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# Irrigation Research in the James River Basin: A Five-Year Progress Report

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# IRRIGATION RESEARCH

## IN THE

# JAMES RIVER BASIN

## A FIVE-YEAR PROGRESS REPORT

AGRICULTURAL EXPERIMENT STATION
SOUTH DAKOTA STATE COLLEGE • BROOKINGS

# *Table of Contents*

**Research on irrigation in the James River Area was conducted by the South Dakota Agricultural Experiment Station in cooperation with the Agricultural Research Service, USDA and the Bureau of Reclamation, USDI.**

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# Irrigation Research
## in the
# James River Area

### *A Five-Year Progress Report*

### *Introduction*

THE PROSPECT OF IRRIGATION in the James River Basin has created much interest in the past few years. To provide a scientific foundation and proceed with a minimum of costly trial and error, research on crop varieties, soil fertility and management, pastures, and water management was increased in the area in 1948. Experiments were conducted on non-irrigated and irrigated land to determine the results and benefits under each condition. The expanded research work was conducted primarily on the Huron Development Farm and the Redfield Development Farm.

### *The James River Area*

*The James Basin* in east central South Dakota is an undulating to nearly level glacial plain having an elevation of 1300 to 1600 feet. Most of the soils have developed in glacial till, the loamy rock debris left by glaciers. Localized along the James River and its tributaries are alluvial and sand and gravel deposits; at the northern end of the basin the soils have developed in the silty and clayey deposits of extinct glacial Lake Dakota.

*The soils of the Redfield farm* represent some of the best adapted soils for irrigation in the James Basin. They are deep, productive soils of good tilth. They are not extensive in occurrence, being developed only on the slightly sloping positions on the plain of glacial Lake Dakota.

*The soils of the Huron farm* are representative of soils developed in glacial till. Although moderately deep and fairly productive, these soils have substrata which are slowly permeable and usually saline, and they occur on irregular topography.

*The growing seasons* (April to October) were moderately dry in 1949, 1950 and 1952. The rainfall in this period was 4 inches below average in 1949, 1.7 below in 1950, and 6.5 below average in 1952. In addition, the distribution of precipitation which did occur was unfavorable. The greatest deficits occurred in July in 1949, in June in 1950, and in May in 1952. Over 64 percent of the precipitation for the 7-month period in 1952 occurred in June.

The years 1951 and 1953 had above-average rainfall: 1951 had 0.2 inches above-average precipitation for the season; however, over

4.5 inches fell in June and less than 1 inch in July. The 1953 season had 21.2 inches for the season, or 5.5 inches over average. September and October had no effective precipitation.

*The temperatures* were 2 to 3 degrees above average in 1949, about 3 degrees below in 1950, about 5 degrees below in 1951, and about average in 1952 and 1953.

The results reported from the experiments conducted on the Huron and Redfield farms will indicate what may be expected from similar crop varieties, soil management, cropping systems, and water management practices on the same types of soil found in the area and under comparable climatic conditions. Numerous experiments are now in progress on the Development Farms. The information given in this circular represents a progress report. Further results will be published as the experiments progress.

# Crop Variety Experiments

## *Small Grain Varieties and Diseases*

Small grain production is an important source of farm income in the James River Area at present. The possible introduction of irrigation practices into this area has made it desirable to test the feasibility of small grain production under irrigation. This has involved sampling the available varieties to determine whether those adapted to dry-land conditions would also be suited to irrigation management.

Variety trials of spring wheat, barley and oats were planted at the Redfield Development Farm during the 5-year period, 1949-53. The 1952 plots were abandoned because of uneven stands and are not included in the averages. The varieties used were not the same from year to year, since efforts were made to find varieties adapted to irrigation. Irrigated and non-irrigated plots were grown in close proximity. The irrigated plots received about one-third more commercial fertilizer than the non-irrigated plots to take maximum advantage of additional water.

The average yields per year for each crop, as based on all varieties in the test, are given in Table 1. These averages indicate a 24 percent gain in wheat for the irrigated plots over the non-irrigated plots. For barley, the gain is 38 percent and for oats, 54 percent. However, all yields are quite low and higher average yield levels would be desirable for successful irrigation.

The varieties with the best performance under dry-land conditions appeared to be the best under irrigation. In spring wheat, Lee was superior on both non-irrigated and irrigated plots. In barley, the same was true of Montcalm and Velvon 11, a malting and a feed barley respectively. In oats, Ajax was superior in both series of tests. These results indicate that for wheat, at

**Table 1. Average Yields in Bushels per Acre of Small Grains at Redfield, 1949-53**

| | Wheat | | Barley | | Oats | |
|---|---|---|---|---|---|---|
| | Non-Irrigated | Irrigated | Non-Irrigated | Irrigated | Non-Irrigated | Irrigated |
| 1949 | 6.9 | 10.0 | 13.8 | 24.5 | 9.4 | 35.6 |
| 1950 | 10.5 | 20.6 | 21.7 | 44.5 | 18.9 | 50.8 |
| 1951 | 37.9 | 42.2 | 51.5 | 64.9 | 95.4 | 120.8 |
| 1953 | 15.9 | 15.6 | 24.9 | 20.4 | 26.6 | 25.0 |
| **Average** | **17.8** | **22.1** | **28.0** | **38.6** | **37.6** | **58.0** |

least, the early, adapted variety Lee, which probably represents a high level of disease resistance is the best present varietal choice. Apparently, disease resistance will be very important in choosing a wheat variety for irrigation.

**Table 2. Average Yields in Bushels per Acre of Small Grain Varieties on Dry Land and under Irrigation at Redfield, 1949-53**

| Variety | Non-Irrigated | Irrigated |
|---|---|---|
| | Bu./A. | Bu./A. |
| **Spring Wheat** | | |
| Lee | 18.4 | 23.2 |
| Rushmore | 17.4 | 20.2 |
| Mida | 17.3 | 21.6 |
| Cadet | — | 20.7 |
| Rival | — | 19.0 |
| Least significant difference (5%)* | 2.2 | 4.5 |
| **Barley** | | |
| Montcalm | 29.1 | 43.4 |
| Velvon | 28.4 | 41.6 |
| Tregal | 27.0 | 40.8 |
| Odessa | 26.7 | 38.2 |
| Feebar | 26.6 | 37.2 |
| Plains | 23.3 | 36.0 |
| Least significant difference (5%)* | 5.2 | 6.3 |
| **Oats** | | |
| Brunker | 30.5 | — |
| Dupree | 39.2 | 61.0 |
| Vikota | 37.9 | — |
| Clinton | 38.0 | 57.2 |
| Ajax | 49.7 | 64.8 |
| Cherokee | 32.2 | — |
| James | 37.4 | 51.7 |
| Least significant difference (5%)* | 6.6 | 8.4 |

*Least significant difference (5%) is the minimum acceptable difference between varietal yields required for reliability. A difference of this magnitude will be due to chance in only 5% of the cases. Differences in yield smaller than those indicated are not statistically significant.

In both barley and oats, the data indicate a relatively late maturing variety will have the greatest advantage. With an adequate water supply, the higher risk involved in growing late maturing varieties may well be reduced considerably, and make the maturity class of Montcalm barley and Ajax oats very acceptable. Four-year average performance of some small grain varieties at Redfield on non-irrigated and irrigated land is given in Table 2.

The general low level of yields suggests that other factors besides water supply may affect the productivity of small grains in Spink County. Paramount among these is probably high temperature, often early in the season, which tends to reduce tillering in small grain and thereby limits yields. These temperatures may be associated with the low altitudes in the James River Basin, and may not favor profitable small grain production under irrigation management.

The numerous problems encountered in growing these nurseries have a bearing on the successful production of small grains under irrigation, and the experience gained in these tests may be beneficial to prospective irrigators in the James River Basin. They will be discussed under three categories: (1) agronomic characteristics (2) production (3) plant diseases.

(1) *Agronomic Characteristics.* In 1951 when very high yields of oats and barley were obtained, it was evident that most of the varieties widely used in South Dakota often lacked sufficient straw strength to support maximum yields. Lodging was very serious in 1951. Strains of these crops with increased standability are available, but are not adapted to South Dakota conditions. A plant breeding program may be necessary to increase straw strength of oats and barleys suited to irrigation in this area.

(2) *Production.* Land leveled for irrigation needs very careful management to get stands of small grains that will compete with the weeds. Early seeding is very important for the same reason. Irrigation water must be applied to small grains at the right time, if any benefits are to be realized in terms of increased yields. This may involve irrigation right after planting to bring up the seedlings quickly and uniformly, as well as irrigation at jointing and heading time. Possibly a good fall irrigation as a fallow substitute might be a very satisfactory practice in small grain production.

(3) *Plant Diseases.* Plant diseases have been more severe on the irrigated plots than on the adjacent non-irrigated plots, as can be seen in Tables 3, 4 and 5. Part of this may be due to the denser foliage on the irrigated crops, as well as the actual process of irrigation itself. When the soil is well watered, the soil and the air spaces just above it become an ideal moist chamber. In such a situation, disease producing organisms may cause the most damage.

**Table 3. A Comparison of the Severity of Stem Rust of Wheat Grown Under Non-Irrigated and Irrigated Conditions, Redfield, 1950**

| | Percent Stem Rust | | | |
|---|---|---|---|---|
| | July 27 | | Aug. 10 | |
| Variety | Non-Irrigated | Irrigated | Non-Irrigated | Irrigated |
| Cadet | 1 | 2 | 5 | 15 |
| Lee | trace | trace | 3 | 10 |
| Mida | 1 | 3 | 5 | 20 |
| Pilot | trace | 2 | 5 | 10 |
| Rival | 1 | 1 | 5 | 20 |
| Rushmore | trace | 2 | 3 | 10 |
| Ns 1831 | 1 | trace | 5 | 15 |
| Tri. x Th. 343 | trace | trace | 3 | 10 |
| Tri. x Th. 630 | trace | trace | 3 | 10 |

**Table 4. A Comparison of the Severity of Scab of Wheat Grown Under Non-Irrigated and Irrigated Conditions, Redfield, 1953**

| | Percent Scab | |
|---|---|---|
| Variety | Non-Irrigated | Irrigated |
| Lee | 10 | 50 |
| Mida | 10 | 40 |
| Rushmore | trace | 30 |
| Thatcher | trace | 30 |
| P.W. 36 | 0 | 20 |
| C.T. 186 | 20 | 70 |

**Table 5. A Comparison of the Severity of Leaf Rust of Oats Grown Under Non-Irrigated and Irrigated Conditions, Redfield, 1953**

| | Percent Leaf Rust | |
|---|---|---|
| Variety | Non-Irrigated | Irrigated |
| Ajax | 3 | 5 |
| Clinton | 5 | 30 |
| Vikota | 0 | 0 |
| Cherokee | 5 | 10 |
| James | 8 | 15 |

# *Corn Variety Tests*

Corn testing has been directed toward determining which commercial hybrids are best adapted for the Redfield area of the James River Basin when grown on both irrigated and non-irrigated soil. At the outset it was not known whether the same varieties would do best under both sets of conditions. Therefore, in 1949 at the beginning of the work, the land was divided, half of it to be used for irrigation and half for non-irrigation.

Large leveling machinery and the resulting compaction of the soil apparently reduced yields for several years. This effect was made apparent by extreme nitrogen stress in the plants and low yields on irrigated plots. These were very noticable in spite of heavy applications of manure and artificial fertilizers.

