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A Preliminary Study of the Relationship of Yield to Preseasonal Climatological Factors in Central South Dakota

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A PRELIMINARY STUDY OF THE RELATIONSHIP OF YIELD TO PRESEASONAL CLIMATOLOGICAL FACTORS IN CENTRAL SOUTH DAKOTA

By

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This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and acceptable as meeting the thesis requirements for this degree; but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser

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CHAPTER I

INTRODUCTION

A. THE PROBLEM AND OBJECTIVE

The risk and uncertainty of Great Plains agriculture have long been cause for concern.

The number of factors that affect crop yields is almost infinite. Many exert great influence while the effect of others is only slight. A knowledge of the various relationships which exist between these factors and production is of considerable importance in making farm management decisions.

One of the most important factors in the determination of yields in South Dakota is precipitation. When rainfall is deficient, yields are generally below average.

The effect of other climatological factors during the growing season is often apparent. High temperatures, drying winds, and cloudless days frequently hasten the appearance of drouth conditions and lessen the beneficial effects of seasonal rainfall, particularly if it is light.

Research conducted in this field in the past has largely ignored the preseasonal period. However, the attention has become focused upon this period due to a study by Pengra[1] in which preseasonal precipitation was used as the independent variable in yield forecasting regression equations.

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1. Ray F. Pengra, "Estimating Crop Yields at Seeding Time in the Great Plains," The Agronomy Journal, May, 1952.

The influence of preseasonal precipitations on crop yields, however, probably depends in part on other preseasonal factors, as relative humidity, wind movement, sunshine, cloud cover, and temperature. These factors are effective to the extent that they limit the actual accumulation of moisture during the preseasonal period.

The objective of this study is to investigate the relationship between the yield per acre of wheat, oats and barley and the preseasonal climatological factors. If these factors are found to exert an important influence, reference will be made to cultural practices which have for their purpose the control of this influence.

B. DEFINITIONS OF TERMS USED

Preseasonal precipitation period. Backward from March 28 through September 13 of the preceding year.

Seasonal precipitation period. March 29 through July 4.

Total crop year precipitation period. Preseasonal precipitation period plus seasonal precipitation period.

Evapotranspiration. Soil moisture losses due to evaporation and transpiration.

Five station average data. Average of data from the U. S. Weather Stations at Huron, Redfield, Forestburg, Clark, and Miller.

"Effective" precipitation. Amount of actual precip-

itation which is retained in the soil for crop production utilization.

C. EXPLANATION OF SYMBOLS

a- Ordinate intercept in regression equation.

b- Regression coefficient and slope of regression line.

d- Deviation from regression.

r- Correlation coefficient.

X- Precipitation in inches.

Y- Yield in bushels.

'- Indicates significance at the five percent level.

"- Indicates significance at the one percent level.

$\bar{X}$- Arithmetic mean.

$/\bar{X}/$- Arithmetic mean of absolute values.

CHAPTER II

METHODS AND PROCEDURES

A. METHOD OF ANALYSIS

Since precipitation is the limiting factor in crop production in South Dakota, regression equations of the type $Y = a + bX$, involving yield (Y) and precipitation (X), give an indication of the yields normally expected from a given amount of precipitation. Deviations of the observed yields from those indicated by the equations represent the variations in yield due to factors other than precipitation.

For example, unusually heavy insect infestation during the growing season could cause the actual yield to be lower than normally would be expected on the basis of total precipitation.

Other seasonal factors which probably contribute to the residual variation are: climatological factors, soil conditions, weed infestation, crop disease, management, etc.

The deviations of the observed yields from those indicated by the equations were related to specified preseasonal climatological factors to determine if the latter do exert an important indirect influence on yield. The results are presented in the form of simple correlation coefficients involving the factor under consideration and the appropriate deviations.

Better results would be obtained from the analysis if the variation due to the seasonal factors could be removed

from the data first. However, the procedures involved would be too complicated, if possible at all, to be practical.

B. CHOICE OF PRESEASONAL CLIMATOLOGICAL FACTORS

Factors[2] which affect evaporation and transpiration are temperature, relative humidity, wind movement, and length of daylight. High temperatures and wind movement increase evaporation and transpiration while high relative humidity decreases these moisture losses. Sunlight aids plant growth thus encouraging transpiration.

The above mentioned factors were those considered.

C. THE SELECTION OF THE DATA

Most weather stations in the state do not have long time records of the variables under consideration; consequently, the data used were determined by the records available rather than random selection.

Beadle County was the only county important agriculturally for which there were appropriate data available.

Fortunately, Beadle County is ideally located for this study in the central part of the eastern portion of the state. The weather station at Huron is centrally located within the county.

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2. Harry F. Blaney, "Climate as an Index of Irrigation Needs," The Yearbook of Agriculture, 1955, U.S. Government Printing Office.

Weather records available included data on precipitation, snowfall, temperature, relative humidity, wind movement, percent of possible sunshine, and cloud cover.

The sunshine and cloud cover data are measurements of the same factor; however, both sets of data were carried throughout the study because they were obtained by different methods. The cloud cover data represent the weather observor's estimate of the cloudiness of the area for each day while the sunshine data were obtained by a marvin type sunshine switch[3] which registers only while the sun is actually striking it.

In addition, it was desired to secure an average of reported precipitation from more than one station in order to reduce fluctuations due to local storms. A five station average was obtained by using precipitation data from the Huron station and the four surrounding stations -- Redfield, Miller, Clark, and Forestburg. For comparison, both the Huron data alone and the five station average data were carried throughout the study.

The temperature data used was also a five station average. It was considered that the five station average would be more representative of the area under study than the data from the Huron station alone.

