EVALUATION OF SECOND CYCLE INBRED LINES OF MAIZE

By

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AN ABSTRACT

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An Abstract

Twenty S_6 second cycle lines developed by inbreeding and selection in the double cross Ohio M 15 (Oh 51 x Oh 26) x (Ill.A x W 23) were used to study the degree of relationship with the four parental lines and among themselves. These lines were crossed on ten testers, seven related (four parental inbreds, two single crosses and the double cross Ohio M 15) and three unrelated testers (inbred M 14, single cross M 14 x W F 9 and double cross Ia. 4483 (M 14 x W F 9) x (B_8 x B16).

Seven of the second cycle lines, four parental lines and one unrelated line, M 14 were used to produce, 66, single crosses. Actual and predicted performance of double crosses were compared with the parental Ohio M 15.

A few of the second cycle lines were more vigorous than and superior to the parental inbreds in combining ability. Second cycle lines were genetically different from some of the parents and from each other.

A few double crosses equal to or slightly better than Ohio M 15 were produced by crossing four second cycle lines or by substituting them with one or more of the parental lines in the pedigree of Ohio M 15. Predicted yield, percentage of moisture and stalk lodging of the double crosses from the single cross data showed significant correlation with the actual yield, percentage of moisture and stalk lodging.

These results indicate that, even the lines of the same origin can be used to produce good hybrids, if they were

extracted from a wide genetic base.

Inbred and single-cross testers were very specific in evaluating the lines for yield and lodging. This suggests the use of more than one of these as testers for general combining ability. The 'r' value between the two double cross testers was a significant (.46) but low enough to suggest the use of more than one tester for evaluating the lines for general combining ability for yield. A high 'r' value for the mean of the four parental inbred testers with the mean of their two single crosses suggested that either four inbreds or their two single crosses may be used for evaluating general combining ability of the lines for yield.

Either the four inbred testers or their two single crosses, or the double cross of the four inbreds could be used to evaluate the lines for resistance to stalk lodging. A similar situation was indicated for resistance to root lodging.

Correlation for the two tester groups (related and unrelated) indicates that either related or unrelated testers, as a group, were reliable for estimating relative general combining ability for yield, maturity, and stalk lodging resistance.

The correlation coefficients for maturity were significant in all cases and were generally high, suggesting fewer testers would be needed to evaluate maturity than yield or lodging resistance.

For related lines, genes conditioning specific combining ability were relatively more important in influencing yield than genes for general combining ability.

Analysis of components of varience shows that for yield, line x tester interaction decreased with increased genetic variation in the tester. This same relationship did not exist for maturity.

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Introduction

The need of more efficient methods of isolating and evaluating improved inbred lines of corn is paramount if corn breeding is to progress significantly beyond its present status. In the early stages of hybrid corn breeding, inbred lines were produced solely from open pollinated varieties. While some of these lines were very desirable for hybrid corn production and are still among the more popular lines in commercial production, a very high percentage was discarded because of poor plant characteristics or inability to transmit high yields and other desirable agronomic characteristics to their hybrids.

In more recent years, new lines have been produced from previously developed lines after combining them in crosses. A number of desirable lines have been isolated by second cycle inbreeding, but very few have been superior in commercial production to the best lines developed through inbreeding in open pollinated varieties. Several workers have reported that the isolation of second cycle inbred lines from single crosses precludes their use in hybrid combinations with each other or with the parental inbreds due to close genetic similarity. Second cycle inbreeding and selection in double cross hybrids and other crosses involving more than four inbred lines of diverse origin might reduce the dangers of close relationship among the inbreds.

Continued inbreeding and selection in open pollinated varieties and other broad gene bases is necessary to maintain or extend genetic diversity among inbred lines. Second and continued cycles of inbreeding and selection among crosses of these lines may lead to further improvement and refinement in the inbreds and their hybrids.

Thus far it has been impossible to isolate inbred lines superior for complexly inherited characteristics such as yield by visual means. Superior lines can be developed only by extensive and expensive testing programs. The top-cross method, using an open pollinated variety or double cross hybrid as a tester to identify lines of superior general combining ability, has been widely used.

In 1948, inbreeding and visual selection for desirable agronomic characteristics was started in the double cross hybrid Ohio M 15 (Oh. 26 X Oh. 51) x (Ill.A x W 23). The hybrid was a popular, productive, medium-early maturing hybrid, well adapted throughout central Michigan. During the course of routine inbreeding and selection, it became apparent that a group of lines distinctly different from the four parental lines in appearance was being developed. No evaluation for combining ability in test crosses had been made during the six generations of inbreeding and selection. Since it has become more or less standard procedure in corn breeding to avoid hybrids containing related inbred lines, it appeared desirable to determine the extent of genetic relationship in this material and how detrimental this

relationship might be in producing improved hybrids in the Ohio M 15 maturity group. The present study has been conducted toward the above end.

Review of literature

Isolation of second cycle lines has been designated by various names such as 'pedigree system of breeding' and 'cumulative selection'. Wu (30), in studying the pedigree method of breeding for improvement of inbred lines isolated from single crosses, measured 11 characters in the progeny inbred lines and in the original parental inbred lines. All of these characters except two showed significant variability. Selection for certain characters by the pedigree method of breeding was effective in isolating inbred lines more desirable in these characters than either parent. Hayes and Johnson (12) isolated inbred lines from single crosses that were improved in vigor, lodging resistance and smut resistance. Similar results were reported by Johnson and Hayes (18), Sprague (27) and Green (11) in the improvement of inbred lines by the pedigree method of breeding.

Genetic diversity among inbred lines has generally produced higher yielding hybrids than when the inbreds were closely related. Wu (30) showed that related inbred lines produced single cross hybrids that yielded consistantly lower than single crosses composed of inbred lines of diverse genetic origin. Hayes and Johnson (12) reported results from the same type of study. In crosses of unrelated lines, twenty eight of forty-three single crosses were equal to or better than standard double crosses in yielding ability and

moisture percentage. Where one parent was common, six out of fifteen crosses and where both parents were common one out of fifteen were equal or better in yield and moisture percentage than the standard double crosses. Johnson and Hayes (18) presented additional data from crosses between related inbred lines to show that genetic diversity was important to obtain maximum expression of hybrid vigor. Eckhardt and Bryan (8 and 9) and Cowan (5) also confirmed the importance of genetic diversity for the production of high yielding hybrids.

Development of inbred lines is comparatively simple compared to problems of evaluating the lines. The importance of this was stressed as early as 1909 by Shull (25). For a time it was customary to make and test as single crosses all possible combinations among the lines. This method was expensive and inefficient, even for the small number of inbreds used.

Jenkins (14) reported correlations for the yield of double crosses with: (a) the mean yield of all six possible single crosses from four inbreds, (b) with the mean yield of the four nonparental single-cross combinations, (c) with the mean yield of all single crosses involving the four lines of the double cross, (d) with the mean yield of the inbred x variety top cross results for the four parent inbreds. Method (b) was more genetically sound and the results agreed better with the actual double cross performance. The correlations for predicted and actual yields for methods (a), (b) and (c)

were 0.75, 0.76 and 0.73 respectively showing little difference for the three methods. The correlations for the inbred variety crosses was 0.61, still significant. Methods (a), (c) and (d) all assume additive gene action. Method (b) no additive effects arising from dominance, epistatis etc.

The effectiveness of predicting the yields of double crosses from the mean yields of the four nonparental single crosses has now been tested at several experiment stations. Doxtator and Johnson (7) compared the predicted and observed yield of seven double crosses and two three way crosses. They reported that by appropriate use of single cross data, the highest yielding double cross combination could be predicted. Anderson (1) compared the actual yield of 15 double crosses with the predicted yield by method (b) of Jenkins and found close agreement between predicted and actual yields. The correlation was 0.9. Hayes, Murphy and Rinke (13) reported a comparison between actual and predicted yield and moisture content of 114 double crosses. There was excellent agreement between the predicted and actual results. Prediction of double-cross yields from data of the four nonparental single crosses has become an accepted method in corn breeding. Millang and Sprague (22), Combs and Zuber (4) have prepared a procedure which facilitates the prediction of the double crosses by use of the punchcard machine method.

The ultimate use of the inbred lines in hybrids and their final selection is based on hybrid performances. In

earlier days, all the lines were crossed with each other and tested. It was a very tedious and expensive job. A more efficient method was available in the use of the inbred x variety crosses.

Jones (19) reported on inbred x variety crosses. He was mainly interested in relative performance, rather than as a method of evaluating the lines. Davis (6) used this method of inbred variety crosses for determining the combining ability of S_2 lines.

Jenkins and Brunson (16) compared the ranking of inbred lines by the inbred x variety crosses and single crosses. Coefficients of correlation for many characters were calculated between the mean performance of inbred lines as single crosses and their performance x in crosses with an open pollinated variety. They concluded that open pollinated varieties were effective in the preliminary testing of new lines.

Johnson and Hayes (18) reported the relation between top cross yield and single yields for 11 inbred lines derived from the variety "Golden Bantam". It was found that the inbreds yielding high in top crosses were most likely to produce the high yielding single crosses. They also recommended this method for the preliminary evaluation of inbred lines.

The choice of the tester depends upon the useto be made of the lines. A suitable tester should detect inherent differences in the combining ability of the lines. Beard (2) has compared the use of single crosses and an open pollinated

variety as testers. He concluded that the single crosses were at least equal to the open pollinated variety for evaluating combining ability. Federer and Sprague (10) concluded that increasing the number of testers improved the estimates of combining value more than increasing the number of replications.

Keller (20) reported the relationship between the use of a related and an unrelated single cross as the tester parent in evaluating a group of selected F_2 plants of maize. The results indicate that the two testers did not rank the lines in the same order due to differences in specific combining ability of the testers. Another study was made to determine the association among the four testers for evaluating the lines. The results suggest that the inbred lines and the variety Krug as testers did not rank the lines similarly. The data suggest the use of a number of testers for evaluating general combining ability. It was also concluded that the use of the tester should be decided by the use to be made of the lines.

Matizinger (21) used 16 inbred lines, divided at random into two groups. One of the groups was used as testers and the other as lines to be tested. The testers included eight inbred lines, two double crosses and four component single crosses. The eight lines tested were placed in the same rank when averages were obtained over all testers within a given type. The variance component estimates of the interactions involving acre yields of the inbred testers x lines, single cross testers x lines and double cross testers x lines

indicate that as the genetic variation within a tester parent increased, the line x tester interaction decreased. This relationship did not hold good in the case of moisture percentage. He concluded that when specific combining ability is of importance the best tester is the opposite single cross parent of the double cross or its component lines. The results indicate that the ranking of lines for general combining ability can be attained the most economically through the use of a tester having a broad gene base.

General and specific combining ability were defined by Sprague and Tatum (29). Variances for these characteristics were obtained from single-cross yield trials. They concluded that general combining ability was relatively more important than specific combining ability among untested lines. Specific combining ability was relatively more important than general combining ability among previously tested lines.

Materials and Methods

Twenty S_6 second cycle inbreds developed by inbreeding and selection in the double cross Ohio M 15 (Oh 51 x Oh 26) x (Ill.A x W 23) were each crossed to ten testers in 1954. Inbreeding and visual selection for desirable agronomic characteristics was started in 1948. None of the lines had been previously evaluated for combining ability. Since visual selection for combining ability for yield among and between inbreds has generally been ineffective (15), the 20 second cycle lines can be considered as a small random sample of the original population with respect to yielding ability.

Origin of the four parental inbreds is:

Oh 51-Early Clarage open pollinated variety
Oh 26-Early Clarage open pollinated variety
Ill.A-Funk Yellow Dent open pollinated variety
W 23-Golden Glow open pollinated variety.

The seven related testers were the four parental inbred lines, Oh 51, Oh 26, Ill.A, and W 23 and the two parental single cross hybrids: (Oh 51 x Oh 26) and (Ill.A x W23) and the parental double cross, Ohio M 15 (Oh 51 x Oh 26) x (Ill.A x W 23). The three unrelated testers were M14 (an inbred line), (M 14 x W F 9) and Ia. 4483 (M 14 x W F 9) x (B 8 x B 16). These 200 crosses were tested in 1955 at two locations (Ingham and Saginaw Counties) in a split plot design with testers as main plots and second cycle lines as sub-plots. Three replications were used at each location.

Seven of the second cycle lines, the four parental lines and the unrelated line M 14 were used to produce the 66 possible single cross combinations in 1954. These were tested in 1955 with two entries of Ohio M 15, Michigan 350, Michigan 480, Michigan 570 and single cross (M 14 x W F 9) in an 8 x 9 rectangular lattice design with three replications at two locations, Saginaw and Ingham Counties.

Each of the five tester inbreds, (Oh 51, Oh 26, Ill.A, W 23, and M 14) was crossed with the other nine testers making 35 crosses. These 35 crosses were tested with the three tester single crosses, (Oh 51 x Oh 26), (Ill.A x W23) and (M 14 x W F 9) and the two double cross testers Ia. 4483 and Ohio M 15. The experiment was planted at two locations (Ingham and Saginaw Counties) in a randomized design with three replications at each location.

Double-cross seed was produced in Florida during the winter of 1954-55. Twenty seven double crosses were made in which one of the four parental lines of Ohio M 15 was replaced with a second cycle line and four crosses with M 14. Forty three double crosses were made using only the second cycle lines. All were "guess" combinations since single-cross and test-cross data were not available for predicting the best double crosses that could be produced. These double crosses were tested in 1955 with three entries of Ohio M 15, Michigan 350, Michigan 430, Michigan 480 and Michigan 570 as standards. The experiment was planted at two locations (Ingham and Saginaw Counties) in a 9 x 9 triple lattice design with three replications.

The Ingham County location was planted on the May 7, 1955 at the Farm Crops Field Laboratory of Michigan State University and the Saginaw County location was planted on May 3, 1955 on the farm of Walter Reinbold near Reese, Michigan. Plots were 2 x 5 hills, thinned to three plants per hill.

The twenty second cycle inbreds, the four parental inbreds and the unrelated inbred M 14 were compared in a randomized block design with four replications in 1954 and in a simple lattice design with four replications in 1955. Plots were 15 feet long, thinned to 15 plants per plot.

Yield trials in 1955

There were five yield trials in 1955 at each of two locations, Ingham and Saginaw Counties.

1) Test crosses -200 test crosses (20 inbreds x 10 testers)
2) Single crosses - 66 single crosses plus 6 standard hybrids (72 entries)
3) Tester crosses - 35 test crosses plus 5 standards (40 entries)
4) Double crosses - 74 crosses plus 7 standards hybrids (81 entries)
5) Inbred lines - 25 inbreds.

Observations

Stand and missing-hill counts were made before harvest at both locations. Counts of stalk lodging (plants broken below the ear) were made. Root lodging counts were made for plants leaning at an angle of 30° or more from vertical.

The Ingham County experiments were harvested on October 3, and Saginaw County on October 23, 1955. Ten ears were taken at random from each plot for determination of moisture percentage in the ear at harvest. A one inch section was cut from the center of each ear with a special machine (3). The composite sample of 10 sections from each plot was weighed in grams, dried in an oven at about 160°F., re-weighed in grams, and moisture percentage calculated by weight loss.

Weight adjustments were made for missing hills but no adjustments were made for missing plants within a hill. Double cross predictions for yield, moisture content and stalk lodging were made from the single-cross data (14).

Weather conditions in 1955 were generally favorable for good corn production. Stalk lodging was relatively high while root lodging was comparatively low.

Correlation coefficients for all combination of testers were calculated for yield, percentage of moisture, stalk and root lodging to determine how closely the testers were evaluating the lines in a similar manner. All possible correlations among the 20 second cycle lines were calculated for average yield, percentage of moisture, and stalk lodging to determine the genetic similarity of the second cycle lines with the four parents and with each other. High correlation coefficients indicate a close genetic relationship and low correlation coefficients indicate greater genetic dissimilarity.

Experimental Results

Performance of 20 S_6 Second Cycle Lines

High performance of inbred lines provides an economic advantage in the ultimate production of hybrid corn seed. The results of the yield trials of twenty-five inbred lines (twenty second cycle S_6 lines, four parental inbreds and the unrelated inbred line, M 14), (Table 1) show that one second cycle line yielded significantly higher than the two highest yielding parental lines, W 23 and Oh 51, and the unrelated line M 14. Eleven second cycle lines were equal to W 23 and fourteen were equal to Oh 51 and M 14 in yield. Eight second cycle lines yielded lower than W 23 and five were lower than Oh 51 and M 14. The comparison of second cycle lines with the two lowest yielding parental lines (Oh 26 and Ill.A) indicate that nine second cycle lines yielded higher than Oh 26 and eight were better than Ill.A. None yielded lower than the two lowest yielding parental lines (Oh 26 and Ill.A). These results indicate that the chances of obtaining lines more vigorous than the high yielding parental lines were small, but the possibilities were relatively good for isolating lines equal to the high parents and more vigorous than the low yielding parents.

Moisture percentage in the ear (Table 1) at harvest showed that two second cycle lines were earlier and one later in maturity than the parental lines and unrelated line M 14.

Table No. 1

Yield, percentage of moisture, stalk and root lodging in the inbred lines

Av. for 1954 and 1955, two locations

Code No.	Pedigree	Yield in Bu. per Acre at 15.5% Moisture	Moisture in ear %	Stalk Lodging %	Root Lodging %
1.	397-1-1-1-1	64.1	25.3	3.5	1.2
2.	236-1-1-4-2	30.8	45.8	0.9	4.6
3.	376-2-1-4-2	46.1	31.7	11.8	12.2
4.	376-2-1-3-2	44.2	32.6	8.8	11.2
5.	376-2-1-4-1	49.7	29.9	13.5	14.8
6.	28-1-1-2-1	56.8	25.1	13.6	1.1
7.	82-1-1-5-1	39.8	27.8	4.3	1.1
8.	3-1-2-2-1	49.5	25.9	12.0	1.2
9.	342-2-1-7-1	39.3	37.1	1.3	1.8
10.	58-3-1-1-1	30.3	20.8	13.7	3.1
11.	50-1-1-3-1	44.4	28.1	0.6	-
12.	52-2-2-3-3	41.6	24.8	8.3	2.4
13.	319-1-1-1-1	51.6	23.0	8.4	1.7
14.	310-1-3-9	49.4	31.7	15.3	5.1
15.	310-1-2-2-3	38.7	24.1	32.5	0.6
16.	163-1-1-2-1	41.4	22.4	16.2	2.3
17.	346-1-3-2-1	51.9	24.6	4.2	-
18.	381-2-1-6-1	43.0	27.6	19.7	18.2
19.	105-1-1-1-2	53.4	25.7	7.1	-
20.	427-1-4-1-2	37.5	19.7	4.6	-
21.	Oh. 51	49.4	25.9	6.8	9.5
22.	Oh. 26	36.2	25.3	-	1.8
23.	Ill. A	37.5	38.2	10.6	2.3
24.	W 23	52.2	26.3	40.1	2.0
25.	M 14	49.3	30.6	1.8	3.0
	L. S. D.	9.6 bu.	4.2		

Among the parental lines, Ill.A was significantly later in maturity than the other parents. Eighteen second cycle lines were earlier in maturity than the late maturing Ill.A, while about one fourth were later than the other three parental lines. It may be concluded that it was possible to select lines earlier or later in maturity than the parents.

The tabulation of stalk lodging, (Table 1), shows that three inbreds were almost as resistant to lodging as Oh 26, the parental line with the best lodging resistance, and the unrelated line M 14. None lodged as badly as the parental line W 23. Again, the chances of improving lodging resistance of inferior parents were good.

Root lodging (Table 1) was greater for four second cycle lines than for the parental lines. A majority were better than the poorest parent (Oh 51). The root lodging in three of the parents and in thirteen second cycle lines was negligible. There were good possibilities for obtaining lines with better resistance to root lodging than the highly susceptible parent.

