DATE, RATE, AND METHOD OF PLANTING CORN

Thesis for the Degree of M. S.

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William T. Rounds

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This is to certify that the

thesis entitled

"Date, Rate, and Method
of Planting Corn"

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William T. Rounds

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E. L. Rossman
Major professor

Date _____

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DATE, RATE, AND METHOD OF PLANTING CORN

by

WILLIAM T. ROUNDS

A THESIS

Submitted to the Graduate School of Michigan State College of Agriculture and Applied Science in partial fulfilment of the requirements for the degree of

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INTRODUCTION

The effects of date, rate, and method of planting on corn production have been the subject of numerous investigations over a number of years. Many of these studies were conducted with open-pollinated varieties which have been replaced by hybrids. It appears worthwhile to repeat some of the earlier research on cultural practices using the hybrids grown by farmers today. Results of experiments conducted in neighboring states do not always apply to other states where the climate, soil conditions, and hybrids may give different results.

The effect of rate of planting and method of planting on corn production in Michigan was studied at two locations in 1949 with several hybrids adapted to Michigan. Date of planting was investigated at one location.

REVIEW OF LITERATURE

Hughes and Henson (4) reviewed a number of the early investigations on the effect of date, rate, and method of planting corn. In general, most of the studies reviewed showed higher corn yields from the earlier dates of planting. Comparisons of drilled versus hill planting from four states, Maryland, Ohio, Minnesota, and Arkansas, showed a consistent yield difference in favor of drilling corn. Long time experiments from a number of stations showed conflicting results for the effect of rate of planting on corn yields. Climatic and soil conditions, and growth habits of the varieties are factors which influenced the results.

Montgomery (8) reported that yields increased steadily as rate of planting increased from one to three plants per hill. Four and five plants per hill gave essentially the same yield as three plants over the six year period. Ear weight, number of ears per 100 plants, number of tillers per 100 plants, and number of two-eared plants per 100 plants decreased as the rate of planting was increased from one to five plants per hill. The percentage of barren stalks increased as the rate of planting was increased. Kiesselbach (5) obtained similar results for a seven year period with Hogue's Yellow Dent. He found that lodging percentage increased as the rate of planting increased from one to five plants per hill. There was no marked difference in date of maturity, height of stalks, ear height,

or shelling percentage for the different rates.

Richey (10) found that corn planted at two different rates yielded approximately the same over a period of years, but the thinner rate of planting yielded more in less favorable seasons. Corn planted at the thinner rate produced larger ears and lodged less than that planted more thickly.

The Ohio Agricultural Experiment Station (9) in rate of planting tests concluded that a stand of four plants per hill with hills spaced 42" x 42" averaged the highest yield of shelled corn over a period of years, while three plants per hill gave a higher yield in poor seasons and five plants produced more in good seasons.

Duncan (2) found that early maturing varieties had smaller stalks and gave their maximum yield when either three or four kernels per hill were planted. Koehler and Holbert (6) found that the higher rate of planting of corn increased the percent of lodging and that late planting resulted in more lodging than early planting.

Eisele and Buchanan (3) reported that at maturity the average cross sectional area of stalks at ground level where there were three plants per hill was 60% as large as where there was one plant per hill. Stalks in five plant hills were only 40% as large as those in one plant hills.

METHODS AND MATERIALS

Two experiments were conducted in 1949. The effects of date, rate, and method of planting were investigated in an experiment conducted in Ingham County near East Lansing. Rate and method of planting were studied in an experiment conducted in Saginaw County near Reese.

The 1949 season was unusually favorable for corn production in most areas of Michigan. The average yield of 48.0 bushels per acre for the state was the highest on record (13). The previous ten year average was 34.0 bushels per acre.

Table 1 presents temperature and precipitation data obtained at the Saginaw and Lansing weather stations (14). Temperature and rainfall conditions at both locations were almost ideal for corn. A period of dry weather in late August matured corn rapidly. The first killing frost occurred on October 24, 1949.

Table 1. Temperature and precipitation data obtained at Lansing and Saginaw weather stations. 1949.

	April	May	June	July	Aug.	Sept.	Oct.
Temperature							
Lansing							
Average	46.2	59.5	71.7	74.1	70.2	57.2	54.9
Departure from normal	0.9	2.7	4.9	2.5	0.9	-4.5	4.6
Saginaw							
Average	44.9	56.9	70.4	73.0	70.1	56.8	53.8
Departure from normal	0.0	0.1	3.7	1.2	0.8	-5.4	3.3
Precipitation							
Lansing							
Average	1.87	2.35	4.89	4.78	1.61	1.91	2.35
Departure from normal	-.71	-1.07	1.38	1.68	-1.21	-1.00	-.12
Saginaw							
Average	2.46	1.20	3.75	3.65	2.28	2.36	2.07
Departure from normal	.12	-2.35	.90	.87	-.73	-.55	-.54

Date, rate, and method of planting - Ingham County

Three dates of planting, three rates of planting, two methods of planting, and three hybrids were combined in a split-plot experiment consisting of 54 treatment combinations with four replications. The experiment was conducted at the Farm Crops experimental farm near East Lansing in Ingham County. Dates of planting were used as the main plot, hybrids were used as the sub-plot, method of planting as the sub-sub-plot, and rate of planting as the sub-sub-sub-plot. All factors were randomized within each subdivision. Each plot was two rows wide and 23' 4" long (seven hills long). The front two hills or 6' 8" of each plot were harvested for pre-harvest moisture samples. Data for the pre-harvest moisture samples are not reported in this study. Ten hills or 33' 4" of drilled corn were harvested for yield.

The experiment was conducted on a level well-drained field of Conover clay loam soil. The field had grown a good crop of corn in 1947. It was plowed in the spring of 1948 and planted to soybeans which were plowed under in late August for green manure. Rye was planted in the field in the fall of 1948. In late April of 1949 the rye was plowed under for green manure when it was approximately 24" in height. Two hundred pounds of 4-16-8 fertilizer per acre were broadcast on the field prior to corn planting in 1949.

Corn was planted in 40" rows with 40" between hills on May 5, May 24, and June 11. The seedbeds for the May 24 and

June 11 plantings were reworked by cultivation with a Gravely garden tractor. Cultivation and hoeing were kept equal for the three dates of planting.

Michigan 51B (W9 x M13) x (Ia.153 x W25), Ohio M15 (Oh51 x Oh26) x (A x W23), and Michigan 29D (A x Oh51A) x (Oh40B x W10) were the three hybrids used. In south-central Michigan, Michigan 51B is rated as a very early maturing hybrid, Ohio M15 is an early hybrid, and Michigan 29D is a mid-season hybrid. Table 2 presents yield and maturity data obtained from the Michigan Hybrid Corn Trials for the three hybrids used in the Ingham County experiment.

Table 2. Two and six-year averages for yield and moisture content for the hybrids used in the Ingham and Saginaw County experiments.

	2 year average 1948-1949		6 year average 1944-1949	
	Yield per acre	Moisture in ears %	Yield per acre	Moisture in ears %
Ingham County				
Michigan 51B	62.8	27.9	-	-
Ohio M15	73.6	32.0	65.3	34.3
Michigan 29D	74.8	35.6	66.0	36.8
Saginaw County				
Michigan 11A	67.5	24.8	-	-
Michigan 51B	81.1	28.7	69.5	35.4
Michigan 36B	82.9	28.3	72.0	35.7
Ohio M15	89.0	30.1	75.8	36.1

The three rates of planting for each of the two methods of planting were as follows:

Drilled - one plant every 20 inches = 7,800 plants per acre
one plant every 13 1/3 inches = 11,700 plants per acre
one plant every 10 inches = 15,600 plants per acre

Hills - two plants per hill = 7,800 plants per acre
three plants per hill = 11,700 plants per acre
four plants per hill = 15,600 plants per acre

The three dates of planting were harvested on September 30, October 18, and November 5. All plots in each date of planting were harvested 147 days after planting.

Rate and method of planting - Saginaw County

The Saginaw County experiment was conducted on a level well-drained field of Brookston clay loam on the farm of Walter Reinbold near Reese. The field was in alfalfa-bromegrass for two years before being plowed in the spring of 1949 for corn. No fertilizer was applied for the corn crop.

Four hybrids, two methods of planting, and three rates of planting were arranged in a split-plot experiment with 24 treatments replicated four times. Hybrids were used as main plots, methods of planting as sub-plots, and rates of planting as sub-sub plots. Each plot was two rows wide and five hills or 17' 6" long. The entire plot was harvested for yield.

Corn was planted in 36" rows on May 11. The spacing between hills was 42". Rates of planting were as follows:

Drilled - one plant every 21 inches = 8,300 plants per acre
one plant every 14 inches = 12,450 plants per acre
one plant every 10½ inches = 16,600 plants per acre

Hills - two plants per hill = 8,300 plants per acre
three plants per hill = 12,450 plants per acre
four plants per hill = 16,600 plants per acre

Michigan 11A (W9 x M13) x (H x 49) , Michigan 51B, Ohio M15, and Michigan 36B (M13 x WR3) x (W23 x W26) were the four hybrids used. Michigan 11A is a very early maturing hybrid, Michigan 51B is an early hybrid, and Michigan 36B and Ohio M15 are mid-season hybrids in north-central Michigan.

The experiment was harvested on October 5 or 147 days after planting.

Data on stand, moisture content of ears, yield, lodging, and ear weight were obtained at harvest at both locations. The few minor deviations from perfect stands did not affect the results to any practical extent at either location. Excess seed was planted and the plots were thinned to the desired stand when the plants were approximately 18" tall.

Moisture samples were taken by cutting one-inch sections of cob and grain from ten randomly selected ears for each plot. The samples were weighed in the field, dried in an oven at the laboratory, and weighed again when dry. Plot yields were converted to bushels of shelled corn containing 15.5% moisture.

Lodging data represent the percentage of plants broken below the ear. Root lodging was negligible at both locations.

The number of ears in each plot was counted and the weight of ear corn was converted to dry weight to obtain the average dry weight per ear.

The data on yield, moisture percentage, and lodging percentage were analyzed by analyses of variance. When experimental errors are used to determine the significance of main effects and interactions, the conclusions apply only to the particular experiment and the specific factors enumerated. Ordinarily these conclusions are not as interesting as those drawn from tests of significance where the conclusions may be projected into statements likely to apply to the population from which the experimental sample was drawn (1, 12). First-order interactions are used to test the significance of main effects, second-order interactions are used to test first-order interactions, and third-order interactions are used to test second-order interactions when these broader conclusions are drawn.

EXPERIMENTAL RESULTS

Ingham County Experiment

Summarized data on yield, moisture content, lodging, and ear weight are presented in Table 3 and the analyses of variance for yield, moisture content, and lodging are given in Table 4.

Table 3. Yield , moisture content, lodging, and ear weight for three hybrids planted at three dates, two methods, and three rates of planting. Ingham County experiment.

