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METHODS OF EXPERIMENTATION WITH CORN.

ELIMINATION OF ERROR IN PLOT TESTS.

BY

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Presented to the Faculty of Graduate Studies and Research of McGill University in partial fulfilment of the requirements for the degree of Master of Science in Agriculture.

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ACKNOWLEDGMENT.

The writer is indebted to the Agronomy Department, Macdonald College, for the data on which this investigation is based and for access to records covering climatic conditions, methods of seeding and harvesting, soil treatment previous to the inception of this experiment, and results obtained in previous cropping.

Thanks are due the members of the staff of this Department for assistance on various occasions and to Professor R. Summerby, in particular, for advice and guidance.

Introduction.

The problem of the elimination of error in field experiments is a very comprehensive one. So many factors may operate to influence results that it is extremely difficult to arrive at definite and accurate conclusions. The more fully the investigator is aware of the extent to which his results may have been influenced by various combinations of factors, the less certain is he that his interpretation of results is correct. Every investigator wishes to obtain accurate data, and to have his conclusions backed by sound experimental evidence. While each investigator realizes that his data obtained from field experiments are not absolutely accurate, many treat numerous sources of errors lightly under the impression that the errors are so small as to have no material effect on the ultimate results. A discussion of some of the factors which may have a direct and marked effect on results may serve to illustrate this point. Other sources of errors were overlooked for many years through lack of a knowledge of their existence, and doubtless many have yet to be discovered.

As the sources of error common to field experiments become known, attempts are made to devise methods of eliminating them. In recent years a great deal of experimental work has been done with this object in view and much valuable information has been secured. However, as each experimental area presents difficulties peculiar to it, there is still much to be accomplished. It was with this in mind that the present investigation was undertaken.

Discussions of Some of the Sources of Error and of Methods of Overcoming Them.

Mechanical Errors.

Of all the errors which are liable to be introduced into field experiment work, those connected with mechanical operations are probably the most difficult to eliminate permanently.

Elaborate systems may be adopted embracing the optimum methods of seeding, methods of harvesting, size and shapes of plots and numbers of replications etc. When once established they are not difficult to follow and thus the errors they were designed to overcome are eliminated. But in many of the mechanical operations the human element plays a prominent part. Each season the investigator, his assistants and helpers must be constantly on guard lest through some slight carelessness, perhaps apparently trifling in itself, an error may be introduced larger than that eliminated by the elaborate system which has been adopted. Distances which on a measure indoors seem to be considerable appear trifling when seen on the ground in the field. Again, in the case of an experiment involving a grain crop, there may easily be a difference in the stage of maturity at which various plots are harvested and also a difference in the tendency of grain from different plots to shatter during the operation of harvesting and transporting to the thrasher. It may also happen that the weighing appliance is not sufficiently fine to respond quickly to small differences in weight. Each of the above mentioned may contribute small errors which in the aggregate cause results to vary considerably from the truth. The following example may serve to illustrate these points.

If experiments are being conducted with grain on one-fortieth acre plots 82.5′ x 13.2′ a measure of 82.7′ x 13.4′, or of 82.3′ x 13.0′, would appear to the eye to be quite nearly correct, if the plots were not contiguous. But, if in trimming two one-fortieth acre plots of oats which would actually yield at the rate of 50 bushels of well matured dry grain per acre, one plot, "A" were trimmed to 82.7′ x 13.4′ and the other, "B" to 82.3′ x 13.0′, both being taken as one-fortieth of an acre, an apparent difference in the yield of 1.76 bushels per acre would be caused thereby. If the oats on "B" were well matured when harvested, naturally inclined to shatter and were hauled and thrashed toward the close of a hot dry afternoon, one pound might easily be lost. If, on the other hand, the oats on plot "A" were not inclined to shatter, were slightly immature when cut, and were thrashed in the morning following a damp night, it might easily contain $1\frac{1}{2}$ pounds more moisture than the oats from plot "B", and suffer no loss in hauling. An unsuitable scale might cause the yield from "B" to be read $\frac{1}{2}$ pound less than it really weighed and from "A" $\frac{3}{4}$ pound more than it really weighed. As a result, "A" would appear to have yielded at the rate of 52.94 bushels per acre and "B" at the rate of 47.65 bushels per acre, a difference of 5.29 bushels in favor of "A", when, in reality, the yields from both plots should have been the same.

Similar and greater errors are liable to be introduced during the process of ploughing, harrowing, cultivating, and the applying of manure or fertilizer, unless care is exercised continuously.

To one unfamiliar with practical plot work the occurrence of errors of this nature may seem to be well nigh impossible; but one familiar with field work will realize how easily such errors may be made during a busy season, if the difficulties due to a shortage of labor, uncertain weather and unsuitable equipment, have to be overcome.

A keen realization, on the part of all connected with the work, of the significance of apparently small errors will probably do more than anything else to foster the habit of accuracy and to eliminate errors of a mechanical nature.

Weeds as a Source of Error.

Care should be taken that the plots are free from weeds before experiments are begun, and that they be kept free from weeds year after year. If this point be neglected a large error in results may be introduced. By tolerating the presence of weeds the investigator is not only subjecting the crop plants to a deleterious influence but the weed seeds and stems may have a marked effect on the weights of the crop harvested. For instance, if, in a plot of timothy, there is a trace of couch, a trace of mouse-ear chickweed, a trace of perennial sow thistle, a trace of ox-eye daisy, a trace of sheep-sorrel, and a trace of dried stubble from the previous year's clover crop, it obviously would be quite incorrect and misleading to regard the total cured yield from this plot as timothy hay. If this were done, not only might an error of at least 5 percent be introduced, but a premium is also placed on a treatment or condition which encouraged the production of this foreign material. If a composite sample were taken for dry-matter determination, the presence of the mature and woody stems of weeds would accentuate the error, as their weight in relation to that of the whole plot would be increased when expressed as dry-matter.

Error in the Interpretation of Yields.

The matter of the interpretation of yields is also important, as in this phase of experimental work alone a very large error may be introduced. Since the ultimate object in the growing of almost all farm crops is the production of food for man or domestic animals, the determination of yields should be based on the actual value of the crop for the particular purpose for which it was grown, and not merely expressed as so many pounds of material regardless of its value for the support of life, for the production of energy, flesh, milk, wool, etc., or for some other special purpose. While it is desirable that the difference in percentage hull of oats be taken into consideration, this may not be sufficient, if there should be a marked difference in the feeding value of the kernel itself. Again, in forage crops, it may seem desirable that yields should be reduced to a dry-matter basis in order to overcome the wide variations in moisture content. But is this sufficient? May it not be the means of introducing an error larger than that it seeks to eliminate unless it be known at what stage of maturity of the plant the dry-matter has the greatest feeding value, unless all plots to be compared be harvested at that stage, and, in the case of crops valuable for adding succulence to the ration, unless it be known from results of extensive feeding experiments how much of the value of the crop depends on its succulence and how much on the actual feed units which the crop provides.

Error Due to Different Rates of Seeding.

Grantham (6a) after experimenting with wheat concluded that there is a wide variation in yield by reason of competition induced by different rates of seeding.

Kiesselbach (11) as a result of experiments conducted with corn at Nebraska Agricultural Experiment Station suggests that, since the optimum rate of seeding of varieties varies considerably, due to differences in type of growth, the optimum rate for each should be determined before comparisons are undertaken.

Error Caused by Seeding on Different Dates.

Seeding on different dates when varieties or treatments are being compared may be the cause of introducing a large error.

Hopkins (10) reports on experiments conducted at Ottawa, Nappan, and Agassiz, by the Dominion Experimental Farms, to determine the influence of date of seeding on yield of grain. The first seeding was made as early in spring as the land was ready to sow. Five successive seedings were made at intervals of one week. The results show very wide variations at Ottawa over a ten year period, and very slight differences at Nappan and at Agassiz over a nine year period. He concludes that differences due to date of seeding depend largely on the climatic conditions of the locality in which the experiments are being conducted. Results are shown in Tables 1 and 2.

Table 1 - Influence of Date of Seeding on Yield of Grain at Ottawa.

	Ten Year Average.			
	Oats	Barley	Spring Wheat	Peas
	bu.	bu.	bu.	bu.
1st. sowing	53.3	38.4	17.9	30.4
2nd. sowing	59.5	44.2	20.5	33.9
3rd. sowing	50.7	33.5	14.1	32.8
4th. sowing	45.9	31.5	12.2	29.9
5th. sowing	40.2	26.1	10.3	26.3
6th. sowing	31.9	23.7	8.6	23.8

Table 2 - Influence of Date of Seeding on Yield of Grain at Nappan and at Agassiz.

