THE RELATION OF SIZE, SHAPE, AND NUMBER OF REPLICATIONS
OF PLATS TO PROBABLE ERROR IN FIELD
EXPERIMENTATION

by

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SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

in the

GRADUATE SCHOOL

of the

UNIVERSITY OF MISSOURI

1916

*Approved
5/15/16
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INTRODUCTION

Altho large numbers of experiments that attempt to measure small variations of characteristics in variety tests or slight differences resulting from unlike soil treatments or tillage operations are conducted each year, comparatively little attention has been given to the establishment of uniform methods that will reduce the error in such experiments. When we consider that the differences which the tests are expected to disclose are only too often smaller than the probable error of the methods used, the need for attention along this line becomes strikingly evident. It has been demonstrated repeatedly that even soils which possess apparent uniformity really vary a great deal. This variation is often so great as to cast doubt on a large portion of published field experiments when yield is primarily involved. The experimental error arising from soil variation is influenced by the size and shape of plats and by the number of replications. To determine the effect of these factors on experimental error is the purpose of this investigation.

A STATISTICAL PROBLEM

Variations in yields of plats are best studied by statistical methods, in which certain biometrical constants are employed. It is necessary to have a clear understanding of these constants before beginning a study of the effect of

size, shape, and arrangement of plats on experimental error.

The mean is a conception of type and gives a good expression of the average value of a character in a group of individuals. It can be determined either by adding the exact values of the character in all the individuals of the group and dividing by the number of individuals, or by arranging the individuals in classes according to the value of the character they possess, taking the average of the two extremes of each class as the value of that class, multiplying that value by the number of individuals in the class, adding all of these products, and dividing the sum by the number of individuals.

In biometrical work, grouping the individuals in classes, as explained above, is found to give practically the same result as is obtained by using the exact value of each individual, provided the number of individuals considered is sufficiently large to prevent excessive accidental variation. As the former method is much shorter than the latter, it is most frequently employed in the determination of all biometrical constants.

The average deviation is an expression of the deviation of a group of individuals from the mean of the group. It is the average amount by which an individual of the group differs from the mean. It is found by multiplying the deviation of each class from the mean by the number of individuals in the class, adding the products, and dividing the sum by the number of individuals in the group.

The standard deviation is also a measure of the deviation of a group of individuals from the mean. For certain mathematical reasons, the standard deviation is a more accurate measure of variation than the average deviation. It is obtained by squaring the deviation of each class from the mean, multiplying the squares by the frequency of the classes, adding the products, dividing the sum by the number of individuals, and extracting the square root of the quotient.

The coefficient of variability, too, is a measure of deviation. It is obtained by dividing the standard deviation by the mean. It is most frequently expressed in per cent, in which case the above quotient is multiplied by one hundred.

The standard deviation and average deviation are concrete expressions of variation. Ordinarily, a standard deviation or average deviation cannot be compared with another standard deviation or average deviation, because one mean may differ greatly from the other, and because the two may be of entirely different units as grams and acres. On the other hand, the coefficient of variability is an abstract expression of variation and can be used in comparing either like or unlike groups.

The probable error of a single variate is another expression of the degree of variation. Davenport defines it "as that departure from the mean, on either side, within which exactly one-half of the variates are found." It is obtained by multiplying the standard deviation by the factor 0.6745.

HISTORICAL REVIEW

While the number of investigations directly bearing upon the effect of the size and shape of experimental plats on probable error is not large, some of these investigations are very extensive.

Montgomery (1913) combined 100 twelve and one-half foot rows of Kherson oats in various ways in order to study the effect of different arrangements on the average deviation and coefficient of variability of grain yield. He found that as the size of the plat was increased, either by combining adjacent rows or rows uniformly distributed thruout the area under experimentation, both the average deviation and the coefficient of variability decreased. For five, ten, and twenty repetitions the average deviation was less for uniformly distributed rows than for adjacent rows. The coefficient of variability of distributed rows was less than that of adjacent rows for five and ten repetitions, but was slightly greater when twenty distributed rows were combined than the coefficient of variability of twenty adjacent rows.

The same investigator similarly studied 500 sixteen foot rows of Turkey wheat. Here, also, the average deviation and coefficient of variability were found to decrease as the number of rows combined was increased. For five, ten, and fifteen repetitions, less variation was found in plats made up of uniformly distributed rows than in those of the same size composed of adjacent rows. Where the single rows were repeated twenty times, the coefficient of variability was

about the same for the two systems of arrangement. When the rows were uniformly distributed fifteen times, the average deviation was about half as much as when five distributed rows were combined. Replicating twenty times did not make a further improvement. Montgomery concluded that with sixteen foot rows, ten to twenty repetitions must be made, depending upon the degree of accuracy desired.

When four of these rows were so combined as to give a single sixty-four foot row, the deviation and variability were reduced almost one-half. Such an arrangement gave results less variable than plats of five adjacent sixteen foot rows, but more variable than those composed of five uniformly distributed rows.

Montgomery also grew Turkey winter wheat for two years on 224 blocks, each five and one-half feet square. When the results for the two years were combined, it was found that the coefficient of variability decreased as the number of blocks combined to form a unit was increased. The coefficient of variability of five, ten, and fifteen uniformly distributed blocks was strikingly less than that of the same number of adjacent blocks. The investigator stated that blocks repeated eight to ten times were almost as accurate as rows repeated fifteen to twenty times.

He found that alternating with check rows gave a high degree of accuracy when as many as ten or more checks were used. The total number of plats required for the same degree of accuracy, however, was greater by this method than by systematic repetition. He concluded that the principal

value of checks is to determine the degree of experimental error.

Montgomery also observed that increasing the size of the block or the length of the row decreased the number of repetitions necessary, but increased the total area required to secure the same accuracy. He recommended rows of two rods in length and blocks five by sixteen feet as desirable sizes where land was plentiful.

Lyon (1910) compared the deviation from normal yield of seven one-tenth acre plats of wheat with that of seven series of ten seventeen-foot rows of wheat each. The plats were the checks of a test in which there were twenty-two one-tenth acre plats. The rows were the checks in a variety test where every tenth row was a check. The normal yield of each plat was assumed to be the average of the two adjacent plats, and the normal yield of each series was considered to be the average of the two adjacent series. It was found that the per cent of mean deviation from normal in the one-tenth acre plats was 6.5, while in the series of rows it was 2.5. The average probable error for the plats was 15.09 and for the series of rows was 14.49. The seven one-tenth acre plats covered an area of 30,492 square feet, while the seventy seventeen foot rows required only 1,190 square feet.

Lyon (1911) found that a series of twenty-four plats, each of which was thirty-three by sixty-six feet in size, varied greatly in relative productiveness from year to year

during the period from 1900 to 1907 inclusive. The probable error of yield of maize silage for any one plat in a series of sixty-eight one-hundredth acre plats was 4.6 per cent. When these small plats were so combined as to make one-twenty-fifth acre units, the probable error was 4.5 per cent. When the one-twenty-fifth acre units were each made up of four widely separated parts, the probable error was reduced to 2.0 per cent.

From data secured on the yield of potatoes, Lyon (1911) concludes that there is no very great increase in the probable error until the plats become as small as one-twenty-fifth of an acre. He found that a plat of one-hundredth acre and growing one hundred maize plants was probably sufficiently large to prevent errors due to the variations of individual plants. It also was noted that long narrow plats were no better than square plats when no checks were used, but that when check plats were placed every second or third plat in the series, the long narrow plats were less liable to error. Concerning the use of check plats, he says: "There can be no doubt that the use of checks every second or third plat allows of greater accuracy than where no checks are used, but the data at hand do not indicate any advantage from the use of check plats at less frequent intervals." He points out that plants need several generations of growth in the environment under which they are to be tested before they are placed in a variety test in that environment.

Taylor (1908) made a study of reports of experiments of the various experiment stations. From his investigation,

he concluded that one-tenth of an acre should be considered the minimum size, while the maximum would be limited largely by the extent of land available. He calls attention to the fact that the size of one-tenth acre is most convenient for computing results, and that the area contained is ample for the use of most machinery. He concluded that, as a general rule, the size of the plats should vary with the degree of uniformity of the soil.

Cory (1908) concludes that two rows of each variety drilled with a garden drill in rows fifty links long and twelve inches apart will probably better indicate the true rank of each variety in fair to favorable seasons than will large field plats.

Morgan (1908) harvested a wheat crop from a plat of ground 112-1/2 feet in width by 945 feet in length and immediately plowed the plat and planted it to fodder corn. Altho the soil was apparently quite uniform, he found that large and striking irregularities existed in its productiveness. He also noted that on one section of the plat corn yielded considerably above average, while the wheat yields were considerably below average; on the second section both wheat and corn yielded about average; while on the third section the results were just the reverse of those on the first section.

This large plat consisted of sixty-three small plats, each 15 by 112-1/2 feet. Calculating the average error for the yields of corn and wheat together, he found that five

and ten replications of these small plats gave results less variable than two and five replications respectively of a unit composed of two small plats. Single plats and thirty-one replications of single plats, however, were more variable respectively than a unit of two adjacent small plats and fifteen replications of such a unit. He found that when checks were used, the variability decreased as the distance between the checks was lessened. Much more accurate results were obtained by replicating, however, than by the use of checks.

Smith (1909) studied 120 one-tenth acre plats that were grown to corn for three years. The first of these years was very unfavorable to corn; the second year was exceptionally favorable; and the third year was somewhat better than the average season. The results of nine of these plats were discarded because they possessed striking irregularities which could be accounted for in the topography of the land. The standard deviation for the remaining plats was 7.00 per cent the first year, 4.73 per cent the second year, and 3.58 per cent the third year. The writer concludes that there is greater variability in seasons that are unfavorable for production. The results obtained strengthened his conviction that the only dependence to be placed upon variety tests and other field experiments is from records involving the average of liberal numbers and extending over long periods of time.

Bull (1909) found that the centgener method of testing small grains gave results of greater value and stability than the row method. He recognizes that the row method possesses great worth as a forerunner of the centgener method, however, as it has the advantage of economy in testing a large number of individuals and rapidly eliminating the poorest inheritances.

Wheeler (1908) points out that a suitable and satisfactory relationship of breadth to length in field plats is about 1:4 to 1:6. It is less expensive to operate long narrow plats, owing to the relatively less number of turns involved in the cultural operations. With narrow plats, however, it is more difficult to prevent contamination by the transference of soil from one plat to another.

Wood and Stratton (1910) investigated the error of field experiments by two independent methods and found it to be about five per cent of the crop in carefully conducted experiments. They held that the size of the plat had no influence on this figure, provided the plat was one-eightieth of an acre or larger.

The first of their methods of investigation consisted of calculations made from 900 one-thousandth acre plats of mangles. Each plat was a 7.26 yard segment of a long row made up of twenty-five such plats. The probable error was found to be 12 per cent. When one-fortieth acre plats were formed by combining the twenty-five segments in each row, the probable error was decreased to 4 per cent. The

probable error of one-twenty-eighth acre plats, each 7.26 yards wide and running across the thirty-six long rows, was 7 per cent. By rearranging the 900 plats into square plats, each measuring one-eightieth of an acre, a probable error of 5 per cent was obtained.

The second method of investigation employed by the investigators consisted in extracting from various publications the results of duplicate pairs of plats. They found the probable error of four hundred pairs of various sized duplicates to be 4.2 per cent; for forty-five pairs of one-half acre plats it was 3.5 per cent; for fifty-two pairs of one-fourth acre plats 3.5 per cent; for twenty-nine pairs of one-twentieth acre plats 3.9 per cent; for two hundred pairs of one-fortieth acre plats 4.6 per cent; and for seventy-five pairs of one-eightieth acre plats 3.1 per cent.

Taking 5 per cent as the probable error of a single plat in carefully conducted field experiments, and taking thirty to one as the lowest odds which can be considered as amounting to practical certainty, Wood and Stratton worked out the following table showing the number of plats necessary to give any desired precision:

Precision desired in percentage difference between yields	Number of plats required
20	1
15	2
10	4
8	6
6	10
4	23
2	91

They also suggest that very small plats replicated a large number of times are useful for variety tests of cereals.

Latta (1895) advocated for field experiments the use of long, narrow one-tenth acre plats with intervening spaces one-half the width of the plats. He stated that these plats should be arranged in series and the treatment duplicated or triplicated if possible.

Alwood and Price (1890) found that within certain limits, the larger the area of the field plat, the more reliable were the results obtained. They point out, however, that the time and attention which must be given to an experiment makes necessary the reduction of the experimental area to the smallest compass possible. They used plats twenty feet long by three feet wide in variety tests of potatoes. The results of such plats, they state, give valuable indications as to earliness, character, and quality of varieties, but should not be accepted as conclusive until the tests have been repeated on larger plats.

Holtsmark and Larsen (1905) worked out a plan to diminish errors in field trials by a system of checks. Woll translated and summarized their work as follows: "The field is divided into squares for comparative trials with different varieties, fertilizers, etc. Every third square is used as a control plat, and in calculating the results the average of the yields on the three control plats lying nearest a trial plat is taken into consideration and the difference between this average and the yield of the trial plat determin-

ed. This difference is calculated for each trial plat, and the average for all the control plats in the field is also found. The calculated difference for each trial plat is finally added to or subtracted from the average of the control plats, according to whether the difference was positive or negative. The errors of the yields obtained for the different plats is represented by the difference between the calculated yields and the average of the actual yields for all trial and control plats."

Montgomery (1913) finds that wheat plants grown under nursery or field conditions show great variation in nitrogen content, due probably to variation in environment rather than to heredity. Centgeners, small plats, and rows vary almost as much as individual plants. The variation can best be overcome by replicating the plats a sufficient number of times to reduce the error to less than one-half the real variation. In testing the nitrogen content of wheat, he found that to bring the experimental error within bounds, it was necessary to repeat single plants from forty to one hundred times, sixteen foot rows five to ten times, and blocks five and one-half feet square eight to sixteen times. He states that the most practical way of growing strains to compare for nitrogen content is to replicate rows twelve to sixteen feet in length ten times. It is advisable to insert check plats every five or ten rows.

Carleton (1909) found that variations in results from plats were lessened by having every third plat a check. Ac-

cording to his theory, the soil varies uniformly from one portion of the field to another, and the yields of some varieties are "corrected by adding or subtracting such a fraction of the difference in yields between these checks as is indicated by reference to their position between the checks." He also points out that if the soil is abruptly variable, but uniform within small areas, very small plats may be preferable to large ones. If the variation extends in one direction, it may be overcome by using long narrow plats which have their greatest dimension in that direction.

Egorov (1909) grew oats on a uniform field composed of two hundred and forty square plats, each of which was one square sazhen or forty-nine square feet in area. He found the yields of the plats to be quite variable. When they were combined to form large units, however, the variation decreased with the increase of plat area. An increase in the number of replications increased the degree of accuracy. The number of replications remaining the same, the larger the plats, the more accurate the results. A large number of replications of small plats gave more accurate results than those obtained from a smaller number of replications of large plats, the total area being the same in each case.

Thorne (1905) recommends one-tenth acre plats for field experiments with corn, as this size is convenient for computation and holds a sufficient number of plants to eliminate the errors arising from individuality. He states that a

smaller plat may be used for small grains, however. Variation due to soil differences can be eliminated better by duplicating the test in small plats than by the use of large plats. Long narrow plats are usually more satisfactory than those of other shapes. Check plats planted to a standard variety should be inserted every second or third plat, and the calculation of increase should be made on the assumption that the variation between the neighboring check plats is due to similar variation in the soil between them.

Caldwell (1897) states that for a very large field lacking in uniformity, large plats are more advisable than for a smaller field of even character. Long narrow plats are considered better than those of other shapes. For corn and potatoes, a plat width of seventeen and one-half feet is recommended; for cereals, plats as wide as can be sown with the drill are satisfactory.

Brooks (1890) recommends the use of long, narrow plats, one-twentieth of an acre in area.