Combining Ability of Second Cycle Lines Compared With Parents

Performances of crosses among the testers are given in Table 2. Table 3 presents the performances of second cycle lines with each tester parent. The four parental lines, (Oh 26, Ill.A, Oh 51 and W 23) when crossed on inbred tester M 14 yielded 87.5, 87.6, 92.0 and 95.1 bushels per acre respectively. Five of the twenty second cycle lines crossed with

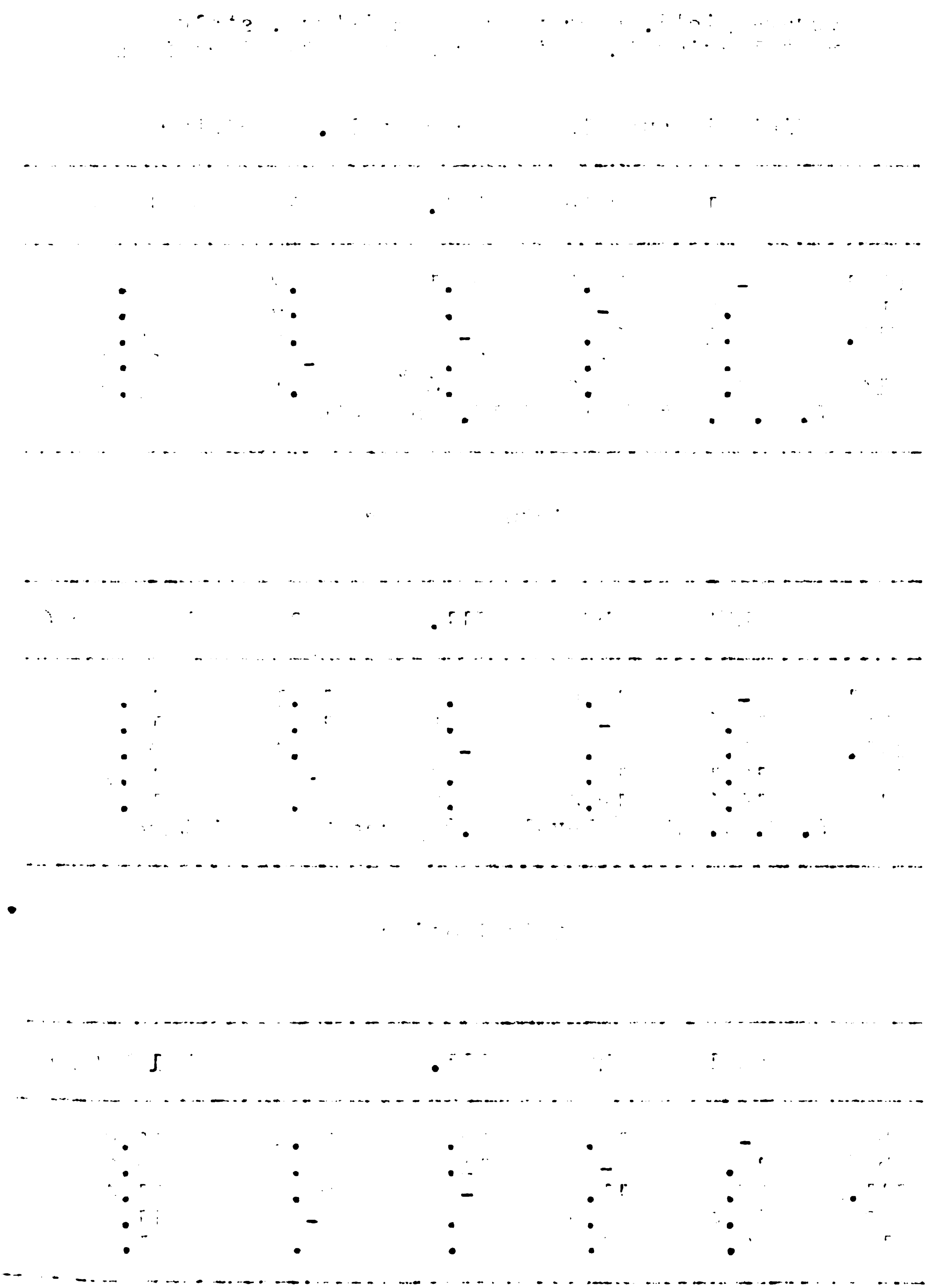

Table 2

Average yield, percentage of moisture, stalk and root lodging in tester crosses at two locations

Yield in bushels per acre at 15.5% moisture

	Oh51	Oh26	Ill.A	W23	Oh51 X Oh26
Oh51	-	72.6	93.1	84.7	50.4
Oh26	72.6	-	90.5	81.9	52.5
Ill.A	93.1	90.5	-	90.6	80.8
W23	84.7	81.9	90.6	-	90.2
M14	92.0	87.5	87.6	95.1	87.2

L. S. D. at 5% level 15.1 bushels

Moisture in ear
%

	Oh51	Oh26	Ill.A	W23	Oh51 X Oh26
Oh51	-	18.6	23.2	19.1	18.6
Oh26	18.6	-	23.5	18.2	15.2
Ill.A	23.2	23.5	-	23.4	26.0
W23	19.1	18.2	23.4	-	17.7
M14	19.6	19.4	27.9	22.5	17.3

L. S. D. at 5% level 3.7 percent of moisture

Stalk lodging
%

	Oh51	Oh26	Ill.A	W23	Oh51 X Oh26
Oh51	-	12.8	37.8	12.4	27.9
Oh26	12.8	-	11.4	8.9	6.7
Ill.A	37.8	11.4	-	24.6	31.4
W23	12.4	8.9	24.6	-	11.2
M14	2.5	4.0	21.6	5.5	1.3

Table 2 (Continued)

Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483	Average
87.2	78.2	92.0	93.3	90.6	82.5
76.6	71.5	87.5	97.2	83.9	79.4
64.7	87.3	87.6	105.8	97.8	88.7
68.7	76.0	95.1	100.6	92.0	86.6
84.3	87.1	-	68.3	76.0	85.0

Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483	Average
20.9	17.8	19.6	23.9	17.6	19.9
18.3	17.3	19.4	19.6	20.0	18.9
26.0	25.9	27.9	24.1	21.3	24.5
22.8	22.4	22.5	25.2	20.9	21.4
20.4	20.8	-	24.1	21.1	21.5

Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483	Average
36.6	10.5	2.5	8.1	16.1	18.3
31.7	30.9	4.0	2.4	4.7	12.6
42.9	15.2	21.6	8.0	8.5	22.4
21.5	24.3	5.5	7.5	22.7	15.4
8.6	9.7	-	6.5	7.6	7.5

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Table 2 (Continued)

Root lodging
%

	Oh51	Oh26	Ill.A	W23	Oh51 X Oh26
Oh51	-	4.6	0.6	0.6	12.1
Oh26	4.6	-	6.9	1.1	0.6
Ill.A	0.6	6.9	-	-	1.9
W23	0.6	1.1	-	-	-
M14	1.8	-	3.5	-	-

Table 2 (Continued)

Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483	Average
2.3	-	1.8	4.0	-	2.9
2.4	3.5	-	-	-	2.1
4.6	-	3.5	1.1	1.7	2.3
-	-	-	-	-	0.2
0.6	2.3	-	0.6	1.7	1.2

Table 3

Average yields of test crosses at two locations
(yield in bu. per acre at 15.5% moisture)

Second cycle lines	Oh51	Oh26	Ill.A	W23	Oh51 x Oh26
1	89.8	84.8	83.8	83.6	70.4
2	70.9	94.0	87.1	82.5	81.5
3	94.2	90.4	66.9	96.3	91.7
4	86.2	91.9	76.5	90.9	86.7
5	81.9	95.2	58.6	83.1	82.5
6	77.8	79.3	76.6	73.6	79.3
7	78.0	69.7	91.5	88.2	77.2
8	85.9	82.2	72.2	87.0	76.5
9	88.1	80.1	74.3	96.0	83.8
10	64.4	66.9	68.6	73.2	62.6
11	76.0	66.4	94.1	97.2	71.1
12	81.1	68.9	84.2	82.2	68.3
13	52.4	66.9	90.3	78.4	61.7
14	62.9	82.1	88.4	85.7	70.0
15	70.1	91.7	83.4	86.6	74.2
16	66.9	60.1	78.6	83.4	65.8
17	63.9	78.6	78.3	83.3	70.8
18	70.1	88.4	53.6	82.0	79.8
19	70.9	62.1	77.4	88.5	83.5
20	59.6	91.1	77.6	94.7	84.1
Av.	74.6	79.5	78.1	85.8	76.1

L. S. D. at 5%

Mean of testers 6.3 bu.
Mean of inbreds 4.7 bu.

Two inbred at the same level of tester 14.5 bu.
Two tester at the same level of inbred 14.9 bu.
To test diagonally 14.9 bu.

Table 3 (Continued)

Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483	Average
78.0	80.4	87.8	88.5	87.9	83.5
87.2	85.9	110.7	101.5	102.6	90.4
76.6	83.0	94.7	101.8	100.2	89.6
91.0	74.8	97.6	109.2	89.1	89.4
83.1	80.0	83.4	98.2	94.2	85.0
70.6	72.7	85.9	93.7	84.6	79.4
82.5	88.3	89.9	94.1	93.8	84.8
75.8	78.4	97.7	99.2	86.8	84.2
84.8	83.0	83.1	103.6	93.2	88.0
79.5	74.8	74.4	85.9	78.9	72.9
88.0	77.3	97.6	95.3	101.3	86.5
81.0	71.3	86.2	89.4	94.5	80.7
79.0	71.6	95.9	97.3	87.9	78.1
83.4	67.5	86.0	94.2	92.2	81.2
80.5	77.4	91.1	83.9	88.1	82.7
77.3	85.4	86.9	91.7	90.8	78.7
81.7	64.9	81.9	88.2	88.8	77.9
62.6	69.0	87.9	92.7	85.3	76.7
70.3	76.0	91.6	105.5	92.0	81.8
84.4	73.1	82.0	88.8	85.3	82.1
79.9	76.5	90.6	94.9	90.9	
				Average	82.7

M 14 yielded more than W 23 x M 14. Since these two tests were grown as separate tests but in the same field, there is no valid L.S.D. and only general comparisons can be made.

Crosses of second cycle lines with the parental testers showed the same general results. Crosses of Oh 26, Ill.A and Oh 51 with W 23 yielded 81.9, 90.6 and 84.7 bushels respectively. When the second cycle lines were crossed with W 23, five second cycle lines (Table 3) yielded higher than the best yielding parental line crossed with W 23.

A comparison of performances of second cycle lines and parental lines crossed on a related and unrelated double cross tester was made. Parental lines Oh 26, Ill.A, Oh 51 and W 23 crossed with Ia. 4483, the unrelated double cross tester, yielded 83.9, 97.8, 90.6 and 92.0 bushels, respectively. Three of the twenty second cycle lines crossed with Ia. 4483 yielded more than 97.8 bushels per acre.

Crosses of Oh 26, Ill.A, Oh 51 and W 23 with Ohio M 15, the parental double cross tester, yielded 71.5, 87.3, 78.2 and 76.0 bushels per acre, respectively. Results for second cycle lines crossed with this same tester show that one line yields higher than the maximum yielding test cross of parental lines crossed with Ohio M 15.

These results and similar results with other testers for second cycle lines compared with parental lines show that some second cycle lines were superior to the parental lines for yield in either specific or general combining ability.

Percentages of moisture for parental lines Oh 26, Ill.A, Oh 51 and W 23 (Table 2) crossed on M 14 were 19.4, 27.9, 19.6 and 22.5 respectively. Results for second cycle lines crossed on these inbred testers (Table 5) show that there were three crosses with a moisture content of 17.1 or 17.2% and the highest moisture content was 26.0%.

A comparison of the moisture percentage of test crosses (Table 5) with moisture percentage of tester crosses (Table 2) shows that the moisture percentage in some of the second cycle line crosses was lower than the lowest moisture percentage of the parental lines crossed with the same tester. Likewise, moisture contents for some second cycle test crosses were higher than that of the parental lines crossed with the same tester. Crosses with inbred 20 generally gave the lowest moisture percentage, while inbred 2 produced relatively late crosses.

Test cross results for stalk lodging (Table 7) and parental tester cross results (Table 2) indicate that there were no second cycle lines superior in stalk lodging resistance to the best parental line (Oh 26), although some of the second cycle lines were superior in stalk lodging resistance to the more lodging susceptible parental lines.

Tabulation of root lodging (Tables 8 and 2) was comparatively low in both second cycle line crosses and parental line crosses. In one parental line (Oh 51) root lodging was 2.9 percent and in second cycle line number 18 it was 6.8 percent.

These results indicate that through inbreeding and selection in a double cross hybrid, a few second cycle lines slightly superior in combining ability and either later or earlier in maturity than the parental lines can be obtained. No improvement in lodging resistance over one excellent parent was found. The results show that there was a good chance of improvement over highly susceptible parents.

Genetic Similarity of the Second Cycle Lines

Yields of the test crosses (Table 3) indicate that second cycle lines, when crossed with the parental lines, showed variations in yielding capacity. When crossed to certain parental lines, a second cycle line yielded as high as it did in crosses with the unrelated inbred M 14, but when crossed to another parent it yielded significantly lower. This was true for all second cycle lines with exception of inbreds 1, 2, 6, 9 and 10. None of the crosses of inbreds 1, 6, 9 and 10 with the parental line yielded higher or lower than with M 14. Inbred 2 yielded significantly lower in crosses with the parental lines than it did in crosses with M 14. These results indicated that except for inbred 2, all the second cycle lines were equal to the unrelated line M 14 in genetic diversity from some of the parental lines. The difference in performances of second cycle lines with parental inbreds as testers shows variation in their genetic relationship with the four parents.

Second cycle lines 3 and 4 were common in pedigree during the first three years of selfing and 3 and 5 were common for the first four years of selfing. The inbred yield trial (Table 1) indicates that the above three inbred lines were similar in yield, maturity, and stalk and root lodging. In general combining ability (Table 3), the three lines produced similar average yields. The 'r' values for yield (Table 4) between line 3 and 4, 3 and 5, and 4 and 5 were .659, .899 and .711 respectively. The higher 'r' value between 3 and 5 may be due to one more year of common pedigree for these lines. The three lines had similar maturity (Table 5). Stalk lodging percentages ranged from 21.2 to 27.3 which were comparatively similar. Also in root lodging, the three lines were similar (Table 8). The 'r' values for maturity and lodging were high in all cases between these three lines, again indicating genetic similarity.

There had been little genetic segregation among these three lines after they were separated with three or four years of inbreeding. This indicates that the lines had established their identity very early and, in a small way, confirm the validity of early testing of inbred lines as suggested by Jenkins (15) and Sprague (27).

Variation in genetic relationship of second cycle lines with the four parental inbreds was seen in comparisons of yields of their crosses with each of the four parents. All second cycle lines (Table 3) with the exception of 1, 6, 8 and

Table 4

Correlation coefficients for yield between second cycle lines in test crosses

Second cycle lines	1	2	3	4	5	6	7	8	9	10
1	-	.356	.372	.351	.244	.485	.343	+.652*	.281	.326
2	.356	-	.304	.545	.404	+.670*	.467	.593	.175	.594
3	.372	.304	-	+.659*	+.899**	+.639*	.066	+.792**	+.766**	.215
4	.351	.545	+.659*	-	+.711*	+.730*	.127	+.810**	+.685*	.533
5	.244	.404	+.899**	+.711*	-	.525	-.133	.611	+.660*	.418
6	.485	+.670*	+.639*	+.730*	.525	-	.360	+.780*	.495	.392
7	.343	.467	.066	.127	-.133	.360	-	.358	.398	+.691*
8	+.652*	.593	+.792**	+.810**	.611	+.780*	.358	-	+.682*	.041
9	.281	.175	+.766**	+.685*	+.660*	.495	.398	+.682*	-	.605
10	.326	.594	.215	.533	.418	.392	.691	.041	.605	-
11	.431	.521	.138	+.665*	-.054	.382	+.883**	.430	.419	+.660*
12	+.655*	.486	.272	.401	.107	.499	+.774*	.525	.501	+.635*
13	.340	+.808**	.016	.430	.020	.513	+.803**	.445	.246	+.774**
14	.345	+.726*	.114	.528	.210	.489	.572	.262	.333	+.658*
15	.363	+.788**	.169	.390	.293	.333	.308	.383	.044	.369
16	.356	.571	.219	.261	.101	.380	+.952**	+.711*	.513	+.824**
17	.303	+.712*	.283	+.639*	.383	.494	.493	.446	.463	+.674*
18	.285	.565	+.891**	+.688*	+.846**	+.70*	.006	+.781**	.594	.265
19	.246	.536	.562	.579	.291	+.723*	+.761*	+.689*	+.709*	.598
20	-.175	.479	.240	.486	.409	.199	.093	.193	.311	.366

r value to be significant at 5% 0.632 degree of freedom 8
r value to be significant at 1% 0.765 degree of freedom 8

Table 4 (Continued)

11	12	13	14	15	16	17	18	19	20
.431	+.655*	.340	.345	.363	.356	.303	.285	.246	-.175
.521	.486	+.808**	+.726*	+.788**	.571	+.712*	.565	.536	.479
.138	.272	.016	.114	.169	.219	.283	+.891**	.562	.240
.665	.401	.430	.528	.390	.261	+.639*	+.688*	.579	.486
-.054	.107	.020	.210	.293	.101	.383	+.846**	.291	.409
.382	.499	.513	.489	.333	.380	.494	+.70*	+.723*	.199
+.883**	+.774*	+.803**	.572	.308	+.952**	.493	.006	+.761*	.093
.430	.525	.445	.262	.383	+.711*	.446	+.781**	+.689*	.193
.419	.501	.246	.333	.044	.513	.463	.594	+.709*	.311
+.660*	+.635*	+.774**	+.658*	.369	+.824**	+.674*	.265	.598	.366
-	+.900**	+.831**	+.746*	.441	+.849**	+.724*	.076	+.701*	.277
+.900**	-	+.700*	+.676*	.323	+.736*	+.673*	.134	+.641*	.063
+.831**	+.700*	-	+.872**	+.651*	+.797**	+.787**	.195	.102	.329
+.746*	+.676*	+.872**	-	+.779**	.571	+.965**	.312	+.811**	+.690*
.441	.323	+.651*	+.779**	-	.317	+.756*	.484	.229	+.710*
+.849**	+.736*	+.797**	.571	.317	-	.541	.173	+.772**	.193
+.724*	+.673*	+.787**	+.965**	+.756*	.541	-	.442	.573	+.754*
.076	.134	.195	.312	.484	.173	.442	-	.518	.521
+.701*	+.641*	.102	+.811**	.229	+.772**	.573	.518	-	.335
.277	.063	.329	+.690*	+.710*	.193	+.754*	.521	.335	-

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10 yielded significantly higher with one or more parents than with the others. Differences in yield of second cycle lines crossed with the four parents may be interpreted to be due to the variation in the genetic relationship. For example (Table 3), inbred 20 crossed with the parental line Oh 51 yielded significantly lower than it did with the other three parents. This indicates close genetic similarity of inbred 20 with Oh 51 than with the other three parents. Inbred 18, when crossed with Ill.A, yielded significantly lower than it did in crosses with the other three parents, indicating that it was genetically more similar to Ill.A for yield factors. Close genetic relationship with one or more of the parents for yield did not generally show a similarly close relationship for other charqcteristics such as lodging resistance and maturity, indicating that genetic factors for these characteristics segregated and recombined.

These results suggest that second cycle lines, while segregating from the double cross, received varying proportions of genes from each inbred parent. This produced different degrees of genetic affinity, and was manifested by low yields in cases of genetic similarity and higher yields where genetic diversity from the parents was greater.