When the work was first started, it was not known what maturity of hybrids, nor what planting rate would be best to use, especially on irrigated plots. Therefore, four hybrids, Kingscrost KE3, DeKalb 56, Sokota 400, and Iowa 4316, which vary from early to late in inherent maturity, were planted on both the non-irrigated and the irrigated area. In the irrigated plots each hybrid was planted so as to make it possible to study yields under rates of 10,700; 14,200; 17,800; 21,300; and 24,900 plants per acre. In the non-irrigated section the rates were 5,300; 7,100; 10,700; 14,200; and 17,800 plants per acre.

**Table 6. Performance of Corn Hybrids Under Irrigation, Redfield, 1950-53**

| | 1953 Averages | | | 2-Year Average | | 3-Year Average | | 4-Year Average | |
|---|---|---|---|---|---|---|---|---|---|
| Hybrid or Variety | Performance Score* | Yield Bu./A.† | Moisture Percent | Yield Bu./A. | Moisture Percent | Yield Bu./A. | Moisture Percent | Yield Bu./A. | Moisture Percent |
| Sokota 220 | 113.88 | 74.2 | 11.6 | 86.9 | 11.9 | 85.1 | 17.1 | — | — |
| Funk's G-1A | 109.13 | 70.5 | 14.0 | 79.4 | 14.6 | — | — | — | — |
| Sokota 400 | 109.12 | 69.8 | 12.5 | 74.3 | 15.2 | 77.9 | 22.5 | 80.1 | 27.1 |
| Sokota 270 | 108.26 | 69.4 | 13.5 | 75.6 | 15.0 | 74.3 | 21.8 | 80.0 | 25.5 |
| Pioneer 377A | 107.12 | 68.1 | 13.2 | 73.6 | 14.6 | 77.6 | 21.4 | 82.0 | 26.0 |
| S. Dak. Exptl. 9 | 104.05 | 64.4 | 11.9 | 78.1 | 14.2 | 77.9 | 19.5 | — | — |
| Sokota 224 | 103.22 | 63.5 | 12.2 | 77.7 | 15.0 | 78.8 | 21.5 | 79.9 | 24.8 |
| Kingscrost KS6 | 102.15 | 63.4 | 13.9 | 74.0 | 14.7 | 73.5 | 22.0 | 76.1 | 25.7 |
| Sokota 262 | 102.11 | 62.9 | 12.9 | 67.1 | 14.1 | — | — | — | — |
| DeKalb 58 | 100.64 | 61.0 | 12.0 | 68.7 | 14.6 | — | — | — | — |
| Cargill 90N | 99.39 | 60.1 | 12.8 | 67.4 | 13.2 | — | — | — | — |
| Disco 95W | 96.61 | 57.3 | 12.8 | 65.1 | 14.0 | — | — | — | — |
| Pfister P.A.G. 33 | 96.36 | 57.0 | 12.7 | — | — | — | — | — | — |
| Van Tassel V54 | 95.75 | 56.1 | 12.1 | — | — | — | — | — | — |
| Pioneer 382 | 93.54 | 54.2 | 12.8 | 71.4 | 14.5 | — | — | — | — |
| Pride PN21 | 90.35 | 51.2 | 13.3 | — | — | — | — | — | — |
| DeKalb 56 | 86.29 | 46.5 | 12.0 | 70.5 | 12.9 | 72.0 | 18.5 | 70.6 | 23.3 |
| Kingscrost KE3 | 82.05 | 41.7 | 10.9 | 60.7 | 13.1 | 59.5 | 17.9 | 59.9 | 21.0 |
| **Average of all entries** | | **60.6** | **12.6** | **72.7** | **14.1** | **75.2** | **20.2** | **75.5** | **24.8** |

*Varieties are ranked on the basis of the 1953 performance score which is obtained by weighting yield 60 percent and moisture at harvest 40 percent.
†Differences in yield of less than 16.8 bushels per acre are not statistically significant.

Table 7. Performance of Corn Hybrids on Non-Irrigated Land, Redfield, 1950-53

| Hybrid or Variety | 1953 Averages: Performance Score* | Yield Bu./A.† | Moisture Percent | 2-Year Average‡: Yield Bu./A. | Moisture Percent | 3-Year Average: Yield Bu./A. | Moisture Percent |
|---|---|---|---|---|---|---|---|
| S. Dak. Exptl. 9 | 108.83 | 68.9 | 10.8 | 56.7 | 25.4 | — | — |
| Sokota 400 | 108.35 | 69.2 | 12.5 | 53.0 | 31.8 | 49.5 | 34.3 |
| Pioneer 377A | 107.97 | 68.4 | 11.6 | 59.8 | 28.0 | 56.1 | 30.9 |
| Kingscrost KS6 | 105.11 | 65.8 | 12.2 | 55.9 | 29.9 | 52.6 | 31.5 |
| Funk's G-1A | 104.42 | 65.1 | 12.2 | — | — | — | — |
| Pfister P.A.G. 33 | 104.41 | 65.0 | 12.0 | — | — | — | — |
| Cargill 90N | 103.43 | 64.1 | 12.2 | — | — | — | — |
| DeKalb 58 | 102.24 | 62.4 | 11.1 | — | — | — | — |
| Sokota 262 | 102.00 | 62.3 | 11.4 | 51.3 | 28.6 | — | — |
| Pioneer 382 | 100.12 | 60.4 | 11.4 | — | — | — | — |
| Sokota 224 | 98.83 | 59.1 | 11.4 | 51.3 | 28.3 | 48.3 | 29.3 |
| Sokota 220 | 97.49 | 57.8 | 11.5 | 52.7 | 21.8 | — | — |
| Sokota 270 | 97.15 | 57.5 | 11.6 | 49.8 | 28.8 | 47.6 | 31.5 |
| Pride PN21 | 95.94 | 56.7 | 12.5 | — | — | — | — |
| DeKalb 56 | 95.00 | 55.2 | 11.3 | 48.7 | 26.8 | 45.7 | 28.2 |
| Disco 95W | 92.59 | 53.1 | 12.0 | — | — | — | — |
| Kingscrost KE3 | 89.30 | 49.1 | 10.5 | 41.2 | 21.6 | 38.8 | 22.6 |
| Van Tassel V54 | 86.75 | 47.4 | 12.4 | — | — | — | — |
| **Average of all entries** | | **60.4** | **11.7** | **52.0** | **27.7** | **48.4** | **29.8** |

*Varieties are ranked on the basis of the 1953 performance score which is obtained by weighting yield 60 percent and moisture at harvest 40 percent.
†Differences in yield of less than 11.4 bushels per acre are not statistically significant.
‡No results were obtained on non-irrigated land in 1952. Therefore, 2-year averages are for 1953 and 1951; 3-year averages are for 1953, 1951, and 1950.

The 1949 results indicated that hybrids which matured at the same time as DeKalb 56 were best suited for that year on non-irrigated land, while Sokota 400 performed well under irrigation. Kingscrost KE3 was too early and Iowa 4316 too late. In most years, irrigation apparently hastened development somewhat, allowing the use of slightly later hybrids than those adapted for non-irrigated conditions. Variation in planting rates had no effect on yield, there being no differences between the highest and lowest rates on either irrigated or non-irrigated land. It should be noted that irrigated yields averaged only 36.3 bushels per acre. These low yields probably resulted not only from low fertility caused by soil compaction but also from inadequate irrigation.

Since 1949, from 10 to 20 hybrids have been included in yield trials each year. Fertilizer practices generally called for 20 tons of manure and 200 pounds of 10-20-0 commercial fertilizer per acre on the irrigated plots, and 10 tons of manure and 100 pounds of 10-20-0 fertilizer per acre on the non-irrigated land. Information obtained was on yield per acre in bushels and on relative maturity at harvest as reflected by moisture percentage in the ears. The results are presented in Tables 6 and 7.

Under irrigated conditions a 4-year average of 75.5 bushels per acre was produced, with the corn having 24.8 percent moisture at the time of harvest. Pioneer 377A had the best 4-year average yield, while of those included for three years, Sokota 220 produced the most corn. Sokota 220, although an early corn, also had the highest yields in 1953 and for the 2-year period 1952-53. On non-irrigated land, Pioneer 377A consistently produced the most corn, except in 1953 when Sokota 400 and South Dakota Experimental 9 outyielded it slightly. Besides Sokota 220 and Pioneer 377A, other hybrids which performed well at Redfield were: Sokota 270, Sokota 400, Sokota 224, Funk's G-1A, and Kingscrost KS6.

# *Forage Strain Trails*

To determine the legumes and grasses best adapted to irrigation, various species and varieties were seeded in each of the five years.

### *Legumes*

The strains used were selected because of their known differential reaction to the leaf diseases and bacterial wilt and because of differences in agronomic adaptation.

Four varieties and six synthetic strains were seeded in 5- by 20-foot plots in April, 1949. Weed competition was exceptionally severe and resulting stands of legumes were not very saisfactory for yield determinations. Compaction of the soil by leveling equipment may have contributed to the unsatisfactory stands. Ladino clover and birdsfoot trefoil, sown under the same conditions, were unable to become established. The trefoil is known to possess low seedling vigor and hence is a very poor competitor. A red clover nursery, similarly handled, survived with about a one-third stand on irrigated plots but failed on the non-irrigated plots.

Although stands under irrigation were not satisfactory for yield determinations, some other observations were made (Table 8). It appears that disease problems, particularly stem and foliar infections, probably will be severe under either irrigated or non-irrigated conditions. No statement can be made with respect to bacterial wilt.

**Table 8. Performance of Selected Varieties and Strains of Alfalfa at Redfield, Under the Indicated Conditions, 1950, 1953**

| | Irrigated | | | | | Non-Irrigated | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1950 | | | | | 1950 | | | | | 1953 | | | | |
| Varieties or Strains | Leaf Spot Damage* | Leafhopper Damage* | Ht. In., Sept. | Ht. Basal Regrowth In., Oct. | Stand Note, Oct. | Leaf Spot Damage* | Leafhopper Damage* | Ht. In., Sept. | Ht. Basal Regrowth In. Oct. | Stand Note, Oct. | Yellow Leaf Blotch* | Black-stem Infection* | Common Leaf-spot* | Stand Note, July | Dry-Matter Yield T./A. Cut July |
| Ladak | 4 | 1 | 18 | 1 | good | 4 | 1 | 4 | 2 | good | 4.0 | 4.0 | 2.5 | good | 2.34 |
| Cossack | 4 | 1 | 20 | 2 | good | 4 | 1 | 5 | 2 | fair | 4.0 | 2.5 | 3.0 | fair | 1.82 |
| Ranger | 5 | 1 | 20 | 3 | good | 5 | 1 | 7 | 3 | fair | 5.0 | 4.0 | 3.0 | good | 2.04 |
| Buffalo | 5 | 1 | 22 | 6 | poor | 5 | 1 | 9 | 4 | fair | 5.0 | 5.0 | 2.0 | poor | 1.80 |
| Wisc. Syn. A | 4 | 1 | 20 | 4 | fair | 4 | 1 | 5 | 2 | good | 4.5 | 3.0 | 2.5 | fair | 2.13 |
| Wisc. Syn. B | 5 | 1 | 20 | 2 | good | 5 | 1 | 7 | 3 | good | 3.0 | 2.0 | 2.0 | good | 2.41 |
| Wisc. Syn. C | 4 | 1 | 21 | 2 | good | 4 | 1 | 7 | 3 | fair | 4.0 | 3.5 | 2.5 | fair | 2.15 |
| Wisc. Syn. D | 4 | 1 | 20 | 4 | poor | 4 | 1 | 7 | 4 | good | 3.5 | 4.0 | 2.0 | good | 2.24 |
| Wisc. Syn. E | 4 | 1 | 21 | 5 | poor | 4 | 1 | 6 | 3 | good | 4.0 | 3.5 | 2.0 | good | 1.78 |
| Vernal | 4 | 1 | 18 | 2 | poor | 4 | 1 | 5 | 2 | good | 3.0 | 5.0 | 2.0 | good | 2.30 |

*Where 1 is slight infection, 5 is severe infection.