Hybrid, method of planting, and rate of planting.	Yield in bushels per acre at 15.5% moisture	Moisture in ears %	Lodging %	Dry Weight per ear in pounds
		May 5 planting		
Michigan 51B				
Drilled every 20"	60.2	26.9	1.3	.44
Drilled every 13 1/3"	78.5	26.1	4.3	.41
Drilled every 10"	94.7	27.9	8.2	.37
Average	77.8	27.0	4.6	.40
Hills - 2 plants	52.9	27.4	1.3	.40
Hills - 3 plants	76.8	27.2	3.3	.39
Hills - 4 plants	90.9	28.1	8.2	.36
Average	73.5	27.6	4.3	.38
Average for Michigan 51B	75.7	27.3	4.4	.39
Ohio M15				
Drilled every 20"	75.6	31.7	1.3	.41
Drilled every 13 1/3"	91.7	31.1	3.4	.39
Drilled every 10"	104.8	31.1	5.6	.39
Average	90.7	31.3	3.4	.40
Hills - 2 plants	69.4	32.3	0.0	.40
Hills - 3 plants	82.1	31.7	5.0	.39
Hills - 4 plants	100.3	31.9	7.6	.39
Average	83.9	32.0	4.2	.39
Average for Ohio M15	87.3	31.6	3.8	.39

Table 3. (continued)

Hybrid, method of planting, and rate of planting.	Yield in bushels per acre at 15.5% moisture	Moisture in ears %	Lodging %	Dry Weight per ear in pounds
		May 5 planting		
Michigan 29D				
Drilled every 20"	76.4	33.5	0.0	.54
Drilled every 13 1/3"	95.6	33.5	2.5	.47
Drilled every 10"	108.9	33.8	3.8	.43
Average	93.6	33.6	2.1	.48
Hills - 2 plants	73.5	33.5	1.3	.53
Hills - 3 plants	90.1	35.1	5.0	.45
Hills - 4 plants	105.1	34.9	5.7	.41
Average	89.5	34.5	4.0	.46
Average for Michigan 29D	91.6	34.1	3.0	.47
Grand average for May 5	84.9	31.0	3.8	.42
		May 24 planting		
Michigan 51B				
Drilled every 20"	48.8	28.8	3.8	.38
Drilled every 13 1/3"	63.6	28.6	5.8	.32
Drilled every 10"	75.9	27.7	6.3	.31
Average	62.7	28.4	5.3	.34
Hills - 2 plants	54.0	28.8	6.3	.40
Hills - 3 plants	65.3	29.0	10.0	.33
Hills - 4 plants	77.6	29.2	9.4	.31
Average	65.6	29.0	8.6	.35
Average for Michigan 51B	64.2	28.7	6.9	.34
Ohio M15				
Drilled every 20"	68.6	28.4	1.3	.39
Drilled every 13 1/3"	79.5	28.6	1.0	.37
Drilled every 10"	89.4	30.3	2.5	.34
Average	79.2	29.1	1.6	.36
Hills - 2 plants	63.4	29.5	3.8	.40
Hills - 3 plants	81.7	30.5	2.5	.38
Hills - 4 plants	104.7	30.3	5.6	.39
Average	83.3	30.1	4.0	.39
Average for Ohio M15	81.2	29.6	2.8	.37

Table 3. (continued)

Hybrid, method of planting, and rate of planting.	Yield in bushels per acre at 15.5% moisture	Moisture in ears %	Lodging %	Dry Weight per ear in pounds
		May 24 planting		
Michigan 29D				
Drilled every 20"	66.2	32.6	3.9	.50
Drilled every 13 1/3"	84.4	33.1	3.5	.44
Drilled every 10"	94.0	34.0	4.4	.37
Average	81.5	33.2	3.9	.44
Hills - 2 plants	66.1	31.8	2.5	.48
Hills - 3 plants	78.9	32.6	5.0	.40
Hills - 4 plants	88.0	33.6	3.8	.35
Average	77.7	32.7	3.8	.41
Average for Michigan 29D	79.6	32.9	3.8	.42
Grand average for May 24	75.0	30.4	4.5	.38
		June 11 planting		
Michigan 51B				
Drilled every 20"	60.5	27.6	19.0	.44
Drilled every 13 1/3"	79.4	26.4	23.3	.41
Drilled every 10"	96.8	27.1	21.4	.39
Average	78.9	27.0	21.2	.41
Hills - 2 plants	62.0	26.5	16.5	.45
Hills - 3 plants	82.3	25.4	15.8	.42
Hills - 4 plants	93.6	28.6	20.2	.37
Average	79.3	26.8	17.5	.41
Average for Michigan 51B	79.1	26.9	19.3	.41
Ohio M15				
Drilled every 20"	71.9	28.9	23.8	.42
Drilled every 13 1/3"	89.2	28.6	20.0	.38
Drilled every 10"	100.3	28.2	26.3	.37
Average	87.1	28.6	23.3	.39
Hills - 2 plants	68.1	29.1	11.3	.39
Hills - 3 plants	86.4	29.6	14.2	.38
Hills - 4 plants	94.1	30.6	15.3	.36
Average	82.9	29.8	13.6	.37
Average for Ohio M15	85.0	29.2	18.5	.38

Table 3. (continued)

Hybrid, method of planting, and rate of planting	Yield in bushels per acre at 15.5% moisture	Moisture in ears %	Lodging %	Dry Weight per ear in pounds
		June 11 planting		
Michigan 29D				
Drilled every 20"	69.9	31.1	15.0	.48
Drilled every 13 1/3"	92.5	32.9	21.0	.46
Drilled every 10"	108.0	32.4	20.6	.42
Average	90.1	32.1	18.9	.45
Hills - 2 plants	68.3	31.3	3.8	.48
Hills - 3 plants	83.0	32.4	7.5	.42
Hills - 4 plants	101.7	31.9	13.1	.39
Average	84.3	31.9	8.1	.43
Average for Michigan 29D	87.2	32.0	13.5	.44
Grand average for June 11	83.8	29.4	17.1	.41

Table 4. Analyses of variance of yield, moisture content, and lodging percentage. Ingham County experiment.

Source of variation	Degrees of freedom	Mean Squares		
		Yield	Moisture content	Lodging
Dates of planting	2	2104.3**	49.1	4044.2**
Replications	3	1370.9**	46.9	63.1
Error (A)	6	151.6	15.4	99.7
Hybrids	2	3705.4**	520.6**	213.5**
Hybrids x dates	4	233.9	19.5**	74.5*
Error (B)	18	120.6	3.1	18.7
Methods of planting	1	312.0*	10.5	178.5*
Methods x dates	2	174.5*	0.9	513.2**
Methods x hybrids	2	81.9	4.1	35.7
M x D x H	4	53.0	2.0	38.5
Error (C)	27	43.4	2.7	30.5
Rates of planting	2	17039.18**	8.4*	290.3**
Rates x dates	4	66.8*	0.5	24.9
Rates x hybrids	4	11.9	3.9	8.5
Rates x methods	2	6.6	2.0	8.8
R x D x H	8	50.3	2.7	13.3
R x D x M	4	26.2	1.4	3.4
R x H x M	4	59.6	0.5	7.4
R x H x M x D	8	38.8	1.6	12.1
Error (D)	108	19.3	2.7	18.2
Total	215			

*Significant at the 5% level of probability when tested with experimental error.

**Significant at the 1% level of probability when tested with experimental error.

Yield. Average corn yields for all treatments were 84.9, 75.0, and 83.8 bushels per acre for the May 5, May 24, and June 11 plantings, respectively. The normal date for corn planting in south-central Michigan corresponds more nearly to the May 24 date than to the other two dates. The significant decrease of approximately 12.0% in yield for the May 24 planting may have been due to the generally higher temperatures and lower moisture supply during and shortly after the tasseling and silking period. Moisture and temperature conditions were generally favorable for the first and third plantings throughout this critical stage of plant development.

The significant differences in yield between Michigan 51B and Ohio M15 and Michigan 29D were expected on the basis of previous data (Table 2). The difference between Ohio M15 and Michigan 29D was not significant.

The decrease in yield of Ohio M15 for the May 24 planting was less than the decrease in yield for the other two hybrids (Table 5). However, all three hybrids decreased in yield and there was no significant interaction of hybrids with date of planting.

Table 5. Average yield and days from planting to 50% silked for three hybrids planted at three dates. Ingham County experiment.

Hybrid	Date of planting		
	May 5	May 24	June 11
	Average yield		
Michigan 51B			
Yield	75.7	64.2	79.1
% of May 24	127.9	100.0	123.2
Ohio M15			
Yield	87.3	81.2	85.0
% of May 24	107.5	100.0	104.7
Michigan 29D			
Yield	91.6	79.6	87.2
% of May 24	115.1	100.0	109.5
Average	84.9	75.0	83.8
	Days from planting to 50% silked		
Michigan 51B	67	61	53
Ohio M15	76	66	57
Michigan 29D	80	69	60

Drill planting averaged 2.4 bushels per acre more than hill planting. This difference was significant at the 5% level of probability when tested with error (C). The significant interaction, methods x dates, indicates that the differences between methods of planting were not alike for all dates of planting. Drill planting averaged 5.1 and 3.2 bushels more than hill planting for the May 5 and June 11 plantings. Hill planting on May 24 averaged 1.0 bushel more per acre than drill planting. All three hybrids gave slightly higher yields for drill planting (Table 6), but Michigan 29D was the only hybrid which showed a significant difference. In general, the yield of all hybrids tended to be greater for drill planting at all dates of planting. The exceptions were Michigan 51B on May 24 and June 11 plantings and Ohio M15 on May 24 planting where hill planting was slightly, but not significantly, superior. In only two cases, Ohio M15 on May 5 planting and Michigan 29D on June 11 planting, were the differences significantly in favor of drill planting.

When the interactions, methods x dates or methods x hybrids, are used to test the significance of the main effect, methods of planting, there is no significance. This comparison is of interest since it indicates that there is likely to be no significant difference in yield between the two methods of planting over all dates of planting and all hybrids under similar environmental conditions in south-central Michigan.

Table 6. Average yields for three hybrids, three dates of planting, and two methods of planting. Ingham County experiment.

Hybrid	Method of planting		Difference
	Drilled	Hills	
	May 5 planting		
Michigan 51B	77.8	73.5	4.3
Ohio M15	90.7	83.9	6.1*
Michigan 29D	93.6	89.5	4.1
Average - May 5	87.4	82.3	5.1**
	May 24 planting		
Michigan 51B	62.7	65.6	-2.9
Ohio M15	79.2	83.3	-4.1
Michigan 29D	81.5	77.7	3.8
Average - May 24	74.5	75.5	-1.0
	June 11 planting		
Michigan 51B	78.9	79.3	-0.4
Ohio M15	87.1	82.9	4.2
Michigan 29D	90.1	84.3	5.8*
Average - June 11	85.4	82.2	3.2*
	Average - all dates		
Michigan 51B	73.1	72.8	0.3
Ohio M15	85.7	83.4	2.3
Michigan 29D	88.4	83.8	4.6**
Average - all dates	82.4	80.0	2.4*

Table 6. (continued)

Differences required for significance between:	5% level of probability	1% level of probability
Two methods of planting any one hybrid at one date of planting	5.5 bu.	7.5 bu.
Two methods of planting at one date of planting	3.2 bu.	4.3 bu.
Two methods of planting any one hybrid	3.2 bu.	4.3 bu.