	Nine Year Average.					
	Spring Wheat		Oats		Barley	
	Nappan, N.S.	Agassiz, B.C.	Nappan, N.S.	Agassiz, B.C.	Nappan, N.S.	Agassiz, B.C.
1st. seeding	21.6	21.9	55.6	45.3	33.0	22.0
2nd. seeding	21.7	22.6	55.9	48.6	29.8	22.8
3rd. seeding	20.3	21.6	60.9	48.0	31.4	22.1
4th. seeding	18.1	23.9	55.1	47.9	31.9	22.4
5th. seeding	19.6	21.4	50.5	51.5	31.4	23.9
6th. seeding	18.6	21.8	42.1	56.3	26.0	25.7

Errors Caused by Competition.

The effect of competition between plants for light, moisture and nutrients may be the means of introducing a large error especially if the plots are small, and have thus a relatively large area in which competition operates.

Stadler (16) in discussing typical systematic errors mentions competition between varieties of different types, resulting from the use of single row plots. As a result of extensive experiments conducted at the University of Missouri, Columbia, Mo. he found that, due to competition, the relative values of varieties under single row conditions were widely different from those obtained under field conditions. This indicates that a considerable error may also result, when plots larger than single rows are used, through competition along their contiguous borders.

Cunningham (5) in experiments conducted at Macdonald College, found that the yield of oats was diminished through competition with adjacent barley plots and that late-sown plots, when adjacent to early-sown plots, are reduced in yield through competition.

Hayes and Arny (2), in comparing adjacent three-row plots of wheat oats and barley, obtained conclusive evidence that there is considerable competition between rows of grain when grown a distance of 1 foot apart.

Kiesselbach (11), after extensive experimentation extending over a number of years, found that there is marked competition in one and two-row corn test plots and in nursery tests of small grains when two varieties are grown adjacent to each other.

Errors Due to Border Effect.

Another point to be considered in the elimination of error is border effect. This effect may tend to increase or decrease the yield as pointed out by Wiener and Broadfoot (19). In experimenting at Winnipeg with 94 plots of Mindum wheat, each 1-100 acre, 6' x 72.6', and separated by four foot borders, one foot on either side of which was occupied by two border rows, it was found that the yield of the outside border rows averaged 26.52 percent greater than the twelve plot rows, and that the effect of the fallow did not extend to the inside border rows. They also point out that, during a season very favorable to growth, the plants in the border rows, being slow in maturing, may not be ripe at time of harvesting the plot or they may be more open to the attack of rust, and in either case may be lower in yield than the inner rows of the plot.

Cunningham (5) has shown that the yield of marginal rows in oat plots was increased by the use of a cultivated path between plots, and that the effect extended to the third row within the plot, though the effect was greatly reduced by the use of one border row. He also found that the rate of seeding in the border row influenced border effect, thick seeding being more effective in reducing it. Neither fall wheat nor fall rye, sown in the border row of oat plots, was as effective in reducing border effect as was oats.

Barber (3) states that at the Maine Agricultural Experiment Station plants in the borders of plots surrounded by alleys had a longer period of growth and a higher yield of grain than those in the interior of the plot.

Hayes and Garber (9) state that when it is desirable to secure yields comparable with those obtained under field conditions the border should be removed to the depth of at least a foot; and that another reason for the removal of a border is provided by the fact that different varieties and strains may have unequal ability to utilize the unoccupied space along the pathway.

Arny and Hayes (2), in conducting variety tests of oats, wheat and barley, on long narrow plots surrounded by an eighteen inch pathway, found that plants occupying at least one foot within the margins were affected by the additional adjacent space, and that there was considerable indication of variations in the response of varieties to border effect.

Arny (1), after extensive experimenting advises the removal of at least two six inch border rows from each side of grain plots bounded by alleys.

While the extent and nature of border effect will vary according to the season, the size and shape of plots, and the care with which manure is applied near borders, it seems desirable that error from this source be reduced by the use of at least two border rows, or their equivalent, all around each plot; and that this area be occupied by plants of the same variety as those in the plot.

Errors Caused by an Imperfect Stand.

The matter of a perfect stand is very important; and variations in stand must be avoided whenever possible, unless such variation is directly caused by the nature of the particular experiment in hand.

The error caused by an imperfect stand is difficult to estimate. It might be considered that where an imperfect stand existed -- 75 percent, for instance -- the yield of the plot, had the stand been perfect, might be estimated as being one and one-third times the actual yield. But Stadler (16) has shown that plants having the benefit of open spaces due to an imperfect stand are materially influenced in growth by lack of competition for food and moisture, and also that plants differing in species, and even in variety, differ widely in the extent to which they are benefited by this extra space.

It is also a matter of common observation that, in a row of mangels or swedes, an individual is usually very much larger than neighboring plants in the same row, if it has been favored by the extra space afforded through the lack of a normal stand.

It is obvious, therefore, that an accurate calculation of the effect of an imperfect stand is extremely difficult.

Errors Due to Climatic Factors.

As the crop which is being grown experimentally is influenced by climatic factors such as moisture, temperature, humidity, sunshine and wind, etc., it is necessary that trials be conducted over a period of years, with all other factors as nearly constant as possible. The period should constitute at least one climatic cycle in order that the error introduced by seasonal differences, if not eliminated, may be reduced to their lowest possible value. This might not be necessary were it not for the fact that climatic factors influence not only the plants themselves but also the response of the soil in which the plants are growing. For instance, a strip of light sandy soil in an experimental area would be much more affected by a dry year than a heavier soil in the same area.

Morgan (12a) reports on work done at the Cornell Experiment Station and states that plots were found to have a tendency to change in relative productiveness as a result of seasonal variations.

Harris and Butt (7), as a result of experiments conducted over a long period of years at the Utah Experiment Station, have been able to show very clearly, the danger of drawing conclusions from experiments which have been conducted but a few years.

Errors Caused by the Application of Manure.

In all instances where the application of manure from animals is necessary to keep up the fertility of an experimental area great care is essential in the methods of handling previous to its application if very large errors are to be avoided. While it is very important that manure be applied at a uniform rate, and in a direction crosswise of that of the plots, it is equally important that the manure be of uniform quality. The quality and value of manure depends so much on the source from which it was obtained, the litter used, the care of the liquid excrement, the amount of fermentation it has undergone, the extent and manner in which it has been exposed to the elements previous to its application, etc. that it is almost always subject to very wide variations, and may vary in value from a product which is almost worthless to one which contains a high percentage of valuable plant nutrients and humus-forming compounds.

Shutt (15), in discussing barnyard manure makes the following statement: "No farm product is so variable as manure, the composition and value of which depends on a great many factors. Among these are the kind, age, function and food of the animal producing it, the quality and nature of the litter employed, and last but not least, the care taken in its production and preservation."

Brooks (4), in an exhaustive discussion of the origin, care and composition of farmyard manure shows the possibility of great variations in its value at the time of applying it to the land.

It is therefore quite apparent, that the task of obtaining a supply of manure of uniform quality to be used on an experimental area is a difficult one; and that careful methods of handling must be adopted to insure a thorough mixing of the manure obtained from various sources, if very large errors are to be avoided. This latter point becomes more important when viewed in the light of the findings at Rothamsted, where experiments with barley have shown that the effect of manure is not of short duration but may extend over a period of at least thirty-five years.

Errors Caused by Soil Variations.

The most universal source of error is, without doubt, that caused by variations in the productive capacity of the soil of experimental areas. That such variations exist has been amply proven and many methods of reducing errors caused thereby have been tested.

One accustomed to think of the soil as merely an inert mass of earthy material, large areas of which appear quite similar to the eye, might be justified in believing that there would be no difficulty in selecting a site for a number of fortieth acre contiguous plots which would vary very little in productive capacity. The general appearance of uniformity in the various crops produced on those areas often serves to corroborate those conclusions. But, when it is considered that the soil, as found today, is the result of the working of many complicated factors which have been operating for centuries, it would be somewhat surprising to find uniformity. When it is further considered that the productive capacity is influenced by temperature, composition and color, position in relation to surrounding areas, nature of subsoil and underlying strata, composition and nature of the soil solution, state as regards colloidal properties, and nature and state of the micro-organic population, and by numerous other factors, it would be still more surprising to find any marked degree of uniformity.

It is therefore but natural that Harris (8) should find positive evidence of soil heterogeneity in areas which appeared to be producing a uniform crop as judged by the eye of trained investigators. As a result of his investigations he states that the lack of uniformity of the experimental field is the most important cause of variation in plot yields.

This error due to unequal productivity of the soil is apparently the most important cause of what Mercer and Hall (12) refer to as the "experimental error" attached to the result of field trials and "due to so many incalculable factors that it may be described as casual".

Elimination of the Experimental Error.

