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Date and Rate of Corn Planting

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"I'd like to grow an early maturing corn but I just can't get the yield." This is how the South Dakota farmer summarizes one of his major problems—how to profit from the potential high quality product of early hybrids without loss of yield.

Considerable emphasis has been placed recently on the need for high plant populations to realize maximum yield levels in corn. Since corn is the major grain crop of South Dakota, grown on 4 million acres annually and with a cash value of more than twice that of the next crop, a study of the effect of different planting rates on yield has broad economic implications.

The reports of successful use of high plant populations in corn production have largely come from humid or irrigated areas of the country. Moisture has not been a limiting factor in most of these trials. South Dakota, on the other hand, is a state in which moisture is often limited; there are large areas where corn is not grown because of insufficient rainfall.

One method of successful small grain production in South Dakota is early planting. Through this method the growing period of the crop is advanced into a period of higher moisture expectation and greater moisture efficiency because of lower temperatures. Obviously, the nature of the corn plant will impose limits on the earliness of planting but there may be a range of planting dates which could be utilized and which might have a relation to the effects of varying the planting rate.

Hybrid corn is planted on most of the South Dakota corn acreage. The typical grower tends to plant a hybrid with a maturity level that will require the entire growing season in favorable years. This choice is made in the hope of obtaining maximum yields per acre, although it involves the risk of getting soft or even wet corn in years of early frost or in cool seasons.

Medium and early maturity hybrids with high yielding ability are available to the grower who wishes to reduce or minimize the risk of harvesting poor quality corn. The grower of these adapted hybrids expects to sacrifice potential yield to insure grain and storage quality. It is desirable to know the effect of higher planting rates and dates on corn hybrids of different maturity levels to determine the degree to which quality and yield may be reconciled.

Division of South Dakota into three basic areas with regard to

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corn production follows natural climatic divisions. It is based on per acre yields of corn as well as its place in the farm enterprise.

The eastern or commercial corn area (where corn is grown as feed or cash grain and where yield expectancy and consistency are high) was taken to include the entire eastern tier of counties plus Hamlin, Kingsbury, Lake, Miner, Sanborn, McCook, Hanson, Davison, Turner, Hutchinson, Clay, Yankton, and Bon Homme. The counties of Roberts and Grant were included primarily because their corn is produced in the Whetstone Valley, rather than the uplands.

The central corn area was considered to include all the remaining East-River counties, plus Tripp and Gregory west of the Missouri.

The remaining area of western South Dakota is an area where thinly planted corn on dryland is used as a summer fallow substitute in line with the long time recommended farm practices for that area. Corn on irrigation in this area is obviously in a special category and must be considered separately.

Using the average 1941-50 corn production figures and dividing the state into three areas, the following picture is obtained:

Factors causing these area differences include soil type, average available rainfall and its distribution, temperature, topography, and many others.

EXPERIMENTAL METHOD

Three rates of planting corn in checked hills 42 inches apart in either direction were tested. The rates used were 2, 3, and 4 kernels per hill. Three commercial corn hybrids, all widely grown in South Dakota, were planted at each of these three rates.

The same three hybrids were used throughout the duration of the experiment and represented an early, a medium, and a moderately late level of maturity for east-central South Dakota. They were classified as 90-, 95-, and 100-day corn respectively. (The latest maturing hybrid used is earlier than some of the corn planted in the area by many farmers.)

Two dates of planting, May 1 and May 20, were used at first, but after 1949 and 1950, a May 30 planting date was added. The three seeding rates and three hybrids at each rate thus gave a total of nine treatment combinations at each planting. This made 18, and later 27, treatment combinations per year, depending on whether two or three

	EASTERN CORN AREA	CENTRAL CORN AREA	WESTERN CORN AREA	TOTAL
Acres corn harvested	1,996,400	1,395,000	286,700	3,678,100
Total yield, bushels	64,829,000	28,428,000	4,687,000	97,944,000
Yield, bushels per acre	32.5	20.4	16.3	26.6
Percent of state acreage	54.3	37.9	7.8	100
Percent of state yield	66.2	29.0	4.8	100

planting dates were used that year.

These tests were conducted at two locations. One was at the main Experiment Station at Brookings, representative of the eastern commercial corn area. The other was at Highmore, which may be considered representative of the central area in yield and production problems. The tests were begun in 1945 and continued at each location for 10 years. While there were no complete crop failures at either location during this period, the years are representative of conditions ranging from poor to very favorable in terms of yield levels of corn. Monthly rainfall totals and average monthly mean temperatures in each year at each location are reported in tables 1 and 2. Each year at each location is evaluated in terms of its suitability for corn production in tables 3 and 4.

The land used for the experiment was part of a 3-year corn-small grain-small grain rotation at Brookings. It received 10 tons of manure per acre at fall plowing before the corn crop and 150 pounds of 0-43-0 fertilizer the year after corn.

At Highmore, the land used was part of the 2-year corn-small grain rotation. The fertility level was maintained by 8 tons of manure before the corn crop and 150 pounds of 16-20-0 per acre before the small grains. Here, because of the risk of wind erosion, spring plowing was used to prepare the land.

Stand counts were made at harvest time. Planting, cultivation, and harvesting methods employed were those generally used in experimental yield tests of corn (hand planting, hand harvesting of the entire plot except for border hills, weighing the entire plot at harvest time, and taking a sample for determination of moisture percentage). All yields were calculated on a basis of 15 percent moisture.

The tests were conducted in a randomized block design with four replications. Consequently, the yields and stands for each treatment combination at each location in each year are averages of four individual determinations, made from four plots. Each plot was 35 feet long and 10½ feet wide and contained 30 hills. The randomized block design permitted a statistical analysis of the results. In this way least significant differences could be calculated to compare results.

The actual number of plants per plot and yields and moisture percentage of the corn produced by each plot each year were recorded. Averages of these were calculated, since each treatment was replicated four times.

EXPERIMENTAL RESULTS

Over the 10-year period there were 10 sets of average stands, yields, and moisture percentages at each station. These represent the experimental conditions of the particular year involved and furnish the material for calculation of estimates of significent differences for those tests.

The value of the study lies in the future rather than in the past. Thus, individual years are important to the degree in which they may be used to evaluate and predict corn performance under certain specific or general conditions.

Grouping the Data. Yield tests run for 10 years provide an enormous mass of data for evaluation. The usual procedure is to average the data for the entire period at each location, and this has been done. However, long-time averages tend to obscure and level out differential responses to definite repeated weather patterns, which may be expected to recur. The degree to which the long-time average reflects the conditions most likely to occur will determine its utility in deriving general recommendations.

The weather data in tables 1 and 2 were used to rate the individual years in terms of general suitability for corn production, which is shown in tables 3 and 4. These ratings, plus the results from individual years, were used to group the data.

Two years, 1950 and 1951, produced unusually poor quality corn at Brookings. Moisture percentages in the harvested corn were exces-

Table 1. Climatic Summary of Growing Season at Brookings, 1945-54*

Year	April	May	June	July	August	September	Total
			Rainfall in Inches				
Normal	2.00	2.91	3.85	2.43	2.68	2.02	15.89
1945	1.48	3.19	5.64	2.49	2.06	2.21	17.07
1946	0.81	2.22	7.09	2.13	0.52	7.30	20.07
1947	3.39	1.22	4.80	0.73	1.12	3.27	14.53
1948	1.77	2.06	4.72	3.43	2.43	0.63	15.04
1949	0.41	2.28	2.82	2.04	1.07	2.90	11.52
1950	1.63	4.99	1.42	3.13	0.98	3.97	16.12
1951	1.46	3.35	4.96	2.27	8.29	1.68	22.01
1952	1.37	1.91	4.46	2.21	3.25	0.94	14.14
1953	3.51	3.58	6.40	3.24	3.85	0.28	20.86
1954	1.21	2.66	3.28	0.57	2.08	3.35	13.15
Average	1.70	2.75	4.56	2.22	2.57	2.65	16.45
			Mean Temperature in Degrees Fahrenheit				
Normal	45.1	56.8	66.1	71.9	69.9	60.9	61.8
1945	43.0	52.2	60.6	70.2	70.7	58.5	59.2
1946	51.9	53.8	67.4	71.9	67.2	59.7	62.0
1947	41.6	52.8	63.7	71.2	77.0	63.6	61.7
1948	51.4	56.5	64.8	64.8	71.3	64.7	62.3
1949	47.5	61.5	69.3	75.1	73.4	57.9	64.1
1950	36.9	53.6	67.2	67.4	65.5	62.3	58.8
1951	40.6	58.6	61.5	68.6	67.1	53.2	58.3
1952	47.0	56.6	69.5	71.3	68.2	61.6	62.4
1953	39.0	55.9	67.9	70.4	70.7	59.7	60.6
1954	46.4	51.1	66.5	73.3	68.6	59.5	60.9
Average	44.5	55.3	65.8	70.4	70.0	60.1	61.0

*Data furnished by U. S. Weather Bureau, Huron, South Dakota.