**Table 9. Precentage Grass Stands Obtained after Seeding with Cultipacker Seeder, Redfield, 1949-50**

| Species | 1949 Spring Planting Irrigated | 1949 Spring Planting Non-Irrigated | 1950 Fall Planting Irrigated | 1950 Spring Planting Irrigated |
|---|---|---|---|---|
| Smooth brome | 25 | 48 | 92 | 35 |
| Ree wheatgrass | trace | 8 | 80 | 20 |
| Crested wheatgrass | 0 | 15 | 18 | 15 |
| Tall wheatgrass | 0 | 6 | 23 | — |
| Pubescent wheatgrass | 0 | 0 | 0 | — |
| Alta fescue | ---- | — | — | 0 |
| Russian wild rye | ---- | — | — | 0 |
| Red fescue | ---- | — | — | 30 |

Irrigation brought about no important changes in the relative performance of strains with respect to their agronomic characteristics; that is, the strains which manifested fall dormancy on irrigated land were those that are known to exhibit dormancy on dry land; and the same was true with respect to yield, forage quality, flower and seed production.

### *Grasses*

Difficulty in obtaining stands of grasses was experienced occasionally because of the smothering growth of warm-season weedy grass stimulated by the irrigation water and also because of the presence of root rot disease organisms in the soil. The percent of stands obtained from the different species of grasses planted in 1949 and 1950 are given in Table 9. Smooth brome was found to give the best stands of any of the grasses tested.

Yields of hay and seed were obtained from grass experiments established at Huron and Redfield. The average forage yields for Homesteader brome and Ree wheatgrass at Huron in 1951 and 1952 are shown to be higher than those of other grasses (Table 10). Crested wheatgrass gave a greater seed yield in 1951 than Homesteader brome, Ree and tall wheatgrass.

In Table 11, hay yields of several grasses at Redfield are shown for 1952 and 1953. Ree wheatgrass again yielded more than the other grasses, followed by Homesteader brome and reed canary grass.

**Table 10. Yield of Grass Hay and Seed Under Irrigation at Huron, 1951-52**

| | Hay Yields 1951 | Hay Yields 1952 | Hay Yields Average | Seed Yield 1951 |
|---|---|---|---|---|
| | T./A. | T./A. | T./A. | Lbs./A. |
| Alta fescue | 0.71 | 2.08 | 1.41 | — |
| Russian wild rye | 0.73 | 1.57 | 1.15 | — |
| Tall wheatgrass | 0.71 | 2.30 | 1.50 | 287 |
| Crested wheatgrass | 0.94 | 1.65 | 1.30 | 366 |
| Ree wheatgrass | 1.29 | 2.01 | 1.65 | 217 |
| Homesteader brome | 1.44 | 1.88 | 1.66 | 210 |
| Astoria bent | — | 1.65 | — | — |
| Tall oatgrass | — | 1.64 | — | — |
| Creeping red fescue | — | 2.16 | — | — |

**Table 11. Yield of Grass Hay at Redfield Under Irrigation, 1952-53**

| | 1952 | 1953 | Average |
|---|---|---|---|
| | T./A. | T./A. | T./A. |
| Lancaster brome | 0.72 | 1.87 | 1.29 |
| Homesteader brome | 0.97 | 2.01 | 1.49 |
| Ree wheatgrass | 1.21 | 2.31 | 1.76 |
| Reed canary grass | 0.57 | 2.25 | 1.41 |
| Orchard grass | 0.78 | 1.85 | 1.31 |
| Tall oatgrass | 0.76 | 1.97 | 1.36 |

# Horticultural Crops

THE EFFECT of irrigation on fruit trees and vegetables was investigated at the Redfield Development Farm. Fruit trees did well under irrigation, but some production problems were encountered which made the planting not as profitable as it should be. Vegetables showed great promise at Redfield under irrigation.

### *Fruit Tree Planting*

Plant growth of the Sapa plums, the fruit trees which were planted, was excellent. Though no check under dry-land condition was maintained at Redfield, comparisons with plantings at Brookings and other places without irrigation point toward the beneficial effect of irrigation on fruit trees.

Insect and fungus diseases, which have been serious in other locations, did not present a problem at Redfield. Winter injury, frost and wind damage, and rodents proved to be a serious handicap to production. Most of these hazards can be checked, though it was not possible to do so within the period of the test. If these hazards are brought under control, the future of fruit trees in this area looks bright.

The winter injury that occurred has now been associated with a virus disease infection, and it appears that the stock carried the virus disease when planted. Most of what is known about this disease has been learned since the planting was made, and it is believed that it can be checked in the future.

It was not possible to provide the planting with a shelterbelt in the five years the plums were grown. The wind and frost damage that occurred clearly indicate the necessity for a shelterbelt in order to grow fruit trees successfully in this area.

### *Vegetables*

The yields of vegetables grown under irrigation at Redfield indicate that they have excellent commercial possibilities. In 1951 a number of vegetable crops were planted. Table 12 gives the yield data.

It should be noted that when the yield data were gathered weather conditions were favorable for vegetables. However, with adequate soil preparation and care, high yields could be expected on commercial acreages even under less favorable weather conditions. Furthermore, additional information on fertilizer requirements, varieties, and wind protection might result in even greater yields for some of these crops. Large acreages of the more perishable vegetables do not seem advisable unless processing plants are built in the area, but there are a number of vegetables that can be

**Table 12. Yields Obtained from Various Vegetable Crops Grown at Redfield in 1951**

| Crop | Variety | Yield T./A. |
|---|---|---|
| Broccoli | Italian Green Sprouting | 3.86 |
| Cabbage | Golden Acre | 23.06 |
| Cauliflower | Snowball | 9.06 |
| Cucumbers | Marketer | 16.63 |
| Lettuce | Great Lakes | 21.78* |
| Peas | Little Marvel | 5.40 |
| Tomatoes | Sioux | 17.96 |

*Average weight of heads, 2 lbs.

**Table 13. Squash Yields as Affected by Wind Protection from Snow Fence, Redfield, 1953**

| | Average Weight of Fruit per Hill, Lbs. |
|---|---|
| Fourth row north of fence | 5.75 |
| Third row north of fence | 8.60 |
| Second row north of fence | 12.16 |
| First row north of fence | 15.50 |
| First row south of fence | 11.16 |
| Second row south of fence | 9.20 |
| Third row south of fence | 6.80 |
| Fourth row south of fence | 4.00 |

grown on an extensive scale without a serious marketing problem.

In 1953, work was begun on wind damage. A snow fence was erected from east to west in a field of butternut squash. The squash was planted on June 4 and the snow fence was erected on July 7. Yields shown in Table 13 indicate the beneficial effects of wind protection.

*Potatoes*. Various phases of the potato research were conducted by the Agronomy, Agricultural Engineering, Horticulture and Plant Pathology departments and the USDA.

Nineteen varieties of potatoes were planted at Redfield in 1953. These varieties, a number of which have been recently named and released by the various Experiment Stations for scab resistance, quality, and type, were compared with a number of standard varieties when grown under irrigated and non-irrigated conditions.

The purpose of these experiments was to determine whether scab and other diseases might become more damaging to potatoes when grown under the above conditions.

**Table 14. Average Yields of Nineteen Potato Varieties Grown Under Irrigated and Non-Irrigated Conditions at Redfield, 1953**

| Variety | Average Yield* Non-Irrigated | Rank in Yield Non-Irrigated | Rank in Yield Irrigated | Average Yield† Irrigated |
|---|---|---|---|---|
| | Bu./A. | | | Bu./A. |
| Kennebec | 307.1 | 1 | 2 | 423.1 |
| Cherokee | 285.8 | 2 | 10 | 330.9 |
| Irish Cobbler | 282.2 | 3 | 8 | 344.6 |
| LaSoda | 279.9 | 4 | 1 | 445.3 |
| Sebago | 267.4 | 5 | 5 | 359.5 |
| Columbia Russet | 260.3 | 6 | 4 | 391.0 |
| Chippewa | 246.0 | 7 | 3 | 406.6 |
| Keswick | 234.7 | 8 | 14 | 277.3 |
| Canso | 230.1 | 9 | 7 | 347.5 |
| Early Ohio | 226.4 | 10 | 6 | 358.0 |
| Katahdin | 222.2 | 11 | 9 | 338.9 |
| Red Pontiac | 214.5 | 12 | 12 | 314.1 |
| Russet Sebago | 211.0 | 13 | 13 | 301.5 |
| Yampa | 191.8 | 14 | 11 | 318.1 |
| Waseca | 189.4 | 15 | 15 | 243.7 |
| Bliss Triumph | 140.0 | 16 | 16 | 236.4 |
| Osage | 114.7 | 17 | 18 | 203.5 |
| White Cloud | 108.1 | 18 | 19 | 122.0 |
| Stark's Red | 94.9 | 19 | 17 | 208.4 |
| **Average** | **216.1** | | | **314.2** |

*Least significant difference (5%) means that only 5 times out of 100 the effect observed would be due to chance and not to variety. Differences in yield of less than 73.6 bushels for non-irrigated conditions are not statistically significant.

†Differences in yield of less than 152.3 bushels for irrigated conditions are not statistically significant.

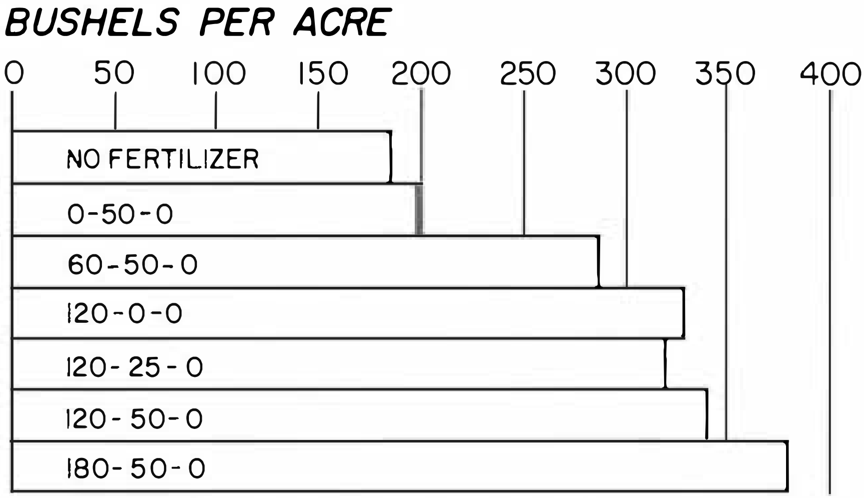



**Fig. 1. Potato yields in fertilizer experiment, Redfield, 1953**

In the fall when these plots were harvested it was found that there was a light infection of scab under both irrigated and non-irrigated conditions. The low intensity of scab was probably due to the fact that potatoes had not been grown on that particular ground for many years. However, the repeated cropping with potatoes in a rotation might well increase scab and certain other diseases. Scab is frequently a cause for serious grade-out in South Dakota when U. S. grade standards are to be met.

Further, it would appear that ringrot would be a disease that would be highly favored by conditions of irrigation. Therefore experimental data are needed to determine the influence of irrigation farming on the development and spread of the major potato diseases.

