A COMPARISON BETWEEN YIELDS CALCULATED FROM THE GRAIN-STRAW RATIO AND THOSE CALCULATED FROM SMALL CUT-OUT AREAS

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

J. F. Davis

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THESIS

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INTRODUCTION

In order to insure a valid interpretation of field plat data the value of correct statistical analysis of the results is practically universally recognized. With the use of statistical methods requiring more replicates the number of field plats is materially increased and the labor involved in the care of these extra plats is correspondingly greater. Therefore, any means that results in a saving of time and will not reflect disadvantageously in the accuracy of the results obtained would be a very desirable addition in the field work operations.

In a recent paper, (1) a plan was suggested in which the yields of experimental plats can be accurately determined from the grain-straw* ratio. If plat yields determined from the grain-straw ratio are sufficiently reliable, the hand labor involved in cutting out small areas in the plat can be eliminated thus materially facilitating harvesting operations. This proposed method of plat yield determination would apply primarily to plats sufficiently large to lend themselves economically to harvesting with a binder. Thirtieth acre plats have an area great enough to make cutting

*The term, grain-straw ratio refers to the relationship existing between the grain weight and the weight of the unthreshed bundles.

with a binder practical. This size of plat is, at the same time, large enough to allow for the discarding of a portion of the crop to eliminate border effects. In order to simulate field conditions and farming practices as closely as possible in carrying out an experiment, a program that allows for that size and shape of plat which makes practical the use of ordinary machinery is very desirable. The relationship of fertilizer placement to growth response of a crop makes it extremely important that results secured from an experiment carried out under one set of conditions are not allowed to refer to similar work carried out under different conditions. For example, in fertilizer studies with small grains it is illogical to assume that fertilizer applied broadcast over a plat is necessarily going to produce the same response as it would if applied with a grain drill with fertilizer attachment, the usual method employed by Michigan farmers. It would appear, then, in this particular case that the plat should be large enough to allow the use of a grain drill. However, this increases the area and requires more labor. Past experience has shown that one of the most important limiting factors in small grain fertilizer experiments is the labor involved at harvesting time. It is for this type of work that determining plat yields with a minimum of work would prove advantageous in the field work program.

Any method then that reduces the hand labor involved and at the same time is sufficiently accurate to give dependable results, is very desirable. In this paper a comparison between yields calculated by this method and yields secured by the usual method of cutting out small areas from the plat, will be made in order to determine which method gives the results most comparable to those obtained from threshing the entire plat.

PROCEDURE

The comparisons between the different methods of harvest were made on a series of sixteen oat plats. These plats were 14 x 150 feet in size, consisting of 22 rows seven inches in width, representing one round with a 11 disc grain drill, the type extensively used in the planting of field plats at the Michigan Station. Six areas, 6 rows x 16½ feet, were cut out of each plat with a hand sickle and each area was labeled to denote the order in which the areas were cut. Since from the appearance of the plats very little difference could be observed in the growth of grain in different portions of an individual plat the cut-out areas were taken alternately from either side of the plat. This constituted a total area of 6 rows by 99 feet that was cut-out of each plat with the hand sickle. The ends of each plat were cut off with the binder, thus leaving approximately 135 feet to be harvested

from the original 150 foot plat. After the cut-out areas were removed and the bundles tied and labeled, the remainder of the plat was cut with the binder. The area cut off the end of each plat allowed for sufficient space for the binder to clean out between any two plats in adjoining blocks. The bundles from each plat were shocked on the plat and when dry were weighed and threshed. During the threshing operations five bundles were selected at random and threshed individually as were the areas cut out with the hand sickle. All the bundles from the plat were then threshed to get the actual yield of each plat. Yields based on one, two, three, four, five, and six cut-out areas were then computed for each plat. In addition, yields for each plat were calculated from the grain-straw ratios and the total bundle weights. This was done for one, two, three, four, and five bundles selected at threshing time. From the six "cut-out" areas one area was selected at random from each plat and a comparison was made between the results thus obtained and those obtained from the systematically selected areas. From the data, correlation co-efficients, corresponding "Z" values, the lines of best fit, standard errors of estimate, and the standard errors of estimate from the line Y = X were calculated.

DISCUSSION

Correlation coefficients: The correlation coefficients obtained in the study are recorded in Table 1. The correlation coefficients represent the relationship between yields calculated by the various methods used in harvesting and the yields secured from threshing the entire plat. The correlation coefficients in each case were found to be significant and ranged from .7500 for the low-yielding cut out area to .9635 for the comparison between the actual plat yield and the yield calculated from five threshed bundles. By examining Fisher's Table V.A. Page 212, in "Statistical Methods for Research Workers," Sixth Edition, it is found that all the correlation coefficients are significant. It can readily be noted that the correlation coefficients for the one, two, three, four, and five bundle comparisons were considerably higher than any of the coefficients from the cut-out area comparisons. The inference, then, is that yields obtained from weight relationships more nearly approach the actual plat yields than do yields based on area relationships. However, due to the small number of comparisons available the "r" values were changed to "z" values in order that a more nearly correct evaluation of the data could be made.