Hall and Russel (1911) find that the sources of experimental error in field experiments are (1) those which increase as the size of the plat decreases, such as individual variation and the occurrence of disease, and (2) those which decrease with a decrease in the size of the plat, such as soil variation. Differences in the second group are less marked when the plats are narrow and lie side by side. The probable error for one-fiftieth acre plats was found to be 4.2 per cent. When a unit of this size was composed of five scatter-

ed parts, the probable error decreased to 2.4 per cent. The probable error of one-fifth acre plats, when composed of five scattered parts, was 1.3 per cent; when made up of ten scattered parts, it was 1.1 per cent; and when composed of two scattered parts, it was 1.7 per cent. The probable error of single one-fifth acre plats was 3.1 per cent.

Thorne (1903) conducted fertilizer tests in a rotation of corn, oats, wheat, timothy and clover (two years), on plats sixteen feet wide by sixteen and one-half rods long. A check was inserted every third plat. It was found that much more consistent results were obtained by assuming that variations are progressive and by treating two fertilized plats and the two check plats between which they stand as the terms of an arithmetical series, than by making comparisons on the basis of simple averages, either of all the checks or of the two nearest checks.

Phelps (1888) recommends the use of long, narrow plats for fertilizer tests.

Montgomery (1911) grew Turkey wheat three years on a plat of land seventy-seven by eighty-eight feet. He found that increasing the size of the plat had only a slight effect on decreasing the variability after a certain minimum size is reached. For the piece of land with which he was working, there seemed to be no advantage in having the plat larger than eleven feet square. Fluctuating variation can best be met by systematic repetition. The coefficient of variability of sixteen systematically distributed blocks,

each five and one-half feet square, was 2.01 per cent. In the case of sixteen adjacent blocks of this size, it was 7.85 per cent. Ten repetitions of a plat five and one-half by sixteen feet are recommended for variety tests.

Spillman (1912) states that many farm problems can be more accurately solved by gathering data in large quantities from farms than by ordinary experimental methods.

Farrell (1913) calculated the probable error of yields of sugar beets, oats, and alfalfa on quarter-acre plats at Scottsbluff, Nebraska, and Huntley, Montana. It was found that a close agreement existed in the probable error of plats of sugar beets and alfalfa at Huntley, where the same field was used for both trials. He argues that these data support in a way the conclusion of Wood and Stratton (1910) that there was no significant difference between the probable error of one crop and that of any other. At Huntley and Scottsbluff very different probable errors were found for oats, being 8.3 per cent in the first case, and 19.1 per cent in the second. These results, he concludes, refute the assumption of Wood and Stratton (1910) that five per cent may be taken as the probable error of a single plat, (one-eightieth of an acre or more in area) in a carefully conducted field experiment. It is recommended that the probable error be given consideration in the interpretation of experimental results to avoid unduly emphasizing insignificant differences.

Mortensen (1911) found one-two-hundredth to one-thousandth hectare (about five hundred and thirty-five square feet) to

be the proper size of plats. The form, he states, should be as nearly quadrangular as possible. Small plats repeated several times are better than single large plats. Eight or ten replications are recommended if not more than two factors are to be determined in the experiment. If more than two factors are to be determined, more than ten replications should be employed.

Bilger (1912) recommends five replications of plats, each 2.4 meters square, for variety tests.

Grégoire (1913) analyzed the results of field experiments made by Mercer and Hall, Wood and Stratton, Mitscherlich, and others. From an analysis of 250 such tests made at least in triplicate, he found that the probable error in each individual test exceeded 4.7 per cent in fifty cases out of one hundred, 6.6 per cent in twenty-five cases, 8.5 per cent in nine, and 10.5 per cent in two. He concludes that out of one hundred field experiments, the probable error will exceed 5 per cent in seventy-three cases, 6 per cent in sixty-four, 7 per cent in fifty-two, 8 per cent in thirty-nine, 9 per cent in thirty, 10 per cent in eighteen, 11 per cent in nine, and 12 per cent in four. It was shown that the results from a single plat are of little value. The probable error is decreased by increasing the number of plats, which, Grégoire states, should never be less than three.

Barber (1914) recommends the use of square plats, because such plats have the smallest number of plants along the more productive borders. He also finds that large plats

are superior to small ones, because they have a smaller proportion of plants along the borders.

Salmon (1913) recommends five replications of plats one hundred and thirty-two feet long and six feet wide for variety tests. For time and rate-of-seeding tests, he recommends three replications of plats of this size.

Olmstead (1914)^{having} made an analysis of the plat experiments of Mercer and Hall (1911), Lyon (1911), and Montgomery (1913), concluded that greater accuracy could be obtained by replicating small plats than by any other method. "Replication also lessens the uncertainties involved in the use of check plats, and may decrease the total area required for the conduct of experiments."

Mercer and Hall (1911) point out that experimental error may be greatly reduced by repeating the experiment over a long period of years and thereby eliminating seasonal variations but not soil variations, or by repeating the number of plats on a given field. The latter method tends to eliminate error due to soil differences, but is subject to errors due to the season. The investigators worked with 200 one-two-hundredth acre plats of mangels and 500 one-five-hundredth acre plats of wheat. Frequency curves of the yields of these plats showed that in both cases the material was sufficiently homogeneous to permit the application of the properties of the normal curve of error to the results obtained. Regression lines of the relation between the weights of roots and leaves and of that between the weights of grain and straw were plotted.

It was found that the yields of roots and leaves varied together as did also those of grain and straw; consequently, it was only necessary to discuss the yields of roots and grain.

Mercer and Hall also determined the standard deviation of various sized plats and of different combinations of plats. They found that the error decreased as the size of the plat increased, but that the reduction was small when the size of the plat was increased above one-fortieth of an acre. They state that "the error may be best diminished by increasing the number of plats similarly treated and scattering them about the area under experiment, but there is not much to be gained by increasing the number of plats above five." Five replications of one-fortieth acre plats are recommended for field experiments.

Pritchard (1916), in working with the sugar content of sugar beets, found that the use of frequent checks gave more accurate results than using the mean of all progeny rows as a standard of comparison. The employment of every alternate row as a check was not sufficient to offset the differences in yield arising from soil variation. The use of ten replications and alternate check rows reduced the experimental error about fifty per cent. So long as comparison was made with alternate check rows, he found practically no difference in the results obtained from consecutive replications and those given by distributed replications.

TABLE I.

PLAN AND WEIGHT IN GRAMS OF FIVE FOOT SEGMENTS OF WHEAT ROWS
UPPER FIGURES GRAIN, LOWER STRAW

ROW	SER.A	SER.B	SER.C	SER.D	SER.E	SER.F	SER.G	SER.H
1	67.2 136.8	59.0 122.0	67.2 124.8	53.5 105.5	50.7 94.3	78.5 170.5	42.4 87.6	70.0 114.0
2	54.0 112.0	51.0 101.0	39.4 92.6	50.4 108.6	51.0 100.0	40.6 92.4	31.3 63.7	46.0 70.0
3	60.0 125.0	44.0 99.0	59.8 110.2	60.5 132.5	51.9 102.1	48.1 114.9	57.8 115.2	35.9 71.1
4	40.5 91.5	45.0 114.5	43.9 87.1	81.4 188.6	59.1 129.9	56.3 123.7	64.8 133.2	87.8 160.2
5	48.0 104.0	64.2 136.9	65.0 132.0	68.6 155.4	60.7 125.3	56.5 131.5	84.4 160.6	45.1 92.9
6	35.9 62.1	27.2 60.8	55.5 111.5	47.2 100.8	28.9 61.1	46.9 105.1	25.4 57.6	56.7 99.3
7	49.7 102.3	39.4 79.6	42.4 78.6	37.7 81.3	33.8 84.2	40.4 94.6	71.4 139.6	58.2 94.8
8	45.6 108.4	78.4 141.6	43.6 85.4	62.7 134.3	58.9 120.1	60.0 121.0	41.0 88.0	34.9 81.1
9	24.6 51.4	84.5 127.5	49.6 101.4	27.2 70.8	33.9 79.1	51.0 118.0	34.7 86.3	16.3 56.7
10	34.8 91.2	34.4 78.6	40.2 77.8	60.5 123.5	53.7 100.3	30.6 71.4	45.7 94.3	55.5 105.5
11	47.3 100.7	35.8 79.2	42.3 83.7	51.3 108.7	39.2 79.8	30.4 77.6	48.2 97.8	36.7 68.3
12	44.0 96.0	53.4 113.6	8.5 28.5	5.4 19.6	30.1 67.9	66.1 133.9	49.2 108.8	15.2 35.8
13	66.1 151.9	62.9 128.1	51.2 107.8	56.7 128.3	17.3 48.7	38.9 87.1	43.9 88.1	65.2 119.8
14	51.6 113.4	36.5 77.5	43.2 91.8	60.3 129.7	53.5 101.5	51.5 107.5	61.2 105.8	47.6 92.4
15	46.0 94.0	31.3 71.7	35.4 71.6	42.5 96.5	48.2 89.8	31.2 74.8	20.8 61.2	41.2 86.8
16	55.0 105.0	68.0 130.0	56.1 103.9	51.8 117.2	66.0 79.0	38.9 88.1	47.1 99.9	40.0 72.0

ROW	SER.A	SER.B	SER.C	SER.D	SER.E	SER.F	SER.G	SER.H
17	41.9 88.1	37.7 73.3	57.9 104.1	59.0 124.0	46.6 99.4	52.0 103.0	34.0 74.0	34.3 75.7
18	70.2 152.8	72.8 143.2	55.1 107.9	42.5 100.5	47.5 91.5	62.9 128.1	85.0 163.0	53.5 102.5
19	49.2 99.8	58.9 119.1	62.2 121.8	80.2 176.8	47.8 89.2	35.8 82.2	24.4 59.6	45.2 84.8
20	56.1 113.9	37.1 82.9	48.2 98.8	49.8 107.2	69.2 132.8	19.7 50.3	44.2 92.8	59.5 103.5
21	42.7 89.3	77.6 147.4	41.5 84.5	40.6 92.4	39.4 76.6	29.4 76.6	46.8 75.2	26.2 66.8
22	52.8 111.2	33.6 64.4	58.8 104.2	33.8 80.2	47.9 102.1	49.0 112.0	55.0 120.0	33.6 63.4
23	36.4 81.6	81.4 143.6	55.0 102.0	45.7 101.3	48.9 93.1	65.3 142.7	43.8 88.2	29.8 69.2
24	70.8 144.2	37.0 72.0	54.6 79.4	62.3 128.7	62.8 117.2	46.2 108.8	56.0 109.0	25.9 59.1
25	34.0 89.0	31.8 60.2	30.3 53.7	36.9 84.1	44.5 89.5	53.5 121.5	39.0 77.0	32.1 67.9
26	33.0 80.0	83.8 118.2	46.8 85.2	43.7 98.3	62.5 133.5	46.4 105.6	31.3 67.7	35.0 69.0
27	30.8 74.2	53.7 99.3	61.5 111.5	51.1 107.9	52.6 97.4	56.2 117.8	60.7 111.3	64.9 112.1
28	39.8 87.2	34.2 69.8	51.3 88.7	52.0 112.0	35.6 69.4	34.5 71.5	47.3 97.7	53.0 115.0
29	18.6 52.4	52.0 99.0	39.0 77.0	43.9 88.1	51.5 103.5	44.4 94.6	41.2 79.8	23.4 56.6
30	49.6 124.4	39.5 69.5	35.3 65.7	33.6 65.4	23.7 54.3	50.6 101.4	27.4 54.6	39.0 76.0
31	54.0 113.0	21.6 45.4	41.4 75.6	46.3 97.7	15.8 44.2	17.4 53.6	39.0 82.0	35.0 74.0
32	37.3 100.7	56.3 104.7	36.9 64.1	28.6 62.4	36.7 70.3	30.6 69.4	52.1 99.9	26.0 57.0
33	60.7 114.3	48.6 84.4	33.8 62.2	32.7 72.3	27.0 61.0	25.6 68.4	43.3 96.7	16.2 40.8
34	28.8 59.2	28.5 51.5	47.8 74.2	37.8 76.2	58.3 103.7	54.7 111.3	48.9 110.1	63.4 116.6

ROW	SER.A	SER.B	SER.C	SER.D	SER.E	SER.F	SER.G	SER.H
35	56.4 112.6	46.0 82.0	44.7 73.3	35.1 73.9	24.5 51.5	29.6 58.4	43.7 82.3	58.0 103.0
36	44.5 80.5	29.0 51.0	29.8 57.2	38.0 58.0	48.6 89.4	44.2 85.8	49.0 96.0	46.0 82.0
37	30.6 57.4	37.6 76.4	40.6 68.4	25.8 60.2	33.2 62.8	25.8 65.2	18.2 40.8	30.1 53.9
38	38.7 79.3	45.8 78.2	37.6 72.4	32.8 69.2	23.8 50.2	60.0 116.0	34.4 70.6	50.5 98.5
39	41.8 78.2	53.5 95.5	28.7 56.3	41.4 84.9	39.2 72.8	28.6 67.4	28.5 61.5	21.5 43.5
40	76.6 148.4	48.2 90.8	39.4 68.6	45.7 89.3	35.8 72.2	28.9 66.1	40.0 80.0	31.7 63.3
41	56.0 109.0	33.5 67.5	58.6 106.4	49.2 95.8	53.5 99.7	50.5 105.5	58.8 110.2	64.3 102.7
42	25.6 58.4	65.0 117.0	24.5 48.8	26.8 61.2	48.2 58.8	44.7 92.3	30.2 54.8	41.8 82.2
43	47.0 98.0	57.1 101.9	61.6 75.4	43.8 89.2	41.6 92.4	49.7 97.3	27.6 60.4	26.0 62.0
44	53.6 109.4	38.2 80.8	36.6 68.4	65.2 123.8	51.2 87.8	20.9 43.1	20.0 44.0	16.2 42.8
45	38.8 90.2	46.9 99.1	38.8 77.2	26.0 63.0	32.1 65.9	69.5 125.5	81.7 156.3	51.7 96.3
46	44.6 73.4	40.7 86.3	50.4 90.6	46.6 113.4	34.1 70.9	53.9 109.1	46.1 84.9	39.6 73.4
47	55.2 111.8	61.8 106.2	49.9 93.1	57.0 114.0	45.4 86.6	65.9 129.1	51.1 103.9	47.5 86.5
48	42.6 89.4	40.4 88.6	50.0 92.0	36.0 78.0	50.5 89.5	29.5 68.5	60.2 114.8	32.1 70.9
49	58.5 130.5	44.8 95.2	61.5 119.5	45.4 100.6	39.5 82.5	68.6 150.4	50.7 100.3	52.7 104.3
50	43.3 94.7	42.6 130.4	63.3 66.7	61.6 122.4	45.1 99.9	28.0 69.0	58.3 89.7	61.8 114.2
51	71.7 148.3	76.7 153.3	55.8 103.2	45.7 92.3	54.4 117.6	58.0 129.0	50.9 102.1	81.1 153.9
52	38.2 83.8	79.3 165.7	84.5 172.5	86.2 174.8	86.4 168.6	63.6 137.4	80.0 143.0	66.2 129.8

