A COMPARISON OF SOME STATISTICAL STUDIES OF HYBRID CORN TRIALS

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E. E. Down

Major professor

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A COMPARISON OF SOME STATISTICAL STUDIES OF HYBRID CORN TRIALS

by

KENNETH J. FREY

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A COMPARISON OF SOME STATISTICAL STUDIES OF HYBRID CORN TRIALS

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INTRODUCTION

In the randomized design used for the Farm Crops Department corn trials in 1943, and years previous, half of the experimental area was used by the check variety. The question arises, is it necessary to use half or even a quarter of the experimental area for checks? This question forms the basis for part of the investigations that the writer presents in this paper.

The other part of these investigations deals with the particular field design for corn used in 1944, and is undertaken with the hope of finding a method by which the lowest valid standard error for the whole experiment can be obtained.

REVIEW OF PREVIOUS LITERATURE

Love (3) states that in the system of randomization and its analysis of variance, there is a general tendency to have few or no check plots. He also states, "For many kinds of experiments it is important to use checks, but although the deviations are smallest when the checks are placed at frequent intervals, it may not be necessary to locate the checks as closely together as indicated by the preliminary data since this will require a considerable area of land for the checks."

The method of averaging standard errors has been used by Down and Brown (1) in wheat studies. Their errors were based upon percentages of mean yields. Hays and Garber (2) feel that the method of obtaining an error is more or less of an arbitrary matter depending on the degree of accuracy wanted.

Hayes and Garber (2) quote the following with regard to using the probable error of the checks for the error of all varieties. "It is possible to use sufficient check plots so that the computed probable error of a single determination, i. e., SD x ±.6745, may be reliable for the variety in question."

Down and Brown (1) in wheat investigations consider the error of checks to be that of the varieties when testing for significance between varieties.

MATERIALS

The data on yield per acre used in this investigation was collected from corn trials in 1943 and 1944.

1943 data:

In 1943 the corn varieties were planted in randomized blocks, each replicated five times, with chedks occurring in every other plot. A plot consisted of one row ten hills long, with each hill being thinned to three stalks when the seedlings were about four inches high. The trials selected for these studies were: Saginaw County with 28 varieties; Huron County with 25 varieties; St. Joseph County with 39 varieties. Other trials were not used because they did not contain sufficient data. The yields were corrected for missing stalks.

1944 data:

A different planting plan was selected for use in 1944, when a design consisting of a series of 6 x 6 Latin squares was adopted. Five varieties were planted in each square along with a sixth variety which was common to all squares. This sixth variety served as a standard. Also, one row of this common variety was planted between successive squares.

The plots in these trials were one row wide and 12 hills long, with the two least desirable hills being discarded at harvest time. The corns were thinned to three stalks per hill as in 1943. Six trials were selected for

investigation. Huron County trial with five squares; Otsego County with three squares; Montcalm County with four squares; Clare County with four squares; Sanilac County with four squares; Ingham County with eight squares. No yield corredtions were made for missing stalks in 1944.

Yields per acre were calculated on the basis of fifteen and one-half per cent moisture, so that all varieties regardless of date of maturity would be on a comparable dry weight basis. The formula used for calculation considered 70 lbs. per bushel, because the weights were taken on ear corn.

For the check-standard, a variety was used which was considered as average for maturity and yield within the locality in which the trial was conducted.

PRESENTATION AND DISCUSSION

1943 data:

Discussion of 1943 data

The order of ranking by actual and coefficient of yield values is given in tables 7, 8, and 9, for the 1943 trials investigated. Coefficient of yield values, often referred to as P/C, were calculated according to Spragg's method (5), with the "C", or theoretical plot yields, being obtained by grading the soil between check plots. The arrangement of checks used in calculating P/C values were as follows: (1) check in every second plot; (2)check in every fourth plot; (3)check in every sixth plot.

It is very apparent from a study of these tables that within the same trial, the P/C rankings of the first and last few varieties conform very closely with the actual yield ranking of the same varieties. In the Saginaw trial (table 7) five of the first seven varieties are common to all four methods of ranking. The same variety, Funk 303, occurs in first place for all methods of analysis, while Funk G12 occurs three times in second place and once third, and Pioneer 373 ranges from second to fourth place. The other two varieties of the five are Walters 274 and 368, with the former dropping to seventh place in the case of checks every second plot. Also in this same trial, five of the last seven places are occupied by varieties common to all methods of ranking, and the arrangement is almost identical to that described for the top ranking varieties. Funk G174 occurs in

last place each time.

The trial in Huron County gave results similar to those found in the Saginaw trial. Five of the first six places were accupied by varieties common to all methods of ranking, and the top three varieties were the same for each method, except that they changed order in two cases. Fourth spot was held by the same variety by each method. The last four spaces were occupied by varieties common to all methods of ranking, but the order is different in each case.

Again, in the St. Joseph trial, the results conform to those already described. As shown in table 9, four of the first seven places are held by varieties common to actual and to the three P/C rankings, and the top variety is Pioneer 314 in all cases; but the bottom place standings do not show quite the unanimity of ranking by the different methods as do the previous trials. Only three of the last seven places are held by varieties common to all methods of ranking.

The central portions of these ranking arrays show no uniformity whatsoever. Within the same trial, the varieties may fluctuate up and down as much as twelve or fourteen places from one method of ranking to another. However, this is to be expected because the difference which distinguishes between two varieties five places apart may be such that if 0.3 of a bushel were added to the lower one, it would supplant the one five places above it. A very small change induced by a different method of analysis could send a variety either way up or way down in the central portion. As a whole, the

checks do not seem to facilitate the selection of top or bottom ranking varieties. Actual yields are about as reliable in picking them, and, if checks are desirable, the results bear out that they give as reliable data from which to draw conclusions when planted every sixth plot as when planted every second or fourth plot, and much less land is used.

1944 data:

1944 tests for significance

Tables 10, 11, 12, 13, 14, and 15 give the varieties ranked in order of decreasing magnitude of actual yield per acre for each trial. In the keys of these tables are given the differences needed between variety means for significance as calculated from standard errors, as obtained from the different methods of analysis.

The difference for significance is calculated from the following formula:

$$\text{diff. for sig.} = st\sqrt{\frac{2}{n}}$$

In the formula, "s" is the standard error as determined from the error line, "t", for the degrees of freedom of the error line, is obtained from a table of "t" values, and "n" is the number of determinations that are included in a variety mean. Analyzing differences between variety means is facilitated by calculating the "difference for significance."

1944 standard error comparison

The standard errors for 1944 data were worked by four different methods of analysis for each trial.

Table 1. Table showing layout and analysis of Square 1, Otsego County

Field arrangement:

	Rows						
Columns	A	B	C	D	E	F	Total
1	70.2	85.6	73.2	66.6	61.2	65.5	422.3
2	80.8	83.3	69.7	60.4	58.8	63.5	416.5
3	72.8	85.5	60.9	58.8	53.2	51.0	382.2
4	84.5	72.9	52.5	61.9	39.0	74.7	385.5
5	94.3	86.6	58.2	51.1	56.0	67.2	413.4
6	89.9	76.9	63.9	62.0	47.1	80.1	419.9
S	492.5	490.8	378.4	360.8	315.3	402.0	2439.8
	82.1	81.8	63.1	60.1	52.7	67.0	

Arrangement by varieties:

	A	B	C	D	E	F		Av
G176	70.2	76.9	58.2	60.4	39.0	51.0	355.7	59.3
177	80.8	86.6	60.9	61.9	47.1	65.5	402.8	67.1
KE1	72.8	72.9	63.9	66.6	58.8	67.2	402.2	67.1
51B	84.5	85.5	73.2	62.0	56.0	63.5	424.7	70.8
F40	94.3	83.3	52.5	58.8	61.2	80.1	430.2	71.7
11A	89.9	85.6	69.7	51.1	53.2	74.7	424.2	70.7
							2439.8	