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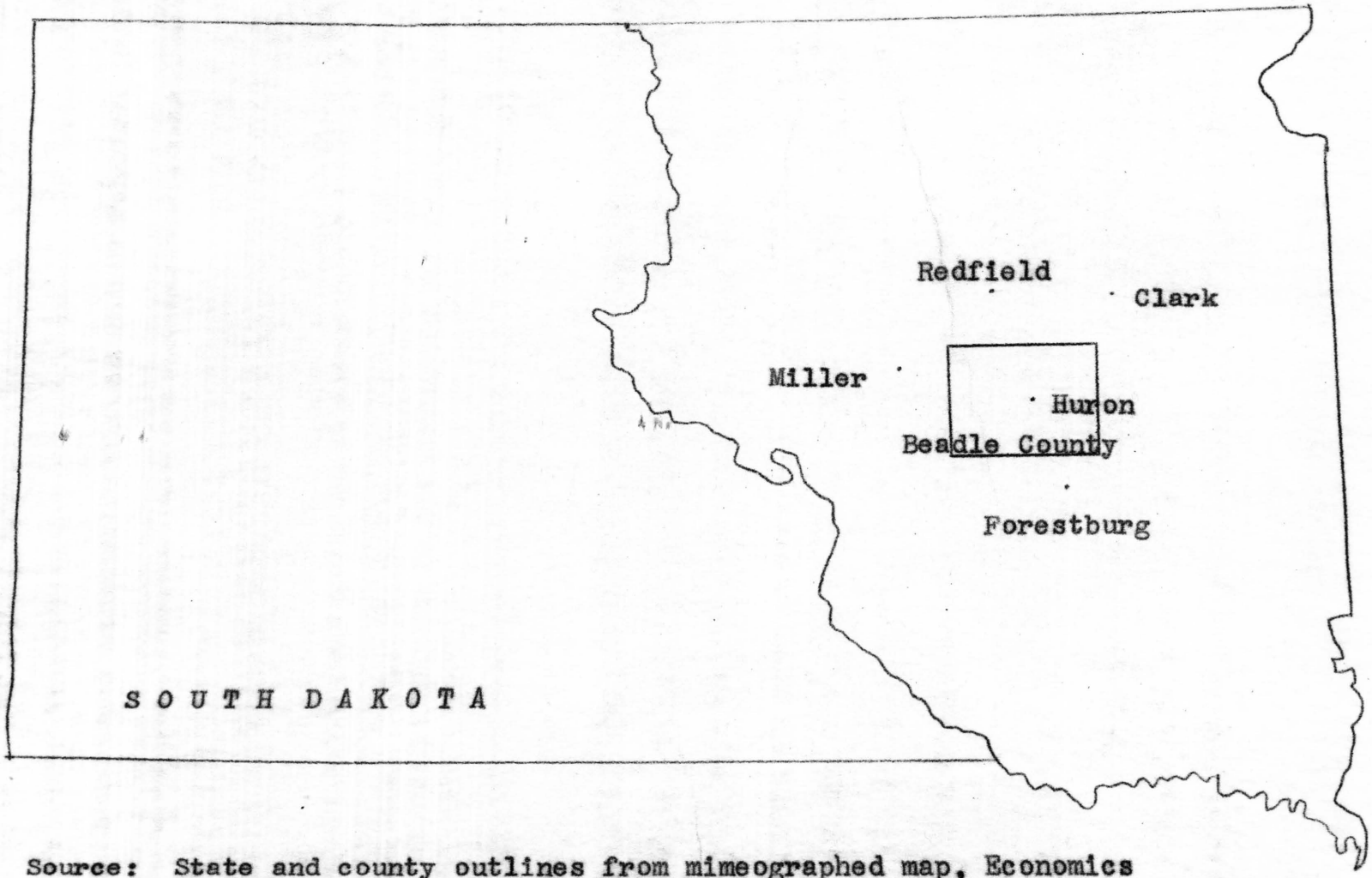
3. U. S. Weather Bureau, Huron, South Dakota.

Fig. 1. Location of Beadle County and five weather stations.



Source: State and county outlines from mimeographed map, Economics Department, South Dakota State College. Station locations from Hammond's New Practical World Atlas, 1956.

D. CROP YIELDS STUDIED

For yield data the three most important small grain crops for Beadle County were chosen. These are spring wheat, oats, and barley. Durum wheat was not included.

E. YEARS STUDIED AND SOURCE OF DATA

It was desired to study consecutive years covering periods of below average precipitation and periods above average. Yield and precipitation data were available for the years 1926 through 1954. This was the period used for the regression equations involving precipitation and yield. For the other climatological factors, data used were for the preseasonal periods of the years 1926 through 1952, 1953, or 1954.

All yield data are from South Dakota Crop Reporting Service reports. Climatological data used are from the United States Weather Bureau Stations at Huron, Redfield, Clark, Miller, and Forestburg.

F. DETERMINATION OF PRECIPITATION PERIODS

The determination of the precipitation periods was somewhat arbitrary. Pengra[4] had concluded that August precipitation did not appear to make a significant contribution to the crop yield the following year. Because of this,

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4. Pengra, loc. cit.

it was felt that it might be well to start the preseasonal precipitation period about the middle of September. The breaking point between the preseasonal and seasonal periods was chosen around the last part of March. Little spring seeding is done before this time.

The choice of the first part of July as the termination point for the seasonal precipitation period was made because it was felt that precipitation could not contribute much to small grain yields after they had begun to ripen.

Actual dates for the periods used were determined by the fact that much of the data was obtained as weekly totals and the dates chosen coincided with the beginning or the ending of a climatological week.

The two precipitation periods were carried separately throughout the study for comparison. The total precipitation period--preseasonal period plus seasonal period--was used in the correlation analysis since it was expected to represent the best relationship between yield and precipitation.

The two precipitation periods were not used as separate independent variables in a multiple correlation analysis because of the expected correlation between them.

G. PRESEASONAL PERIOD COVERED BY CLIMATOLOGICAL DATA OTHER THAN PRECIPITATION

Dates covered by the climatological data were those in which evapotranspiration in the preseasonal period would,

most likely, be heaviest. The exact dates were determined by the beginning and ending of climatological weeks. They were from August 2 through October 17.

The middle of October was chosen as the cutoff date because the likelihood in percent[5] of freeze temperatures occuring on any day later than this approaches 100 for this area.

H. ALLOWANCE FOR MISSING DATA AND ADJUSTMENT OF DATA

Occasionally precipitation or temperature data from a single weather station was missing. When this occurred, the average of the other four stations was used as the five station average figure.

Relative humidity data was recorded four times a day at 12:00 P.M., 6:30 and 12:00 A.M., and 6:30 P.M. No record had been kept for the midnight reading for the years 1921-1936, 1938, and the years 1948-1951.

In adjusting for the missing data, it was noted that for a thirty year period the 12:00 P.M. readings followed the 6:30 A.M. readings very closely, tending always to be less. The 6:30 P.M. readings followed the 12:00 A.M. readings tending always to be slightly larger. The actual

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5. Ray F. Pengra and M. D. Magnuson, "Likelihood of Damaging Low Temperature During Growing Season," Agricultural Experiment Station Bulletin 441, South Dakota State College, August 1954, page 27.

percentages were 89.52 and 104.17 respectively. The missing data was computed by applying these percentages to the appropriate reading for each year.

The wind movement totals were adjusted because it was noted that subsequent to 1938 none of the totals were as low as the previous high had been. On checking the weather bureau pamphlet, "Local Climatological Data, 1954," for Beadle County, it was found that in 1938 the station location had been changed. Rather than throw out the early data, the data recorded subsequent to 1938 were adjusted downward to make them comparable. The average of the pre-1938 period was 74.6 percent of the post-1938 period average. The adjustment downward of the post-1938 data was accomplished by multiplying .746 times each figure.

CHAPTER III

PRESENTATION AND EXPLANATION OF THE RESULTS

Beadle County yield data is presented in table I. For the period under consideration the average yields in bushels per acre for wheat, oats, and barley were approximately nine, twenty, and fourteen respectively.