Table 2. Climatic Summary of Growing Season at Highmore, 1945-54*

Year	April	May	June	July	August	September	Total
			Rainfall in Inches				
Normal	1.86	2.60	3.31	2.35	2.06	1.39	13.57
1945	1.27	2.59	4.94	2.76	2.78	1.93	16.27
1946	1.75	2.63	6.30	2.46	0.97	3.88	17.99
1947	1.77	0.62	6.44	0.44	0.66	1.30	11.23
1948	2.23	1.19	5.06	0.73	3.09	0.62	12.92
1949	0.59	2.52	3.43	0.33	2.35	2.29	11.51
1950	0.82	2.25	1.02	2.12	2.25	1.84	10.30
1951	1.36	2.84	2.96	1.51	3.59	0.12	12.38
1952	0.02	1.07	3.33	1.07	3.08	0.00	8.57
1953	3.58	2.57	4.58	1.69	6.67	0.09	19.18
1954	0.82	0.44	5.08	0.65	1.31	0.69	8.99
Average	1.42	1.87	4.31	1.38	2.68	1.28	12.93
			Mean Temperature in Degrees Fahrenheit				
Normal	45.5	56.5	65.6	73.7	71.7	62.4	62.6
1945	43.2	51.8	58.5	71.0	70.8	60.2	59.3
1946	52.5	53.1	67.4	73.5	68.6	61.1	62.7
1947	41.0	53.0	61.5	71.8	75.8	62.8	61.0
1948	49.6	56.2	62.1	71.4	71.7	65.0	62.7
1949	48.6	59.1	68.3	74.1	73.8	57.2	63.5
1950	37.2	52.8	66.0	68.0	68.5	60.4	58.8
1951	41.8	55.8	59.7	70.3	68.8	56.4	58.8
1952	47.7	57.7	71.1	74.2	70.7	67.0	64.7
1953	40.5	55.0	68.0	72.1	72.5	62.8	61.8
1954	46.6	53.2	64.7	76.2	71.9	61.3	62.3
Average	44.9	54.8	64.7	72.3	71.3	61.4	61.6

*Data furnished by U. S. Weather Bureau, Huron, South Dakota.

sively high and yields intermediate. Both years had low temperatures during the latter months of the growing season. Corn grew slowly and never matured properly. These two years were grouped as cool or "wet corn" years.

Likewise, 1948, 1952, 1953, and 1954 appeared similar in general pattern. Yields were excellent. Moisture percentages in the corn were low. The growing season was long, and precipitation was sufficient to allow normal development of corn. These four years were grouped as favorable years.

Four other years, 1945, 1946, 1947, and 1949 had lower yield levels than those of the favorable years. Corn grain moisture percentages were higher but not excessive. In each of these years, one or more limiting factors operated to reduce the length of the effective growing season.

In 1946, 1947, and 1949 there were July and August rainfall deficiencies, coupled in 1949 with frost on September 1. In 1946 there was a severe late spring freeze in mid-May. In 1945 an unusually cool June slowed early growth of corn,

Table 3. Rating of the Individual Years 1945 Through 1954 for Corn Production at Brookings

Year	Departure from Normal		Date of	Main Features of Growing Season	Rating
	Rainfall, in.	Temp. °F	First Frost		
1945	+1.18	—2.6	Oct. 9	Cool spring and fall—crop fair	Fair
1946	+4.18	+0.2	Sept. 29	Dry July and August	Fair
1947	—1.36	—0.1	Sept. 22	Dry July and August	Fair
1948	—0.85	+0.5	Oct. 9	Excellent corn year	Excellent
1949	—4.37	+2.3	Sept. 1	General seasonal moisture deficiency	Fair
1950	+0.23	—3.0	Oct. 3	Cold season	V. Poor
1951	+6.12	—3.5	Sept. 22	Cold and wet season	Poor
1952	—1.75	+0.6	Sept. 19	Excellent corn year	V. Good
1953	+4.97	—1.2	Sept. 21	Excellent corn year	V. Good
1954	—2.74	—0.9	Sept. 22	Some fall drought—good crop	V. Good

Table 4. Rating of the Individual Years 1945 Through 1954 for Corn Production at Highmore

Year	Departure from Normal		Date of	Main Features of Growing Season	Rating
	Rainfall, in.	Temp. °F	First Frost		
1945	+2.70	—3.3	Sept. 25	Fairly good growing season	Good
1946	+4.42	+0.1	Sept. 1	Very short season—late spring, early fall frost	Poor
1947	—2.34	—1.6	Sept. 22	Drought—July and August	Poor
1948	—0.65	+0.1	Oct. 7	Excellent corn year	Good
1949	—2.06	+0.9	Sept. 13	Drought—July and August	Poor
1950	—3.27	—3.8	Oct. 2	Below normal temperatures—cold	Poor
1951	—1.19	—3.8	Sept. 22	Much below normal temperature	Poor
1952	—5.00	+2.1	Oct. 2	Good corn year	Good
1953	+5.61	—0.8	Sept. 21	Good corn year	Good
1954	—4.58	—0.3	Sept. 21	Some July drought—good crop	Good

and subsequent adequate temperatures in later months only permitted partial restoration of normal development. These four years were not ideal corn years, and yet in all, yields between 30 and 50 bushels per acre were produced. They were grouped as "fair" or intermediate corn years.

During the 10-year period, there was no failure of corn in this area. Growing conditions were such that it was possible to produce 30 bushels per acre of acceptable quality corn by the proper selection of hybrid, planting date, and planting rate.

Grouping of the Highmore results indicated a large difference between the two areas. The best corn performances at Highmore were comparable to the intermediate yields at Brookings. There were no bumper crops at that station. Five years—1945, 1948, 1952, 1953, and 1954—permitted the production of corn of good quality with yields ranging from 30 to 50 bushels per acre. For the central part of the state these are classed as favorable years.

Three years—1946, 1947, and 1949—were classed as dry years. July and August moisture deficiencies in all three years resulted in yields at the 20-bushel level and less. A killing frost on September 1 in 1946 shortened that season further. Moistures in corn these years were low, and so were the yields.

The 1950 and 1951 seasons resulted in very poor quality corn at Highmore. Moisture percentages in the grain were very high and yields low. The cool summer temperatures delayed corn growth to a point where normal maturity was not possible. These two years were therefore combined as cool or "wet corn" years.

It is reasonable to assume that in favorable corn years, the optimum planting date would be the first date after which corn could make rapid, uninterrupted growth. The high rate of planting and the late maturing hybrid should be outstanding in performance.

Seasons involving limited availability of one or more major growth factors—temperature, moisture, length of growing season—should favor earlier hybrids. Quality considerations would become paramount in wet corn years. All these seasons would require a conservative utilization of the environment.

Stands. Yields of corn obtained are related to the stands in most cases. One of the main purposes of this work was to study the effect of stands on yield, the yield levels resulting from the interrelationships of stand with date of planting, and stand with the maturity of the hybrid used.

In this experiment 2, 3, and 4 seeds per hill were planted. These seeding rates produced stands somewhat lower than 2, 3, and 4 plants per hill. The actual stands obtained are reported as *average plants per hill* in tables 5 through 20.

The question may be properly asked: Are these stand deficiencies peculiar to experimental work, and would they be as great on large farm acreages? There is no easy answer to this question. Gophers, pheasants, field mice, cut worms, and crows all deplete stands and may be harder to control on small experimental plots than on large acreages. On the other hand, poor germination or survival may be due to a particular hybrid or a particular lot of seed. In such situations, problems on large acreages would be no different from small plots. Plots are usually laid out on well drained, uniform land, and deficient stand or stunting due to poor drainage is unlikely.

From the results reported here, there seems to be a rather consistent stand deficiency of the early-maturing hybrid. This may be due to a lack of inherent resistance to cold in the seedling stage. It may also be due to the nature of the particular lots of seed used since degree of maturity of seed corn and processing injury may affect germination. The other two hybrids gave stands very similar to each other.

Even though the stands obtained fall between 1.6 to 3.5 plants per hill, inferences about higher stand levels may still be made. For example, table 5 shows average performance of corn at Brookings in favorable years. At the May 1 planting the early hybrid yielded 51.5

bushels per acre at 1.7 plants per hill, 65.3 bushels per acre at 2.5 plants per hill, and 73.9 bushels per acre at 3.1 plants per hill. The continuous rise in the yield of the early hybrid as the stand increased would indicate that a further yield increase might be expected if 4-plant hills had been grown.