$CT = 165,350.67$

$SS_{tot} = 171,499.14 - 165,350.67 = 6,148.47$

$SS_{col} = 165,618.70 - 165,350.67 = 268.03$

$SS_{row} = 169,637.03 - 165,350.67 = 4,286.36$

$SS_{var} = 165,987.10 - 165,350.67 = 636.43$

Analysis:

Source	D.F.	S.S.	M.S.	Error
Total	35	6,148.47		
Col	5	268.03	53.61	
Row	5	4,286.36		
Var	5	636.43	127.29	
Error	20	957.65	47.88	6.98

Table 2. Table showing layout and analysis of Square 2, Otsego County

Field arrangement:

	Rows						
Columns	A	B	C	D	E	F	Total
1	79.1	77.7	72.0	59.3	65.9	72.3	426.3
2	80.9	85.9	67.1	77.5	49.5	79.2	440.1
3	77.1	79.8	80.0	62.3	48.8	80.7	428.7
4	81.4	80.6	75.7	61.9	58.0	66.4	424.0
5	84.1	65.4	77.3	53.6	60.4	71.9	412.7
6	81.3	75.7	70.2	63.5	64.5	67.7	422.9
S	483.9	465.1	442.3	378.1	347.1	438.2	2554.7
	80.7	77.5	73.7	63.0	57.8	73.0	

Arrangement by varieties:

	A	B	C	D	E	F		Av
F21	79.1	75.7	77.3	77.5	58.0	80.7	448.3	74.7
KE2	80.9	65.4	80.0	61.9	64.5	72.3	425.0	70.8
W225	77.1	80.6	70.2	59.3	49.5	71.9	408.6	68.1
MS2	81.4	79.8	72.0	63.5	60.4	79.2	436.3	72.7
S4	84.1	85.9	75.7	62.3	65.9	67.7	441.6	73.6
Ck	81.3	77.7	67.1	53.6	48.8	66.4	394.9	65.8

$CT = 181,291.45$

$SS_{tot} = 184,716.84 - 181,291.45 = 3425.39$

$SS_{col} = 181,357.51 - 181,291.45 = 66.06$

$SS_{row} = 183,593.96 - 181,291.45 = 2302.51$

$SS_{var} = 181,644.35 - 181,291.45 = 352.90$

Analysis:

Source	D.F.	S.S.	M.S.	Error
Total	35	3,425.39		
Col	5	66.06	13.21	
Row	5	2,302.51		
Var.	5	352.90	70.60	
Error	20	703.92	35.19	5.93

Table 3. Table showing layout and analysis of Square 3, Otsego County

Field Arrangement:

Columns	Rows A	B	C	D	E	F	Total
1	83.4	79.2	83.8	61.4	63.1	62.5	433.4
2	75.9	84.0	70.1	67.0	71.2	54.4	422.6
3	78.9	68.1	76.9	69.2	64.0	68.8	425.9
4	74.4	75.7	62.1	65.2	74.9	59.0	411.3
5	80.7	71.5	61.5	57.5	52.1	59.2	382.5
6	76.2	57.9	63.3	70.6	59.6	51.1	378.7
S	469.5	436.4	417.7	390.9	384.9	355.0	2454.4
	78.3	72.7	69.6	65.2	64.2	59.2	

Arrangement by varieties:

	A	B	C	D	E	F		Av
KF1	83.4	57.9	61.5	67.0	74.9	68.8	413.5	68.9
KF2	75.9	71.5	76.9	65.2	59.6	62.5	411.6	69.6
W255	78.9	75.7	63.3	61.4	71.2	59.2	409.7	68.3
240	74.4	68.1	83.8	70.6	52.1	54.4	403.4	67.2
MS4	80.7	84.0	62.1	69.2	63.1	51.1	410.2	68.4
Ck	76.2	79.2	70.1	57.5	64.0	59.0	406.0	67.7

$CT = 167,335.53$

$SS_{tot} = 170,261.66 - 167,335.53 = 2,926.13$

$SS_{col} = 167,784.12 - 167,335.53 = 448.59$

$SS_{row} = 168,720.72 - 167,335.53 = 1,395.19$

$SS_{var} = 167,347.08 - 167,335.53 = 11.55$

Analysis:

Source	D.F.	S.S.	M.S.	Error
Total	35	2,926.13		
Col	5	448.59	89.72	
Row	5	1,395.19		
Var	5	11.55	2.31	
Error	20	1,070.80	53.54	7.31

Method one or "individual squares average" method, is the method where each square of a trial is analyzed individually, giving a standard error for each. From these, an average of the standard errors of all the individual squares is obtained and this average is used as the error for the whole experiment. This method is illustrated by the data from Otsego County. Analyses of these squares are given in tables 1, 2, and 3. The averaging is done as follows:

Sq. No.	Error obtained
1	6.98
2	5.93
3	7.31
Average	6.35

Method two or "as a randomized experiment" is illustrated by data obtained from Otsego County as given in table 4. The analysis table is as follows:

Analysis of variance

Source	D.F.	S.S.	M.S.	Error
Total	107	12726		
Between Rep.	5	6493		
Between Var.	15	1146	74.40	
Within stand.	12	403	33.55	
RxV (error)	75	4684	62.45	
Error + Within St.	87	5087	58.47	7.64

"Within standards" is obtained from an "analysis of standards" table:

Analysis of variance on standards

Source	D.F.	S.S.
Total	17	2596
Rep.	5	2193
Within st.	12	403

In this design, the rows of the Latin squares become the replications, so all row A's in the squares are included in replication one, B's in replication two, etc., thus making

Table 4. Otsego County data. Table showing how data is set up for analysis by method two.

	Standards from square				Varieties from square 1				
Rep	1	2	3	s of standards	Funk G176	Funk G177	Kgscrost KE1	Mich 51B	Masters F40
1	89.9	81.3	76.2	247.4	70.2	80.8	72.8	84.5	94.3
2	85.6	77.7	79.2	242.5	76.9	86.6	72.9	85.5	83.3
3	69.7	67.1	70.1	206.9	58.2	60.9	63.9	73.2	82.5
4	51.1	53.6	57.5	162.2	60.4	61.9	66.6	62.0	88.8
5	53.2	48.8	64.0	166.0	39.0	47.1	58.8	56.0	61.2
6	74.7	66.4	59.0	200.1	51.0	65.5	67.2	63.5	80.1
Var s	424.2	394.9	406.0	1225.1	355.7	402.8	402.2	424.7	430.2

	Varieties from square 2					Varieties from square 3					
Rep	Masters F21	Kgscrost KE2	Wisc 255	Mich 52	Mich 54	Kgscrost KF1	Kgscrost KF2	Wisc 255	Wisc 240	Mich 54	Rep Sum
1	79.1	80.9	77.1	81.4	84.1	83.4	75.9	78.9	74.4	80.7	1445.9
2	75.7	65.4	80.6	79.8	85.9	57.9	71.5	75.7	68.1	84.0	1392.3
3	77.3	80.0	70.2	72.0	75.7	61.5	76.9	63.3	83.8	62.1	1238.4
4	77.5	61.9	59.3	63.5	62.3	67.0	65.2	61.4	70.6	69.2	1129.8
5	58.0	64.5	49.5	60.4	65.9	74.9	59.6	71.2	52.1	63.1	1047.3
6	80.7	72.3	71.9	79.2	67.7	68.8	62.5	59.2	54.4	51.1	1195.2
Var s	448.3	425.0	408.6	436.3	441.6	413.5	411.6	409.7	403.4	410.2	7448.9

the replications continuous across the field. The randomized design formed is very special in that each variety occurs within a width of six plots for all replications.