Precipitation data from the Huron station is presented in table II. Table III contains the five station average data. In general, the five station average data is slightly higher than the corresponding data recorded at the Huron station alone.

The close relationship between total precipitation and yield is indicated in figure 2. It can be seen that much of the variation in yield is associated with variation in precipitation.

Figure 3 presents an example of yield plotted against total crop year precipitation. The corresponding regression line is also shown. The regression line fits the data quite well with the exception of a few low yielding years. The true total production function for yield and precipitation is not linear due to the fact that an oversupply of moisture will result in lowered yield. However, this situation rarely occurs in central South Dakota.

Regression equations were developed for all precipitation periods and yields by the method of least squares. These

equations are presented in tables IV, V, and VI. Standard errors of the estimate for each of these equations were calculated. They are presented in table VII.

The standard errors serve as a measure of the residual variation. The smallest errors are associated with the regression equations involving total crop year precipitation and yield.

The regression coefficients are presented separately in table VIII. All are highly significant. The indications are that one would normally expect that each additional inch of total crop year precipitation would add to yield approximately one bushel for wheat, two and one-fourth bushels for oats, and one and one-fourth bushels for barley.

Correlation coefficients were computed between each precipitation period and the yield for each small grain crop. All of the coefficients were highly significant. The largest coefficients were obtained between total crop year precipitation and yield. These coefficients are tabulated in table IX.

Deviations of observed yields from yields calculated on the basis of the regression equations are presented in tables X, XI, and XII. The total precipitation deviations represent the data that were correlated with the preseasonal climatological data.

Tables XIII, XIV, and XV present the preseasonal clim-

atological data used. All data is expressed in terms of daily average figures with the exception of snowfall which is represented by the totals accumulated over the preseasonal periods.

The correlation coefficients between the deviations and the various climatological factors are presented in tables XVI, XVII, XVIII, IXX, and XX. For the factors of wind movement, temperature, relative humidity, sunshine, and cloud cover, the deviations used were those obtained from the regression lines involving total crop year precipitation and yield.

The correlation coefficients involving the cloud cover data were all positive. All exhibited significance at the five percent level while two were significant at the one percent level. This indicates that positive deviations from regression tended to be associated with above average amounts of cloud cover in the preseasonal period while negative deviations tended to be associated with below average amounts.

The sunshine correlation coefficients varied in a negative direction. Only one was significant at the five percent level.

Correlation coefficients involving relative humidity were all positive with one exhibiting significance at the one percent level and only one failing to exhibit significance at the five percent level.

The correlation coefficients for temperature were all negative. Two exhibited significance at the five percent level.

No significance was exhibited by the wind movement correlation coefficients. All were negative.

For the snowfall correlations, the table is divided into two parts. The first part shows the correlation coefficients obtained for snowfall and yield while the second part shows the correlation coefficients for snowfall and the deviations obtained from the regression equations involving seasonal precipitation and yield.

The deviations from regression involving total crop year precipitation cannot be used in this case because part of the preseasonal precipitation is made up of snowfall. To keep the variables independent, snowfall and preseasonal precipitation cannot both be used at the same time in the analysis.

All of the snowfall correlation coefficients are extremely low.

Table I

Beadle County, Average Yield Data, 1926-1955

Year	Wheat (bu.)	Oats (bu.)	Barley (bu.)
1926	3.6	7.1	8.3
27	14.5	27.9	23.2
28	6.9	18.8	14.4
29	10.3	19.3	12.7
30	12.2	24.4	21.4
31	4.2	3.8	7.1
32	9.0	18.2	15.1
33	1.3	1.9	0
34	0	0	0
35	9.3	16.9	12.3
36	1.2	1.0	1.7
37	4.1	11.0	9.0
38	8.5	18.0	17.0
39	6.1	13.5	10.0
40	7.6	12.1	9.5
41	9.8	17.9	16.0
42	12.5	40.5	23.0
43	6.0	20.5	10.0
44	10.5	26.5	11.5
45	19.5	41.0	25.5
46	12.0	24.0	17.0
47	16.0	28.5	21.0
48	14.0	33.0	23.0
49	8.5	18.0	12.0
50	11.0	20.5	15.0
51	16.0	41.0	24.0
52	6.0	17.0	11.0
53	8.5	23.0	14.5
54	10.0	27.5	19.0
55	7.5	17.0	11.5
$\bar{X}$	8.9	19.7	13.9

Source: South Dakota Crop and Livestock Reporting Service.

Table II

Precipitation data as recorded at Huron, South Dakota, 1926-1953

Year	Preseasonal Precipitation (in.)	Seasonal Precipitation (in.)	Total Crop Year Precipitation (in.)
1926	3.19	5.37	8.56
27	6.25	9.49	15.74
28	3.93	9.63	13.56
29	6.67	5.50	12.17
30	5.79	8.07	13.86
31	6.15	5.27	11.42
32	6.86	6.32	13.18
33	3.17	4.21	7.38
34	1.44	3.66	5.10
35	4.29	9.10	13.49
36	3.71	4.46	8.17
37	5.65	7.62	13.27
38	4.54	10.44	14.98
39	3.30	7.87	11.17
40	4.03	4.66	8.69
41	3.08	7.20	10.28
42	10.36	12.00	22.36
43	5.09	9.34	14.43
44	5.86	13.09	18.95
45	5.04	10.48	15.52
46	6.39	6.77	13.16
47	10.53	9.25	19.78
48	6.89	10.56	17.45
49	3.24	5.88	9.12
50	5.30	5.02	10.32
51	7.68	13.15	20.83
52	6.31	3.51	9.82
53	4.49	11.13	15.62
$\bar{X}$	5.3	7.8	13.1

Source: U. S. Weather Bureau, Huron, South Dakota.