As above stated the experimental error may be considered as being due to many incalculable factors and accompanies even the most carefully conducted experiments. While its elimination is apparently impossible, a great deal of work has been done with the view of reducing it to its lowest value. The methods used in reducing this error have been based on the use of various sizes, shapes and replications of plots, and correction by the use of checks.

Mercer and Hall (12) found that within the limits of their experiments at Rothamsted four systematic replications of fortieth acre plots reduced the experimental error to within 2 percent of the result.

Stadler (16) after investigating the value of check plots for the adjusting of yields, found a decrease in plot variability in three tests and an increase in five; but that, as a rule, they were useful in areas of high variability and useless on areas of low variability.

Pritchard (13) after experimenting with sugar beets which had been planted in rows 16 inches apart and 50 feet long, concluded that no number of check rows situated more than 16 inches from the test rows is useful as a basis of comparison of varieties or strains of sugar beets, except when repeated in combination with replications of the test rows.

Olmstead (12b) made calculations based on data obtained from results of Mercer and Hall's (12) mangold plots, Montgomery's wheat plots and Lyon's potato plots. As a result of his investigations he advises the replication of small plots, not only for obtaining greater accuracy, but also as means of providing a measure of the reliability of the data, of eliminating check plots and possibly decreasing the total area required for field experiments.

The Committee on Standardization of Field Experiments (14) recommend the use of long narrow plots laid out crosswise of the greatest soil variations. For experiments in soil fertility they advise the use of plots from one-twentieth acre to one-tenth acre, depending on the number of plots required and the land available; and for field experiments with farm crops, plots of not less than one-eightieth acre and not more than one-twentieth.

They also state that the use of check plots may be avoided by replication; but, if checks are used for the purpose of deriving probable errors, a large proportion of such plots appears to be necessary.

Day (6) obtained data from a one-fourth acre plot of Fulcaster wheat, containing 100 rows 155 feet long, which was harvested in 5-foot row segments. From a statistical investigation of this data he concluded that the shape of the plot has an important effect on variation. Single long narrow plots which extend in the direction of greatest variation are more accurate than plots of other shapes, but square plots are more accurate than long narrow plots extending in the direction of least variation. Large single plots were found to be more accurate than small single plots. Increasing the number of replications of a plot of given size increased the accuracy of the result, as did an increase in the size of the plot when a given number of replications were used.

Kiesselbach (11) worked on data based on yields of 207 thirtieth acre plots of Kherson oats. He was unable to obtain any reliable measure for correcting yields, by the use of systematically distributed check plots. It was also found that the coefficient of variability was reduced much more by the use of long narrow plots than by wide plots of the same length. Reduction of variability by enlarging the plots was far less marked than by systematic replication.

Summerby (17) in experimenting with oat plots to determine the value of replication as a means of increasing accuracy, found that under the conditions of the experiment large plots were more accurate than small plots; and that an increase in the length of plots reduced variability more rapidly than an increase in width. Replication, however, was more potent as a means of reducing variation than was either the size or shape of plots. When the experimental area is limited, greater accuracy may be obtained by using many replications of small plots than by fewer replications of large plots.

As a result of experiments conducted at Cornell with 300 oat plots. Summerby (18) found that small plots were more effective in reducing variability than were large plots within the limits of size and shapes of plots used, and that variation decreased rapidly as the number of plantings increased to four. An investigation of the value of checks as a means of correcting yields showed that, if three times the probable error were taken as a standard, no consistent significant correction was obtained by any methods of checking or frequency of checks.

While the work of the above mentioned investigators give strong evidence in favor of replication as a means of securing greater accuracy, it would be erroneous to conclude that the nature of variation which might appear in successive crops on an experimental area could be ascertained from a single years crop of one kind only. It would, therefore, seem desirable that where an area is being chosen for experimental purposes, investigations be carried on for a period of several years, and that tests be made with the different types of crops which are to be grown in future experiments.

The Present Investigation.

Object.

The object of the present investigation is to determine the effect of sizes and shapes of plots, and of numbers of replications on the reduction of variation as measured by the coefficient of variability.

Material and Methods.

The data on which this investigation is based was obtained from results of an experiment conducted at Macdonald College, during the season of 1922, to provide material for a study of soil heterogeneity.

At that institution an area 110 links, from South to North by 770 links, from West to East, in what is known as the South-East Field, was chosen as being of fair uniformity and representative of other areas in that locality. For at least twelve years previous to the inception of the experiment, this area had received uniform treatment, the yields of the various crops being such as would have very little effect in creating differences in the productivity.

In the spring of 1922 it was seeded with North Western Dent corn in hills 5 links x 5 links, there being 3388 hills in all. The seed used was composite material obtained from a corn breeding block.

Early in the season the plants were thinned so as to leave three in each hill. A very uniform stand was obtained and a fair crop harvested. Each hill was harvested separately, weighed green, and the weight recorded in decagrams.

Climatic Conditions.

The season of 1922 was characterized by low precipitation during the month of May and very high precipitation during the month of June, and by low temperatures during the months of July and August.

Tables 3 and 4 compiled from data contained in the meteorological records at Macdonald College give the mean monthly temperatures and the mean monthly precipitation for the months of April to September, for the ten year period, 1911 - 1920, and also for the same months of the year 1922.

Table 3. - Mean Monthly Temperatures.

Year	Apr.	May	June	July	Aug.	Sept.
1911-20	40.6	54.9	63.5	70.4	66.9	57.6
1922	42.0	57.5	64.6	67.9	65.5	60.3

Table 4. - Mean Monthly Precipitation.

Year	Apr.	May	June	July	Aug.	Sept.
1911-20	2.10	3.20	3.10	2.10	3.50	3.60
1922	5.45	2.09	6.29	3.16	3.09	1.46

Methods of Grouping Yields of Hills.

In order that the method of grouping yields of hills may be clearly understood, the rows of hills extending from South to North are hereafter termed "rows" and are numbered 1 to 154, from West to East. Each row is considered as being made up of 22 hills, the hills in each row being numbered 1 to 22, from South to North.

In this investigation the outside hills all around the area have been eliminated as border, as have rows No. 146 and upward. There then remained 2880 hills on the yields of which calculations are based. Various sizes and shapes of plots could then be formed by combining two or more rows.
Thus Row 2, containing hills 2 to 21 inclusive, may be regarded as a plot 5 links x 100 links. By combining Row 2, hills 2 to 21, and Row 3, hills 2 to 21, a plot 10 links x 100 links may be formed. Plots 50 links long and of various widths may be formed by considering the area as being divided into

two sections, lengthwise. Thus Row 2, plots 2 to 11 inclusive forms a plot 5 links x 50 links, and Row 2, plots 12 to 21 forms another plot 5 links x 50 links. By combining these half rows, plots of various sizes and shapes may be formed.

This plan of grouping hills so as to form various sizes and shapes of plots will be more clearly understood by reference to Fig. 1.

Fig. 1.

Plan of experiment consisting of 3388 hills of North Western Dent corn, hills 5 links x 5 links, numbered in rows from 1 to 154; and hills in each row numbered from 1 to 22.