* Difference between methods of planting significant at 5% level of probability.
**Differences between methods of planting significant at 1% level of probability.

Rate of planting influenced corn yields more than any of the other factors. There was practically a straight line relationship between rate of planting and yield (Figure 1). Increasing the plant population from 7,800 plants per acre to 11,700 plants increased yields 17.0 bushels per acre, from 65.3 to 82.3 bushels (Table 7). The increase amounted to 26.1% as an average for all hybrids, dates of planting, and methods of planting. Doubling the population per acre, 7,800 to 15,600 plants per acre, increased yields 30.8 bushels per acre or 47.2% (from 65.3 to 96.1 bushels) for the entire experiment. When the rate of planting was increased from 11,700 to 15,600, the average corn yield increased 13.8 bushels (from 82.3 to 96.1). The increase amounted to 16.8%.

Figure 1. Relationship between yield and rate of planting. Ingham County experiment.

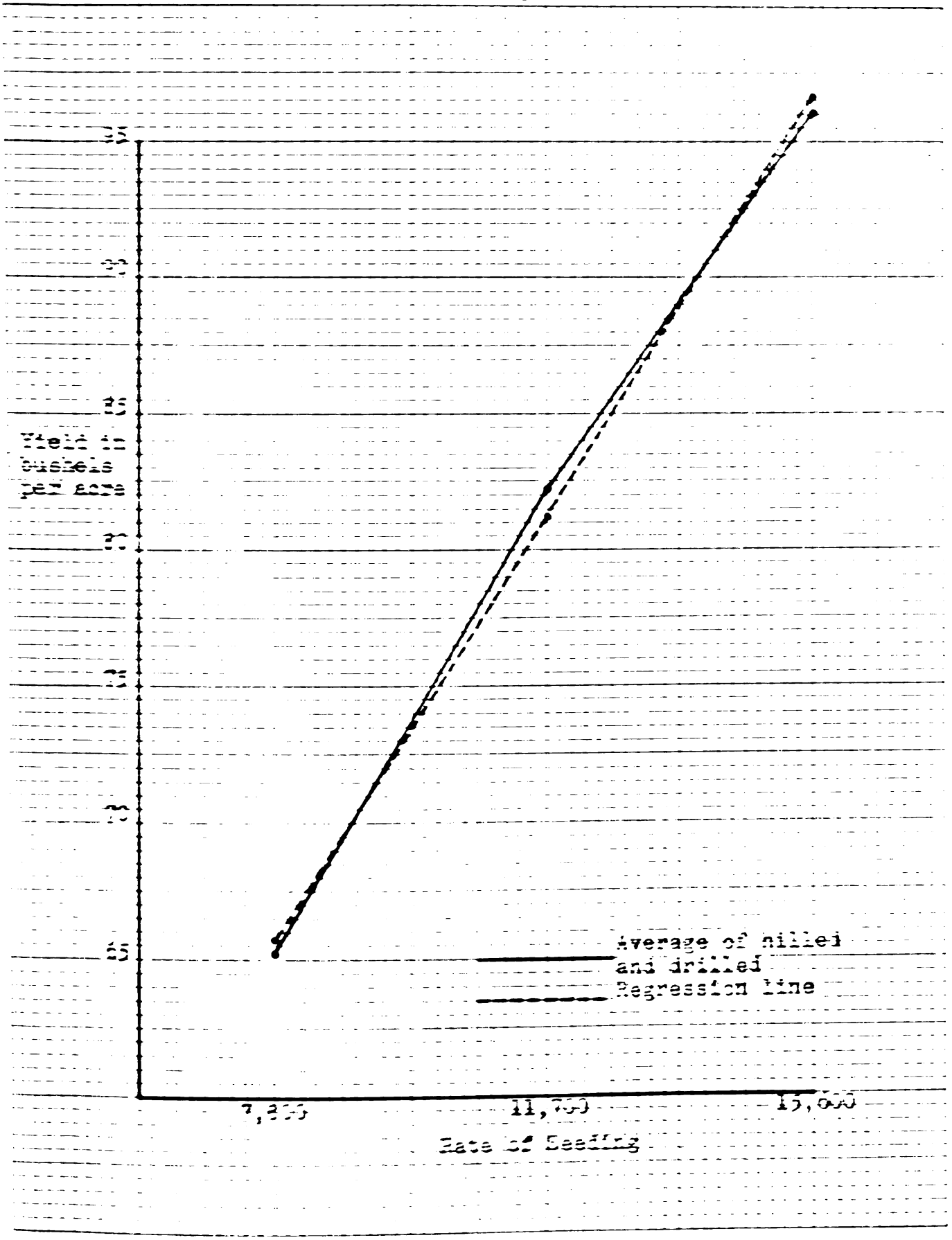


Figure 1. Relationship between yield and rate of planting. Ingham County experiment.

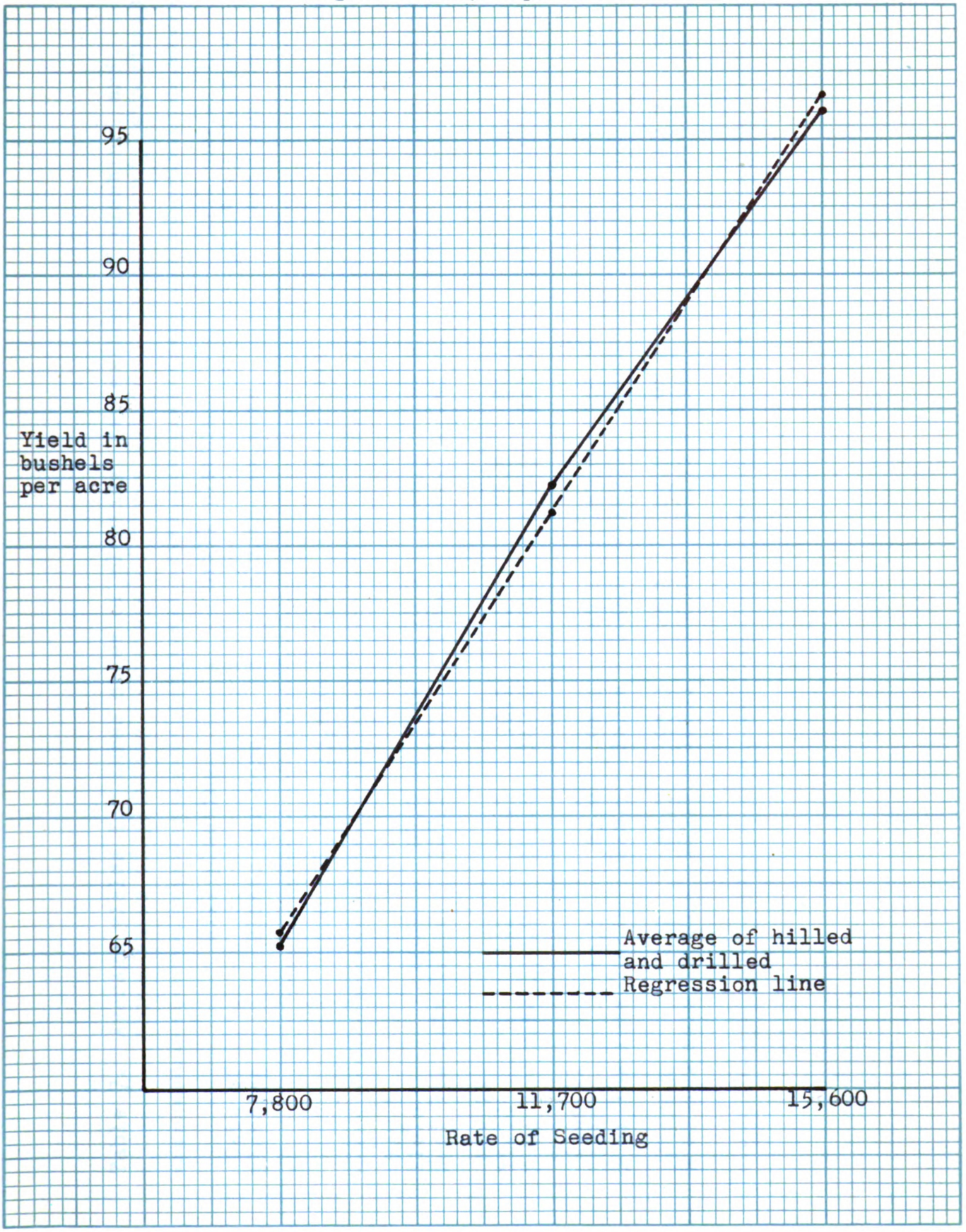


Table 7. Average yields for three dates of planting, two methods of planting, and three rates of planting. Average of three hybrids. Ingham County experiment.

Date of planting	Hill planting, Plants per acre			Drill planting, Plants per acre			Hill and drill planting averaged, Plants per acre		
	7,800	11,700	15,600	7,800	11,700	15,600	7,800	11,700	15,600
May 5									
Yield	65.3	83.0	98.7	70.7	88.6	102.8	68.0	85.8	100.8
% of low rate	100.0	127.1	151.2	100.0	125.3	145.4	100.0	126.2	148.2
May 24									
Yield	61.2	75.3	90.1	61.2	75.8	86.4	61.2	75.6	88.3
% of low rate	100.0	123.0	147.2	100.0	123.9	141.2	100.0	123.5	144.3
June 11									
Yield	66.1	83.9	96.4	67.4	87.0	101.7	66.8	85.5	99.1
% of low rate	100.0	126.9	145.8	100.0	129.1	150.8	100.0	128.0	148.3
Average	64.2	80.7	95.1	66.4	83.8	97.0	65.3	82.3	96.1
% of low rate	100.0	125.7	148.1	100.0	126.2	146.1	100.0	126.1	147.2

The regression, Y = 34.4 + .004X (X = number of plants per acre) indicates that yields increased at a rate of 4.0 bushels per 1000 plants within the range of 7,800 to 15,600 plants per acre. A yield of 50.0 bushels is indicated for a plant population of 3,900 plants per acre using this regression. If the same relationship between yield and rate of planting continued to exist, a yield of 112.4 and 128.0 bushels per acre could be predicted for populations of 19,500 and 23,400 plants per acre. These populations would correspond to five and six plants per hill or one plant every 8" and one plant every 6 2/3" respectively.

The only significant interaction involving rate of planting was rates x dates which was significant at the 5% level of probability when tested with error (D) (Table 4). Yield did not increase as much with increased rate of planting for the May 24 planting as for the other two dates (Table 7). The rate x date interaction is not significant when tested with either of the two second-order interactions, rates x dates x hybrids or rates x dates x methods. These tests indicate that the interaction, rates x dates, is not likely to be significant in the population with all hybrids and methods of planting. With these rates of planting and comparable soil and climatic conditions in south-central Michigan, yields can be expected to increase as rate of planting increases irregardless of date of planting, hybrid, or method of planting.

Moisture content. Moisture content of the ears at harvest was significantly affected by hybrid and rate of planting in the

Ingham County experiment. The differences between hybrids were expected from previous information on the three hybrids.