The correlations (Table 4) for yield among all possible comparisons of second cycle lines in test crosses were calculated to determine how closely they were genetically similar. Low coefficients of correlation indicate that there was a tendency

for the lines to be genetically different from each other. Some lines showed very little genetic relationship, the value of 'r' between line 1 and 20, 8 and 10, 5 and 13 were -.175, .041, and .020, respectively. There were a few of the second cycle lines with high genetic similarity, where 'r' values approached 1.0. For example, the correlations between 17 and 14, 7 and 16, 11 and 12 were .965, .952 and .900, respectively. However, the results indicate that the chances were greater for obtaining second cycle lines that were genetically different from each other than for obtaining lines genetically similar to each other.

Test cross results (Table 3) indicate that second cycle lines showed variation in average yielding ability when compared with the mean of the experiment (82.7 bushels). Comparing average yields of the lines in all test crosses with the experiment average of 82.7 bushels as a measure of general combining ability for yield showed that lines 2, 3, 4 and 9 were the best and lines 10, 17 and 18 were the poorest. Among the rest of the lines, none yielded lower or higher than the mean of the experiment.

Results for moisture percentage of test crosses (Table 5) indicate that inbred 20 was the earliest (15.7% moisture) and line 10 was the next earliest line. The latest maturing line was inbred 2 (26.3% moisture) and lines 3, 4 and 9 were nearly as late.

Table 5

Average percentage of moisture for test crosses at two locations (M.S.U. Farm and Saginaw County)

Second cycle lines	Oh51	Oh26	Ill.A	W23	Oh51 X Oh26
1	21.1	19.5	29.7	20.3	20.4
2	23.0	24.9	30.5	26.1	23.2
3	24.4	22.7	29.8	21.4	22.3
4	23.5	23.0	32.0	23.2	22.8
5	22.9	23.5	30.9	23.4	21.4
6	21.6	20.3	25.1	24.3	20.3
7	19.0	15.4	24.3	20.8	18.7
8	20.5	19.0	26.3	21.9	19.8
9	24.9	22.8	29.5	22.5	23.7
10	16.9	15.3	22.9	18.7	15.1
11	18.8	16.5	24.0	22.3	19.2
12	16.2	17.5	23.3	19.4	17.4
13	18.5	16.9	23.3	20.8	17.7
14	24.2	21.3	27.4	22.2	21.4
15	21.9	21.8	27.4	23.9	21.2
16	22.4	17.1	29.0	20.3	19.2
17	19.3	15.8	23.4	20.7	16.9
18	18.3	20.0	27.4	23.7	18.4
19	20.5	22.1	27.3	22.9	19.4
20	15.5	15.7	14.6	17.1	15.1
Av.	20.7	19.6	26.4	21.8	19.7

L. S. D. at 5%

Average of experiment 21.7

Testers 1.8

Second cycle line 2.4

Table 5 (Continued)

Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483	Average
22.9	21.4	22.4	19.7	21.1	21.8
28.5	27.7	26.0	26.4	20.4	26.3
24.3	25.0	21.1	25.3	22.3	23.9
26.2	24.1	21.5	23.1	24.1	24.4
25.1	22.4	21.9	22.9	21.5	23.6
23.0	23.5	23.9	24.0	21.7	22.8
21.8	20.2	18.4	21.3	17.9	19.8
21.5	19.5	19.1	22.8	26.5	21.7
26.0	23.8	23.8	27.2	23.8	24.8
19.4	17.2	17.1	18.4	19.3	18.0
20.1	24.4	21.0	20.6	19.4	20.6
20.8	19.0	18.5	20.0	18.5	19.0
22.2	17.9	17.2	22.1	19.4	19.6
25.8	23.1	24.3	23.3	21.8	23.5
25.1	25.4	20.9	23.9	23.6	23.5
21.0	22.1	20.2	22.4	20.2	21.3
19.9	20.8	18.3	20.3	19.7	19.5
24.6	20.6	22.7	20.1	21.5	21.7
23.5	24.1	22.8	21.9	22.4	22.7
15.2	15.9	17.1	17.0	14.3	15.7
22.8	21.9	20.9	22.1	21.3	

[illegible]

Most of the correlation coefficients for moisture percentage of test crosses of second cycle lines with different testers (Table 6) were significant indicating that, except for inbred 20 and 8, the second cycle lines were more genetically similar for maturity with each other than for yield. The low percentage of moisture for inbred 20 with different testers (Table 5) indicates its dominant effect for early maturity and it did not show relationship for maturity with the rest of the lines.

Second cycle lines showed variation among themselves for stalk lodging resistance (Table 7). Inbred 9 had the lowest lodging percentage, 13.6, and inbred 15 had the highest, 34.1. Inbreds 6, 14, and 15 were lowest in resistance to lodging while inbreds 9 and 11 had the best resistance. The rest of the lines were nearly alike in lodging resistance and ranged between 20.3 and 27.3%.

Correlations for stalk lodging among second cycle lines were significantly in most cases (Table 8). This indicates close genetic similarity of second cycle lines with each other for lodging resistance. Only one of the four parental inbreds, Oh 26, showed any appreciable degree of resistance to lodging and thus there was little opportunity to improve lodging resistance in the second cycle lines.

The percentages of root lodging were small (Table 9). The maximum lodging was 6.8 percent. In some cases it was nearly nil. Therefore no correlations were calculated.

Table 6

Correlation coefficients for the moisture percentage between second cycle lines in test crosses

Second cycle lines	1	2	3	4	5	6	7	8	9	10
1	-	.629	.754*	.907**	.884**	.563	.69*	.536	.760*	.794**
2	.629	-	.632*	.613	.736*	.713*	.743*	.735*	.584	.524
3	.754*	.632*	-	.866**	.828*	.457	.724*	.483	.892**	.669*
4	.907**	.613	.866**	-	.914**	.444	.745*	.659*	.787**	.832**
5	.884**	.736*	.828*	.914**	-	.521	.712*	.498	.775**	.780**
6	.563	.713*	.457	.444	.521	-	.789**	.371	.522	.730*
7	.69*	.743*	.724*	.745*	.712*	.789*	-	.500	.799**	.806**
8	.536	.735*	.483	.659*	.498	.371	.500	-	.567	.831**
9	.760*	.584	.892**	.787**	.775**	.522	.799**	.567	-	.736*
10	.794**	.524	.669*	.832**	.780**	.730*	.806**	.831**	.736*	-
11	.555	.645*	.479	.489	.424	.829**	.752*	.278	.379	.590
12	.781**	.790**	.702*	.827**	.813**	.757*	.839**	.600	.767**	.895**
13	.548	.553	.637*	.703*	.696*	.649*	.866**	.711*	.775**	.856**
14	.864**	.724*	.727*	.753*	.790**	.645*	.791**	.336	.832**	.735*
15	.665*	.694*	.791**	.832**	.754*	.648*	.770**	.628	.649*	.834**
16	.868**	.596	.901**	.837**	.799**	.681*	.860**	.594	.864**	.814**
17	.678**	.568	.712*	.713*	.644*	.834**	.905**	.663*	.666*	.744*
18	.799**	.695*	.414	.736*	.778**	.740*	.679*	.528	.510	.850**
19	.809**	.765**	.662	.794**	.820**	.738*	.645*	.499	.566	.812**
20	-.416	.184	-.378	-.559	-.318	.382	.044	.494	-.265	-.281

r value to be significant at 5% 0.632 degree of freedom 8
r value to be significant at 1% 0.765 degree of freedom 8

Table 6 (Continued)

11	12	13	14	15	16	17	18	19	20
.555	.781**	.548	.864**	.665*	.868**	.678**	.799**	.809**	-.416
.645*	.790**	.553	.724*	.694*	.596	.568	.695*	.765**	.184
.479	.702*	.637*	.727*	.791**	.901**	.712*	.414	.662*	-.378
.489	.827**	.703*	.753*	.832**	.837**	.713*	.736*	.794**	-.559
.424	.813**	.696*	.790**	.754*	.799**	.644*	.778**	.820**	-.318
.829**	.757*	.649*	.645*	.648*	.681*	.834**	.740*	.738*	.382
.752*	.839**	.866**	.791**	.770**	.860*	.905**	.679*	.645*	.044
.278	.600	.711*	.336	.628	.594	.663*	.528	.499	.494
.379	.767**	.775**	.832**	.649*	.864**	.666*	.510	.566	-.265
.590	.895**	.856**	.735*	.834**	.814**	.744*	.850**	.812**	-.281
-	.647*	.766**	.495	.710*	.695*	.826**	.573	.715*	.138
.647*	-	.833**	.703*	.856**	.727*	.766**	.882**	.864**	-.124
.766**	.833**	-	.637*	.769**	.684*	.775**	.678*	.563	-.116
.495	.703*	.637*	-	.628	.813**	.683*	.705*	.714*	-.163
.710*	.856**	.769**	.628	-	.751*	.870**	.719*	.840**	-.295
.695*	.727*	.684*	.813**	.751*	-	.874**	.589	.712*	-.245
.826**	.766**	.775**	.683*	.870**	.874**	-	.674*	.755*	-.096
.573	.882**	.678*	.705*	.719*	.589	.674*	-	.891**	-.109
.715*	.864**	.563	.714*	.840**	.712*	.755*	.891**	-	-.148
.138	-.124	-.116	-.163	-.295	-.245	-.096	-.109	-.148	-

* significant at 5% all values positive

** significant at 1% all values positive

Table No. 7

Average percentage stalk lodging for test crosses
at two locations
(M. S. U. Farm and Saginaw County)

Second cycle lines	Oh 51	Oh 26	Ill. A	W23	Oh 51 X Oh 26
1	27.3	11.8	31.0	40.2	29.9
2	27.3	13.7	40.7	52.0	29.1
3	24.1	9.1	87.5	22.7	17.9
4	30.5	11.6	64.0	40.2	9.0
5	40.6	4.7	60.5	27.0	7.7
6	30.9	14.1	74.1	47.6	19.6
7	37.1	6.5	52.4	43.2	14.4
8	27.6	7.6	40.6	35.2	24.9
9	10.6	2.5	38.3	18.6	7.4
10	16.9	13.3	67.0	40.3	15.5
11	25.2	7.1	41.5	21.0	15.0
12	28.5	19.8	55.2	20.0	28.9
13	24.4	8.8	51.2	34.1	22.5
14	47.4	6.6	60.7	49.7	35.0
15	42.2	7.9	69.3	49.2	22.8
16	28.3	9.5	40.7	27.7	24.9
17	18.9	3.6	45.5	28.9	12.9
18	24.4	13.5	66.6	62.7	33.1
19	42.8	7.3	22.9	48.3	21.5
20	31.4	16.6	32.5	28.4	22.4
Av.	29.3	9.8	52.1	36.9	20.7

Table No. 7 (Continued)

Ill. A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483	Av.
52.7	32.2	2.9	10.1	20.7	25.9
33.6	26.3	4.1	8.6	15.1	25.1
54.2	33.1	7.4	7.4	9.1	27.3
45.5	31.7	2.3	11.9	11.2	25.8
53.0	27.3	16.6	14.5	14.4	21.2
61.4	39.0	11.1	8.6	18.4	32.5
46.2	28.8	5.7	6.0	7.3	24.8
41.9	29.0	11.1	3.9	12.9	23.5
23.9	22.0	2.3	5.9	4.6	13.6
42.3	18.5	5.3	9.9	6.9	23.6
47.5	21.7	0.5	5.7	2.8	18.8
47.9	30.4	16.1	8.5	11.6	26.7
45.1	23.4	4.1	5.3	6.9	22.6
47.8	39.3	14.8	15.0	18.0	33.4
64.3	43.3	6.1	17.4	18.2	34.1
54.9	38.1	15.6	7.8	11.3	25.9
42.0	24.6	10.1	7.2	9.4	20.3
64.2	49.0	10.9	12.6	36.5	27.3
48.3	26.5	4.6	9.6	12.3	24.4
35.5	25.6	19.6	8.3	12.4	23.3
47.6	30.5	8.6	9.2	13.0	

[illegible]

Table 8

Correlation coefficients for stalk lodging between second cycle lines in test crosses

2nd cycle lines	1	2	3	4	5	6	7	8	9	10
1	-	.834**	.601	.726**	.673*	.789**	.814**	.787**	.682*	.657*
2	.834**	-	.620	.802**	.586	.810**	.867**	.770*	.737*	.797**
3	.601	.620	-	.915**	.894**	.933**	.834**	.712*	.954**	.920**
4	.726**	.802**	.915**	-	.908**	.973**	.956**	.765**	.957**	.942**
5	.673*	.586	.894**	.908**	-	.900**	.900**	.719*	.865**	.822**
6	.789**	.810**	.933**	.973**	.900**	-	.949**	.816**	.960**	.948**
7	.814**	.867**	.834**	.956**	.900**	.949**	-	.832**	.889**	.883**
8	.787**	.770*	.712*	.765**	.719*	.816**	.832**	-	.635*	.727*
9	.682*	.737*	.954**	.957**	.865**	.960**	.889**	.635*	-	.926**
10	.657*	.797**	.920**	.942**	.822**	.948**	.883**	.727*	.926**	-
11	.837**	.722*	.887**	.903**	.903**	.927**	.921**	.800**	.739*	.849**
12	.670*	.589	.941**	.824**	.838**	.770**	.810**	.742*	.858**	.830**
13	.839**	.860**	.906**	.938**	.861**	.969**	.953**	.841**	.917**	.938**
14	.801**	.878**	.800**	.885**	.838**	.889**	.955**	.835**	.859**	.819**
15	.846**	.823**	.883**	.967**	.917**	.967**	.974**	.825**	.935**	.887**
16	.861**	.672*	.803**	.727*	.828**	.874**	.859**	.816**	.822**	.723*
17	.793**	.767**	.923**	.945**	.920**	.984**	.940**	.820**	.950**	.921**
18	.875**	.866**	.776**	.859**	.713*	.920**	.852**	.795**	.872**	.842**
19	.882**	.810**	.422	.996**	.624	.660**	.825**	.718*	.530	.536
20	.604	.752*	.740*	.794**	.816**	.841**	.910**	.818**	.740*	.729*

* r value to be significant at 5% 0.632 degree of freedom 8

** r value to be significant at 1% 0.765 degree of freedom 8

Table 8 (Continued)

11	12	13	14	15	16	17	18	19	20
.837**	.670*	.839**	.801**	.846**	.861**	.793**	.875**	.882**	.604
.722*	.589	.860**	.878**	.823**	.672*	.767**	.866**	.810**	.752*
.887**	.941**	.906**	.800**	.883**	.803**	.923**	.776**	.422	.740*
.903**	.824**	.938**	.885**	.967**	.727*	.945**	.859**	.996**	.794**
.903**	.838**	.861**	.838**	.917**	.828**	.920**	.713*	.624	.816**
.927**	.770**	.969**	.889**	.967**	.874**	.984**	.920**	.660**	.841**
.921**	.810**	.953**	.955**	.974**	.859**	.940**	.852**	.825**	.910**
.800**	.742*	.841**	.835**	.825**	.816**	.820**	.795**	.718*	.818**
.739*	.858**	.917**	.859**	.935**	.822**	.950**	.872**	.530	.740*
.849**	.830**	.938**	.819**	.887**	.723*	.921**	.842**	.536	.729*
-	.924**	.955**	.865**	.949**	.936**	.936**	.801**	.738*	.883**
.924**	-	.905**	.785**	.838**	.882**	.877**	.696*	.489	.841**
.955**	.905**	-	.927**	.960**	.889**	.961**	.889**	.728*	.882**
.865**	.785**	.927**	-	.940**	.835**	.893**	.833**	.799**	.882**
.949**	.838**	.960**	.940**	-	.894**	.967**	.895**	.776**	.848**
.936**	.882**	.889**	.835**	.894**	-	.911**	.812**	.735*	.899**
.936**	.877**	.961**	.893**	.967**	.911**	-	.903**	.679*	.477
.801**	.696*	.889**	.833**	.895**	.812**	.903**	-	.688*	.716*
.738*	.489	.728*	.799**	.776**	.735*	.679*	.688*	-	.803**
.883**	.841**	.882**	.882**	.848**	.899**	.477	.716*	.803**	-

* significant at 5%   All values positive

** significant at 1%   All values positive

.825

Table 9

Average percentage of root lodging for test crosses at two locations
(M. S. U. Farm and Saginaw County)

Second cycle line	Oh 51	Oh 26	Ill. A	W23	Oh 51 X Oh 26
1	5.6	7.5	10.8	-	0.6
2	9.8	3.2	2.8	9.4	3.6
3	13.2	8.0	7.4	4.5	5.8
4	2.9	5.2	1.7	4.0	7.3
5	7.8	5.2	15.7	1.2	5.9
6	2.8	4.5	2.8	-	-
7	-	2.4	1.2	-	2.3
8	-	1.7	2.8	-	1.7
9	2.9	3.3	0.6	2.5	3.2
10	4.1	-	2.2	0.6	1.2
11	5.2	2.6	-	2.3	1.2
12	-	2.4	1.2	-	-
13	7.3	7.2	0.6	4.1	2.3
14	3.4	2.3	-	0.6	2.8
15	5.2	1.7	1.7	6.8	4.5
16	3.9	8.2	10.5	5.4	2.9
17	3.1	1.7	1.7	0.6	0.6
18	18.1	5.7	16.8	3.4	10.3
19	-	-	7.8	2.8	0.6
20	1.3	-	2.4	1.2	3.4
Av.	4.8	3.6	4.5	2.5	3.0

Table 9 (Continued)

Ill. A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483	Av.
1.7	0.6	1.2	-	-	2.8
6.3	2.3	-	2.3	0.6	4.0
3.4	6.5	2.9	4.6	1.2	5.8
2.2	10.1	2.2	-	4.5	4.0
3.0	2.3	2.9	1.7	5.0	5.1
1.8	0.6	2.2	1.2	0.6	1.7
0.6	0.6	-	-	0.6	0.8
0.6	1.2	-	0.6	-	0.8
-	-	1.1	0.6	-	1.4
-	1.2	-	-	-	0.9
-	4.2	-	1.1	1.7	1.8
1.8	-	2.8	-	-	0.8
0.6	-	5.2	-	5.1	3.2
1.7	4.9	1.2	0.6	4.0	2.1
4.0	5.4	3.3	5.8	0.6	3.9
0.6	2.8	1.7	10.6	3.8	5.0
-	0.6	4.6	-	0.6	1.4
0.6	3.4	-	2.8	7.2	6.8
-	-	-	-	-	1.1
-	-	-	-	1.8	1.0
1.4	2.3	1.5	1.5	1.9	

Performances of Single and Double Crosses of Second Cycle Lines

Single cross performance in all possible combinations, Table 10, indicates that a majority of the second cycle lines crossed with the parental lines yielded as high as the parental line crossed with the unrelated line M 14. Twenty-one single crosses out of 28 crosses of second cycle lines with parental lines, yielded as high as the average yield of two entries of Ohio M 15. These results suggest that a majority of the second cycle lines included in the single crosses were genetically different from the parents and might be used with the parental lines to produce good yielding hybrids.

The twenty-one single crosses (Table 10) among seven second cycle lines indicate that some of the lines were genetically different. The single cross 2 x 3 yielded 105.5 bushels per acre which was better than Ohio M 15 at the 10% level of significance. Fifteen of these single crosses yielded as high as Ohio M 15. This suggests that some second cycle lines were genetically different from the others and might be used in crosses among themselves to produce commercial hybrids.