By contrast, the full season hybrid at the same planting date in the same years produced 71.8 bushels per acre at 1.8 plants per hill, 78.4 bushels per acre at 2.7 plants per hill, and 78.9 bushels per acre at 3.4 plants per hill. The increase in stand from 2.7 to 3.4 plants per hill resulted in an increase of only half a bushel in yield. It appears that increasing the stand beyond 3.4 plants per hill could not increase the yield.

This same technique of comparison between stands may be used under less favorable conditions. Table 15, giving the average performance at Highmore in dry years, illustrates the penalties for excessive stand. Thus, at the May 20 planting, the full season hybrid yielded 15.6 bushels per acre with 1.8 plants per hill, 11.7 bushels per acre with 2.4 plants per hill, and 9.4 bushels per acre with 3.1 plants per hill. Obviously, here the thin stand of 1.8 plants per hill was superior in yield to higher stands, and even it may have been overcrowded. Certainly, any stand increase beyond 1.8 plants per hill reduced the yield.

A critical examination of the results along these lines of reasoning may reveal limits to stand density by using the available yields and stands.

Moisture Percentages. Moisture samples were taken in duplicate for each treatment combination in each year at each station at the time of harvest. The moisture percentages for each treatment combination, main effect, and interaction average are given in the tables along with the yield and stand.

Average moisture percentages varied widely—from over 60 percent to around 10 percent. Moisture content has always been important in corn quality, especially in relation to marketing and storing. The moisture figures therefore permit classifying the corn produced as sound, soft, or wet.

In ordinary practice, sound corn is corn safe for cribbing, having 15 percent or less moisture. Soft corn would range from 15 to 25 percent moisture. Corn that has above 25 percent moisture would be classified as wet.

These experiments were harvested shortly after frost, so the normal drying process after freezing may not have been completed. *Because the corn was not allowed to dry out normally, higher moisture levels were allowed for sound, soft, and wet corn classes.* Sound corn was considered as having a moisture percentage of 30 or less. Soft corn was considered to range from 30 to 40 percent moisture. Any samples which contained over 40 percent moisture were classed as wet corn.

Yields. Yields were obtained by husking and weighing all the ears produced in a plot. They are expressed on a 15 percent moisture basis so that they reflect true dry matter production in terms of ear corn. The yields were then averaged for each treatment combination and analyzed statistically to determine the amount of difference necessary at the 5 percent level of significance.

STATISTICAL ANALYSIS

The analysis of variance was used, which is based on the assumption of a normal distribution of yields as well as errors of their estimation. The actual yields were affected by variation in stand due to rates of seeding as well as uncontrolled factors. Since stand procurement is an essential part of corn culture, the stands that were obtained were accepted, along with the resulting yields.

INTERPRETATION OF DATA

Results of these experiments are reported in tables 5 through 20, where the individual year's results have been combined as already indicated. Stand, yield, and moisture percentage for each treatment or over-all effect are always reported together. This is because these considerations cannot be entirely separated, and the yields are certainly influenced by the stands.

Even so, the yield differences are affected by chance as well as actual difference due to treatment. The significant differences reported at the bottom of each table may be used to differentiate real treatment differences from those due to chance and experimental error.

The least significant difference reported in the odd-numbered tables—where the yields of individual treatment combinations are listed—may be used to compare any yield due to a specific treatment with any other specific treatment yield. Unless the difference is as great as, or exceeds the least significant difference, it may be considered due to chance.

In the even-numbered tables, significant differences are supplied to differentiate main effects and interactions. A main effect is a single variable factor, such as date of planting. The least significant difference for yield of main effects may be used in comparing average yields at different planting dates—like May 1 compared with May 20. It will serve to compare yields from different planting rates or from different hybrids.

Interactions involve the yields resulting by varying two of the factors of the experiment together, such as date of planting and hybrid. Thus there would be an average yield for each hybrid at each date of planting. Yield differences in these interaction tables may be evaluated by using the least significant difference for interactions.

The May 30 date of planting was not added to the experiment until 1950 at Brookings and 1951 at Highmore. All averages from this date of planting involve less years than the other dates. The May 30 planting date results are therefore not comparable with results from the other planting dates in tables where the years combined included years with and without a May 30 planting.

This is very evident from the 10-year average at Highmore (tables 19 and 20). The reason for the high yields at the May 30 planting at Highmore is due to the three excellent corn years, 1952, 1953, and 1954, which have strongly weighted those averages. For May 1 and 20 plantings, poor yields in 1946, 1947, and 1949 have lowered the averages and made them more nearly representative of the long-time corn production picture at that location.

Since plantings were made on May 30, and since rate and hybrid comparisons at those dates may be made, results from May 30 are reported. They are results from actual experiments and furnish valuable information. They need to be used with caution and with an appreciation of their limitations.

EASTERN AREA RESULTS

Favorable Years. These were years when climatic conditions favored high yields of good quality corn. Moisture and temperature were adequate, and the growing season was long enough to permit normal maturing even of the late hybrid at the last planting date. The average yield, stand, and moisture percentages for the individual treatment combinations are given in table 5. The main effects and interactions are given in table 6.

The data indicate little difference in yield due to planting date (averaged over all rates and hybrids). The May 20 date was not significantly different from May 1; the May 30 results, which do not include 1948 yields, appear slightly inferior in both yield and quality.

Planting rate averages indicate that actual stands between 1.8 to 3.3 plants per hill had no effect on corn quality, but that on the average 3.3 plants per hill resulted in higher yields than lower rates.

The late and midseason hybrids were very similar in yield and stand, although the early one definitely yielded less. All hybrids used produced acceptable corn.

The high planting rate at May 1 gave the highest yield, as well as excellent quality corn. At the May 20 date, both the high and intermediate rates gave excellent yields approaching the high rate on May 1.

The late hybrid produced its best yield from May 1 planting. The early and medium hybrids did best at May 20 planting. All hybrids performed best at the high planting rate, with stands from 3.2 to 3.4 plants per hill. The outstanding single combinations were the full season hybrid planted early at the high rate and the medium hybrid planted May 20 at the high rate.

Intermediate Years. This class involves the years that produced corn yields in the range from 30 to 50 bushels. Emergence was uneven and moistures at harvest time ranged from 22 to 38 percent. Individual treatment combinations and over-all main effects and interactions are summarized in tables 7 and 8, giving average stands, yields, and moistures.

Yields from May 20 planting were definitely superior to those from the earlier date. Corn moisture levels increased as planting was delayed.

The highest planting rate produced the highest yields. Average stand differences between the two planting dates are of sufficient magnitude to account for the yield differences.

The late hybrid was higher in yield, stand, and moisture, although the 3-bushel difference compared to the medium hybrid may be a matter of stand.

The high rate of planting gave maximum yields at the May 20 date. At May 1 planting, the late hybrid was best by far, but at the May 20 date the yields were nearly equal for all three. The medium hybrid was slightly superior in yield with

Table 5. Average Stand, Yield, and Moisture of Corn in Favorable Years 1948, 1952, 1953, and 1954 at Brookings—Individual Treatment Combinations

TREATMENT					
Date of Planting	Planting Rate per Hill	Hybrid	Plants per Hill	Yield bu/Acre	Moisture Percent
May 1	2	Early	1.7	51.1	18.2
	2	Medium	1.9	62.5	21.0
	2	Late	1.8	71.8	23.1
	3	Early	2.5	65.3	17.9
	3	Medium	2.7	74.4	19.5
	3	Late	2.7	78.4	25.1
	4	Early	3.1	73.9	17.4
	4	Medium	3.3	75.9	19.9
	4	Late	3.4	78.9	24.5
May 20	2	Early	1.9	65.3	19.5
	2	Medium	1.9	63.7	20.9
	2	Late	1.9	67.4	27.0
	3	Early	2.7	72.4	23.1
	3	Medium	2.9	73.8	21.7
	3	Late	2.8	75.4	28.3
	4	Early	3.4	71.9	24.0
	4	Medium	3.5	81.4	21.8
	4	Late	3.6	72.8	27.7
May 30	2	Early	1.8	56.7	25.4
	2	Medium	1.8	60.4	25.1
	2	Late	1.8	62.4	28.4
	3	Early	2.6	64.7	24.0
	3	Medium	2.6	66.1	25.7
	3	Late	2.6	64.4	28.7
	4	Early	3.0	67.5	24.5
	4	Medium	3.2	70.2	26.2
	4	Late	3.1	68.6	28.5
Least significant difference for yields of individual treatments				6.2	

Table 6. Average Stand, Yield, and Moisture of Corn in Favorable Years 1948, 1952, 1953, and 1954 at Brookings—Main Effects and Interactions