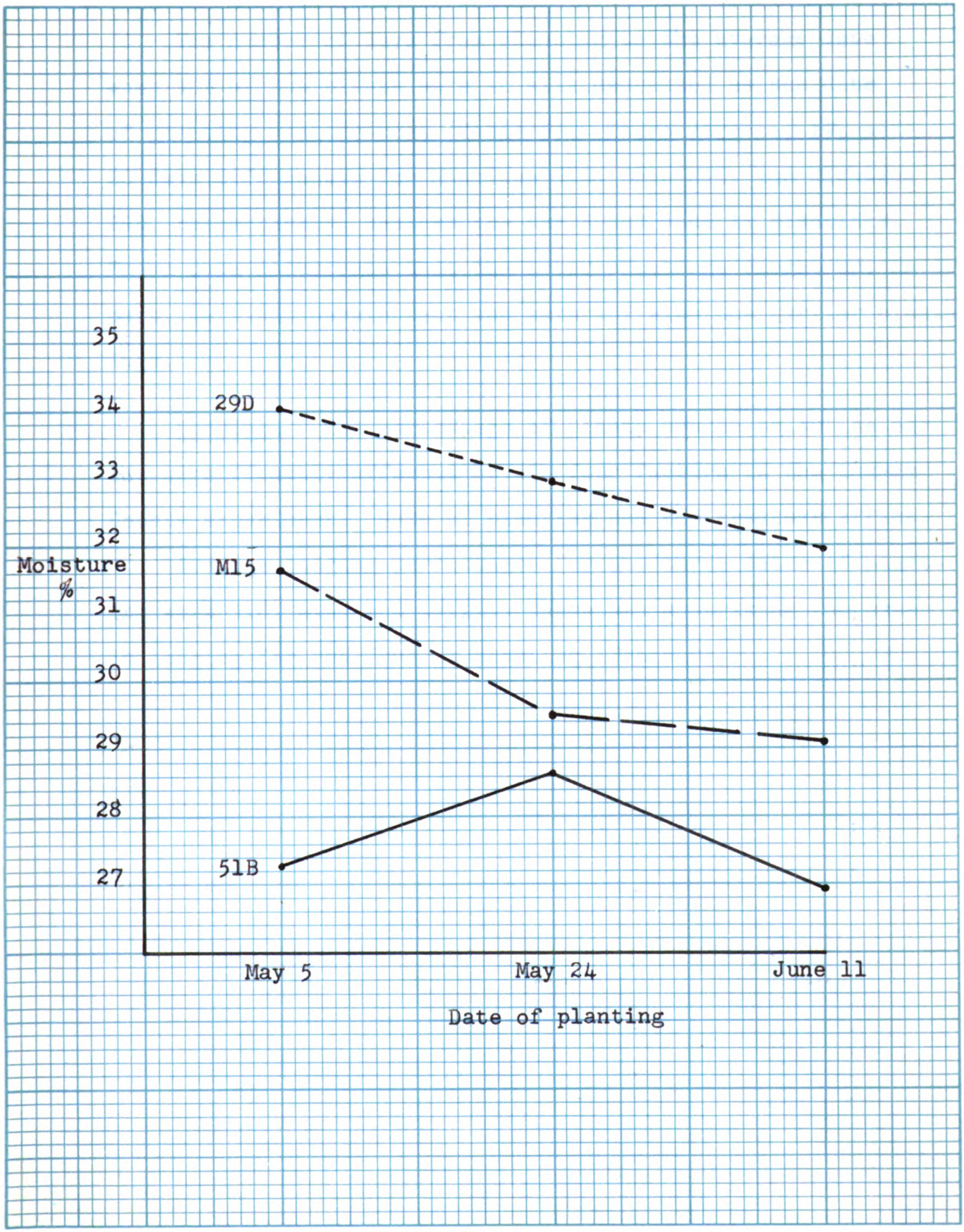
Considering the entire experiment, date of planting had no significant effect on moisture content at harvest when the different dates of planting were harvested the same number of days (147) after planting. However, hybrids differed in their response to date of planting as indicated by the significant interaction, hybrids x date of planting (Table 4). Moisture content at harvest for Michigan 29D and Ohio M15 decreased as date of planting advanced, but the moisture content for Michigan 51B increased for the second date of planting. Figure 2 illustrates this interaction.

Method of planting had no effect on moisture content. There was a slight tendency for moisture content to increase as rate of planting increased (Table 8). The effect of rate of planting was significant when tested with error (D), but not significant when tested with the first-order interactions. The latter test indicates that, in general, rate of planting is not likely to affect moisture content of the ears at harvest.

Table 8. Average moisture content of ears at harvest for three dates of planting, two methods of planting, and three rates of planting. Ingham County experiment.

Rate of planting - Plants per acre	Method of planting		Average
	Hills	Drilled	
	May 5 planting		
7,800	31.1	30.7	30.9
11,700	31.3	30.2	30.8
15,600	31.6	31.0	31.3
Average	31.3	30.6	31.0
	May 24 planting		
7,800	30.0	29.9	30.0
11,700	30.7	30.1	30.4
15,600	31.0	30.6	30.8
Average	30.6	30.2	30.4
	June 11 planting		
7,800	29.0	29.2	29.1
11,700	29.1	29.3	29.2
15,600	30.3	29.2	29.8
Average	29.5	29.2	29.4
	Average - all dates		
7,800	30.0	29.9	30.0
11,700	30.4	29.9	30.1
15,600	31.0	30.3	31.3
Average	30.5	30.0	30.5

Figure 2. Effect of date of planting on moisture content of ears at harvest for three hybrids. Ingham County experiment.



The number of days from planting to the average date when 50% of the plants were in silk decreased as the date of planting was advanced (Table 5). There were 14, 19, and 20 days differences for Michigan 51B, Ohio M15, and Michigan 29D, respectively, between the May 5 and June 11 plantings. These data illustrate that the later plantings caught up, in part, in plant development and maturity with the earlier plantings.

Lodging. The percentage of plants broken below the ear was significantly affected by all four factors in the Ingham County experiment. Date of planting had the greatest effect.

Average lodging percentages for the three dates of planting were 3.8, 4.5, and 17.1%. There was a striking increase in lodging for the June 11 planting (Table 9).

Table 9. Average lodging percentage for three dates of planting, two methods of planting, and three rates of planting. Ingham County experiment.

Rate of planting	Method of planting		Average
Plants per acre	Hills	Drilled	
	May 5 planting		
7,800	0.8	0.8	0.8
11,700	4.5	3.4	4.0
15,600	7.1	5.9	6.5
Average	4.1	3.4	3.8
	May 24 planting		
7,800	4.2	2.9	3.6
11,700	5.8	3.4	4.6
15,600	6.3	4.4	5.4
Average	5.4	3.6	4.5
	June 11 planting		
7,800	10.5	19.2	14.9
11,700	12.5	21.4	17.0
15,600	16.2	22.7	19.5
Average	13.1	21.1	17.1
	Average - all dates		
7,800	5.2	7.6	6.4
11,700	7.6	9.4	8.5
15,600	9.9	11.0	10.5
Average	7.5	9.4	8.5

The interaction, hybrids x dates of planting, was significant, indicating a differential response of hybrids with date of planting. Michigan 51B had the highest lodging percentage at all three dates. Ohio M15 and Michigan 29D interchanged relative positions with respect to lodging percentage depending on date of planting.

Drill planting averaged 9.4% lodging and hill planting averaged 7.5%. The difference was significant when tested with error (C) but not significant when tested with the first-order interactions. The only significant difference occurred in the June 11 planting, where drill planting averaged 21.1% lodging compared with 13.1% for hill planting. The two methods of planting did not respond alike at the different dates of planting, but this interaction is not significant when tested with the second-order interaction.

Rate of planting had a significant effect on lodging when tested with either error (D) or the first-order interactions. Lodging increased as rate of planting increased. Plant populations of 7,800, 11,700, and 15,600 averaged 6.4, 8.5, and 10.4% lodging, respectively. The effect of rate of planting on lodging was generally consistent as evidenced by the lack of significance for all interactions involving rate of planting.

Ear weight. Ear weights, in pounds of dry matter, were not subjected to analysis of variance. Examination of the data (Table 10) showed that rate of planting was the only factor consistently affecting ear weight. Ear weight decreased as the rate of planting was increased.

Table 10. Average dry weight per ear in pounds for three dates of planting, two methods of planting, and three rates of planting. Ingham County experiment.

Rate of planting - Plants per acre	Method of planting: Hills	Method of planting: Drilled	Average
May 5 planting			
7,800	.43	.46	.45
11,700	.41	.42	.42
15,600	.38	.39	.39
Average	.41	.42	.42
May 24 planting			
7,800	.42	.43	.43
11,700	.37	.38	.38
15,600	.35	.34	.35
Average	.38	.38	.38
June 11 planting			
7,800	.44	.45	.45
11,700	.40	.41	.41
15,600	.37	.39	.38
Average	.40	.42	.41
Average - all dates			
7,800	.43	.45	.44
11,700	.39	.40	.40
15,600	.37	.37	.37
Average	.40	.41	.40

Saginaw County Experiment

Table 11 presents the summarized data on yield, moisture content, lodging, and ear weight. Analyses of variance for yield, moisture content, and lodging are given in Table 12.

Yield. The effects of hybrids, methods of planting, and rates of planting were highly significant when tested with the appropriate experimental errors. Rate of planting affected corn yields more than hybrid or method of planting.

The differences among hybrids were expected from previous information. The differences between Michigan 11A and the other three hybrids were highly significant. There was no significant difference between Michigan 51B and Michigan 36B. Ohio M15 gave the highest yield.

Drill planting averaged 92.6 bushels compared to 84.8 bushels per acre for hill planting. The difference, 7.8 bushels, was highly significant when tested with error (B). The difference is not significant when the first-order interaction, methods x hybrids, is used to test significance. Therefore, there is likely to be no significant difference between hill and drill planting for all hybrids under similar environmental conditions in north-central Michigan.

With populations of 8,300, 12,450, and 16,600 plants per acre, the yields were 69.1, 91.2, and 105.9 bushels per acre, respectively. Yields increased 22.1 bushels or 32% when rate of planting was increased from 8,300 to 12,450 plants per acre.

Table 11. Yield, moisture content, lodging, and ear weight for four hybrids, two methods of planting, and three rates of planting. Saginaw County experiment.