Value of Z: The magnitudes of the Z values bring out more clearly the differences existing between the various methods of harvest. However, the only significant differences in the Z values are in the comparisons between one and two cut out areas and the five bundles selected at harvest time. The difference between the Z value for the four cut-out areas and that from the five bundles closely approaches significance. It should be mentioned here that the standard error of a Z value is calculated as the reciprocal of the square root of a number three less than the number of items. It can easily be seen, then, that with a Z value calculated from data in which the number of items is necessarily limited the corresponding standard error is relatively large as compared to a similar Z value obtained from a larger number of items. In previous work (1) it was found that Z values obtained from similar data but with more replicates showed significant differences. It seems logical to assume that significant differences would actually exist between yields based on five and six cut-out areas and yields secured from the weight relationship of five bundles and the entire plat. The regression lines recorded in Table 2 and in the accompanying graphs between actual and estimated plat yields secured from the various harvesting methods point out clearly the comparative degree of closeness of fit to the line $Y = X$, this line

denoting unit changes in X and Y values. Comparisons between the regression lines for the various harvesting methods and the line Y = X are shown by the accompanying graphs. The fact that the regression lines secured from the weight relationships are very close to the line Y = X and in the case of the "three bundle" method of harvest practically coincident with it and in contrast all regression lines secured from the area methods of harvest are rather widely divergent from the line Y = X, show the superiority of a weight relationship method of harvest.

Standard errors of estimate and errors of estimate from the line Y = X: The standard errors of estimates from the regression lines found in Table 2 indicate again that the weight relationship methods of harvest give yields that compare more closely to actual yields than do yields secured from the area methods of harvest. When the yields are estimated from five bundles the standard error of estimate is 2.36 bushels. As the number of bundles threshed decreases the standard error of estimate consistently increases to 3.82 bushels for yields based on one bundle. The standard errors of estimate for the area methods are greater ranging from 4.70 bushel for six "cut-out" areas to 5.832 bushels for one "cut-out" area. It should be noted the error for six "cut-out" areas is approximately .9 of a bushel greater than for one bundle. When it is to be remembered that the amount of work involved in the

two methods of harvest is much less in the method which employs the binder and the results so obtained conform more closely to the actual plat yields it appears logical that the binder should be used whenever applicable to the experimental setup.

A more logical comparison can be made if errors are calculated from the line Y = X since this line represents perfect agreement with actual plat yields. When these errors are calculated it serves to accentuate the differences between the harvesting methods. For the "bundle" method of harvest this value varies from 2.40 bushels to 3.92 bushels, and for the area methods from 7.63 bushels to 9.40 bushels, showing again the superiority of the bundle method of harvest over the area method. Referring to the Z values and the t values in Table 3 calculated to show the significant differences between the standard errors both from the lines of best fit and the line Y = X it is found in all cases at the 5% point that the yields based on five threshed bundles are significantly better than yields based on one bundle threshed or any yields calculated from small cut-out areas. Also, the yields from the five threshed bundles are significantly different than any yields secured from area methods of harvest at the 1% point, indicating again that yields estimated from weight relationships are closer to the actual yields than when the yields are secured from "cut-out" areas. No significant differences were found between yields based on five

threshed bundles and yields obtained from four, three, or two threshed bundles, indicating that probably yields based on two or three threshed bundles are nearly as reliable as those secured from five bundles. Likewise, according to these data increasing the number of "cut-out" areas would not materially increase the reliability of the results if yields are to be calculated from small areas cut out by hand. It is also very interesting to note that the Z test and the t test for the comparisons of the standard errors of estimate between the results from five bundles threshed and other methods of harvest show the same degree of significance in every case. The differences that are significant at the 5% point and the 1% point for the Z values are also significant according to the "t" test applied.

The main question to be considered in any work dealing with a comparison of methods is whether in using one method the estimated results vary far enough from the actual yields of the plats to give erroneous conclusions. For this reason Table 4 is presented.

An examination of the table is quite convincing as to closer association of results with the actual when these results are estimated from weight relationships rather than from area relationships. The argument is often made that comparative results between treatments are all that is required and the true yield of any plat is not essential providing the

method of taking yields is essentially the same for all plats. The data indicate, however, that in order to get comparable results from a series of treatments a great deal of dependance would have to be placed in compensating errors in order to arrive at results that would give this comparison between treatments if small "cut-out" areas are used. The significance of the results in Table 4 is demonstrated in the consideration of the magnitude of the errors from the line Y = X of the various harvesting methods. As previously stated, the larger this error became the more divergent the calculated plat yields are from the actual plat yields. This point has been previously discussed.

Comparison of results from one area selected at random with one area selected systematically: An examination of Table 5 indicated that the statistical constants obtained from a random area do not differ materially from the corresponding constants secured from a systematically selected area. In no case does a significant difference exist between constants derived from either method.

CONCLUSIONS

Yields obtained on three types of harvesting methods were secured from a series of oat plats. In the first method the entire plat was cut and threshed, in the second, yields were calculated from small areas cut-out with a hand sickle, while in the third, yields were obtained from the grain-straw

ratio in a portion of the plat and the bundle weight of the entire plat.

Higher values for r and Z were obtained when actual plat yields were compared to yields calculated from weight relationships than from area relationships.

The regression lines obtained from the weight relationships compared more closely in all cases to the line Y = X than did the regression lines obtained from the area methods of calculating yields.

The standard errors of estimate and the errors of estimate from the line Y = X varied significantly between all area methods and the method in which the weight relationship of five bundles to the total grain and straw weight of the entire plat was used. The ~~errors~~ error for the yields based on one bundle was significantly greater than the errors for yields based on five bundles. The magnitude of the errors in every case was considerably lower when yields were calculated from weight relationships than from the area methods.