TREATMENT			Plants per Hill	Yield bu/Acre	Moisture Percent
Dates:	May 1		2.6	70.2	20.7
	May 20		2.7	71.6	23.8
	May 30		2.5	64.5	26.3
Rates of Planting:	2 per hill		1.8	62.4	23.2
	3 per hill		2.7	70.5	23.7
	4 per hill		3.3	73.4	23.8
Hybrids:	Early		2.5	65.4	21.6
	Medium		2.7	69.8	22.4
	Late		2.7	71.1	26.8
Dates x Rates:	May 1	2 per hill	1.8	61.8	20.8
		3 per hill	2.7	72.7	20.8
		4 per hill	3.3	76.2	20.6
	May 20	2 per hill	1.9	65.5	22.5
		3 per hill	2.8	73.9	24.4
		4 per hill	3.5	75.4	24.5
	May 30	2 per hill	1.8	59.8	26.3
		3 per hill	2.6	65.1	26.1
		4 per hill	3.1	68.8	26.4
Dates x Hybrids:	May 1	Early	2.4	63.4	17.8
		Medium	2.6	70.9	20.1
		Late	2.7	76.4	24.2
	May 20	Early	2.7	69.9	22.2
		Medium	2.8	73.0	21.5
		Late	2.8	71.9	27.7
	May 30	Early	2.5	63.0	24.6
		Medium	2.6	65.6	25.7
		Late	2.5	65.1	28.5
Rates x Hybrids:	2 per hill	Early	1.8	57.7	21.0
	2 per hill	Medium	1.9	62.2	22.3
	2 per hill	Late	1.9	67.2	26.2
	3 per hill	Early	2.6	67.5	21.7
	3 per hill	Medium	2.7	71.4	22.3
	3 per hill	Late	2.7	72.7	27.4
	4 per hill	Early	3.2	71.1	22.0
	4 per hill	Medium	3.3	75.8	22.6
	4 per hill	Late	3.4	73.4	26.9
Least significant difference between averages of main effects				2.1	
Least significant difference between individual interaction averages				3.6	

6 percent less moisture than the late hybrid.

The data show that the high rate gave comparable yields with all hybrids, so the quality factor would favor midseason or early corn. All hybrids planted at high rates on May 20 gave superior yields, as did the late hybrid at high rate on May 1 planting. Quality considerations definitely favor the medium or early hybrid planted May 20.

Cool Years. These two seasons were marked by adequate rainfall and low growing season temperatures. All moistures were high and corn was soft or wet. Performance for these years is given in tables 9 and 10.

Yields from the May 1 and May 20 planting were about the same and superior to those from the May 30 planting. Quality at the late date was very poor. Planting rate had little effect on corn moisture, and yields were highest with the maximum planting rate used.

Yield differences between hybrids were not too great and would point to the medium hybrid as the best yield-quality compromise.

The high rate of planting gave superior yields at the May 1 and 20 dates. At the May 1 planting the

Table 7. Average Stand, Yield, and Moisture of Corn in Intermediate Years 1945, 1946, 1947, and 1949 at Brookings—Individual Treatment Combinations

TREATMENT					
Date of Planting	Planting Rate per Hill	Hybrid	Plants per Hill	Yield bu/Acre	Moisture Percent
May 1	2	Early	1.5	33.1	22.7
	2	Medium	1.6	36.6	27.5
	2	Late	1.8	44.8	30.5
	3	Early	2.1	38.9	21.7
	3	Medium	2.2	40.2	30.9
	3	Late	2.4	47.5	32.7
	4	Early	2.6	42.4	23.4
	4	Medium	2.6	42.6	27.3
	4	Late	3.0	46.8	34.0
May 20	2	Early	1.9	41.9	28.3
	2	Medium	1.9	42.8	30.8
	2	Late	1.9	43.1	36.8
	3	Early	2.6	48.9	27.5
	3	Medium	2.7	50.1	32.0
	3	Late	2.7	48.7	38.4
	4	Early	3.1	50.2	28.3
	4	Medium	3.1	52.2	31.0
	4	Late	3.4	50.0	35.7
Least significant difference for yields of individual treatments				4.1	

Table 8. Average Stand, Yield, and Moisture of Corn in Intermediate Corn Years 1945, 1946, 1947, and 1949 at Brookings—Main Effects and Interactions

TREATMENT			Plants per Hill	Yield bu/Acre	Moisture Percent
Dates:	May 1		2.2	41.4	27.9
	May 20		2.6	47.5	32.1
Rates of Planting:	2 per hill		1.7	40.4	29.4
	3 per hill		2.5	45.7	30.5
	4 per hill		3.0	47.4	30.5
Hybrids:	Early		2.3	42.6	25.3
	Medium		2.3	44.1	29.9
	Late		2.5	46.8	34.7
Dates x Rates:	May 1	2 per hill	1.6	38.2	26.9
		3 per hill	2.3	42.2	28.4
		4 per hill	2.7	43.9	28.2
	May 20	2 per hill	1.9	42.6	32.0
		3 per hill	2.7	49.2	32.6
		4 per hill	3.2	50.8	31.7
Dates x Hybrids:	May 1	Early	2.1	38.1	22.6
		Medium	2.1	39.8	28.6
		Late	2.4	46.4	32.4
	May 20	Early	2.5	47.0	28.0
		Medium	2.6	48.4	31.3
		Late	2.7	47.3	37.0
Rates x Hybrids:	2 per hill	Early	1.7	37.5	25.5
	2 per hill	Medium	1.7	39.7	29.2
	2 per hill	Late	1.8	44.0	33.7
	3 per hill	Early	2.4	43.9	24.6
	3 per hill	Medium	2.5	45.2	31.5
	3 per hill	Late	2.6	48.1	35.6
	4 per hill	Early	2.9	46.3	25.9
	4 per hill	Medium	2.8	47.4	29.2
	4 per hill	Late	3.2	48.4	34.9
Least significant difference between averages of main effects				1.8	
Least significant difference between individual interaction averages				2.4	

late hybrid was outstanding in yield. At May 20, the late hybrid yielded high but produced wet corn, while the midseason hybrid yielded almost as much but had better quality. Use of high rates gave good yields with the early and medium hybrids. The best individual combination was the medium hybrid planted at a high rate on May 1. Next were the early and medium hybrids at the May 20 planting, both at a high rate.

Ten-Year Average. The average stands, yields, and moistures obtained in this experiment over the 10-year period are shown in table 11. This table gives the average results of the individual treatment combinations. The response to

Table 9. Average Stand, Yield, and Moisture of Corn in Cool Years 1950 and 1951 at Brookings—Individual Treatment Combinations

TREATMENT					
Date of Planting	Planting Rate per Hill	Hybrid	Plants per Hill	Yield bu/Acre	Moisture Percent
May 1	2	Early	1.6	39.8	28.3
	2	Medium	1.7	41.2	33.9
	2	Late	1.9	53.9	41.0
	3	Early	2.3	40.4	35.0
	3	Medium	2.7	49.2	36.1
	3	Late	2.7	57.2	39.8
	4	Early	3.1	50.0	32.5
	4	Medium	3.5	59.1	34.5
	4	Late	2.9	57.7	40.2
May 20	2	Early	1.9	47.7	33.3
	2	Medium	1.9	45.5	41.0
	2	Late	2.0	52.9	40.3
	3	Early	2.6	45.3	41.8
	3	Medium	2.8	53.6	42.7
	3	Late	2.9	56.8	45.0
	4	Early	3.5	59.0	39.3
	4	Medium	3.4	58.7	38.0
	4	Late	3.5	56.9	47.7
May 30	2	Early	1.7	32.5	40.3
	2	Medium	1.8	37.5	47.5
	2	Late	1.8	35.2	52.5
	3	Early	2.3	38.3	43.3
	3	Medium	2.7	39.0	52.0
	3	Late	2.5	36.8	53.0
	4	Early	3.0	44.4	39.5
	4	Medium	3.5	40.0	54.5
	4	Late	3.2	32.5	58.5
Least significant difference for yields of individual treatments				9.7	

Table 10. Average Stand, Yield, and Moisture of Corn in Cool Years 1950 and 1951 at Brookings—Main Effects and Interactions