Hybrid	Hill planting Rate of planting			Average	Drill planting Rate of planting			Average	Grand Average
	8,300	12,450	16,600		8,300	12,450	16,600		
Yield in bushels per acre at 15.5% moisture									
Mich. 11A	61.2	77.0	92.3	76.8	63.9	88.0	99.4	83.7	80.3
Mich. 51B	66.5	80.7	93.4	80.2	71.9	94.5	115.6	94.0	87.1
Mich. 36B	65.5	94.5	106.2	88.7	69.9	94.3	107.3	90.5	89.6
Ohio M15	73.9	94.8	111.9	93.6	80.1	105.9	120.8	102.2	97.9
Average	66.8	86.7	100.9	84.8	71.4	95.6	110.8	92.6	88.7
Moisture content in ears at harvest - %									
Mich. 11A	24.9	24.5	25.8	25.1	24.8	23.9	25.4	24.7	24.9
Mich. 51B	28.2	27.9	29.0	28.4	27.7	28.3	26.6	27.5	28.0
Mich. 36B	31.4	31.0	29.9	30.7	31.3	30.6	31.7	31.2	31.0
Ohio M15	30.9	29.4	30.0	30.1	31.5	30.1	29.4	30.3	30.2
Average	28.8	28.2	28.7	28.6	28.8	28.2	28.3	28.5	28.5
Lodging percentage									
Mich. 11A	2.7	3.6	3.2	3.2	1.8	0.6	2.8	1.7	2.4
Mich. 51B	0.9	1.2	7.7	3.3	7.1	3.6	8.3	6.3	4.8
Mich. 36B	0.9	0.6	3.6	1.7	0.9	1.8	0.5	1.1	1.4
Ohio M15	3.6	0.0	1.8	1.8	0.0	1.2	3.2	1.5	1.6
Average	2.0	1.4	4.1	2.5	2.5	1.8	3.7	2.6	2.6

Table 11. (continued)

Hybrid	Hill planting Rate of planting			Average	Drill planting Rate of planting			Average	Grand Average
	8,300	12,450	16,600		8,300	12,450	16,600		
	Dry weight per ear in pounds								
Mich. 11A	.43	.37	.35	.38	.43	.44	.38	.42	.40
Mich. 51B	.44	.38	.35	.39	.46	.43	.44	.44	.42
Mich. 36B	.45	.44	.39	.43	.49	.45	.40	.45	.44
Ohio M15	.42	.42	.39	.41	.42	.42	.41	.42	.41
Average	.43	.40	.37	.40	.45	.43	.41	.43	.42

Table 12. Analyses of variance of yield, moisture content, and lodging percentage. Saginaw County experiment.

Source of variation	Degrees of freedom	Mean squares		
		Yield	Moisture content	Lodging
Hybrids	3	1270.6**	179.0**	58.1
Replications	3	34.1	14.6	32.1
Error (A)	9	73.8	8.1	17.6
Methods of planting	1	1457.0**	0.3	0.6
Methods x hybrids	3	151.8	2.1	23.6
Error (B)	12	69.1	1.5	9.5
Rates of planting	2	10945.4**	3.2	44.0*
Rates x hybrids	6	35.9	2.6	11.2
Rates x methods	2	60.3*	0.6	2.1
R x H x M	6	44.8	2.5	14.8
Error (C)	48	17.2	2.2	9.3
Total	95			

* Significant at the 5% level of probability when tested with experimental error.

** Significant at the 1% level of probability when tested with experimental error.

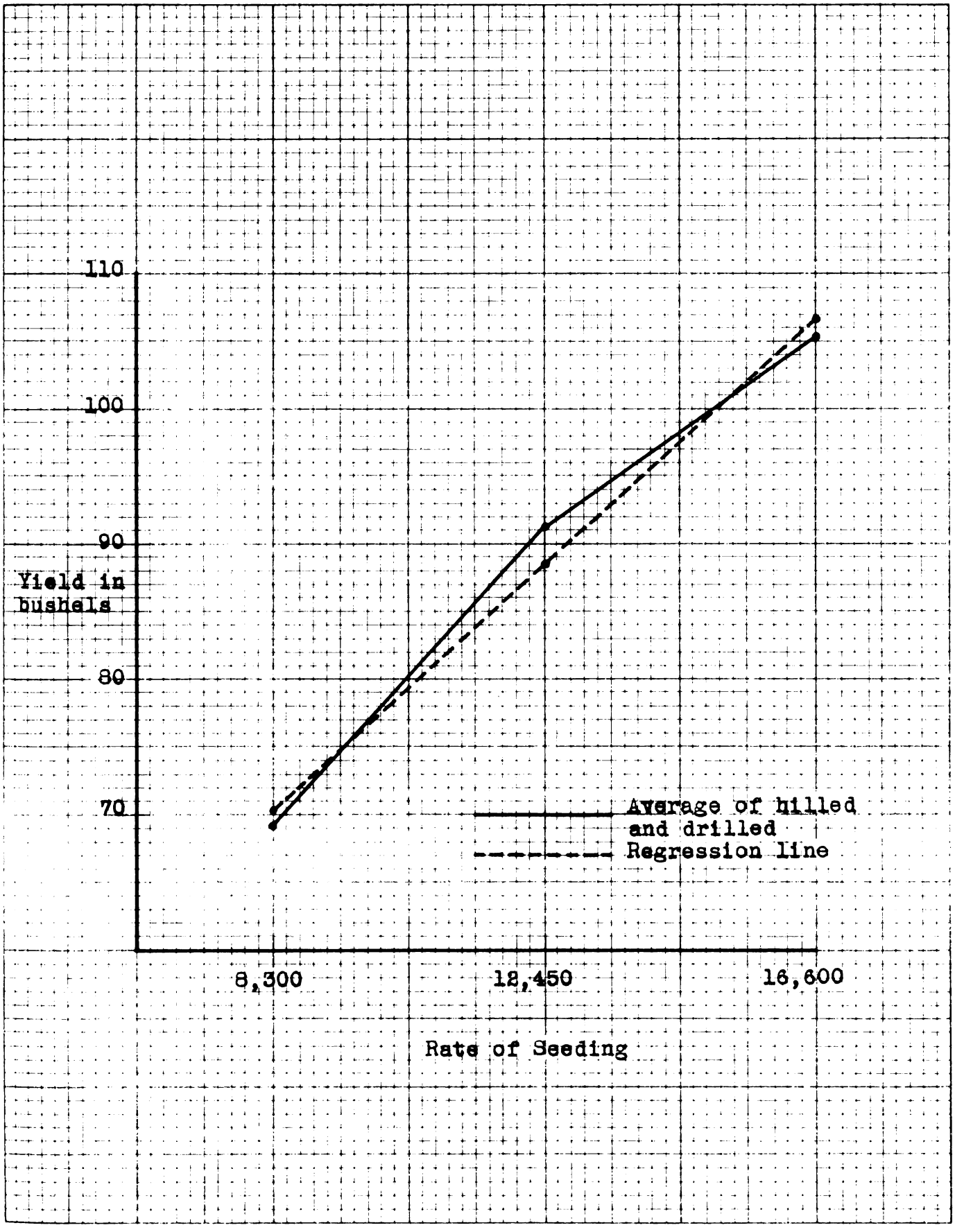
Increasing the population from 12,450 to 16,600 plants gave 14.7 bushels or 16.1% more corn per acre. When the population was doubled, 8,300 to 16,600 plants, yield increased 36.8 bushels or 53.3%.

The relationship between yield and rate of planting was not as straight for the Saginaw County experiment as it was for the Ingham County experiment (Figures 1 and 3). The regression, $Y = 33.9 + .0044X$, indicates that yields increased 4.4 bushels per acre with each increase of 1,000 plants within the range 8,300 to 16,600. A stand of 4,150 plants would be expected to yield 52.2 bushels per acre if the same relationship between yield and rate of planting existed. Likewise, populations of 20,750 and 29,900 plants per acre would yield 124.2 and 142.5 bushels per acre, respectively. These two populations would provide five and six plants per hill or one plant every 8.4" and one plant every 7".

The interaction, rates x methods, was significant when tested with error (C), indicating that in this particular experiment the relationship of yield and rate of planting differed depending on the method of planting (Figure 3). The interaction is not significant when tested with the second-order interaction. Assuming comparable soil and climatic conditions in north-central Michigan, yields can be expected to increase as rate of planting increases irregardless of hybrid or method of planting.

Moisture content. Moisture content of the ears at harvest was not affected by method or rate of planting. The differences between hybrids were expected.

Figure 5. Relationship between yield and rate of planting. Saginaw County experiment.



None of the interactions was significant. Differences in moisture content were due to varietal characteristics in this experiment.

Lodging. Rate of planting was the only factor significantly affecting lodging in the Saginaw County experiment. Populations of 8,300, 12,450, and 16,600 plants averaged 2.3, 1.6, and 3.9% lodging, respectively. The difference between the first two rates of planting was significant at the 5% level of probability. The differences between the first and third and between the second and third rates were highly significant.

The main effect, rate of planting, is not significant when tested with the first-order interaction, rates x hybrids, indicating that rate of planting is not likely to affect lodging for all hybrids in the north-central part of Michigan.

Ear weight. As in the Ingham County experiment, ear weight decreased as rate of planting increased.

Two Locations Combined

Two hybrids, Michigan 51B and Ohio M15, were common in both the Ingham County and Saginaw County experiments. The data for the May 5 planting in Ingham County and the data for the Saginaw County experiment (planted May 11) were subjected to an analysis of variance to determine the effect of location.

Average agronomic data are presented in Table 13 and the analyses of variance in Table 14.

Table 13. Yield, moisture content, lodging, and ear weight for two hybrids, two methods of planting, and three rates of planting. Two locations combined.

Hybrid	Hill planting Rate of planting			Average	Drill planting Rate of planting			Average	Grand Average
	8,050	12,075	16,100		8,050	12,075	16,100		
	Yield in bushels per acre at 15.5% moisture								
Mich. 51B	59.7	80.0	92.1	76.9	66.1	86.5	105.1	85.9	81.4
Ohio M15	71.7	88.4	106.1	88.7	77.8	98.7	112.8	96.5	92.6
Average	65.7	83.6	99.1	82.8	71.9	92.6	109.0	91.2	87.0
	Moisture content in ears at harvest - %								
Mich. 51B	27.80	27.51	28.58	27.96	27.31	27.17	27.27	27.26	27.61
Ohio M15	31.56	30.55	30.91	31.01	31.61	30.58	30.23	30.81	30.91
Average	29.68	29.03	29.74	29.48	29.46	28.87	28.75	29.03	29.26
	Lodging percentage								
Mich. 51B	1.07	2.26	7.92	3.75	4.19	3.91	8.22	5.44	4.60
Ohio M15	1.78	2.50	4.67	2.98	.62	2.30	4.39	2.44	2.71
Average	1.42	2.38	6.29	3.36	2.40	3.10	6.30	3.94	3.65
	Dry weight per ear in pounds								
Mich. 51B	.42	.38	.35	.38	.45	.42	.40	.42	.40
Ohio M15	.41	.40	.39	.40	.41	.40	.40	.40	.40
Average	.41	.39	.37	.39	.43	.41	.40	.41	.40

Table 14. Analyses of variance for yield, moisture content, and lodging. Two locations combined.

Source of variation	Degrees of freedom	Mean squares		
		Yield	Moisture content	Lodging
Locations	1	2900.7**	3.30	19.36
Hybrids	1	3027.4**	262.02**	85.27*
Methods of planting	1	1687.6**	5.05	7.83
Rates of planting	2	9963.2**	2.94	173.45**
Locations x hybrids	1	4.3	27.10**	39.44
Methods x hybrids	1	10.3	1.60	29.82
Methods x locations	1	195.8*	.80	15.06
Rates x hybrids	2	2.6	4.07	49.37*
Rates x methods	2	28.6	1.62	2.02
Rates x locations	2	37.9	2.59	17.60
M x H x L	1	88.3	1.93	7.94
R x M x H	2	39.7	.03	6.90
R x L x H	2	81.8	3.19	2.87
R x L x M	2	77.9	.05	1.16
R x L x M x H	2	37.9	2.42	29.28
Error	72	40.2	3.95	14.68
Total	95			

* Significant at the 5% level of probability when tested with experimental error.