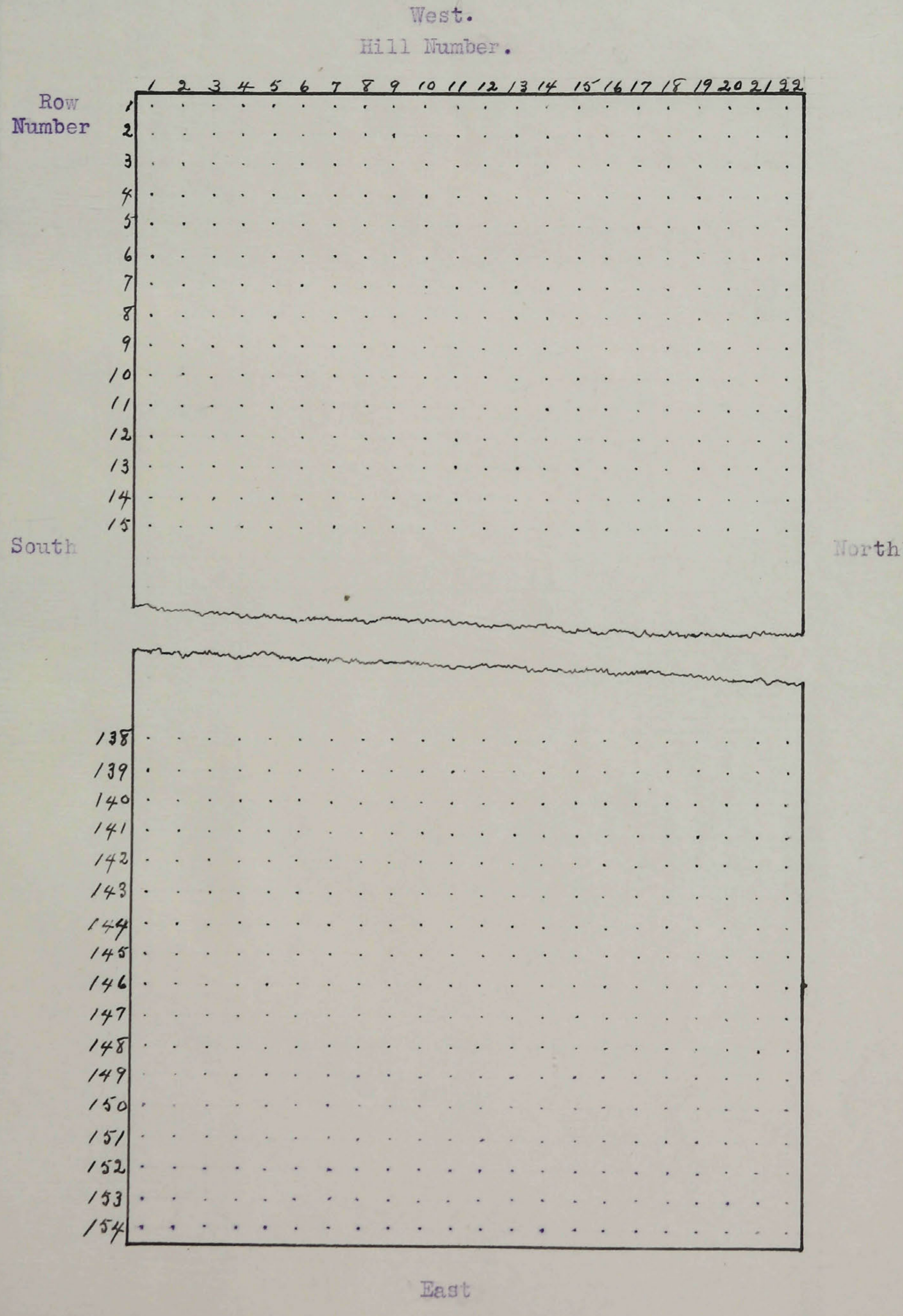
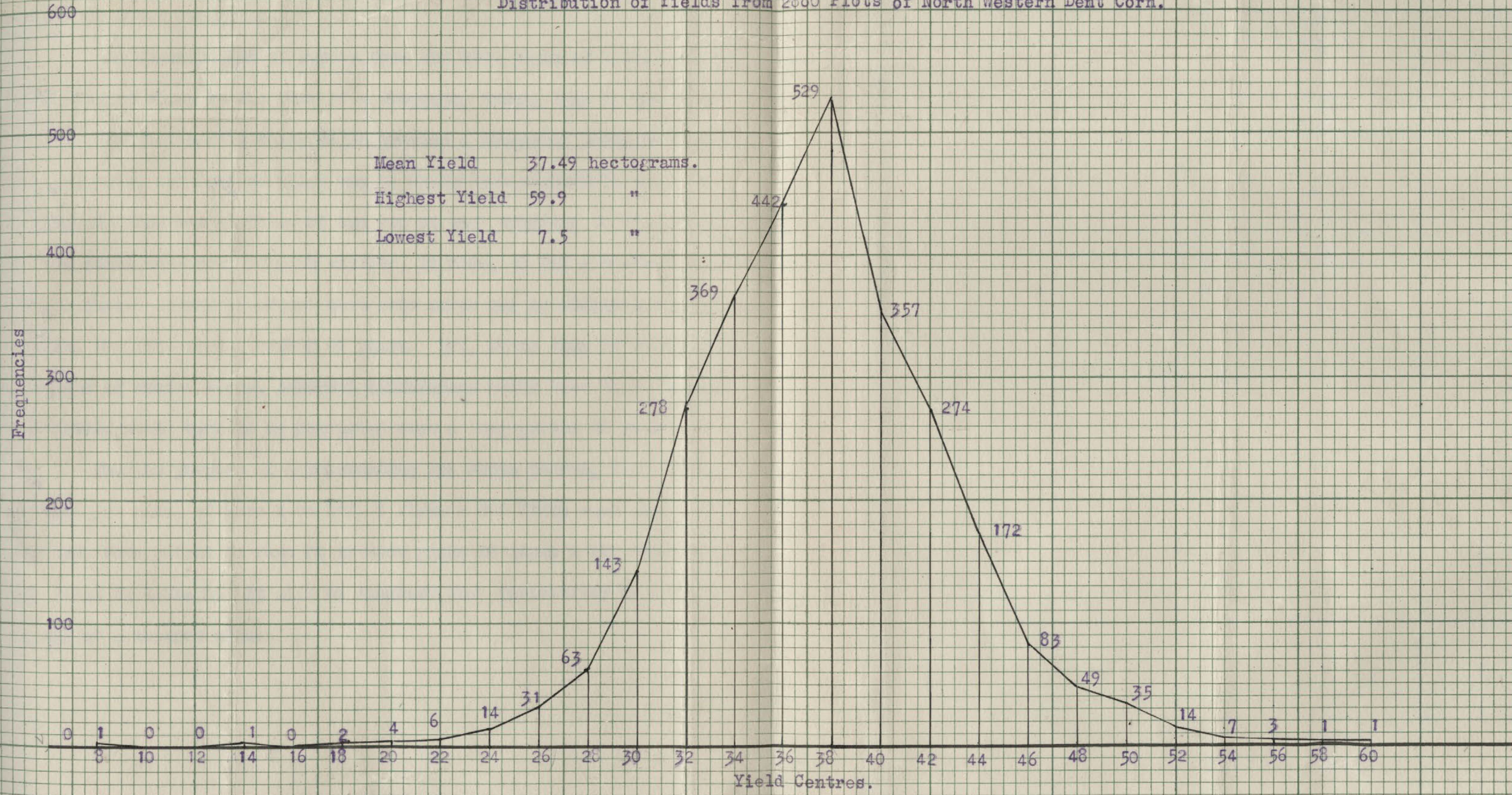


Fig. 2.

Distribution of Yields from 2880 Plots of North Western Dent Corn.



Discussions of Yields.

As before stated the yields of only 2880 hills are considered in this investigation. The highest yielding hill produced 599 decagrams of green corn: the lowest 75 decagrams. The average production of the 2880 hills was 374.9 decagrams.

The distribution of yields from the 2880 plots of North Western Dent corn is shown in the form of a frequency curve, Fig. 2, pg. 21-A.

The yields from these hills provide a practical demonstration of the erroneous conclusions which may be drawn from results in tests of varieties, when one planting of one row of each variety, or one planting of two contiguous rows of each variety, is made, as was a common practice in the past. It may be argued that this error may be eliminated by continuing the test over a number of years. But, since this is dependent on the laws of chance alone, inherent differences would have to be marked, and trials would have to be conducted over a long period of years.

For the purpose of demonstrating the above points, the yields, in tons per acre, of rows 2 to 145, 5 links x 100 links each, and also the same rows paired to form 72 two-row plots 10 links x 100 links each, are shown in Table 5. It will be observed that variability is reduced by use of a two-row plot.

Table 5. - Yields, in tons per acre, of 144 single row plots and also 72 two-row plots of North Western Dent corn.

Yields of Plots. 5 links x 100 links. Tons per acre.	Yields of Plots. 10 links x 100 links. Tons per acre.
14.95	
16.77	15.86
16.18	
16.22	16.20
16.52	
15.71	16.12
15.81	
16.84	16.32
15.83	
16.66	16.24
16.43	
14.68	15.55
15.66	
16.74	16.20
15.33	
16.43	15.88
14.60	
14.40	14.50
15.15	
15.54	15.35
15.23	
16.72	15.98
14.94	
13.54	14.24
15.50	
16.84	16.17
16.05	
16.48	16.27
15.75	
16.61	16.18
16.88	
16.73	16.81
17.85	
17.41	17.63
17.46	
16.28	16.87
16.63	
17.52	17.07
17.38	
17.00	17.19
17.74	
16.47	17.11
17.82	
17.55	17.69
17.23	
17.93	17.58
17.14	
15.87	16.50

(Table 5. cont'd.)

Yields of Plots. 5 links x 100 links. Tons per acre.	Yields of Plots. 10 links x 100 links. Tons per acre.
17.02	
17.62	17.32
17.92	
16.53	17.23
17.46	
16.64	17.05
17.33	
17.81	17.57
17.53	
16.67	17.10
18.33	
16.12	17.22
16.91	
17.63	17.27
17.03	
17.66	17.35
17.09	
16.77	16.93
16.16	
17.20	16.68
16.33	
16.78	16.56
16.71	
16.35	16.53
16.15	
17.90	17.02
17.73	
17.00	17.36
16.65	
16.38	16.52
16.41	
17.17	16.79
17.25	
17.71	17.48
16.79	
16.29	16.54
17.56	
17.21	17.39
17.66	
17.12	17.39
16.77	
15.93	16.35
16.37	
16.69	16.53
16.15	
16.37	16.26
15.96	
15.82	15.89
16.14	
16.64	16.39
16.73	
16.80	16.77

(Table 5. cont'd.)