TREATMENT			Plants per Hill	Yield bu/Acre	Moisture Percent
Dates:	May 1		2.5	49.8	35.7
	May 20		2.7	52.9	41.0
	May 30		2.5	37.4	49.0
Rates of Planting:	2 per hill		1.8	42.9	39.8
	3 per hill		2.6	46.3	43.2
	4 per hill		3.3	50.9	42.7
Hybrids:	Early		2.4	44.2	37.0
	Medium		2.7	47.1	42.2
	Late		2.6	48.9	46.4
Dates x Rates:	May 1	2 per hill	1.7	45.0	34.4
		3 per hill	2.6	48.9	37.0
		4 per hill	3.1	55.6	35.7
	May 20	2 per hill	2.0	48.7	38.2
		3 per hill	2.8	51.9	43.2
		4 per hill	3.5	58.2	41.7
	May 30	2 per hill	1.8	35.1	46.8
		3 per hill	2.5	38.0	49.4
		4 per hill	3.2	39.0	50.8
Dates x Hybrids:	May 1	Early	2.3	43.4	31.9
		Medium	2.6	49.8	34.8
		Late	2.5	56.3	40.3
	May 20	Early	2.7	50.7	38.1
		Medium	2.7	52.6	40.6
		Late	2.8	55.5	44.3
	May 30	Early	2.3	38.4	41.0
		Medium	2.7	38.8	51.3
		Late	2.5	34.8	54.7
Rates x Hybrids:	2 per hill	Early	1.7	40.0	34.0
	2 per hill	Medium	1.8	41.4	40.8
	2 per hill	Late	1.9	47.3	44.6
	3 per hill	Early	2.4	41.3	40.0
	3 per hill	Medium	2.7	47.3	43.6
	3 per hill	Late	2.7	50.3	45.9
	4 per hill	Early	3.2	51.1	37.1
	4 per hill	Medium	3.5	52.6	42.3
	4 per hill	Late	3.2	49.0	48.8
Least significant difference between averages of main effects				3.2	
Least significant difference between individual interaction averages				5.6	

planting date, rate, and hybrid and their interactions, as averaged over individual combinations, is shown in table 12.

A long-time average is a great leveller, and this one is no exception. It obscures some of the striking contrasts and obvious comparisons when similar seasons are grouped together. But that is not undesirable if the lessons of the individual seasons are properly considered. Every strong departure from the normal, such as the cool seasons of 1950 and 1951, will ultimately be matched by departures in the other direction so that the average will be maintained. Ultimately,

Table 11. Average Stand, Yield, and Moisture of Corn at Brookings 1945 to 1954—Individual Treatment Combinations

TREATMENT					
Date of Planting	Planting Rate per Hill	Hybrid	Plants per Hill	Yield bu/Acre	Moisture Percent
May 1	2	Early	1.6	41.6	22.0
	2	Medium	1.7	47.9	26.1
	2	Late	1.8	57.4	29.6
	3	Early	2.3	49.8	22.8
	3	Medium	2.5	55.7	27.4
	3	Late	2.6	61.8	31.1
	4	Early	2.9	56.5	22.8
	4	Medium	3.0	59.2	25.8
	4	Late	3.1	61.8	31.4
May 20	2	Early	1.9	52.4	25.8
	2	Medium	1.9	51.7	28.9
	2	Late	1.9	54.8	33.6
	3	Early	2.7	57.6	28.6
	3	Medium	2.8	60.2	30.0
	3	Late	2.8	61.0	35.7
	4	Early	3.3	60.6	28.8
	4	Medium	3.3	65.2	28.7
	4	Late	3.5	60.5	34.9
May 30	2	Early	1.8	47.0	31.4
	2	Medium	1.8	51.2	34.0
	2	Late	1.8	51.5	38.0
	3	Early	2.5	54.1	31.7
	3	Medium	2.6	55.2	36.1
	3	Late	2.6	53.3	38.4
	4	Early	3.0	58.2	30.5
	4	Medium	3.4	58.1	37.5
	4	Late	3.1	54.2	40.5
Least significant difference for yields of individual treatments				3.6	

Table 12. Average Stand, Yield, and Moisture of Corn at Brookings, 1945 to 1954—Main Effects and Interactions

TREATMENT			Plants per Hill	Yield bu/Acre	Moisture Percent
Dates:	May 1		2.4	54.6	26.6
	May 20		2.7	58.2	30.5
	May 30		2.5	53.7	35.4
Rates of Planting:	2 per hill		1.8	50.6	29.9
	3 per hill		2.6	56.5	31.3
	4 per hill		3.2	59.4	31.2
Hybrids:	Early		2.4	53.1	27.1
	Medium		2.6	56.0	30.5
	Late		2.6	57.4	34.8
Dates x Rates:	May 1	2 per hill	1.7	49.0	25.9
		3 per hill	2.5	55.7	27.1
		4 per hill	3.0	59.2	26.7
	May 20	2 per hill	1.9	52.9	29.4
		3 per hill	2.7	59.6	31.4
		4 per hill	3.4	62.1	30.8
	May 30	2 per hill	1.8	49.9	34.5
		3 per hill	2.6	54.2	35.4
		4 per hill	3.2	56.8	36.2
Dates x Hybrids:	May 1	Early	2.3	49.3	22.5
		Medium	2.4	54.2	26.4
		Late	2.5	60.4	30.7
	May 20	Early	2.6	56.9	27.7
		Medium	2.7	59.0	29.2
		Late	2.7	58.7	34.7
	May 30	Early	2.4	53.1	31.2
		Medium	2.6	54.8	35.9
		Late	2.5	53.0	39.0
Rates x Hybrids:	2 per hill	Early	1.7	47.0	26.4
	2 per hill	Medium	1.8	50.2	29.7
	2 per hill	Late	1.9	54.3	33.7
	3 per hill	Early	2.5	53.8	27.7
	3 per hill	Medium	2.7	57.0	31.2
	3 per hill	Late	2.6	58.7	35.0
	4 per hill	Early	3.1	58.5	27.4
	4 per hill	Medium	3.2	60.8	30.7
	4 per hill	Late	3.3	58.8	35.6
Least significant difference between averages of main effects				1.2	
Least significant difference between individual interaction averages				2.1	

a recommendation for the future must rest on averages; and where the averages involve as much as 10 of South Dakota's 70 years of agriculture, they have stature.

An average based largely on a series of unusually favorable years or unusually unfavorable years may be misleading. But such is not the case here. This experiment was run over a wide range of seasons, ranging from the "bumper" corn year of 1948 to the near failure of 1951 and the near drought of 1949. It can thus be considered a fair sample of conditions in eastern South Dakota, except that, fortunately, there were no complete crop failures.

Half the years ran below normal in rainfall in the growing season, half above. Temperature variation likewise involved the same number of departures from the normal in each direction. The 10-year average may thus be considered representative. What does it indicate?

The May 20 planting date gave higher yields than either the earlier or later date. In the case of the May 1 date, the yield difference of 3.5 bushels per acre may be due to a stand deficiency of three-tenths plants per hill. This stand difference would indicate that if corn hybrids can be produced that can make an adequate stand from a May 1 planting, this might be the best time to plant corn. This is borne out by the results in favorable years, when warm springs gave excellent stands and yields at this planting date. The quality of corn produced from the early planting was far superior to that from later plantings.

The highest rate of planting gave the highest yields and indicates that optimum stands of corn in eastern South Dakota may be somewhat in excess of three plants per hill *if* other sound management practices are carefully observed. Careful observation of the rate of yield increase as stands increased indicates that the best stand level may not exceed 4 plants per hill. Thickness of stand had very little effect on moisture in the corn.

Over all planting dates and rates, the yield of the full season hybrid excelled that of the early or medium hybrid. The early hybrid's poor yield performance may no longer be typical of its maturity class, since it seemed to be consistently poorer in ability to make a stand than the other two hybrids.

Improvements in seedling emergence and survival of corn hybrids have been made, and early hybrids are available that have excellent germination, seedling vigor, and survival capacity. On the other hand, the full season hybrid consistently produced soft corn, while the early and medium hybrids generally produced an acceptable corn. This consideration is very important in an area where corn is a cash crop.

All these results indicate that there is considerable productivity in South Dakota's commercial corn acreages. This productivity can be utilized by planting somewhat earlier than May 20, and somewhat thicker than 3 plants per hill.

The next question then hinges on which combinations of these practices will give the best results. Is it possible to make full use of the corn producing potential of the land and still enjoy the high probability of getting sound corn that goes with the early maturing hybrids? The interaction averages and the individual combinations furnish answers to these questions.

The dates x rates interaction indicates that the high rate of planting was the best at all dates.

Very significant information comes from the interaction of planting date with hybrids and rate of planting with hybrids. Thus the medium hybrid at the high rate of planting yielded more than the full season hybrid at any rate of planting. The early hybrid at high-stand level likewise yielded as much as the full season hybrid at any rate, and of course, offered a great safety margin in terms of quality.

Hybrid performance was also influenced by planting date. The full season hybrid produced its highest yield at the May 1 planting, the other two at the May 20 planting. The way to realize maximum potential of the full season hybrid is to lengthen its growing season by advancing its planting date. This practice is not necessary for the early and medium hybrids.

