	57	31.3
Rival	1	44.0	50	57	25.0	2	57	31.7
Pilot	3	37.7	50	57	22.0	3	57	32.5
Cadet	2	40.4	60	54	17.8	1	55	28.7
Durum wheats								
Vernum	3	30.6	0	59	23.0	4	57	33.2
Mindum	1	39.8	0	61	23.2	2	59	34.5
Stewart	1	43.1	0	60	20.8	1	61	34.2

*Where 1 is the least severe, 5 the most severe.
†Rust injury given in percent infection.

tions of 1949. Tillering was absent in both seasons.

Spring Frost

A late spring freeze at Brookings in 1946 caused considerable injury to wheat in the seedling stage. Table 15 presents the degree of frost resistance of spring wheat varieties, together with the yields for that season. The greatest injury was sustained by Mida of the bread wheats and Vernum of the durums. Yields of these two varieties were reduced by 25 percent.

Grasshoppers

Grasshoppers commonly injure nearly mature wheats by clipping the heads. Notes taken at Cottonwood in 1944 showed the importance of earliness in escaping grasshopper injury. Six early bread wheats averaged 3 percent clipping; but the three durums—about five days later in maturity—had 30 percent clipping injury. Earliness alone, however, is no absolute safeguard. The very early bread wheat variety Reward is extremely susceptible to grasshopper injury.

Lodging

Most of the bread wheat varieties have fairly good straw strength so that lodging prior to maturity is uncommon. It has occurred at Brookings in wet years, but the presence of the rusts in those years prevents any estimation of the effect of lodging on yield. The bread wheats having the most resistance to lodging are Rushmore, Thatcher and Cadet. Mida, Rival and Ceres are moderately susceptible, while Pilot and Lee have the weakest straw. All three durum varieties have lodged heavily in most years. Stewart has stood up a little better than Mindum and Vernum.

Shattering and Breaking

These forms of harvest injury are common in South Dakota. Care has been taken to prevent such losses in experimental yield tests by timely harvesting of varietal plots and nurseries. At Brookings the border rows of the wheat plots are left standing after the yield rows are harvested. Shattering notes taken on these border rows confirm the predisposition of Rival, Ceres and Mida to shattering injury. Rushmore, Cadet, Lee, Pilot and Thatcher have considerable shattering resistance. Pilot and the three durum varieties tend to break down badly after maturity.

Plant Diseases

Stem rust caused by *Puccinia graminis tritici* has been largely responsible for reducing the average yield of Ceres at Brookings. In 1944, 50 percent stem rust on this variety reduced its yield to 4.5 bushels per acre as compared to 18.6 bushels for the resistant variety Pilot. The test weight of Ceres was 40 pounds per bushel as compared to 50 for Pilot. Except for Ceres and Mindum, all the spring wheat varieties under consideration have the mature plant type of resistance to stem rust, which has been entirely adequate for all ordinary forms of the stem rust pathogen. In 1950, the appearance of Race 15B of stem rust resulted in damage to the varieties at Brookings, especially the durum wheats. Stewart had 50 percent rust and yielded 17.1 bushels per acre. Rust readings on the bread wheats were less and the yields higher. Lee produced 25.8 bushels per acre despite a stem rust reading of 30 percent.

Leaf rust, caused by *Puccinia rubigo-vera* has occurred at Brookings in every year of the decade and the average yields in Table 13 for the State Experiment Station, Brookings, reflect the effect of this disease. Lee and the durum varieties have the most resistance and the highest yield averages. Cadet and Thatcher have been infected most severely and have the lowest yields. Leaf rust has not been so severe in the central and western parts of the state, and here the resistant durums and Lee have no yield advantage over the susceptible bread wheats. The effect of leaf rust on yield and test weight at Brookings in 1949 is shown in Table 15. This was a drouth year and moisture shortage also affected varietal performance. The poor performance of Thatcher in 1949 despite its earliness and known drouth resistance must be attributed to leaf rust injury, which reduced its yield to 19.6 bushels per acre and its test weight to 54 pounds per bushel.

Scab, caused by *Fusarium* spp. has affected the performance of wheat at Brookings in several seasons. The average effect of scab on the yield and test weight during the seasons 1948 and 1951 is shown in Table 15.

Varieties showing the highest incidence of scab are Mida, Lee and Vernum durum. A comparison of these figures with the long-time averages of these varieties in Table 13 suggests that scab has prevented these three varieties from expressing their full yield capacity for the favorable seasons. Their average test weights were 2.5 pounds per bushel less than those recorded in two comparable years when scab did not occur. The scab damage on these three varieties in terms of market grade was high. The relatively low incidence of scab on the later varieties indicates that delayed maturity may afford some protection against scab.

Loose smut, *(Ustilago tritici)*, was noted at Brookings in 1948 when Mida had 4 percent loose smut and Lee 8 percent. Only trace amounts occurred on other varieties.

Conclusions

The preceding analysis of the factors influencing the yields of small grain crops during the past 10 years indicates that some of these factors have similar effects on the different crops. The effect of drouth is intensified by high temperature and low soil fertility. Heat as a factor in drouth was more severe in flax and oats than in wheat and barley.

Moderate earliness as a varietal characteristic was at a definite advantage under drouth conditions in wheat, oats and barley, but offered no yield advantage in flax. The value of earliness as a factor permitting escape from midsummer hazards has been established in the case of grasshoppers on barley, wheat and oats, and in the extreme degree of leaf rust injury on late bread wheat varieties. The long-time yield averages in oats, barley and bread wheat show that the frequency of all July crop hazards is great enough to give the moderately early varieties a distinct margin of productivity over the late strains.

The effect of plant diseases, frost injury, lodging, and shattering within each crop depends on the variety concerned. Genetic factors for resistance to these hazards are available. A single factor may often make the difference between a good crop and a poor one. Finally, there are varieties within each crop admirably adapted to South Dakota climatic conditions.

The one certain feature about the South Dakota growing season is the continued rise of daily mean temperature to a peak in late July. Until the latter part of June, this temperature rise is usually accompanied by an increased moisture supply. In July the moisture supply declines and the average temperature starts exceeding the optimum for small grain, 65° F. Heat itself can reduce small grain yields (Table 10) as it rises over the optimum. Time and increasing temperature accelerate the natural increase of such factors as the growth and appetite (within the temperature feeding range) of grasshoppers, the incidence of some plant diseases, the likelihood and severity of drouth and the frequency of hail and storms. The adaptation of farm practices and small grain varieties to the inescapable fact of rising temperature in July with decreasing moisture, but rapidly increasing crop hazards, is essential to achieving crop stability.

The 10-year results show that some varieties in each crop have shown less violent yield fluctuations than others. Rushmore spring wheat, Plains barley and Vikota oats in a limited area are examples of varieties that have a high degree of stability, which has been achieved by breeding. Further work to combine a maximum of disease resistance with desirable agronomic characters (and adaptation to the South Dakota climate with its critical period, July,) may make for greater crop assurance than so far obtained. Under extreme conditions, such as occurred in the thirties, foundation livestock breeding herds were lost because of lack of feed supplies. A combination of proper tillage methods and very early, dependable (even if low yielding) varieties of barley and oats would have been valuable. It is desirable that such varieties should be available.

Not all the weight of insuring crop stability can be carried by the plant breeder. Moisture conservation, timely farm operations, weed and insect control, and maintenance of soil fertility are essential if agriculture is to take full advantage of adapted small grain varieties.