Yields of Plots. 5 links x 100 links.	Yields of Plots. 10 links x 100 links.
Tons per acre	Tons per acre.
16.36	
15.06	15.72
16.65	
17.30	16.98
16.53	
16.50	16.51
16.65	
15.23	15.94
16.46	
17.28	16.87
16.54	
16.30	16.42
16.43	
15.98	16.20
15.73	
16.68	16.20
16.21	
17.13	16.67
16.39	
15.09	15.74
15.88	
17.47	16.67
16.25	
17.09	16.67
16.33	
15.92	16.13
17.29	
17.45	17.37
16.31	
17.14	16.73
16.41	
15.59	16.00
17.11	
17.10	17.11
16.78	
16.81	16.80
15.97	
15.82	15.89
16.31	
15.15	15.73
16.20	
16.09	16.15
15.76	
13.76	14.76
14.98	
16.42	15.70
15.27	
15.42	15.34
15.12	
13.83	14.47
14.75	
15.06	14.91

Method Employed in Measuring Variation.

The mean yields obtained from the various sizes, shapes and replications of plots were found, and from these the standard deviation and the coefficient of variability were determined. The probable error of the mean, of the standard deviation and of the coefficient of variability, were calculated in accordance with the following formula:-

$$Em = \frac{\pm 0.6745\,\sigma}{\sqrt{n}}$$

$$E\sigma = \frac{\pm 0.6745\,\sigma}{\sqrt{2n}}$$

$$Ec = \frac{\pm 0.6745c}{\sqrt{2n}}$$

$$E.\ \text{of the mean of averages} = \frac{\sqrt{(P.E_1)^2 + (P.E_2)^2 + (P.E_3)^2 + \cdots\ (P.E_n)^2}}{N}$$

The coefficient of variability along with its probable error is herein employed as a means of comparing the efficiency of the different sizes, shapes, and replications of plots in reducing variability.

Sizes and Shapes of Plots as a Means of Reducing Variability.

From the 144 rows of hills, each row 5 links x 100 links, plots 10 x 100, 15 x 100, 20 x 100, 30 x 100, 40 x 100, 60 x 100, and 120 x 100, were found by grouping 2, 3, 4, 6, 8, 12 and 24 adjacent rows. The results are shown in Table 6, pg. 32.

On the whole there is a tendency towards a gradual decrease in the coefficient of variability as the size of the plots is increased. This, however, is not quite uniform; and, since variation is high, there is no marked indication of reduction in variation following an increase in the size of plots.

Assuming that twelve varieties were to be tested and that the total area used was to be the same in each case, 24, 12, 6, 4, 3 and 2, tests were made with plots 50 links x 5, 10, 20, 30, 40 and 60 links, respectively. These various sized plots were formed by grouping adjacent rows 5 links x 50 links as previously explained. The results of the various tests are shown in Tables 7, 9, 12, 15, 16 and 19, respectively, and summarized in Table 20.

On the same assumption 12, 6, 4, 3 and 2 tests were made with plots 100 links x 5, 10, 15, 20 and 30 links, respectively. The results of the various tests are shown in Tables 8, 10, 11, 13 and 14, respectively, and summarized in Table 21.

By referring to Table 20 it will be seen that the average coefficient of variability is reduced from 4.86 percent to 3.59 percent, when plots were increased in size from 5 links x 50 links to 10 links x 50 links. When size of plots was increased to 20 links x 50 links, however, the average coefficient of variability was 3.34 percent, though twice as much land was required as for the first reduction.

When plots are increased in size from 5 links x 100 links to 10 links x 100 links, as shown in Table 21, the average coefficient of variability is reduced from 3.96 to 3.13 percent. Increasing the latter size of plot by one-half reduces the average coefficient of variability to 2.81 percent. When variation, as indicated by the P.E., is considered, however, the reductions mentioned above are not significant. Again, with plots 20 links x 100 links and 30 links x 100 links, the reduction is less than with plots 10 links x 100 links.

The reduction in the coefficient of variability accompanying the increase in the length of plot is most marked with plots 5 links wide, as the length is increased from 50 links to 100 links, though a decrease occurs with all widths as the length of the plot is doubled, and, therefore, would appear to be significant though the P.E. is high.

In addition, four tests and three tests were made with plots 5 links x 100 links and 10 links x 100 links, respectively, to test the effect of spreading the experimental area over a wider territory, as is necessary when border rows are used. In these tests plots 5 links x 100 links occupied Rows 3, 6, 9, etc., and plots 10 links x 100 links Rows 3 and 4, 7 and 8, 11 and 12, etc., the intervening rows in each case being regarded as border rows to be discarded at time of harvesting. This permitted of only a few tests being made. The results are shown in Table 21. It will be seen that there is no apparent advantage in the use of the larger sized plot, though the smaller plot can scarcely be regarded as a true measure of the variation in the productivity of the land, since only one-third of the total area is represented.

Size, Shape and Direction of Plots.

To further determine the extent to which size, shape and direction of plots affects variation in yields, 10 plots, 70 links x 100 links, were formed by combining 14 adjacent rows for each plot, and 10 plots, 10 links x 700 links, by taking paired adjacent hills of each of Rows 2 to 141. The former plots had their greatest dimension from South to North, the latter from West to East. In addition a plot 50 links x 360 links, with its greatest dimension from West to East, was obtained by taking Hills 2 to 11 of Rows 2 to 73. This method permitted of the entire area being divided into 4 plots. The results are shown in Tables 24 and 25.

From a study of these Tables it will be observed that the coefficient of variability is reduced to almost one-half by the use of the extremely long narrow plots extending almost the full length of the area, and that it was again considerably reduced by using a plot two and one-half times as large, with its greatest dimension lengthwise of the area. While the plots 50 links x 360 links cover slightly more land than those of the two first mentioned shapes, the yields of the extra land covered by the latter are not such as effect results to any extent.

Direction of Plots.

Variability as affected by direction of plots was determined by comparing plots 5 links x 100 links extending from South to North, with plots of the same size and shape, extending from West to East. Twenty plots of each covering the same area were taken as a single test. The entire area permitted of seven tests being made. The results are shown in Table 22 and summarized in Table 23.

A study of the coefficient of variability shown in Table 22 indicates that the soil variations are patchy in nature, and that the differences in productivity do not extend for any distance in any one direction. On the whole, plots extending from West to East are more effective in overcoming variation, as shown by the reduction of the average coefficient of variability from 4.13 percent to 3.72 percent; but, when P.E. is considered, these results are not significant.

Replication.

A study of the effect of replication was made with plots, 5 links x 100 links, formed by single rows. The entire area thus permitted of 2, 3, 4, 6 and 12 plantings being made. With 2 plantings, 72 varieties or treatments could be tested, with 3 plantings 48 varieties or treatments, with 12 plantings 12 varieties or treatments. Results are shown in Table 26.

A study of the coefficient of variability indicates a reduction in variability due to replication. By referring to Table 6 it will be seen that the coefficient of variability of yields of 144 single plots is 5.07 percent. By one replication it is reduced to 3.83 percent - Table 26 -, by two replications to 3.55 percent and by three replications to 2.99 percent. With six plantings the coefficient of variability is slightly increased and with twelve plantings it is but little less than with four. When it is considered that on a given area four plantings permit of three times as many tests being made as when twelve plantings are used, the reduction in coefficient of variability is out of proportion with the land required for the extra number of plantings. It would therefore appear that a plan of planting which calls for three systematic replications is most desirable if single row plots are to be used.

The effect of replicating two-row plots was also investigated. These plots were formed in the same manner as single row plots except that the yields of two adjacent rows were combined in each case. Results are shown in Table 27.

In comparing single row plots with two-row plots it will be seen that a considerable reduction in variability was effected in every case, and that the greatest reduction occurs as plantings increase from one to four, (see also Table 6.)

Size, Shapes and Replication of Plots.

With a view of making direct comparisons, between the effect of different sizes, shapes and replications of plots on variability, tests were made as though the entire area had been used in testing 12 varieties or treatments. The use of plots 5 links x 100 links made up of single rows, permitted of 12 plantings. Similarly, plots 10 links x 100 links made up of two adjacent rows permitted of six plantings. With plots 15, 20, 30, and 60 links x 100 links, 4, 3, 2 and 1 planting, respectively, could be made. Single row plots 5 links x 100 links and double row plots 10 links x 100 links, each protected by border rows, were also tested.