Method three treats the whole experiment as one unit, but the squares making up the trial retain their individuality. This type of analysis will be illustrated by data from Otsego County. The complete analysis is as follows:

Analysis of variance

Source	D.F.	S.S.	M.S.	Error
Total	107	12726		
Between Sqs.	2	218		
Between Rep.	5	6493		
S x R	10	1107		
Between Col.	15	783		
Between Var.	15	1146	76.46	
Error	60	2979	49.65	7.05

S x R is obtained from the two-way table, analysis of R by S.

Analysis of variance for S x R

Source	D.F.	S.S.
Total	17	7818
Sq.	2	218
Rep.	5	6493
S x R	10	1107

Col. S.S. is obtained by adding the "Column Sums of Squares" from individual analysis. Var. S.S. is obtained the same as Col. S.S.

Method four (checks and standards) errors are calculated from the assembled data of checks and standards, with each being considered as a variety, so that between x's (varieties) and "between replications" sums of squares can be extracted from the total. The table of analysis worked on Otsego County data by this method is as follows:

Analysis of variance of checks and standards

Source	D.F.	S.S.	M.S.	Error
Total	41	5667		
Between Rep.	6	3769		
Between x's	5	687		
Error	30	1211	40.37	6.35

Discussion of standard error comparison

Table 5. 1944 overstate corn trials. Standard errors given in bushels as obtained by different methods of analysis.

Method No.	Nature of method	County trials					
		Huron	Mont-calm	Otsego	Sani-lac	Clare	Ingham
I	Individual sqs. (Av.)	10.02	9.55	6.74	8.03	7.75	8.17
II	Randomized exp.	9.94	8.54	7.64	7.60	8.81	9.02
III	As unit with sqs. retaining indi-viduality	10.10	9.88	7.22	8.34	7.44	8.14
IV	Checks and stand-ards	9.81	6.34	6.35	5.66	7.55	10.00
	Am't needed for sig. between methods at 5% level	4.00	3.90	3.68	3.37	3.57	2.79

The standard errors as obtained by these four methods of analysis are assembled in table 5.

Table 5 shows that the errors obtained by the average of individual squares are higher than the "checks and standards" errors in every case but one, that being in Ingham County where a reversal occurred. Huron County trial with a difference in errors of 0.21 bushels between methods one and four represents the smallest difference, while Montcalm County with 3.21 bushels represents the largest, the difference being in favor of method four in each case. This latter difference approaches the amount needed for significance between methods.

When comparing methods two and four, the same relationship holds as did with the former case. Ingham County again was opposite the other five trials. It is of interest to note that even before calculations were started, Ingham County trial was labeled as a poor experiment, for the trial was non-uniform. The differences between standard errors for methods two and four range from 0.13 bushels in Huron County to 2.2 bushels for Montcalm County. This shows that a somewhat closer relationship exists between methods two and four than exists between methods one and four.

Errors by method one are higher than those by method two in three trials, Huron, Montcalm, and Sanilac; while errors occur lower by method one than by method two in three trials also, Otsego, Clare, and Ingham. Errors by "average of individual square" analyses range from 1.01 bushels higher in Montcalm County to 1.06 bushels lower in Clare County than errors by the randomized experiment.

Under method three, lowest errors of any method are gotten in two county trials, Clare and Ingham, and in three of the trials, Huron, Montcalm, and Sanilac, the highest error is obtained by this method. In Otsego County trial, the randomized experiment analysis gives a slightly higher error than any other method used. Errors by methods one and three are very close together, ranging from 0.48 bushels below in Otsego County for method one than method three, to .31 bushel above in Clare County. This latter statement is to be expected because the methods are very similar; only one difference is present: replications are considered in method

three as they are in method two. Errors obtained by method three are lower than those by method one in two out of the six cases, being 0.31 bushels lower in Clare County and 0.06 bushels lower in Ingham County. A comparison of methods two and three shows that the errors by the latter are smaller in three out of six counties, these being Otsego, Clare, and Ingham. Differences between methods three and four approach significance in Montcalm, Sanilac, and Ingham counties.

Errors obtained by method four are smaller than errors by any other method in Huron, Montcalm, Sanilac, and Otsego Counties.

No significant difference is present between the errors as obtained by different methods within any of the trials. This was tested at the 5% point, and the differences needed for significance are given in the lower line of table 5.

Probably the greatest disadvantage of obtaining an error by method one is that if one square has an exceptionally large error, the average error is boosted enormously.

The corn experiments here in Michigan are laid out so that varieties of about equal maturity occur in the same square. This means that early maturing varieties occur in one square, medium maturing varieties in another, and late maturing in still another, and the early maturing square is not expected to yield as well as is the late maturing one. The varieties so arranged in a square will need heavy moisture and high temperatures at approximately the same time, so weather conditions will be either beneficial or detrimen-

tal to a whole square. From this, it becomes apparent that a difference is apt to occur between squares, and if this does occur, it would be eliminated by extracting the difference between squares as in method three. This method takes out "difference between squares", which is lacking in the randomized experiment method.

The method of analysis giving the lowest error in Huron, Montcalm, Otsego, and Sanilac Counties is "checks and standards," which is in reality a measure of soil heterogeneity of the experimental field. If all varieties are expected to respond nearly the same to environmental factors as the standard variety, an error obtained from the standard and check variety would be a logical one to use when testing for significance between variety means, but if all varieties throughout the experiment do not respond alike, as they seldom do, some other method for analyzing should be used.

Ranking of varieties in 1944

Tables 16, 17, 18, 19, 20, and 21 give ranking of varieties in 1944 trials in bushels per acre according to decreasing magnitude. Section one in each table contains the varieties as they ranked with yield per acre calculated by what will be referred to here as method one or the "add and subtract" method. This is done in the following manner: the mean yields of the checks on either side of the square and the mean yield of the standard within that square are averaged. The amount that this average is above or below the average yield of all checks and standards in the trial is added to or subtracted from the mean of each variety

within this particular square. The method proceeds for all squares in like manner.

Method two or actual yield ranking of varieties given in section two of each table is from the raw data, letting each variety stand as it yielded with no corrections.

Method three or P/S method of ranking varieties is given in section three of each table. P/S yields in 1944 were derived by dividing the mean yield of each variety in a square by the mean yield of the standard within that square.

First place is held by the same variety for all three methods of ranking in four of the trials; Mich 30 in Huron, Ohio M15 in Montcalm, Master F21 in Otsego, and Mich 59 in Sanilac, but in Clare trial, Mich 20 ranks first in sections one and two, and drops to third place in section three. Ingham County shows no consistency of first place holders.

It is of interest to note the Otsego trial where the first three and last three places are occupied by the same varieties in all sections.

Rankings by the add and subtract method conform more closely to actual yield rankings than do those by P/S method, but section one seems to be more closely related to section three than does section ? to section three. In other words, the add and subtract method seems to form "a happy medium" between the other two methods.

Table 6. 1944 data. Correlation coefficients between different methods of ranking varieties.

County trial	Between methods			Cor. coef. needed for sig. at 2 levels	
	1 & 2	1 & 3	2 & 3	5%	1%
Huron	0.551	0.818	0.556	0.396	0.505
Montcalm	.937	.358	.109	.444	.561
Otsego	.899	.938	.876	.514	.641
Sanilac	.890	.719	.394	.444	.561
Clare	.952	.527	.345	.444	.561
Ingham	.888	.835	.580	.325	.418

Key:	Method No.	Method
	1	Add and subtract
	2	Actual yield
	3	[illegible]

Discussion of correlation coefficients

For further evidence as to which method of ranking proves best, correlation coefficients have been worked between the yields as obtained by methods one and two, one and three, and two and three for the six trials, and these coefficients are assembled in table 6. All values are positive.