The principal results obtained from these experiments in 1953 were the comparative yielding ability of the new scab resistant varieties with a number of popular varieties. The results are presented in Table 14.

Figure 1 shows the results of a fertilizer and rotation program conducted by the Agronomy Department. The greatest increases in yield were obtained from increased nitrogen applications. It should be noted that the yields listed are the average of yields from five varieties. Actually, responses to the various treatments were not the same for all varieties, although a similar trend was noted for all. Bliss Triumph showed the greatest variation. It had higher yields on the plots which were given 120 pounds of nitrogen, and either 25 or 50 pounds of phosphorus ($P_2O_5$) than on plots that had received 180 pounds of nitrogen and 50 pounds of phosphorus.

The degree of response to fertilizers was also found to vary with the variety. Kennebec yielded 209 bushels per acre with no fertilizer but yielded 472 bushels per acre with 180 pounds of nitrogen and 50 pounds of phosphorus. Nitrogen deficiency appeared to be greater in places where the land was packed by a leveler.

In these trials, LaSoda and Kennebec have been found to be the highest yielding potato varieties.

# Pasture Trials

During the 5-year period (1948-52), seven different pastures at the Huron Development Farm were grazed by livestock. These pastures included native grass, grass mixtures and legume - grass mixtures grown under irrigated and non-irrigated conditions. The native grass was made up largely of western wheatgrass and blue grama with about 10 percent little blue stem, feather bunchgrass and weeds. The tame pastures included such grasses and legumes as bromegrass, Ree wheatgrass, orchard grass, Kentucky bluegrass, meadow fescue, tall fescue, alfalfa, Ladino clover, birdsfoot trefoil, alsike clover and Dutch white clover. Of these species, orchard grass, Ladino clover and birdsfoot trefoil were found to be non-winterhardy.

All of the tame pastures were fertilized to maintain and increase productivity. From 100 to 250 pounds of ammonium nitrate were used each year on the grass pastures, whereas 100 to 250 pounds of treble-superphosphate were used on the legume-grass mixtures. On one of the native pastures 100 pounds of ammonium nitrate per year were applied.

High - grade, yearling, Hereford steers and heifers were used. They had been wintered to gain about 1 pound per head daily, and were in good, thrifty condition when placed on the pastures each spring. Random selection within sexes was used in making up the lots assigned to each pasture. Single - day weights were used in starting and completing the experiment and weights were obtained at 28- to 34-day intervals (the majority of intervals were 28 days in length) during the trials to determine if seasonal differences in gain occurred.

The pastures were not of equal size, but they were sufficiently large to provide an adequate measure of yielding ability. Each irrigated pasture was divided into two or three parts. In this way rotational grazing could be practiced in order to permit watering and plant recovery. The cattle were allowed to graze for 10 to 14 days, depending upon the vegetative growth, and were then moved to the other part of the pasture. After the cattle were shifted, the pasture was irrigated and given an opportunity to recover in growth before being put to use again.

Throughout the grazing period an attempt was made to maintain vegetative growth of 3 to 7 inches in height on all tame pastures. The cattle were not placed on pastures until there was at least 6 inches of vegetative growth, and the number

**Table 15. Hay Yields on Pastures at Huron Development Farm, 1948-52**

| | 1948 | 1949 | 1950 | 1951 | 1952 |
|---|---|---|---|---|---|
| | T./A. | T./A. | T./A. | T./A. | T./A. |
| **Non-Irrigated** | | | | | |
| Native | 1.22 | 0.55 | 0.47 | 1.26 | 0.28 |
| Native + nitrogen | ---- | 0.72 | 0.56 | 1.84 | 0.58 |
| Alfalfa-brome | ---- | ---- | 1.36 | 2.64 | 2.00 |
| **Irrigated** | | | | | |
| Grass mixture + nitrogen | 3.62 | 2.75 | 2.66 | ---- | ---- |
| Alfalfa-brome | ---- | 4.60 | 3.09 | 2.88 | ---- |
| Alfalfa-Ree-brome | ---- | ---- | ---- | 3.80 | 3.40 |
| Grass-legume-mixtures | ---- | ---- | ---- | ---- | 3.70 |

of cattle was increased and decreased according to the utilization of the pasture. If it appeared that they were not utilizing all the pasture, more cattle were added. If the rate of utilization was too rapid, the cattle numbers were reduced in order to have the pasture last the desired length of the grazing period.

The cattle had access to salt at all times while on pastures, but got no supplemental feed of any kind.

At the beginning of the experiment, cattle placed on pastures with legumes in the mixture, were fed a dry hay for the first few days as a precaution against bloat. They were started on the pastures the latter part of May and removed in September.

Hay yields, reported in Table 15, varied greatly because of season, fertilizer and kind of forage. Native, unfertilized grass yielded from 0.28 tons to 1.26 tons per acre, whereas fertilized grass yielded from 0.56 tons to 1.84 tons per acre. The alfalfa-brome mixture on non-irrigated land produced from 1.36 to 2.64 tons of hay and the same mixture on irrigated land yielded from 2.88 to 4.6 tons per year. The hay yields on the alfalfa-Ree-brome pasture were 3.4 and 3.8 tons per acre.

The pounds of beef per acre obtained on the seven pastures are shown in Table 16. It will be noted that from 71 to 115 pounds of beef per acre were produced from the untreated native pasture. When 100 pounds ammonium nitrate were applied each year to similar pastures,

**Table 16. Pounds of Beef Produced Per Acre, Huron Development Farm, 1948-50**

| | 1948 | 1949 | 1950 | 1951 | 1952 |
|---|---|---|---|---|---|
| | Lbs./A. | Lbs./A. | Lbs./A. | Lbs./A. | Lbs./A. |
| **Non-Irrigated** | | | | | |
| Native | 99.3 | 90.2 | 98.5 | 115 | 71 |
| Native + nitrogen | ---- | 94.3 | 91.8 | 134 | 74 |
| Alfalfa-brome | ---- | ---- | 264.4 | 402 | 222 |
| **Irrigated** | | | | | |
| Grass mixture + nitrogen | 310.5 | 353.0 | 376.8 | ---- | ---- |
| Alfalfa-brome | ---- | 400.4 | 354.4 | 375 | ---- |
| Alfalfa-Ree-brome | ---- | ---- | ---- | 429 | 404* |
| Grass-legume mixtures | ---- | ---- | ---- | 239† | 476† |

*One animal died. Regarding this as a loss to the pasture, the gain would be 354 pounds per acre.
†The gains of the animals that died of bloat were credited to the pounds of beef produced. If the weight of the dead animals is regarded as a loss, then the gains are 11 pounds for 1951 and 305 pounds per acre in 1952.

**Table 17. Number of Acres Required Per Animal for 4-Months Grazing Season, Huron, 1948-52**

| | Acres per Animal | | | | |
|---|---|---|---|---|---|
| | 1948 | 1949 | 1950 | 1951 | 1952 |
| **Non-Irrigated** | | | | | |
| Native | 2.20 | 2.60 | 2.60 | 1.87 | 2.85 |
| Native + nitrogen | ...... | 2.62 | 2.62 | 1.60 | 2.83 |
| Alfalfa-brome | ...... | — | 0.70 | 0.80 | 0.99 |
| **Irrigated** | | | | | |
| Grass mixture + nitrogen | 0.64 | 0.71 | 0.57 | — | — |
| Alfalfa-brome | — | 0.55 | 0.60 | 0.56 | — |
| Alfalfa-Ree-brome | — | — | — | 0.52 | 0.55 |
| Grass-legume mixtures | — | — | — | 0.51 | 0.48 |

the beef gains per acre varied from 74 to 134 pounds. Non-irrigated, alfalfa-brome pastures yielded from 222 to 402 pounds of beef for the years studied. Irrigated pastures of alalfa-brome mixture yielded from 354.4 to 400.4 pounds of beef per acre. It should be pointed out that the stand of this mixture was becoming thinner in 1951 and no doubt affected the yield. The irrigated grass mixture which received from 200 to 250 pounds of ammonium nitrate annually produced from 310.5 to 376.8 pounds of beef per acre. The irrigated alfalfa - Ree-brome pasture produced 429 and 404 pounds of beef in 1951 and 1952. The grass-legume mixture, originally consisting of Ladino clover, alfalfa, bromegrass and orchard grass, produced 239 and 476 pounds of beef per acre. Bloat occurred on this pasture both years and the gains made by the animals that died of bloat were credited to the beef produced.

Table 17 gives the number of acres required per animal for a 4-month grazing season. On the western wheatgrass pastures from 1.87 to 2.85 acres were needed, whereas from 1.60 to 2.83 acres were required on the fertilized native pastures. From 0.70 to 0.99 acres per animal were needed on non-irrigated alfalfa-brome pastures, and 0.55 to 0.60 for similar irrigated pastures. On the other irrigated grass-legume mixtures the acres required varied from 0.48 to 0.71 acres.

The 5-year summary in Table 18 reveals that the native pastures in the Huron area averaged 96 pounds of beef per acre. The improved grass-legume pasture on dry land averaged 296 pounds of beef per acre, but about one-sixth of the area of this pasture appeared to receive additional moisture because of seepage from the irrigated plots. The average of all irrigated grass-legume pastures was 372 pounds of beef per acre. In two of the five years, bloat occurred on some of the irrigated pastures, and the gains by the animals that died of bloat are credited to the beef produced.

**Table 18. Summary of Pasture Trials on Non-Irrigated and Irrigated Land, Huron, 1948-52**

| Kind of Pastures | Hay Yields T./A. | Beef Lbs./A. | Acres per Animal for 4 Months |
|---|---|---|---|
| **Non-Irrigated** | | | |
| Native | 0.8 | 96 | 2.42 |
| Alfalfa-brome | 2.0 | 296 | 0.83 |
| **Irrigated** | | | |
| Grass-legume | 3.4 | 372 | 0.56 |

# Soil Experiments

## *Rotation Experiments*

TO DETERMINE the crop rotations best suited to irrigated farming in the James River Basin and to compare crop performance on irrigated and non-irrigated land under similar conditions, four rotation experiments were begun in 1949 on the Redfield farm. These experiments had as one objective the determination of fertilizer needs of various crops grown in the rotations.

The four rotation studies were a 2 - year corn - wheat and a 4 - year corn-wheat-alfalfa-alfalfa sequence, both on irrigated and on non-irrigated land. In each rotation, the land was divided up into blocks for the different crops, and the crop blocks were, in turn, divided into smaller plots for the fertilizer treatments. There were six basic fertilizer treatments for each rotation. Each complete rotation, with its crop blocks and fertilizer plots, was repeated twice for increased accuracy.

### *Corn Yields*

In the five years that these experiments have been operated, crop performance has changed remarkably on the different rotations. There has been a general upward trend in crop yields, even on unfertilized plots of the non-legume rotations. This may be partly attributed to the fact that all crop residues were returned to the soil, and to the general improvement in the physical condition of the soil.

The corn yields over the 5-year period, with and without nitrogen fertilizer, on the 2-year and 4-year rotations, irrigated and non-irrigated, are presented in Fig. 2. Neither phosphorus nor potassium has influenced corn yields, so only nitrogen effects are shown. The effects shown are those which resulted from a minimum application of 60 pounds of nitrogen on the irrigated plots and 30 pounds on non-irrigated plots.

The major conclusions and observations which may be drawn from these experiments for the conditions encountered in the years 1949 to 1953 are as follows:

1. Corn yields were essentially doubled by irrigation.

2. To date, yields of irrigated corn have been essentially the same if adequate nitrogen is supplied, whether grown in an alfalfa rotation or in a simple corn-wheat rotation.