In these tests replication was effected in the following manner: Results from twelve plantings of twelve varieties in plots 5 links x 100 links were obtained by considering Row 2 as representing the first planting of Variety 1, and Rows 14, 26, 38, 50, 62, 74, 86, 98, 110, 122, and 134 as representing eleven replications. Similarly the first planting of Variety 2 occupied Row 3, and replications were obtained as above. Plots larger than 5 links x 100 links were formed by grouping adjacent rows, and replications obtained as before. Results are shown in Table 28.

From this Table it may be seen that the coefficient of variability is largest when single large plots are used. Replicating once, using plots half as large as the former, reduces the coefficient of va riability from 3.10 percent to 2.25 percent. Plots one-third as large as the first mentioned, but replicated twice, further reduces the coefficient of variability to 2.03 percent. But the coefficient of variability is reduced to the minimum - 1.31 percent - when plots 15 links x 100 links and four plantings are used. From this point, when the size of plot is decreased and number of replications increased, there is an increase in the coefficient of variability till, with twelve replications in single row plots 5 links x 100 links, it is 2.78 percent, which is somewhat higher than when two plantings are made, using plots 6 times as large.

When border rows were used the area of available land permitted of only 4 plantings in single row plots or three plantings in two row plots. While the coefficient of variability is 2.05 percent when four plantings in single row plots are used as compared with 2.55 percent with three plantings of two row plots, the reduction is not significant when the high P.E. is considered.

Table 6. Mean yields, in decagrams, of various sized plots of North Western Dent corn, together with their standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
144	5x100	7498.1181 ± 21.3789	380.3520 ± 15.1171	5.0726 ± .2016
72	10x100	14996.2361 ± 50.5917	636.4505 ± 35.7738	4.2441 ± .2385
48	15x100	22494.3542 ± 82.4774	847.1761 ± 58.3200	3.7662 ± .2592
36	20x100	29992.4722 ± 126.1120	1121.8266 ± 89.1744	3.7404 ± .2973
24	30x100	44988.7083 ± 215.4110	1564.5695 ± 152.3198	3.4776 ± .3385
18	40x100	59984.9444 ± 345.6900	2174.3885 ± 244.4375	3.6249 ± .4075
12	60x100	89977.4166 ± 543.5230	2791.4318 ± 384.3275	3.1023 ± .4271
6	120x100	179954.8333 ± 1373.2250	4986.9779 ± 971.0217	2.7712 ± .5395

Table 7. Means of yields, in decagrams, of plots of North Western Dent corn, plots 5 links by 50 links, treated as resulting from twenty-four tests of twelve varieties each, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
12	5x50	3719.1666 ± 41.7300	214.3174 ± 29.5074	5.7625 ± .7933
12	5x50	3512.3333 ± 52.3630	268.9264 ± 37.0261	7.6566 ± 1.0541
12	5x50	3786.5 ± 42.4957	218.2497 ± 30.0488	5.7638 ± .7935
12	5x50	3915.5 ± 28.8692	148.2669 ± 20.4135	3.7866 ± .5213
12	5x50	3948.4166 ± 28.3839	145.7746 ± 20.0704	3.6919 ± .5083
12	5x50	3887. ± 23.5027	120.7055 ± 16.6188	3.1053 ± .4275
12	5x50	3873.0833 ± 27.1062	139.2123 ± 19.1669	3.5943 ± .4949
12	5x50	3807.5 ± 25.7130	132.0571 ± 18.1817	3.4683 ± .4775
12	5x50	3768.25 ± 24.3467	125.0401 ± 17.2156	3.3182 ± .4568
12	5x50	3705.5833 ± 27.2597	140.0008 ± 19.2754	3.7781 ± .5201
12	5x50	3793.5833 ± 35.9772	184.7721 ± 25.4396	4.8706 ± .6705
12	5x50	3667.4166 ± 35.7225	183.4641 ± 25.2595	5.0025 ± .6887
12	5x50	3560.75 ± 34.9430	179.4608 ± 24.7083	5.0400 ± .6939
12	5x50	3453.1666 ± 44.2656	227.3514 ± 31.3020	6.5839 ± .9064
12	5x50	3767.6666 ± 41.4059	212.6528 ± 29.2782	5.6441 ± .7770
12	5x50	3881.8333 ± 31.3842	161.1835 ± 22.1919	4.1522 ± .5716
12	5x50	3875.0833 ± 48.0450	246.7497 ± 33.9727	6.3676 ± .8766
12	5x50	3771.25 ± 28.0947	144.2891 ± 19.8658	3.8260 ± .5267
12	5x50	3815.9166 ± 42.4337	217.9314 ± 30.0050	5.7111 ± .7863
12	5x50	3737.3333 ± 34.2363	175.8314 ± 24.2086	4.7047 ± .6477
12	5x50	3663.25 ± 35.8075	183.9008 ± 25.3196	5.0201 ± .6911
12	5x50	3710.9166 ± 32.9486	169.2180 ± 23.2981	4.5600 ± .6278
12	5x50	3733.3333 ± 32.3195	165.9871 ± 22.8533	4.4461 ± .6121
12	5x50	3622.5833 ± 48.9113	251.1992 ± 34.5854	6.9343 ± .9547

Coefficients of Variability:- Highest 7.6566 ± 1.0541
Average 4.8662 ± .1409
Lowest 3.1053 ± .4275

Table 8. Means of yields, in decagrams, of North Western Dent corn, plots 5 links by 100 links, treated as resulting from twelve tests of twelve varieties each, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
12	5x100	7279.9166 ± 58.3272	299.5575 ± 41.2434	4.115 ± .5665
12	5x100	6965.5 ± 80.9624	415.8073 ± 57.2488	5.969 ± .8218
12	5x100	7554.1666 ± 59.4891	305.5244 ± 42.0649	4.044 ± .5567
12	5x100	7797.3333 ± 51.8792	266.4415 ± 36.6839	3.417 ± .4704
12	5x100	7823.5 ± 55.5824	285.4603 ± 39.3025	3.649 ± .5024
12	5x100	7658.25 ± 40.2762	206.8510 ± 28.4794	2.701 ± .3718
12	5x100	7689. ± 51.1590	262.7426 ± 36.1747	3.417 ± .4704
12	5x100	7544.8333 ± 54.1357	278.0305 ± 38.2795	3.685 ± .5073
12	5x100	7431.5 ± 53.8270	276.4451 ± 38.0612	3.720 ± .5121
12	5x100	7416.5 ± 49.6006	254.7392 ± 35.0727	3.435 ± .4729
12	5x100	7526.9166 ± 55.9417	287.3060 ± 39.5566	3.817 ± .5255
12	5x100	7290. ± 79.1486	406.4921 ± 55.9662	5.576 ± .7677

Coefficients of Variability:- Highest 5.969 ± .8218
Average 3.962 ± .1613
Lowest 2.701 ± .3718

Table 9. Means of yields, in decagrams, of North Western Dent corn, plots 10 links by 50 links, treated as resulting from twelve tests of twelve varieties each, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
12	10x50	7231.5 ± 60.0977	308.6504 ± 42.4953	4.2681 ± .5876
12	10x50	7702. ± 51.8828	254.5994 ± 35.0535	3.3056 ± .4551
12	10x50	7835.4166 ± 21.1856	108.8052 ± 14.9804	1.3886 ± .1911
12	10x50	7680.5833 ± 41.2399	211.8001 ± 29.1608	2.7576 ± .3796
12	10x50	7473.8333 ± 36.9984	190.0166 ± 26.1617	2.5424 ± .3500
12	10x50	7461. ± 59.4961	305.5604 ± 42.0699	4.0954 ± .5638
12	10x50	7013.9166 ± 72.7371	373.5638 ± 51.4327	5.3260 ± .7332
12	10x50	7649.5 ± 59.8196	307.2223 ± 42.2987	4.0162 ± .5529
12	10x50	7646.3333 ± 43.0768	221.2342 ± 30.4597	2.8933 ± .3983
12	10x50	7553.25 ± 64.3957	330.7239 ± 45.5344	4.3785 ± .6028
12	10x50	7374.1666 ± 49.8761	256.1542 ± 35.2676	3.4736 ± .4782
12	10x50	7355.9166 ± 67.6065	347.2138 ± 47.8047	4.7201 ± .6498

Coefficients of Variability:- Highest 5.3260 ± .7332
Average 3.5971 ± .1488
Lowest 1.3886 ± .1911

Table 10. Means of yields, in decagrams, of plots of North Western Dent corn, plots 10 links by 100 links, treated as resulting from six tests of twelve varieties each, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
12	10x100	14245.4166 ±116.5005	598.3239 ± 82.3770	4.2001 ±.5782
12	10x100	15351.5 ± 93.7772	481.6215 ± 66.3102	3.1372 ±.4319
12	10x100	15481.75 ± 56.1581	288.4170 ± 39.7095	1.8629 ±.2564
12	10x100	15233.8333 ± 89.3979	459.1305 ± 63.2136	3.0139 ±.4149
12	10x100	14848. ± 71.1555	365.4411 ± 50.3143	2.4612 ±.3388
12	10x100	14816.9166 ±119.5035	613.7466 ± 84.5013	4.1422 ±.5703