ROW	SER.A	SER.B	SER.C	SER.D	SER.E	SER.F	SER.G	SER.H
53	73.2 155.8	62.2 120.8	72.0 140.0	63.4 137.6	56.8 130.2	51.9 137.9	82.8 152.2	68.2 134.8
54	92.3 202.7	35.7 73.3	65.1 124.9	51.4 103.6	64.2 121.8	75.1 159.9	67.9 130.1	94.6 187.4
55	32.7 65.3	70.3 152.7	44.3 90.7	55.9 110.1	61.1 128.9	42.1 99.9	55.2 110.8	48.5 103.5
56	83.9 166.1	54.4 115.6	40.3 100.7	62.8 127.2	55.9 117.1	56.2 121.8	51.6 104.4	37.3 85.7
57	65.8 144.2	24.6 57.4	48.7 98.3	29.6 58.4	36.5 80.5	46.7 92.3	38.5 79.5	49.5 108.5
58	44.6 90.4	40.5 84.5	52.8 104.2	46.5 95.5	34.7 74.3	43.3 91.7	36.6 79.4	35.0 90.0
59	36.0 74.0	39.2 88.8	42.6 93.4	47.6 84.4	31.4 61.2	41.2 83.8	44.5 81.5	27.9 57.1
60	68.6 141.4	29.5 64.5	95.3 180.7	43.0 85.0	36.5 81.5	32.0 66.0	29.8 67.2	35.1 89.9
61	40.9 90.1	49.7 101.3	21.2 50.8	35.8 83.2	40.4 90.6	63.8 133.2	52.8 106.2	36.1 80.9
62	54.1 112.9	63.8 121.2	34.6 76.4	40.9 78.1	36.7 83.3	45.2 97.8	34.4 87.6	45.9 98.1
63	57.2 114.8	44.7 99.3	32.2 80.8	19.6 51.4	37.1 80.9	63.4 135.6	44.3 80.7	14.2 38.8
64	50.7 102.3	19.8 39.2	41.2 82.8	26.1 56.9	20.9 49.1	39.7 80.3	39.5 79.5	28.5 58.5
65	67.8 131.2	39.7 81.3	42.9 88.1	35.1 69.9	34.6 87.4	44.9 97.1	20.0 55.0	23.2 60.8
66	40.5 116.5	57.5 125.5	48.7 100.3	58.5 105.5	60.9 95.1	47.4 99.6	42.6 89.4	67.8 119.2
67	47.3 87.7	54.2 114.8	42.6 94.4	45.1 91.9	34.8 88.2	36.9 91.1	43.8 96.2	44.1 92.9
68	51.5 98.5	62.1 120.9	37.9 79.1	30.6 92.4	32.2 80.8	31.1 76.9	50.0 98.0	42.6 87.4
69	44.3 97.7	34.2 70.8	38.7 85.3	26.3 60.7	37.6 81.4	39.4 95.6	37.3 85.7	56.6 105.4
70	54.2 111.8	23.8 54.2	62.8 123.6	39.2 91.8	35.6 69.8	10.6 28.4	21.1 57.9	31.1 70.9

ROW	SER.A	SER.B	SER.C	SER.D	SER.E	SER.F	SER.G	SER.H
71	62.5 133.5	32.0 73.0	25.4 58.6	45.7 79.3	67.4 133.6	30.6 71.4	51.2 99.8	32.5 74.5
72	78.1 157.9	43.6 86.4	46.7 91.3	60.0 113.0	43.4 88.7	32.8 71.2	49.4 93.6	40.8 86.2
73	40.0 85.0	47.0 103.0	21.8 46.2	35.1 69.9	47.6 99.4	61.3 105.7	44.9 88.1	20.6 50.4
74	30.0 73.0	37.5 75.5	52.9 101.1	44.7 95.3	32.4 71.6	23.3 48.7	37.6 69.4	39.6 85.4
75	55.4 118.6	51.3 97.7	30.5 68.5	23.0 48.0	31.4 70.6	24.0 59.0	40.9 77.1	57.4 121.6
76	38.8 82.2	49.0 90.0	28.8 68.2	20.0 54.0	23.0 54.0	73.1 133.9	53.1 101.9	41.8 83.2
77	38.9 76.1	62.6 125.4	46.6 97.4	66.8 132.2	17.6 44.4	45.7 94.3	78.3 154.7	62.2 131.8
78	31.0 72.0	43.0 93.0	67.4 136.6	45.7 92.3	46.7 106.3	56.6 113.4	48.7 107.3	43.0 90.0
79	55.7 109.3	17.0 38.0	36.1 83.9	35.1 83.9	42.7 91.3	42.2 92.8	40.0 83.0	37.1 100.9
80	30.8 75.2	43.7 102.3	40.2 82.8	44.7 91.3	44.0 90.0	31.5 71.5	35.2 89.8	28.0 62.0
81	40.0 74.0	76.7 148.3	57.4 122.6	37.5 89.5	62.4 115.6	53.2 114.8	42.6 84.4	42.8 106.2
82	44.5 96.5	27.1 54.9	24.7 60.3	38.2 82.8	20.0 48.0	82.5 166.5	59.8 114.2	36.4 73.6
83	40.1 91.9	23.3 45.7	64.6 134.4	52.2 117.8	41.3 92.7	48.8 107.2	68.9 129.1	51.1 107.9
84	33.2 81.8	17.4 46.6	35.8 88.2	35.6 76.4	41.5 101.5	47.7 107.3	32.9 73.1	34.2 69.8
85	31.2 76.8	31.3 78.7	20.0 50.0	47.0 90.0	56.0 106.0	61.4 122.6	55.1 101.9	50.4 102.6
86	32.1 66.9	42.0 80.0	47.5 114.5	21.2 42.8	41.4 90.6	42.5 89.5	29.7 59.3	21.9 49.1
87	41.2 90.8	42.6 90.4	43.1 95.9	68.8 123.2	53.5 101.5	73.2 146.8	67.3 128.8	43.4 82.6
88	56.5 113.5	71.6 137.4	67.4 124.6	32.8 67.2	65.4 140.6	50.8 99.2	45.1 89.9	26.0 62.0

ROW	SER.A	SER.B	SER.C	SER.D	SER.E	SER.F	SER.G	SER.H
89	45.7 94.3	62.9 114.1	30.2 73.8	32.7 70.3	49.1 103.9	36.7 78.3	33.9 71.1	39.2 77.8
90	19.4 55.6	28.7 61.3	39.2 92.8	38.0 90.0	25.3 57.7	45.1 93.9	40.0 79.0	42.3 84.7
91	58.2 117.8	34.9 79.1	41.8 82.2	44.8 90.2	36.3 76.7	45.1 89.9	41.9 83.1	42.1 75.9
92	55.1 105.9	75.7 139.3	40.7 98.3	43.2 88.8	62.2 126.8	68.3 139.7	95.8 151.2	61.1 107.9
93	61.4 116.6	26.6 57.4	49.9 102.1	48.0 91.0	45.4 102.6	45.0 97.0	37.0 76.0	39.0 80.0
94	49.0 105.0	56.2 108.8	37.8 90.2	64.6 120.4	48.0 94.0	60.7 110.3	57.1 111.9	55.4 106.6
95	35.7 90.3	34.4 85.6	47.1 98.9	58.0 113.0	46.6 103.4	49.0 98.0	29.7 68.3	34.1 73.9
96	37.8 76.2	20.5 45.5	35.7 76.3	39.2 70.8	16.6 72.4	24.1 58.9	29.6 58.4	30.5 59.5
97	30.8 74.2	33.3 75.7	32.1 68.9	40.0 81.0	91.8 180.2	60.0 123.0	64.8 124.2	63.7 125.3
98		65.1 131.9	60.0 90.0	65.4 114.6	51.4 106.6	49.9 68.1	42.2 81.8	40.0 88.0
99	32.2 67.8	51.7 108.3	41.2 83.8	58.7 111.3	57.3 110.7	54.1 111.9	46.7 83.3	77.4 148.6
100	43.0 82.0	29.8 69.2	33.8 76.2	20.7 46.3	37.5 85.5	56.7 102.3	40.2 80.8	21.1 58.9

ROW	SER.I	SER.J	SER.K	SER.L	SER.M	SER.N	SER.O	SER.P
1		63.3 111.7	42.8 83.2	60.2 101.8	71.4 134.6	51.8 85.2	60.5 113.5	56.2 115.8
2	21.3 51.7	38.7 71.3	51.9 99.1	55.8 89.2	70.9 124.1	53.3 99.7	42.3 71.7	37.7 78.3
3	61.5 125.5	41.4 97.6	38.9 68.1	30.7 40.3	39.5 78.5	41.2 77.8	34.7 67.3	62.9 134.0
4	48.7 103.3	77.1 151.9	83.1 156.7	69.8 126.2	45.7 99.3	53.8 99.2	78.4 153.6	59.7 145.3
5	49.0 96.0	38.6 89.4	55.5 99.5	34.6 64.4	36.8 80.2	47.7 96.3	49.0 105.0	50.0 111.0
6	55.4 109.6	56.0 100.0	33.1 72.9	48.8 88.2	61.9 104.1	41.5 68.5	18.6 42.4	60.2 133.8
7	51.8 101.2	31.6 80.4	47.1 95.9	43.2 72.8	47.2 86.8	51.5 88.5	43.2 76.8	30.2 67.8
8	19.0 54.0	56.9 110.1	14.0 39.0	45.7 93.3	58.3 115.7	31.4 63.3	32.6 71.4	29.5 75.5
9	35.9 83.1	70.8 139.2	56.6 127.4	28.0 57.0	37.0 86.0	41.7 84.3	32.7 73.5	48.6 117.4
10	49.5 103.5	23.0 57.0	45.7 92.3	28.4 63.6	56.3 113.7	35.1 68.9	28.3 35.7	34.3 85.7
11	34.6 75.4	43.5 88.5	15.5 41.5	33.7 60.3	37.8 79.2	28.4 61.6	23.5 49.5	32.9 85.1
12	71.5 130.5		18.5 44.5	21.3 42.7	13.5 33.5	12.4 34.6	5.9 27.1	6.3 15.7
13	57.7 123.3	52.9 105.1	27.0 60.0	54.0 91.0	72.3 129.7	29.5 60.5	35.2 78.8	66.6 145.4
14	52.7 111.3	64.9 115.1	70.5 139.5	48.9 102.1	64.6 127.4	75.6 138.4	39.0 88.0	43.4 96.6
15	47.2 93.8	34.0 70.0	40.0 78.0	39.7 71.3	39.5 82.5	22.2 46.8	19.5 40.5	28.1 69.9
16	51.6 98.4	46.9 93.1	34.7 129.3	34.5 66.5	39.5 79.5	30.5 64.5	26.1 53.9	71.2 157.8

ROW	SER.I	SER.J	SER.K	SER.L	SER.M	SER.N	SER.O	SER.P
17	38.4 79.6	28.4 67.6	32.2 55.8	24.8 53.2	56.4 127.6	50.3 101.7	22.7 49.3	32.5 77.5
18	63.5 118.5	59.7 113.3	52.4 100.6	68.7 122.3	54.7 120.3	36.7 72.3	48.7 85.3	44.0 93.0
19	46.8 89.2	68.8 115.2	47.4 94.6	78.5 140.5	100.0 238.0	54.8 98.2	55.6 101.4	49.7 131.3
20	67.8 129.2	35.0 73.0	26.7 74.3	37.7 64.3	25.8 62.2	66.2 114.8	32.6 69.4	41.4 111.6
21	27.0 62.0	45.4 80.6	58.7 108.3	44.0 79.0	41.4 91.6	32.8 60.2	58.4 96.6	27.5 67.5
22	39.1 76.9	38.5 82.5	31.7 54.3	49.5 95.5	53.9 104.1	91.0 150.0	38.2 65.8	37.5 75.5
23	44.7 89.3	42.4 85.6	28.7 64.3	40.5 68.5	45.2 83.8	24.4 50.6	68.7 122.3	28.1 64.9
24	45.2 101.8	47.3 95.7	67.6 125.4	87.8 148.2	48.6 91.4	57.2 113.8	24.8 54.2	53.4 97.6
25	25.7 63.3	37.3 75.7	26.6 58.4	31.9 61.1	27.2 58.8	31.8 61.2	34.5 70.5	33.4 70.6
26	46.0 73.0	29.0 56.0	49.9 93.1	45.2 75.8	44.3 72.7	24.5 53.5	24.9 45.1	26.7 65.3
27	64.2 110.8	46.0 88.0	22.0 44.0	55.1 96.9	57.7 106.3	59.8 112.2	77.2 127.8	21.1 46.9
28	56.0 103.0	43.0 79.0	55.0 102.0	40.7 79.3	35.4 76.6	32.8 66.2	29.5 66.5	71.2 148.8
29	56.7 101.3	53.9 96.1	34.6 70.4	47.2 90.8	41.5 85.5	41.9 80.1	27.6 64.4	27.4 67.6
30	17.9 43.1	16.2 36.8	44.6 80.4	30.0 66.0	57.6 114.4	20.3 48.7	57.4 101.6	27.7 64.3
31	47.9 92.1	57.0 100.0		32.5 62.5	22.3 51.7	36.0 66.0	28.9 56.1	27.8 68.2
32	21.8 48.2	37.8 56.2	16.1 38.9	18.8 39.2	44.3 83.7	28.0 58.0	32.6 63.4	17.6 48.4
33	41.7 84.3	28.6 50.4	20.0 44.0	43.0 77.0	38.2 74.8	45.9 80.1	34.7 57.3	52.7 123.3
34	45.4 90.6	55.0 103.0	33.5 64.5	37.4 70.6	53.1 98.9	23.3 51.7	45.2 80.8	12.8 29.2

ROW	SER.I	SER.J	SER.K	SER.L	SER.M	SER.N	SER.O	SER.P
35	42.2 79.8	47.1 88.9	45.6 99.4	25.5 40.5	26.6 67.4	48.7 92.3	8.2 30.8	53.5 113.5
36	43.5 78.5	39.7 72.3	27.4 64.6	33.1 64.9	22.9 52.1	36.6 73.4	15.0 36.0	33.6 72.4
37	57.6 105.4	20.2 46.8	38.8 78.2	39.8 65.2	34.9 70.1	25.4 55.6	41.6 72.4	12.2 29.8
38	25.9 57.1	22.4 48.6	22.3 56.7	37.4 65.6	27.1 61.9	30.9 57.1	19.2 32.8	21.0 52.0
39	54.2 78.8	31.1 58.9	38.1 69.9	34.0 66.0	21.4 45.6	17.3 41.7	36.8 66.2	26.4 55.6
40	23.5 58.5	27.3 57.8	21.5 38.5	61.1 108.9	45.4 90.6	57.7 95.3	64.0 116.0	15.8 48.2
41	34.5 83.5	39.6 86.4	41.0 74.0	31.7 53.3	65.7 127.3	41.8 76.2	23.7 49.3	62.7 94.3
42	27.5 66.5	28.5 60.5	53.5 106.5	33.5 64.5	38.6 74.4	45.8 79.2	43.3 83.7	27.0 64.0
43	70.3 134.7	38.6 71.4	37.6 86.4	51.2 92.8	31.6 55.4	27.3 52.7	45.8 81.2	36.6 75.4
44	40.8 80.2	72.5 125.5	48.6 103.4	41.6 71.4	22.7 48.3	21.1 46.9	56.4 96.6	23.2 53.8
45	20.2 49.8	55.8 114.2	45.4 92.6	41.0 74.0	33.8 73.2	65.0 118.0	42.5 80.5	22.5 56.5
46	56.7 108.3	40.6 76.4	53.5 93.9	59.2 104.8	24.5 50.5	40.7 69.3	26.7 51.3	47.2 116.8
47	40.2 86.8	34.3 63.7	61.4 95.6	43.6 76.4	46.2 86.8	39.8 70.2	55.5 95.5	89.4 76.6
48	47.1 86.9	37.0 78.0	40.0 80.0	58.9 113.1	53.1 104.9	45.1 83.9	56.8 107.2	26.1 74.9
49	49.6 93.4	51.5 96.9	50.0 101.0	29.9 61.1	40.7 95.3	45.2 86.8	38.0 78.0	51.7 110.3
50	60.3 108.7	77.9 159.1	23.5 47.5	64.8 129.2	40.8 87.2	41.9 88.1	54.1 108.9	30.6 67.4
51	86.1 174.9	73.3 139.7	51.2 90.8	66.1 120.9	87.7 144.3	50.5 98.5	38.8 80.2	45.7 104.3
52	57.8 105.2	77.2 148.8	87.3 158.7	74.2 152.8	78.7 148.3	69.4 151.6	52.3 112.7	26.4 67.6