Determination of the relative importance of general and specific combining ability in the single cross corn hybrids was made using the method given by Sprague and Tatum (29) with a correction in the formula (24). Estimates of general and specific combining ability obtained by the formulae are relative for the particular group of lines involved in the hybrids under test. For related lines (Table 11), the estimates for specific

[illegible]

Table 10

Yield, and percentages of moisture, stalk and root lodging in single crosses

		Yield in Bu/acre at 15.5% moisture			Moisture in ear %		
S.N.	Pedigree	M.S.U. Farm	Saginaw County	Av.	M.S.U. Farm	Saginaw County	Av.
1	Oh51 X Oh26	62.9	84.7	73.5	25.9	17.2	21.6
2	Oh51 X Ill.A	76.0	117.1	95.9	26.7	19.5	23.1
3	Oh51 X W23	84.4	103.8	92.8	20.2	18.9	19.6
4	Oh51 X M14	82.3	93.6	87.8	24.3	18.5	21.4
5	Oh51 X 1	69.6	85.7	77.4	21.2	19.0	20.1
6	Oh51 X 2	63.0	83.6	72.7	27.4	23.2	25.3
7	Oh51 X 3	70.6	84.2	77.8	27.1	19.0	23.1
8	Oh51 X 6	71.6	85.3	78.1	22.3	19.8	21.1
9	Oh51 X 9	73.7	84.5	86.3	30.3	20.3	25.3
10	Oh51 X 11	68.6	80.6	75.0	22.1	18.6	20.4
11	Oh51 X 14	54.6	84.6	68.7	25.1	19.4	22.3
12	Oh26 X Ill.A	77.6	97.9	87.5	29.1	19.4	24.3
13	Oh26 X W23	68.8	98.2	83.3	23.2	19.0	21.1
14	Oh26 X M14	88.9	94.2	91.1	26.8	17.2	22.0
15	Oh26 X 1	74.9	76.8	76.0	24.4	20.5	22.5
16	Oh26 X 2	67.8	67.0	67.1	28.8	22.0	25.4
17	Oh26 X 3	94.9	105.7	99.0	29.1	22.4	25.8
18	Oh26 X 6	75.9	82.4	80.3	23.1	18.8	21.0
19	Oh26 X 9	67.4	69.9	69.1	26.2	15.9	21.1
20	Oh26 X 11	90.2	100.0	96.2	23.4	20.3	21.9
21	Oh26 X 14	72.0	87.4	76.9	22.5	17.3	19.9
22	Ill.A X W23	69.0	95.9	82.7	27.5	22.2	24.9
23	Ill.A X M14	80.6	103.7	92.5	30.2	22.7	26.5
24	Ill.A X 1	82.5	106.1	89.6	27.4	20.6	24.0
25	Ill.A X 2	80.1	96.5	88.7	32.1	29.9	31.0
26	Ill.A X 3	87.1	87.8	78.3	27.2	25.7	26.0
27	Ill.A X 6	48.1	90.4	67.6	29.5	24.1	26.8
28	Ill.A X 9	70.3	95.7	82.9	35.4	23.5	29.0
29	Ill.A X 11	67.9	93.0	78.4	28.2	21.9	25.1
30	Ill.A X 14	51.4	119.5	84.3	28.6	24.5	26.6
31	W23 X M14	95.9	102.6	99.4	25.0	19.2	22.1
32	W23 X 1	80.5	106.7	90.6	21.9	20.0	21.0
33	W23 X 2	75.5	93.3	84.0	23.1	24.7	23.9
34	W23 X 3	80.0	104.8	92.0	27.5	22.9	25.2
35	W23 X 6	67.5	83.7	75.8	26.8	21.2	24.0
36	W23 X 9	93.1	102.1	97.7	28.3	21.2	24.8
37	W23 X 11	69.0	105.1	87.0	22.7	20.8	21.8
38	W23 X 14	61.9	82.7	72.0	24.1	25.3	24.7
39	M14 X 1	80.3	92.9	86.5	23.4	16.3	19.9

Table 10 (Continued)

Stalk lodging %			Root lodging %		
M.S.U. Farm	Saginaw County	Av.	M.S.U. Farm	Saginaw County	Av.
10.0	8.0	9.0	-	5.8	2.9
48.9	50.8	49.9	1.1	1.4	1.3
6.0	28.9	17.5	4.8	3.3	4.1
-	18.6	9.3	3.4	3.5	3.5
15.7	53.4	34.6	-	-	-
48.3	53.1	50.7	2.2	19.7	11.0
22.4	51.2	36.8	4.5	-	2.3
11.8	33.1	22.5	-	2.3	1.2
9.0	4.0	6.5	2.2	13.7	7.7
22.6	6.8	14.7	-	13.5	6.8
64.0	72.4	68.2	1.2	6.9	4.1
20.9	16.8	18.9	-	-	-
4.9	24.4	14.7	-	-	-
-	2.4	1.2	-	-	-
2.4	17.1	9.8	-	3.7	1.9
21.4	12.1	16.8	1.8	-	0.9
2.4	10.6	6.5	3.6	2.6	3.1
9.4	60.3	34.9	1.2	3.8	2.5
2.9	-	1.5	-	-	-
3.5	2.5	3.0	-	2.5	1.3
3.4	19.7	23.1	-	3.5	1.8
39.1	96.3	67.7	-	-	-
9.4	42.9	26.2	-	-	-
28.0	57.7	42.9	-	4.2	2.1
39.1	65.0	52.1	2.6	1.2	1.9
75.9	81.9	78.9	8.8	-	4.4
50.0	81.3	65.7	3.5	-	1.8
9.6	11.9	10.8	-	4.0	2.0
19.7	30.4	25.1	3.5	4.0	3.8
77.3	62.7	70.0	-	-	-
-	67.5	38.8	-	2.5	1.3
29.1	40.0	34.6	-	-	-
36.0	33.8	34.9	3.5	2.6	3.1
13.7	39.9	26.8	21.7	3.4	12.6
52.9	61.2	57.1	-	3.5	1.8
-	39.9	20.0	-	2.3	1.2
23.2	56.2	39.7	-	1.2	0.6
23.9	40.5	32.2	-	8.1	4.1
25.8	23.8	24.8	1.1	-	0.6

[illegible]

Table 10 (Continued)

S.N.	Pedigree	Yield in Bu/acre at 15.5% moisture: M.S.U. Farm	Saginaw County	Av.	Moisture in ear %: M.S.U. Farm	Saginaw County	Av.
40	M14 X 2	91.5	118.3	104.6	29.4	22.4	25.9
41	M14 X 3	87.9	100.0	92.3	26.4	18.0	22.2
42	M14 X 6	66.4	105.1	84.6	23.9	20.0	22.0
43	M14 X 9	90.4	105.9	97.9	29.1	19.8	24.5
44	M14 X 11	83.9	109.5	96.4	24.6	16.8	20.7
45	M14 X 14	79.1	116.0	96.9	25.2	20.3	22.8
46	1 X 2	83.6	103.9	92.9	27.5	21.6	24.6
47	1 X 3	66.3	74.3	70.0	23.3	19.8	21.6
48	1 X 6	79.0	77.8	77.1	24.7	20.8	22.8
49	1 X 9	89.0	111.4	102.6	27.8	18.5	23.2
50	1 X 11	79.5	94.1	89.7	23.3	18.8	21.1
51	1 X 14	67.4	92.6	82.6	27.1	22.0	24.6
52	2 X 3	94.6	110.6	105.5	29.8	24.4	27.1
53	2 X 6	84.9	87.2	88.6	31.6	27.6	29.6
54	2 X 9	32.9	73.7	51.5	32.8	28.5	30.7
55	2 X 11	47.1	77.0	65.3	33.7	25.3	29.5
56	2 X 14	77.0	107.3	93.4	28.1	24.5	26.3
57	3 X 6	85.8	100.8	94.0	27.1	20.7	23.9
58	3 X 9	102.4	94.4	99.0	30.1	21.9	26.0
59	3 X 11	85.3	110.0	96.9	26.7	20.5	23.6
60	3 X 14	86.2	90.0	87.7	27.0	21.8	24.4
61	6 X 9	82.7	65.1	74.7	29.4	23.9	26.7
62	6 X 11	79.8	85.9	83.1	25.9	20.8	23.4
63	6 X 14	60.3	79.8	68.7	27.1	21.5	24.3
64	9 X 11	87.5	78.0	83.5	29.8	23.2	26.5
65	9 X 14	83.1	101.2	94.2	28.1	23.3	25.7
66	11 X 14	81.0	80.8	79.6	26.4	20.4	23.4
67	Oh M15	82.3	93.5	88.2	21.8	19.2	20.5
68	Oh M15	78.2	102.8	92.5	22.3	19.4	20.9
69	WF9 X M14	79.4	108.0	93.5	28.2	21.4	24.8
70	Mich. 350	80.4	91.1	92.4	21.9	17.2	19.6
71	Mich. 480	107.7	95.1	100.8	22.8	22.2	22.5
72	Mich. 570	94.6	107.9	101.4	24.5	19.4	22.0
	L.S.D. 5%	22.3 bu	21.0 bu	15.2 bu	4.3	3.0	2.8

Table 10 (Continued)

Stalk lodging %			Root lodging %		
M.S.U. Farm	Saginaw County	Av.	M.S.U. Farm	Saginaw County	Av.
5.6	8.3	7.0	-	8.3	4.2
2.2	3.3	2.8	18.9	3.3	11.1
2.2	29.0	15.5	-	-	-
-	6.0	3.0	-	3.6	1.8
2.3	2.5	2.4	-	-	-
5.6	19.7	12.7	-	-	-
29.9	47.5	38.7	1.3	7.5	4.4
56.6	47.2	51.9	7.2	1.2	4.2
12.3	41.0	26.7	2.5	-	1.3
5.9	6.1	6.0	-	-	-
13.4	23.4	18.4	4.5	-	2.3
41.4	31.9	36.7	2.2	3.5	2.9
66.7	27.6	47.2	3.4	-	1.7
38.8	22.5	30.7	18.9	11.2	15.1
63.7	-	31.9	16.4	-	8.2
13.9	14.8	14.4	1.2	3.3	2.3
29.6	62.6	46.1	-	-	-
50.0	15.6	32.8	5.6	-	2.8
2.3	20.4	11.4	9.2	1.2	5.2
66.3	9.3	37.8	6.7	8.0	7.4
45.6	40.5	43.1	-	3.7	1.9
10.3	26.4	18.4	1.1	6.0	3.6
28.1	38.4	33.3	3.7	-	1.9
64.0	42.3	53.2	-	-	-
-	7.1	3.6	-	7.1	3.6
9.1	37.8	23.5	-	4.7	2.4
31.9	45.2	38.6	2.3	8.3	5.3
18.2	31.7	25.0	-	7.3	3.7
33.0	28.9	31.0	1.2	-	0.6
-	2.4	1.2	-	-	-
2.4	21.9	12.2	-	-	-
6.2	8.5	7.4	-	-	-
7.7	22.6	15.2	-	-	-

combining ability were higher than those for general combining ability in all cases. Some combinations did relatively better and other poorer than expected on the basis of general combining ability. The data for the single crosses (Table 11) indicate that the related lines produced high yields in certain combinations and low yields in others. This indicates that genes with dominance and epistatic effects were relatively more common than genes for additive effect.

The estimates for general combining ability for M 14 were higher than those for specific combining ability (Table 11). Large values for general combining ability may arise because a particular line does much better or much poorer than the remaining lines with which it is compared (29). The high value for general combining ability for M 14 was due to its high yield in most combinations in which it appeared. The average yield for this line was highest of the lines included.

Variance for general combining ability, σ^2G for inbred 6 was nearly equal to its variance for specific combining ability, σ^2S. The average yield of inbred 6 was the lowest of the inbreds compared. A high σ^2G value is obtained when a line does much better or poorer than the other lines with which it is compared (29). On the other hand, inbred 6 yielded as high as 93.5 bushels per acre in some crosses and as low as 71.8 bushels in others. This variation in yields is due to specific combining ability. The difference between minimum and maximum yield is not as high as it is for other related lines. Therefore the value of σ^2S is small in comparison to

Table 11

Average yields in bushels per acre for single crosses at two locations and estimates of general ($\sigma^2 y$) and specific ($\sigma^2 s$) combining ability

Inbred	Oh51	Oh26	Ill.A	W23	M14	1
Oh51	-	74.0	96.3	89.3	89.2	79.6
Oh26	74.0	-	89.5	83.0	92.4	75.5
Ill.A	96.3	89.5	-	81.7	90.3	93.0
W23	89.3	83.0	81.7	-	99.5	92.4
M14	89.2	92.4	90.3	99.5	-	85.1
1	79.6	75.5	93.0	92.4	85.1	-
2	73.3	69.4	88.9	87.4	104.1	92.0
3	76.4	98.0	81.9	94.2	94.7	66.0
6	77.0	75.7	71.8	74.5	82.6	79.0
9	81.0	67.7	81.1	94.1	95.4	101.4
11	74.4	91.2	79.8	86.1	85.8	85.3
14	71.8	77.0	86.9	73.2	94.0	80.9
General Combining Ability	21.1	5.9	-4.57	1.13	65.75	-5.86
Specific Combining Ability	44.01	57.24	55.98	34.74	28.35	113.22

Table 11 (Continued)

2	3	6	9	11	14	Total	Av.
73.3	76.4	77.0	81.0	74.4	71.8		80.2
69.4	98.0	75.7	67.7	91.2	77.0		81.2
88.9	81.9	71.8	81.1	79.8	86.9		85.6
87.4	94.2	74.5	94.1	86.1	73.2		86.9
104.1	94.7	82.6	95.4	85.8	94.0		92.1
92.0	66.0	79.0	101.4	85.3	80.9		84.6
-	102.3	88.5	50.4	65.1	96.6		83.5
102.3	-	93.5	98.3	98.3	87.4		90.1
88.5	93.5	-	72.7	80.9	74.1		79.1
50.4	98.3	72.7	-	83.5	93.0		83.5
65.1	98.3	80.9	83.5	-	80.1		82.8
96.6	87.4	74.1	93.0	80.1	-		83.2

1.05	33.13	27.33	-5.31	-3.08	-4.48
211.23	120.51	32.94	180.36	53.64	55.35

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rest of the related lines.

σ^2S was high for inbred 2 because it yielded high in some combinations and low in others. The minimum and maximum yields for this line were 50.4 and 104.1 bushels per acre, respectively, which were the minimum and maximum yields for the experiment. This high variation in yields accounts for the high σ^2S for this line. The high σ^2S for lines 1, 3, and 9 were also due to a wide range in yields for these lines in single crosses. These results suggest that specific combining ability was more important than the general combining ability in influencing the yields of related lines.

In maturity, six single crosses out of twenty-one crosses among the seven second cycle lines (Table 10) were equal to the average of two entries of Ohio M 15. Ten were equal to the early parental single cross (Oh 51 x Oh 26). Sixteen single crosses among second cycle lines, were similar to the late maturing single cross parent (Ill.A x W 23), and three crosses were significantly later, and two were earlier. None of the single crosses among second cycle lines was earlier in maturity than Ohio M 15 or the early maturing single cross parent, Oh 51 x Oh 26. Most of the single crosses among second cycle lines were similar in maturity to the late single cross Ill.A x W 23.

While there is no critical evidence for it, a general trend toward late maturity in the single crosses of second cycle lines could be expected due to closer genetic similarity between two second cycle lines than between two unrelated lines

combined in a single cross. Pressure of inbreeding would be comparatively higher in single crosses of second cycle lines than in crosses of two unrelated inbreds. Since one of the effects of inbreeding is to delay maturity, the single crosses of second cycle lines with relatively higher pressure of inbreeding might be expected to be generally later in maturity.

Single crosses among the seven second cycle lines were generally more resistant to stalk lodging (Table 10) than the lodging susceptible parental single cross, Ill.A x W 23. Only four crosses were as resistant as the lodging resistant parental single cross, Oh 51 x Oh 26. One of the single crosses of second cycle lines (9 x 11) was better than Oh 51 x Oh 26 in lodging resistance.

Root lodging (Table 10) was not high in any of the single crosses, although the cross 2 x 6 had 15.1% root lodging. Nearly 50% of the single crosses among second cycle lines were as resistant to root lodging as the two parental single crosses.

Some of the single crosses of the second cycle lines were used to make double cross hybrids. These double crosses were "guess" combinations made up before any test cross or single cross data were available for prediction. Out of 43 double crosses (Table 12) using only second cycle lines, there were only three double crosses that were significantly below the average of 90.6 bushels for the three entries of Ohio M 15. Five double crosses showed small but not significant increases in yield compared to Ohio M 15. The best double cross, No. 68 (1 x 9)(3 x 14) averaged 96.0 bushels compared to 90.6 average for Ohio M 15.

Table 12

Mean yield and percentages of moisture, stalk and root lodging for double-cross hybrids

S.N.	Pedigree	Yield in Bu/acre at 15.5% moisture: M.S.U. Farm	Saginaw County	Av.
1	(Oh51 X Oh26)(Ill.A X W23)	83.5	95.2	89.4
2	(Oh51 X Oh26)(Ill.A X M14)	87.6	81.7	84.7
3	(Oh51 X Oh26)(Ill.A X 1)	80.7	88.7	84.7
4	(Oh51 X Oh26)(Ill.A X 2)	76.4	85.2	80.8
5	(Oh51 X Oh26)(Ill.A X 3)	80.7	104.0	92.4
6	(Oh51 X Oh26)(Ill.A X 6)	73.6	86.7	80.2
7	(Oh51 X Oh26)(Ill.A X 9)	71.0	81.5	76.3
8	(Oh51 X Oh26)(Ill.A X 11)	71.0	93.5	82.3
9	(Oh51 X Oh26)(Ill.A X 14)	74.5	81.5	78.0
10	(Oh51 X Oh26)(W23 X M14)	70.4	83.2	76.8
11	(Oh51 X Oh26)(W23 X 1)	78.4	83.9	81.2
12	(Oh51 X Oh26)(W23 X 2)	81.9	82.9	82.4
13	(Oh51 X Oh26)(W23 X 3)	87.9	92.0	90.0
14	(Oh51 X Oh26)(W23 X 6)	74.0	89.4	81.7
15	(Oh51 X Oh26)(W23 X 9)	77.2	85.1	81.2
16	(Oh51 X Oh26)(W23 X 11)	68.5	82.4	75.5
17	(Oh51 X Oh26)(W23 X 14)	72.3	82.3	77.3
18	(Oh51 X M14)(Ill.A X W23)	83.5	96.9	90.2
19	(Oh51 X 1)(Ill.A X W23)	83.7	79.3	81.5
20	(Oh51 X 2)(Ill.A X W23)	73.2	80.4	76.8
21	(Oh51 X 3)(Ill.A X W23)	64.6	88.4	76.5
22	(Oh51 X 9)(Ill.A X W23)	69.4	90.3	79.9
23	(Oh51 X 11)(Ill.A X W23)	81.9	77.6	79.8
24	(Oh51 X 14)(Ill.A X W23)	77.7	85.2	81.5
25	(Oh26 X M14)(Ill.A X W23)	92.1	85.8	89.0
26	(Oh26 X 1)(Ill.A X W23)	78.3	81.6	80.0
27	(Oh26 X 2)(Ill.A X W23)	73.1	95.3	84.2
28	(Oh26 X 3)(Ill.A X W23)	89.4	96.9	93.2
29	(Oh26 X 6)(Ill.A X W23)	78.8	85.2	82.0
30	(Oh26 X 9)(Ill.A X W23)	83.8	93.5	88.7
31	(Oh26 X 11)(Ill.A X W23)	96.4	93.6	95.0
32	(Oh26 X 14)(Ill.A X W23)	83.5	87.4	85.5
33	(1 X 2)(3 X 6)	83.8	87.7	85.8
34	(1 X 2)(3 X 9)	78.3	92.6	85.5
35	(1 X 2)(3 X 11)	76.0	95.5	85.8
36	(1 X 2)(3 X 14)	73.8	94.2	84.0
37	(1 X 2)(6 X 9)	77.4	91.9	84.7
38	(1 X 2)(6 X 11)	68.2	89.5	78.9
39	(1 X 2)(6 X 14)	81.8	78.2	80.0