The calculated yields varied progressively from the actual plat yield with the decrease in the number of bundles weighed and with the number of areas cut but the yields from one bundle were closer to the actual plat yields than when yields were based on six areas.

From the data presented it would appear that three bundles weighed from a plat of this particular size would give a very accurate estimate of the plat yields and would be the recommended number to use in yield estimation.

A harvested area as small as 1000 square feet has been satisfactorily taken care of by this method.

When compared to the method of cutting out small areas, the grain-straw ratio method of harvest has the advantage of being more accurate and more efficient in the use of labor. An experiment consisting of 108 plats of oats was harvested in 4½ hours. Four men were required to do the work, two of the men were required to run the binder since the tractor did not have a power take-off. The amount of hand labor involved is materially lessened since the grain is cut with the binder.

Table 1. Correlation Coefficients, Corresponding Z Values, And Mean Differences of Z Values of Five Bundles Threshed and Other Methods of Harvest

Methods of Harvest	r*	Z	Mean Difference
5 bundles threshed	.9635	1.9935	
4 " "	.9632	1.9894	.0041 ± .3922
3 " "	.9456	1.7857	.2078 ± .3922
2 " "	.9203	1.5910	.4025 ± .3922
1 " "	.9018	1.4819	.5116 ± .3922
6 areas "	.8462	1.2429	.7506 ± .3922
5 " "	.8487	1.2516	.7419 ± .3922
4 " "	.8336	1.2000	.7935 ± .3922
3 " "	.8773	1.3642	.6293 ± .3922
2 " "	.7819	1.0503	.9432 ± .3922
1 " "	.7500	.9730	1.0205 ± .3922

*r (5% point) = .6226

Table 2. Regression Lines and Standard Errors of Estimate And Errors of Estimate From the Line Y = X.

Methods of Harvest	Regression Lines	Std. Errors of Estimate	Errors of Estimate From Line Y = X
5 bundles threshed	$\bar{y} = .970x + 1.40$	2.360	2.401
4 " "	$\bar{y} = .979x + 1.12$	2.373	2.412
3 " "	$\bar{y} = 1.00x + 0.14$	2.869	2.840
2 " "	$\bar{y} = .953x + 3.15$	3.453	3.534
1 " "	$\bar{y} = .930x + 3.75$	3.816	3.920
6 areas "	$\bar{y} = .783x + 8.57$	4.700	7.630
5 " "	$\bar{y} = .782x + 8.50$	4.663	7.729
4 " "	$\bar{y} = .821x + 5.24$	4.785	8.550
3 " "	$\bar{y} = .750x + 10.38$	4.230	7.857
2 " "	$\bar{y} = .601x + 21.04$	5.494	8.265
1 " "	$\bar{y} = .610x + 19.37$	5.832	9.402

Table 3. Z Values and t Values for Differences Between Standard Errors of Estimate and Z Values for Differences Between Errors from the Line Y = X of Five Threshed Bundles and Other Methods of Harvest.

Method of Harvest	*Z Value for Errors of the Line Y = X*	Z Values of Standard Errors of Estimate	t**Values of Standard Errors of Estimates
4 bundles threshed	.004	.005	.031
3 " "	.168	.195	1.092
2 " "	.387	.380	1.133
1 " "	.490	.480	2.588
6 areas "	1.156	.689	3.551
5 " "	1.168	.680	3.516
4 " "	1.269	.707	3.624
3 " "	1.185	.583	3.076
2 " "	1.236	.845	4.178
1 " "	1.365	.904	4.553

Z (5% point) .459
Z (1% point) .659
t (5% point) 2.048
t (1% point) 2.763

$$*Z = \frac{1}{2}\log_e \frac{(\sigma_e \text{ of line } Y = X \text{ of treatment compared})}{(\sigma_e \text{ of line } Y = X \text{ of 5 bundles threshed})}$$

**t Values calculated from the following formula:

$$t = \frac{\sigma_{e_1} - \sigma_{e_2}}{\frac{S}{\sqrt{2N}}}$$

This formula was derived by Professor W. D. Baten, who has not yet published his findings.

Table 4. Actual Plat Yields* and Plat Yields Calculated by the Various Harvesting Methods.

	Plat number															
Method of harvest	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Entire Plat yield	62.5	58.2	40.4	36.4	61.0	66.0	59.4	65.6	57.7	57.3	66.1	63.0	55.8	60.7	65.5	59.
5 bundles threshed	64.6	57.1	43.8	37.4	67.7	64.4	59.1	66.6	55.7	54.8	66.5	63.1	54.7	59.9	66.6	58.
4 " "	62.7	57.6	43.6	37.4	67.7	64.4	59.3	68.1	55.7	55.1	65.4	62.7	53.4	59.9	65.2	59.
3 " "	61.6	57.9	44.0	37.9	68.5	64.1	58.5	67.0	55.1	55.0	64.2	61.3	54.2	58.1	64.0	61.
2 " "	62.0	56.6	45.5	36.9	67.7	63.6	54.5	68.2	52.6	56.3	62.2	65.0	55.9	56.6	64.8	60.
1 " "	59.3	59.0	46.4	38.5	66.5	67.5	55.1	64.5	53.4	54.1	70.4	67.4	59.0	56.9	61.5	61.
6 areas "	70.7	60.5	51.9	40.3	60.7	70.1	69.3	62.3	61.7	59.3	75.2	68.2	62.3	59.5	72.7	75.
5 " "	69.1	61.3	51.2	39.6	61.1	69.8	71.9	61.5	64.4	58.9	75.7	68.1	62.5	59.6	73.5	73.
4 " "	74.3	60.7	53.6	42.7	59.8	69.3	64.5	65.4	63.6	65.1	76.9	67.2	62.8	61.3	74.3	76.
3 " "	71.5	62.1	51.5	38.9	60.1	73.1	72.7	66.4	61.3	54.2	77.8	68.4	60.9	62.5	74.3	70.
2 " "	63.6	60.1	46.0	35.4	62.5	71.9	79.0	56.1	57.8	59.6	71.9	70.2	61.3	56.1	69.5	75.
1 " "	70.7	69.5	58.9	35.4	56.6	75.4	64.8	66.0	74.3	50.7	70.7	69.5	57.8	61.3	74.3	69.