** Significant at the 1% level of probability when tested with experimental error.

Yield. Location, hybrids, methods of planting, and rates of planting produced highly significant effects when tested with experimental error (Table 14). Temperature and rainfall conditions were generally similar at both locations (Table 1). The more fertile Brookston soil type and the alfalfa-bromegrass sod plowed under were probably responsible for the higher corn yields obtained at the Saginaw County experiment.

Drill planting produced 8.4 bushels or 10.1% more per acre than hill planting. Rate of planting was the most important factor affecting corn yields. Plant populations differed slightly at the two locations because of the different row widths. Average yields for the two locations were 68.3, 88.1, and 104.1 bushels per acre for average plant populations of 8,050, 12,075, and 16,100 respectively. Yields increased 29.0% when the plant population was increased from 8,050 to 12,075. A further increase of 18.2% resulted from increasing the population from 12,075 to 16,100 plants per acre. Doubling the plant population from 8,050 to 16,100 resulted in an average increase in yield of 52.4%.

Methods x locations was the only significant interaction when tested with the error term. While drill planting produced higher yields at both locations in these experiments, the magnitude of the differences was not the same at both locations. The differences between drill and hill planting were larger in the Saginaw County experiment. The interaction is not significant when tested with the second-order interaction, methods x hybrids x locations, indicating that there is likely to be no interaction in the population from which these experimental samples were

drawn.

The lack of significant interactions indicates that the effects of location, hybrids, methods of planting, and rate of planting are independent of each other.

The main effects, hybrids and rates of planting, are highly significant when tested with either of the three first-order interactions, indicating that real differences in yield due to hybrids and rates of planting may be expected in the population. The main effect of location was significant at the 5% level of probability when tested with locations x hybrids and rates x locations but not significant when tested with methods x locations. Location differences may be expected for all hybrids and rates of planting but not for all methods of planting. The difference between drill and hill planting was significant at the 5% level of probability when tested with rates x methods but not significant when tested with methods x locations and methods x hybrids. There does not appear to be a clear-cut advantage for drill planting under all conditions.

Moisture content. As expected, the two hybrids differed significantly in moisture content. Location x hybrids was the only significant interaction when tested with the error term. This interaction is not significant when tested with the second-order interactions.

Lodging. Rate of planting and hybrids produced significant effects on lodging percentage (Table 14). As the rate of planting increased, the percent of lodging increased. The incidence

of lodging in Michigan 51B was significantly higher than in Ohio M15. The rate x hybrids interaction was significant at the 5% level when tested with the error term. Although the average percent lodging increased for the two hybrids as the rate of planting increased, the two hybrids did not respond the same as the rate of planting increased. This interaction was not significant, however, when the third-order interaction was used for testing.

Ear weight. Ear weights decreased as rate of planting increased (Table 13).

DISCUSSION

Results from one year's data are not sufficient to make broad recommendations for optimum date, rate, and method of planting corn. Weather and soil conditions in Michigan are so variable from year to year and from place to place that results for a period of years and for a number of locations are desirable before general recommendations can be made with a very high degree of accuracy.

The season of 1949 was unusually favorable for corn production as evidenced by the highest average corn yield on record for Michigan. Weather conditions and other environmental factors responsible for the unusually high yields may have influenced the experiments reported here so that the conclusions may not apply in less favorable seasons. The results and conclusions of the present study may be considered typical for comparable soil and weather conditions. Experiments of the type reported in this study will be continued to obtain additional data from which more generalized recommendations can be made.

Yield. Rate of planting had a greater effect on corn yields than date of planting, hybrid, method of planting, or location. In general, interactions involving these factors were small and not significant when tested with the next higher order interactions. Therefore, these factors may generally be expected to operate independently of each other with respect to their effects on corn yields. A few of the first-order interactions were significant

when tested with the appropriate experimental errors, indicating that these few interactions were operating to some extent in these particular experiments. However, the interactions were not of sufficient magnitude that they are likely to be operating to any extent in the populations from which these experimental samples were drawn. Within the range of plant populations studied, yields increased 4.0 and 4.4 bushels per acre for each increase of 1,000 plants in the Ingham and Saginaw County experiments, respectively. With comparable soil and climatic conditions in central Michigan, highest corn yields would be expected with plant populations of four plants per hill (40"x40" or 42"x36") or one plant every 10" or 11" in 40" or 42" rows. Since the 1949 season was more favorable for corn than generally expected in Michigan and until additional information is obtained in less favorable seasons, a stand of three plants per hill or one plant every 13" or 14" in 40" or 42" rows is recommended for average corn growing seasons and average soil fertility. To obtain this stand at harvest, it would be necessary to increase the planting rate to allow for plant losses due to poor germination, faulty cultivation, birds, etc. Unpublished data from experiments conducted in 1948 on droughty, light sandy soils near White Cloud in Newaygo County and near Gaylord in Otsego County showed that yields were significantly higher for three plants per hill in 40" rows than for two plants per hill (11). Highest corn yields in 1949 were obtained with four plants per hill (40" x 40") in experiments conducted in Monroe, Kalamazoo, and Newaygo Counties (11). Zurakowski (16), in a comparison of two versus three plants

per hill for a large number of hybrids in the 1947 and 1948 hybrid corn trials conducted in Ingham County near East Lansing, found that three plants per hill gave significantly higher yields than two plants per hill. In general, all hybrids responded alike to increased rate of planting.

It is possible that further increases in yield might have been obtained if the next higher equivalent of stand (19,500 and 21,750 plants per acre for the Ingham and Saginaw County experiments, respectively) had been tested. From the results of rate of planting studies at other experiment stations (4) it is probable that the increase in yield would have been small.

Inspection of a number of corn fields in Michigan in 1949 revealed that the average stand was approximately one plant in every 18" of 40" rows. This is equivalent to 8,700 plants per acre. On the basis of rate of planting studies conducted to date, it appears that Michigan farmers could increase corn yields materially by increasing the number of plants per acre.

Increasing the number of plants per acre reduced the weight per ear but the additional number of ears per acre more than offset the reduction in ear weight. Many farmers erroneously measure their corn yields by size of ears - the larger the ear, the bigger the yield. The fallacy of this practice is evident from the results presented in this study.

Approximately 75% of the corn land in Michigan is drilled in the row. The Ingham and Saginaw County experiments conducted in 1949 showed 2.4 and 7.8 bushels, respectively, higher yields for drill planting than for hill planting. These differences

were significant for these particular experiments but were not of sufficient magnitude that they are likely to occur with all hybrids, dates of planting, and rates of planting in central Michigan. The advantage of two-way cultivation in weed control for hill planting was not measured in these experiments since all plots were kept equally free of weeds. In weedy fields this advantage in cultivation may more than offset any possible yield advantage in favor of drill planting.

The highly significant decrease in yield for the May 24 planting date compared with the May 5 and June 11 plantings in the Ingham County experiment was not expected. In south-central Michigan, May 24 generally would be considered an optimum date of planting, more so than the May 5 or June 11 dates. Ideal weather conditions for corn in 1949 prevailed from early May through October. Daily temperatures were generally higher and there was less rainfall during the critical tasseling-silking period and shortly thereafter for the May 24 planting. This might account, in part, for the lower yields from May 24 planting. Average daily temperatures not exceeding 74°F, with no daily peaks exceeding 96°F, and sufficient moisture to keep the top soil damp at all times are considered ideal during the three-week period following tasseling and silking (15).

The effect of location on corn yield was expected in view of the more fertile soil in the Saginaw County experiment. First-order interactions involving location were not significant when tested with second-order interactions, indicating that the effects of hybrids, methods of planting, and rates of planting are

independent of location effects (Table 14). Hybrids, methods of planting, and rates of planting generally responded alike at both locations. The 4.2 bushel difference in favor of drill planting was not significant when tested with interactions of methods x hybrids and methods x locations. It was significant at the 5% level of probability when tested with rates x methods interaction, indicating that drill planting may be expected to provide higher yields at some rates of planting in the population. The difference does not approach the 1% level of probability.

Moisture content. Date, method, and rate of planting did not significantly affect moisture content of the ears at harvest when these effects were tested with first-order interactions. In the Ingham County experiment the effect of rate of planting was significant when tested with error (D). In this particular experiment there was a trend toward higher moisture content with the higher rates of planting. However, the differences were not large enough that they are likely to occur consistently under all conditions.

Lodging. Late planting, June 11, in the Ingham County experiment resulted in significantly more lodging than the two earlier days of planting. Several light frosts and a general killing frost on October 24 preceded harvest of the third planting. The more brittle and dry condition of the stalks undoubtedly added to the stalk breakage. The difference does not appear to be due to differences in corn-borer infestation, although no detailed data on borer infestation were taken. Marston (12)

found that the number of corn-borer eggs decreased as the date of planting advanced, but the percentage of larvae survival increased except for the late date of planting. The multivoltine form which lays its eggs in May or early June and again in July is not believed to be present generally in central Michigan.

There was a trend toward more lodging with drill planting than with hill planting. The differences were not great enough that they are likely to be a general characteristic of the population. In areas where root lodging is a problem, more lodging might be expected in hill planting where one infected plant could infect the other plants in the hill more easily. Where stalk lodging is due to corn-borer and/or stalk-rotting diseases, more lodging might be expected in drill planting since there is less protection from wind in drilled corn.

Lodging percentage generally increased as the rate of planting increased. The one exception was in the Saginaw County experiment where there was less lodging for the second rate of planting than for the low rate of planting. The general trend is likely due to somewhat smaller stalk size at the heavier rates of planting.

CONCLUSIONS

The effects of three dates of planting, two methods of planting, and three rates of planting for three hybrids on yield, moisture content, lodging, and ear weight were investigated in an experiment conducted in Ingham County. Two methods of planting and three rates of planting for four hybrids were studied in a second experiment, conducted in Saginaw County. Both experiments were conducted in 1949, which was an unusually favorable year for corn production in Michigan.

(1) Rate of planting had a greater effect on corn yields than date of planting, hybrid, method of planting, or location. These five factors appear to operate independently of each other as evidenced by the general lack of significance for interactions involving these factors.

(2) Highest average yields were produced with populations of 15,600 and 16,600 plants per acre at the Ingham and Saginaw County experiments, respectively. Within the ranges 7,800 to 15,600 and 8,300 to 16,600 plants per acre for the Ingham and Saginaw County experiments, yields increased 4.0 and 4.4 bushels, respectively, for each increase of 1,000 plants. It is suggested that Michigan farmers may increase corn yields materially by increasing the plant population per acre.

(3) Drill planting averaged 2.4 and 7.8 bushels per acre more corn in the Ingham and Saginaw County experiments, respectively. These differences are not of sufficient magnitude that they are likely to occur with much certainty for all hybrids, dates of planting, and rates of planting in central Michigan.

(4) May 24 planting in the Ingham County experiment resulted in a significantly lower yield than May 5 or June 11 plantings. Long-time data are needed to establish optimum planting dates.