ROW	SER.I	SER.J	SER.K	SER.L	SER.M	SER.N	SER.O	SER.P
53	72.1 141.9	65.2 136.8	72.7 136.3	81.1 147.9	61.2 140.8	74.7 169.3	41.7 87.3	74.1 181.9
54	64.2 129.8	61.7 97.3	83.3 161.7	45.8 91.2	71.7 145.9	66.4 131.6	34.1 72.9	72.7 156.3
55	53.1 103.9	61.7 129.3	33.7 74.3	51.2 101.8	44.3 91.7	47.2 91.8	76.9 159.1	63.0 166.0
56	54.3 104.7	58.7 117.3	60.7 127.3	33.6 74.4	53.3 102.7	47.0 101.0	57.8 117.2	42.3 103.7
57	50.3 98.7	33.4 80.6	29.2 71.8	19.7 38.3	34.0 75.0	35.2 72.8	42.3 90.7	18.9 63.1
58	50.2 101.8	54.8 93.2	37.0 80.0	27.2 58.8	28.3 66.7	46.1 89.9	41.7 91.3	28.5 97.5
59	40.4 82.6	56.2 102.8	37.6 77.4	33.4 65.6	37.4 78.6	29.0 58.0	34.1 69.9	34.0 84.0
60	79.5 148.5	25.3 57.7	54.4 105.6	36.6 73.4	54.7 108.3	28.8 63.2	32.6 64.4	36.8 94.2
61	27.8 62.2	33.3 66.7	19.3 49.7	53.2 95.8	26.2 58.8	38.7 79.3	52.5 103.5	41.7 92.3
62	57.2 107.8	45.9 97.1	62.2 117.8	65.3 119.7	48.0 95.0	49.8 93.2	21.2 59.8	60.5 113.5
63	39.7 71.3	16.5 38.5	58.5 115.5	70.4 134.6	47.3 98.7	67.5 121.5	70.3 141.7	47.3 106.7
64	4.0 14.0	52.9 100.1	37.7 72.3	35.9 66.1	34.3 71.7	36.2 62.8	66.4 129.6	24.2 52.8
65	54.0 96.0	24.2 54.8	57.9 112.1	34.0 68.0	59.1 104.9	33.1 70.9	33.0 67.0	44.2 69.8
66	42.4 84.6	53.4 96.6	22.5 53.5	39.7 70.3	35.9 73.1	35.4 67.6	36.0 84.0	68.0 151.0
67	39.0 70.0	33.8 20.2	63.3 116.7	95.0 163.0	68.2 118.8	91.0 162.0	31.0 70.0	57.8 112.2
68	27.7 54.3	64.2 118.8	15.9 35.1	38.3 72.7	57.5 114.5	76.9 135.1	71.4 140.6	58.5 141.5
69	62.1 103.9	41.4 75.6	40.4 76.6	19.4 49.6	25.4 55.6	42.4 89.6	37.4 74.6	49.5 113.5
70	32.5 79.5	29.8 64.2	30.0 63.0	26.3 58.7	57.6 104.4	47.6 85.4	39.6 92.4	60.2 150.8

ROW	SER.I	SER.J	SER.K	SER.L	SER.M	SER.N	SER.O	SER.P
71	30.6 63.4	49.8 96.2	37.2 65.8	23.6 42.4	40.9 89.1	56.3 99.7	50.4 99.6	61.8 119.2
72	56.2 107.8	34.5 67.5	42.8 75.2	48.5 77.5	36.4 64.6	39.6 80.4	59.2 103.8	56.0 128.0
73	35.8 77.2	39.1 81.9	62.7 112.3	31.5 61.5	54.3 105.7	63.5 115.5	49.1 92.9	36.5 76.5
74	40.9 77.1	58.5 111.5	60.3 111.7	28.9 50.1	15.9 44.1	22.5 51.5	35.1 83.9	54.7 126.3
75	43.8 93.2	46.5 82.5	55.5 110.5	60.3 95.7	78.9 152.1	66.5 127.5	24.3 73.9	41.9 96.1
76	65.5 113.5	65.2 132.8	48.3 84.7	39.6 72.4	47.6 113.4	42.3 86.7	51.8 105.2	43.5 99.5
77	61.0 110.0	55.2 105.8	43.5 78.5	72.1 126.9	36.6 72.4	60.0 133.0	84.5 174.5	40.5 83.5
78	72.8 137.2	62.2 123.8	74.9 123.1	64.5 111.5	65.0 124.0	68.0 143.0	49.2 102.8	84.7 173.3
79	31.6 63.4	40.5 92.5	57.5 103.5	61.6 112.9	41.4 83.6	49.2 114.8	68.0 142.0	46.9 110.1
80	56.0 84.0	48.5 105.5	43.1 79.9	37.5 71.5	51.3 101.7	87.1 181.9	36.7 80.3	51.6 103.4
81	40.8 81.2	26.3 65.7	46.2 95.8	34.2 66.8	49.4 103.6	45.6 109.4	64.2 124.8	59.5 145.5
82	35.5 74.5	37.5 102.5	28.1 59.5	39.6 81.4	31.3 79.7	53.1 174.9	40.0 92.4	43.6 57.2
83	57.2 101.8	59.8 125.2	73.1 123.9	44.2 82.8	61.4 125.6	60.1 143.9	42.3 79.7	53.6 126.4
84	29.4 65.6	34.3 81.7	48.1 85.9	28.7 57.3	54.1 85.9	67.9 148.1	51.3 95.7	48.0 112.0
85	59.6 85.4	19.6 41.4	38.0 79.0	81.1 120.9	18.2 41.8	40.0 84.0	49.5 89.5	59.8 130.2
86	31.7 69.3	22.4 58.6	49.2 82.8	21.6 38.9	65.7 121.3	67.0 130.0	24.1 57.9	56.8 151.2
87	60.1 115.1	41.6 81.5	34.9 64.1	37.0 57.0	20.3 46.7	32.1 69.9	84.0 164.0	38.1 86.9
88	46.5 85.5	50.0 106.0	28.1 59.8	38.6 68.4	37.5 73.5	35.6 72.4	53.9 74.1	32.9 84.1

ROW	SER.I	SER.J	SER.K	SER.L	SER.M	SER.N	SER.O	SER.P
89	50.7 93.3	48.8 99.2	48.6 83.4	37.1 70.9	32.7 68.3	48.5 96.5	72.1 140.9	40.7 103.3
90	39.5 90.5	41.5 94.5	52.2 91.8	32.8 57.2	38.7 74.3	32.2 66.8	49.2 107.8	34.1 74.9
91	63.5 120.5	63.2 118.8	34.8 76.2	45.0 90.0	36.1 82.9	36.9 96.1	33.5 72.5	34.8 69.2
92	59.2 105.8	58.5 122.5	49.2 85.8	52.0 88.0	17.0 42.0	14.4 41.6	33.4 60.6	62.0 145.0
93	71.1 116.9	42.8 94.2	40.0 79.0	43.1 83.9	45.8 92.2	47.2 86.8	60.5 104.5	35.5 77.5
94	58.8 104.2	41.7 85.3	52.2 96.8	58.8 99.2	49.6 100.4	50.1 101.9	53.1 103.9	47.4 117.6
95	27.5 55.5	41.6 100.4	55.0 113.0	46.3 93.7	37.7 75.3	32.6 70.4	49.0 90.0	35.2 77.8
96	51.6 91.4	13.3 41.7	68.1 132.9	38.6 75.4	41.0 88.0	31.5 66.4	36.1 74.9	13.3 36.7
97	43.0 85.0	44.3 103.7	36.4 72.6	25.5 48.5	25.6 48.4	50.1 101.9	64.8 146.2	51.3 122.7
98	51.8 93.2	71.6 148.4	68.8 118.2	73.1 123.9	67.6 129.4	43.4 84.6	28.5 68.5	25.2 65.8
99	59.8 106.2	62.5 127.5	41.8 73.2	39.2 74.8	37.0 72.0	34.6 89.4	51.8 101.2	71.5 153.5
100	32.8 72.2	30.9 72.1	46.0 86.0	32.8 58.2	57.6 107.4	40.5 84.5	27.8 79.2	52.5 105.5

ROW	SER.Q	SER.R	SER.S	SER.T	SER.U	SER.V	SER.W	SER.X
1	75.4 142.6	59.6 110.4	58.5 105.5	64.7 123.3	64.1 105.9	59.0 112.0	45.7 88.3	36.2 72.8
2	49.4 89.6	40.7 81.3	25.3 45.7	37.1 73.9	61.5 108.5	46.7 87.6	48.6 97.4	38.6 65.4
3	37.6 79.4	45.9 88.1	36.1 58.9	27.8 69.2	34.9 71.1	32.8 69.2	31.9 65.1	42.9 90.1
4	52.2 101.8	84.4 190.6	90.0 171.0	98.7 169.3	66.2 117.8	55.2 105.8	79.8 147.2	54.0 98.0
5	58.3 124.7	37.7 77.3	45.9 103.1	68.3 141.7	32.3 64.7	32.3 67.7	34.9 75.1	48.5 96.5
6	21.0 42.0	46.9 93.1	53.0 94.0	43.1 86.9	44.7 89.3	30.9 68.1	34.6 74.4	77.4 151.6
7	31.1 78.9	21.4 46.6	24.5 56.5	48.4 95.6	35.6 60.4	50.8 121.2	39.0 76.0	27.0 58.0
8	54.4 121.6	45.6 92.4	38.1 82.9	35.6 71.4	52.5 86.5	27.8 67.2	66.1 120.9	38.3 84.7
9	39.1 88.9	39.1 84.9	35.3 77.7	48.8 93.2	37.5 76.5	38.9 84.1	21.3 53.7	23.5 61.5
10	27.0 64.0	42.0 91.0	11.6 33.4	15.5 40.5	26.2 63.8	22.1 56.9	34.6 74.4	48.6 99.4
11	28.3 67.7	55.7 123.3	47.7 92.3	45.8 97.2	54.4 88.6	34.8 73.2	48.5 90.5	46.0 78.0
12	46.5 103.5	56.3 114.7	49.5 90.5	62.1 107.9	40.6 76.4	55.4 101.6	39.6 79.4	43.6 87.4
13	66.9 126.1	54.5 48.5	47.5 84.5	38.9 75.1	56.2 108.8	39.4 77.6	25.5 58.5	41.9 80.1
14	39.2 92.8	71.9 148.1	64.0 111.0	56.2 121.8	73.1 128.9	47.0 86.0	49.8 98.2	32.8 65.2
15	51.7 100.3	47.9 97.1	18.5 34.5	27.8 52.2	36.1 76.9	50.6 92.4	60.1 103.9	58.9 114.1
16	47.1 99.9	45.3 80.7	30.9 61.1	55.6 106.4	53.6 99.4	20.8 55.2	35.1 63.9	26.3 58.7

ROW	SER.Q	SER.R	SER.S	SER.T	SER.U	SER.V	SER.W	SER.X
17	48.7 103.3	47.3 98.7	55.1 94.9	34.3 61.7	53.6 105.4	69.8 126.2	46.1 82.9	28.0 59.0
18	63.7 128.3	79.5 158.5	46.5 80.5	59.5 123.5	42.1 78.9	43.9 89.1	54.7 101.6	44.9 84.1
19	22.9 55.1	52.0 102.0	50.8 94.2	89.2 168.8	54.7 114.3	47.5 90.5	84.4 150.6	46.0 78.0
20	49.6 97.4	4.9 22.1	10.0 29.0	26.0 61.0	30.3 66.7	16.5 43.5	11.6 29.4	35.2 69.8
21	27.5 60.5	57.1 99.9	50.4 94.6	41.8 86.2	34.2 78.8	65.7 125.3	30.0 67.0	49.7 100.3
22	20.5 53.5	59.2 99.8	32.8 58.2	18.5 43.5	74.0 142.0	44.2 90.8	37.3 94.7	53.4 105.6
23	57.1 108.9	34.0 67.0	42.9 82.1	54.0 105.0	19.0 38.0	38.4 77.6	29.6 60.4	26.0 54.0
24	28.8 66.2	50.6 89.4	46.4 88.6	32.4 71.6	54.2 98.8	33.1 70.9	57.7 110.3	51.5 105.5
25	47.0 87.9	45.1 79.9	30.4 60.6	31.3 63.7	49.2 93.8	52.8 95.2	36.5 74.5	48.3 96.7
26	20.8 53.2	39.5 75.5	32.5 68.5	50.6 100.4	44.5 82.5	25.8 50.2	32.0 71.0	33.4 73.6
27	60.4 107.6	36.3 68.7	25.5 53.5	33.3 70.7	56.0 93.0	51.2 99.8	44.8 89.2	64.2 123.8
28	53.6 93.4	66.7 130.3	72.9 137.1	35.6 77.4	27.8 51.2	40.9 83.1	43.4 75.6	56.6 109.4
29	43.5 93.5	29.7 59.3	20.3 40.7	29.7 59.3	50.2 94.8	28.7 62.3	35.7 68.3	41.9 83.1
30	52.9 95.1	57.3 115.7	28.7 58.3	25.0 60.0	36.2 68.8	46.3 88.7	42.8 85.2	81.6 145.4
31	42.7 74.3	12.8 31.2	31.6 69.4	40.0 84.0	36.5 67.5	31.4 66.6	20.6 49.4	22.2 46.8
32	51.4 92.6	17.6 49.4	32.0 58.0	29.0 63.0	50.7 84.3	49.0 82.0	42.4 79.6	31.5 67.5
33	27.3 49.7	40.0 89.0	24.0 52.0	28.7 59.3	24.9 46.1	17.2 35.8	32.4 56.6	27.3 63.7
34	44.2 91.8	65.8 120.2	51.8 96.2	54.1 97.9	28.1 54.9	43.0 82.0	44.2 79.8	35.2 66.8

ROW	SER.Q	SER.R	SER.S	SER.T	SER.U	SER.V	SER.W	SER.X
35	31.2 63.8	27.2 46.8	36.5 66.5	27.2 56.8	41.4 73.6	28.6 63.4	23.6 43.4	55.5 104.5
36	38.9 70.1	28.1 57.9	24.9 57.1	48.4 90.6	17.9 39.1	33.6 60.4	39.3 77.7	24.0 54.0
37	21.9 51.1.	43.7 90.3	30.0 61.0	34.8 74.2	27.0 55.0	28.9 57.1	56.6 111.4	29.8 65.2
38	32.9 64.1	30.0 66.0	23.8 47.2	45.8 103.2	23.0 49.0	32.0 64.0	23.5 52.2	40.4 76.6
39	30.7 75.3	15.3 36.7	28.4 63.6	63.0 117.0	31.2 57.8	38.6 77.4	54.9 98.1	23.5 50.5
40	42.6 88.7	30.8 64.2	32.2 70.8	34.9 72.1	50.1 92.9	39.9 76.1	22.5 48.5	60.1 127.9
41	21.5 44.5	58.3 118.7	37.2 80.8	45.3 109.7	19.7 40.3	33.5 64.5	53.0 100.0	39.1 83.9
42	36.9 63.1	26.0 55.0	50.0 98.0	38.6 78.4	38.2 73.8	32.8 75.2	50.9 92.1	54.2 104.8
43	36.5 64.5	17.5 110.5	39.4 82.6	44.6 86.4	22.9 44.1	31.6 66.4	28.7 66.3	69.2 130.8
44	28.0 70.0	43.3 88.7	48.3 87.7	31.1 74.9	53.8 88.2	12.9 28.1	42.0 82.0	11.3 27.7
45	50.0 95.0	51.5 107.5	66.8 120.2	40.6 80.4	39.4 74.6	56.1 110.9	42.8 71.2	59.1 119.9
46	38.0 75.0	40.3 91.7	49.3 87.7	37.8 83.2	54.1 93.9	40.7 82.3	31.9 66.1	51.6 96.4
47	44.8 80.2	28.0 60.0	37.7 76.3	26.8 52.2	26.6 54.4	38.8 80.2	36.5 66.5	45.3 92.7
48	46.1 88.1	40.5 81.5	29.6 71.4	45.5 96.5	41.1 80.9	26.5 65.5	49.1 104.9	36.1 73.9
49	39.0 82.0	64.9 138.6	44.9 95.1	66.3 124.7	38.7 79.3	43.9 97.1	35.4 70.6	49.4 104.6
50	50.5 114.5	42.0 88.0	45.7 87.3	35.0 80.0	56.8 112.2	50.4 100.6	48.9 99.1	59.7 122.3
51	35.0 82.0	39.1 78.9	35.8 73.2	68.1 175.9	37.5 80.5	58.0 118.0	73.6 140.4	53.1 109.9
52	89.8 184.2	72.1 157.9	83.3 164.7	70.6 154.4	73.8 166.2	96.0 184.1	68.9 148.1	78.7 161.3