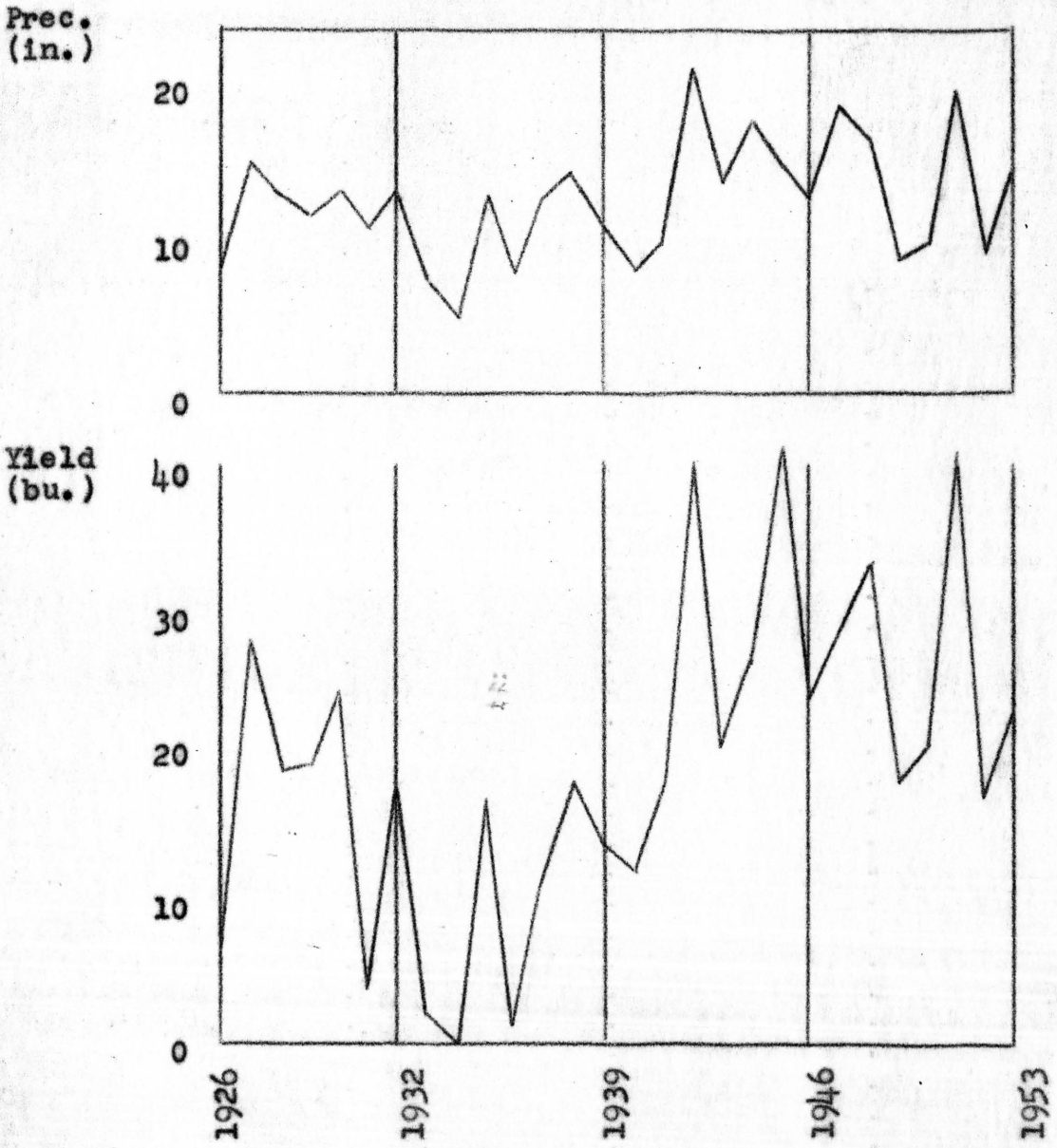
Table III

Five Station Average of Precipitation Data, 1926-1954

Year	Preseasonal Precipitation (in.)	Seasonal Precipitation (in.)	Total Crop Year (in.)
1926	3.41	5.21	8.62
27	6.35	10.22	16.57
28	4.02	6.19	10.21
29	6.68	5.36	12.04
30	8.14	8.81	16.95
31	7.81	7.30	15.11
32	6.77	7.77	14.54
33	4.95	5.66	10.61
34	2.86	4.25	7.11
35	5.25	9.58	14.83
36	3.02	4.75	7.77
37	5.62	7.56	13.18
38	4.54	10.69	15.23
39	3.92	9.70	13.62
40	6.20	5.87	12.07
41	3.93	9.78	13.71
42	10.47	12.60	23.07
43	4.40	9.06	13.46
44	5.15	12.74	17.89
45	5.97	10.16	16.13
46	7.13	8.78	15.91
47	11.23	9.36	20.59
48	7.88	9.91	17.79
49	4.11	6.44	10.55
50	6.32	7.37	13.69
51	7.92	10.78	18.70
52	6.16	5.04	11.20
53	4.86	12.32	17.18
54	6.40	7.86	14.26
$\bar{X}$	5.9	8.3	14.2

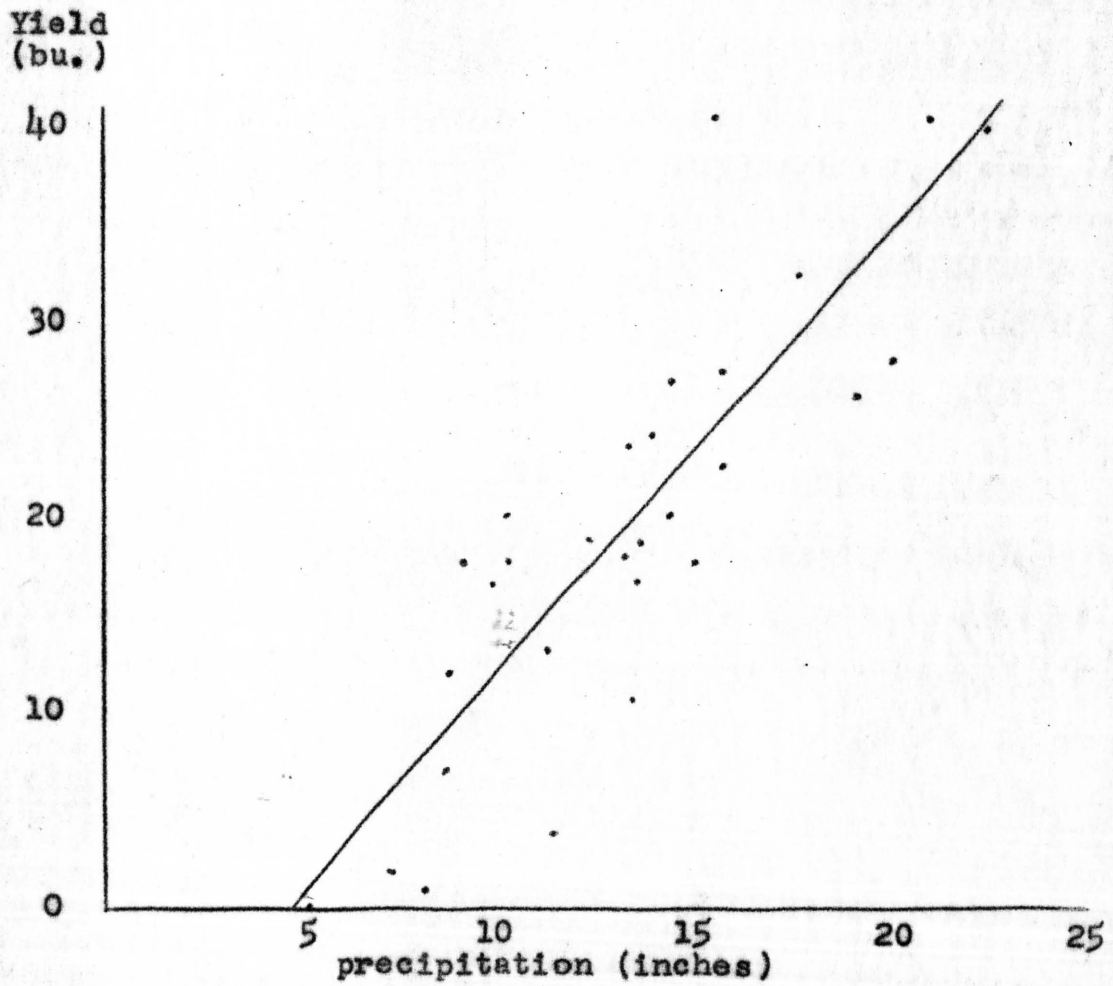
Source: U. S. Weather Bureau Station at Huron Redfield, Miller, Forestburg, and Clark, South Dakota.