(5) Date, method, and rate of planting did not significantly affect moisture content of the ears at harvest. While there was a trend toward higher moisture content at the higher rates of planting in the Ingham County experiment, the differences are not likely to occur consistently in the population as a whole.

(6) Late planting (June 11) in the Ingham County experiment resulted in significantly more lodging than the two earlier dates of planting.

(7) There was a trend toward more lodging with drill planting than with hill planting, but the differences were not large enough so that they are likely to be a general characteristic of the entire population.

(8) In the Ingham County experiment, lodging increased as the rate of planting increased. The high rate of planting in the Saginaw County experiment also gave the highest percentage of lodging, but the second rate of planting lodged less than the low rate.

(9) Ear weight decreased as the rate of planting increased, but the additional number of ears per acre at the high rate of planting more than offset the decrease in ear weight.

(10) Additional experiments at more locations in good and poor seasons are needed before general recommendations can be made.

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APPENDIX

Tables 15 - 22 inclusive

Table 15. Yield in bushels. Ingham County experiment.

Hybrid, date of planting, method of planting, and rate of planting	Replications				Total
	1	2	3	4	
51B - 1 - 1	57.7	58.2	44.7	51.0	211.6
2	90.7	66.1	80.0	70.4	307.2
3	96.4	89.2	93.5	84.5	363.6
4	74.1	59.6	50.9	56.2	240.8
5	84.2	75.9	76.9	76.9	313.9
6	105.0	92.1	88.3	93.5	378.9
M15 - 1 - 1	76.3	71.3	67.3	62.8	277.7
2	87.4	82.4	78.4	80.1	328.3
3	105.1	104.7	95.2	96.1	401.1
4	86.9	77.9	69.3	68.4	302.5
5	107.8	92.3	88.1	78.6	366.8
6	117.4	104.1	100.5	97.3	419.3
29D - 1 - 1	81.5	72.7	69.6	70.1	293.9
2	98.0	93.8	84.7	83.9	360.4
3	107.4	117.4	100.5	94.9	420.2
4	71.4	76.7	81.5	75.8	305.4
5	87.7	103.6	95.2	95.7	382.2
6	93.0	127.3	112.3	103.1	435.7
51B - 2 - 1	63.2	52.9	50.0	50.0	216.1
2	70.1	66.8	59.8	64.5	261.2
3	78.8	80.7	72.3	78.4	310.2
4	58.5	48.1	43.4	45.3	195.3
5	74.3	58.7	58.7	62.5	254.2
6	85.8	71.9	69.0	76.7	303.4
M15 - 2 - 1	73.8	63.6	55.1	61.2	253.7
2	88.0	84.8	71.9	82.0	326.7
3	113.7	109.0	95.6	100.3	418.6
4	72.6	74.0	61.2	66.4	274.2
5	81.4	88.5	68.6	79.5	318.0
6	94.2	96.1	78.1	89.2	357.6
29D - 2 - 1	84.5	59.2	61.0	59.7	264.4
2	90.7	81.3	74.6	68.8	315.4
3	98.1	90.2	83.2	80.5	352.0
4	75.5	67.9	61.2	60.3	264.9
5	89.1	86.5	79.4	82.5	337.5
6	100.2	94.0	89.2	92.7	376.1

Table 15. Yield in bushels. Ingham County experiment.

Hybrid, date of planting, method of planting, and rate of planting	Replications				Total
	1	2	3	4	
51B - 1 - 1	57.7	58.2	44.7	51.0	211.6
2	90.7	66.1	80.0	70.4	307.2
3	96.4	89.2	93.5	84.5	363.6
4	74.1	59.6	50.9	56.2	240.8
5	84.2	75.9	76.9	76.9	313.9
6	105.0	92.1	88.3	93.5	378.9
M15 - 1 - 1	76.3	71.3	67.3	62.8	277.7
2	87.4	82.4	78.4	80.1	328.3
3	105.1	104.7	95.2	96.1	401.1
4	86.9	77.9	69.3	68.4	302.5
5	107.8	92.3	88.1	78.6	366.8
6	117.4	104.1	100.5	97.3	419.3
29D - 1 - 1	81.5	72.7	69.6	70.1	293.9
2	98.0	93.8	84.7	83.9	360.4
3	107.4	117.4	100.5	94.9	420.2
4	71.4	76.7	81.5	75.8	305.4
5	87.7	103.6	95.2	95.7	382.2
6	93.0	127.3	112.3	103.1	435.7
51B - 2 - 1	63.2	52.9	50.0	50.0	216.1
2	70.1	66.8	59.8	64.5	261.2
3	78.8	80.7	72.3	78.4	310.2
4	58.5	48.1	43.4	45.3	195.3
5	74.3	58.7	58.7	62.5	254.2
6	85.8	71.9	69.0	76.7	303.4
M15 - 2 - 1	73.8	63.6	55.1	61.2	253.7
2	88.0	84.8	71.9	82.0	326.7
3	113.7	109.0	95.6	100.3	418.6
4	72.6	74.0	61.2	66.4	274.2
5	81.4	88.5	68.6	79.5	318.0
6	94.2	96.1	78.1	89.2	357.6
29D - 2 - 1	84.5	59.2	61.0	59.7	264.4
2	90.7	81.3	74.6	68.8	315.4
3	98.1	90.2	83.2	80.5	352.0
4	75.5	67.9	61.2	60.3	264.9
5	89.1	86.5	79.4	82.5	337.5
6	100.2	94.0	89.2	92.7	376.1

Table 15. (continued)

Hybrid, date of planting, method of planting, and rate of planting	Replications 1	2	3	4	Total
51B - 3 - 1	59.9	64.3	64.3	59.4	247.9
2	84.0	88.5	79.6	77.1	329.2
3	100.3	92.3	96.1	85.6	374.3
4	63.8	55.2	58.5	64.3	241.8
5	86.3	91.7	66.3	73.2	317.5
6	100.0	102.4	93.3	91.3	387.0
M15 - 3 - 1	62.0	73.8	67.2	69.5	272.5
2	87.7	90.5	85.4	82.1	345.7
3	93.4	98.9	92.5	91.5	376.3
4	73.0	73.5	71.6	69.3	287.4
5	84.2	97.0	95.1	80.4	356.7
6	93.8	107.6	108.0	91.8	401.2
29D - 3 - 1	68.3	77.9	71.0	56.0	273.2
2	93.2	88.3	81.1	69.5	332.1
3	121.9	100.2	97.5	87.1	406.7
4	78.6	78.1	64.9	58.0	279.6
5	100.9	96.5	100.5	72.0	369.9
6	117.4	116.1	111.6	86.9	432.0

Key applicable to all Ingham County experiments

Hybrids: Michigan 51B
Ohio M15
Michigan 29D

Date of planting: 1 May 5,1949
2 May 24,1949
3 June 11,1949

Method of planting: Hilled 1, 2, 3
Drilled 4, 5, 6

Rate of planting:
1 & 4 plant per acre equivalent 7,800
2 & 5 plant per acre equivalent 11,700
3 & 6 plant per acre equivalent 15,600

Table 16. Moisture percentages. Ingham County experiment.

Hybrids, date of planting, method of planting, and rate of planting	Replications				Total
	1	2	3	4	
51B - 1 - 1	29.1	27.2	26.5	26.9	109.7
2	30.4	27.6	26.2	24.4	108.6
3	32.9	28.8	22.2	28.6	112.5
4	27.7	27.1	26.1	26.8	107.7
5	30.9	24.8	23.8	24.7	104.2
6	28.7	28.5	26.8	27.9	111.9
M15 - 1 - 1	32.8	33.4	30.8	32.1	129.1
2	33.1	31.7	30.4	31.7	126.9
3	31.7	30.5	33.3	32.0	127.5
4	32.6	31.9	31.5	30.8	126.8
5	32.6	30.9	30.8	30.0	124.3
6	34.3	29.2	29.6	31.3	124.4
29D - 1 - 1	35.4	32.8	31.8	33.9	133.9
2	37.0	35.1	32.6	35.5	140.2
3	36.0	34.7	34.7	34.2	139.6
4	34.3	33.1	33.2	33.5	134.1
5	35.5	33.5	32.6	32.5	134.1
6	35.1	33.9	32.5	33.8	135.3
51B - 2 - 1	29.5	29.7	24.9	31.1	115.2
2	32.0	29.4	23.5	31.0	115.9
3	29.6	27.6	27.6	31.8	116.6
4	30.5	25.6	25.8	33.2	115.1
5	28.4	28.1	26.0	32.0	114.5
6	29.3	27.2	27.2	26.9	110.6
M15 - 2 - 1	27.9	28.5	29.0	32.6	118.0
2	33.8	29.4	28.3	30.4	121.9
3	30.8	31.1	29.1	30.0	121.0
4	32.6	27.8	26.5	26.5	113.4
5	29.0	29.2	28.0	28.1	114.3
6	33.1	28.5	29.0	30.4	121.0
29D - 2 - 1	32.8	29.4	29.6	35.2	127.0
2	35.5	30.4	31.5	32.9	130.3
3	34.3	34.2	30.9	35.1	134.5
4	34.3	30.0	33.3	32.8	130.4
5	34.3	30.9	32.6	34.7	132.5
6	35.6	31.8	35.6	32.8	135.8

Table 16. (continued)

Hybrids, date of planting, method of planting, and rate of planting	Replications				Total
	1	2	3	4	
51B - 3 - 1	27.7	26.8	25.8	25.8	106.1
2	24.9	25.8	24.5	26.5	101.7
3	29.2	26.5	28.1	30.4	114.2
4	26.8	27.2	27.8	28.6	110.4
5	25.9	24.3	28.0	27.2	105.4
6	24.3	29.0	26.5	28.4	108.2
M15 - 3 - 1	29.4	28.1	27.8	31.1	116.4
2	30.0	28.7	30.0	29.6	118.3
3	29.6	30.4	29.4	32.9	122.3
4	27.9	29.8	28.7	29.1	115.5
5	28.5	29.1	26.9	29.8	114.3
6	26.5	28.8	28.5	29.0	112.8
29D - 3 - 1	35.1	32.7	27.7	29.8	125.3
2	29.8	36.8	30.7	32.3	129.6
3	33.0	30.0	31.0	33.6	127.6
4	32.7	31.4	28.1	32.0	124.2
5	30.2	32.1	37.0	32.3	131.6
6	30.9	30.8	33.0	34.7	129.4

Table 17. Lodging data expressed in percent. Ingham County experiment.