ROW	SER.Q	SER.R	SER.S	SER.T	SER.U	SER.V	SER.W	SER.X
53	41.0 96.0	67.8 162.2	76.7 157.3	65.0 159.0	74.9 156.1	79.4 172.6	82.4 161.6	65.8 137.2
54	37.7 70.3	80.7 180.3	66.7 162.3	51.9 102.1	67.5 146.5	79.9 161.1	23.0 50.0	85.3 185.7
55	52.7 103.3	62.4 128.6	50.0 109.0	55.2 111.8	61.2 128.8	34.6 75.4	66.9 123.1	41.0 89.0
56	32.4 60.6	52.4 116.6	51.8 99.2	26.2 58.8	35.8 83.2	54.8 114.2	34.8 78.2	53.2 100.8
57	72.2 130.8	46.7 106.3	43.2 86.8	53.3 98.7	59.6 123.4	46.6 93.4	37.0 85.0	53.8 115.2
58	20.8 51.2	31.1 74.9	42.5 76.5	39.2 78.8	37.0 77.0	29.6 61.4	31.6 73.4	31.7 60.3
59	39.0 73.0	53.7 131.3	45.0 90.0	57.6 105.4	42.3 86.7	34.7 74.3	33.8 70.2	10.3 31.7
60	41.8 79.2	30.0 79.0	56.5 102.5	51.3 93.7	34.7 84.3	26.1 62.9	60.0 113.0	64.1 114.9
61	22.4 45.6	68.5 136.5	49.6 93.4	35.6 73.4	61.7 123.3	47.9 104.1	36.1 79.9	55.7 105.3
62	39.1 66.9	33.9 67.1	21.7 57.3	35.8 80.2	48.1 92.9	49.2 94.8	27.0 55.0	24.5 52.5
63	29.5 60.5	30.7 77.3	40.0 80.0	33.9 75.1	46.2 92.8	36.9 83.1	25.6 62.4	34.2 80.8
64	57.0 118.0	37.2 70.8	30.0 55.0	29.1 61.9	30.2 62.8	44.4 91.6	39.1 71.9	35.4 61.6
65	29.4 65.6	50.2 111.8	44.8 93.2	67.6 123.4	31.1 60.9		42.9 83.1	58.8 113.2
66	52.6 113.4	46.2 92.8	37.3 72.7	55.9 123.1	68.6 123.4	47.0 96.0	70.0 128.0	46.0 93.0
67	48.7 97.3	60.6 120.4	36.3 76.7	46.7 90.3	74.0 131.0	44.7 93.3	72.5 129.5	74.0 137.0
68	37.8 76.2	25.6 70.4	23.5 51.5	30.5 62.5	52.6 114.4	61.4 130.6	67.2 106.8	48.1 96.9
69	60.2 115.8	62.7 112.3	65.4 114.6	61.7 122.3	49.9 104.1	53.7 107.3	28.2 58.8	69.0 128.0
70	51.6 105.4	55.5 117.5	46.1 91.9	20.0 45.0	49.2 91.8	54.9 115.1	46.2 87.8	32.4 73.6

ROW	SER.Q	SER.R	SER.S	SER.T	SER.U	SER.V	SER.W	SER.X
71	45.5 107.5	28.8 59.2	40.9 72.1	44.9 96.1	31.4 68.6	42.8 83.2	68.3 124.7	28.9 62.1
72	20.8 47.2	73.2 144.8	41.7 78.3	47.5 94.5	25.1 61.9	58.8 120.2	35.9 78.1	64.9 135.1
73	28.0 55.0	27.8 52.2	32.3 70.7	36.1 68.9	27.8 67.2	31.3 69.7	27.8 62.2	65.7 141.3
74	37.1 89.9	50.4 97.6	48.3 89.7	42.5 79.5	45.5 89.5	32.7 75.3	56.3 100.7	48.9 91.1
75	51.9 89.1	48.5 93.5	61.8 110.2	34.6 64.4	45.4 90.6	60.4 119.6	20.0 56.0	30.7 68.3
76	44.6 95.4	60.1 116.9	47.1 88.9	31.1 58.9	40.9 84.1	25.8 60.2	44.6 88.4	24.2 53.8
77	65.6 114.4	62.7 109.3	46.5 91.5	31.2 67.8	47.0 93.0	63.7 127.3	81.8 157.2	55.1 116.9
78	35.3 79.7	82.0 157.0	65.5 125.5	49.8 94.2	86.1 157.9	61.0 143.0	63.7 118.3	34.6 77.4
79	61.0 129.0	77.3 140.7	41.3 83.7	47.4 86.6	46.5 90.5	69.3 132.7	45.2 90.8	71.4 143.6
80	33.1 74.9	47.3 90.7	39.7 72.3	45.7 84.3	46.4 90.6	53.6 113.4	61.3 112.7	55.1 108.9
81	40.9 90.1	34.5 71.5	39.1 79.9	28.3 58.7	63.9 118.1	48.4 92.6	39.2 82.8	39.6 83.4
82	33.2 77.8	87.4 186.6	25.1 52.9	20.0 43.0	59.6 106.4	22.5 55.5	77.9 142.1	41.1 85.9
83	43.4 116.6	42.4 94.6	54.4 85.6	46.9 86.1	41.1 80.9	33.7 77.3	72.6 143.4	40.1 82.9
84	63.1 106.9	40.5 93.5	54.2 110.8	45.2 87.8	67.8 127.2	68.5 138.5	52.2 99.8	87.7 171.3
85	66.7 129.3	52.6 112.4	33.2 66.8	47.8 91.2	18.8 49.2	45.1 86.9	51.0 88.0	56.3 113.7
86	49.4 90.6	39.8 89.2	56.4 118.6	16.9 43.1	51.4 96.6	64.7 125.3	41.7 78.3	46.9 87.1
87	37.8 73.2	37.1 77.9	30.6 72.4	26.7 64.3	31.0 64.0	47.1 90.1	64.1 122.9	35.7 67.3
88	45.1 82.9	82.6 160.4	30.0 63.0	32.9 70.1	26.3 60.7	35.1 81.9	30.4 67.6	57.9 111.1

ROW	SER.Q	SER.R	SER.S	SER.T	SER.U	SER.V	SER.W	SER.X
89	51.7 92.3	26.5 63.5	28.0 60.0	36.0 73.0	28.1 79.9	58.8 88.2	38.4 75.6	26.8 59.2
90	54.1 94.9	32.2 69.8	39.2 82.7	18.1 40.9	30.0 65.0	32.5 67.5	42.5 81.5	47.7 92.3
91	48.4 91.6	53.2 110.8	49.7 101.3	41.8 83.2	52.7 111.3	50.6 102.4	55.0 102.0	60.2 116.8
92	47.3 91.7	39.3 79.7	70.8 127.2	41.0 83.0	55.8 111.2	40.7 78.3	25.6 53.4	56.7 119.1
93	26.1 60.9	57.1 117.9	37.3 70.7	30.3 64.0	28.2 60.8	56.6 109.4	40.5 71.5	50.4 98.6
94	27.5 73.5	38.4 87.6	52.8 129.2	61.1 113.9	43.9 91.9	34.8 68.2	20.2 49.8	52.5 108.5
95	47.7 97.3	30.8 69.2	40.7 75.3	33.9 62.1	29.5 58.5	18.7 47.3	26.8 69.2	19.5 42.5
96	50.5 104.5	46.4 80.6	35.3 65.7	31.4 65.6	45.2 84.8	35.0 72.0	28.1 67.9	47.7 93.3
97	58.7 112.5	17.1 47.9	42.8 89.2	17.1 29.9	43.3 81.7	34.1 70.9	48.3 94.7	45.6 90.4
98	86.1 165.9	73.9 153.1	43.4 82.6	79.0 148.0	58.6 104.4	54.7 113.3	72.7 123.3	43.0 93.0
99	53.1 103.9	94.3 199.7	49.5 93.5	50.4 94.6	39.5 68.5	69.1 118.9	50.4 92.6	54.2 71.8
100	49.7 98.3	25.4 64.6	19.1 41.9	43.6 78.4				

ROW	SER.Y	SER.Z	SER.AA	SER.BB	SER.CC	SER.DD	SER.EE.
1	27.5 54.5	25.8 54.2	29.4 67.6	40.5 82.5	47.7 90.3	37.6 69.4	35.6 69.4
2	43.6 80.4	44.8 80.2	34.4 70.6	35.5 70.5	20.5 54.5	51.6 85.4	44.2 79.8
3	43.5 83.5	52.6 96.4	35.2 71.8	26.6 58.4	20.6 87.4	27.0 56.0	27.6 57.4
4	38.7 76.4	29.3 54.7	31.8 82.2	44.7 92.3	73.6 151.4	82.0 149.0	68.1 139.9
5	47.5 99.5	50.0 113.0	73.0 158.0	67.1 143.9	34.0 86.0	51.1 97.9	12.5 25.5
6	51.6 95.4	51.1 108.9	40.0 103.0	27.9 64.1	39.5 89.5	45.8 77.0	31.6 64.0
7	20.8 50.2	15.1 33.9	21.3 52.7	38.4 84.6	42.0 89.0	24.6 44.4	55.4 114.6
8	57.8 127.2	62.6 125.4	55.4 121.6	39.8 88.2	45.8 101.2	48.8 90.2	22.2 47.8
9	41.8 86.2	42.7 98.3	16.7 51.3	42.7 93.3	29.6 78.5	33.0 67.0	53.3 103.7
10	34.0 75.0	56.0 121.0	35.5 87.5	32.9 84.1	35.2 85.8	81.1 160.9	47.3 97.7
11	34.7 68.3	22.9 61.1	52.8 113.2	22.2 66.8	34.2 73.8	17.5 40.5	99.1 180.9
12	25.1 51.9	17.7 48.3	14.5 42.5	80.6 158.4	7.5 35.5	58.5 127.5	32.7 70.3
13	42.7 79.3	66.6 134.4	10.6 33.4	31.3 63.7	52.2 97.8	31.2 72.8	31.1 91.9
14	50.0 90.0	27.6 62.4	21.2 51.8	34.7 85.3	23.0 55.0	33.8 65.2	15.3 47.7
15	42.5 85.5	25.7 55.3	41.2 83.8	23.3 55.7	67.2 148.8	77.4 147.6	80.9 167.1
16	17.6 37.4	48.7 92.3	40.2 86.8	24.2 53.8	44.5 83.5	9.3 26.7	29.1 68.9

ROW	SER.Y	SER.Z	SER.AA	SER.BB	SER.CC	SER.DD	SER.EE
17	36.7 69.3	40.4 77.6	36.7 69.3	37.9 77.1	35.0 73.0	41.0 84.0	75.6 142.4
18	78.5 139.5	49.5 95.3	26.6 68.4	88.6 171.4	49.3 69.7	67.2 120.8	14.4 37.6
19	42.7 72.3	45.1 90.9	64.3 125.7	46.3 92.7	87.9 157.1	60.2 113.8	47.7 88.3
20	28.1 55.9	14.8 33.2	25.7 64.3	28.0 64.0	43.9 91.1	57.9 108.1	54.1 94.9
21	50.6 85.4	43.5 84.5	25.0 54.0	24.8 47.2	59.5 114.5	40.4 76.6	47.9 100.1
22	58.6 101.4	26.4 72.6	26.2 62.8	38.9 82.1	62.6 114.4	42.5 78.8	37.8 78.2
23	38.7 71.3	29.0 66.0	32.8 81.2	19.7 46.3	33.7 69.3	28.1 54.9	52.1 98.9
24	53.1 101.9	48.6 94.4	54.2 116.8	59.7 115.3	65.2 132.8	66.7 128.3	6.8 30.2
25	51.0 96.0	45.1 91.9	23.0 61.0	21.2 42.8	23.8 59.2	35.3 72.7	63.4 128.6
26	51.1 91.9	32.0 70.0	50.7 104.3	13.4 41.6	39.3 87.7	50.8 86.2	28.5 62.5
27	47.5 90.5	39.2 85.8	27.9 47.1	39.7 87.3	39.1 80.9	61.2 104.8	54.3 105.7
28	78.8 145.2	58.6 102.4	20.0 43.0	24.3 55.7	31.6 83.4	26.6 56.4	29.0 62.0
29	19.3 38.7	42.1 81.9	35.0 73.0	25.7 60.3	18.3 43.7	29.7 68.3	32.3 67.7
30	39.1 82.9	41.9 79.1	28.1 61.9	51.7 107.3	31.4 72.6	50.2 99.8	18.1 37.9
31	48.1 86.9	28.4 63.4	18.0 47.0	15.6 41.4	58.6 112.4	31.2 62.8	41.7 84.3
32	32.7 58.3	43.6 81.4	33.2 67.8	25.4 63.6	17.5 46.5	31.6 66.4	29.8 63.2
33	36.9 69.1	21.8 54.2	32.1 67.9	33.9 68.1	35.7 76.3	19.5 57.5	39.6 76.4
34	25.6 52.4	42.0 75.0	13.9 29.1	24.5 57.5	33.4 72.6	24.1 51.9	16.3 38.7

ROW	SER.Y	SER.Z	SER.AA	SER.BB	SER.CC	SER.DD	SER.EE
35	83.9 144.1	46.2 89.8	69.6 134.4	38.7 75.3	33.9 65.1	27.5 57.5	36.3 78.7
36	17.6 33.4	20.6 45.4	29.7 56.3	35.6 71.4	31.8 55.2	30.5 64.5	33.1 61.9
37	29.5 56.5	18.9 44.1	29.4 45.6	29.2 60.8	32.6 72.4	19.4 32.6	59.7 112.3
38	40.3 76.7	40.2 76.8	18.7 48.3	22.9 54.1	27.2 65.8	34.7 66.3	28.0 54.0
39	11.6 30.4	14.7 36.3	16.1 39.9	16.0 43.0	14.7 35.3	17.7 47.3	34.0 71.0
40-	38.5 85.5	40.5 83.5	41.4 66.6	33.8 70.2	38.1 73.9	50.3 91.7	25.9 56.1
41	66.9 128.1	46.5 95.5	21.5 41.5	18.8 41.2	38.5 82.5	27.8 58.2	43.6 94.4
42	23.0 51.0	31.9 59.1	46.0 91.0	67.4 114.6	53.0 113.0	30.7 66.3	33.8 77.4
43	59.4 106.6	46.7 86.3	24.5 44.5	9.1 25.9	27.9 69.1	46.8 84.2	42.5 88.5
44	22.8 29.2	33.2 63.8	21.5 48.5	13.2 37.8	38.1 76.9	35.0 67.0	46.8 94.2
45	54.1 95.9	55.8 105.2	40.2 76.8	45.5 85.5	49.6 98.4	47.7 87.3	27.6 57.4
46	19.0 41.0	18.5 45.5	41.5 79.5	50.0 94.0	29.6 64.4	37.5 78.5	31.1 60.9
47	51.3 98.7	58.9 115.1	68.8 137.2	36.9 73.1	59.2 110.8	61.4 113.6	59.8 114.2
48	49.7 94.3	13.6 32.4	36.9 85.1	41.9 94.1	52.3 103.7	39.5 77.5	36.4 77.6
49	24.0 52.0	54.8 113.2	69.5 140.5	50.5 97.5	45.8 96.2	62.6 117.4	38.0 79.0
50	45.2 85.8	24.4 61.6	31.9 66.1	33.7 70.3	20.4 45.6	27.8 60.2	40.5 84.5
51	56.2 96.8	53.4 114.6	58.6 120.4	82.2 153.8	33.5 75.5	32.1 67.9	37.0 79.0
52	102.3 192.7	76.4 145.6	79.8 150.2	57.1 110.9	65.8 135.2	51.4 107.6	23.0 48.0