3. Alfalfa in the rotation builds up soil productivity almost as fast as commercial nitrogen fertilizer. Only in three of the five years has commercial nitrogen increased corn yields in the alfalfa rotation. In the non-irrigated plots, there has been practically no advantage in the use of nitrogen fertilizer on corn following alfalfa.

4. The differences in yield between the control plots and nitrogen plots in the non-legume rotations, irrigated and non-irrigated,

are increasing with time.

5. Corn crop failures may occur on non-irrigated land in some years, as in 1952, when the alfalfa is allowed to grow well into the spring and deplete the soil moisture to the point where corn will not germinate. There was no spring rain to ger-

**Fig. 2. Corn yields with and without nitrogen fertilizer on the 2-year and 4-year rotations, irrigated and non-irrigated, Redfield, 1949 to '53**

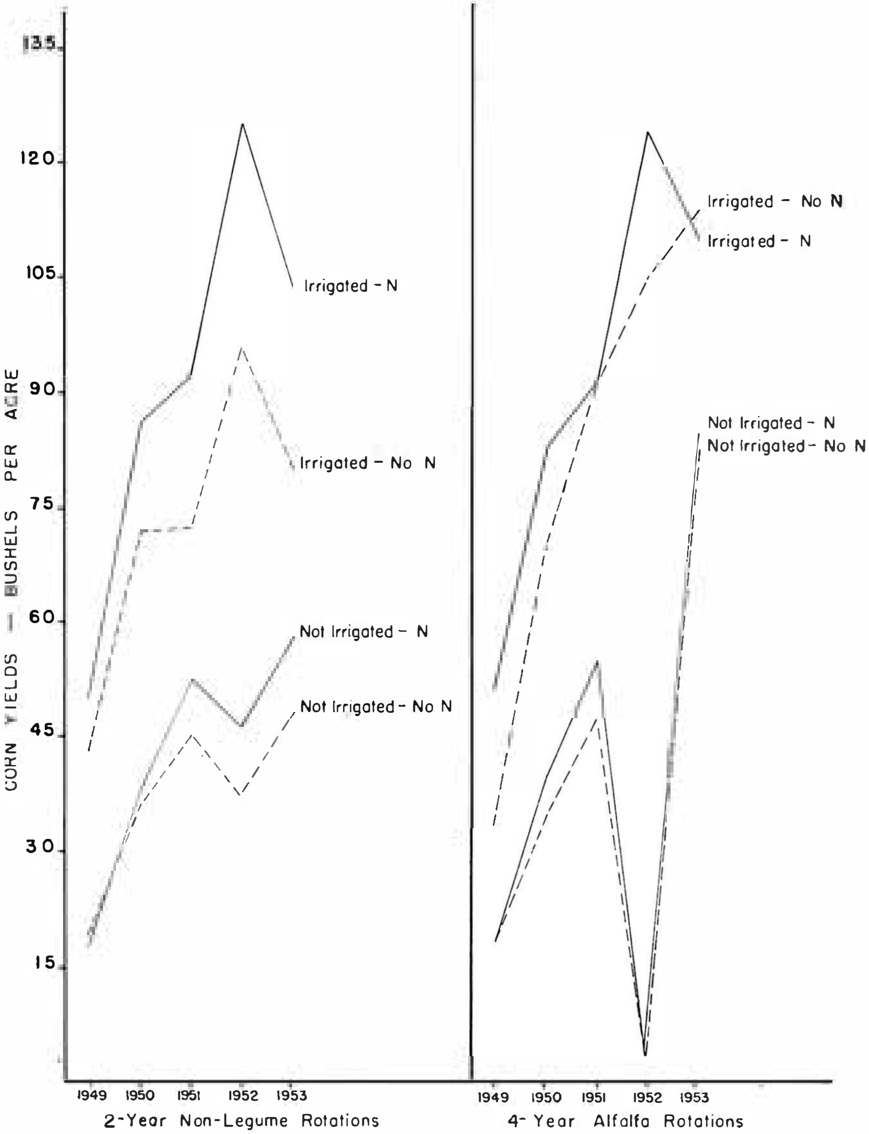


**Table 19. The Effects of Irrigation, Rotation and Nitrogen Fertilizer on Wheat Yields, Redfield, 1949-53**

| Treatment | Irrigated Rotations 4-Year C-W-A-A* | 2-Year C-W | % Increase for Alfalfa | Non-Irrigated Rotations 4-Year C-W-A-A | 2-Year C-W | % Increase for Alfalfa |
|---|---|---|---|---|---|---|
| | Bu./A. | Bu./A. | % | Bu./A. | Bu./A. | % |
| None | 22.4 | 20.1 | 11.4 | 20.4 | 14.9 | 36.9 |
| Nitrogen† | 33.9 | 32.8 | 3.3 | 25.6 | 22.6 | 13.3 |
| Percent increase for fertilizer | 51.3 | 63.1 | — | 25.5 | 51.6 | — |

*Corn, wheat, alfalfa, alfalfa.
†Nitrogen rates are 30 pounds per acre and 60 pounds per acre on non-irrigated and irrigated plots, respectively.

minate corn in this case until late June, resulting in a corn failure in the non-irrigated alfalfa rotation.

### *Wheat Yields*

The effects of irrigation, rotations, and nitrogen fertilizers on spring wheat yields are presented in Table 19. Here again, nitrogen was the only fertilizer element having a consistent significant effect on wheat yields.

The major observations which can be made on the basis of results so far as concerns wheat yields are:

1. Nitrogen fertilizer has had more effect on yields than rotation or irrigation. However, the effect of nitrogen is greater *within* the irrigated rotations than in the non-irrigated rotations.

2. As would be expected, nitrogen has increased wheat yields more in the non-legume rotations, both irrigated and non-irrigated, than in the legume rotations.

3. Percentage and actual bushel yield increases from nitrogen have been greater in the irrigated than in the non-irrigated rotations.

4. Response to irrigation alone ranged from 10 percent for the unfertilized wheat in an alfalfa rotation to 45 percent in the 2-year, fertilized comparison.

5. Contrary to the results with corn, alfalfa in the rotation two years out of four has not induced the degree of productivity in wheat that nitrogen fertilizer has produced. This disparity is greater in the irrigated rotations than in non-irrigated. The reason for this may lie in the fact that corn followed alfalfa and wheat followed corn, which gave the corn crop the opportunity to utilize a major part of the nitrogen stored by the alfalfa.

6. In a detailed inspection of the data, it was observed that in three of the five years of this study, well fertilized non-irrigated plots outyielded the irrigated plots with no fertilizer nitrogen. Thus, in this period, fertility limited production more often than did moisture.

### *Alfalfa Yields*

The yields of alfalfa hay harvested in the four years, 1950 to 1953, are shown in Table 20.

The effect of irrigation has been to increase alfalfa yields approximately 2.25 tons per acre per year, or about 81 percent. There has been no significant effect from the use of phosphate fertilizer on hay yields on this soil.

**Table 20. Alfalfa Hay Produced on Phosphate Fertilized and on Control Plots in Irrigated and Non-Irrigated Rotations at Redfield, 1950-53***

| Year | Irrigated | | Non-Irrigated | |
|---|---|---|---|---|
| | Phosphate | No Phosphate | Phosphate | No Phosphate |
| | T./A. | T./A. | T./A. | T./A. |
| 1950 | 4.94 | 4.66 | 2.04 | 2.04 |
| 1951 | 4.79 | 4.55 | 2.40 | 2.59 |
| 1952 | 5.09 | 5.09 | 2.16 | 2.16 |
| 1953 | 5.40 | 5.40 | 4.25 | 4.25 |
| Average | **5.05** | **4.92** | **2.71** | **2.76** |

*15 percent moisture basis.

# *Corn Fertilization and Management*

Because of the economic importance of corn and the probable increased emphasis under irrigation, major attention has been given experiments concerned with the culture of this crop. These experiments have ranged in nature from simple nitrogen fertility trials to extensive experiments combining methods of planting, rate of planting, fertility and moisture.

For satisfactory performance, corn must have adequate fertility available in the root zone at all times during the growing season. A 100-bushel crop of corn absorbs from the soil at least 155 pounds of nitrogen, 30 pounds of phosphorus and 115 pounds of potash per acre. This requires that at least double these amounts be available in the soil. In most South Dakota soils there is adequate phosphorus and potassium, so most of the work has been concerned with nitrogen; however, phosphorus and potassium have been variables in some experiments.

**Table 21. Yields of Irrigated Corn in a Corn-Wheat and a Wheat-Alfalfa-Alfalfa-Corn Rotation with Various Fertilizer Treatments, Redfield, (Averages for 1950—1953)**

| Fertilizer Treatment* | Corn-Wheat Rotation | Alf.-Alf.-Corn-Wheat |
|---|---|---|
| | Bu./A. | Bu./A. |
| 0- 0-0 | 65.3 | 96.1 |
| 0-100-0 | 74.1 | 96.4 |
| 40-100-0 | 82.8 | —— |
| 60-100-0 | —— | 101.4 |
| 80-100-0 | 99.8 | —— |
| 100-100-0 | 100.0 | 102.5 |
| 140-100-0 | 103.0 | —— |
| 160-100-0 | —— | 101.8 |
| 180-100-0 | 101.9 | —— |

*Figures indicate pounds of nitrogen, phosphoric acid and potassium oxide, respectively, applied per acre.

### *Legumes Supply the Nitrogen to Corn*

An exploratory experiment at the Huron farm in 1950 showed that extra nitrogen in the form of commercial fertilizer was of little value when the corn was grown on land which had grown alfalfa in the years just preceding. Nitrogen applications of 0, 80, 160, and 240 pounds per acre resulted in yields of 87, 78, 89, and 88 bushels of corn per acre, respectively. In this case the alfalfa was plowed the fall preceding the corn crop.

Experiments at Redfield with corn following alfalfa showed moderate nitrogen response in 1950, slight response in 1952 and no response in 1951 and 1953. It appears that corn grown on land which has had a legume for at least two preceding years required no fertilizer nitrogen under conditions similar to those of 1950 to 1953.

The data in Table 21 present some of the results of fertilizer experiments conducted from 1949 to 1953 under conditions where there was no legume in the rotation and where two years of alfalfa preceded the corn.

These data illustrate the effectiveness of alfalfa in supplying the nitrogen needs of the corn crop, inasmuch as only a 5-bushel yield increase was obtained by adding nitrogen fertilizer for corn following alfalfa. The response of corn to nitrogen seems to reach its optimum at about 80 pounds per acre in the non-legume rotation, as only 2 or 3 bushels more are obtained by further increments.

The beneficial effect of alfalfa in the rotation has increased with time. Corn yields have shown a steadily increasing advantage in the alfalfa rotation as compared to the non-legume rotation. Yields thus derived are at this time apparently about equal to the effect of 80 pounds of nitrogen applied as commercial fertilizer.

### *Methods of Planting, Plant Populations, and Irrigation of Corn*

Experiments were conducted at Redfield in 1950 and in 1951 to determine the conditions of plant population, or stand, and row width, combined with fertility, which are required for maximum yields of corn. The work in 1950 showed that 30-inch rows could slightly exceed 36-inch rows in yield at very high plant populations, but the practical difficulties of handling 30-inch rows of corn make the use of this row spacing of doubtful value. An experiment comparing drill and hill planting, each at two plant population, 14,520 and 19,360 per acre, was conducted at Redfield in 1951. In addition, each method-population combination was planted at three levels of soil nitrogen, 0, 50 and 100 pounds of nitrogen added per acre. This resulted in 12 method-population - fertility combinations, each of which was repeated four times. The effect of these practices on yields of hybrid corn (Sokota 270) are presented in Table 22.