Fig. 2. Total precipitation and oat yields for Beadle County for the years 1926-1953 inclusive.



Source: U.S. Weather Bureau and South Dakota Crop Reporting Service.

Fig. 3. Total precipitation plotted against oat yield for Beadle County for the years 1926-1954 inclusive and the corresponding regression line.



Regression equation: $Y = -10.515 + 2.294X$.

Table IV

Regression equations involving Beadle County wheat yields in bushels (Y) and preseasonal, seasonal, and total crop year precipitation in inches (X) for Huron and five station average data for the years 1926-1954, inclusive.

Precipitation Data	Regression Equations
Huron Preseasonal	Y = 1.217 + 1.437 X
Huron Seasonal	Y = .656 + 1.058 X
Huron Total Crop Year	Y = -2.083 + .835 X
5 Station Ave. Preseasonal	Y = .260 + 1.467 X
5 Station Ave. Seasonal	Y = -1.209 + 1.220 X
5 Station Ave. Total Crop Year	Y = -4.838 + .968 X

Table V

Regression equations involving Beadle County oat yields in bushels (Y) and preseasonal, seasonal, and total crop year precipitation in inches (X) for Huron and five station average data for the years 1926-1954, inclusive.

Precipitation Data	Regression Equations
Huron Preseasonal	Y = .146 + 3.651 X
Huron Seasonal	Y = -4.182 + 3.059 X
Huron Total Crop Year	Y = -10.515 + 2.294 X
5 Station Ave. Preseasonal	Y = .168 + 3.312 X
5 Station Ave. Seasonal	Y = -7.510 + 3.279 X
5 Station Ave. Total Crop Year	Y = -14.564 + 2.412 X

Table VI

Regression equations involving Beadle County barley yields in bushels (Y) and preseasonal, seasonal, and total crop year precipitation in inches (X) for Huron and five station average data for the years 1926-1954, inclusive.

Precipitation Data	Regression Equations
Huron Preseasonal	Y = 2.188 + 2.188 X
Huron Seasonal	Y = .872 + 1.670 X
Huron Total Crop Year	Y = -3.201 + 1.299 X
5 Station Ave. Preseasonal	Y = 1.225 + 2.150 X
5 Station Ave. Seasonal	Y = -1.601 + 1.869 X
5 Station Ave. Total Crop Year	Y = -6.734 + 1.453 X

Table VII

Standard errors of the estimate for regression equations of Beadle County small grain yields in bushels on preseasonal, seasonal, and total crop year precipitation in inches for Huron and five station average data for the years 1926-1954, inclusive.

Precipitation Data	Wheat (bu.)	Oats (bu.)	Barley (bu.)
Huron Preseasonal	3.60	8.18	5.24
Huron Seasonal	3.54	6.98	5.05
Huron Total Crop Year	3.12	5.74	4.33
5 Station Ave. Preseasonal	3.56	8.76	5.33
5 Station Ave. Seasonal	3.57	7.67	5.18
5 Station Ave. Total Crop Yr.	2.97	6.60	4.35

Table VIII

Summary of regression coefficients of Beadle County small grain yields in bushels on preseasonal, seasonal, and total crop year precipitation in inches for Huron and five station average data for the years 1926-1954, inclusive.

Precipitation Data	Wheat	Oats	Barley
Huron Preseasonal	1.437"	3.651"	2.188"
Huron Seasonal	1.058"	3.059"	1.670"
Huron Total Crop Year	.835"	2.294"	1.299"
5 Station Ave. Preseasonal	1.467"	3.312"	2.150"
5 Station Ave. Seasonal	1.220"	3.279"	1.869"
5 Station Ave. Total Crop Year	.968"	2.412"	1.453"

" Denotes significance at the one percent level.

Table IX

Correlation coefficients of Beadle County small grain yields on preseasonal, seasonal, and total crop year precipitation for Huron and five station average data for the years 1926-1954, inclusive.

Precipitation Data	Wheat	Oats	Barley
Huron Preseasonal	.624"	.667"	.641"
Huron Seasonal	.635"	.771"	.675"
Huron Total Crop Year	.738"	.852"	.773"
5 Station Ave. Preseasonal	.634"	.602"	.626"
5 Station Ave. Seasonal	.632"	.714"	.653"
5 Station Ave. Total Crop Year	.763"	.799"	.772"

" Denotes significance at the one percent level.

Table X

Deviations in bushels of observed Beadle County wheat yields from yield expected on the basis of regression equations involving yield and preseasonal, seasonal, and total crop year precipitation from Huron and five station average data for the years 1926-1954.

Year	d_1^*	d_2^*	d_3^*	d_4^*	d_5^*	d_6^*
1926	-2.2	-2.7	-1.5	-1.7	-1.5	.1
27	4.3	3.8	3.4	4.9	3.2	3.3
28	.0	-3.4	-2.3	.7	.6	1.9
29	- .5	3.8	2.2	.2	5.0	3.5
30	2.7	3.0	2.7	.0	2.7	.6
31	-5.9	-2.0	-3.3	-7.5	-3.5	-5.6
32	-2.1	1.7	.1	-1.2	.7	- .2
33	-4.5	-3.8	-2.8	-6.2	-4.4	-4.1
34	-3.3	-4.5	-2.2	-4.5	-4.0	-2.0
35	1.8	1.0	.1	1.3	-1.2	- .2
36	-5.3	-4.2	-3.5	-3.5	-3.4	-1.5
37	-5.2	-4.6	-4.9	-4.4	-3.9	-3.8
38	.8	-3.2	-1.9	1.6	-3.3	-1.4
39	.1	-2.9	-1.1	.1	-4.5	-2.2
40	.6	2.0	2.4	-1.8	1.6	.8
41	4.2	1.5	3.3	3.8	- .9	1.4
42	-3.6	.9	-4.1	-2.9	-1.7	-5.0
43	-2.5	-4.5	-4.0	- .7	-3.8	-2.2
44	.9	-4.0	-3.2	2.7	-3.8	-2.0
45	11.0	7.8	8.6	10.5	8.3	8.7
46	1.6	4.2	3.1	1.3	2.5	1.4
47	- .3	5.6	1.6	- .7	5.8	.9
48	2.9	2.2	1.5	2.2	3.1	1.6
49	2.6	1.6	3.0	2.2	1.9	3.1
50	2.2	5.0	4.5	1.5	3.2	2.6
51	3.7	1.4	.7	4.1	4.1	2.7
52	-4.3	1.6	- .1	-3.3	1.1	.0
53	.8	-3.9	-2.5	1.1	-5.3	-3.3
54	- .4	1.0	.2	.4	1.6	1.0
/X/	2.8	3.2	2.6	2.7	3.1	2.3

* Subscripts refer to precipitation periods used in regression equations.
1. Huron station preseasonal.
2. Huron station seasonal.
3. Huron station total crop year.
4. Five station average preseasonal.
5. Five station average seasonal.
6. Five station average total crop year.