With these considerations, it is possible to examine table 11 for cultural methods that will combine high yield with quality of corn. These are evident. The combination with the outstanding yield is the medium hybrid at the high rate planted May 20. This averaged 65.2 bushels per acre with 28.7 percent moisture at harvest. Slightly less yield, but still better quality, might be obtained by substituting the early hybrid in the above combination, which gave 60.6 bushels per acre. The top performance of the full-season corn comes from the medium rate at the May 1 planting —61.9 bushels per acre—31.1 percent moisture. Other combinations approach but do not equal these.

CENTRAL AREA RESULTS

Favorable Years. Five years were grouped as being free of unusual production hazards (1945, 1948, 1952, 1953, and 1954), and their results are averaged in tables 13 and 14. Moisture percentages in corn were low, stands fair, and yields ranged from 30 to 50 bushels.

The last date of planting has the best yield, which cannot be compared as such with the other dates because there was no May 30 planting date in 1945 and 1948.

There was little difference in yield among planting rates, but the intermediate rate was superior in yield to the high rate. There is very little yield difference among hybrids that may not be accounted for by stand differences. Corn moisture is definitely related to the hybrid maturity level.

The intermediate planting rate, which produced 2.6 plants per hill, was superior in yield at all planting dates and resulted in good quality corn.

Hybrid performance depended on planting date. At May 1, the late hybrid yielded best, but by May 30 the yield advantage had passed to the early hybrid, which had a consistent quality advantage. This yield advantage existed despite a markedly inferior stand of the early hybrid.

The effect of planting rate on hybrid performance is only evident at the low rate. Here the full season hybrid yielded more than the others, but no more than the early or medium hybrids at higher rates of planting.

The apparent superiority of the May 30 date is probably linked with the seasonal nature of precipitation. By corn planting time soil moistures are depleted. In 1952, 1953, and 1954 a dry May was followed by high rainfall in June. Be-

Table 13. Average Stand, Yield, and Moisture of Corn in Good Corn Years 1945, 1948, 1952, 1953, and 1954 at Highmore—Individual Treatment Combinations

TREATMENT					
Date of Planting	Planting Rate per Hill	Hybrid	Plants per Hill	Yield bu/Acre	Moisture Percent
May 1	2	Early	1.6	29.4	16.2
	2	Medium	1.8	33.7	20.0
	2	Late	1.8	35.6	23.1
	3	Early	2.2	33.5	15.7
	3	Medium	2.6	34.7	19.5
	3	Late	2.5	38.0	24.8
	4	Early	2.9	34.5	17.9
	4	Medium	3.2	35.2	17.9
	4	Late	3.2	35.2	25.3
May 20	2	Early	1.9	36.1	20.4
	2	Medium	1.8	37.6	21.8
	2	Late	1.8	39.4	30.2
	3	Early	2.5	41.7	18.8
	3	Medium	2.7	39.9	19.9
	3	Late	2.6	41.5	28.5
	4	Early	3.2	37.5	22.9
	4	Medium	3.5	37.1	18.9
	4	Late	3.4	43.4	27.6
May 30	2	Early	1.6	40.0	15.2
	2	Medium	1.7	41.1	19.6
	2	Late	1.7	47.1	20.9
	3	Early	2.4	46.5	13.0
	3	Medium	2.6	47.3	21.2
	3	Late	2.8	43.8	29.3
	4	Early	2.8	46.5	10.6
	4	Medium	3.4	43.5	24.0
	4	Late	3.4	39.5	30.2
Least significant difference for yields of individual treatments				5.0	

Table 14. Average Stand, Yield, and Moisture of Corn in Good Corn Years 1945, 1948, 1952, 1953, and 1954 at Highmore—Main Effects and Interactions

TREATMENT			Plants per Hill	Yield bu/Acre	Moisture Percent
Dates:	May 1		2.4	34.4	20.0
	May 20		2.6	39.4	23.2
	May 30		2.6	43.9	20.4
Rates of Planting:	2 per hill		1.8	37.8	20.8
	3 per hill		2.6	40.8	21.2
	4 per hill		3.2	39.2	21.7
Hybrids:	Early		2.4	38.4	16.7
	Medium		2.6	38.9	20.3
	Late		2.6	40.4	26.7
Dates x Rates:	May 1	2 per hill	1.7	32.9	19.8
		3 per hill	2.4	35.4	20.0
		4 per hill	3.1	35.0	20.4
	May 20	2 per hill	1.8	37.7	24.1
		3 per hill	2.6	41.0	22.4
		4 per hill	3.4	39.3	23.1
	May 30	2 per hill	1.9	42.7	18.6
		3 per hill	2.6	45.9	21.2
		4 per hill	3.2	43.2	21.6
Dates x Hybrids:	May 1	Early	2.2	32.5	16.6
		Medium	2.5	34.5	19.1
		Late	2.5	36.3	24.4
	May 20	Early	2.5	38.4	20.7
		Medium	2.7	38.2	20.2
		Late	2.6	41.4	28.8
	May 30	Early	2.3	44.3	12.9
		Medium	2.6	44.0	21.6
		Late	2.7	43.5	26.8
Rates x Hybrids:	2 per hill	Early	1.8	35.2	17.3
	2 per hill	Medium	1.9	37.5	20.5
	2 per hill	Late	1.8	40.7	24.7
	3 per hill	Early	2.4	40.6	15.8
	3 per hill	Medium	2.6	40.6	20.2
	3 per hill	Late	2.6	41.1	27.5
	4 per hill	Early	3.0	39.5	17.1
	4 per hill	Medium	3.4	38.6	20.3
	4 per hill	Late	3.3	39.4	27.7
Least significant difference between averages of main effects				1.7	
Least significant difference between individual interaction averages				2.9	

cause of the delayed rainfall, there was no advantage of planting the corn early.

Dry Years. Typically these dry years (1946, 1947, and 1949) had high summer temperatures, with abundant June rainfall followed by a moisture deficiency in July and later parts of the growing season. There were only two planting dates in these years and results are summarized in tables 15 and 16.

There was no difference in yield or moisture between the May 1 and May 20 planting dates. The low rate of planting, resulting in 1.6 plants per hill, was greatly superior to the two higher rates (2.3 and 2.9 plants per hill).

The early and medium hybrids were definitely superior to the late.

At individual dates of planting, the low planting rate was best at each date. There was a very significant decline in yield for the higher rates as planting date was delayed.

The late hybrid was inferior in yield and moisture at both dates. Stand variability probably accounted for any difference in yield between early and medium hybrids at individual planting dates.

At the low rate of planting (1.6 plants per hill), the medium hybrid

Table 15. Average Stand, Yield, and Moisture of Corn in Dry Years 1946, 1947, and 1949 at Highmore—Individual Treatment Combinations

TREATMENT					
Date of Planting	Planting Rate per Hill	Hybrid	Plants per Hill	Yield bu/Acre	Moisture Percent
May 1	2	Early	1.6	15.8	19.2
	2	Medium	1.4	15.2	22.3
	2	Late	1.7	13.3	27.2
	3	Early	2.1	16.1	20.0
	3	Medium	2.0	12.8	23.6
	3	Late	2.3	13.4	26.3
	4	Early	2.7	15.1	21.5
	4	Medium	2.7	12.8	21.4
	4	Late	3.0	12.0	28.7
May 20	2	Early	1.5	14.4	24.6
	2	Medium	1.8	15.5	23.4
	2	Late	1.8	15.6	28.7
	3	Early	2.4	15.3	20.8
	3	Medium	2.5	14.6	22.3
	3	Late	2.4	11.7	35.2
	4	Early	2.9	13.5	22.6
	4	Medium	3.0	11.6	22.0
	4	Late	3.1	9.4	33.8
Least significant difference for yields of individual treatments				2.9	

Table 16. Average Stand, Yield, and Moisture of Corn in Dry Years 1946, 1947, and 1949 at Highmore—Main Effects and Interactions

TREATMENT			Plants per Hill	Yield bu/Acre	Moisture Percent
Dates:	May 1		2.2	14.1	23.4
	May 20		2.4	13.5	25.9
Rates of Planting:	2 per hill		1.6	15.0	24.2
	3 per hill		2.3	14.0	24.7
	4 per hill		2.9	12.4	25.0
Hybrids:	Early		2.2	15.0	21.5
	Medium		2.2	13.8	22.5
	Late		2.4	12.6	30.0
Dates x Rates:	May 1	2 per hill	1.6	14.8	22.9
		3 per hill	2.1	14.1	23.3
		4 per hill	2.8	13.3	23.9
	May 20	2 per hill	1.7	15.2	25.6
		3 per hill	2.4	13.9	26.0
		4 per hill	3.0	11.4	26.1
Dates x Hybrids:	May 1	Early	2.1	15.7	20.2
		Medium	2.0	13.6	22.4
		Late	2.3	12.9	27.4
	May 20	Early	2.3	14.4	22.7
		Medium	2.4	13.9	22.6
		Late	2.4	12.2	32.6
Rates x Hybrids:	2 per hill	Early	1.6	15.1	21.9
	2 per hill	Medium	1.6	15.4	22.9
	2 per hill	Late	1.7	14.5	28.0
	3 per hill	Early	2.2	15.7	20.4
	3 per hill	Medium	2.3	13.7	23.0
	3 per hill	Late	2.4	12.6	30.8
	4 per hill	Early	2.8	14.3	22.1
	4 per hill	Medium	2.8	12.2	21.7
	4 per hill	Late	3.1	10.7	31.5
Least significant difference between averages of main effects				1.0	
Least significant difference between individual interaction averages				1.7	

was best in yield. At higher planting rates giving 2.2 and 2.8 plants per hill, the yield advantages lay with the early hybrid. The late hybrid was definitely inferior.