The data in the table indicate that the fertility status of the soil and the plant population are the most important factors in corn production, and method of planting

**Table 22. Yield of Corn at Three Levels of Soil Nitrogen as Influenced by Method and Rates of Planting, Redfield, 1951**

| Nitrogen Added to | Planting Method and Number of Plants per Acre | | | | |
|---|---|---|---|---|---|
| Soil Lbs. | Drill :14,520 | Drill :19,360 | Hill :14,520 | Hill :19,360 | Average |
| | Bu./A. | Bu./A. | Bu./A. | Bu./A. | Bu./A. |
| 0 | 65.6 | 60.6 | 65.3 | 58.8 | 62.6 |
| 50 | 82.5 | 91.1 | 81.1 | 83.9 | 84.5 |
| 100 | 86.4 | 92.3 | 87.8 | 89.7 | 89.0 |
| **Average** | **78.2** | **81.3** | **78.1** | **77.5** | |

*Left,* irrigation in tasseling stage, none thereafter; *right,* irrigation in milk and denting stages only

least important. A population of about 19,000 plants per acre is attained by spacing plants 9 inches apart in drilled 36-inch rows or by planting 4 to the hill in hill-planted 36-inch rows. It is essential that plant population of at least that many plants be combined with adequate soil fertility in order to attain satisfactory yields.

Analysis of the data on average ear weights showed that the yield increases were due mainly to larger ears at the higher nitrogen levels, and only slightly to increases in number of ears.

In regards to timing of irrigation for corn, the primary principle learned to date is the need for adequate moisture in the tasseling through pollinating stage of growth. This is the critical period in the life of the corn plant.

# Sugar Beet Management

Sugar beets have been grown to some extent for the last four years on the Redfield farm and have proved to be quite a satisfactory crop for that area.

An experiment was set up in 1952 on the Redfield farm with various nitrogen, phosphorus and soil moisture levels, to study their effect upon sugar beet phsyiology and growth. The treatments applied in the experiment are shown in Table 23, along with the corresponding yields produced. The fertilizer was applied in bands 2 inches to the side and 1 inch below the seed at planting time.

By maintaining the soil moisture supply at a high level, it was possible to produce a yield of 21.2 tons of beets per acre as compared to 18.4 tons produced on plots where moisture supply was limited. Through the use of nitrogen fertilizer, yields were increased from 17 to 21.8 tons per acre. Nitrogen increased yields on plots at both high and low moisture levels. Phosphorus application however, depressed yields slightly (1 ton per acre) on

**Table 23. Sugar Beet Yields Produced at Two Moisture Levels as Influenced by Nitrogen and Phosphorus Fertilizer Banded at Seeding Time, Redfield, 1952**

| Nitrogen Fertilizer | Phosphorus Fertilizer | Beet Yields: Low Moisture | Beet Yields: High Moisture |
|---|---|---|---|
| Lbs./A. | Lbs./A. | T./A. | T./A. |
| 0 | 0 | 14.3 | 17.4 |
| 0 | 40 | 15.8 | 21.0 |
| 40 | 0 | 18.1 | 20.3 |
| 40 | 40 | 18.3 | 20.8 |
| 80 | 0 | 21.0 | 21.0 |
| 80 | 40 | 18.5 | 23.4 |
| 120 | 0 | 22.6 | 21.8 |
| 120 | 40 | 19.1 | 23.7 |
| Average | | 18.4 | 21.2 |

plots having insufficient moisture, but, conversely, increased yields over 2 tons per acre on plots having sufficient moisture.

At any specific nitrogen level with high moisture, phosphorus increased the yield. Thus it appears that at high moisture levels, phosphorus, as well as nitrogen, is a real limiting factor. To obtain maximum yields then, all three factors: nitrogen, phosphorus and moisture must be readily available to the plant in proper balance.

An additional effect of nitrogen was to cause more luxuriant top growth. It also slightly increased sugar content of the beets at the low moisture level. The sugar content and purity in this experiment were unusually high, according to the analysis made by the Utah-Idaho Sugar Company, Belle Fourche, South Dakota. The average sugar content for the experiment was 18.5 percent with a purity of 86.3 percent.

Another effect of nitrogen application was an increase in the efficiency of the utilization of fertilizer phosphate by the beet plant. This efficiency was increased approximately 100 percent by the band application of 80 pounds of nitrogen per acre with the phosphate.

# *Effect of Fertilizer on Grass Seed and Hay Production*

Experiments concerned with the seed and hay produced by various grasses were conducted at both the Huron and Redfield Development Farms. In both places only some of the more common grasses have been studied.

### *Seed Production*

As in non-irrigated farming, the chief limiting factor in seed production of grasses under irrigation is usually available soil nitrogen. With this in mind, seedings of nine grasses were made at the Huron Development Farm in 1950. In 1951 and 1952 each of these grasses was treated with nitrogen fertilizer at the rates of 40, 80 and 160 pounds of actual nitrogen. This corresponds to applications of 120, 240 and 480 pounds of 33-0-0 per acre. These treatments were replicated four times on each grass, along with control plots in each set. Seed yields were determined on four of these grasses in 1951 and the results are presented in Table 24.

All four grasses responded markedly to nitrogen additions up to 80 pounds per acre; crested wheat grass gave a further increase at 160 pounds of nitrogen, whereas the other three species showed a sharp decrease. The reason seemed to be that the other three grasses were sod-forming types and became too

**Table 24. Seed Yields of Grasses Grown Under Irrigation at Four Levels of Nitrogen, Huron, 1951**

| Nitrogen Added | Brome | Ree Wheat | Tall Wheat | Crested Wheat |
|---|---|---|---|---|
| Lbs./A. | Lbs./A. | Lbs./A. | Lbs./A. | Lbs./A. |
| 0 | 91 | 106 | 148 | 93 |
| 40 | 252 | 242 | 296 | 405 |
| 80 | 291 | 326 | 372 | 433 |
| 160 | 204 | 193 | 331 | 532 |

dense in growth and entirely too vegetative in character at the 160 pound nitrogen level, whereas crested wheatgrass did not respond in this manner.

### *Hay Yields*

Experiments which included six grasses in 1951 and nine in 1952 were conducted at the Huron Development Farm. One crop of hay was cut in 1951 and two were cut in 1952. The yield results are presented in Table 25.

A similar experiment was conducted at the Redfield farm on six grasses during the years 1952 to 1953. One difference was that instead of the 160-pound nitrogen application, alfalfa was sown with the grass. The yield results of this experiment for the two years are shown in Table 26.

The data for both Huron and Redfield illustrate the progressive increase in hay yields with increasing nitrogen applications. For every grass at Redfield, yields were increased approximately 100 percent by the first 40-pound increment of nitrogen. The results at Huron were slightly less striking, but nevertheless impressive. Alfalfa sown with the grass caused approximately the same yield increases of forage as those obtained by the 80-pound application of nitrogen. Thus, if the forage is to be used for hay only and not grazed, it is economical to seed alfalfa with the grass. However, if the bloat problem has to be considered when grazing the forage, the risk that occurs with alfalfa makes the use of commercial nitrogen an attractive alternative.

Protein values were determined on the nitrogen-fertilized hays and on the alfalfa-grass mixtures. The first cutting is always considerably higher in protein, and crude protein values in the first crop ranged from 7.24 percent with no nitrogen to

**Table 25. Influence of Nitrogen Fertilizer on Hay Yields of Grasses under Irrigation, Huron, 1951 and 1952**

| Grass | Year | Hay Yields at 15% Moisture: No Nitrogen | 40 Lbs. N. per Acre | 80 Lbs. N. per Acre | 160 Lbs. N. per Acre |
|---|---|---|---|---|---|
| | | T./A. | T./A. | T./A. | T./A. |
| Alta fescue | 1951 | 0.23 | 0.64 | 0.92 | 1.05 |
| | 1952 | 0.75 | 1.50 | 2.62 | 3.45 |
| Russian wild rye | 1951 | 0.22 | 0.67 | 0.85 | 1.19 |
| | 1952 | 0.73 | 1.26 | 1.93 | 2.39 |
| Tall wheatgrass | 1951 | 0.33 | 0.52 | 0.91 | 1.07 |
| | 1952 | 1.65 | 1.72 | 2.45 | 3.36 |
| Crested wheatgrass | 1951 | 0.34 | 0.82 | 1.17 | 1.44 |
| | 1952 | 0.98 | 1.41 | 1.54 | 2.66 |
| Ree wheatgrass | 1951 | 0.55 | 1.29 | 1.51 | 1.83 |
| | 1952 | 1.07 | 1.75 | 2.07 | 3.15 |
| Smooth brome | 1951 | 0.57 | 1.34 | 1.87 | 1.99 |
| | 1952 | 0.82 | 1.29 | 1.93 | 3.49 |
| Astoria bent | 1952 | 0.96 | 1.41 | 1.70 | 2.53 |
| Tall oatgrass | 1952 | 0.94 | 1.38 | 1.63 | 2.60 |
| Creeping red fescue | 1952 | 0.75 | 1.71 | 2.22 | 3.97 |

**Table 26. Yields of Hay Produced at Redfield by Six Grasses Under Irrigation with Three Levels of Soil Nitrogen and with Alfalfa, 1952-53**

| | | Hay Yields at 15% Moisture | | | | |
|---|---|---|---|---|---|---|
| Grass | Year | Number of Crops | No Nitrogen | 40 Lbs. N. per Acre | 80 Lbs. N. per Acre | Grass with Alfalfa |
| | | | T./A. | T./A. | T./A. | T./A. |
| Lancaster brome | 1952 | one | 0.38 | 0.82 | 0.97 | 1.88 |
| | 1953 | two | 0.92 | 1.98 | 2.71 | 2.28 |
| Homesteader brome | 1952 | one | 0.42 | 1.04 | 1.46 | 2.04 |
| | 1953 | two | 1.00 | 2.19 | 2.85 | 3.45 |
| Ree wheatgrass | 1952 | one | 0.61 | 1.44 | 1.59 | 2.03 |
| | 1953 | two | 1.39 | 2.61 | 2.95 | 3.44 |
| Reed canary | 1952 | one | 0.49 | 0.67 | 0.56 | 1.95 |
| | 1953 | two | 1.57 | 2.26 | 2.94 | 3.03 |
| Orchard grass | 1952 | one | 0.36 | 0.89 | 1.10 | 1.39 |
| | 1953 | two | 1.18 | 1.77 | 2.62 | 2.66 |
| Tall oatgrass | 1952 | one | 0.27 | 1.04 | 0.96 | 1.76 |
| | 1953 | two | 0.98 | 2.06 | 2.88 | 2.38 |

23.0 percent with 160 pounds of nitrogen in the Huron experiment, and from 7.71 percent with no nitrogen to 11.32 percent with 160 pounds of nitrogen in the second cutting.

Protein contents found in the variously fertilized grass hays and in the grass-alfalfa mixtures in the first cutting at Redfield in 1952 varied considerably. They ranged from 10.7 percent in tall oat grass with no nitrogen fertilizer to 18.1 percent in reed canary grass fertilized with 80 pounds of nitrogen per acre, and to 20.2 percent in the Lancaster brome-alfalfa mixture.

On the basis of total pounds of protein produced per acre, the most economical protein is produced at the highest nitrogen fertilizer level, inasmuch as highest yields and highest protein percentage result from this treatment. However, the grass-alfalfa mixtures produced a greater total amount of protein per acre, in most cases, than the 80-pound nitrogen application, but not as much as 160 pounds did in the Huron experiment.