Table XI

Deviations in bushels of observed Beadle County oat yields from yield expected on the basis of regression equations involving yield and preseasonal, seasonal, and total crop year precipitation from Huron and five station average data for the years 1926-1954.

Year	d_1^*	d_2^*	d_3^*	d_4^*	d_5^*	d_6^*
1926	-4.7	-5.1	-2.0	-4.4	-2.5	.9
27	4.9	3.1	2.3	6.7	1.9	2.5
28	4.3	-6.5	-1.8	5.3	6.0	8.7
29	-5.2	6.7	1.9	-3.0	9.2	4.8
30	3.1	3.9	3.1	-2.7	3.0	-1.9
31	-18.8	-8.1	-11.9	-22.2	-12.6	-18.1
32	-7.0	3.0	-1.5	-4.4	.2	-2.3
33	-9.8	-6.8	-4.5	-14.7	-9.1	-9.1
34	-5.4	-7.0	-1.2	-9.6	-6.4	-2.6
35	.7	-6.8	-3.5	- .7	-7.0	-4.3
36	-12.7	-8.5	-7.2	-9.2	-7.1	-3.2
37	-9.8	-8.1	-8.9	-7.8	-6.3	-6.2
38	1.3	-9.8	-5.8	2.8	-9.5	-4.2
39	1.3	-6.4	-1.6	.3	-10.6	-4.8
40	-2.8	2.0	2.7	-8.6	.4	-2.4
41	6.5	.1	4.8	4.7	-6.7	- .6
42	2.5	8.0	- .3	5.7	6.7	- .6
43	1.8	-3.9	-2.1	5.8	-1.7	2.6
44	5.0	-9.4	-6.5	9.3	-7.8	-2.1
45	22.5	13.1	15.9	21.1	15.2	16.7
46	.5	7.5	4.3	.2	2.7	.2
47	-10.1	4.4	-6.4	-8.9	5.3	-6.6
48	7.7	4.9	3.5	6.7	8.0	4.7
49	6.0	4.2	7.6	4.2	4.4	7.1
50	1.0	9.3	7.3	- .6	3.8	2.0
51	12.8	5.0	3.7	14.6	13.2	10.5
52	-6.2	10.4	5.0	-3.6	8.0	4.5
53	6.5	-6.9	-2.3	6.7	-9.9	-3.9
54	4.0	7.6	5.3	6.1	9.2	7.7
/X/	6.4	6.4	4.7	6.9	6.7	5.0

* Subscripts refer to precipitation periods used in regression equations.
1. Huron station preseasonal.
2. Huron station seasonal.
3. Huron station total crop year.
4. Five station average preseasonal.
5. Five station average seasonal.
6. Five station average total crop year.

Table XII

Deviations in bushels of observed Beadle County barley yields from yield expected on the basis of regression equations involving yield and preseasonal, seasonal, and total crop year precipitation from Huron and five station average data for the years 1926-1954.

Year	d_1^*	d_2^*	d_3^*	d_4^*	d_5^*	d_6^*
1926	- .9	-1.5	1.4	- .3	.2	2.5
27	7.3	6.5	6.0	8.3	5.7	5.9
28	3.6	-2.6	.0	4.5	4.4	6.3
29	-4.1	2.6	.1	-2.9	4.3	1.9
30	6.5	7.1	6.6	2.7	6.5	3.5
31	-8.5	-2.6	-4.5	-10.9	-4.9	-8.1
32	-2.1	3.7	1.2	- .7	2.2	.7
33	-9.1	-7.9	-6.4	-11.9	-9.0	-8.7
34	-5.3	-7.0	-3.4	-7.4	-6.3	-3.6
35	.5	-3.8	-2.0	- .2	-4.0	-2.5
36	-8.6	-6.6	-5.7	-6.0	-5.6	-2.9
37	-5.6	-4.6	-5.0	-4.3	-3.5	-3.4
38	4.9	-1.3	.7	6.0	-1.4	1.6
39	.6	-4.0	-1.3	.3	-6.5	-3.1
40	-1.5	.8	1.4	-5.1	.1	-1.3
41	7.1	3.1	5.8	6.3	- .7	2.8
42	-1.9	2.1	-2.8	- .7	1.1	-3.8
43	-3.3	-6.5	-5.5	- .7	-5.3	-2.8
44	-3.5	-11.2	-9.9	- .8	-10.7	-7.8
45	12.3	7.1	8.5	11.4	8.1	8.8
46	.8	4.8	3.1	.4	2.2	.6
47	-4.2	4.7	-1.5	-4.4	5.1	-2.2
48	5.7	4.5	3.5	4.8	6.1	3.9
49	2.7	1.3	3.4	1.9	1.6	3.4
50	1.2	5.7	4.8	.2	2.8	1.8
51	5.0	1.2	.1	5.7	5.5	3.6
52	-5.0	4.3	1.4	-3.5	3.2	1.5
53	2.5	-5.0	-2.6	2.8	-6.9	-3.7
54	2.8	5.0	3.7	4.0	5.9	5.0
/X/	4.4	4.5	3.5	4.1	4.5	3.7

* Subscripts refer to precipitation periods used in regression equations.
1. Huron station preseasonal.
2. Huron station seasonal.
3. Huron station total crop year.
4. Five station average preseasonal.
5. Five station average seasonal.
6. Five station average total crop year.

Table XIII

Preseasonal climatological data expressed as a daily average for the periods August 2 - October 17, for the years 1926-1952.