Table 12 (Continued)

Moisture in ear %			Stalk lodging %			Root lodging %		
M.S.U. Farm	Saginaw County	Av.	M.S.U. Farm	Saginaw County	Av.	M.S.U. Farm	Saginaw County	Av.
26.5	18.7	22.6	22.1	52.2	37.2	-	1.2	0.6
27.6	18.2	22.9	13.4	26.2	19.8	2.4	8.3	5.4
26.9	17.3	22.1	14.6	27.1	20.9	-	7.4	3.7
28.1	18.7	23.4	23.9	39.6	31.8	5.0	3.6	4.3
29.9	20.6	25.3	24.3	28.1	26.2	5.1	4.9	5.0
29.6	20.9	25.3	25.2	51.1	38.2	2.5	-	1.3
32.1	19.0	25.6	13.0	36.9	25.0	7.8	4.9	6.4
28.2	18.4	23.3	17.4	27.1	22.3	8.1	4.9	6.5
29.3	19.0	24.2	22.0	46.0	34.0	-	8.0	4.0
27.6	19.3	23.5	6.2	12.5	9.4	-	-	-
24.5	18.0	21.3	34.2	45.5	39.9	3.4	6.5	5.0
27.4	19.6	23.5	15.1	40.2	27.7	1.3	6.9	4.1
25.3	17.4	21.4	8.3	42.9	25.6	1.2	7.0	4.1
25.2	19.1	22.2	28.1	53.5	40.8	-	3.5	1.8
30.5	16.9	23.7	8.3	34.8	21.6	-	7.0	3.5
23.9	18.2	21.2	17.4	31.3	24.4	-	-	-
26.3	18.3	22.3	9.8	38.8	24.3	1.2	6.8	4.0
29.5	18.9	24.2	21.2	63.4	42.3	-	-	-
26.9	18.6	22.8	17.8	70.6	44.0	-	1.2	0.6
30.0	21.4	25.7	38.0	72.4	55.2	12.6	5.8	9.2
30.6	21.7	26.2	24.6	59.5	42.0	13.5	-	6.8
26.2	21.2	23.7	27.0	51.9	39.5	-	5.3	2.7
26.9	20.3	23.6	23.0	47.1	35.1	6.4	-	3.2
30.6	21.7	26.2	47.2	76.7	62.0	3.5	9.3	6.4
27.3	20.0	23.7	20.9	48.3	34.6	1.5	-	0.8
28.0	18.9	23.5	17.2	49.9	33.6	2.5	-	1.3
27.3	20.8	24.1	33.0	38.1	35.6	2.6	2.4	2.5
29.4	20.0	24.7	14.3	42.2	28.3	-	-	-
29.6	21.7	25.7	14.3	37.8	26.1	6.0	1.2	3.6
29.3	19.0	24.2	3.8	50.6	27.2	1.2	-	0.6
28.5	20.0	24.3	12.3	65.2	38.8	2.2	4.5	3.4
29.5	19.7	24.6	13.1	60.0	36.6	1.2	-	0.6
29.3	21.8	25.6	32.9	78.3	55.6	-	3.6	1.8
39.6	24.5	32.1	18.5	44.3	31.4	1.3	8.6	5.0
30.0	22.7	26.4	18.2	54.3	36.3	9.1	4.9	7.0
33.0	22.2	26.6	30.7	39.0	34.9	1.3	3.9	2.6
34.1	23.6	28.9	19.8	34.0	26.9	18.5	2.5	10.5
30.4	23.5	27.0	35.0	46.6	40.8	5.0	-	2.5
30.9	25.3	28.1	31.7	53.2	42.5	6.1	3.8	5.0

Table 12 (Continued)

S.N.	Pedigree	Yield in Bu/acre at 15.5% moisture M.S.U. Farm	Saginaw County	Av.
40	(1 X 2)(9 X 11)	82.8	91.3	87.1
41	(1 X 2)(9 X 14)	95.6	85.0	90.3
42	(1 X 2)(11 X 14)	70.3	81.1	75.7
43	(1 X 3)(6 X 9)	81.7	83.2	82.5
44	(1 X 3)(6 X 11)	78.3	92.7	85.5
45	(1 X 3)(6 X 14)	72.3	89.6	81.0
46	(1 X 3)(9 X 11)	84.1	87.3	85.7
47	(1 X 3)(9 X 14)	80.2	91.3	85.8
48	(1 X 3)(11 X 14)	81.8	101.7	91.8
49	(1 X 6)(9 X 11)	77.9	100.8	89.4
50	(1 X 6)(9 X 14)	70.2	82.0	76.1
51	(1 X 6)(11 X 14)	74.5	85.8	80.2
52	(1 X 9)(11 X 14)	68.8	86.8	77.8
53	(2 X 3)(6 X 9)	75.8	88.2	82.0
54	(2 X 3)(6 X 11)	83.8	86.9	85.4
55	(2 X 3)(6 X 14)	88.8	82.4	85.6
56	(2 X 3)(9 X 11)	89.1	98.6	93.9
57	(2 X 3)(9 X 14)	76.8	97.6	87.2
58	(2 X 3)(11 X 14)	81.7	101.9	91.8
59	(2 X 6)(9 X 11)	90.0	91.0	90.5
60	(2 X 6)(9 X 14)	76.2	94.7	85.5
61	(2 X 6)(11 X 14)	78.5	98.0	88.3
62	(2 X 9)(11 X 14)	73.3	91.9	82.6
63	(3 X 6)(9 X 11)	87.2	81.0	84.1
64	(3 X 6)(11 X 14)	73.4	89.7	81.6
65	(3 X 9)(11 X 14)	79.7	86.3	83.0
66	(6 X 9)(11 X 14)	80.3	94.4	87.4
67	(1 X 9)(3 X 11)	90.1	87.7	88.9
68	(1 X 9)(3 X 14)	91.0	100.9	96.0
69	(1 X 9)(3 X 6)	83.8	97.9	90.9
70	(1 X 9)(6 X 11)	89.2	78.7	84.0
71	(2 X 9)(6 X 14)	70.2	82.9	76.6
72	(1 X 6)(3 X 11)	82.7	84.6	83.7
73	(1 X 6)(3 X 14)	68.5	91.4	80.0
74	(2 X 6)(3 X 11)	87.7	83.6	85.7
75	(2 X 6)(3 X 14)	80.7	92.0	86.4
76	Oh M15	86.6	93.8	90.2
77	Michigan 350	84.4	88.6	86.5
78	Michigan 480	93.7	109.0	101.4

Table 12 (Continued)

Moisture in ear %			Stalk lodging %			Root lodging %		
M.S.U. Farm	Saginaw County	Av.	M.S.U. Farm	Saginaw County	Av.	M.S.U. Farm	Saginaw County	Av.
32.4	23.0	27.7	17.5	29.3	23.4	10.0	4.9	7.5
33.8	22.5	28.2	23.2	40.6	31.9	3.7	3.7	3.7
33.2	18.8	26.0	39.4	43.9	41.7	4.9	-	2.5
31.9	22.4	27.2	12.0	30.0	21.0	8.4	5.3	6.9
28.5	18.5	23.5	22.8	42.8	32.8	1.1	3.8	2.5
30.3	19.5	24.9	29.5	63.1	46.3	2.5	6.0	4.3
30.9	20.4	25.7	10.4	41.6	26.0	3.4	-	1.7
32.7	20.9	26.8	21.6	41.3	31.5	13.2	2.4	7.8
28.0	18.8	23.4	39.6	21.6	30.6	-	-	-
29.4	21.5	25.5	13.5	16.0	14.8	-	3.7	1.9
32.8	22.9	27.9	35.3	42.2	38.8	1.3	2.6	2.0
25.3	18.7	22.0	23.0	46.4	34.7	1.3	1.2	1.3
29.8	20.8	25.3	26.5	17.1	21.8	2.5	2.4	2.5
33.7	27.1	30.4	15.9	29.0	22.5	17.1	-	8.5
30.7	23.6	27.4	22.0	50.0	36.0	6.1	-	3.1
31.6	24.2	27.9	31.2	53.9	42.6	11.2	-	5.6
33.8	22.7	28.3	22.1	31.2	26.7	2.5	6.0	4.3
33.7	24.9	29.3	26.5	55.3	40.9	12.6	2.4	7.5
31.5	21.2	26.4	27.1	38.0	32.6	7.1	13.8	10.5
31.1	21.1	26.1	19.8	44.4	32.1	13.2	-	6.6
35.1	24.3	29.7	13.2	72.8	43.0	9.6	-	4.8
27.2	22.2	24.7	20.9	72.7	46.8	6.2	2.3	8.5
33.0	24.1	28.6	19.7	44.1	31.9	18.4	11.3	14.9
30.7	22.0	26.4	11.5	47.2	29.4	1.3	2.2	2.3
33.4	22.2	27.8	32.8	40.3	36.6	-	-	-
32.7	21.3	27.0	15.9	34.8	25.4	9.8	9.3	9.6
32.2	23.6	27.9	14.3	60.2	37.3	6.0	9.1	7.6
32.7	21.2	27.0	13.4	35.6	24.5	-	-	-
31.6	22.4	27.0	21.2	29.0	25.1	1.2	2.5	1.9
29.3	21.8	25.6	15.9	56.1	36.0	8.5	3.4	6.0
30.0	20.5	25.3	9.0	36.6	22.8	5.1	2.4	3.8
34.8	27.0	30.9	21.3	59.8	40.6	30.6	10.4	15.5
26.2	20.5	23.4	17.5	43.3	30.4	-	5.7	2.9
29.5	21.3	25.4	13.2	52.4	32.8	9.6	-	4.8
30.7	23.2	27.0	16.5	36.9	26.7	23.6	-	11.8
33.2	23.5	28.4	58.1	67.4	62.8	14.8	11.6	13.2
28.4	17.6	23.0	13.8	35.7	24.8	3.4	9.5	6.5
22.4	16.1	19.3	10.7	18.9	14.8	1.2	-	0.6
27.0	17.3	22.2	14.6	20.7	17.7	3.7	-	1.9

Table 12 (Continued)

S.N.	Pedigree	Yield in Bu/acre at 15.5% moisture M.S.U. Farm	Saginaw County	Av.
79	Oh M15	82.4	102.0	92.2
80	Michigan 430	93.2	89.5	91.4
81	Michigan 570	80.5	110.3	95.4
	L.S.D. at 5%	17.7	18.8	13.0

(a) Correlation coeficient between actual yield and predicted yield of double crosses r = .400*

(b) Correlation coeficient between actual moisture percentage and predicted moisture percentage r = .826**

(c) Correlation coeficient between actual percentage of stalk lodging and predicted percentages r = .628**

Table 12 (Continued)

Moisture in ear %			Stalk lodging %			Root lodging %		
M.S.U. Farm	Saginaw County	Av.	M.S.U. Farm	Saginaw County	Av.	M.S.U. Farm	Saginaw County	Av.
25.3	16.4	20.9	15.9	36.0	26.0	-	3.6	1.8
29.6	17.2	23.4	7.5	14.8	11.2	-	2.3	1.2
27.6	18.8	23.2	25.3	22.7	24.0	-	1.3	0.7
4.0	3.4	2.5						

In 27 double crosses (Table 12), where second cycle lines were substituted for one of the parents Ohio M 15, five double crosses were lower than Ohio M 15 (90.6 average of three entries) and none was better while the remainder yielded as well as Ohio M 15.

The perdentage of moisture (Table 12) indicates that five double crosses of second cycle lines were as early in maturity as the three entries of Ohio M 15 which averaged 22.2% moisture. Thirty-eight double crosses among second cycle lines were later in maturity and none were earlier than Ohio M 15. The early maturing lines from the test cross trials were not included in the single or double crosses.

The percentage of the stalk lodging in one of the better yielding double crosses of second cycle lines, No. 49 (1 x 6) x (9 x 11) was 14.8% compared to the average of 29.3% for Ohio M 15. Several other double crosses were as resistant to stalk lodging as Ohio M 15.

Average root lodging for three entries of Ohio M 15 was 3%. Nineteen double crosses of second cycle lines compared favorably with Ohio M 15 in root lodging resistance.

These results, with "guess" crosses, indicate that a slightly better yielding double cross might be produced by crossing the best second cycle lines among themselves or by substituting in the pedigree of the parental double-cross hybrid.

The predicted yields, moisture percentages, and stalk lodging percentages for the best 44 double crosses (Table 13) predicted from the single cross data show that some high

Table 13

Predicted yield, moisture percentage and stalk lodging for 44 best yielding double-crosses predicted from single-cross data

S.N.	Pedigree	Yield in Bu/acre at 15.5% moisture	Moisture in ear %	Stalk lodging %
1	(M14 X 3)(2 X 9)	100.0	25.9	17.2
2	(W23 X 2)(M14 X 3)	99.8	25.1	28.7
3	(Oh26 X 2)(M14 X 3)	99.5	23.7	17.0
4	(M14 X 1)(2 X 9)	98.5	24.6	13.7
5	(1 X 3)(2 X 9)	98.5	25.3	25.8
6	(M14 X 3)(2 X 11)	98.0	24.3	23.6
7	(M14 X 3)(2 X 14)	97.6	25.1	27.5
8	(2 X 9)(3 X 14)	97.6	26.3	32.1
9	(M14 X 2)(3 X 14)	97.5	24.6	27.2
10	(M14 X 14)(2 X 9)	97.5	25.6	19.9
11	(W23 X 9)(M14 X 1)	97.2	22.8	19.4
12	(W23 X 3)(M14 X 9)	97.0	23.8	17.0
13	(W23 X 2)(M14 X 1)	96.8	23.4	28.5
14	(W23 X 2)(M14 X 3)	96.4	24.5	18.8
15	(Oh26 X 14)(3 X 9)	96.4	24.3	31.6
16	(W23 X 14)(M14 X 9)	96.3	23.9	22.5
17	(W23 X 9)(1 X 3)	96.3	23.9	19.7
18	(Oh26 X 9)(M14 X 3)	96.1	23.1	7.0
19	(M14 X 3)(2 X 6)	96.0	24.7	25.7
20	(1 X 14)(2 X 9)	96.0	25.0	28.6
21	(M14 X 9)(3 X 14)	95.9	24.2	12.6
22	(Oh26 X W23)(M14 X 3)	95.9	22.3	18.6
23	(W23 X 3)(M14 X 2)	95.9	23.8	29.7
24	(M14 X 14)(2 X 3)	95.8	24.7	24.8
25	(Oh26 X 2)(Ill.A X 3)	95.8	25.6	32.7
26	(M14 X 6)(2 X 3)	95.7	25.4	18.3
27	(W23 X M14)(2 X 9)	95.6	24.8	16.2
28	(W23 X M14)(3 X 9)	95.6	24.2	13.2
29	(1 X 3)(9 X 11)	95.6	23.5	18.4
30	(W23 X 3)(2 X 9)	95.6	25.5	28.4
31	(W23 X 2)(1 X 3)	95.4	24.5	36.8
32	(W23 X 1)(M14 X 9)	95.4	22.6	21.2
33	(M14 X 9)(1 X 3)	95.1	22.9	11.3
34	(Ill.A X 9)(M14 X 1)	95.0	24.6	19.6
35	(W23 X M14)(2 X 3)	95.0	24.3	17.9
36	(Ill.A X 2)(M14 X 1)	94.6	25.3	28.7

[illegible]

Table 13 (Continued)

S.N.	Pedigree	Yield in Bu/acre at 15.5% moisture	Moisture in ear %	Stalk lodging %
37	(M14 X 3)(9 X 11)	94.6	23.7	13.7
38	(1 X 3)(2 X 11)	94.6	24.1	35.5
39	(W23 X 2)(M14 X 6)	94.6	25.6	25.5
40	(Oh51 X 2)(Ill.A X M14)	94.5	25.4	29.6
41	(Oh51 X M14)(Ill.A X W23)	94.4	22.8	31.9
42	(W23 X 11)(M14 X 3)	94.4	22.9	25.2
43	(Ill.A X 3)(M14 X 2)	94.4	26.7	32.1
44	(Oh26 X 3)(M14 X 11)	94.4	22.4	11.2
45	Ohio M15	90.9	22.0	25.3

yielding double crosses may be produced from some of the second cycle lines. It is evident from the results that most of the high yielding double crosses have two or three second cycle lines as their parents. The predicted yield for Ohio M 15 is the lowest of the double crosses listed in the Table 13. Some of the predicted double crosses, where a second cycle line was one of the parents, were as early in maturity as Ohio M 15. However, none of the double crosses were earlier in maturity than Ohio M 15. The percentages of stalk lodging indicates that some of the predicted double crosses of second cycle lines were better in lodging resistance than Ohio M 15.

Correlations were calculated for the actual yield, moisture percentage, and stalk lodging of the double crosses (Table 12) with the predicted yield, moisture percentage, and stalk lodging. In all cases the correlation coefficients were significant indicating that the predicted data of the double crosses gave a good indication of the actual performance of the double crosses.

Evaluation of Second Cycle Lines By Different Types of Related and Unrelated Testers

A comparison of different types (inbred, single cross, or double-cross) of related and unrelated tester parents to detect inherent differences in combining ability of 20 second cycle lines was made. The two groups of testers, related and unrelated, differed in vigor as expressed by mean yields

in bushels per acre (Table 3). The mean yields of each of the three unrelated tester types was higher than the mean yield of related testers of the same type. This situation could be expected since the related testers had more genetic similarity with the second cycle lines than the unrelated testers.

Correlation coefficients were calculated to determine the rank association between different testers for evaluating yielding ability of the lines. The results (Table 14) indicate that there was little correlation between the inbred testers in their ability to evaluate the lines for yield in similar order. This may be due to differences in specific combining ability of the testers with the tested lines.

Except in one case, yields with inbred testers were significantly correlated with yields of single cross testers in which the inbred tester was one of the parents. Correlations for inbred testers and double cross testers were generally not significant. The broader gene base of the double cross tester reduced the possibilities of inbred testers evaluating the lines in rank similar to that of the double cross tester.

Except in one case, there was no association among single cross testers in their ability to evaluate the lines for yield, Table 14. This indicates that the single cross testers were affected to a great extent by genes for specific dombining ability. More than one single cross tester would be needed to evaluate these inbred lines for general combining ability.

Table 14

Correlation coefficients for yield between testers in the test crosses

S.N.	Testers	Oh51	Oh26	Ill.A	W23
1	Oh51	-	+.31	-.24	+.38
2	Oh26	+.31	-	-.05	+.19
3	Ill.A	-.24	-.05	-	+.12
4	W23	+.38	+.19	+.12	-
5	Oh51 X Oh26	+.53*	+.61*	-.405	.56*
6	Ill.A X W23	+.05	+.17	+.50*	+.39
7	Ohio M15	+.46*	+.01	+.10	+.30
8	M14	+.17	+.20	+.35	+.25
9	M14 X WF9	+.40	+.12	-.10	+.40
10	Ia. 4483	+.34	+.08	+.33	+.53*

Correlation coefficients between -

(a) Average of four related inbred testers and M14 the unrelated inbred tester .453*

(b) Average of four related inbred testers and average of two related single crosses .783**

(c) Average of four related inbred testers and OhioM15 .400

(d) Average of two related single cross tester and Ohio M15 .349

(e) Average of two related single cross tester and M14 X WF9, the unrelated single cross .578**

(f) Average of all related testers and average of unrelated testers .623**

Table 14 (Continued)

Oh51 X Oh26	Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483
+.53*	+.05	+.46*	+.17	+.40	+.34
+.61*	+.17	+.01	+.20	+.12	+.08
-.405	+.50*	+.10	+.35	-.10	+.33
.56*	+.39	+.30	+.25	+.40	+.53*
-	+.01	+.28	+.26	+.62**	+.32
+.01	-	+.34	+.20	+.16	+.40
+.28	+.34	-	+.38	+.29	+.46*
+.26	+.20	+.38	-	+.54*	+.602**
+.62**	+.16	+.29	+.54*	-	+.447*
+.32	+.40	+.46*	+.602**	+.447*	-

* Significant at 5%

** Signigicant at 1%

r value to be significant at 5% 0.444 degree of freedom 18

r value to be significant at 1% 0.561 degree of freedom 18

Except in one case, single cross testers also did not show any rank association with the double-cross testers. Differences in rank association may be attributed largely to differences in specific combining ability of the testers with the line being tested.