ROW	SER.Y	SER.Z	SER.AA	SER.BB	SER.CC	SER.DD	SER.EE
53	71.4 139.6	55.5 110.5	44.1 94.9	77.1 154.9	72.2 151.8	82.1 172.9	29.8 69.2
54	85.3 176.7	97.1 191.9	75.2 161.8	78.7 156.3	92.3 190.7	94.6 187.4	63.4 137.6
55	22.6 46.4	20.8 44.2	27.5 62.5	74.3 146.7	40.7 83.3	75.5 144.5	71.7 148.3
56	52.5 108.6	24.1 63.9	47.2 93.8	33.4 71.6	35.3 77.7	27.8 62.2	82.2 165.8
57	34.3 70.7	79.1 146.9	56.7 113.3	59.2 118.8	47.2 92.8	43.1 91.9	53.6 103.4
58	64.6 115.4	51.1 93.9	40.3 75.7	51.4 117.6	48.6 104.4	46.8 83.2	23.8 54.2
59	32.7 69.3	29.5 63.5	33.3 66.7	19.8 35.2	34.4 75.6	35.6 75.4	74.5 145.5
60	50.6 99.4	41.0 79.0	9.0 27.0	4.7 20.3	13.1 33.9	35.3 71.7	29.4 69.6
61	64.5 122.5	65.5 129.5	60.1 121.9	37.9 70.1	52.8 121.2	32.9 72.1	10.0 35.0
62	41.0 73.0	40.8 80.2	30.0 60.0	24.5 48.5	27.3 66.7	37.2 64.8	48.5 103.5
63	50.8 87.2	57.6 112.4	47.0 95.0	53.4 107.6	43.3 84.7	59.4 105.6	46.3 85.7
64	28.1 61.9	48.9 93.1	40.0 77.0	59.1 118.9	31.4 65.6	9.0 23.0	62.1 133.9
65	61.3 110.7	52.8 110.2	63.4 110.6	43.6 86.4	28.5 67.5	34.0 65.0	33.6 71.4
66	25.1 47.9	35.5 75.5	44.0 87.0	50.6 111.4	22.3 65.7	47.2 92.8	33.3 59.7
67	50.9 101.1	87.1 162.9	40.0 83.0	69.0 134.0	56.0 113.0	63.1 118.9	24.7 53.3
68	54.0 103.0	57.0 113.0	22.7 55.3	77.9 152.1	65.9 124.1	117.5 228.5	51.7 103.3
69	63.1 107.9	43.8 90.2	42.8 84.2	62.9 118.1	45.6 79.4	58.7 109.3	48.7 98.3
70	53.9 99.1	49.3 90.7	49.7 89.3	31.5 69.5	36.3 73.7	38.0 70.0	36.4 77.6

ROW	SER.Y	SER.Z	SER.AA	SER.BB	SER.CC	SER.DD	SER.EE
71	25.4 50.6	30.4 58.6	30.5 58.5	49.1 91.1	35.7 71.3	36.3 73.7	51.3 101.7
72	73.6 136.4	71.0 142.0	19.8 39.2	78.7 163.3	60.9 113.1	100.4 179.6	32.1 74.9
73	31.2 60.8	24.8 55.2	57.4 108.6	30.5 74.5	24.4 58.6	38.4 73.6	24.8 58.6
74	65.2 131.8	50.8 96.2	25.8 49.2	42.5 89.5	38.9 78.1	57.7 104.3	43.0 90.0
75	20.0 42.0	58.0 104.0	37.0 77.0	45.5 104.5	61.7 108.3	70.7 120.3	78.6 157.4
76	33.2 75.8	35.6 72.4	35.0 83.0	20.5 52.5	38.9 83.1	69.3 123.7	53.4 118.6
77	37.4 71.6	43.5 83.5	15.8 42.2	41.7 86.3	25.8 55.2	79.8 147.2	81.0 176.0
78	70.5 135.5	64.4 135.6	40.1 79.9	63.3 123.7	63.4 123.6	70.5 138.5	55.9 119.1
79	73.2 157.8	72.0 147.0	52.2 114.8	58.8 117.2	43.7 80.3	66.6 133.4	56.1 111.9
80	60.3 87.7	44.3 94.7	69.3 129.7	49.3 112.7	63.8 122.2	48.7 92.3	70.0 129.0
81	33.8 57.2	38.0 77.0	41.0 85.0	66.6 128.4	74.0 136.0	75.2 140.8	36.6 76.4
82	41.1 80.9	23.6 47.4	30.3 58.7	36.6 72.4	22.3 53.7	65.5 132.5	58.1 115.9
83	31.9 67.1	73.6 116.4	29.0 53.0	63.1 130.9	64.7 122.3	59.8 119.2	50.0 108.0
84	77.1 147.9	40.8 87.2	68.7 121.3	60.9 122.1	59.0 102.0	49.6 93.4	56.7 112.3
85	84.8 156.2	59.5 115.5	39.0 81.0	50.6 99.4	53.1 98.9	27.8 60.2	82.6 166.4
86	28.8 63.2	59.6 118.4	57.0 112.0	63.7 125.3	56.8 109.2	50.0 87.0	56.1 113.9
87	35.2 69.8	26.5 65.5	59.1 120.9	20.4 45.6	42.4 79.6	21.0 122.0	34.0 70.0
88	63.5 115.5	33.5 75.5	33.5 67.4	93.5 183.5	90.9 166.1	62.5 118.5	26.1 55.9

ROW	SER.Y	SER.Z	SER.AA	SER.BB	SER.CC	SER.DD	SER.EE
89	35.3 73.7	23.8 61.5	54.1 114.9	38.3 80.7	32.5 65.5	68.1 126.9	49.2 109.8
90	46.0 93.0	45.4 93.6	49.7 100.3	13.8 35.2	27.5 56.5	66.0 125.0	43.8 100.2
91	31.2 70.8	45.2 88.8	27.8 49.2	58.7 115.3	60.8 123.2	55.3 97.7	58.4 130.6
92	39.5 79.5	38.2 79.8	56.9 112.1	26.7 67.3	31.2 62.8	45.6 92.4	48.1 95.9
93	39.1 88.9	14.7 37.3	39.6 78.4	9.2 35.8	16.3 77.7	18.8 51.2	41.2 96.8
94	69.0 129.0	77.9 144.1	57.1 116.9	42.2 88.6	41.6 92.4	22.1 48.9	25.2 56.8
95	33.1 65.9	43.2 98.8	41.4 83.6	82.5 157.5	59.7 118.3	54.9 139.1	66.9 133.1
96	21.2 51.8	18.6 55.4	51.5 102.5	46.4 90.6	43.5 81.5	55.0 105.0	57.8 111.2
97	32.3 63.7	33.2 67.9	41.3 78.7	33.5 81.5	56.4 108.6	51.8 95.2	50.9 98.1
98	29.3 67.7	56.2 99.8	35.9 78.1	49.8 102.2	56.2 108.8	32.4 71.6	36.0 76.6
99	42.2 88.8	46.0 102.0	39.3 79.7	61.9 118.1	38.2 72.8	45.1 97.9	32.7 72.3
100		52.3 102.7	48.4 98.6	30.6 60.8	37.7 71.3	49.6 88.4	49.7 97.3

MATERIAL

The data for these studies were secured at the Shelbina field of the Missouri Agricultural Experiment Station. The plat was approximately one-fourth of an acre in area and was apparently very uniform thruout. It was situated on the Putnam silt loam. In the fall of 1912 Fulcaster wheat was drilled at the rate of five pecks an acre in rows eight inches apart, each row being one hundred and fifty-five feet in length. There were one hundred and one of these rows. The following June they were harvested by hand in five foot segments, and the yields of grain and straw together and grain alone was recorded in grams. The yield of straw was secured by difference. The yields of grain and of straw are shown in Table I. The rows in that table are numbered from 1 to 101. The adjacent five foot rows running completely across the rows constitute a series. There are thirty-one of the series, and they are designated by letters. The grain and straw of several of the segments was lost before being weighed, and consequently, a few blank spaces appear in the table. So many segments were lost from row 101 that the yields of the remaining segments of that row were used only in calculating the biometrical constants of single five foot rows. In making these calculations for various sized units composed of a single row, every unit in which a lost segment appeared was omitted.

Figure 1.

In all other cases, the yield of the lost segment was assumed to be the average of the remaining segments in the same row.

Figure I is a curve of the yield of grain of the five foot row segments. From this curve it can be seen that, while the extreme variation is quite large, the material used in the experiment is homogeneous. To obtain this curve, the segments were grouped in classes according to yield of grain, and the mid-value of each class was taken as the value of all of the individuals in the class. The classes varied from one another by five grams.

In Figure II is shown the variation that existed along the rows and across them. The yields of the various series were compared to indicate the variation that existed along the rows. To indicate the variation across the rows, the yields of plats composed of three adjacent 155 foot rows were compared. The area of such a plat was practically the same as that of a series.

As can be seen in Figure II, the variation is much greater across the rows than along them. We would expect a condition such as this if the rate of seeding of the different hoes of the drill varied greatly, and at first thought it might seem that the existence of greater variation between the rows than between plats running perpendicular to them was due to different rates of seeding of the drill hoes. If such were the case, however, the variation of a plat composed of eight long rows, or one drill width, would be materially

Figure 2.

less than that of a plat composed of either slightly less or slightly more long rows. The coefficient of variability of a plat composed of five adjacent 155 foot rows was found to be 13.07 per cent; that of a plat composed of ten such rows was 9.43 per cent; and that of a plat consisting of eight such rows was 11.92 per cent, which is intermediate between the two plats just mentioned, and is what we would expect if the variation in yield was due merely to variation in soil. The conclusion is justified, then, that if any variation existed in the rate of seeding of the different drill hoes, the difference was not sufficiently great to influence the yield of the rows, and that the existence of greater variation between the rows than between the series is due to the fact that there is greater soil variation across the rows than along them.

The yields of series and of three row plats is shown in Table II:

TABLE II.

Yields of Plat Composed of Three Adjacent 155 Foot Rows			In decigrams	Yields of Series	
43040	35225	46268	47488	44233	44481
48293	29319	43131	46826	44397	43710
38430	38065	39494	45376	44792	44517
34880	37584	48149	44674	44670	45919
42211	40327	45389	44352	43266	44576
43495	46383	44210	46540	42470	43304
42281	63806	41740	46773	43720	39288

DEPARTMENT OF ENGINEERING, UNIVERSITY OF MO.

PLATE A - FOR SALE BY THE UNIVERSITY CO-OPERATIVE STORE, COLUMBIA, MO.

Figure 3.

TABLE II. Con.

Yields of Plat Composed of Three Adjacent 155 Foot Rows			Yields of Series		
41890	44798	39746	43124	46444	42423
38876	36999	41945	47101	42287	42322
37023	39939	39370	44500	42672	47069
31076	39104	45921			43859

In Figure III is platted a regression line showing the relation of yield of grain to that of straw. To obtain this line, the five foot segments were grouped into classes according to yield of grain, and the average yield of grain and of straw of the segments of each class was determined. From the results obtained the regression line was platted. If the yield of straw had been exactly proportional to the yield of grain, a straight line would have been obtained. It can be seen that the line in the graph is approximately straight, the principal deviation being at the extremes where the number of individuals is small. The average yield of grain in each class and the corresponding yield of straw is shown in Table III.

TABLE III.

AVERAGE YIELD OF SEGMENTS IN EACH CLASS

Grain	Straw	Grain	Straw
4.35	19.15	57.52	111.88
8.15	27.84	62.34	119.97
12.99	34.35	67.34	130.58
18.02	44.83	72.36	141.19
22.63	52.28	77.70	150.26
27.71	61.21	82.64	159.76
32.75	70.22	87.27	168.83
37.64	77.47	92.84	179.33
42.64	86.35	97.41	189.01
47.47	94.14	101.35	186.15
52.45	102.86	117.50	228.50

The correlation between yields of straw and grain of the segments is shown in Table IV. As is shown there, the strong positive correlation of $.9416 \pm .00137$ exists between these two characters. This correlation, together with the nature of the regression line obtained, shows that the yields of straw and grain vary together to such an extent that further discussion may be confined to the grain. This limitation of the discussion is further justified by the fact that it is usually the yield of grain with which we are concerned in variety tests.

	2.5	7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5	77.5	82.5	87.5	92.5	97.5	102.5	107.5	112.5	117.5	Total
15	1	2																							3
25	2	7	8	1																					18
35	5	20	27	3	1				1																57
45		5	57	64	11	1				1															139
55			13	81	104	25	1		2																226
65			1	12	145	147	49	4	3				1												362
75			1	1	16	133	194	75	13	2				1											436
85				1		32	109	160	90	20	6	1													419
95					1	4	14	100	199	93	17	6													434
105							4	11	66	103	80	22	1	1											288
115			1					3	16	49	99	41	13	2		1									245
125				1		1			2	10	34	57	53	10	1	2									171
135								1		2	7	21	34	22	4										91
145											3	5	15	22	26	5	1								77
155						1					1	2	6	15	17	10	3	1	1						57
165												1	1	2	5	14	6	3							32
175									1				1		2	6	6			1					17
185															1	2	3	4	3						13
195																	1	2	1	1					5
205																			1						1
215																									0
225																							1		1
235																				1					1
Total	3	14	33	101	163	278	344	371	354	392	251	247	177	125	75	55	41	19	11	6	2	0	0	1	3093

Yield of straw in grams, subject

Yield of grain in grams, relative

Coefficient of correlation, .9416 ± .00137

Note: On account of lack of space, the center of the class is recorded instead of the class range.

TABLE IV.

DATA

TABLE V.

THE RELATION OF SIZE OF PLAT AND VARIATION IN YIELD

Size of Plat	Standard Deviation	Coefficient of Variability
3 adj.155 foot rows	5885.40	14.19
5 " " " "	9022.00	13.07
10 " " " "	13018.31	9.43
20 " " " "	19405.81	7.03
1 5 foot row	164.84	37.20
1 10 " "	262.89	29.58
1 15 " "	354.07	26.52
1 20 " "	434.67	24.41
1 25 " "	518.07	22.81
1 30 " "	602.27	22.53
1 35 " "	661.48	21.32
1 40 " "	728.73	20.28
1 45 " "	796.60	19.85
1 50 " "	922.68	20.76
1 60 " "	1021.62	18.99
1 75 " "	1309.56	19.64
1 100 " "	1502.29	16.74
1 125 " "	1912.73	17.01
1 150 " "	2333.92	17.36
3 adj.50 foot rows	2186.24	16.37
5 " " " "	3227.66	14.49
10 " " " "	5443.76	12.13
15 " " " "	6802.67	10.18

TABLE V. Con.