Year	Relative Humidity (percent)	Wind Movement Readings	Sunshine (percent)	Cloud Cover (percent)
1926	59.6	212	55.42	48.33
27	69.3	226	55.60	45.77
28	63.2	204	69.38	42.31
29	61.5	198	67.90	42.18
30	63.6	185	60.81	47.95
31	62.4	187	64.86	45.51
32	57.0	206	66.31	39.62
33	56.8	226	69.32	37.56
34	55.7	224	78.52	38.46
35	52.5	189	61.96	37.56
36	56.5	227	75.72	30.77
37	53.6	227	73.20	33.85
38	59.0	236	70.94	33.97
39	55.2	217	65.36	34.87
40	53.6	235	70.04	39.62
41	59.5	231	65.60	47.69
42	62.9	245	65.55	51.28
43	74.6	188	60.68	42.56
44	65.2	224	76.63	38.97
45	74.6	198	70.20	49.49
46	66.6	206	66.22	47.69
47	72.9	219	54.65	55.90
48	63.6	225	71.20	50.13
49	64.0	206	68.68	48.46
50	60.5	201	61.90	45.77
51	65.0	191	70.09	51.79
52	67.1	181	64.94	60.38
$\bar{x}$	62.1	212	66.73	44.02

Source: U. S. Weather Bureau Station, Huron, South Dakota.

Table XIV

Five station average of preseasonal temperature data for the years 1926-1954.

Year	Temperature (degrees F.)
1926	63.94
27	62.51
28	62.00
29	63.14
30	63.14
31	65.31
32	67.44
33	63.36
34	65.40
35	63.78
36	63.51
37	66.13
38	65.98
39	69.13
40	65.22
41	66.05
42	65.45
43	62.80
44	63.74
45	62.33
46	62.87
47	60.49
48	68.09
49	64.74
50	62.82
51	61.40
52	60.67
53	63.24
54	66.12
$\bar{X}$	64.17

Source: U. S. Weather Bureau Stations at Huron, Redfield, Miller, Forestburg, and Clark, South Dakota.

Table XV

Preseasonal snowfall data as recorded at Huron, South Dakota, 1926-1953.

Year	Preseasonal Snowfall (inches)
1926	29.2
27	16.7
28	20.9
29	32.2
30	29.2
31	9.2
32	30.5
33	21.4
34	19.5
35	10.6
36	42.4
37	50.6
38	47.3
39	20.7
40	36.5
41	25.3
42	21.0
43	28.6
44	32.7
45	16.5
46	31.6
47	29.9
48	46.5
49	29.7
50	37.9
51	38.6
52	48.3
53	36.9
$\bar{X}$	30.0

Source: U. S. Weather Bureau Station, Huron, South Dakota.

Table XVI

Correlation coefficients of cloud cover and sunshine against the deviations of small grain yields in Beadle County from yields expected on the basis of regression equations involving small grain yields and total crop year precipitation for Huron and five station average data. Cloud cover and sunshine data was observed at the Huron weather station during the preseasonal periods for the years 1926-1952, inclusive.

Precipitation Data	r_{37}*	r_{38}*	r_{39}*
Huron Total	.440'	.505"	.470"
5 Station Ave. Total	.376'	.396'	.405'

Precipitation Data	r_{47}*	r_{48}*	r_{49}*
Huron Total	-.259	-.077	-.348'
5 Station Ave. Total	-.138	-.065	-.216

' Denotes significance at the five percent level one tailed test.
" Denotes significance at the one percent level one tailed test.
* Subscripts:
3. Cloud Cover.
4. Sunshine.
7. Wheat yield deviations.
8. Oat yield deviations.
9. Barley yield deviations.

Table XVII

Correlation coefficients of relative humidity and the deviations of small grain yields in Beadle County from yields expected on the basis of regression equations involving small grain yields and total crop year precipitation for Huron and five station average data. Relative humidity data was recorded at the Huron weather station during the preseasonal periods for the years 1926-1952, inclusive.

Precipitation Data	r_{57}*	r_{58}*	r_{59}*
Huron Total	.343'	.364'	.218
5 Station Ave. Total	.425'	.466"	.357'

' Denotes significance at the five percent level, one tailed test.
" Demotes significance at the one percent level, one tailed test.
* Subscripts:
5. Relative humidity.
7. Wheat yield deviations.
8. Oat yield deviations.
9. Barley yield deviations.

Table XVIII

Correlation coefficients of temperature against the deviations of observed small grain yields in Beadle County from yields expected on the basis of regression equations involving small grain yields and total crop year precipitation for Huron and five station average data. Temperature data is the five station averages from preseasonal periods for the years 1926-1954, in clusive.

Precipitation Data	r_{27}*	r_{28}*	r_{29}*
Huron Total	-.225	-.194	-.069
5 Station Ave. Total	-.367'	-.341'	-.215

' Denotes significance at the five percent level, one tailed test.

* Subscripts:
  2. Temperature.
  7. Wheat yield deviations.
  8. Oat yield deviations.
  9. Barley yield deviations.

Table IXX

Correlation coefficients of wind movement and the deviations of observed small grain yields in Beadle County from yields expected on the basis of regression equations involving small grain yields and total crop year precipitation for Huron and five station average data. Wind movement data is from preseasonal periods for the years 1926-1952, inclusive, observed at the Huron station.

Precipitation Data	r_{17}*	r_{18}*	r_{19}*
Huron Total Crop Year	-.228	-.227	-.182
5 Station Ave. Total Crop Yr.	-.272	-.230	-.218

* Subscripts:
1. Wind Movement.
7. Wheat yield deviations.
8. Oat yield deviations.
9. Barley yield deviations.

Table XX

Correlation coefficients of snowfall versus small grain yields in Beadle County for the years 1926-1953, inclusive, and correlation coefficients of snowfall versus the deviations of small grain yields from yields expected on the basis of regression equations involving small grain yields and seasonal precipitation for the five station average data. The snowfall data was recorded at the Huron weather station during the preseasonal periods from 1926-1953, inclusive.

Snowfall Data	Wheat	Oats	Barley
Huron Preseasonal	-.033	.046	.032
Precipitation Data	r_{67}^{*}	r_{68}^{*}	r_{69}^{*}
5 Station Seasonal	.037	.127	.093

* Subscripts:
6. Snowfall
7. Wheat yield deviations.
8. Oat yield deviations.
9. Barley yield deviations.

CHAPTER IV

SUMMARY AND CONCLUSIONS

A. SUMMARY OF PROCEDURE

In a previous study, Pengra established that preseasonal precipitation was an important factor in crop production. Other preseasonal climatological factors act on the actual precipitation received to determine what "effective" precipitation will remain to contribute to yield. The objective of this study was to investigate the relationship between preseasonal climatological factors and yield.

The method of procedure was as follows:

1. Regression equations involving precipitation and yield were fitted to available data.

2. Deviations of the observed yields from the regression lines were obtained.

3. The appropriate deviations were compared with various preseasonal climatological factors by means of simple correlation analysis in order to present the relationship between the factors and the residual variation.

Preseasonal factors of relative humidity, temperature, sunshine, cloud cover, wind movement, and snowfall were used. Data for all factors, except snowfall, were for the seventy-eight day period of August 2 through October 17. It was felt that these factors would exert the greatest influence during the period considered. These factors were compared with the

deviations from regression involving total crop year precipitation and yield.