Correlation between the two double cross testers, one parental and the other nonparental, was .46, which was significant at the 5% level but low for much predictive value. As pointed out by Sprague and Tatum (29), a broad gene base tester, in addition to effecting general combining ability, probably contains factors with strong dominance and epistatic effects. Thus, the evaluation of the tested lines for general combining ability might be more greatly influenced by dominant and epistatic factors than would be desirable for evaluating general combining ability.

A high 'r' value (.783**) for the means of the four parental inbred testers with the means of the two related single crosses (Table 14) suggests that either four inbreds or their two single crosses may be used as testers to evaluate the lines for yield. These results indicate that the average yield obtained from crosses with two or more tester parents tends to reduce the effects due to specific combining ability. The 'r' value, .623, for the two tester groups (related and unrelated) indicates that, either related testers or unrelated testers, as a group, were reliable for estimating general combining ability.

Table 15

Correlation coefficients for percentage of moisture between testers in test crosses

S.N.	Testers	Oh51	Oh26	Ill.A	W23
1	Oh51	-	.785**	.828**	.612**
2	Oh26	.785**	-	.771**	.776**
3	Ill.A	.828**	.771**	-	.674**
4	W23	.612**	.776**	.674**	-
5	Oh51 X Oh26	.905**	.859**	.828**	.720**
6	Ill.A X W23	.786**	.879**	.860**	.839**
7	Ohio M15	.773**	.768**	.727**	.815**
8	M14	.713**	.810**	.677**	.800**
9	M14 X WF9	.853**	.763**	.693**	.720**
10	Ia. 4483	.674*	.632**	.723**	.606**

Correlation coefficients between -

(a) Average of four related inbred testers and M14, the unrelated inbred tester r = .831**

(b) Average of four related inbred testers and average of two related single crosses .970**

(c) Average of four related inbred testers and Oh M15 .859**

(d) Average of two related single cross tester and Oh M15 .828**

(e) Average of two related single cross tester and M14 X WF9, the unrelated single cross .869**

(f) Average of all related testers and average of unrelated testers .879**

Table 15 (Continued)

Oh51 X Oh26	Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483
.905**	.786**	.773**	.713**	.853**	.674*
.859**	.879**	.768**	.810**	.763**	.632**
.828**	.860**	.727**	.677**	.693**	.723**
.720**	.839**	.815**	.800**	.720**	.606**
-	.861**	.829**	.775**	.873**	.667**
.861**	-	.770**	.798**	.804**	.640**
.829**	.770**	-	.807**	.769**	.514*
.775**	.798**	.807**	-	.661**	.547*
.873**	.804**	.769**	.661	-	.669**
.667**	.640**	.514*	.547*	.669**	-

* significant at 5%

** significant at 1%

r value significant at 5% 0.444 degree of freedom 18

r value significant at 1% 0.561 degree of freedom 18

Correlations were calculated for moisture percentage in the test crosses to assess the ability of different testers to evaluate maturity (Table 15). All the testers, irrespective of type and relationship with the lines under test, showed significant rank association for evaluating maturity of the lines.

Correlations among testers for evaluating maturity (Table 15) were generally high in contrast to those for yield (Table 14). This suggests that fewer testers would be needed to evaluate maturity than for yield.

Correlations between inbred testers for stalk lodging were low (Table 16) showing that inbred testers did not rank the lines in the same order. This failure of inbred testers to give the same evaluation may be attributed to differences in specific combining ability for lodging resistance of the testers (19).

Except in one case, where the significant 'r' value, .471, was rather low, single cross testers also did not evaluate the lines alike for stalk lodging. Single cross testers were also specific in action for lodging resistance and the evaluation with any one of them did not apply for other testers. Evaluation with single cross testers correlated significantly with that obtained with double cross testers.

Related and unrelated double cross testers showed good association, .805**, for evaluating stalk lodging resistance, suggesting that a double cross tester might be best for evaluating stalk lodging. A high 'r' value, .924**, between

Table 16

Correlation coefficients for percentage of stalk lodging between testers in test crosses

S.N.	Testers	Oh51	Oh26	Ill.A	W23
1	Oh51	-	-.043	+.04	+.41
2	Oh26	-.043	-	+.127	+.171
3	Ill.A	+.04	+.127	-	+.149
4	W23	+.41	+.171	+.149	-
5	Oh51 X Oh26	+.279	+.480*	-.092	+.490*
6	Ill.A X W23	+.205	+.277	+.518*	+.399
7	Ohio M15	+.411	+.190	+.430	+.550*
8	M14	+.315	+.286	+.086	-.110
9	M14 X WF9	+.561**	+.051	+.376	+.484*
10	Ia. 4483	+.279	+.322	+.203	+.710**

Correlation coefficients between -

(a) Average of four related inbred testers and M14, the unrelated inbred tester — +.143

(b) Average of four related inbred testers and average of two related single crosses — .724**

(c) Average of four related inbred testers and Oh M15 — +.712**

(d) Average of two related single cross tester and Oh M15 — +.924**

(e) Average of two related single cross tester and M14 X WF9 the unrelated single cross — +.561*

(f) Average of all related testers and average of unrelated testers — +.723**

Table 16 (Continued)

Oh51 X Oh26	Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483
+.279	+.205	+.411	+.315	+.561**	+.279
+.480*	+.277	+.190	+.286	+.051	+.322
-.092	+.518*	+.430	+.086	.376	+.203
+.490*	+.399	+.550*	-.110	+.484*	+.710**
-	+.304	+.535*	+.288	+.176	+.617**
+.304	-	+.764**	+.178	+.471*	+.588**
+.535*	+.764**	-	+.309	+.520*	+.805**
+.288	+.178	+.309	-	+.190	+.288
+.176	+.471*	+.520*	+.190	-	+.534*
+.617**	+.588**	+.805**	+.288	+.534*	-

* significant at 5%

** significant at 1%

r value to be significant at 5% 0.444 degree of freedom 18

r value to be significant at 1% 0.561 degree of freedom 18

the mean performance of the two related single crosses with their double cross, Ohio M 15 indicated that either a double cross tester or the two single crosses of the double-cross may be used to evaluate general combining ability of the lines for stalk lodging. Correlations for the mean of the four related inbred testers with the mean of their two single crosses, .724**, with the related double cross, .712**, indicated that the four inbred testers could be replaced with their two single crosses or the double cross in evaluating general combining ability for resistance to stalk lodging.

Mean performances of the related and unrelated testers showed high association, .723**, in evaluating lines for stalk lodging. This suggests that either related or unrelated testers provided valid information on resistance to stalk lodging.

Four out of ten correlations among inbred testers for root lodging, Table 17, were significant. In general, inbred testers were not very effective in evaluating the lines in similar order. Likewise, correlations among single cross and double cross testers were low, indicating specific reactions between tester and tested lines. It was apparent, that inbred and single testers could not be depended upon to provide evaluation applicable to other testers. However, the amount of root lodging was generally low and may not present a true picture of the situation if the incidence of the root lodging had been higher.

Table 17

Correlation coefficients for percentage of root lodging between testers in test crosses

S.N.	Testers	Oh51	Oh26	Ill.A	W23
1	Oh51	-	+.665**	.553*	+.471*
2	Oh26	+.665**	-	.485*	+.263
3	Ill.A	+.553*	+.485*	-	+.09
4	W23	+.471*	+.263	+.09	-
5	Oh51 X Oh26	+.702**	+.357	+.497*	+.433
6	Ill.A X W23	+.375	+.238	+.085	+.618**
7	Oh M15	+.337	+.286	+.029	+.414
8	M14	+.069	+.392	+.084	+.088
9	M14 X WF9	+.334	+.460*	+.364	+.572*
10	Ia. 4483	+.549*	+.480*	+.461*	+.198

Correlation coefficients between -

(a) Average of four related inbred testers and M14, the unrelated inbred tester — +.101

(b) Average of four related inbred testers and average of two related single crosses — +.694**

(c) Average of four related inbred testers and Oh M15 — +.341

(d) Average of two related single cross tester and Oh M15 — +.665**

(e) Average of two related single cross tester and M14 X WF9, the unrelated single cross — +.368

(f) Average of all related testers and average of unrelated testers — +.600**

Table 17 (Continued)

Oh51 X Oh26	Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483
.702**	+.375	+.337	+.069	+.334	.549*
+.357	+.238	+.286	+.392	.460*	+.480*
+.497*	+.085	+.029	+.084	+.364	+.461*
+.433	.618**	+.414	+.088	+.572*	+.198
-	+.289	+.612**	+.025	+.299	+.71**
+.289	-	+.404	+.167	+.397	-.011
+.612*	+.404	-	+.093	+.32	+.395
+.025	+.167	+.093	-	+.114	+.195
+.299	+.397	+.32	+.114	-	+.310
+.710**	-.011	+.395	+.195	+.310	-

* Significant at 5%

** Significant at 1%

r value to be significant at 5% 0.444 degree of freedom 18

r value to be significant at 1% 0.561 degree of freedom 18

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Correlation of average root lodging scores of the four related inbred testers with the averages from the two related single cross testers and with the double cross Ohio M 15, were significant, suggesting that either four inbred testers, or their two single crosses, or the double cross made up from the four tester inbreds would be effective in evaluating root lodging. Correlating the averages for the related and unrelated testers showed a significant association, suggesting that either related or unrelated testers could be effective for root lodging evaluation.

Variance Components

Variance components for "testers" and "tester x line" interaction were compared for yield and maturity percentage. The method of calculating the components of variance is presented in Table 18, 19, 20, 21, 22 and the results are given in Table 23.

The mean yields for inbred, single and double cross testers in test crosses were 81.7, 83.6 and 83.7 bushels per acre, respectively. These three means were quite similar. There was no significant tester type x line interaction Table 22 and the variance component was .01 (Table 23), related and unrelated testers evaluated the lines similarily for yield.

The differences among the five inbred testers, three single cross and two double cross testers were significant as

Table 18

Mean square expectations for yield and moisture percentage comparing inbred single cross and double cross testers

Source of Variation	Value of Mean Squares
Tester Type	$\sigma^2 aT_y + 194.4\sigma^2 l.T_y + 372\ \sigma^2 T_y$
Line X Tester Type	$\sigma^2 bT_y + 9.8\ \sigma^2 l.T_y.L + 19.9\ \sigma^2 T_y.L$
Inbred Testers	$\sigma^2 a_i + 60\ \sigma^2 l.Ti + 120\ \sigma^2 Ti$
(a) Error	$\sigma^2 a_i$
Inbred Tester X Line	$\sigma^2 b_i + 3\ \sigma^2 l.Ti.L + 6\ \sigma^2 Ti.L$
(b) Error	$\sigma^2 b_i$
Single Cross Testers	$\sigma^2 a_s + 60\ \sigma^2 l.T_s + 120\ \sigma^2 T_s$
(a) Error	$\sigma^2 a_s$
Tester X Line	$\sigma^2 b_s + 3\ \sigma^2 l.T_s.L + 6\ \sigma^2 Ti.L$
(b) Error	$\sigma^2 b_s$
Double Cross Tester	$\sigma^2 a_d + 60\ \sigma^2 l.T_d + 120\ \sigma^2 T_d$
(a) Error	$\sigma^2 a_d$
Double Cross Tester X Line	$\sigma^2 b_d + 3\ \sigma^2 l.T_d.L + 6\ \sigma^2 T_d.L$
(b) Error	$\sigma^2 b_d$

Table 19

Component of Variance for inbred testers

	D.F.	M.S.S. Yield	M.S.S. Moisture	
Total	599			
Replications	4	53.92	46.3	
Tester	4	125.72*	847.17*	σ^2ai + 60 σ^2l.Ti. + 120 σ^2Ti.
Location	1	130.8	1753.8	σ^2ai + 60 σ^2l.Ti. + 300 σ^2l
Location X Tester	4	9.67	40.3	σ^2ai + 60 σ^2l.Ti.
(a) Error	16	15.34	19.77	σ^2al
Line	19	3.72	205.2	σ^2bi + 3 σ^2l.Ti.L. + 6 σ^2Ti.L. + 30 σ^2l.L + 60 σ^2L
Line X Location	19	11.12	30.78	σ^2bi + 3 σ^2l.Ti.L. + 30 σ^2l.L
Tester X Line	76	12.71*	15.77*	σ^2bi + 3 σ^2l.Ti.L + 6 σ^2T.L
Line X Tester X Location	76	5.42	5.31	σ^2bi + 3 σ^2l.Ti.L
Error	380	3.90	4.25	σ^2bi

Note: l = Location

L = Line

Ti = Tester inbred

* significance at 5%

Table 20

Component of Variance for single cross testers

	D.F.	M.S.S. Yield	M.S.S. Moisture %	
Total	359			
Replication	4	26.8	62.5	
Tester	2	353.5*	328.3*	$\sigma^2 a_s + 60\ \sigma^2 l.Ts. + 120\ \sigma^2 Ts.$
Location	1	120.5	1039.3	$\sigma^2 a_s + 60\ \sigma^2 l.Ts. + 180\ \sigma^2 l$
Location X Tester	2	9.7	78.9	$\sigma^2 a_s + 60\ \sigma^2 l.Ts.$
(a) Error	8	19.51	7.74	$\sigma^2 a_s$
Line	19	23.3	11.77	$\sigma^2 b_s + 3\ \sigma^2 l.TsL. + 6\ \sigma^2 TsL. + 30\ \sigma^2 l.L + 60\ \sigma^2 L.$
Line X Location	19	8.35	17.85	$\sigma^2 b_s + 3\ \sigma^2 l.Ts.L + 30\ \sigma^2 l.L.$
Line X Tester	38	5.88*	6.98	$\sigma^2 b_s + 3\ \sigma^2 l.TsL. + 6\ \sigma^2 TsL$
Line X Location X Tester	38	3.12	5.41	$\sigma^2 b_s + 3\ \sigma^2 l.Ts.L.$
(b) Error	228	3.72	4.11	$\sigma^2 b_s$

L = Line

l = Location

Ts = Tester single cross

* significance at 5%

Table 21

Components of Variance of double cross testers

	D.F.	M.S.S. Yield	M.S.S. Moisture	
Total	239			
Replication	4	22.95	34.55	
Tester	1	264.8*	22.6	$\sigma^2 a_d + 60$ 1.Td. $+ 120\ \sigma^2$Td.
Location	1	51.0	709.3	$\sigma^2 a_d + 60\ \sigma^2$1.Td. $+ 120\ \sigma^2$1
Location X Tester	1	86.0	22.8	$\sigma^2 a_d + 60\ \sigma^2$1.Td.
(a) Error	4	8.05	4.88	$\sigma^2 a_d$
Line	19	15.70	63.89	$\sigma^2 b_d + 3\ \sigma^2$1.Td.L. $+ 6\ \sigma^2$Td.L. $+ 30\ \sigma^2$1.L $+ 60\ \sigma^2$L
Line X Location	19	3.40	47.5	$\sigma^2 b_d + 3\ \sigma^2$1.Td.L. $+$ 301.L
Line X Tester	19	2.35	16.98*	$\sigma^2 b_d + 3\ \sigma^2$1.Td.L. $+ 6\ \sigma^2$Td.L
Line X Tester X Location	19	8.26	8.67	$\sigma^2 b_d + 3\ \sigma^2$1.Td.L
(b) Error	152	3.76	5.12	$\sigma^2 b_d$

1 = Location

L = Line

Td = Tester double cross

* significance at 5%

Table 22

Components of Variance of type of testers

	D.F.	M.S.S. for Yield	M.S.S. for Moisture	
Total	359			
Replication	4			
Location	1			
Type	2	11.2	12.8	$\sigma^2 aT_y + 194.4\, \sigma^2 1.T_y + 372\, \sigma^2 T_y$
Location X Type	2	2.95	0.05	$\sigma^2 aT_y + 194.4\, \sigma^2 1.T_y$
(a) Error	8	13.71	10.85	$\sigma^2 aT_y$
Line	19	66.9	39.4	$\sigma^2 bT_y + 9.8\, \sigma^2 1.T_yL + 19.9\, \sigma^2 T_yL +$ $30\ {}^2 1.L + 60\, \sigma^2 L$
Line X Location	19	19.9	57.7	$\sigma^2 bT_y + 9.8\, \sigma^2 1.T_yL + 30\, \sigma^2 1.L$
Line X Type	38	4.39	9.46	$\sigma^2 bT_y + 9.8\, \sigma^2 1.T_y.L + 19.9\, \sigma^2 T_y.L$
Line X Type X Location	38	1.75	9.06	$\sigma^2 bT_y + 9.8\, \sigma^2 1.T_y.L$
(b) Error	228	4.08	5.22	$\sigma^2 bT_y$

L = Line

1 = Location

Ty = Type

Table 23

Variance components for yield and moisture

Source of Variation	D.F.	Mean Square Yield	Mean Square Moisture	Variance Components	Variance components estimate Yield	Variance components estimate Moisture
Tester types	2	11.2	12.8	σ^2_T	.022	.005
(a) Error	8	13.71	10.85	$\sigma^2_{a.T}$	13.71	10.85
Line X Tester type	38	4.39	9.46	$\sigma^2_{bT.L}$	0.01	.02
(b) Error	228	4.08	5.22	σ^2_{bT}	4.08	5.22
Inbred Tester	4	125.72	847.17	σ^2_i	.93	6.72
(a) Error	16	15.34	19.77	$\sigma^2_{a_i}$	15.34	19.77
Inbred Tester X Line	76	12.71	15.77	$\sigma^2_{b_iL}$	1.22	1.74
(b) Error	380	3.90	4.25	$\sigma^2_{b_i}$	3.90	4.25
Single Cross Tester	2	353.5	328.3	σ^2_s	2.86	2.1
(a) Error	8	19.51	7.74	σ^2_{as}	19.51	7.74
Single Cross Tester X Line	38	5.88	6.98	$\sigma^2_{s.L}$	.46	0.26
(b) Error	228	3.72	4.11	$\sigma^2_{b_s}$	3.72	4.11
Double Cross Tester	1	264.8	22.6	σ^2_d	1.49	.002
(a) Error	4	8.05	4.88	$\sigma^2_{a_d}$	8.05	4.88
Double Cross Tester X Line	19	2.35	16.98	$\sigma^2_{d.L.}$	-.23	1.58
(b) Error	152	3.76	5.12	σ^2_{bd}	3.76	5.12

Correlation between inbred and single cross testers		.698**
Degree of freedom	18	
Correlation between inbred and double cross testers		.624**
Degree of freedom	18	
Correlation between single and double testers		.529*
Degree of freedom	18	

judged by the 'F' test, (Table 19, 20, and 21). The difference in the yield due to the different testers within a group may be due to the variation in the amount of genetic similarity of the testers with the lines being tested. Testers more similar genetically to the tested lines would be expected to give lower average yields than testers which were different genetically from the tested lines.

Correlation coefficients showed that the three groups of testers ranked the lines for the yield similarily, Table 23. Interactions for inbred tester x lines and single cross tester x lines were significant but not for the double cross tester x line, Table 19, 20 and 21. Components of variance estimates for the interactions inbred testers x lines, single-cross testers x lines and double - cross testers x lines were 1.22, .46 and -.23 respectively. The decrease in relative size of these interaction components indicate that performances with inbred and single cross testers were more specific than those with double cross testers. The relative size of the interaction component for tester x line decreased as the gene base became broader. This same relationship for tester types was shown by Matzinger (21).