Coefficients of Variability:- Highest 4.2001± .5782
Average 3.1362± .1825
Lowest 1.8629± .2564

Table 11. Means of yields, in decagrams, of plots of North Western Dent corn, plots 15 links by 100 links, treated as resulting from four tests of twelve varieties each, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
12	15x100	21799.5833 ± 165.4842	849.8946 ±117.0144	3.8986 ±.5367
12	15x100	23279.0833 ± 83.5057	428.8689 ± 59.0471	1.8422 ±.2536
12	15x100	22665.3333 ± 115.9111	595.2969 ± 81.9611	2.6264 ±.3616
12	15x100	22233.4166 ± 125.3393	643.7182 ± 88.6278	2.8952 ±.3986

Coefficients of Variability:- Highest 3.8986 ± .5367
Average 2.8156 ± .2003
Lowest 1.8422 ± .2536

Table 12. Means of yields, in decagrams, of North Western Dent corn, plots 20 links by 50 links, treated as resulting from six tests of twelve varieties each, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
12	20x50	14933.5 ± 125.1742	642.8706 ± 88.5111	4.3048 ± .5926
12	20x50	15516. ± 67.2324	345.2926 ± 47.5402	2.2253 ± .3063
12	20x50	14934.8333 ± 77.3379	397.1928 ± 54.6859	2.6595 ± .3661
12	20x50	14663.4166 ± 151.5051	778.1008 ± 107.1298	5.3064 ± .7305
12	20x50	15199.5833 ± 83.4346	428.5039 ± 58.9969	2.8191 ± .3881
12	20x50	14730.0833 ± 78.1056	401.1355 ± 55.2288	2.7232 ± .3749

Coefficients of Variability:- Highest 5.3064 ± .7305

Average 3.3397 ± .1975

Lowest 2.2253 ± .3063

Table 13. Means of yields, in decagrams, of plots of North Western Dent corn, plots 20 links by 100 links, treated as resulting from four tests of twelve varieties each, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
12	20x100	29596.9166 ± 270.1738	1387.5600 ± 191.0408	4.6881 ± .6454
12	20x100	30715.5833 ± 142.8739	733.7728 ± 101.0266	2.3889 ± .3289
12	20x100	29664.9166 ± 141.0944	724.6334 ± 99.7683	2.4427 ± .3363

Coefficients of Variability:- Highest 4.6881 ± .6454
Average 3.1732 ± .2662
Lowest 2.3889 ± .3289

Table 14. Means of yields, in decagrams, of plots of North Western Dent corn, plots 30 links by 100 links, treated as resulting from two tests of twelve varieties each, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
12	30x100	45078.6666 ± 375.8418	1930.2501 ± 265.7590	4.2819 ± .5895
12	30x100	44898.75 ± 209.1409	1074.1067 ± 147.8842	2.3922 ± .3293

Coefficient of Variability:- Average 3.3370 ± .3376

Table 15. Means of yields, in decagrams, of plots of North Western Dent corn, plots 30 links by 50 links, treated as resulting from four tests of twelve varieties each, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
12	30x50	22768.9166 ± 183.0635	940.1786 ± 129.4448	4.1292 ± .5685
12	30x50	22615.4166 ± 105.5840	542.2589 ± 74.6588	2.3977 ± .3301
12	30x50	22309.75 ± 202.4617	1039.8039 ± 143.1614	4.6607 ± .6416
12	30x50	22283.3333 ± 108.9416	559.5028 ± 77.0329	2.5108 ± .3456

Coefficients of Variability:- Highest 4.6607 ± .6416
Average 3.4246 ± .2454
Lowest 2.3977 ± .3301

Table 16. Means of yields, in decagrams, of plots of North Western Dent corn, plots 40 links by 50 links, treated as resulting from three trials of twelve varieties each, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviations	Coefficient of Variability
12	40x50	30449.5 ± 224.7334	1154.1873 ± 158.9098	3.7904 ± .5218
12	40x50	29598.25 ± 234.9172	1206.4891 ± 166.1108	4.0762 ± .5612
12	40x50	29929.6666 ± 168.4443	865.0971 ± 119.1075	2.8904 ± .3979

Coefficients of Variability:- Highest 4.0762 ± .5612
Average 3.5856 ± .2878
Lowest 2.8904 ± .3979

Table 17. Means of yields, in decagrams, of plots of North Western Dent corn, plots 5 links by 100 links, treated as resulting from four tests of twelve varieties each, with border rows discarded at harvest, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
12	5x100	7377.0833 ±73.0520	375.1812 ± 51.6553	5.0858 ±.7002
12	5x100	7930. ±35.0104	179.8068 ± 24.7560	2.2674 ±.3121
12	5x100	7638.1666 ±42.1125	216.2818 ± 29.7779	2.8315 ±.3898
12	5x100	7500. ±59.9876	308.0849 ± 42.4174	4.1077 ±.5655

Coefficients of Variability:- Highest 5.0858 ± .7002
Average 3.5731 ± .2573
Lowest 2.2674 ± .3121

Table 18. Means of yields, in decagrams, of plots of North Western Dent corn, plots 10 links by 100 links, treated as resulting from three tests of twelve varieties each, with border rows discarded at harvest, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
12	10x100	14981.7500 ± 139.8847	718.4209 ± 98.9130	4.7953 ± .6602
12	10x100	15421.0833 ± 102.0209	523.9597 ± 72.1393	3.3977 ± .4677
12	10x100	14954.1666 ± 72.7703	373.7343 ± 51.4561	2.4992 ± .3440

Coefficients of Variability:- Highest 4.7953 ± .6602
Average 3.5640 ± .2931
Lowest 2.4992 ± .3440

Table 19. Means of yields, in decagrams, of plots of North Western Dent corn, plots 60 links by 50 links, treated as resulting from two tests of twelve varieties each, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
12	60x50	45384.3333 ± 271.0355	1391.9855 ± 191.6501	3.0671 ± .4222
12	60x50	44593.0833 ± 281.3466	1444.9415 ± 198.9412	3.2402 ± .4461

Average coefficient of variability: 3.1536 ± .3071

Table 20. Summary of results of sizes and shapes of plots as measured by the coefficient of variability.

Number of Tests	Size of Plots	Coefficient of Variability. Highest	Lowest	Average
	links			
24	5x50	7.6566 ± 1.0541	3.1053 ± .4275	4.8662 ± .1409
12	10x50	5.3260 ± .7332	1.3886 ± .1911	3.5971 ± .1488
6	20x50	5.3064 ± .7305	2.2253 ± .3063	3.3397 ± .1975
4	30x50	4.6607 ± .6416	2.3977 ± .3301	3.4246 ± .2454
3	40x50	4.0762 ± .5612	2.8904 ± .3979	3.5856 ± .2878
2	60x50	3.2402 ± .4461	3.0671 ± .4222	3.1536 ± .3071

Table 21. Summary of results of sizes and shapes of plots as measured by the coefficient of variability.

Number of Tests	Size of Plots	Coefficient of Variability		
		Highest	Lowest	Average
	links			
12	5x100	5.969 ± .8218	2.701 ± .3718	3.962 ± .1615
6	10x100	4.2001 ± .5782	1.8629 ± .2564	3.1362 ± .1825
4	15x100	3.8986 ± .5367	1.8422 ± .2536	2.8156 ± .2003
3	20x100	4.6881 ± .6454	2.3889 ± .3289	3.1732 ± .2662
2	30x100	4.2819 ± .5895	2.3922 ± .3293	3.3370 ± .3376
		(Border rows discarded at harvest)		
4	5x100	5.0658 ± .7002	2.2674 ± .3121	3.5731 ± .2573
3	10x100	4.7953 ± .6602	2.4992 ± .3440	3.5640 ± .2931

Table 22. Mean yields, in decagrams, of North Western Dent corn, of plots occupying the same area but extending in opposite directions, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
		(First test)		
S-N 20	5x100	7176.7 ± 51.6244	342.2825 ± 36.5034	4.7693 ± .5036
W-E 20	5x100	7176.7 ± 56.0631	371.7121 ± 39.6420	5.1794 ± .5523
		(Second test)		
S-N 20	5x100	7457.3 ± 69.4512	460.4788 ± 49.1087	6.1748 ± .6585
W-E 20	5x100	7457.3 ± 52.6579	349.1348 ± 37.2341	4.6817 ± .4992
		(Third test)		
S-N 20	5x100	7818.25 ± 44.3118	293.7984 ± 31.3327	3.7578 ± .4007
W-E 20	5x100	7818.25 ± 27.4424	181.9505 ± 19.4044	2.3272 ± .2481
		(Fourth test)		
S-N 20	5x100	7665.4 ± 35.5267	235.5513 ± 25.1208	3.0729 ± .3277
W-E 20	5x100	7665.4 ± 46.7996	310.2934 ± 33.0918	4.0479 ± .4316
		(Fifth test)		
S-N 20	5x100	7573.65 ± 38.6655	256.3619 ± 27.3402	3.3849 ± .3609
W-E 20	5x100	7573.65 ± 42.8840	284.3317 ± 30.3231	3.7542 ± .4003
		(Sixth test)		
S-N 20	5x100	7405. ± 42.6360	282.6878 ± 30.1478	3.8175 ± .4071
W-E 20	5x100	7405. ± 32.7345	217.0380 ± 23.1464	2.9309 ± .3135
		(Seventh test)		
S-N 20	5x100	7488.3 ± 44.4423	294.6635 ± 31.4249	3.9349 ± .4196
W-E 20	5x100	7488.3 ± 35.6395	236.2989 ± 25.2005	3.1555 ± .3365

Table 23. Summary of Table 22.