The snowfall data used were the totals for each year accumulated over the entire preseasonal period. These data were correlated with the deviations from regression involving seasonal precipitation and yield.

B. CONCLUSIONS

The yield-weather relationship under study is a difficult one to isolate. Deviations from regression used in the analysis reflect the influence of a multitude of factors which affect yield. The fact that a significant relationship was obtained for some of the preseasonal factors and the deviations indicates that their indirect influence on yield is of some importance.

The indication is that the relationship between yield and the preseasonal climatological factors results because these factors tend to hasten or retard evaporation and transpiration in the preseasonal period. This, along with runoff and deep percolation, causes the "effective" preseasonal precipitation to differ from the actual preseasonal precipitation received. In other words, the difference between the "effective" and actual preseasonal precipitation is in part a function of the climatological factors and their

influence is of sufficient magnitude that yield is affected. The lowness of all the snowfall coefficients suggests that snowfall adds little or, at best, only randomly to yield. This is probably true because snow often drifts across open fields and collects in ditches and around other wind breaking obstacles. Also, in the Spring, much of the snow melts and runs off while the ground is still frozen.

C. FARM MANAGEMENT IMPLICATIONS

The results of the study indicate that higher yields would result if evapotranspiration in the preseasonal period could be reduced.

It is logical to assume that this would apply equally well to runoff losses.

Cultural practices followed during the preseasonal period, which are designed to cut down on these moisture losses, would be of benefit to the farmer.

D. SUGGESTIONS FOR FUTURE RESEARCH

In order to be in a position to better aid South Dakota farmers in making farm management decisions, it will be necessary to have information of yield, soil-type, weather relationships. Data of this type are, at present, extremely limited.

Sufficient data could be obtained in a fairly short time

if funds were available for making a random sample of observations over the state.

Results of a study such as this would provide information concerning yields obtainable from any given amount of precipitation for each soil type or group of similar soil types. This, together with information on probable occurence of precipitation, would help reduce the risk in agriculture.

APPENDIX

Table XXI

Preseasonal precipitation in inches recorded at Clark, Redfield, Miller, and Forestburg for the years 1926 through 1954.

Year	Preseasonal Precipitation			
	Clark	Redfield	Miller	Forestburg
1926	5.84	3.16	1.27	3.59
27	5.68	5.62	5.76	8.46
28	----	5.13	3.69	3.33
29	7.42	5.76	5.22	8.35
30	9.69	8.49	6.25	10.45
31	9.13	10.38	7.41	5.97
32	7.75	6.28	5.22	7.74
33	6.36	4.72	5.33	5.18
34	3.83	2.83	3.17	3.03
35	6.11	6.03	4.41	5.30
36	3.13	2.46	2.26	3.53
37	5.19	4.98	4.62	7.68
38	5.12	4.23	3.42	5.39
39	4.83	4.07	3.55	3.84
40	6.44	7.54	7.85	5.12
41	3.90	3.80	4.40	4.46
42	10.21	9.66	11.24	10.87
43	6.42	3.27	3.86	3.34
44	7.19	3.87	4.67	4.18
45	6.49	5.42	7.26	5.64
46	7.77	7.10	5.94	8.46
47	14.17	8.65	10.47	12.32
48	----	5.93	7.89	10.80
49	4.86	3.52	2.92	6.01
50	----	5.32	7.85	6.80
51	8.32	5.90	7.41	10.31
52	4.84	6.38	6.37	6.91
53	4.01	5.75	4.63	5.42
54	6.16	6.38	5.40	7.64

Source: U. S. Weather Bureau Stations at Redfield, Miller, Forestburg, and Clark, South Dakota.

Table XXII

Seasonal precipitation in inches recorded at Clark, Redfield, Miller, and Forestburg for the years 1926 through 1954.

Year	Seasonal Precipitation			
	Clark	Redfield	Miller	Forestburg
1926	5.73	4.12	4.48	6.36
27	9.99	12.11	6.60	12.92
28	4.64	4.58	4.89	7.22
29	5.07	4.32	6.09	5.83
30	10.85	8.54	9.43	7.18
31	9.62	7.04	5.53	9.04
32	7.94	8.13	9.31	7.16
33	5.99	5.27	7.15	5.68
34	4.46	4.22	3.43	5.50
35	13.11	7.65	8.10	9.96
36	6.18	4.26	3.86	5.01
37	8.19	6.23	8.02	7.73
38	10.08	9.10	9.91	13.93
39	8.72	9.75	12.52	9.66
40	6.17	5.76	5.04	7.73
41	9.42	10.12	11.10	11.07
42	11.94	9.97	14.97	14.12
43	9.25	8.37	12.10	6.23
44	11.23	9.97	11.92	17.51
45	10.99	10.01	9.01	10.30
46	8.62	10.95	10.97	6.61
47	7.20	7.43	10.58	12.35
48	10.02	9.28	7.14	12.57
49	----	6.39	7.29	6.19
50	7.45	5.84	10.82	7.73
51	7.25	9.53	10.71	13.25
52	5.42	6.07	4.73	5.46
53	14.21	12.62	12.05	11.59
54	7.42	6.85	8.28	8.89

Source: U. S. Weather Bureau Stations at Redfield, Miller, Forestburg, and Clark, South Dakota.

Table XXIII

Preseasonal temperature data recorded at Clark, Redfield, Miller, and Forestburg for the years 1926-1954. Data is expressed as daily averages for the seventy-eight day period, August 2 through October 17.

Year	Preseasonal Temperature (Degrees F.)			
	Clark	Redfield	Miller	Forestburg
1926	62.3	65.0	64.0	64.0
27	60.4	63.7	61.9	63.8
28	60.7	62.4	61.9	62.9
29	62.4	63.6	63.1	63.6
30	61.5	64.3	63.4	63.6
31	63.4	66.7	64.6	66.8
32	66.3	67.8	67.0	68.9
33	61.8	64.2	62.4	64.9
34	64.2	65.6	65.8	66.0
35	62.4	63.6	----	65.2
36	61.0	64.8	62.8	65.1
37	64.5	66.8	65.1	67.5
38	64.5	67.9	64.5	66.5
39	67.9	70.5	67.7	69.9
40	63.4	66.5	64.9	66.5
41	64.4	66.8	65.8	66.5
42	63.5	66.4	64.9	66.4
43	61.6	63.6	62.9	63.0
44	61.9	64.6	64.5	64.5
45	61.3	63.3	62.8	62.2
46	60.5	63.9	64.0	62.8
47	60.4	60.9	60.9	60.2
48	66.0	69.3	68.7	68.5
49	62.5	65.4	65.7	65.2
50	----	63.9	63.8	63.7
51	60.6	61.9	61.2	61.6
52	59.5	61.2	60.3	61.7
53	62.5	63.6	63.2	63.6
54	64.6	66.2	66.4	66.7

Source: U. S. Weather Bureau Stations at Redfield, Miller, Forestburg, and Clark, South Dakota.

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