*Yields are expressed in bushels per acre.

Table 5. Comparison of Results Secured from One Area Selected at Random and One Area Selected Systematically.

Statistical Constant	Random Selection	Systematic Selection
r	.7230	.7500
Z	.9139	.9730
Mean Diff. Z	1.0796 ± .3922	1.0205 ± .3922
Regression Line	$\bar{y}$ = .587x + 21.73	$\bar{y}$ = .610x ± 19.37
Std. Error of Estimate	5.885	5.832
Error of Estimate From Line Y = X	8.77	9.402
Diff. in Z Values From Five Bundles Threshed and One Area Threshed	.948	.904

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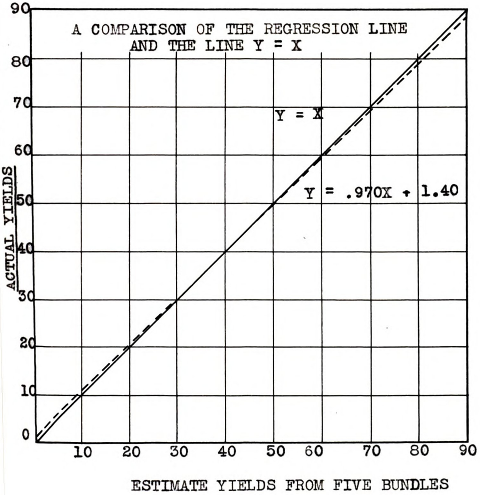
3. Love, H. H., A table for transferring the correlation coefficient, r, to Z of correlation analysis. Jour. Amer. Soc. Agron., 27: 807-812, 1935.

4. Snedecor, G. W., Calculation and interpretation of analysis of variance and covariance. Monograph Number One, Division of Industrial Science, Iowa State College, 1934.

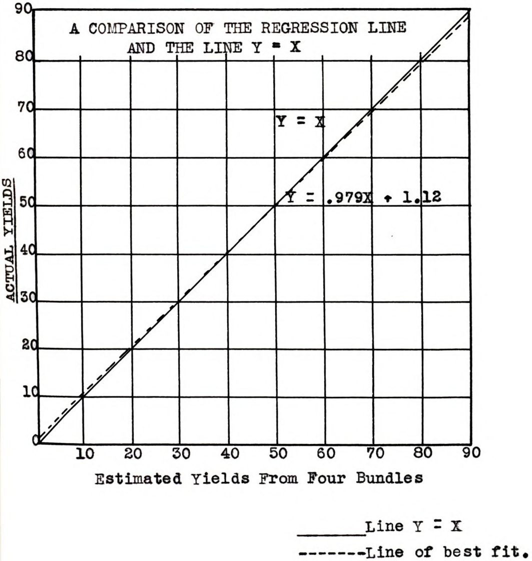
Fig. 1. The data on the various harvesting methods were obtained from this uniform stand of oats on Brookston soil.

Fig. 2. The blocks may be easily separated by cutting across the ends of the plots with a binder.



________Line Y = X

-------Line of best fit.


A COMPARISON OF THE REGRESSION LINE
AND THE LINE Y = X
Y = X
Y = .979X + 1.12
ACTUAL YIELDS
0
10
20
30
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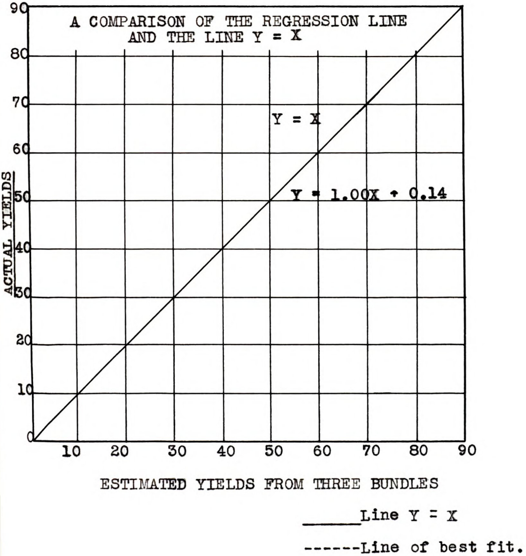
50
60
70
80
90
Estimated Yields From Four Bundles
_______Line Y = X
-------Line of best fit.