# *Soybean Management*

The first soybean experiment was conducted on the Redfield farm in 1952, the second in 1953. These tests were made to determine the yield potentialities of soybeans as affectted by various moisture regimes, and to measure the effects of row spacing and plant populations.

*1952 Experiments:* Two moisture levels were used in the experiment; half of the plots were provided with adequate moisture, the other half received no irrigation. Beans were planted in rows 9, 18, and 36 inches apart, with plant spacings of 2, 3 and 4 inches within the row. The

**Table 27. Soybean Yields in a Moisture-Row Spacing-Planting Rate Experiment at Redfield, 1952**

| Moisture Treatment | Plant Spacing in Row | Row Spacing in Inches 36 | 18 | 9 | Average |
|---|---|---|---|---|---|
| | Inches | Bu./A. | Bu./A. | Bu./A. | Bu./A. |
| Irrigated | 4 | 29.8 | 44.2 | 36.6 | 36.9 |
| | 3 | 30.1 | 53.1 | 34.5 | 39.2 |
| | 2 | 30.9 | 46.6 | 33.9 | 37.1 |
| **Average** | | 30.3 | **48.0** | **35.0** | **37.7** |
| Non-Irrigated | 4 | 27.7 | 42.6 | 45.0 | 38.4 |
| | 3 | 26.7 | 40.7 | 30.8 | 32.7 |
| | 2 | 23.0 | 39.3 | 26.1 | 29.5 |
| **Average** | | **25.8** | **40.9** | **33.9** | **33.5** |
| **Over-all Average** | | **28.0** | **44.4** | **34.5** | **35.6** |

Least significant difference (5%) for spacing, 4.7*

Least significant difference (5%) for Moisture x Row Sp. x Pop., 11.7†

*Least significant difference (5%) means that only 5 times out of 100 the effect observed would be due to chance and not to treatment. Differences in yield of less than 4.7 bushels for spacing are not statistically significant.
†Difference in yield of less than 11.7 bushels for Moisture x Row. Sp. x Pop. are not statistically significant.

beans were planted on recently plowed grass land on May 15 at a depth of 1½ to 2 inches. The stand was later adjusted by thinning and some replanting. The irrigated plots received three irrigations during the summer. The crop was harvested fully ripe on September 16. The yields obtained with the various treatments are presented in Table 27.

Soybeans planted in 18-inch rows gave greater yields than in either 9-inch or 36-inch rows in all combinations of plant spacing and moisture level, except for the 4-inch spacing in the 9-inch rows on the low moisture plots. On an over-all average, the 9-inch rows yielded better than the 36-inch rows. The results show that the row-width plant spacing combination found best under irrigation is not the optimum combination for non-irrigated conditions. The surprising lack of response of soybeans to irrigation in this experiment is attributed to the excellent physical condition of the soil and the fact that rainfall occurred in June at the time of greatest need.

In undertaking another experiment in 1953, with similar objectives, it was hoped to confirm the conclusions drawn from the 1953 work as well as to add to the information already obtained. In this experiment three moisture conditions were set up as follows: $M_0$—no irrigation; $M_1$—adequate irrigation to three weeks after first bloom, none thereafter; $M_2$—adequate irrigation to maturity of crop. Three varieties were planted in 18- and 36-inch rows. The three variables (moisture, varieties, and row spacing) appeared in all combinations in each of six replications of the experiment.

The soybeans were planted May 19. Two of the varieties, Capital and

Ottowa Mandarin, were harvested September 15; Blackhawk matured about five days later. $M_1$ moisture treatment received one irrigation on July 27. $M_2$ received two irrigations: July 22 and August 25.

Both Capital and Blackhawk exhibited a branching, semi-decumbent type growth, whereas Ottowa Mandarin displayed a more desirable, erect, single-stem growth habit. The latter variety had a tendency to fruit closer to the soil surface than either Capital or Blackhawk. Neither maturity nor the degree of lodging seemed to be influenced by row spacing or moisture treatment. Yields resulting from the various treatments are shown in Table 28.

As seen in the table, moisture treatments $M_1$ and $M_2$ produced greater yields than did $M_0$. Significantly higher yields were obtained on the 18-inch rows than on 36-inch rows, with greater differences occurring for the Capital variety than for Blackhawk, and Ottowa Mandarin falling between the two. This difference in performance, evidenced by the significant interaction between variety and spacing, points up the improved performance of Capital and Ottowa Mandarin on the 18-inch rows as compared to the 36-inch rows. The yields of the three varieties were not significantly different.

On the basis of the two experiments, it is concluded that under irrigated conditions the greatest yields can be obtained by planting in 18-inch rows with plants about 3 inches apart within the rows. The moisture supply should be kept adequate throughout the development of the crop to insure maximum yields.

In a growing season shortened by early frost, later varieties such as Blackhawk may not mature. It would, therefore, seem advisable to use an earlier variety. Of the three varieties tested, Ottowa Mandarin had the most desirable characteristics for combining.

**Table 28. Soybean Yields in a Moisture-Row Spacing-Variety Experiment at Redfield, 1953**

| | Variety | | | | | | |
|---|---|---|---|---|---|---|---|
| | Capital | | Ottawa Mandarin | | Blackhawk | | |
| | 18" Rows | 36" Rows | 18" Rows | 36" Rows | 18" Rows | 36" Rows | Average |
| Moisture Treatment | Bu./A. | Bu./A. | Bu./A. | Bu./A. | Bu./A. | Bu./A. | Bu./A. |
| $M_0$ | 35.2 | 26.1 | 33.9 | 28.3 | 30.4 | 26.6 | 30.1 |
| $M_1$ | 36.6 | 28.1 | 34.8 | 27.8 | 33.8 | 29.2 | 31.8 |
| $M_2$ | 37.8 | 29.4 | 37.5 | 28.7 | 34.4 | 31.3 | 33.2 |
| **Average** | **36.6** | **27.9** | **35.4** | **28.3** | **32.9** | **29.0** | **31.7** |
| Variety Average | 32.2 | | 31.9 | | 31.0 | | |

Least significant difference (5%) for Moisture, 1.6*

Least significant difference (5%) for Var. x Sp., 1.8†

*Least significant difference (5%) means that only 5 times out of 100 the effect observed would be due to chance and not to treatment. Differences in yield for moisture of less than 1.6 bushesl are statistically not significant.

†Differences in yield for Var. x Sp. of less than 1.8 bushels are statistically not significant.

# Water Management

## Soil Moisture Depletion

A SUCCESSFUL irrigation enterprise depends in part upon the irrigation management, which includes a knowledge of (1) the amount of water required by a particular crop, (2) at what depth the soil profile water is used by specific plants, and (3) the time this water should be supplied to the plants for most economical and abundant production.

Crops need a fairly definite amount of moisture during the growing season. They use it at rates which are not constant over any extended period of time. Some crops have a gradually increasing rate from planting time until the peak use period is reached, then a gradual decrease until harvest, while others use moisture more uniformly all year. Different crops require water in varying amounts, from different soil depths and may have different peak use periods.

In the last few years, considerable research has been conducted at the Redfield Development Farm with regard to irrigation efficiencies, use of moisture by various crops, infiltration rates, and proper management of irrigation water.

### Consumptive Use of Water

The consumptive use of water (water used by vegetative growth) by various crops was actually measured and these figures plus the yield figures are given in Table 29.

The seasonal consumptive use remained nearly constant from year to year, but yields varied. This indicates that specific plants, at a certain location, use a definite quantity of water regardless of other variables which affect yield. The yield variations are a result of fertility and weather differences, and disease infestation.

Alfalfa data in the table show a consumptive use of about 23 inches. It should be kept in mind that 23 inches would be the requirement up until the third crop is harvested. If, as in many years, a fourth crop is possible, or late growth is desired for keeping a hardy stand, an additional 4 to 5 inches of water would be consumed.

The consumptive use figures in this report can be considered accurate enough for most practical purposes in this area. Consumptive use data for other areas of South Dakota are available.[1]

### Profile Consumptive Use

It is not only important to know how much water the plant uses, but where in the soil the plant obtains this moisture. In order to find this out, measurements were made at 1-foot intervals through a 4-foot profile from 1951 till 1953. The 1953 studies included a depth of 5 feet.

[1]Leonard J. Erie, "Consumptive Use and Irrigation Requirements of Crops in South Dakota," Brookings, South Dakota, USDA, Soil Conservation Service Research, Division of Irrigation and Water Conservation 1952.

Leonard J. Erie and Niel A. Dimick, "Soil Moisture Depletion by Irrigated Crops Grown in South Dakota," South Dakota Experiment Station Circular 105, 1954.

Data in Table 30 indicate that nearly 90 percent of the moisture used was consumed from the top 3 feet, approximately 75 percent from the first 2 feet, and over half of the water used was from the top foot. Only a small percentage of the water used by crops is taken from below 3 feet.

### *Field Irrigation Efficiency and Infiltrations*

During the past four years various measurements have been made of infiltrations, rates of advance, irrigation efficiencies, and proper streams of water on various widths of rows and borders. These measurements indicate that relatively high irrigation efficiencies may be achieved on the Beotia silt loam soil. The irrigation trials were carried out on fields having slopes averaging 3½ inches per 100 feet.

Field irrigation efficiency is expressed as the percentage of irrigation water delivered to the field that is available in the soil for use by the crops. Average field irrigation efficiencies calculated from measurements made on 60 borders were 70 percent. Runoff water amounted to 15 percent, which indicates that 15 percent of the water was lost to deep percolation and evaporation.

Trials on 22-inch sugar beet rows showed a 63 percent field irrigation efficiency. Runoff measurements indicated a loss in water of 20 percent; thus 17 percent of the water was lost through evaporation and deep percolation. Efficiency trials on 36-inch rows, indicated a runoff of 34 percent; thus a field irrigation

**Table 29. Consumptive Use of Water and Yield of Crops, Redfield, 1950 to 1953**

| | | Consumptive Use(Inches) | | |
|---|---|---|---|---|
| Crop | Year | Seasonal† | Daily | Yield |
| Alfalfa* | 1950 | 21.8 | 0.20 | 5.88 T. |
| | 1951 | 20.5 | 0.19 | 4.93 T. |
| | 1952 | 23.1 | 0.20 | 6.74 T. |
| | 1953 | 23.6 | 0.17 | 5.40 T. |
| Dry beans | 1952 | 15.8 | 0.15 | |
| | 1953 | 17.0 | 0.17 | 1354 Lbs. |
| Corn | 1951 | 16.7 | 0.15 | |
| | 1952 | 16.8 | 0.13 | 85 Bu. |
| | 1953 | 16.4 | 0.14 | 92 Bu. |
| Flax | 1952 | 16.0 | 0.15 | 24.9 Bu. |
| | 1953 | 14.0 | 0.16 | 21.4 Bu. |
| Potatoes | 1950 | 15.3 | 0.15 | 506 Bu. |
| | 1951 | 15.7 | 0.14 | 273 Bu. |
| | 1952 | 15.1 | 0.13 | 450 Bu. |
| | 1953 | 16.8 | 0.15 | 297 Bu. |
| Soybeans | 1952 | 15.3 | — | 37.7 Bu. |
| | 1953 | 16.0 | 0.14 | 31.7 Bu. |
| Sugar beets | 1951 | 24.7 | 0.18 | 24.7 T. |
| | 1952 | 23.3 | 0.15 | 19.6 T. |
| | 1953 | 24.0 | 0.15 | 15.4 T. |
| Wheat | 1953 | 16.3 | 0.18 | 31.3 Bu. |

*Consumptive use figures for alfalfa represent that moisture used during the growth of three hay crops, and not that used for the entire growing season.