The correlation coefficients between methods one and two, given in column one, all prove to be highly significant when tested against the values needed for significance given in column four. Huron trial gives the lowest value in this comparison with a coefficient equal to 0.551, and the next lowest coefficient value is 0.888 for Ingham County.

In the comparison between methods one and three, the correlation coefficients are highly significant in four cases and significant in one case. The Montcalm trial coefficient is not significant at either the 5% or the 1% level. In only two instances did the coefficients for

methods one and three exceed the coefficients for methods one and two, these being Huron and Otsego counties. It can be said, in general, that the coefficients in column two are lower than those in column one.

The correlation coefficients between methods two and three are high enough for significance in only three counties, Huron, Otsego, and Ingham, and all of these are highly significant. The coefficient for Montcalm is 0.109, and only one coefficient goes above the 0.580 of Ingham, this being Otsego with 0.876. Correlation coefficients obtained between methods two and three are lower in every case than either of the first two comparisons, with the exception of Huron County, where the coefficient in column three is 0.556 and in column one is 0.551.

From the foregoing discussion on the correlation coefficients, it can be seen that a closer relationship exists between the add and subtract and actual yield methods of treating varieties than exists between either of these two methods and the P/S method. A closer relationship also exists between add and subtract and P/S methods than exists between actual yield and P/S methods of treating varieties. The statements made in this paragraph further substantiate the fact that method one places varieties on a plane between the other two methods.

Discussion of ranking arrays

A true picture of why a drop occurs in correlation coefficient when P/S method enters into it, can be better shown

Table 6a. Scatter diagrams showing relationship between the placement of varieties by the three methods of ranking. Montcalm County data.

1.

Add and subtract \ Actual yield	82	80	78	76	74	72	70	68	66	64	62	60
80	1											
78												
76			1									
74												
72					1							
70							2	1				
68							1	3		1		
66									2		1	
64								1		2	2	
62												1

r = 0.937

2.

P/S \ Actual yield	82	80	78	76	74	72	70	68	66	64	62	60
74	1									1		
72											2	
70			1								1	
68					1							1
66												
64							1	3				
62							2		1			
60								2		1		
58									1			
56										1		

r = 0.109

3.

Add and subtract \ P/S	74	72	70	68	66	64	62	60	58	56	54	52
80	1											
78												
76			1									
74												
72				1								
70						1	2					
68	1					3		1				
66		1					1		1			
64		1	1					2		1		
62				1								

r = 0.358

by the accompanying tables 6a1, 2, and 3. These tables are called scatter diagrams and are designed to present graphically the relationship between variety placement by two methods of ranking, for each diagram.

In table 6a1, it can be seen that the population forms a homogeneous group running diagonally from the upper left hand corner to the lower right hand corner, and this makes a high correlation coefficient. In table 6a2, a large group of the population runs the same as in table 6a1, but in the upper right hand corner is a group of five varieties. When the original data of these particular varieties is examined, it is found that they all occur in the same square. The same group of five varieties are found in a group by themselves in the lower left hand corner of table 6a3. A group of values separated in this manner will cause the correlation coefficient to be reduced considerably. The value worked from table 6a2 gave a coefficient 0.109 and table 6a3 gave a coefficient of 0.358, neither of them being high enough for significance.

As mentioned above, each of those small groups that are apart from the rest of the population are the same group, and the group is composed of five varieties from the same square. In this particular square the standard had an exceptionally low value, so all P/S values in this square were boosted up enormously. The same thing occurred in several of the other trials. This provides a limitation on the use of the P/S method of ranking varieties.

The "add or subtract" method has an advantage over the P/S method, because an average of 18 plots is used to determine how much will be added to or subtracted from variety means, while in the latter, the corrections are based upon the average of only six plots. In the first method, use is made of the six plots used in P/S determinations plus the 12 check plots, six on either side of the square. It is better to draw conclusions from results where more determinations are used, in order to obtain more accuracy.

When ranking by actual yield, the varieties are allowed to fall wherever in the ranking array they will, with no corrections. If one of the plots does fall down, the whole average is dragged down with it. If a square should happen to occur on a poor part of the field, all of the varieties in that square will be dropped down in the ranking array, but if corrections are made according to checks and standards, which will also probably be low, the varieties will be raised to an equal basis with the remainder of the field.

SUMMARY

For this investigation there were available data from three hybrid corn trials grown in 1943 and from six trials grown in 1944. The investigation was carried on to attempt an answer to two questions: (1) does a check planted every sixth plot give as valid results upon which to judge varieties on test as if planted every second or fourth plot? (2) what is the method of analysis by which the lowest valid error can be obtained from the design composed of 6 x 6 Latin squares?

Calculations have been worked on the data and from the results given in this paper, the following conclusions may be drawn:

(1) The first few and last few varieties of the ranking array, as ranked by actual yields and by $\frac{P}{C}$ values calculated from checks every other plot, checks every fourth plot, and checks every sixth plot, are approximately the same. This fact leads one to believe that if checks are needed at all, it is quite sufficient if they are placed in every sixth plot.

(2) Varieties within the central portion of these ranking arrays do not show the uniformity of placement as mentioned in conclusion number one. However, they behave as would be expected, because 0.32 bushels added to a variety yield by another method of ranking could boost that variety five places or even more.

(3) Of four methods of analysis used on 1944 data, the method which treated the experiment as a unit but left the

squares with their individuality, gave the lowest errors in two cases, and the "checks and standards" errors were lowest in four cases. The "as a unit with squares retaining individuality" errors were lower than the "average of individual squares" errors in two out of six cases, and lower than "randomized experiment" errors in three out of six cases.

(4) "Checks and standards" errors are lower than errors from either "average of individual square" errors, or "randomized experiment" errors in five out of six cases.

(5) No significant differences were found between any two of the methods of analysis within the same trial, but in several cases, the differences approach significance.

(6) From the methods of ranking 1944 varieties, the "add and subtract" method seems to place varieties somewhere between P/S and actual yield ranking. This conclusion is based upon data given in tables 16, 17, 18, 19, 20, and 21, and upon correlation coefficients worked between the different methods of ranking the varieties.

(7) A limitation occurred in use of the P/S method, because several trials were found, where a poor standard yield would boost all of the varieties of a square way out of line with the remainder.

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APPENDIX

Tables 7 - 21 inclusive

In the following tables Hoosiercrost and Kingscrost are abbreviated respectively as Hsrcrost and Kgscrost.

Table 7. Saginaw County data. Comparison of methods of ranking varieties.