THE RELATION OF SIZE OF PLAT AND VARIATION IN YIELD

Size of Plat	Standard Deviation	Coefficient of Variability
20 adj. 50 foot rows	7417.98	8.32
30 " " " "	7295.68	5.46
50 " " " "	15135.71	6.79
3 " 15 " "	749.30	18.68
5 " " " "	1101.14	16.49
10 " " " "	1694.70	12.72
20 " " " "	2659.38	9.98
50 " " " "	4960.03	7.45
100 " " " "	3688.95	2.77
100 " 30 " "	6326.87	2.38
8 " 5 " "	595.02	16.77
16 " " " "	869.78	12.36
24 " " " "	1120.85	10.54
32 " " " "	1238.05	8.74
64 " " " "	1599.08	5.66
96 " " " "	1786.46	4.20
100 " " " "	1787.98	4.02

Table V shows the effect of increasing the size of the plat. The data in it bears out the accepted theory that in general an increase in the size of the plat increases the accuracy of the results obtained. When one hundred and fifty-five foot rows were combined to form the unit of comparison, it was found that without exception an increase in the size of the plat brought about a decrease in the co-

efficient of variability. When three, five, ten, and twenty 155 foot rows were combined, this biometrical constant was 14.19 per cent, 13.07 per cent, 9.43 per cent, and 7.03 per cent respectively.

When the unit of comparison consisted of single rows, it was found that increasing the length of the row decreased the variation regularly until a plat length of forty-five feet was attained. Beyond this point, further increase in length usually produced some decrease in the coefficient of variability, but this decrease was small and quite variable. The amount of variation was not lessened at all by increasing the length of the row above one hundred feet. In short, the results indicate that on this plat there is not much to be gained by increasing the length of single rows above fifty feet in the direction of least variation.

It was also found that with one exception the coefficient of variability decreased as the number of combined adjacent 50 foot rows was increased. When the unit of comparison was composed of three, five, ten, fifteen, twenty, thirty, and fifty such rows, the coefficient of variability was 16.37 per cent, 14.49 per cent, 12.13 per cent, 10.18 per cent, 8.32 per cent, 5.46 per cent, and 6.79 per cent respectively. The increase in variation with a unit of fifty 50 foot rows over a unit of thirty rows of a similar length is probably due to the fact in the case of the larger unit, there were only six individuals available for comparison, and the laws of chance did not have an opportunity to

overcome the error resulting from accidental combinations.

When adjacent 15 foot rows were combined, the coefficient of variability again decreased with an increase in the width of the plat. It was 18.68 per cent, 16.49 per cent, 12.72 per cent, 9.98 per cent, 7.45 per cent, and 2.77 per cent, as the unit of comparison was composed of three, five, ten, twenty, fifty, and one hundred fifteen foot rows. It should be noted that the variation in the latter case is markedly low, due to the fact that the greatest dimension of the plat is in the direction of the greatest variation.

A similar decrease in the coefficient of variability is found when the number of combined adjacent five foot rows is increased. When the unit was composed of eight, sixteen, twenty-four, thirty-two, sixty-four, ninety-six, and one hundred such rows, the coefficient of variability was 16.77 per cent, 12.36 per cent, 10.54 per cent, 8.74 per cent, 5.66 per cent, 4.20 per cent, and 4.02 per cent respectively. Here again the variation is small in the case of plats that extend entirely across the area and have their greatest dimension in the direction of greatest variation.

It was also found that with the exception of single rows, an increase in plat length, even in the direction of least variation, decreased the coefficient of variability when the width of the plat remained constant. This decrease was not nearly so marked as when the plat was increased in the direction of greatest variation, however. When the unit was composed of three adjacent 15 foot rows, three ad-

ja cent 50 foot rows, and three adjacent 155 foot rows, the coefficient of variability was 18.68 per cent, 16.37 per cent, and 14.19 per cent, respectively. When it was composed of five adjacent 15 foot rows, five adjacent 50 foot rows, and five adjacent 155 foot rows, the constant was 16.49 per cent, 14.49 per cent, and 13.07 per cent. With a unit of ten adjacent 15 foot rows, ten adjacent 50 foot rows, and ten adjacent 155 foot rows, the coefficient of variability was 12.72 per cent, 12.13 per cent, and 9.43 per cent. When the unit consisted of twenty adjacent 15 foot rows, twenty adjacent 15 foot rows, twenty adjacent 50 rows, and twenty adjacent 155 foot rows, the coefficient of variability was 9.98 per cent, 8.32 per cent, and 7.03 per cent.

It is evident, then, that on fairly uniform soil, an increase in the size of the plat up to at least one-twentieth of an acre will decrease the variation. Exceptions to this may occur, however, in the case of very narrow long plats that run in the direction of least variation. It can also be seen that even single one-twentieth acre plats often do not reduce the variation to a point that will permit the detection of differences between varieties or fertilizer treatments.

As previously noted, Montgomery (1913), Lyon (1910), Alwood and Price (1890), and Egorov (1909) found that increasing the size of the plat increased the degree of accuracy obtained. Lyon (1910) pointed out, however, that the re-

duction in variation was small after a plat size of one-twenty-fifth of an acre was reached.

THE RELATION OF SHAPE OF PLAT AND VARIATION IN YIELD

TABLE VI.

Units of which plat is composed	Length of rows in plat	Shape of Plat	Standard Deviation	Coeffi- cient of Variabil- ity
1 adj.150 foot row	150 ft.	Long in dir. of least var.	2333.92	17.36
3 " 50 " rows	150 "	Long in dir. of least var.	2186.24	16.37
10 " 15 " "	150 "	Rectangular	1694.70	12.72
24 " 5 " "	120 "	Long in dir. of most var.	1120.85	10.54
- - - - -				
5 adj.155 foot rows	775 ft.	Long in dir. of least var.	9022.00	13.07
15 " 50 " "	750	Long in dir. of least var.	6802.67	10.18
50 " 15 " "	750	Long in dir. of most var.	2960.03	7.45
100 " 5 " "	500	Long in dir. of most var.	1787.98	4.02
- - - - -				
10 adj.155 foot rows	1550 ft.	Long in dir. of least var.	13018.31	9.43
30 " 50 " "	1500 "	Somewhat long in dir. of least var.	7295.68	5.46
100 " 15 " "	1500 "	Long in dir. of most var.	3688.95	2.77
- - - - -				

TABLE VI. Con.

Units of which plat is composed				Length of rows in plat	Shape of Plat	Standard Devia- tion	Coeffi- cient of Varia- bility
3 adj. 155 foot rows				465 ft.	Long in dir. of least var.	5885.40	14.19
20 "	15 "	"	"	300 "	Square	2659.38	9.98
- - - - -							
1 "	50 "	row		50 ft.	Long in dir. of least var.	922.68	20.76
3 "	15 "	rows		45 "	Long in dir. of least var.	749.30	18.68
8 "	5 "	"		40 "	Square	595.02	16.76
- - - - -							
5 adj. 50 foot rows				250 ft.	Long in dir. of least var.	3227.66	14.49
10 "	15 "	"	"	150 "	Long in dir. of least var.	1694.70	12.72
32 "	5 "	"	"	160 "	Long in dir. of most var.	1238.05	8.74
- - - - -							

The data in Table VI shows the effect of the shape of the plat on the accuracy of experimental results. In each of the divisions of the table, plats of approximately the same area but of different shapes have been taken. It is quite evident that those plats that have their greatest dimension in the direction of least variation are more variable than plats that approximate squares in shape; and these plats in turn are more variable than plats having their greatest dimension in the direction of greatest variation. That the more uniform results obtained in the latter plats is due entirely

to their shape is borne out by the fact that none of these plats are larger than the corresponding plats that lie lengthwise in the other direction.

Where single plats of a given area are to be used, then more accurate results can be obtained from long narrow plats lying in the direction of greatest variation. In an experimental area that was as variable in its length as its width, the shape of the plat would exert no influence. When an investigator is unable to ascertain in which direction his soil is most variable, the use of square plats is probably advisable. If long narrow plats are used in such a case, the chances are even that they will extend in the direction of least variation and, therefore, be less reliable than square plats. A better method, however, would be to ascertain the nature of the soil in a preliminary test and use plats that have their greatest dimension in the direction of greatest variation.

Carleton (1909), Latta (1895), Caldwell (1897), Brooks (1890), and Phelps (1888), found that long narrow plats were superior to those of other shapes. Lyon (1911) found that square plats were as efficient as long narrow ones. It seems probable that the latter investigator was either working with land in which the variation was approximately equal in the length and width of the experimental area, or that his long narrow plats did not extend in the direction of greatest variation. Barber (1914) recommended the use of square plats, because they have the smallest amount of border.

He did not ascertain the amount of variation existing in plats of different shapes, however.

The data thus far presented indicate that it is possible to secure fairly accurate results from single plats under certain conditions. On the area which forms the basis of these studies, no plat that was much below one-twentieth of an acre in area or that had its greatest dimension in the direction of least variation gave a coefficient of variability of less than 2.5 per cent. A series of plats composed of 30 foot rows and extending 66.6 feet in the direction of greatest variation gave a coefficient of variability of 2.38 per cent. This variation is sufficiently low to indicate that such a plat would give accurate results. The plat just mentioned was slightly less than one-twentieth of an acre. It is probable that on an experimental area where the plats could be so arranged that the length in the direction of greatest variation could be increased much beyond 66.6 feet, while the plat width was decreased, a plat of even smaller area would give dependable results.

THE RELATION OF REPLICATION OF PLATS
AND VARIATION IN YIELD
TABLE VII.
(First division)

Composition of unit	Standard Deviation	Coefficient of Variability
3 dist. 155 foot rows	3972.75	9.58
5 " " " "	3663.36	5.31
10 " " " "	5992.95	4.34
15 " " " "	5820.50	2.81
20 " " " "	7835.50	2.84
3 " 50 " "	1590.41	11.86
5 " " " "	1657.22	7.43
10 " " " "	2651.13	5.95
15 " " " "	2934.72	4.39
20 " " " "	3939.99	4.42
30 " " " "	4550.91	3.40
60 " " " "	5497.99	2.06
3 " 15 " "	539.03	13.43
6 " " " "	923.25	11.52
12 " " " "	1217.31	7.59
18 " " " "	1542.75	6.42
26 " " " "	1428.38	3.97
52 " " " "	2197.54	3.05
78 " " " "	3177.47	2.89
104 " " " "	3383.64	2.35
156 " " " "	3984.77	1.85

[illegible]

(Second division) Con.

Composition of unit									Standard Deviation	Coefficient of Variability
11	dist.blocks	of	16	adj.5	foot	rows			2891.73	3.71
14	"	"	"	"	"	"	"	"	2857.67	2.88
18	"	"	"	"	"	"	"	"	3123.77	2.45
22	"	"	"	"	"	"	"	"	4645.04	2.98
36	"	"	"	"	"	"	"	"	1679.44	0.66
5	"	"	"	100	"	"	"	"	4456.79	2.00
5	"	"	"	3	"	155	"	"	10183.75	4.92

The effect of using a unit of comparison composed of systematically distributed parts is shown in Table VII. A comparison of the data in the first division of that table with those in Table V makes evident the fact that a unit composed of replicated rows gives more accurate results than a continuous unit of the same area. In every instance there was much less variation in units composed of replicated rows than in similar sized units composed of adjacent rows. The coefficient of variability of three adjacent 155 foot rows, for example, was 14.19 per cent, while that of three distributed 155 foot rows was 9.58 per cent; the coefficient of variability of twenty adjacent 155 foot rows was 7.02 per cent, and that of twenty distributed rows of this length was 2.84 per cent. Similar differences in favor of replication exist thru all the results obtained, and there can be no doubt that a higher degree of accuracy is obtained where replication

is employed than where the same amount of soil is used in a single plat.

This conclusion is also verified by the work of Montgomery (1911), Morgan (1908), Wood and Stratton (1910), Egorov (1909), Hall and Russel (1911), Mortensen (1911), Gregoire (1913), Olmstead (1914), and Mercer and Hall (1911). No data in favor of single plats over the same area in distributed plats have been collected by any investigator.

The data presented in Table VII also justify the conclusion that the same degree of accuracy can be obtained on a much smaller area when a unit composed of replicated parts is used. Ten adjacent 155 foot rows, for example, gave a coefficient of variability of 9.43 per cent, which was only slightly below that of a series of units composed of three systematically distributed 155 foot rows. The coefficient of variability in the latter case was 9.58 per cent. A further comparison of Tables V and VII shows that five distributed 155 foot rows are more accurate than twenty adjacent rows of that length; three distributed 50 foot rows are more accurate than ten adjacent 50 foot rows; five distributed 50 foot rows are more accurate than twenty adjacent 50 foot rows; three distributed 15 foot rows are not much more variable than sixteen adjacent 15 foot rows; and twelve distributed 15 foot rows give almost the same coefficient of variability as fifty adjacent 15 foot rows.

A study of the first division of Table VII furthermore shows that as the number of replications of rows of a given length is increased, more accurate results are obtained. It

has been shown that increasing the size of the unit by combining adjacent rows reduces variation. The data presented in Table VII show that the increase in accuracy is even much more rapid when the size of the unit is increased by increasing the number of replicated rows. By increasing the size of the unit from three to five distributed rows, for example, a reduction in the coefficient of variability from 9.58 per cent to 5.31 per cent is obtained. A similar increase in the number of adjacent 155 foot rows reduces the biometrical constant only from 14.19 per cent to 13.07 per cent.

Likewise, when the number of replications remain the same, an increase in the size of the parts replicated decreases the variation. Three distributed 15 foot rows, for example, gave a coefficient of variability of 13.43 per cent, while in three distributed 50 foot rows this constant was 11.96 per cent, and in three distributed 155 foot rows it was 9.58 per cent. In five replications of 50 and 155 foot rows the coefficient of variability was 7.43 per cent and 5.31 per cent. In twenty replications of 50 foot rows it was 4.42 per cent, and in the same number of replications of 155 foot rows it was 2.84 per cent.

As to the length of row that makes the most desirable unit for replication, it is rather difficult to make a definite statement from the results obtained. It is, of course, true that a given number of replications of a long row is more reliable than the same number of replications of a shorter row. It can be seen in the first division of

Table VII, however, that when an equal area is employed in each series, the results are in favor of the shorter rows. The length of row selected as the unit of replication, then, will depend largely upon the amount of land available. With long rows a few^{er} number of replications are necessary, and the difficulties of harvesting and making calculations is lessened; but more land is required. With short rows the number of replications necessary to secure the same degree of accuracy is greater than in the case of long rows, but less land is required.

In the second division of Table VII are given the data secured by replicating blocks that contain three or more rows or parts of rows. It is difficult to test the efficiency of replicating such blocks in so small an area, because two or more of the replicated parts of a series often include segments of the same rows, thus lessening the effect secured from proper distribution. The first apparent irregularity in the data occurs where fifteen distributed blocks of three adjacent 50 foot rows gives a decidedly larger coefficient of variability than ten and fourteen replications of such blocks. An examination of figure IV will explain the existence of this difference. Each line in figure IV represents a block of three adjacent 50 foot rows. To secure ten distributed replications, every ninth block was combined. For fourteen and fifteen replications, every seventh and sixth plat were taken respectively. In the figure the plats taken for the first series of ten replications are indicated

FIGURE IV.

1	X	B	034	67	O
2			35	68	
3			36	B	69
4			37	X	070
5			38		71 B
6			39		72
7			040	73	X O
8		B	41	74	
9			42	75	
10	X		43	B	076
11			44		77
12			45		78 B
13			046	X	79 O
14			47		80
15		B	48		81
16			49		082
17			50	B	83
18			51		84
19	X		052		85 B O
20			53		86
21			54		87
22		B	55	X	088
23			56		89
24			57	B	90
25			058		91
26			59		92 B
27			60		93
28	X		61		094
29		B	62		95
30			63		96
31			064	X B	97
32			65		98
33			66		99

by X; those in the first series of fourteen replications are indicated by B; and those in the first series of fifteen replications are indicated by O. It is evident, then, that the plats in each series of ten and fourteen replications are well distributed, while those in each series of fifteen replications are not. In the first series of fifteen replications, for example, blocks 1 and 67 contain segments of the same rows, as do also blocks 7 and 73, 13 and 79, 19 and 85. The effect of fifteen well distributed replications is,

therefore, not secured.