†Seasonal use divided by daily use equals the number of days used in determining the consumptive use figure (usually planting date to harvest date).

Table 30. Consumptive Use Derived From Each Foot of Soil Profile, Redfield, 1951-53

| Crop | Year | Percent of Moisture Used for Different Depths 0-1 Feet | 1-2 Feet | 2-3 Feet | 3-4 Feet | 4-5 Feet |
|---|---|---|---|---|---|---|
| Alfalfa | 1951 | 54 | 23 | 16 | 7 | -- |
| | 1952 | 42 | 25 | 22 | 11 | -- |
| | 1953 | 47 | 23 | 18 | 9 | 3 |
| Dry beans | 1952 | 53 | 23 | 15 | 9 | -- |
| | 1953 | 57 | 22 | 13 | 8 | 0 |
| Corn | 1951 | 49 | 19 | 19 | 13 | -- |
| | 1952 | 44 | 25 | 20 | 11 | -- |
| | 1953 | 58 | 23 | 12 | 5 | 2 |
| Flax | 1952 | 52 | 21 | 17 | 10 | -- |
| | 1953 | 68 | 20 | 12 | 0 | 0 |
| Potatoes | 1951 | 69 | 13 | 11 | 7 | -- |
| | 1952 | 54 | 21 | 18 | 7 | -- |
| | 1953 | 52 | 20 | 15 | 9 | 4 |
| Sugar beets | 1951 | 54 | 22 | 15 | 9 | -- |
| | 1952 | 52 | 25 | 15 | 8 | -- |
| | 1953 | 52 | 24 | 12 | 9 | 3 |
| Wheat | 1953 | 56 | 21 | 13 | 9 | 1 |

efficiency of about 55 percent could be expected, assuming an 11-percent water loss due to deep percolation and evaporation.

Irrigation efficiencies are affected by length of run, size of irrigation stream, slope, compaction, crops, width of rows, skill of the irrigator and many other factors. Considerable variation can be expected among the many different irrigation enterprises. It would be reasonable to expect a field irrigation efficiency of 75 percent on borders, 70 percent on narrow rows with light irrigations and a 50 percent on 36-inch rows on soils in this region. Lower efficiencies may be expected on steeper slopes.

Infiltration rates on the Beotia silt loams make these soils well adapted to relatively long runs. These soils have a high initial infiltration rate which decreases to a relatively low final infiltration rate. The final infiltration rate as determined from field measurements on 15 borders is 0.48 of an inch per hour at the end of 10 hours.

Ring infiltrometer measurements indicate that the first 1½ inches of irrigation water will often penetrate the soil in less than one hour. The first one-half inch will penetrate in approximately six minutes. Infiltration rates may vary between fields, irrigations, and seasons; however, the infiltration rate trends indicate that the Beotia silt loam soils lend themselves very well to relatively high efficiencies and long runs. The maximum length of run, on areas of fairly flat topography will be limited by the size of the stream of water that a border or row will hold and control, rather than by the erosion limitations or infiltration rates. The erosion limitation would, however, be one of the main factors in controlling the length of run on the steeper slopes.

# *Sprinkler Irrigation Efficiency*

A sprinkler irrigation experiment, utilizing different size sprinkler nozzles, was initiated at the Redfield Development Farm on alfalfa plots to determine field irrigation efficiencies. This experiment was conducted during the 1951 and 1952 growing seasons.

Wind velocity, relative humidity, application rate, temperature, and sunshine hours were considered to be the influencing factors. Measurements were made of these factors and recorded. Standard recommended practices, with regard to sprinkler spacing and operating pressures, were used to obtain the field irrigation efficiencies that are shown in Table 31.

Inspection of the table reveals that the various factors have different degrees of influence on the field irrigation efficiency. The relative humidity of the air and the rate of water application have a greater effect than the wind velocity during the irrigation. Further analysis indicates that when high relative humidity prevails, less irrigation water is lost. When the air temperature is low it minimizes the effect of low humidity, because air at low temperatures has little capacity for added moisture, and the resultant evaporation rate from the sprinkled water will be low. Higher efficiencies will be experienced during periods of comparatively low temperature and high relative humidity.

High application rates will decrease the detrimental effect of hot, dry, windy conditions. If the irrigation field layout permits, sprinkler systems should be so designed that the water application rate is as high as possible without causing surface runoff, because the application rate will influence the field irrigation efficiency. The higher the rate of water application, the more efficient the application will be, provided it is not applied at such a high rate

**Table 31. Sprinkler Irrigation Field Application Efficiencies, Redfield, 1951 and '52***

| Wind M.P.H. | Relative Humidity % | Application Rate Inch/Hr. | Temperature °F | Sunshine Hours % | Efficiency† % |
|---|---|---|---|---|---|
| 2.0 | 55 | 0.7 | 65 | 100 | 95 |
| 10.0 | 75 | 0.7 | 70 | 50 | 90 |
| 6.0 | 60 | 0.7 | 80 | 60 | 90 |
| 5.0 | 50 | 0.7 | 60 | 90 | 89 |
| 6.0 | 35 | 0.7 | 75 | 50 | 88 |
| 18.0 | 40 | 0.7 | 80 | 80 | 84 |
| 5.5 | 60 | 0.45 | 70 | 50 | 76 |
| 14.5 | 30 | 0.7 | 80 | 100 | 74 |
| 7.5 | 40 | 0.45 | 80 | 100 | 72 |
| 19.0 | 30 | 0.7 | 90 | 100 | 68 |
| 14.0 | 35 | 0.45 | 90 | 100 | 65 |

*No runoff water occurred during irrigation, therefore, the water loss is accountable to either deep percolation and/or evaporation.
†Field irrigation efficiencies are arrayed.

that surface runoff occurs.

Air movement or wind has a bearing on the amount of water lost. However, it has a more detrimental distortion effect on the sprinkling pattern than on the actual water loss. To overcome the distortion of the sprinkling pattern, proper equipment, such as adequate sprinkler head, sprinkler spacings, proper management of distance of move, and pressures must be considered.

The experiment showed that if an application rate of at least 0.7 of an inch per hour is used, it is reasonable to expect that an average field irrigation efficiency of about 75 percent can be attained.

# Summary

Extensive research on crop varieties, soil fertility and mangement, pastures, and water management on irrigated and non-irrigated land has been carried on in the James River Area during the last five years. Most of the work was conducted at the Huron and Redfield Development Farms.

The field crops investigated were small grains, corn, legumes and grasses. Fruit trees and vegetables were included in the trials conducted by the Horticulture Department. In order to find out what effect irrigation would have on pastures, controlled pasture trials were run with native grass as well as with improved grass-legume pastures.

Research concerning rotations, management of corn, sugar beets and soybeans, and grass and hay production was carried on by soil scientists. Also, at the Redfield Development Farm, work on irrigation efficiencies, use of moisture by various crops, infiltration rates and proper management of irrigation water was initiated.

*Small grain* yield trials during the period 1949 to 53 indicate that varieties well adapted to dry-land conditions are generally also the best to grow under irrigation. Of the present varieties, Lee spring wheat, Montcalm barley and Ajax oats were best under irrigation. Lodging may be a problem in irrigation; and production problems, such as getting stands, maintaining good tilth, weed control and proper timing of water applications should be considered. Plant diseases are likely to increase in severity and number under irrigation, making their control by good farm practices, chemicals and the breeding of superior varieties very important.

*Corn* yield tests have shown that generally the same hybrids have performed well on both irrigated and non-irrigated soil. Among the better ones were Pioneer 377A, Sokota 220, Sokota 400, Sokota 224, S. Dak. Exptl. 9, Funk's G-1A, and Kingscrost KS6. In most years, irrigation hastened maturity slightly.

In the *forage strain* trials it was found that irrigation resulted in increased plant vigor and yield for alfalfa. The leaf and stem diseases of alfalfa were severe under both the irrigation and dry-land conditions. Irrigation has brought about

no marked changes in *relative* performance of strains with respect to such characteristics as dormancy, quality of forage, flower and seed production.

From tests seeded on the irrgation farms it was found that the easiest grass to establish was smooth bromegrass and that the highest yielding grasses were Ree wheatgrass, Homesteader brome and Reed canary grass.

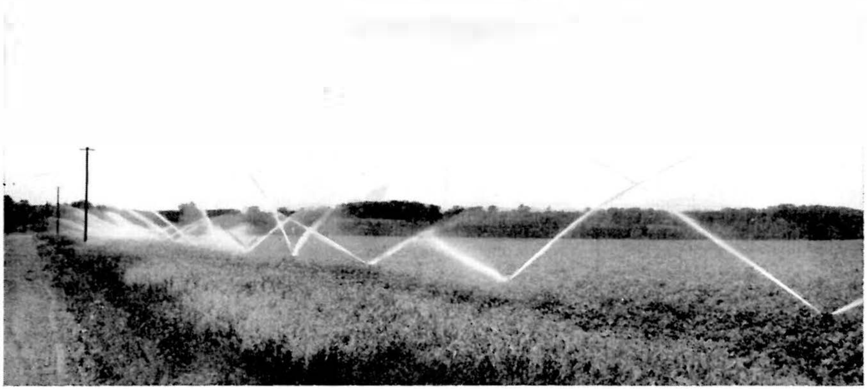
A number of *horticultural crops* grown in plots at Redfield appear to offer commercial possibilities for intensive cultivation of irrigated land. Promising vegetable crops have already been tried successfully in the area. The problem of wind protection is one that is now being studied, since it was found to be an important yield factor. Potato yields responded sharply with fertilizer applications, particularly nitrogen.

A 5-year summary of the *pasture experiments* revealed that native pastures in the Huron area averaged 96 pounds of beef per acre. The improved grass-legume pasture on non-irrigated land averaged 296 pounds of beef per acre. The average of all irrigated grass-legume pastures was 372 pounds of beef per acre.

*Soil management* experiments with the major field crops conducted in the period 1949 to 1953 have shown the need of the combined usage of all good cultural practices for maximum yields. Rotations must include legumes, or large amounts of nitrogen fertilizer will be required. Adequate plant populations, row spacings, fertility, and moisture conditions must prevail for maximum performance of row crops such as corn, soybeans, sugar beets, and potatoes. Grasses must have nitrogen applications of approximately 80 pounds per acre per year to produce good seed and hay yields. When used for forage only, grass-alfalfa mixtures will equal heavily fertilized grasses sown alone.

Research in *water management* indicated that nearly 90 percent of

**Sprinkler irrigation at Redfield**



the moisture used by crops grown under irrigation at Redfield is extracted from the top 3 feet, approximately 75 percent from the first 2 feet and over 50 percent from the top foot. Since 90 percent of the moisture is used from the top 3 feet the aim of the irrigator should be to apply enough water to bring the 3 feet to field capacity.

With sprinkler irrigation, if standard recommended practices are used, it is reasonable to expect that an average field irrigation efficiency of about 75 percent can be attained. The relative humidity, rate of water application, wind, and air temperature while irrigating will have an influence on the field irrigation efficiency.

It would be reasonable to expect, on a Beotia silt loam under gravity irrigation, with careful irrigation practices, a field irrigation efficiency of 75 percent on borders, 70 percent on narrow rows with light irrigations and 50 percent on 36-inch rows. Efficiencies on all methods of gravity irrigation can be improved by utilizing cut back streams. Lower efficiencies may be expected on steeper slopes.


**View of part of rotation experimental plots at Redfield**

This 5-year progress report will provide a basis for better understanding of the problems involved in irrigation in this area.