Method of ranking:

Rank No.	Actual yield	Yield in bu.	P/C values from checks every two plots	Yield in bu.	P/C values from checks every four plots	Yield in bu.	P/C values from checks every six plots	Yield in bu.
1	Funk 303	103.1	Funk 303	103.0	Funk 303	101.7	Funk 303	102.0
2	Funk G12	97.4	Funk G12	98.4	Pioneer 373	100.6	Funk G12	96.7
3	Pioneer 373	96.4	Mich 30	95.5	Funk G12	100.1	Pioneer 373	95.4
4	Walters 274	89.6	Pioneer 373	93.5	Walters 368	94.8	Walters 274	92.2
5	Walters 368	89.2	Mich 44	92.5	Mich 30	93.1	Walters 368	91.8
6	Mich 35	88.6	Walters 368	92.2	Walters 274	92.6	Mich 38	91.3
7	Ohio M15	87.3	Walters 274	91.8	Mich 38	92.2	Pioneer 355	88.7
8	Pioneer 370	87.2	Mich 38	88.6	Pioneer 355	90.1	Funk 213	86.8
9	Mich 30	86.5	Mich 35	88.2	Mich 35	90.0	Ohio M15	86.6
10	Pioneer 355	86.4	Ohio M34	86.6	Funk 213	87.8	Mich 30	85.8
11	Mich 38	85.8	Ohio M15	86.6	Ohio M34	87.2	Mich 44	84.9
12	Mich 44	84.4	Pioneer 355	86.6	Mich 44	86.4	Mich 35	84.8
13	Funk 213	84.3	Funk 213	86.5	Ohio M15	85.2	Kings KN1	83.9
14	Kings KN1	84.3	Pioneer 370	85.9	Mich 20	84.8	Kings KS6	83.9
15	Ohio M34	83.8	Mich 20	84.1	Kings KN1	84.2	Mich 20	83.7
16	Mich 20	83.0	Kings KN1	83.7	Pioneer 370	83.9	Pioneer 370	83.7
17	Pioneer 375	82.8	Kings KS6	80.7	Kings KS6	83.0	Ohio M34	83.3
18	Kings KS6	82.6	Pioneer 359	79.3	Pioneer 359	80.4	Pioneer 359	81.7
19	Pioneer 359	81.8	Pioneer 375	78.7	Pioneer 375	80.2	Pioneer 375	80.5
20	Kings KS2	75.9	Mich 36B	74.7	Kings KS2	74.9	Kings KS2	75.3
21	Kings D4	74.6	Kings D4	74.5	Kings D4	74.4	Kings D4	72.9
22	Mich 49	71.1	Mich 40	73.3	Mich 36B	72.7	Mich 36B	72.6
23	Mich 36B	70.5	Kings KS2	72.5	Mich 40	72.3	Mich 40	72.0
24	Mich 40	70.1	Mich 51B	68.9	Mich 49	71.9	Mich 51B	68.9
25	Mich 51B	69.3	Jacques 1001j	68.6	Mich 51B	69.7	Mich 49	68.4
26	Jacques 1001j	69.1	Mich 49	68.0	Jacques 1001j	69.5	Jacques 1001j	68.3
27	Funk G174	67.6	Funk G174	63.8	Funk G174	66.0	Funk G174	68.2

Table 8. Huron County data. Comparison of methods of ranking varieties.

Method of ranking:

Rank No.	Actual yield		P/C values from checks every two plots		P/C values from checks every four plots		P/C values from checks every six plots	
		Yield in bu.		Yield in bu.		Yield in bu.		Yield in bu.
1	Funk G175	93.8	Funk G175	92.8	Funk 213	93.5	Funk G175	95.1
2	Walter 368	90.2	Walter 368	92.8	Funk G175	92.3	Funk 213	93.3
3	Funk 213	88.2	Funk 213	92.8	Walters 368	88.8	Walter 368	90.0
4	Mich 20	86.9	Mich 20	88.4	Mich 20	88.2	Mich 20	88.6
5	Kings KS6	86.0	Pioneer 355	87.4	Pioneer 355	85.9	Pioneer 355	87.2
6	Pioneer 355	84.8	Kings KS6	85.6	Walters 274	83.6	Kings KS6	86.6
7	Walter 274	84.8	Kings KN1	84.1	Mich 30	83.6	Pioneer 379	83.8
8	Ohio M34	82.8	Pioneer 379	84.0	Kings KS6	83.4	Kings KS2	83.6
9	Funk 303	82.7	Ohio M34	83.1	Funk 303	83.3	Pioneer 358	83.6
10	Pioneer 370	82.8	Walters 274	83.1	Pioneer 379	83.0	Funk 303	83.5
11	Mich 30	82.3	Mich 30	82.9	Pioneer 358	82.5	Pioneer 370	83.4
12	Pioneer 379	82.1	Pioneer 358	82.6	Kings KN1	82.0	Mich 30	82.6
13	Kings KS2	82.0	Kings KS2	81.2	Ohio M34	81.2	Kings KN1	81.9
14	Pioneer 358	80.5	Pioneer 370	81.0	Kings KS2	80.9	Walters 274	81.6
15	Mich 38	78.9	Funk 303	80.9	Pioneer 370	80.8	Ohio M34	80.5
16	Mich 35	77.8	Mich 35	79.6	Mich 35	78.7	Mich.35	79.0
17	Kings KN1	77.8	Mich 38	78.4	Mich 38	77.7	Ohio M15	78.6
18	Ohio M15	75.9	Ohio M15	77.8	Ohio M15	76.0	Mich 38	77.3
19	Pioneer 359	73.1	Mich 361B	73.6	Mich 36B	75.2	Mich 36B	75.2
20	Mich 40	72.8	Mich 40	72.1	Mich 40	72.1	Mich 40	71.7
21	Mich 36B	72.8	Pioneer 359	71.9	Funk G174	71.0	Pioneer 359	71.4
22	Mich 49	70.7	Mich 49	71.3	Pioneer 359	70.3	Kings D4	70.6
23	Mich 51B	69.9	Funk G174	70.8	Kings D4	69.8	Mich 49	70.1
24	Kings D4	68.3	Kings D4	69.9	Mich 49	68.9	Mich 51B	69.6
25	Funk G174	66.7	Mich 51B	68.0	Mich 51B	67.6	Funk G174	69.3

Table 9. St. Joseph County data. Comparison of methods of ranking varieties.

Method of ranking:

Rank No.	Actual yield		P/C values from checks every two plots		P/C values from checks every four plots		P/C values from checks every six plots	
		Yield in bu.		Yield in bu.		Yield in bu.		Yield in bu.
1	Pioneer 314	88.3	Pioneer 314	82.2	Pioneer 314	82.2	Pioneer 314	81.7
2	Funk G21	86.4	Funk G20	79.7	Funk G20	82.1	Mich 28	79.7
3	Funk G20	85.2	Mich 28	79.7	Mich 28	81.8	Funk G21	78.2
4	Funk G114	84.7	Pioneer 322	76.6	Funk G114	77.2	Funk G20	78.0
5	Funk F138	83.0	Funk G21	76.0	Pioneer 322	76.9	Pioneer 322	77.0
6	Funk G67	82.1	Funk G67	75.8	Mich 16	76.6	Funk G114	76.6
7	Mich 16	81.7	Funk G114	75.8	Funk G21	76.4	Mich 18	75.4
8	Lowe 14	80.3	Mich 16	75.4	Lowe 14	74.2	Mich 16	75.1
9	Pioneer 341	79.5	Mich 18	74.7	Funk F138	73.8	Funk G67	74.8
10	Ohio M34	79.0	Funk G138	74.4	Mich 18	73.5	Funk F138	74.7
11	Mich 12	78.7	Mich 31	73.1	Funk G67	73.4	Pioneer 341	73.5
12	Mich 18	78.3	Lowe 14	72.9	Mich 27	73.3	Mich 31	72.8
13	Mich 28	77.6	Pioneer 341	71.6	Ohio M34	72.7	Mich 34	72.1
14	Mich 34	77.5	Mich 34	71.4	Mich 34	72.0	Ohio M34	72.1
15	Pioneer 322	77.4	Mich 27	71.3	Mich 31	71.7	Mich 27	71.6
16	Ind 416C	77.2	Ind. 416C	71.1	Pioneer 341	71.3	Ohio M24	71.3
17	Lowe 6W	76.8	Mich 12	71.0	Ohio M21	69.9	Mich 29	71.2
18	Mich 26	76.8	Ohio M34	71.0	Mich 13	69.7	Lowe 14	70.8
19	Mich 31	76.5	Lowe 15	70.5	Ind. 416C	69.5	Ind. 416C	70.3
20	Mich 27	76.3	Mich 21	70.2	Lowe 15	69.4	Lowe 6U	70.3
21	Kgscrost KY	75.7	Mich 29	70.0	Mich 12	69.4	Kings KY	69.9
22	Lowe 15	74.9	Jacques 1001j	69.9	Mich 22	69.1	Mich 12	69.1
23	Pioneer 324	74.8	Lowe 6W	69.8	Lowe 6W	68.9	Mich 26	68.9
24	Mich 13	74.5	Mich 13	69.8	Pioneer 353A	68.8	Pioneer 324	68.9
25	Ohio M34	73.8	Ohio M34	69.8	Mich 21	68.5	Jacques 1157j	68.6
26	Mich 17	73.7	Pioneer 324	69.4	Pioneer 324	68.4	Ind 210B	68.3
27	Mich 21	73.5	Mich 26	69.3	Mich 32	68.2	Mich 21	68.3
28	Mich 29	73.3	Kings KY	68.9	Kings KY	68.1	Lowe 15	67.3
29	Lowe 22	72.3	Ind 210B	67.8	Mich 17	68.0	Mich 13	67.9
30	Mich 20	71.8	Mich 17	67.5	Mich 26	67.9	Mich 17	67.7
31	Mich 22	71.0	Mich 22	66.6	Mich 29	67.8	Pioneer 353A	67.1
32	Jacques 1157j	70.5	Mich 32	65.7	Ind 210B	67.6	Ohio M15	66.7
33	Mich 32	70.2	Pioneer 353A	65.7	Kings KR2	66.8	Mich 22	66.5
34	Indiana 210B	69.8	Kings KR2	64.9	Jacques 1157j	66.2	Lowe 22	66.0
35	Wisc 648	69.5	Ohio M15	64.9	Ohio M15	65.1	Mich 32	65.2
36	Kings KR2	68.0	Lowe 22	64.8	Wisc 648	64.8	Wisc 648	64.9
37	P ioneer 353A	67.3	Wisc 648	64.8	Lowe 22	62.9	Mich 20	63.9
38	Ohio M15	67.2	Mich 20	63.0	Mich 20	61.8	Kings KR2	63.7
39	Mich 24B	62.3	Mich 24B	57.8	Mich 24B	57.3	Mich 24B	57.5