A COMPARISON OF THE REGRESSION LINE
AND THE LINE Y = X
Y = X
Y = 1.00X + 0.14
ACTUAL YIELDS
ESTIMATED YIELDS FROM THREE BUNDLES
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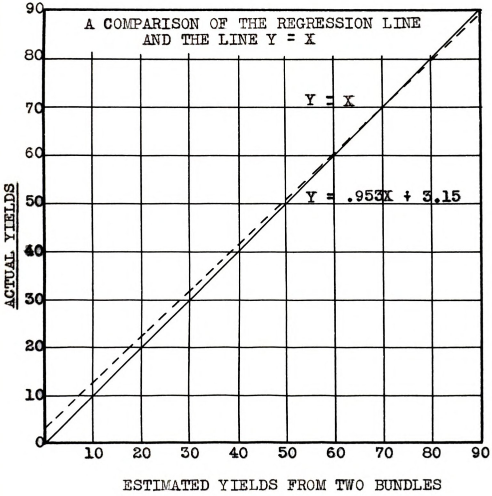
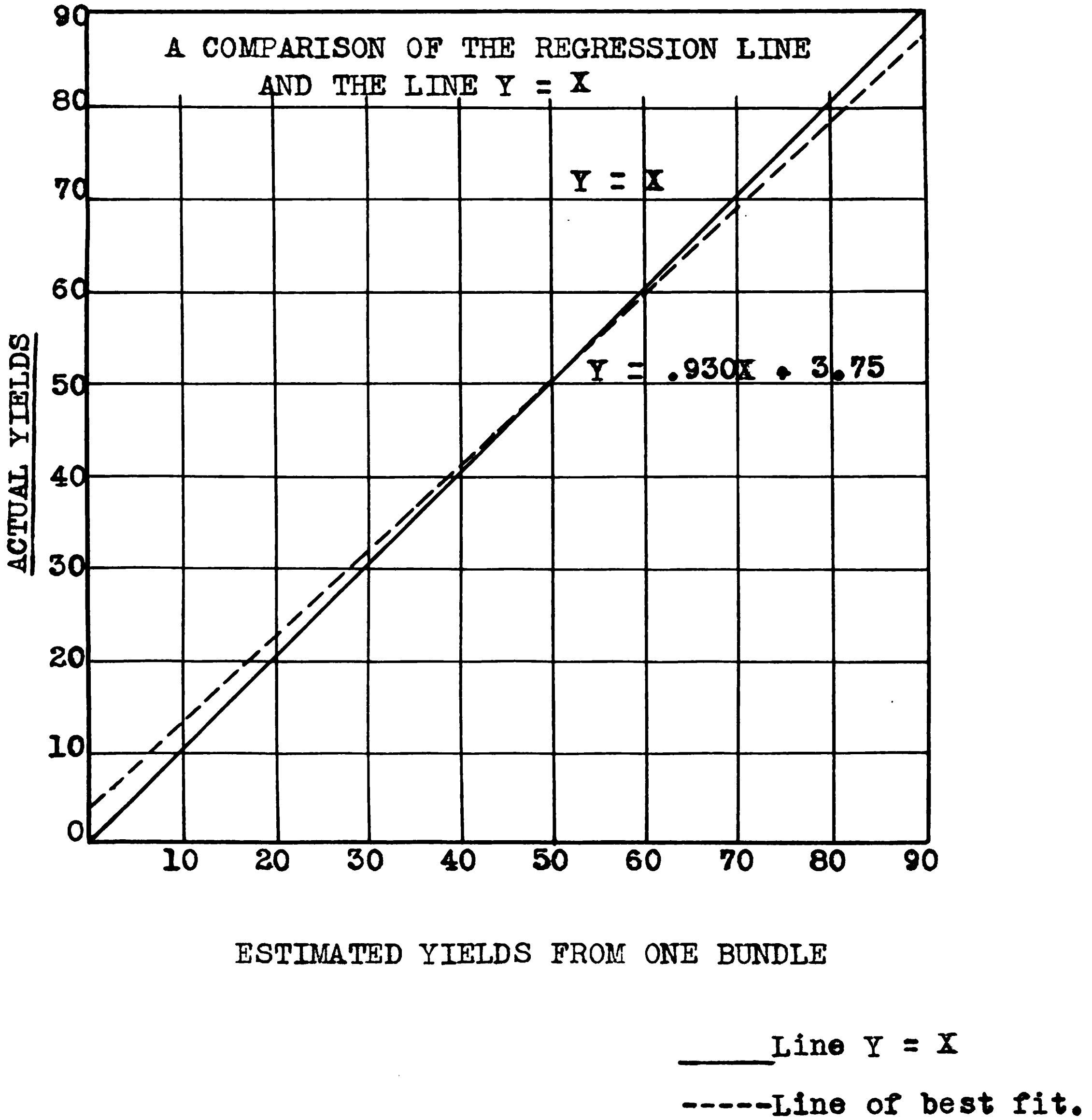
90
______Line Y = X
------Line of best fit.



______Line Y = X

------Line of best fit.