Mean moisture percentages for inbred, single and double cross testers were 21.9, 21.5 and 21.6 respectively. There were no differences for type of testers or for line x type interactions as judged by 'F' tests (Table 22). The component of variance for line x type interaction was .02 again indicating no interaction.

The data for different testers x line interaction indicate that there was no significant line x single cross tester interaction for moisture (Table 22). This suggests that the three single cross testers were evaluating the lines similarily for maturity. Interactions for inbred testers x lines and double cross testers x lines were significant as judged by 'F' test (Tables 19 and 21) and the components of variance were 1.74 and 1.58 respectively. Like yield, these interactions components were small compared to the error components indicating that factors contributing to error components were more effective than the components for interactions.

Discussion

The results reported in this investigation have indicated that some second cycle lines, more vigorous and better in combining ability than the parental lines, were produced by inbreeding and selection in a double cross corn hybrid. Since only the better lines were used to produce the initial double cross hybrid, Ohio M 15, the desirable factors from each of the parental inbreds were concentrated in one variety. Thus the chances of obtaining a higher percentage of usable lines from such sources are likely to be better than from the older open pollinated varieties. The isolation of some superior lines from double cross hybrids may be due to the cumulative effect of large number of factors affecting yield (28). Similar results were reported by Wu (30), Hayes and Johnson (12) and Johnson and Hayes (18) who worked with single cross hybrids. Sprague (28) suggests that continued cycles of isolating new lines may be repeated as long as improved lines are obtained. The production of vigorous lines is an economic factor in production of hybrid seed corn from inbred lines whereas lines superior in combining ability lead to better hybrids.

Through inbreeding and selection in a double-cross hybrid, second cycle lines genetically different from the parents and with each other were produced. The results from single and double cross tests among second cycle lines indicated that selected lines produced some hybrids equal or

slightly better yielding than Ohio M 15, from which they were extracted. Since yield is controlled by a large number of genetic factors, there is little possibility of similar yield factors recombining in second cycle lines to produce lines similar to the parental lines. The chances of recombining all of the parental characters in one recovered line exactly or even close to the parental genotype are relatively remote. Thus, recovered lines varying in genetic relationship with each other and also with the four parental inbreds were produced.

Several hybrids using second cycle lines were superior to the parental double cross, Ohio M 15, in lodging resistance. Resistance to lodging is very important from the standpoint of ease and thoroughness of mechanical harvest. Any improvement in lodging resistance represents an important contribution to corn production and increases corn yields by reducing harvest losses.

These results show that lines from the same genetic background can be used to produce good hybrids, if they were extracted from a wide genetic base equivalent at least to a double-cross hybrid as source material for extraction. Close genetic similarity with the parents and among the second cycle lines has been reported (30, 12) for lines isolated from single crosses. In addition to improving combining ability, lines earlier or later in maturity than the parents and equal to the best parent and better than the other parents in root and stalk lodging resistance were isolated.

The results were encouraging in that some lines genetically different from the parent and with each other were produced. Previous workers, using single crosses as source material, isolated some superior lines, but closer genetic relationship largely precluded the use of the second cycle lines with their parental lines in double cross combinations. These results have shown that there are chances to isolate genetically divergent lines in second cycle selection from a double cross.

As a feature of routine corn breeding program, the extensive evaluation of a group of second cycle lines from the same source as was done here would probably be less effective in developing improved hybrids than the same effort devoted to evaluating a group of lines from several sources. However, the present study does serve to point out the possibilities of improvement where it is desired to improve a highly popular double-cross hybrid using it as inbreeding source material.

Evaluation of second cycle lines for yield, maturity and lodging using different types of related and unrelated testers was compared. Inbred testers irrespective of the relationship with the lines under test were specific in evaluating the lines for yield. Also single and double cross testers (related and unrelated) either showed little or no similarity in evaluating yield. These results support the view of Sprague and Tatum (29) who suggest more than one single or double cross tester for evaluating lines for general combining ability.

The specific action of these testers for yield has been indicated by the analyses of components of variance. The line x tester interaction for yield indicated that as genetic variation within testers increased (inbred to single cross to double cross), the line x tester interaction component decreased. These results concur with the findings of Matzinger (21) and suggest that the inbred or single cross testers be selected according to the use which is to be made of the new lines. For example if the new lines were to be used as a substitute for one of the parents in the pedigree of a double cross the best tester will be the opposite single cross.

There was no interaction for the yields due to line x double cross testers and the correlation was significant .46. While the correlation between the two double cross testers was not high, they did identify most of the sam inbreds as being high in general combining ability.

The comparison between the two tester groups (related and unrelated) indicated that either related testers or unrelated testers, as a group were reliable for estimating general combining ability. The two groups of testers showed significant association for all the characteristics under study indicating that the relationship of the tester parents to the tested lines did not affect the ranking of the lines.

The analyses for types of testers suggests that the evaluation of the lines for general combining ability can be

done most economically with two or more double cross testers irrespective of relationship with the lines under test. If other types of testers (inbreds and single crosses) are to be used, the number of testers should be increased.

Correlations of the mean performances of four inbred testers with the means of their two single crosses suggest that the two types of testers within a group ranked the lines similarily for all the characters under study. This suggests either four parental inbreds or their two single crosses as testers for approximately equal precision.

Correlations among testers for maturity were generally high, suggesting fewer testers would be needed for evaluating maturity. Closer association among testers in the evaluation of maturity might be due to fewer genes affecting the expression of maturity than yield and stalk lodging resistance. Yield is highly multi-genic. Resistance to stalk lodging is determined by resistance to both corn borer and stalk rotting fungi coupled with stiffness of stalk and, as such, becomes relatively multi-genic.

The results for stalk and root lodging showed that inbred and single cross testers, regardless of relationship with the tested lines, did not evaluate the lines in similar order. The two double cross testers did evaluate the lines for stalk lodging in similar order but not for root lodging where the use of more than one double cross tester was needed. The amount of root lodging was relatively low and these results

may not apply in tests where root lodging is high.

It should be emphasized that in a corn breeding program, the evaluation for maturity and lodging is done in conjunction with yield. The results have suggested the use of more than one tester irrespective of the relation for evaluating the lines for yield. On the other hand, for all characters under study, the use of more than one tester has produced a high precision. This suggests that with the evaluation of lines for yield, other characters will also be evaluated with a relatively high degree of accuracy.

Summary

Twenty S_6 second cycle lines developed by inbreeding and selection in the double cross Ohio M 15 (Oh 51 x Oh 26) x (Ill.A x W 23) were used to study the degree of relationship with the four parental lines and among themselves. These lines were crossed on ten testers, seven related (four parental inbreds, two single crosses and the double cross Ohio M 15) and three unrelated testers (inbred M 14, single cross M 14 x W F 9 and double cross Ia. 4483 (M 14 x W F 9) x (B_8 x B16).

Seven of the second cycle lines, four parental lines and one unrelated line, M 14 were used to produce, 66, single crosses. Actual and predicted performance of double crosses were compared with the parental Ohio M 15.

1. A few of the second cycle lines were more vigorous than and superior to the parental inbreds in combining ability.
2. Second cycle lines were genetically different from some of the parents and from each other.
3. A few double crosses equal to or slightly better than Ohio M 15 were produced by crossing four second cycle lines or by substituting them with one or more of the parental lines in the pedigree of Ohio M 15.
4. Predicted yield, percentage of moisture and stalk lodging of the double crosses from the single cross data showed significant correlation with the actual yield, percentage of moisture and stalk lodging.

These results indicate that, even the lines of the same

origin can be used to produce good hybrids, if they were extracted from a wide genetic base.

5. Inbred and single-cross testers were very specific in evaluating the lines for yield and lodging. This suggests the use of more than one of these as testers for general combining ability. The 'r' value between the two double cross testers was a significant (.46) but low enough to suggest the use of more than one tester for evaluating the lines for general combining ability for yield. A high 'r' value for the mean of the four parental inbred testers with the mean of their two single crosses suggested that either four inbreds or their two single crosses may be used for evaluating general combining ability of the lines for yield.

6. Either the four inbred testers or their two single crosses, or the double cross of the four inbreds could be used to evaluate the lines for resistance to stalk lodging. A similar situation was indicated for resistance to root lodging.

7. Correlation for the two tester groups (related and unrelated) indicates that either related or unrelated testers, as a group, were reliable for estimating relative general combining ability for yield, maturity, and stalk lodging resistance.

8. The correlation coefficients for maturity were significant in all cases and were generally high, suggesting fewer testers would be needed to evaluate maturity than yield or lodging resistance.

9. For related lines, genes conditioning specific combining ability were relatively more important in influencing yield than genes for general combining ability.

10. Analysis of components of varience shows that for yield, line x tester interaction decreased with increased genetic variation in the tester. This same relationship did not exist for maturity.

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Appendix Table I

Yield and percentage of moisture in the inbred lines at one location in 1954 and two locations in 1955

Inbred lines	Yields of grain in lbs. per plot			Moisture in ear %		
	M.S.U. Farm 1954	M.S.U. Farm 1955	Saginaw County 1955	M.S.U. Farm 1954	M.S.U. Farm 1955	Saginaw County 1955
1	3.04	3.37	3.36	32.8	23.5	19.5
2	1.37	-	1.71	60.6	-	31.0
3	2.47	2.17	2.1	39.7	33.6	21.7
4	2.12	2.46	2.15	41.7	35.6	20.5
5	2.67	2.50	2.06	40.5	30.2	18.9
6	2.84	2.97	2.71	33.7	24.4	17.2
7	1.82	2.29	2.03	35.6	23.8	24.0
8	2.11	2.86	2.81	37.7	25.1	14.9
9	1.99	1.82	2.05	45.3	45.0	21.0
10	1.74	1.30	1.27	29.6	18.2	14.7
11	2.07	2.57	2.17	42.4	21.3	20.6
12	1.58	2.68	2.47	37.8	21.7	15.0
13	2.51	2.51	2.78	26.5	25.4	17.0
14	2.12	2.67	2.92	39.2	32.7	23.3
15	1.68	2.14	2.25	31.8	25.6	15.0
16	1.85	2.22	2.36	29.5	23.6	14.1
17	2.36	2.96	2.69	30.3	24.3	19.3
18	1.8	2.27	2.72	37.3	29.1	16.5
19	2.31	2.89	3.17	41.5	21.5	14.2
20	2.03	1.68	1.76	28.2	18.4	12.6
21	2.62	2.03	2.60	30.0	29.3	18.3
22	1.48	2.37	1.91	40.7	20.4	14.9
23	1.65	2.15	2.07	46.7	40.3	27.5
24	2.63	2.49	2.69	34.1	26.6	18.1
25	2.29	2.59	2.77	41.4	33.3	17.2
L.S.D. 5%	.58	0.44	0.42	4.4	4.6	2.8

Appendix Table II

Percentage of stalk and root lodging in the inbred lines at one location in 1954 and at two locations in 1955

	Stalk lodging %			Root lodging %		
Inbred lines	M.S.U. Farm 1954	M.S.U. Farm 1955	Saginaw County 1955	M.S.U. Farm 1954	M.S.U. Farm 1955	Saginaw County 1955
1	6.7	2.0	1.8	1.7	2.0	-
2	-	-	2.9	-	13.7	-
3	10.0	16.1	9.4	11.6	23.2	1.9
4	10.0	9.6	6.7	10.0	13.5	10.0
5	16.7	13.0	10.9	16.7	22.2	5.5
6	8.6	16.7	15.5	3.4	-	-
7	1.7	2.1	9.1	3.4	-	-
8	12.3	14.8	8.8	-	-	3.5
9	-	1.8	2.1	-	5.4	-
10	10.3	3.8	26.9	1.7	7.5	-
11	1.8	-	-	-	-	-
12	3.3	4.1	17.6	3.3	-	3.9
13	11.6	7.0	6.7	3.3	1.9	-
14	10.0	5.5	30.5	3.3	1.8	10.2
15	16.7	49.0	31.7	-	-	1.7
16	31.6	7.0	10.0	5.0	1.8	-
17	5.1	7.4	-	-	-	-
18	15.3	27.8	15.9	13.6	20.4	20.5
19	-	7.8	13.4	-	-	-
20	-	12.1	1.7	-	-	-
21	6.7	8.6	5.0	15.0	10.3	3.3
22	-	-	-	-	-	5.3
23	8.3	3.8	19.6	1.7	5.2	-
24	63.3	15.7	41.2	-	5.9	-
25	1.7	3.7	-	3.3	5.7	-

Appendix III

Yield, percentage of moisture, stalk and root lodging in tester crosses at two locations (1955)

S. N.	Pedigree	Yield in bu. per acre at 15.5% moisture — University Farm	Saginaw
1	Oh26 X Ill.A	93.7	87.3
2	Oh26 X W23	73.5	90.3
3	Oh26 X (Oh51 X Oh26)	50.0	54.9
4	Oh26 X (Ill.A X W23)	79.8	73.4
5	Oh26 X Ohio M15	66.7	76.3
6	Oh26 X M14	85.2	89.8
7	Oh26 X (M14 X WF9)	89.5	104.9
8	Oh26 X Ia. 4483	78.2	89.6
9	Ill.A X W23	99.2	82.0
10	Ill.A X (Oh51 X Oh26)	80.6	80.9
11	Ill.A X (Ill.A X W23)	55.7	73.7
12	Ill.A X Ohio M15	96.7	77.8
13	Ill.A X M14	80.5	94.7
14	Ill.A X (M14 X WF9)	114.3	97.2
15	Ill.A X Ia. 4483	102.6	93.0
16	M14 X (Oh51 X Oh26)	80.7	93.6
17	M14 X (Ill.A X W23)	88.9	79.6
18	M14 X Ohio M15)	83.6	90.6
19	M14 X (M14 X WF9)	64.0	72.6
20	M14 X Ia. 4483	82.6	69.4
21	Oh51 X Oh26	72.6	72.5
22	Oh51 X Ill.A	96.4	89.8
23	Oh51 X W23	84.0	85.4
24	Oh51 X (Oh51 X Oh26)	45.0	55.7
25	Oh51 X (Ill.A X W23)	89.7	84.7
26	Oh51 X Ohio M15	72.7	83.7
27	Oh51 X M14	90.5	93.4
28	Oh51 X (M14 X WF9)	95.0	99.5
29	Oh51 X Ia. 4483	81.9	99.3
30	W23 X (Oh51 X Oh26)	80.9	99.4
31	W23 X (Ill.A X W23)	69.2	68.1
32	W23 X Ohio M15	70.2	71.8
33	W23 X M14	100.7	89.5
34	W23 X(M14 X WF9)	97.1	104.0
35	W23 X Ia. 4483	94.1	89.9
36	Oh51 X Oh26	47.8	76.6
37	Ill.A X W23	67.4	82.5
38	Ohio M15	71.2	87.7
39	M14 X WF9	99.0	95.4
40	Ia. 4483	82.7	105.0
	L. S. D. at 5%	20.3	20.7

Appendix (Continued)

Percentage of moisture in ear		Percentage of stalk lodging		Percentage of root lodging	
University Farm	Saginaw	University Farm	Saginaw	University Farm	Saginaw
29.6	17.3	6.7	16.1	1.1	12.6
21.2	15.2	7.8	10.0	1.1	1.1
18.5	11.9	6.9	6.4	1.2	-
22.6	13.9	14.6	48.7	-	4.8
21.6	13.0	14.6	17.2	3.4	6.9
25.0	13.7	6.8	1.2	-	-
23.5	15.7	2.2	2.3	-	-
23.5	16.5	8.1	1.2	-	-
26.9	19.9	11.2	38.0	-	-
31.0	20.9	15.9	46.8	3.7	-
29.7	22.3	24.7	61.1	9.1	-
29.1	22.7	10.4	20.1	-	-
32.0	23.8	17.7	25.5	4.7	2.3
29.0	19.2	9.1	6.8	1.1	1.1
24.9	17.7	11.1	5.8	-	2.3
21.1	13.4	2.6	-	-	-
24.5	16.2	10.4	6.7	1.2	-
25.4	16.2	9.0	10.4	1.1	3.5
28.8	19.4	11.9	1.1	1.2	-
25.2	16.9	7.1	8.0	-	3.4
21.5	15.7	9.4	16.2	1.2	8.0
25.8	20.5	25.5	50.0	1.1	-
21.6	16.6	8.3	16.5	1.2	-
20.2	17.0	8.6	47.1	1.2	23.0
23.8	17.9	23.2	50.0	4.6	-
20.7	14.8	12.6	8.3	-	-
23.7	15.5	4.9	-	1.2	2.4
26.9	20.0	4.7	11.5	1.2	6.9
21.2	14.0	17.2	15.0	-	-
20.3	15.1	4.6	17.8	-	-
27.0	18.5	9.2	33.8	-	-
25.3	19.4	24.0	24.6	-	-
27.1	17.8	9.8	1.2	-	-
28.4	22.0	4.8	10.1	-	-
24.3	17.4	2.5	42.9	-	-
20.0	15.0	20.5	-	-	-
26.4	20.0	15.3	62.6	2.8	-
22.3	16.3	11.1	15.1	1.6	-
31.5	18.5	7.5	1.2	-	-
23.4	17.8	1.4	4.0	-	-
3.94	3.66				

Appendix IV

Average yield of test crosses at University Farm (yield in bu per acre at 15.5% moisture)

	Oh51	Oh26	Ill.A	W23	Oh51 X Oh26
1	87.9	80.5	84.2	84.8	76.8
2	70.3	90.1	88.1	65.1	76.5
3	99.9	94.4	64.3	105.7	96.9
4	101.5	101.5	86.3	92.9	97.6
5	83.1	100.1	73.1	90.9	92.0
6	84.5	73.2	71.4	72.9	80.5
7	79.9	77.3	90.8	90.8	76.5
8	91.0	80.8	95.1	80.5	73.2
9	85.4	72.4	70.9	101.0	84.4
10	72.6	65.1	74.5	73.6	61.9
11	78.1	70.9	101.2	94.8	68.4
12	87.8	70.7	79.4	77.4	68.7
13	50.0	56.5	93.8	79.6	53.2
14	60.6	84.2	85.8	84.2	65.2
15	63.7	85.3	83.3	75.0	71.8
16	68.4	58.6	82.4	83.9	64.8
17	71.6	73.5	86.2	84.0	67.1
18	79.6	85.7	55.2	82.4	85.5
19	70.5	51.4	70.1	90.6	79.4
20	71.2	86.8	71.9	88.9	82.6
	77.9	78.0	80.4	85.0	76.2

L. S. D. at 5% — **Mean of testers 11.4 bu.** **Mean of inbreds 6.2 bu.**

Two inbreds at one level of tester 19.6 bu.

Two tester at one level of inbred 20.8 bu.

To test diagonally 20.8 bu.