Table 10. Huron County data. Varieties ranked by actual yields. Differences needed for significance in bushels given for different methods of analysis.

Rank No.	Variety	Yield in bu.
1	Mich 30	97.7
2	Pioneer 370	90.6
3	Mich 20	89.1
4	Hsrcrost 112A	88.8
5	Hsrcrost 213	88.3
6	Ohio M15	86.9
7	Pfister 274	86.8
8	Pioneer 373	86.7
9	Funk G1A	86.7
10	Mich 29	86.5
11	Pioneer 355	86.0
12	Kingscrost D4	84.8
13	Funk G175	83.8
14	Wisc 464	83.0
15	Mich 51B	82.0
16	Funk G177	81.6
17	Wisc 416	81.5
18	Pioneer 359	81.0
19	Kingscrost KN1	80.5
20	Kingscrost KS6	79.8
21	Wisc 412	78.2
22	Master F60	77.3
23	Kingscrost KS2	76.9
24	Mich 57	76.7
25	Mich 56	76.2

Method used	Bu. difference for significance at 2 levels	
	5%	1%
1. Av. of Ind. sqs.	11.5	15.2
2. Randomized exp.	11.3	15.0
3. As a unit with sqs. as individuals	11.6	15.3
4. Checks and standards	11.4	15.2

Table 11. Montcalm County data. Varieties ranked by actual yields. Differences needed for significance in bushels given for different methods of analysis.

Rank No.	Variety	Yield in bu.	Method used	Bu. difference for significance at 2 levels	
				5%	1%
1	Ohio M15	82.5			
2	Funk G1A	78.0	1. Av. of Ind. sqs.	11.2	14.9
3	Mich 20	74.9	2. Randomized exp.	9.7	12.9
4	Master F60	70.8	3. As a unit with sqs. as individuals	11.3	15.0
5	Funk G174	70.1	4. Checks and standards	7.4	9.9
6	Kingscrost KA4	69.4			
7	Mich 52	68.9			
8	Mich 36B	67.9			
9	Mich 56	67.7			
10	Funk G177	67.2			
11	Pioneer 359	67.1			
12	Mich 57	66.2			
13	Pioneer 373	66.1			
14	Mich 30	64.0			
15	Mich 29	63.7			
16	Kingscrost D4	63.4			
17	Kingscrost KE1	63.0			
18	Wisc 464	61.4			
19	Wisc 416	61.2			
20	Kingscrost KE2	59.4			

Table 12. Otsego County data. Varieties ranked by actual yields. Differences needed for significance in bushels given for different methods of analysis.

Rank No.	Variety	Yield in bu.	Method used	Bu. difference for significance at 2 levels	
				5%	1%
1	Master F21	74.7			
2	Mich 54	73.6	1. Av. of Ind. sqs.	7.8	10.4
3	Mich 52	72.7	2. Randomized exp.	8.7	11.5
4	Master F40	71.7	3. As a unit with sqs. as individuals	8.3	11.1
5	Kingscrost KE2	70.8			
6	Mich 51B	70.8			
7	Kingscrost KF2	69.6	4. Checks and standards	7.5	10.1
8	Kingscrost KF1	68.9			
9	Mich 54	68.4			
10	Wisc 255	68.3			
11	Wisc 255	68.1			
12	Wisc 240	67.2			
13	Funk G177	67.1			
14	Kingscrost KE1	67.1			
15	Funk G176	59.3			

Table 13. Sanilac County data. Varieties ranked by actual yields. Differences needed for significance in bushels given for different methods of analysis.

Rank No.	Variety	Yield in bu.
1	Mich 59	87.4
2	Kingscrost D4	85.5
3	Funk G175	85.5
4	Mich 54	83.8
5	Funk G177	83.6
6	Kingscrost KA4	82.5
7	Pioneer 370	82.3
8	Mich 36B	81.6
9	Funk G1A	80.1
10	Master F60	80.1
11	Wisc 416	79.7
12	Pioneer 373	79.1
13	Mich 30	78.7
14	Mich 57	78.2
15	Kingscrost KS6	76.1
16	Pioneer 359	75.3
17	Mich 11A	75.1
18	Kingscrost KE1	75.0
19	Wisc 255	74.9
20	Kingscrost KS2	70.4

Method used	Bu. difference for significance at 2 levels	
	5%	1%
1. Av. of Ind. sqs.	9.6	12.7
2. Randomized exp.	8.7	11.5
3. As a unit with sqs. as individuals	9.6	12.7
4. Checks and standards	6.6	8.8

Table 14. Clare County data. Varieties ranked by actual yields. Differences needed for significance in bushels given for different methods of analysis.

Rank No.	Variety	Yield in bu.	Method used	Bu. difference for significance at 2 levels	
				5%	1%
1	Mich 20	74.4			
2	Funk G1A	73.7	1. Av. of Ind. sqs.	9.1	12.0
3	Master F60	73.6	2. Randomized exp.	10.0	13.3
4	Mich 30	69.5	3. As a unit with sqs. as individuals	8.5	11.3
5	Mich 57	68.8			
6	Ohio M15	68.6			
7	Mich 56	68.3	4. Checks and standards	8.8	11.7
8	Mich 52	67.6			
9	Funk G174	66.9			
10	Kingscrost KA4	65.4			
11	Mich 54	65.1			
12	Funk G177	63.7			
13	Mich 11A	63.0			
14	Kingscrost D4	63.0			
15	Wisc 416	63.0			
16	Pioneer 359	62.8			
17	Kingscrost KE1	62.5			
18	Kingscrost KE2	59.6			
19	Mich 29	59.0			
20	Wisc 464	57.1			

Table 15. Ingham County data. Varieties ranked by actual yields. Differences needed for significance in bushels given for different methods of analysis.