The outstanding single combinations were the medium hybrid at the low rate, planted May 20, and the early hybrid at the intermediate rate, planted May 1.

Cool Years. These years (1950 and 1951) were below normal in temperature. Moisture in 1950 appeared ample for the temperature level and was abundant in 1951. Re-

Table 17. Average Stand, Yield, and Moisture of Corn in Cool Years 1950 and 1951 at Highmore—Individual Treatment Combinations

TREATMENT					
Date of Planting	Planting Rate per Hill	Hybrid	Plants per Hill	Yield bu/Acre	Moisture Percent
May 1	2	Early	1.6	21.4	32.4
	2	Medium	1.8	24.6	35.9
	2	Late	1.8	25.4	39.8
	3	Early	2.1	23.0	35.0
	3	Medium	2.5	23.8	36.2
	3	Late	2.5	27.6	41.9
	4	Early	2.8	21.5	36.3
	4	Medium	3.1	22.1	33.5
	4	Late	3.2	23.7	41.0
May 20	2	Early	1.9	25.3	34.8
	2	Medium	1.8	24.3	38.0
	2	Late	1.8	25.0	47.7
	3	Early	2.5	24.1	38.5
	3	Medium	2.6	22.6	35.9
	3	Late	2.6	25.8	47.0
	4	Early	3.0	22.3	46.4
	4	Medium	3.3	17.8	46.0
	4	Late	3.4	23.8	47.5
May 30*	2	Early	1.5	27.3	44.0
	2	Medium	1.7	20.7	46.0
	2	Late	1.6	15.2	61.0
	3	Early	1.9	25.3	51.0
	3	Medium	2.4	22.8	45.0
	3	Late	2.3	15.6	58.0
	4	Early	2.9	22.5	47.0
	4	Medium	3.2	18.6	50.0
	4	Late	3.2	17.2	59.0
Least significant difference for yields of individual treatments					3.8

*1950 not included in May 30.

Table 18. Average Stand, Yield, and Moisture of Corn in Cool Years 1950 and 1951 at Highmore—Main Effects and Interactions

TREATMENT			Plants per Hill	Yield bu/Acre	Moisture Percent
Dates:	May 1		2.4	23.7	36.9
	May 20		2.5	23.4	42.4
	May 30		2.3	20.6	51.2
Rates of Planting:	2 per hill		1.7	23.2	42.2
	3 per hill		2.4	23.4	43.2
	4 per hill		3.1	21.1	45.2
Hybrids:	Early		2.2	23.6	40.6
	Medium		2.5	21.9	40.7
	Late		2.5	22.1	49.2
Dates x Rates:	May 1	2 per hill	1.7	23.8	36.0
		3 per hill	2.4	24.8	37.7
		4 per hill	3.0	22.4	36.9
	May 20	2 per hill	1.8	24.9	40.2
		3 per hill	2.6	24.2	40.5
		4 per hill	3.2	21.3	46.6
	May 30	2 per hill	1.6	21.1	50.3
		3 per hill	2.2	21.2	51.3
		4 per hill	3.1	19.4	52.0
Dates x Hybrids:	May 1	Early	2.1	22.0	34.6
		Medium	2.5	23.5	35.2
		Late	2.5	25.6	40.9
	May 20	Early	2.4	23.9	39.9
		Medium	2.6	21.6	40.0
		Late	2.6	24.9	47.4
	May 30	Early	2.1	25.0	47.3
		Medium	2.5	20.7	47.0
		Late	2.3	16.0	59.3
Rates x Hybrids:	2 per hill	Early	1.7	24.7	37.1
	2 per hill	Medium	1.8	23.2	40.0
	2 per hill	Late	1.7	21.9	49.5
	3 per hill	Early	2.1	24.1	41.5
	3 per hill	Medium	2.5	23.1	39.0
	3 per hill	Late	2.5	23.0	49.0
	4 per hill	Early	2.9	22.1	43.2
	4 per hill	Medium	3.2	19.5	43.2
	4 per hill	Late	3.2	21.6	49.2
Least significant difference between averages of main effects				2.2	
Least significant difference between individual interaction averages				1.3	

sults of the tests are given in tables 17 and 18.

On the basis of yield and quality, the early planting was superior. Even so, May 1 planting produced soft corn. Later planting dates produced very wet corn as well as less yield. Planting rate as such had little effect on either yield or moisture. The late hybrid was inferior to the other two in yield and moisture content. The general superiority of the early planting date was consistent at all planting rates.

Early and medium hybrids produced soft corn at the first date. The late hybrid produced very low quality corn from the beginning, and late planting gave wet corn regardless of hybrid.

Best individual treatment combinations involved the early hybrid at the low planting rate at either the May 1 or May 20 planting but no later. These plantings produced soft corn. The medium hybrid at low rate, May 1 planting, was comparable to these two. All other combinations were inferior in yield or quality or both.

Ten-Year Average. The climate during the 10-year period at Highmore is not quite as representative as that during the same period at Brookings. The period was marked by below normal temperatures and deficient rainfall in the growing season in 7 of the 10 years. Conclusions drawn from the Highmore averages must be adjusted to these conditions.

On the other hand, the extreme fluctuations in growing conditions at this location probably indicate that the *average* performance should be used with great caution. Also, due consideration should be given to performance under below-average conditions, some of which have already been discussed. The central area average appears to be composed of extremes rather than a distribution of normal data.

The 10-year average performances for individual treatment combinations at Highmore are shown in table 19. The results of the work averaged for main effects and interactions are shown in table 20. The results at May 30 date of planting are obviously not comparable with results at the other two dates because they represent only 4 years, 3 of which were favorable.

Over the entire 10-year period, there appears to be a definite yield advantage for the May 20 planting and the medium rate of planting, which produced 2.5 plants per hill. The differences between hybrids are not significant in yield, indicating that the early hybrid might be safely chosen on the basis of its low moisture content without any sacrifice of yield.

Interaction of date of planting with rate indicates a general advantage to low or moderate planting rates on May 20.

The lack of difference in yield for the different hybrids at the May 20 planting would again indicate a sound choice of the early hybrid with its low moisture percentage.

There appears to be little interaction of hybrids with planting date except that at May 30, even in only 4 years, the early hybrid is showing yield superiority.

Differences between planting rates for different hybrids indicate that the late hybrid did best at the low rate of planting, the other two were best at the intermediate rate. This gives 2.3 to 2.5 plants per hill as being the best rate for these hybrids.

Over the 10-year period, the early hybrid planted at the medium rate on May 20 gave the best yield and very satisfactory quality. Several other high-yielding combinations can be seen in the table, but all of those involving the medium or full season hybrid involved poorer quality corn without the least advantage in yield.