A COMPARISON OF THE REGRESSION LINE
AND THE LINE Y = X
Y = X
Y = .930X + 3.75
ACTUAL YIELDS
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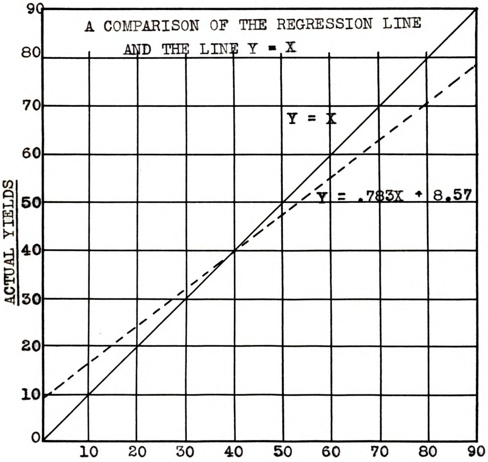
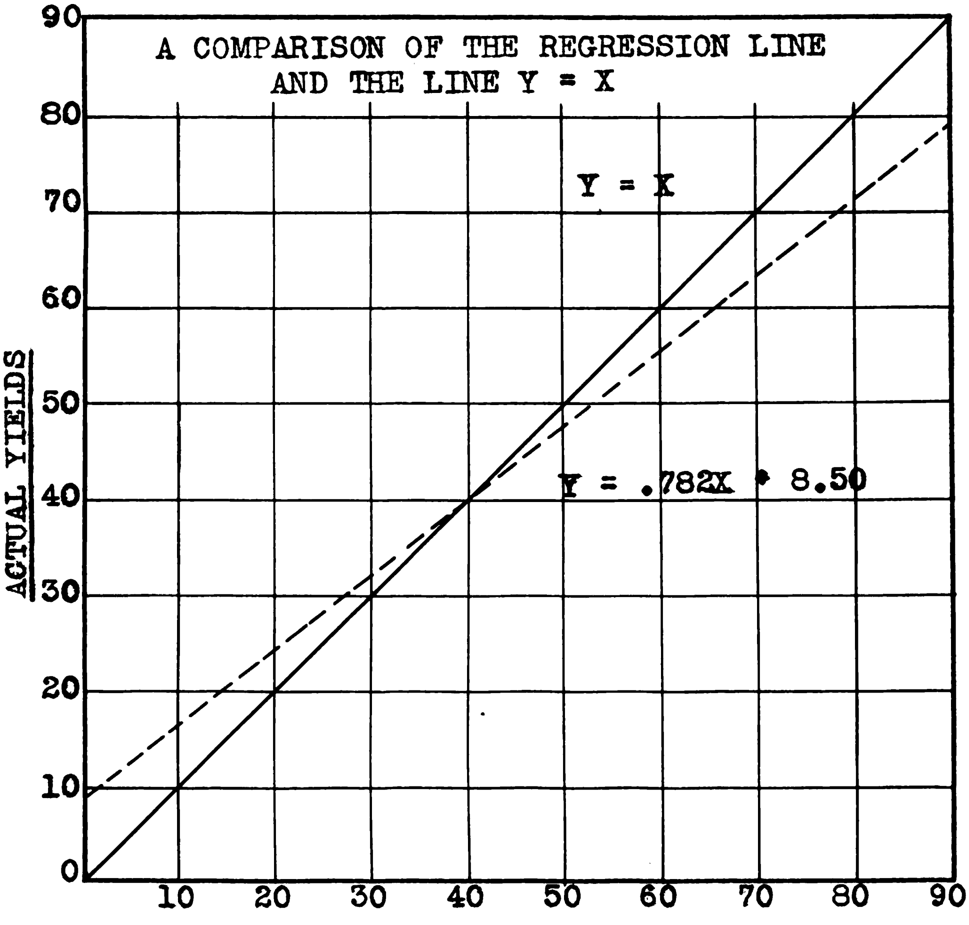
ESTIMATED YIELDS FROM ONE BUNDLE
____Line Y = X
-----Line of best fit.



ESTIMATED YIELDS FROM SIX AREAS

____Line Y = X

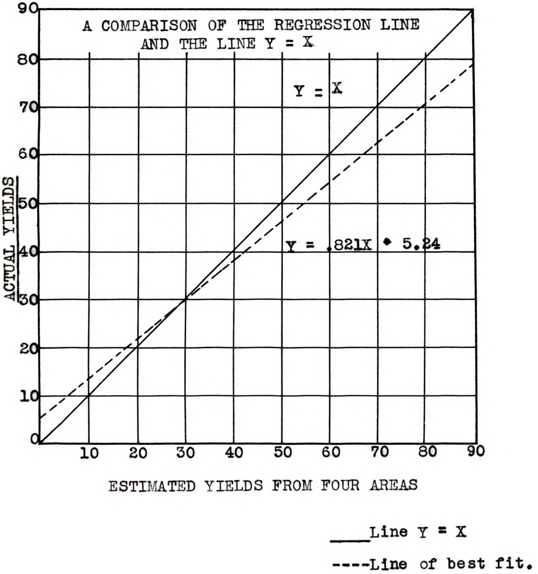
----Line of best fit.



ESTIMATED YIELDS FROM FIVE AREAS

____Line Y = X

----Line of best fit.