Rank No.	Variety	Yield in bu.
1	Hsrcrost F138	69.7
2	Pioneer 322	69.3
3	Mich 16	66.7
4	Mich 24B	66.3
5	Pioneer 373	65.8
6	Mich 22	65.2
7	Mich 12	64.7
8	Mich 18	64.4
9	Mich 31	64.2
10	Mich 32	63.8
11	Ohio M15	62.1
12	Kingscrost KR2	62.1
13	Mich 19	62.1
14	Mich 55	62.1
15	Wisc 643	61.7
16	Mich 39	61.7
17	Mich 34	61.5
18	Funk G12	61.4
19	Ohio M34	61.3
20	Mich 28	61.3
21	Mich 59	61.1
22	Mich 55	61.1
23	Wisc 608	60.3
24	Mich 43	59.8
25	Mich 20	59.5
26	Mich 30	58.1
27	Kingscrost KN1	57.7
28	Mich 58	57.3
29	Mich 29	57.1
30	Mich 21	56.4
31	Pioneer 355	53.8
32	Mich 51B	52.9
33	Funk G550W	51.5
34	Wisc 412	49.8
35	Wisc 464	48.0
36	Kingscrost KS6	48.0
37	Mich 54	47.7
38	Mich 36B	47.5
39	Mich 11A	46.2
40	Mich 57	40.7

Method used	Bu. difference for significance at 2 levels	
	5%	1%
1. Av. of Ind. sqs.	9.2	12.2
2. Randomized exp.	10.5	13.8
3. As a unit with sqs. as individuals	9.2	12.2
4. Checks and standards	11.5	15.2

Table 16. Huron County data. Varieties ranked by different methods.

Methods ranked by:

Rank No.	Add and subtract		Actual yields		P/S	
	Variety	Yield in bu.	Variety	Yield in bu.	Variety	Yield in bu.
1	Mich 30	94.9	Mich 30	97.7	Mich 30	86.4
2	Mich 51B	90.5	Pioneer 370	90.6	Pioneer 373	84.7
3	Pioneer 373	88.9	Mich 20	89.1	Hsrcrost 112A	84.2
4	Pioneer 355	88.2	Hsrcrost 112A	88.8	Pioneer 355	84.1
5	Pioneer 370	87.8	Hsrcrost 213	88.3	Mich 51B	84.0
6	Wisc 412	86.7	Ohio M15	86.9	Hsrcrost 213	83.7
7	Hsrcrost 112A	86.5	Pfister 274	86.8	Pfister 274	82.3
8	Mich 20	86.3	Pioneer 373	86.7	Funk G1A	82.2
9	Hsrcrost 213	86.0	Funk G1A	86.7	Wisc 464	81.1
10	Master F60	85.8	Mich 29	86.5	Pioneer 370	80.2
11	Kgscrost KS2	85.4	Pioneer 355	86.0	Wisc 412	80.0
12	Wisc 464	85.2	Kingscrost D4	84.8	Wisc 416	79.6
13	Mich 57	85.2	Funk G175	83.8	Master F60	79.1
14	Pfister 274	84.5	Wisc 464	83.0	Mich 20	78.8
15	Funk G1A	84.4	Mich 51B	82.0	Kingscrost D4	78.7
16	Ohio M15	84.1	Funk G177	81.6	Kgscrost KS2	78.7
17	Mich 29	83.7	Wisc 416	81.5	Mich 57	78.5
18	Wisc 416	83.7	Pioneer 359	81.0	Kgscrost KS6	78.0
19	Kingscrost D4	82.8	Kgscrost KN1	80.5	Funk G175	78.0
20	Kgscrost KS6	82.0	Kgscrost KS6	79.8	Funk G177	77.4
21	Funk G175	81.8	Wisc 412	78.2	Ohio M15	76.8
22	Funk G177	79.3	Master F60	77.3	Mich 29	76.5
23	Pioneer 359	79.0	Kgscrost KS2	76.9	Pioneer 359	75.2
24	Kgscrost KN1	78.5	Mich 57	76.7	Kgscrost KN1	74.7
25	Mich 56	74.2	Mich 56	76.2	Mich 56	70.8

Table 17. Montcalm County data. Varieties ranked by different methods.

Methods ranked by:

Rank No.	Add and subtract		Actual yields		P/S	
	Variety	Yield in bu.	Variety	Yield in bu.	Variety	Yield in bu.
1	Ohio M15	79.6	Ohio M15	82.5	Ohio M15	74.2
2	Funk G1A	75.1	Funk G1A	78.0	Mich 29	73.8
3	Mich 20	72.0	Mich 20	74.9	Kgscrost KE1	73.0
4	Master F60	70.7	Master F60	70.8	Wisc 464	71.1
5	Mich 52	69.7	Funk G174	70.1	Wisc 416	70.8
6	Kgscrost KA4	69.1	Kgscrost KA4	69.2	Funk G1A	70.2
7	Mich 36B	68.7	Mich 52	68.9	Kgscrost KE2	68.8
8	Pioneer 359	67.9	Mich 36B	67.9	Mich 20	67.4
9	Mich 56	67.6	Mich 56	67.7	Mich 52	64.9
10	Funk G174	67.2	Funk G177	67.2	Mich 36B	64.0
11	Mich 29	67.2	Pioneer 359	67.1	Pioneer 359	63.2
12	Mich 57	67.0	Mich 57	66.2	Funk G174	63.1
13	Kgscrost KE1	66.5	Pioneer 373	66.1	Master F60	62.9
14	Pioneer 373	66.0	Mich 30	64.0	Mich 57	62.4
15	Wisc 464	64.9	Mich 29	63.7	Kgscrost KA4	61.5
16	Wisc 416	64.7	Kingscrost D4	63.4	Funk G177	60.4
17	Funk G177	64.3	Kgscrost KE1	63.0	Mich 56	60.2
18	D4 (N)	64.2	Wisc 464	61.4	Kingscrost D4	59.7
19	Mich 30	63.9	Wisc 416	61.2	Pioneer 373	58.8
20	Kgscrost KE2	62.9	Kgscrost KE2	59.4	Mich 30	56.9

Table 18. Otsego County data. Varieties ranked by different methods.

Methods ranked by:

Rank No.	Add and subtract		Actual yields		P/S	
	Variety	Yield in bu.	Variety	Yield in bu.	Variety	Yield in bu.
1	Master F21	74.8	Master F21	74.7	Master F21	79.2
2	Mich 54	73.7	Mich 54	73.6	Mich 54	78.0
3	Mich 52	72.8	Mich 52	72.7	Mich 52	77.1
4	Kgscrost KE2	70.9	Master F40	71.7	Kgscrost KE2	75.1
5	Kgscrost KF2	70.9	Kgscrost KE2	70.8	Wisc 255	72.2
6	Kgscrost KF1	70.2	Mich 51B	70.8	Kgscrost KF1	71.1
7	Mich 54	69.7	Kgscrost KF2	69.6	Kgscrost KF2	70.8
8	Wisc 255	69.6	Kgscrost KF1	68.9	Master F40	70.8
9	Master F40	69.1	Mich 54	68.4	Mich 54	70.5
10	Wisc 240	68.5	Wisc 255	68.3	Wisc 255	70.4
11	Mich 51B	68.2	Wisc 255	68.1	Mich 51B	69.9
12	Wisc 255	68.2	Wisc 240	67.2	Wisc 240	69.4
13	Funk G177	64.5	Funk G177	67.1	Funk G177	66.3
14	Kgscrost KE1	64.5	Kgscrost KE1	67.1	Kgscrost KE1	66.2
15	Funk G176	56.7	Funk G176	59.3	Funk G176	58.3

Table 19. Sanilac County data. Varieties ranked by different methods.