Table 19. Average Stand, Yield, and Moisture of Corn at Highmore, 1945 to 1954—Individual Treatment Combinations

TREATMENT					
Date of Planting	Planting Rate per Hill	Hybrid	Plants per Hill	Yield bu/Acre	Moisture Percent
May 1	2	Early	1.6	23.7	20.4
	2	Medium	1.7	26.3	23.8
	2	Late	1.7	26.9	27.7
	3	Early	2.2	26.2	20.8
	3	Medium	2.4	26.0	24.0
	3	Late	2.4	28.6	28.7
	4	Early	2.8	26.0	22.6
	4	Medium	3.0	25.8	22.1
	4	Late	3.1	25.9	29.5
May 20	2	Early	1.8	27.4	24.5
	2	Medium	1.8	28.3	25.5
	2	Late	1.8	29.4	33.2
	3	Early	2.5	30.3	23.4
	3	Medium	2.6	28.8	23.8
	3	Late	2.6	29.4	34.2
	4	Early	3.1	27.3	27.5
	4	Medium	3.3	25.6	25.3
	4	Late	3.3	29.3	33.4
May 30	2	Early	1.7	36.8	22.4
	2	Medium	1.9	36.0	26.2
	2	Late	1.8	39.1	31.0
	3	Early	2.3	41.2	22.5
	3	Medium	2.6	41.2	27.1
	3	Late	2.6	36.8	36.5
	4	Early	2.8	40.5	19.7
	4	Medium	3.3	37.3	30.5
	4	Late	3.4	34.0	37.4
Least significant difference for yields of individual treatments				2.7	

Table 20. Average Stand, Yield, and Moisture of Corn at Highmore, 1945 to 1954—Main Effects and Interactions

TREATMENT			Plants per Hill	Yield bu/Acre	Moisture Percent
Dates:	May 1		2.3	26.2	24.4
	May 20		2.5	28.4	27.9
	May 30		2.5	38.1	28.1
Rates of Planting:	2 per hill		1.8	30.4	26.1
	3 per hill		2.5	32.0	26.8
	4 per hill		3.1	30.2	27.6
Hybrids:	Early		2.3	31.0	22.6
	Medium		2.5	30.6	25.4
	Late		2.5	31.0	32.4
Dates x Rates:	May 1	2 per hill	1.7	25.6	24.0
		3 per hill	2.3	26.9	24.5
		4 per hill	3.0	25.9	24.7
	May 20	2 per hill	1.8	28.4	27.8
		3 per hill	2.6	29.5	27.1
		4 per hill	3.2	27.4	28.7
	May 30	2 per hill	1.8	37.3	26.5
		3 per hill	2.5	39.7	28.7
		4 per hill	3.2	37.2	29.2
Dates x Hybrids:	May 1	Early	2.2	25.3	21.3
		Medium	2.4	26.0	23.3
		Late	2.4	27.1	28.6
	May 20	Early	2.4	28.3	25.1
		Medium	2.6	27.6	24.9
		Late	2.6	29.4	33.6
	May 30	Early	2.3	39.5	21.5
		Medium	2.6	38.2	28.0
		Late	2.6	36.6	35.0
Rates x Hybrids:	2 per hill	Early	1.7	29.3	22.4
	2 per hill	Medium	1.8	30.2	25.2
	2 per hill	Late	1.8	31.8	30.6
	3 per hill	Early	2.3	32.6	22.2
	3 per hill	Medium	2.5	32.0	25.0
	3 per hill	Late	2.5	31.6	33.1
	4 per hill	Early	2.9	31.3	23.3
	4 per hill	Medium	3.2	29.6	26.0
	4 per hill	Late	3.3	29.7	33.4
Least significant difference between averages of main effects				0.9	
Least significant difference between individual interaction averages				1.6	

DISCUSSION

The results obtained at the individual locations have been reported, and the important comparisons have been recognized. The problem is now one of evaluating these results in terms of the long-time climatic conditions, the farming practices, and the place and use of corn in the farm economy of each area.

In the eastern area, with fairly high yield expectancies and a generally adequate rainfall and temperature, the problem is one of maximum utilization of the available resources. There are many ways in which the grower's best intentions may fall short of this mark. Very often he follows well established seeding practices, both as to date and rate of planting, as being unchangeable patterns.

The grower's primary weapons in getting full production are better soil fertility practices and growing the latest maturing hybrid he dares, and planting May 20, seeding 3 kernels per hill. The choice of a late maturing hybrid brings a great risk of soft or even wet corn.

The 10-year averages for the eastern station indicate a remarkably consistent pattern throughout the period, and lead readily to general conclusions for making recommendations.

The general yield superiority of the medium hybrid at the high rate of planting on May 20 is suggested by the 10-year average. This is also indicated by the averages of favorable, cool, and less favorable years.

Lack of an intervening May 10 date does not permit as close an evaluation of the best planting time as could be desired. The sharp drop in yield due to the May 30 planting in the years after 1949 must be considered as indicating that May 20 is close to the later limit for planting time. The obviously reduced stands at the May 1 planting are probably a great factor in the reduced yields at this date. Actually, the yield at the May 1 planting might approach May 20 yield results if stands from the two planting dates were equal.

The choice of the medium hybrid at a rate of planting resulting in 3.3 to 3.5 plants per hill gave maximum yields on the average. It also produced grain of acceptable quality.

As far as grain quality is concerned, the conclusion is inescapable. The later the hybrid, the softer the corn. Some of the combinations of treatments with the late hybrid produced soft corn consistently. To get quality corn for sealing or marketing, it is absolutely necessary to choose a hybrid of early or medium maturity. Where a grower is depending on the cash return from his corn crop, he will do well to operate with hybrids of high safety margins. By increasing his planting rate and planting at the right time, the grower may have his safety margin as well as high yield.

It remains to be seen if this practice could be extended to early hybrids by planting at higher rates than those used in this experiment. The early hybrid would give maximum assurance of quality.

The grower preferring a full season corn should consider planting earlier than May 20. If one can get a stand from the May 1 planting, that may be the best opportunity to achieve maximum yields with some chance of getting sound corn.

All considerations for the eastern area are based on the principle that, in nearly all years, it is possible to produce ear corn. The utilization of corn as fodder or silage is not the first objective but may become necessary. The silage value of different hybrids as different rates or dates of planting (within the ranges tested) would probably be similar. This is because dry matter production largely depends on total moisture available to the crop before it is damaged beyond recovery for grain production.

A general recommendation for the central corn area appears difficult to establish. In 5 of the 10 years, drought or cold conditions would indicate that the best combination would involve the early hybrid at the May 1 planting and at a rate of 2 seeds per hill. This gives 1.6 to 1.8 plants per hill.

In the other 5 years when conditions were more favorable, the early hybrid combination yielded 25 percent less than the medium hybrid, planted 3 seeds per hill, giving 2.3 plants per hill, and planted May 20 or later. Using this recommendation in drought or cold years would lead to very low yields or very low quality corn.

The farmer cannot predict the season at planting time. His practices then must involve a choice between getting sound ear corn practically every year or striving for the maximum yield in the occasional favorable season.

The choice involves other factors. Land is cheaper, native hay is usually available, and corn may not be a cash crop but a source of feed and used as a fallow substitute. The area is predominantly on a livestock and cash small grain economy. The grower going for maximum yields may have to utilize his corn as silage or fodder in almost half the years.

The problem of insufficient moisture has been recognized by growers in the area. The lessons of the dry years have been learned well, and much corn is planted at the rate of 2 seeds per hill. In view of this, the conservative choice (early hybrid, early planting) with this low planting rate would appear preferable.

This would also increase the grower's safety margin when planting in dry soil. The rain can come a week later and he may still get a crop. Moisture shortages in May are fairly frequent in this area, and corn goes on small grain land where the moisture reserves are depleted. Seasonal precipitation makes the corn crop. The land is intended for small grain in the year after corn, and this again suggests a practice of conservative land utilization rather than a recovery of maximum possible yields.

SUMMARY

Corn is South Dakota's most important grain crop. It is grown on 4 million acres annually. South Dakota ranks ninth among the states as a corn producer, having one-twen-

tieth of the national acreage and one-thirtieth of the production.

The state may be divided into three areas on the basis of the place of corn on the farm: the eastern area, where corn is dominant; the central area, where corn is complementary to wheat and grazing; and the western area, where corn is supplementary to grazing.

Corn, like any crop, is grown for its yield. The grower generally expects a favorable season and chooses a full season hybrid. Therefore, he often harvests immature corn. Experiment station recommendations, however, are based on the average season as the most likely.

Grouping the seasons into favorable, cool, and intermediate categories for the eastern area indicated a remarkably consistent performance pattern for hybrid, rate, and date. Grouping the seasons for the central area showed some flexibility in management practices between favorable and unfavorable seasons. As seasonal weather prediction methods are perfected, it may be possible for the grower to use these results to exploit the predicted climate.

Three commercial hybrids of different maturity levels were grown at three planting rates. They were planted at two, and later three, dates in May to determine if maximum yields could be reached without loss of corn quality. This experiment was conducted at two locations, representing the eastern and central areas of South Dakota for 10 successive years, beginning in 1945. Soils at both locations were maintained under fertility management systems recommended for the areas.

The highest average yields in the eastern area were obtained by growing a hybrid of medium maturity, planted at a rate sufficient to give 3.3 plants per hill, and planted about mid-May. This combination produced good quality corn in most years. Use of the late hybrid gave much poorer quality corn. As corn hybrids with better early May germination become available, it may be possible to plant earlier and get still better yields without loss of quality.

In the central area, the best yields were made by the early hybrid planted May 20 at a rate giving 2.5 plants per hill. However, the considerations of stability and land use patterns in this area suggest that the grower would be well advised to go to the low rate and an earlier date of planting with this hybrid.