Hybrids, date of planting, method of planting, and rate of planting	Replications				Total
	1	2	3	4	
51B - 1 - 1	0	5.0	0	0	5.0
2	0	6.67	3.33	3.33	13.33
3	5.13	7.50	5.0	15.0	32.63
4	0	0	5.0	0	5.0
5	0	10.0	3.45	3.57	17.02
6	5.0	10.0	10.26	7.5	32.76
M15 - 1 - 1	0	0	0	0	0
2	6.67	10.0	0	3.33	20.0
3	7.50	7.69	10.0	5.0	30.19
4	0	0	5.0	0	5.0
5	3.33	0	6.67	3.57	13.57
6	0	12.50	10.0	0	22.5
29D - 1 - 1	0	0	5.0	0	5.0
2	6.67	6.67	0	6.67	20.01
3	12.50	5.0	2.63	2.56	22.69
4	0	0	0	0	0
5	3.33	0	3.33	3.33	9.99
6	5.13	0	2.5	7.5	15.13
51B - 2 - 1	5.0	15.0	5.0	0	25.0
2	16.67	6.67	10.0	6.67	40.01
3	7.50	10.26	10.0	10.0	37.76
4	0	5.0	5.26	5.0	15.26
5	6.67	3.33	3.33	10.0	23.33
6	2.70	5.0	10.0	7.5	25.20
M15 - 2 - 1	0	5.0	5.0	5.0	15.0
2	3.33	0	3.33	3.33	9.99
3	2.5	2.5	7.5	10.0	22.5
4	5.0	0	0	0	5.0
5	0	3.85	0	0	3.85
6	2.5	5.0	0	2.5	10.0
29D - 2 - 1	0	5.0	0	5.0	10.0
2	6.67	6.67	3.33	3.33	20.0
3	2.5	5.0	2.56	5.13	15.19
4	0	10.53	0	5.0	15.53
5	3.33	3.70	3.45	3.33	13.81
6	2.5	7.5	0	7.5	17.50

Table 17. (continued)

Hybrids, date of planting, method of planting, and rate of planting	Replications				Total
	1	2	3	4	
51B - 3 - 1	20.0	15.0	15.0	15.79	65.79
2	10.0	23.33	13.33	16.67	63.33
3	25.64	32.50	12.5	10.0	80.64
4	30.0	0	30.0	15.79	75.79
5	30.0	34.48	18.52	10.0	93.0
6	34.21	23.68	20.0	7.5	85.39
M15 - 3 - 1	25.0	10.0	5.0	5.0	45.0
2	23.33	6.67	16.67	10.0	56.67
3	17.95	12.5	18.42	12.5	61.37
4	35.0	20.0	30.0	10.0	95.0
5	20.0	20.0	16.67	23.33	80.0
6	17.5	27.5	30.0	30.0	105.0
29D - 3 - 1	0	10.0	0	5.0	15.0
2	10.0	10.0	3.33	6.67	30.0
3	17.50	10.0	10.0	15.0	52.50
4	20.0	10.0	20.0	10.0	60.0
5	32.14	25.0	16.67	10.0	83.81
6	25.0	17.5	20.0	20.0	82.5

Table 18. Ear weight in pounds. Ingham County experiment.

Hybrids, date of planting, method of planting, and rate of planting	Replications				Total
	1	2	3	4	
51B - 1 - 1	.43	.42	.34	.39	1.58
2	.44	.33	.41	.37	1.55
3	.35	.35	.40	.32	1.42
4	.56	.41	.34	.43	1.74
5	.41	.39	.41	.42	1.63
6	.40	.35	.35	.36	1.46
M15 - 1 - 1	.39	.39	.39	.41	1.58
2	.40	.41	.35	.39	1.55
3	.41	.41	.35	.37	1.54
4	.52	.39	.36	.35	1.62
5	.44	.40	.39	.34	1.57
6	.40	.42	.38	.37	1.57
29D - 1 - 1	.57	.50	.51	.53	2.11
2	.46	.47	.46	.42	1.81
3	.40	.47	.41	.37	1.65
4	.53	.53	.62	.48	2.16
5	.43	.50	.49	.46	1.88
6	.37	.51	.43	.39	1.70
51B - 2 - 1	.41	.40	.40	.37	1.58
2	.36	.33	.32	.32	1.33
3	.30	.34	.28	.31	1.23
4	.43	.38	.36	.36	1.53
5	.37	.30	.31	.30	1.28
6	.34	.29	.28	.31	1.22
M15 - 2 - 1	.39	.40	.37	.42	1.58
2	.36	.38	.36	.40	1.50
3	.40	.39	.37	.38	1.54
4	.36	.40	.40	.40	1.56
5	.36	.43	.30	.38	1.47
6	.33	.37	.30	.34	1.34
29D - 2 - 1	.57	.44	.48	.43	1.92
2	.45	.42	.39	.34	1.60
3	.38	.36	.35	.31	1.40
4	.56	.53	.46	.46	2.01
5	.44	.50	.42	.40	1.76
6	.37	.39	.35	.37	1.48

Table 18. (continued)

Hybrids, date of planting, method of planting, and rate of planting	Replications				Total
	1	2	3	4	
51B - 3 - 1	.45	.46	.41	.46	1.78
2	.44	.44	.41	.40	1.69
3	.38	.37	.37	.36	1.48
4	.44	.42	.42	.46	1.74
5	.44	.47	.36	.36	1.63
6	.41	.41	.37	.38	1.57
M15 - 3 - 1	.36	.43	.37	.38	1.54
2	.39	.35	.37	.39	1.50
3	.36	.37	.36	.34	1.43
4	.51	.39	.40	.39	1.69
5	.37	.38	.41	.36	1.52
6	.36	.38	.38	.35	1.47
29D - 3 - 1	.44	.52	.51	.43	1.90
2	.49	.42	.40	.35	1.66
3	.45	.39	.37	.35	1.56
4	.50	.53	.46	.43	1.92
5	.53	.49	.43	.37	1.82
6	.45	.46	.43	.33	1.67

Table 19. Yield in bushels. Saginaw County experiment.

Hybrids, method of planting, and rate of planting	Replications				Total
	1	2	3	4	
11A - 1	64.7	62.6	57.3	60.0	244.6
2	82.2	83.2	76.9	65.7	308.0
3	93.6	94.1	95.2	86.3	369.2
4	59.0	56.9	68.0	71.7	255.6
5	87.4	88.5	85.8	90.1	351.8
6	94.1	99.4	96.8	107.2	397.5
51B - 1	67.5	68.5	63.5	66.5	266.0
2	86.3	80.3	78.3	77.8	322.7
3	97.6	91.6	95.1	89.1	373.4
4	74.2	67.1	69.6	76.7	287.6
5	96.1	85.0	98.1	98.6	377.8
6	109.7	113.3	120.5	119.0	462.5
36B - 1	65.4	67.8	72.6	56.3	262.1
2	100.7	105.0	89.5	82.8	378.0
3	112.9	111.9	103.6	96.2	424.6
4	65.6	78.6	69.9	65.6	279.7
5	89.1	94.0	106.2	87.7	377.0
6	99.8	116.2	113.3	99.8	429.1
M15 - 1	73.1	70.2	77.9	74.5	295.7
2	94.1	100.5	89.1	95.5	379.2
3	116.4	114.9	108.5	108.0	447.8
4	77.4	79.8	83.2	79.8	320.2
5	99.5	106.3	109.3	108.3	423.4
6	117.3	113.9	124.2	127.7	483.1

Key applicable to all Saginaw County experiments

Hybrids: Michigan 11A
Michigan 51B
Michigan 36B
Ohio M15

Method of planting:
Hilled 1, 2, 3
Drilled 4, 5, 6

Rate of planting:
1 & 4 plant per acre equivalent 8,300
2 & 5 plant per acre equivalent 12,450
3 & 6 plant per acre equivalent 16,600

Table 20. Moisture percentages. Saginaw County experiment.

Hybrids, method of planting, and rate of planting	Replications				Total
	1	2	3	4	
11A - 1	29.4	24.1	22.5	23.6	99.6
2	26.8	24.4	24.4	22.3	97.9
3	26.8	24.4	28.1	24.0	103.3
4	27.8	24.4	24.2	22.8	99.2
5	26.8	22.5	23.6	22.7	95.6
6	27.2	25.8	24.4	24.2	101.6
51B - 1	32.0	29.0	25.8	25.9	112.7
2	29.8	28.8	26.1	26.8	111.5
3	30.2	30.8	27.9	27.2	116.1
4	29.5	25.5	26.5	29.3	110.8
5	29.0	30.6	27.1	26.5	113.2
6	28.1	25.8	25.8	26.8	106.5
36B - 1	29.4	32.8	31.9	31.3	125.4
2	30.5	31.1	30.5	31.7	123.8
3	29.2	29.8	31.4	29.2	119.6
4	30.6	32.1	31.3	31.3	125.3
5	30.7	27.8	32.1	31.8	122.4
6	32.2	31.3	32.6	30.8	126.9
M15 - 1	32.2	32.5	29.8	28.9	123.4
2	32.0	26.5	30.4	28.6	117.5
3	29.2	28.1	31.5	31.0	119.8
4	31.1	31.8	31.9	31.3	126.1
5	29.4	29.8	31.9	29.2	120.3
6	30.8	25.0	30.4	31.3	117.5

Table 21. Lodging data expressed in percent. Saginaw County experiment.

Hybrids, method of planting, and rate of planting	Replications				Total
	1	2	3	4	
11A - 1	0	3.57	0	7.14	10.71
2	2.38	2.38	4.76	5.00	14.52
3	0	1.82	7.41	3.57	12.80
4	0	7.14	0	0	7.14
5	0	0	2.50	0	2.50
6	1.79	3.85	3.57	1.79	11.00
51B - 1	0	3.57	0	0	3.57
2	2.38	2.44	0	0	4.82
3	1.79	5.36	21.82	1.79	30.76
4	0	7.14	10.71	10.71	28.56
5	0	2.38	9.52	2.33	14.23
6	3.57	12.96	11.11	5.36	33.00
36B - 1	0	3.57	0	0	3.57
2	0	2.38	0	0	2.38
3	5.36	7.14	1.79	0	14.29
4	0	3.57	0	0	3.57
5	0	4.88	2.38	0	7.26
6	0	0	0	1.92	1.92
M15 - 1	10.71	3.57	0	0	14.28
2	0	0	0	0	0
3	0	5.36	0	1.79	7.15
4	0	0	0	0	0
5	0	0	2.50	2.38	4.88
6	0	0	7.27	5.36	12.63

Table 22. Ear weight in pounds. Saginaw County experiment.

Hybrids, method of planting, and rate of planting	Replications				Total
	1	2	3	4	
11A - 1	.40	.45	.42	.43	1.70
2	.39	.38	.36	.34	1.47
3	.35	.37	.37	.32	1.41
4	.40	.41	.44	.47	1.72
5	.42	.43	.43	.46	1.74
6	.33	.41	.38	.40	1.52
51B - 1	.44	.42	.44	.44	1.74
2	.41	.39	.36	.37	1.53
3	.37	.33	.36	.33	1.39
4	.42	.48	.47	.45	1.82
5	.45	.37	.46	.45	1.73
6	.39	.45	.47	.45	1.76
36B - 1	.47	.44	.50	.40	1.81
2	.47	.46	.43	.39	1.75
3	.44	.40	.37	.35	1.56
4	.48	.55	.46	.45	1.94
5	.43	.46	.49	.41	1.79
6	.37	.45	.43	.36	1.61
M15 - 1	.40	.35	.51	.43	1.69
2	.40	.44	.40	.42	1.66
3	.41	.39	.38	.37	1.55
4	.39	.41	.47	.42	1.69
5	.39	.39	.46	.43	1.67
6	.38	.42	.43	.39	1.62