Methods ranked by:

Rank No.	Add and subtract		Actual yields		P/S	
	Variety	Yield in bu.	Variety	Yield in bu.	Variety	Yield in bu.
1	Mich 59	87.3	Mich 59	87.4	Mich 59	88.7
2	Mich 54	83.7	Kingscrost D4	85.5	Master F60	86.3
3	Funk G175	82.7	Funk G175	85.5	Wisc 416	85.8
4	Kingscrost D4	82.7	Mich 54	83.8	Mich 54	85.0
5	Mich 36B	82.7	Funk G177	83.6	Mich 57	84.2
6	Kgscrost KA4	82.4	Kgscrost KA4	82.5	Kgscrost KA4	83.7
7	Master F60	81.7	Pioneer 370	82.3	Mich 36B	82.4
8	Wisc 416	81.3	Mich 36B	81.6	Kgscrost KE1	80.8
9	Funk G177	80.8	Funk G1A	80.1	Pioneer 373	79.9
10	Pioneer 373	80.2	Master F60	80.1	Mich 30	79.6
11	Mich 30	79.8	Wisc 416	79.7	Funk G175	78.6
12	Mich 57	79.8	Pioneer 373	79.1	Kingscrost D4	78.6
13	Pioneer 370	79.5	Mich.30	78.7	Funk G177	76.9
14	Funk G1A	77.3	Mich 57	78.2	Kgscrost KS6	76.8
15	Kgscrost KS6	77.2	Kgscrost KS6	76.1	Mich 11A	76.1
16	Kgscrost KE1	76.6	Pioneer 359	75.3	Pioneer 359	76.0
17	Pioneer 359	76.4	Mich 11A	75.1	Wisc 255	76.0
18	Mich 11A	75.0	Kgscrost KE1	75.0	Kgscrost KS2	75.9
19	Wisc 255	74.8	Wisc 255	74.9	Pioneer 370	75.7
20	Kgscrost KS2	72.0	Kgscrost KS2	70.4	Funk G1A	73.7

Table 20. Clare County data. Varieties ranked by different methods.

Methods ranked by:

Rank No.	Add and subtract		Actual yields		P/S	
	Variety	Yield in bu.	Variety	Yield in bu.	Variety	Yield in bu.
1	Mich 20	74.1	Mich 20	74.4	Mich 52	72.1
2	Funk G1A	73.4	Funk G1A	73.7	Mich 54	69.5
3	Master F60	71.6	Master F60	73.6	Mich 20	67.8
4	Mich 52	69.3	Mich 30	69.5	Master F60	67.4
5	Ohio M15	68.3	Mich 57	68.8	Funk G1A	67.2
6	Mich 30	67.5	Ohio M15	68.6	Kingscrost D4	67.2
7	Mich 54	66.8	Mich 56	68.3	Mich 11A	67.2
8	Mich 57	66.8	Mich 52	67.6	Pioneer 359	67.0
9	Funk G174	66.6	Funk G174	66.9	Wisc 416	66.0
10	Mich 56	66.6	Kgscrost KA4	65.4	Kgscrost KE1	65.5
11	Kingscrost D4	64.7	Mich 54	65.1	Mich 30	63.7
12	Mich 11A	64.7	Funk G177	63.7	Mich 57	63.1
13	Wisc 416	64.5	Mich 11A	63.0	Mich 56	62.6
14	Pioneer 359	64.5	Kingscrost D4	63.0	Ohio M15	62.6
15	Kgscrost KE1	64.0	Wisc 416	63.0	Kgscrost KE2	62.5
16	Funk G177	63.4	Pioneer 359	62.8	Mich 29	61.9
17	Kgscrost KA4	63.4	Kgscrost KE1	62.5	Funk G174	61.0
18	Kgscrost KE2	61.1	Kgscrost KE2	59.6	Kgscrost KA4	59.9
19	Mich 29	60.5	Mich 29	59.0	Wisc 464	59.9
20	Wisc 464	58.6	Wisc 464	57.1	Funk G177	58.1

Table 21. Ingham County data. Varieties ranked by different methods.

Methods ranked by:

Rank No.	Add and subtract		Actual yields		P/S	
	Variety	Yield in bu.	Variety	Yield in bu.	Variety	Yield in bu.
1	Pioneer 322	67.9	Hsrcrost F138	69.7	Pioneer 373	70.4
2	Hsrcrost F138	67.8	Pioneer 322	69.3	Mich 24B	70.3
3	Pioneer 373	67.5	Mich 16	66.7	Pioneer 355	66.6
4	Mich 24B	65.8	Mich 24B	66.3	Mich 55	66.2
5	Mich 16	64.8	Pioneer 373	65.8	Mich 39	66.0
6	Kgscrost KR2	64.0	Mich 22	65.2	Mich 34	65.8
7	Mich 55	63.6	Mich 12	64.7	Mich 51B	65.5
8	Mich 39	63.4	Mich 18	64.4	Mich 59	65.4
9	Mich 12	63.3	Mich 31	64.2	Kgscrost KR2	64.8
10	Mich 34	63.2	Mich 32	63.8	Pioneer 322	64.7
11	Ohio M34	63.2	Ohio M15	62.1	Mich 55	64.7
12	Mich 31	62.8	Kgscrost KR2	62.1	Hsrcrost F138	64.3
13	Mich 18	62.5	Mich 19	62.1	Ohio M34	64.0
14	Mich 32	62.4	Mich 55	62.1	Mich 20	63.0
15	Mich 22	61.9	Wisc 643	61.7	Mich 30	62.2
16	Mich 55	60.6	Mich 39	61.7	Wisc 412	61.7
17	Mich 59	60.5	Mich 34	61.5	Mich 16	61.5
18	Pioneer 355	60.3	Funk G12	61.4	Mich 58	61.3
19	Mich 19	60.2	Ohio M34	61.3	Kgscrost KN1	61.2
20	Mich 28	59.9	Mich 28	61.3	Mich 29	60.5
21	Mich 30	59.8	Mich 59	61.1	Mich 12	60.5
22	Funk G12	59.5	Mich 55	61.1	Mich 31	59.9
23	Mich 51B	59.4	Wisc 608	60.3	Mich 22	59.8
24	Mich 20	59.0	Mich 43	59.8	Mich 32	59.6
25	Ohio M15	58.8	Mich 20	59.5	Wisc 464	59.5
26	Wisc 643	58.4	Mich 30	58.1	Kgscrost KS6	59.4
27	Mich 21	58.3	Kgscrost KN1	57.7	Mich 18	59.3
28	Kgscrost KN1	57.7	Kingscrost 58	57.3	Mich 21	58.9
29	Wisc 608	57.0	Kingscrost 29	57.1	Mich 19	57.2
30	Mich 58	56.7	Kingscrost 21	56.4	Mich 28	57.2
31	Mich 29	56.6	Pioneer 355	53.8	Ohio M15	57.0
32	Mich 43	56.6	Mich 51B	52.9	Funk G12	56.6
33	Wisc 412	56.3	Funk G550W	51.5	Wisc 643	56.6
34	Kgscrost KS6	54.5	Wisc 412	49.8	Wisc 608	55.3
35	Wisc 464	54.5	Wisc 464	48.0	Mich 43	54.8
36	Funk G550W	53.4	Kgscrost KS6	48.0	Funk G550W	53.7
37	Mich 36B	49.4	Mich 54	47.7	Mich 54	51.0
38	Mich 54	47.1	Mich 36B	47.5	Mich 36B	49.6
39	Mich 11A	45.6	Mich 11A	46.2	Mich 11A	49.4
40	Mich 57	40.1	Mich 57	40.7	Mich 57	43.5