A COMPARISON OF THE REGRESSION LINE
AND THE LINE Y = X
Y = X
Y = .821X + 5.24
ACTUAL YIELDS
ESTIMATED YIELDS FROM FOUR AREAS
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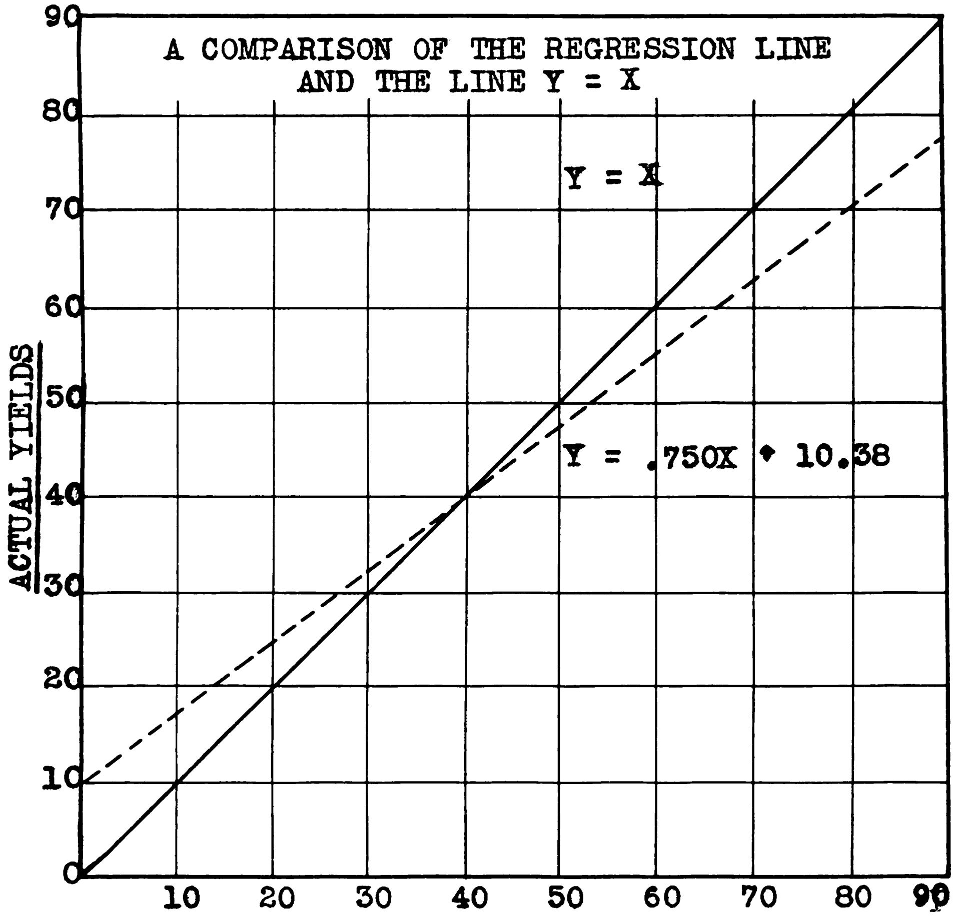
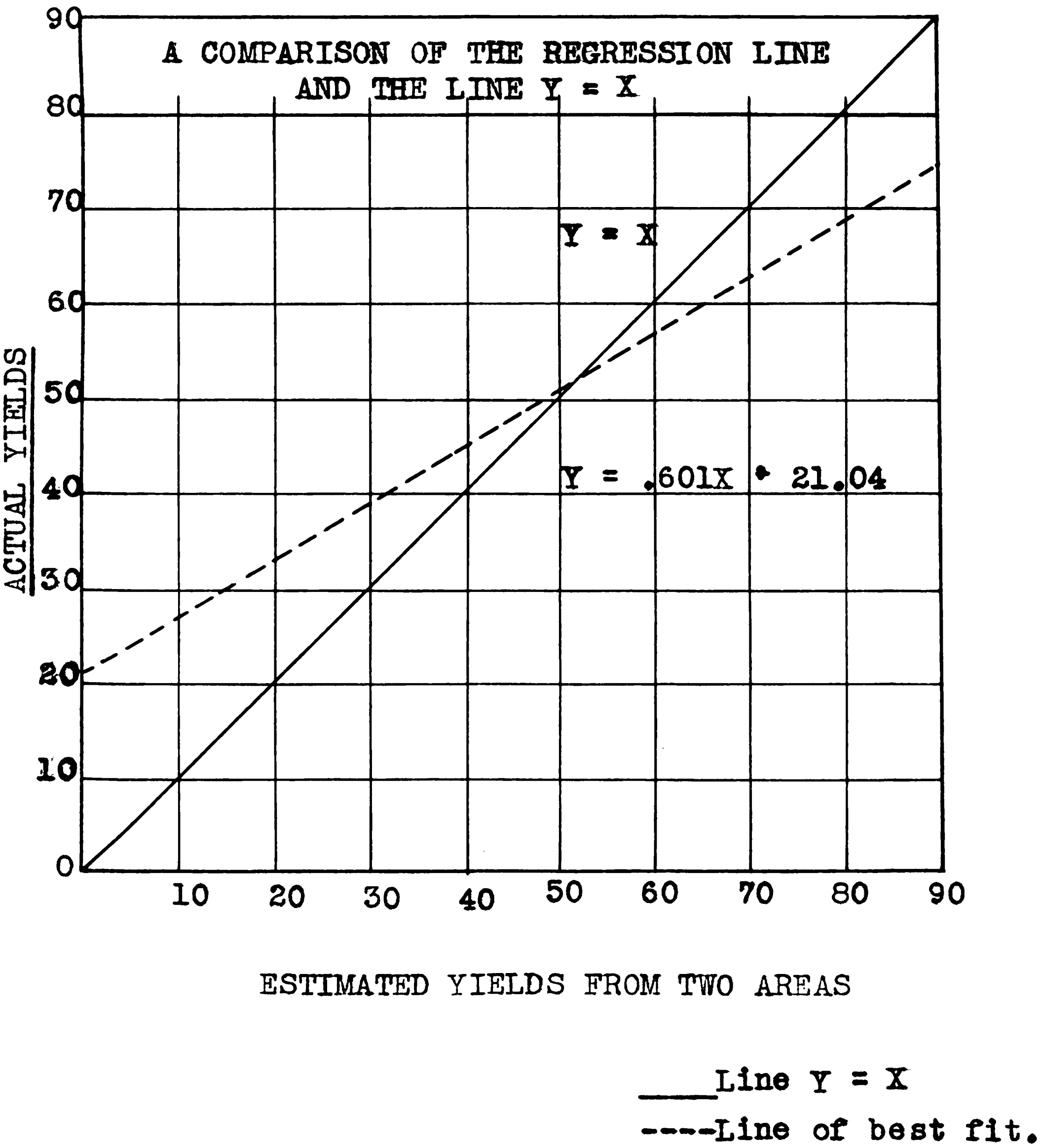
____Line Y = X
----Line of best fit.