Likewise, sixteen replications of blocks composed of ten adjacent 15 foot rows gave results more variable than fourteen replications of such blocks, because the replicated parts in the latter instance were well distributed, while in the former case they were not. Thirteen and twenty-six replications of eight adjacent 5 foot rows were poorly distributed. Fifty-two replications of such blocks also included in each series blocks containing segments of the same rows, but the number of replications here was so large that all parts of the experimental area were represented in each series, and the coefficient of variability was very small. The distribution in five, fourteen, and thirty-six replications of sixteen adjacent 5 foot rows was good. In the other replications made of blocks of this size the distribution was only fair.

The data presented make evident the fact that mere replication does not insure sufficient replication when rather large blocks are replicated in a comparatively small experimental area. Replication of blocks in such cases, however, will sufficiently reduce variation, if a system of replication is used that will provide a good distribution of the parts of each series. In larger experimental areas there is less probability of the replicated parts of a series occurring near each other.

The cases where good distribution of replicated blocks was secured prove that in general the conditions that apply

to the replication of rows are also applicable to the replication of blocks. Replicated blocks gave more accurate results than the same area in a single block. The same degree of accuracy was secured on a smaller area when replication was employed. As the number of replications of blocks of a given area was increased, more accurate results were obtained. The exceptions that occurred to this were due to the fact that proper distribution was not secured, as has been previously pointed out. On a larger experimental area these exceptions probably would not occur. Ten replications of three adjacent 50 foot rows gave less variation than five such replications. Ten replications of five adjacent 50 foot rows were less variable than five replications of five adjacent 50 foot rows. Twenty-eight, fourteen, and seven replications of five adjacent 15 foot rows gave coefficients of variability that increased in the order in which the combinations were mentioned. The coefficient of variability of five distributed blocks of sixteen adjacent 5 foot rows was 4.32; that of fourteen replications of sixteen replications of sixteen adjacent five foot rows was 2.88 per cent; and that of thirty-six such replications was 0.66 per cent.

A comparison of the combinations of blocks where efficient distribution occurs also shows that where the number of replications is the same, an increase in the size of the parts replicated decreased variation. Thus, five replications of sixteen adjacent 5 foot rows, five replications of three adjacent 50 foot rows, and five replications of five

adjacent 50 foot rows gave coefficients of variability that were in the inverse order of the total area of the corresponding series. A similar condition prevailed with ten replications of three 50 foot rows and ten replications of five 50 foot rows; 14 replications of 5 adjacent 15 foot rows and 14 replications of 10 adjacent 15 foot rows; and seven replications of 5 adjacent 15 foot rows and seven replications of 10 adjacent 15 foot rows.

The data also show that with reference to shape, the best block for replication is that which gave the best results with single plats, - that is, a long narrow plat with its greatest dimension in the direction of greatest variation. Five replications of three adjacent 155 foot rows, for example, gave a coefficient of variability of 4.92 per cent, while five replications of a plat five feet in width and running entirely across the experimental area gave a coefficient of variability of 2.00 per cent. The area of the two series was approximately the same. It should also be noted that 2.00 per cent is much below any other coefficient of variability obtained by only five replications.

The replication of long narrow plats was recommended by Latta (1895), Caldwell (1897), and Salmon (1913). No data in favor of plats of other shapes over long narrow plats have been obtained.

The most effective shape of experimental plats, then, is undoubtedly one that is long and narrow and that extends in the direction of greatest variation. As to the most

desired number of replications and size of plat, however, no such definite statement can be made. These two factors depend largely upon other conditions, such as the uniformity of the soil, the nature of the test, the amount of land available, and the period thru which the test will extend.

Montgomery (1913) recommended for experimental tests the use of fifteen to twenty replications of sixteen foot rows or eight to ten replications of blocks five and one-half feet square. The same investigator (1911) recommended ten replications of a plat five and one-half by sixteen feet for variety tests. Bilger (1912) recommended five replications of plats each 2.4 meters square for variety tests. Mercer and Hall (1911) recommended five replications of one-fortieth acre plats for field experiments.

For fertilizer or cultural tests, a few replications of fairly large plats probably is desirable. The results obtained from five replications of one hundred adjacent 5 foot rows indicate that such an arrangement would be sufficiently accurate. In variety tests it is usually necessary to employ a smaller unit because of the large number of varieties that are tested at one time. In order to obtain conclusive results in one year on the land on which this experiment was conducted, and with the use of rows running in the direction of least variation, as was the case in this experiment, it would be necessary to use at least twenty replications of 155 foot rows, from fifty to sixty replications of 50 foot rows, or from seventy-five to one hundred repli-

cations of 15 foot rows. It has been shown, however, that plats that have their greatest dimension in the direction of greatest variation are much less variable than those that extend in the other direction, and it is undoubtedly true that a similar reduction in variation would occur in rows that extended in the direction of greatest variation. If the rows in this experiment had extended across the plat, a considerably smaller number of replications would have been necessary to secure the same degree of accuracy.

In variety tests it is usually necessary to employ a smaller number of replications than is required to give absolutely conclusive results the first year. The results of such tests indicate fairly well the strikingly superior strains or varieties, and these can be tested out more accurately with a larger number of replications, or in larger plats the next year. It is true that owing to place variation some desirable strains will be overlooked in the preliminary test, but the saving in time and labor resulting from this practice justifies its use. Desirable arrangements would probably be ten replications of 15 or 16 foot rows running in the direction of greatest variation for the preliminary test, and for the subsequent test five replications of long narrow one-hundredth-acre blocks which also extend in the direction of greatest variation.

THE USE OF CHECKS

Check plats and rows frequently have been employed as

a means of correcting the yields of tests. Where checks are used, it usually is assumed that the soil varies uniformly from one check to another, and the data in Table VIII was calculated to determine the accuracy of results given by this method.

TABLE VIII.

Composition of Unit	Standard Deviation	Coefficient of Variability
1 155 foot row (every other row a check)	1666.30	12.18
1 " " " (no checks)	2385.22	17.17
10 adj.155 foot rows (every other plat a check)	14262.66	10.33
" " " " " (no checks)	13018.31	9.43
" dist.155 " " (every other series a check)	6513.78	4.72
" " " " " (no checks)	5992.95	4.34
*1 155 foot row (every other row a check)	1601.87	11.71

In the first three arrangements in Table VIII where checks were employed, the variability of each row, plat, or series from the average of the adjoining checks was determined. In the case of the single 155 foot rows marked with an asterisk, each row was multiplied by the quotient obtained by dividing the average of all checks by the average of the two checks adjoining the row, and the deviation of the corrected row from the average of all checks was determined.

The results indicate that even when checks are as close together as every other plat, their use does not greatly increase the accuracy of the results obtained. In fact, with ten adjacent 155 foot rows, and with ten distributed rows of this length, the results obtained where checks were used were more variable than where they were omitted. In the case of single rows or very narrow plats, the use of checks increase the accuracy to an appreciable extent; but it should be remembered that such a system of checks doubles the area needed for an experiment and greatly increases the amount of calculation necessary. The employment of an equal area in replicated plats would give less variable results.

These conclusions are largely verified by the work of other investigators. Montgomery (1913) found that alternating with check rows gave a high degree of accuracy when as many as ten or more checks were used. The total number of plats required for the same degree of accuracy, however, was greater than where systematic replication was employed. Lyon (1911) in writing of the use of checks stated that "there can be no doubt that the use of checks every second or third plat allows of greater accuracy than where no checks are used, but the data at hand do not indicate any advantage from the use of checks at less frequent intervals." He was working with long narrow plats, and his conclusions are not applicable to plats of other shapes. He did not compare the accuracy obtained with checks and that secured by

the use of the ^{same} area in replicated plats. Morgan (1908) found that when checks were used the variation decreased as the distance between checks was lessened, but that more accurate results were obtained by replication than by the use of checks. Holtsmark and Larsen (1905), Carleton (1909), and Thorne (1905 and 1913) recommended the use of a system of checks to diminish error in field trials. They did not compare the results obtained with their systems and those secured by replication, however. Olmstead (1914) concluded that greater accuracy could be obtained by replicating small plats than by the use of check plats. Pritchard (1916) found that the use of every alternate row as a check was not sufficient to offset the differences in yield arising from soil variation.

The data in Table VIII and the work of other investigators, then, indicate that the use of checks as a means of correcting the results of test plats is not advisable. Series of checks may well be introduced in replicated tests, however, to furnish an idea of the accuracy of the results obtained in the tests.

SUMMARY

1. The object of the experiment was to determine the effect of size, shape, and number of replications upon the probable error of field experiments.

2. The problem was a statistical one, and was handled by the biometrical method.

3. The data upon which the experiment was based were obtained on an apparently uniform field, one-fourth acre in extent, at the Shelbina Field of the Missouri Agricultural Experiment Station. Wheat was grown on this field and was harvested in 5 foot row segments.

4. These 5 foot segments were arranged in various combinations, for which the coefficients of variability and standard deviations were determined. The results obtained are given in Table IX.

TABLE IX.

SUMMARY OF RESULTS

Composition of unit		Standard Deviation	Coefficient of Variability
1	5 foot row	164.84	37.20
1	10 "	262.89	29.58
1	15 "	354.07	26.52
1	20 "	434.67	24.41
1	25 "	518.07	22.81
1	30 "	602.27	22.53
1	35 "	661.47	21.32
1	40 "	728.73	20.28
1	45 "	796.60	19.85
1	50 "	922.68	20.76
1	60 "	1021.62	18.92
1	75 "	1309.56	19.64
1	100 "	1502.29	16.74
1	125 "	1912.73	17.01
1	150 "	2333.92	17.36

TABLE IX. Con.

Composition of unit		Standard Deviation	Coefficient of Variability
3 adj. 155 foot rows		5885.40	14.19
5 " " " "		9022.00	13.07
8 " " " "		13134.10	11.92
10 " " " "		13018.31	9.43
20 " " " "		19405.81	7.29
3 dist. 155 foot rows		3972.75	9.58
5 " " " "		3663.36	5.31
10 " " " "		5992.95	4.34
15 " " " "		5820.50	2.81
20 " " " "		7835.80	2.84
3 adj. 50 foot rows		2186.24	16.37
5 " " " "		3227.66	14.49
10 " " " "		5443.76	12.13
15 " " " "		6802.67	10.18
20 " " " "		7417.98	8.32
30 " " " "		7295.68	5.46
50 " " " "		15135.71	6.79
3 dist. 50 foot rows		1590.41	11.86
5 " " " "		1657.22	7.43
10 " " " "		2651.13	5.95
15 " " " "		2934.72	4.39
20 " " " "		3939.99	4.42
30 " " " "		4550.91	3.40
60 " " " "		5497.99	2.06
5 dist. blocks of 3 50-foot rows		2654.38	3.97
10 " " " " " " "		4481.34	3.35
14 " " " " " " "		6549.04	3.50
15 " " " " " " "		9013.98	4.53
5 " " " 5 " " "		3277.15	2.94
10 " " " " " " "		5309.54	2.38
5 dist. blocks of 3 155-foot rows		10183.75	4.92
3 adj. 15 foot rows		749.30	18.68
5 " " " "		1101.14	16.49
10 " " " "		1694.70	12.72
20 " " " "		2659.38	9.98
50 " " " "		4960.03	7.45
100 " " " "		3688.95	2.77
100 adj. 30 foot rows		6326.87	2.38

TABLE IX. Con.

Composition of unit				Standard Deviation	Coefficient of Variability
3 dist. 15 foot rows				539.03	13.43
6 "	"	"	"	923.25	11.52
12 "	"	"	"	1217.31	7.59
18 "	"	"	"	1542.75	6.42
26 "	"	"	"	1428.38	3.97
52 "	"	"	"	2107.54	3.05
78 "	"	"	"	3117.47	2.89
104 "	"	"	"	3383.64	2.35
156 "	"	"	"	3984.77	1.85
7 dist. blocks of 5 15-foot rows				2343.33	5.04
14 "	"	"	"	3087.07	3.32
28 "	"	"	"	3395.89	1.83
3 dist. blocks of 10 15-foot rows				2385.96	5.97
7 "	"	"	"	3486.28	3.75
14 "	"	"	"	3080.94	1.66
16 "	"	"	"	6168.27	2.90
3 dist. blocks of 20 15-foot rows				3584.34	4.52
6 "	"	"	"	2016.34	1.27
3 dist. blocks of 50 15-foot rows				10566.53	5.29
8 adj. 5 foot rows				595.02	16.77
16 "	"	"	"	869.78	12.36
24 "	"	"	"	1120.85	10.54
32 "	"	"	"	1238.05	8.74
64 "	"	"	"	1599.08	5.66
96 "	"	"	"	1786.46	4.20
100 "	"	"	"	1787.98	4.02
5 dist. blocks of 8 5-foot rows				1334.90	7.53
10 "	"	"	"	1541.28	4.35
13 "	"	"	"	3609.50	7.83
26 "	"	"	"	4720.93	5.12
52 "	"	"	"	2077.35	1.13
5 dist. blocks of 16 5-foot rows				1530.27	4.32
7 "	"	"	"	1936.41	3.90
9 "	"	"	"	2132.85	3.34
11 "	"	"	"	2891.73	3.71
14 "	"	"	"	2857.67	2.88
18 "	"	"	"	3123.77	2.45
22 "	"	"	"	4645.04	2.98
36 "	"	"	"	1679.44	0.66
5 dist. blocks of 100 5-foot rows				4456.79	2.00
5 dist. blocks of 3 155-foot rows				10183.75	4.92

TABLE IX. Con.

Composition of unit	Standard Deviation	Coefficient of Variability
1 155 foot row (every other row a check)	1666.30	12.18
10 adj. 155 foot rows (every other plat a check)	14262.66	10.33
10 dist. 155 foot rows (every other series a check)	6513.78	4.72

CONCLUSIONS

From the results obtained and from those of other investigators, it is evident that:

1. Increasing the size of the plat to at least one-twentieth of an acre and probably much beyond, reduces variation, except in the case of single rows or very narrow plats that are increased in length in the direction of least variation.

2. More accurate results are obtained from single plats that are long and narrow and extend in the direction of greatest variation than from those of other shapes. Square plats, however, are to be preferred to long narrow plats that have their greatest dimension in the direction of least variation.

3. The results obtained from single plats are usually not sufficiently accurate to determine small differences between varieties or between fertilizer and cultural treat-

ments.

4. The use of a unit of comparison composed of systematically distributed parts gives results less variable than those obtained from an equal area in a single plat.

5. Where replication is employed, the same degree of accuracy can be obtained on a much smaller area than is the case with single plats.

6. As the number of replications of a given sized plat is increased, the variation is rapidly reduced.

7. When the number of replications remains the same, an increase in the size of the plat replicated decreases variation.

8. XY replications of a plat of size X are usually more accurate than Y replications of a plat of size $2X$.

9. When rather large blocks are replicated on a small area, it is essential to select carefully a system that secures good distribution of the parts in each series.

10. The most effective shape of replicated blocks is one that is long and narrow and extends in the direction of greatest variation.

11. The size of the plat and the number of replications employed must be determined by the uniformity of the soil, the nature of the test, the amount of land available, and the period thru which the experiment is to extend.

12. For fertilizer or cultural tests a few replications of fairly large plats probably are to be desired. The results obtained from five replications of one hundred adja-

cent 5 foot rows indicate that such a series would be sufficiently accurate.

13. For variety tests, the employment of a considerably larger number of smaller units is recommended. To give conclusive results in one year on the land on which this experiment was conducted, it would be necessary to use at least twenty replications of 155 foot rows, from fifty to sixty replications of 50 foot rows, or seventy-five to one hundred replications of 15 foot rows, when the rows run in the direction of least variation. A smaller number of replications probably would be required, however, with rows extending in the opposite direction. The use of ten replications of 15 or 16 foot rows extending in the direction of most variation would probably permit a selection of most of the markedly superior varieties in the first year. These varieties could then be further tested the next year in five replications of long and narrow one-hundredth acre plats.

14. The chief value of checks is to indicate the dependence that can be placed upon results from tests. Their use as a means of correcting experimental results is not recommended.

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