Appendix (Continued)

Ill.A X W23	M15	M14	M14 X WF9	Ia. 4483	Average
75.5	87.5	89,0	82.4	91.3	84.0
90.8	86.4	116.8	99.2	102.1	88.5
78.2	84.4	97.5	110.3	97.3	92.9
102.2	92.3	99.9	118.5	87.8	98.1
94.3	97.9	103.9	107.5	91.4	93.4
67.3	76.6	81.5	96.9	81.0	78.6
88.8	89.0	84.6	95.7	94.4	86.8
71.4	80.8	96.0	111.9	83.7	86.4
80.9	85.9	105.0	99.6	90.9	87.6
85.3	78.7	80.2	84.3	79.6	75.6
88.6	71.8	95.5	92.9	99.9	86.2
80.8	77.2	88.1	86.0	94.8	81.1
81.8	70.5	95.5	99.2	83.8	76.4
93.2	70.0	84.1	96.3	82.7	79.6
78.6	76.5	85.6	86.9	75.1	78.2
81.0	83.4	81.6	98.1	86.8	78.9
95.2	75.6	83.3	88.9	91.0	81.4
64.0	75.3	84.5	87.8	76.9	77.7
75.7	75.3	86.8	110.7	90.5	80.1
85.2	88.1	94.7	87.4	83.9	84.1
82.4	81.2	91.7	97.0	88.2	

[illegible] 58 [illegible]

Appendix V

Average yield of test crosses at Saginaw County (yield in bu per acre)

	Oh51	Oh26	Ill.A	W23	Oh51 X Oh26
1	91.7	89.0	83.3	82.3	63.9
2	71.5	97.8	86.0	99.9	86.5
3	88.4	86.4	69.4	86.4	86.5
4	70.8	82.3	66.7	88.8	75.8
5	80.6	90.3	44.0	75.3	73.0
6	71.0	85.4	81.8	74.3	78.0
7	76.1	62.1	92.2	85.6	77.8
8	80.9	83.5	49.2	93.4	79.8
9	90.7	87.7	77.7	91.0	83.2
10	56.2	68.7	62.7	72.8	63.2
11	74.0	61.9	86.9	99.8	73.8
12	74.3	67.0	88.9	87.0	67.9
13	54.8	77.2	86.7	77.2	70.2
14	65.2	80.0	90.9	87.1	74.5
15	76.4	98.0	83.4	98.1	76.6
16	65.3	61.6	74.7	82.9	66.8
17	56.2	83.7	70.3	82.5	74.4
18	60.6	91.1	52.0	81.6	74.1
19	71.3	72.8	84.7	86.4	87.6
20	48.0	95.4	83.3	100.5	85.5
Av.	71.2	81.1	75.7	86.6	76.0

L. S. D. at 5%

Mean of testers 6.5 bu

Mean of inbreds 7.3 bu

Two inbreds at one level of tester 21.5 bu.

Two tester at one level of inbreds 21.7 bu.

To test diagonally 21.7 bu.

Appendix (Continued)

Ill.A X W23	M15	M14	M14 X WF9	Ia. 4483	Average
80.4	73.2	86.5	94.5	84.4	82.9
83.5	85.4	104.6	104.3	103.1	92.3
74.9	81.6	91.9	93.3	103.1	86.2
79.7	57.2	95.2	99.8	90.3	80.7
71.8	62.0	82.9	88.9	96.9	76.6
73.9	68.7	90.3	90.5	88.2	80.2
76.1	77.5	95.2	92.5	93.1	82.8
80.2	75.9	99.4	86.5	89.9	81.9
88.7	80.0	81.1	107.5	95.4	88.3
73.6	70.8	68.5	87.4	78.2	70.2
87.3	82.8	99.7	97.6	102.7	86.7
81.2	65.4	84.2	92.7	94.1	80.3
76.1	72.7	96.2	95.3	91.9	79.8
83.6	64.9	87.9	92.0	101.7	82.8
82.4	78.3	96.6	80.8	101.1	87.2
73.5	87.4	92.2	85.2	94.8	78.4
68.1	54.2	80.5	87.5	86.5	74.4
61.2	62.6	91.2	97.5	93.7	75.6
65.4	76.6	96.4	100.3	93.4	83.5
83.6	58.0	69.3	90.1	86.6	80.0
77.3	71.8	89.5	92.7	93.5	

Appendix VI

Average percentage of moisture for test crosses at University Farm

	T1	T2	T3	T4	T5	T6
1	21.6	22.5	31.3	20.9	23.0	24.9
2	23.9	28.4	33.0	27.6	24.0	30.5
3	27.7	26.6	31.5	24.4	25.9	27.5
4	27.2	26.5	33.1	25.7	25.4	28.5
5	25.8	27.1	31.7	26.8	24.0	27.9
6	23.5	22.2	26.0	25.7	20.7	23.1
7	18.7	15.0	26.9	21.3	20.1	22.5
8	20.6	21.0	27.7	22.5	21.5	22.7
9	27.9	26.8	32.7	25.1	26.3	28.3
10	15.6	15.4	24.1	19.0	16.0	19.2
11	19.8	16.0	25.0	24.7	21.1	20.4
12	14.9	17.7	23.6	20.5	15.3	21.0
13	18.6	17.9	24.5	21.5	17.8	22.5
14	24.4	24.8	30.4	22.6	23.3	26.8
15	22.9	25.5	29.2	26.6	23.7	27.7
16	24.6	17.8	30.4	22.3	20.0	20.8
17	21.2	16.1	23.6	22.8	16.5	19.8
18	19.6	20.7	27.4	25.9	19.0	24.7
19	21.7	25.1	29.7	25.1	21.7	25.3
20	14.8	15.9	13.3	16.5	15.2	14.7
Av.	21.8	21.4	27.8	23.4	21.0	23.9

L. S. D.		L. S. D.	
Tester	1% - 2.16	Inbred	1% - 1.68
	5% - 1.57		5% - 1.28

Mean of the expt. = 23.4

Appendix (Continued)

T7	T8	T9	T10	Total	Av.
24.1	24.9	21.3	20.9	[illegible]	23.5
29.5	29.9	28.6	28.6		28.4
29.2	23.6	28.6	24.7		27.0
28.5	25.5	27.5	25.4		27.3
22.8	24.8	25.7	22.4		25.9
26.2	26.7	26.4	23.2		24.4
21.2	20.5	24.0	18.2		20.8
21.0	20.7	25.6	29.8		23.3
27.0	28.2	32.6	27.3		28.2
19.2	17.7	19.5	20.9		18.7
29.7	23.7	21.7	20.7		22.3
18.7	18.5	22.1	19.6		19.2
19.5	19.5	27.3	20.6		21.0
25.5	27.0	25.9	22.2		25.3
29.1	23.6	26.7	25.9		26.1
23.3	23.8	25.0	21.4		22.9
20.4	19.9	22.9	20.0		20.3
23.3	27.2	22.8	23.6		23.4
26.9	26.3	23.5	25.2		25.0
13.3	18.0	17.9	13.2		15.3
23.9	23.5	24.8	22.7		

T1 - Oh 51

T2 - Oh 26

T3 - Ill.A

T4 - W23

T5 - Oh 51 x Oh 26

T6 - Ill.A x W23

T7 - Ohio M15

T8 - M14

T9 - M14 x WF9

T10 - Ia. 4483

Appendix VII

Average percentage of moisture for test crosses at Saginaw County

	T1	T2	T3	T4	T5	T6
1	20.5	16.4	28.2	19.6	17.8	20.8
2	22.0	21.4	27.9	24.6	22.3	26.5
3	21.1	18.8	28.0	18.3	18.7	21.1
4	19.9	19.6	30.8	20.8	20.2	23.9
5	19.9	20.0	30.0	20.0	18.9	22.3
6	19.7	18.5	24.2	23.0	19.9	22.8
7	19.2	15.7	21.7	20.2	17.4	21.2
8	20.3	17.1	24.8	21.3	18.1	20.3
9	21.9	18.8	26.3	20.0	21.2	23.6
10	18.2	15.3	21.8	18.4	14.3	19.7
11	17.8	16.9	23.0	19.8	17.3	19.8
12	17.5	17.3	22.9	18.2	19.5	20.6
13	18.4	15.8	22.1	20.1	17.6	21.8
14	24.1	17.9	24.4	21.7	19.5	24.8
15	20.9	18.0	25.5	21.1	18.6	22.5
16	20.2	16.4	27.5	18.3	18.4	21.2
17	17.3	15.5	23.3	18.7	17.4	20.0
18	16.9	19.3	27.5	21.5	17.7	24.4
19	19.3	19.1	24.9	20.6	17.1	21.6
20	16.2	15.6	15.9	17.6	15.1	15.6
	19.6	17.7	25.0	20.2	18.3	21.7

L. S. D.

Testers 1% - 1.66
5% - 1.2

L. S. D.

Inbreds 1% - 1.09
5% - .829

Average moisture = 20.0

Appendix (Continued)

T7	T8	T9	T10	Av.
18.7	19.9	18.1	21.2	20.1
25.9	22.0	24.1	25.4	24.2
20.9	18.6	21.9	19.8	20.7
19.6	17.5	18.7	22.8	21.4
21.9	19.0	20.1	20.5	21.2
20.8	21.2	21.6	20.2	21.2
19.1	16.3	18.7	17.6	18.7
18.0	17.4	19.9	23.1	20.0
20.5	19.4	21.8	20.2	21.4
15.3	16.4	17.2	17.7	17.4
19.1	18.3	19.4	18.0	18.9
19.3	18.4	17.9	17.3	18.9
16.2	14.9	16.9	18.1	18.2
20.7	21.6	20.8	21.3	21.7
21.6	18.1	21.0	21.3	20.9
20.9	16.6	19.9	19.0	19.8
21.2	16.7	17.8	19.3	18.7
17.8	18.1	17.3	19.4	20.0
21.3	19.3	20.4	19.6	20.3
18.5	16.2	16.0	15.4	16.2
19.9	18.3	19.5	19.9	

T1 - Oh 51

T2 - Oh 26

T3 - Ill.A

T4 - W23

T5 - Oh 51 x Oh 26

T6 - Ill.A x W23

T7 - Ohio M15

T8 - M14

T9 - M14 x WF9

T10 - Ia. 4483

Appendix VIII

Percentage stalk lodging in test crosses at M. S. U. Farm

Second cycle lines	Oh51	Oh26	Ill.A	W23	Oh51 X Oh26
1	16.8	9.8	9.0	16.2	20.7
2	20.7	3.4	12.3	45.2	20.1
3	6.7	6.7	78.4	11.1	9.1
4	4.6	8.1	39.9	10.1	9.0
5	26.2	4.8	26.7	21.8	9.4
6	19.6	4.6	50.6	13.4	14.6
7	12.6	5.7	23.0	12.6	5.6
8	7.8	6.0	7.2	10.3	18.6
9	9.6	4.9	7.8	8.9	7.8
10	8.3	8.8	42.2	12.0	15.0
11	10.4	12.8	6.7	6.7	13.4
12	9.5	3.6	16.0	4.4	10.1
13	41.4	13.1	4.6	6.9	29.8
14	30.7	8.5	21.3	21.1	23.3
15	11.6	8.9	46.0	37.0	10.1
16	15.1	7.5	10.4	9.0	15.5
17	10.1	3.7	8.0	5.6	9.1
18	14.6	9.1	39.9	35.3	23.2
19	12.6	6.8	21.3	15.5	11.1
20	11.9	9.1	10.7	8.0	12.5
Tester	300.8	145.9	482.2	311.1	288.0
Average	15.0	7.3	24.1	15.6	14.4

Appendix (Continued)

Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483		Av.
33.1	14.4	-	9.4	10.1	139.5	14.0
11.5	8.0	3.4	9.1	10.6	144.3	14.4
33.6	13.2	5.6	6.7	7.1	178.2	17.8
16.6	14.4	-	2.4	7.8	112.9	11.3
25.3	7.8	1.2	4.5	10.3	138.0	13.8
34.5	17.8	7.8	4.4	12.2	179.5	18.0
17.9	8.1	4.6	4.6	6.7	101.4	10.1
17.4	6.9	8.9	5.6	8.0	96.7	9.7
3.6	2.3	3.3	4.7	5.8	58.7	5.9
8.4	9.1	4.4	6.8	9.1	124.1	12.4
14.8	12.5	1.1	6.7	1.1	86.2	8.6
14.4	10.7	3.3	2.2	8.3	82.5	8.3
7.8	8.0	3.5	4.7	7.0	126.8	12.7
21.1	20.7	7.8	7.0	15.7	177.2	17.7
41.0	11.6	3.3	11.5	13.8	194.8	19.5
20.2	13.3	6.7	3.4	5.6	106.7	10.7
8.0	9.2	4.6	1.2	4.4	63.9	6.4
34.2	27.4	10.3	9.0	12.2	215.2	21.5
17.4	11.2	1.1	3.4	3.4	103.8	10.4
11.1	14.4	5.8	9.1	6.7	99.3	9.9
391.9	241.0	86.7	116.4	165.9		
19.6	12.0	4.3	5.8	8.3		

Appendix IX

Percentage stalk lodging in test crosses at Saginaw County

Second cycle lines	Oh51	Oh26	Ill.A	W23	Oh51 X Oh26
1	37.7	13.7	53.0	64.1	39.1
2	62.7	23.9	69.1	58.8	38.1
3	41.4	11.4	96.6	34.2	26.7
4	56.3	15.0	88.0	70.2	8.9
5	55.0	4.6	94.3	32.2	5.9
6	42.2	23.5	97.6	81.8	24.6
7	61.6	7.2	81.8	73.8	23.2
8	47.3	9.2	73.9	60.0	31.1
9	11.6	-	68.7	28.3	7.0
10	25.5	17.8	9.18	68.6	16.0
11	39.9	1.3	76.3	35.3	16.5
12	47.5	36.0	94.4	35.5	47.7
13	7.3	4.4	97.8	61.2	15.1
14	64.0	4.6	100.0	78.2	46.6
15	72.7	6.9	92.6	61.4	35.5
16	41.4	11.5	70.9	46.4	34.2
17	27.7	3.4	83.0	52.2	16.6
18	34.2	17.9	93.3	90.0	43.0
19	73.0	7.7	24.4	81.1	31.9
20	50.8	24.0	54.3	48.8	12.2
	899.8	244.0	1601.8	1162.1	519.9

Appendix (Continued)

Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483		
72.2	50.0	5.8	10.7	31.3	377.6	37.8
55.7	44.5	4.7	8.0	19.6	385.1	38.5
74.7	52.9	9.2	8.0	11.1	366.2	36.6
74.4	48.9	4.5	21.3	14.6	402.1	40.2
80.7	46.8	31.9	24.4	18.5	394.3	39.4
88.2	60.2	14.4	12.8	24.6	469.9	46.9
74.4	49.4	6.7	7.3	7.8	393.2	39.3
66.3	51.1	13.3	2.2	17.7	372.1	37.2
44.1	41.6	1.2	7.1	3.4	213.0	21.3
76.1	27.8	10.1	13.0	4.6	351.3	35.1
80.2	30.8	-	4.6	4.4	289.3	28.9
71.4	50.0	28.9	14.8	14.8	441.0	44.1
82.4	38.8	4.6	5.8	6.7	324.1	32.4
74.4	57.8	21.7	23.0	20.2	490.5	49.0
87.5	75.0	8.9	23.2	22.6	486.3	48.0
89.5	62.8	24.4	12.2	16.9	410.2	41.0
75.9	39.9	15.5	13.1	14.4	341.7	34.2
94.2	70.5	11.5	16.1	60.7	531.4	53.1
79.1	41.8	8.0	15.7	21.1	383.8	38.4
59.8	36.8	33.3	7.5	18.0	345.5	34.6
1501.2	977.4	258.6	250.8	353.0		
75.1	48.9	12.9	12.5	17.7		

[illegible]

Appendix X

Percentage of root lodging for test crosses at M.S.U. Farm

Second cycle lines	Oh51	Oh26	Ill.A	W23	Oh51 X 26
1	1.2	1.2	6.7	-	1.2
2	9.2	2.3	5.6	11.6	3.5
3	2.2	3.4	14.8	2.2	-
4	1.1	-	3.4	5.6	5.6
5	1.1	-	31.3	2.3	7.1
6	-	1.2	5.6	-	-
7	-	-	2.3	-	-
8	-	-	1.2	-	1.2
9	-	2.4	1.1	-	2.2
10	7.1	-	4.4	1.2	-
11	10.4	-	-	1.1	-
12	-	-	2.3	-	-
13	-	-	1.1	5.8	-
14	1.2	-	-	1.1	-
15	5.8	-	3.4	6.7	2.2
16	-	2.5	1.2	-	-
17	1.1	-	3.4	-	1.1
18	20.2	8.0	30.8	6.8	4.6
19	-	-	5.6	1.1	1.1
20	1.2	-	4.8	2.3	1.1
	61.8	21.0	129.0	47.8	30.9
	3.1	1.0	6.5	2.4	1.5

Appendix (Continued)

Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483		
2.3	-	-	-	-	12.6	1.3
1.2	4.6	-	1.1	1.2	40.3	4.0
3.4	6.0	1.1	1.1	2.4	36.6	3.7
4.4	13.3	2.2	-	2.2	37.8	3.8
1.2	2.2	1.2	-	3.4	49.8	5.0
3.6	1.1	1.1	-	-	12.6	1.3
1.1	1.2	-	-	-	4.6	.4
1.2	2.3	-	1.1	-	7.0	.7
-	-	2.2	1.2	-	9.1	.9
-	2.3	-	-	-	15.0	1.5
-	5.7	-	2.2	1.1	20.5	2.1
-	-	-	-	-	2.3	.2
1.1	-	-	-	-	8.0	.8
1.1	6.1	-	1.2	5.6	16.3	1.6
5.7	10.8	3.3	2.3	1.2	41.4	4.1
1.1	3.3	-	1.1	1.1	10.3	1.0
-	1.2	9.1	-	1.1	17.0	1.7
1.1	5.7	-	5.6	12.2	95.0	9.5
-	-	-	-	-	7.8	.78
-	-	-	-	-	9.4	.94
28.5	65.8	20.2	16.9	31.5		
1.4	3.3	1.0	0.8	1.6		

Appendix XI

Percentage of root lodging for test crosses at Saginaw County

Second cycle lines	Oh51	Oh26	Ill.A	W23	Oh51 X 26
1	10.0	13.7	14.8	-	-
2	10.4	4.0	-	7.1	3.6
3	24.2	12.5	-	6.8	11.6
4	4.6	10.4	-	2.4	8.9
5	14.4	10.4	-	-	4.7
6	5.6	7.8	-	-	-
7	-	4.8	-	-	4.6
8	-	3.4	4.4	-	2.2
9	5.8	4.1	-	4.9	4.2
10	1.1	-	-	-	2.3
11	-	5.2	-	3.4	2.4
12	-	4.8	-	-	-
13	14.6	14.4	-	2.4	4.6
14	5.6	4.6	-	-	5.6
15	4.6	3.4	-	6.8	6.7
16	7.8	13.8	19.7	10.7	5.7
17	5.0	3.4	-	1.1	-
18	16.0	3.4	2.7	-	16.0
19	-	-	10.0	4.4	-
20	1.4	-	-	-	5.6
	131.5	204.1	51.6	50.0	88.7
	6.6	10.2	2.6	2.5	4.4

Appendix (Continued)

Ill.A X W23	Ohio M15	M14	M14 X WF9	Ia. 4483		
1.1	1.2	2.3	-	-	43.1	4.3
11.3	-	-	3.4	-	39.8	4.0
3.4	6.9	4.6	8.0	-	78.0	7.8
-	6.8	2.2	-	6.7	42.0	4.2
4.8	2.4	4.6	3.3	6.6	131.2	13.1
-	-	3.3	2.3	1.1	20.1	2.0
-	-	-	-	1.1	10.5	1.1
-	-	-	-	-	10.0	1.0
-	-	-	-	-	19.0	1.9
-	-	-	-	-	3.4	.3
-	2.5	-	-	2.2	15.7	1.6
3.6	-	5.6	-	-	14.0	1.4
-	-	10.4	-	10.1	56.5	5.7
2.2	3.6	2.3	-	2.4	26.3	2.6
2.3	-	3.3	9.3	-	36.4	3.1
-	2.3	3.3	20.0	6.5	89.8	9.0
-	-	-	-	-	9.5	.9
-	1.1	-	-	2.2	41.4	4.1
-	-	-	-	-	14.4	1.4
-	-	-	-	3.6	10.6	1.1
28.7	26.8	41.9	46.3	42.5		
1.4	1.3	2.1	2.3	2.1		