ESTIMATED YIELDS FROM THREE AREAS

____Line Y = X

----Line of best fit.


A COMPARISON OF THE REGRESSION LINE
AND THE LINE Y = X
Y = X
Y = .601X + 21.04
ACTUAL YIELDS
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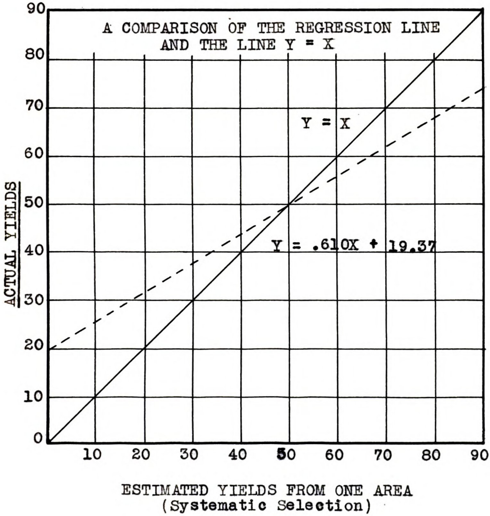
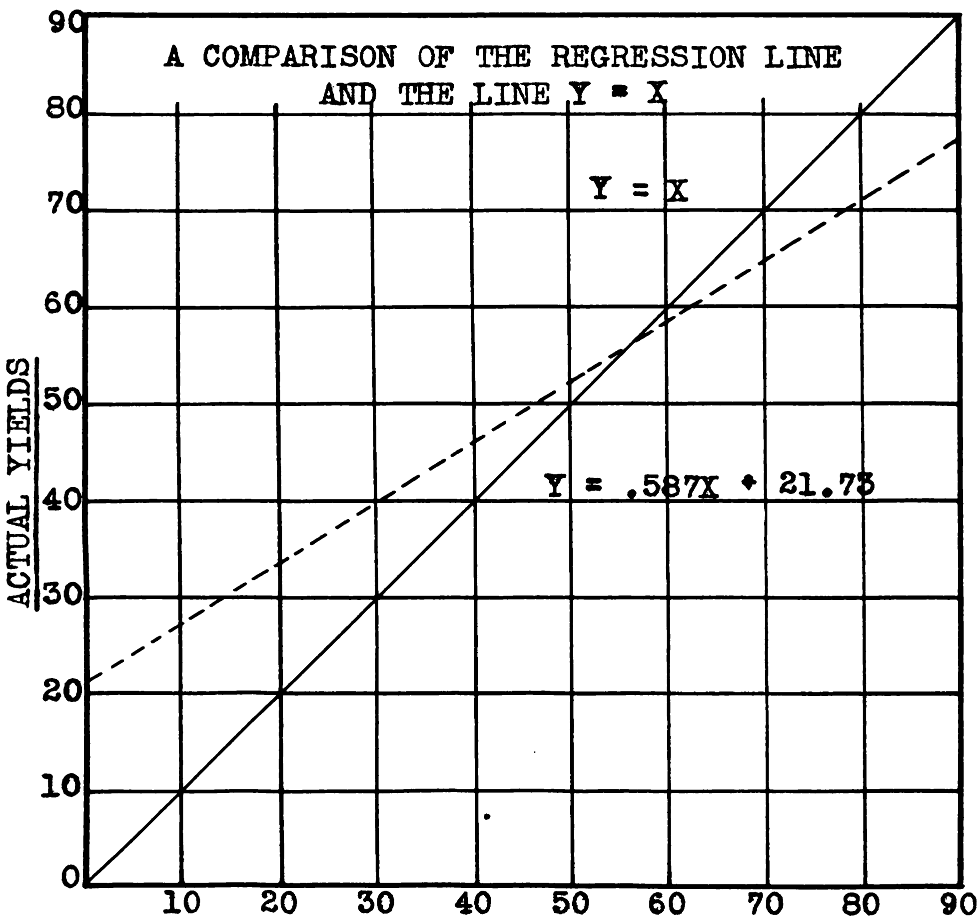
ESTIMATED YIELDS FROM TWO AREAS
____Line Y = X
----Line of best fit.



_____Line Y = X

-----Line of best fit.



ESTIMATED YIELDS FROM ONE AREA
(Random Selection)

____Line Y = X

----Line of best fit.