Direction of Plots	Coefficient of Variability		
	Highest	Lowest	Average
S. to N.	6.1748 ± .6585	3.0729 ± .3277	4.1303 ± .1710
W. to E.	5.1794 ± .5523	2.3272 ± .2481	3.7252 ± .1547

Table 24. Mean yield, in decagrams, of North Western Dent corn, of short wide plots 70 links by 100 links, and of long narrow plots 10 links by 700 links, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
10	70x100	105169.2 ± 673.8203	3159.1137 ± 476.4701	3.0038 ±.4530
10	10x700	105169.2 ± 373.1958	1749.6773 ± 263.8933	1.6637 ±.2509

Table 25. Mean of yields, in decagrams, of four plots of North Western Dent corn, plots 360 links by 50 links, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean Yield	Standard Deviation	Coefficient of Variability
4	360x50	269932.25 ±830.9891	2464.0152 ±587.6037	.9128 ±.2176

Table 26. Means of total yields, in decagrams, of plots of North Western Dent corn, plots 5 links by 100 links, resulting from two, three, four, six and twelve plantings, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean of Total Yield	Standard Deviation	Coefficient of Variability
		(Two plantings)		
72	5x100	14996.2361 ± 45.7535	575.5859 ± 32.3527	3.8382 ±.2157
		(Three plantings)		
48	5x100	22494.3542 ± 77.8305	799.4445 ± 55.0342	3.5539 ±.2446
		(Four plantings)		
36	5x100	29992.4722 ± 100.7077	895.8425 ± 71.2108	2.9868 ±.2374
		(Six plantings)		
24	5x100	44988.7083 ± 196.9274	1430.3149 ±139.2493	3.1792 ±.3095
		(Twelve plantings)		
12	5x100	89977.4166 ± 488.2700	2507.6635 ±345.2580	2.7869 ±.3837

<u>Note</u> - Replication, as shown in the above table, was effected as follows:

Two plantings - Rows 2 and 74; 3 and 75; 4 and 76; etc.
Three " - Rows 2, 50 and 98; 3, 51 and 99; 4, 52 and 100; etc.
Four " - Rows 2, 38, 74 and 110; 3, 39 and 111; etc.
Six " - Rows 2, 26, 50, 74, 98 and 122; 3, 27, 51, 75, 99 and 123; etc.
Twelve " - Rows 2, 14, 26, 38, 50, 62, 74, 86, 98, 110, 122 and 134; etc.

Table 27. Means of total yields, in decagrams, of plots of North Western Dent corn, plots 10 links by 100 links, resulting from two, three four, six and twelve plantings, together with standard deviations and coefficients of variability.

Number of Plots	Size of Plots	Mean of Total Yield	Standard Deviation	Coefficient of Variability
		(Two plantings)		
36	10x100	29992.4722 ± 103.9981	925.1128 ± 73.5376	3.0844 ±.2451
		(Three plantings)		
24	10x100	44986.7083 ± 162.8832	1183.0467 ± 115.1763	2.6296 ±.2560
		(Four plantings)		
18	10x100	59984.9444 ± 195.9757	1232.6861 ± 138.5744	2.0549 ±.2310
		(Six plantings)		
12	10x100	89977.4166 ± 413.2220	2122.2317 ± 292.1913	2.3586 ±.3247
		(Twelve plantings)		
6	10x100	179954.8333 ± 939.1610	3410.6403 ± 664.0907	1.8953 ±.3690

Note - Replication, as shown in the above table, was effected as follows:

Two plantings - Rows 2 and 3, 74 and 75; 4 and 5, 76 and 77; etc.
Three " - Rows 2 and 3, 50 and 51, 98 and 99; etc.
Four " - Rows 2 and 3, 38 and 39, 74 and 75, 110 and 111; etc.
Six " - Rows 2 and 3, 26 and 27, 50 and 51, 74 and 75, 98 and 99, 122 and 123; etc.
Twelve " - Rows 2 and 3, 14 and 15, 26 and 27, 38 and 39, 50 and 51, 62 and 63, 74 and 75, 86 and 87, 98 and 99, 110 and 111, 122 and 123, 134 and 135; etc.

Table 28. Means of total yields, in decagrams, of North Western Dent corn, treated as resulting from various tests of twelve different varieties to ascertain the comparative value of different sizes and replications of plots.

Number of Plots	Size of Plots	Mean of Total Yields	Standard Deviation	Coefficient of Variability
	links	(Twelve plantings)		
12	5x100	89977.4166 ± 488.270	2507.6635 ± 345.2580	2.7869 ± .3837
		(Six plantings)		
12	10x100	89977.4166 ± 413.222	2122.2317 ± 292.1913	2.3586 ± .3247
		(Four plantings)		
12	15x100	89977.4166 ± 230.2044	1182.2848 ± 162.7780	1.3140 ± .1809
		(Three plantings)		
12	20x100	89977.4166 ± 356.0772	1828.7430 ± 251.7834	2.0324 ± .2798
		(Two plantings)		
12	30x100	89977.4166 ± 395.2504	2029.9288 ± 279.4828	2.2560 ± .3106
		(One planting)		
12	60x100	89977.4166 ± 543.523	2791.4318 ± 384.3275	3.1023 ± .4271
		(Four plantings, border rows discarded at harvest)		
		(Mean Yield per Plot)		
12	5x100	7611.3125 ± 30.3674	155.9613 ± 21.4729	2.0491 ± .2821
		(Three plantings, border rows discarded at harvest)		
		(Mean Yield per Plot)		
12	10x100	15118.9999 ± 75.0227	385.3023 ± 53.0488	2.5485 ± .3508

SUMMARY

Under the conditions of this experiment, the results of tests with various sizes, shapes, directions and replications of plots indicate that:

1. Increase in size of plots, without regard to direction or replication, has not proven to have any effect in reducing variability.
2. Doubling the length of plots, the width remaining the same, gave increased accuracy.
3. Long narrow plots are more efficient in reducing variability than are short wide plots.
4. That direction of plots has no influence in reducing variability.
5. Replication is more efficient in securing accuracy than either size, shape or direction of plots.
6. When a fixed number of varieties or treatments are to be tested and the area of available land is limited, the use of border rows increases the variability caused by soil heterogeneity.
7. Within the limits of the sizes, shapes and numbers of replications used in this investigation, .01 ac. plots, 10 links x 100 links, replicated three times, are the most efficient in reducing variability.
8. If twelve varieties or treatments are to be tested, the greatest accuracy is obtained by the use of .015 ac. plots replicated three times (four plantings).

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Yields in decagrams of 3388 hills of North Western Dent corn 5 links x 5 links.

Hill Number.

Row Number.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1-	145	332	272	322	290	412	300	257	275	285	315	362	220	282	367	307	315	322	257	386	270	287
2-	276	340	405	325	365	330	392	380	350	332	251	410	361	350	342	330	387	272	327	257	277	207
3-	522	400	333	513	387	467	372	460	467	402	357	337	338	383	365	352	340	280	320	362	372	340
4-	345	322	335	390	335	502	382	285	375	345	332	307	420	437	330	280	387	327	495	411	342	423
5-	329	320	333	497	384	362	427	410	376	372	285	347	392	334	380	320	350	405	340	382	342	386
6-	371	335	475	359	350	380	415	385	312	495	385	367	372	435	392	390	187	357	312	420	372	324
7-	300	363	382	444	462	365	382	388	325	357	317	305	325	332	390	235	335	372	390	360	295	243
8-	321	277	472	314	325	475	392	301	345	350	360	414	319	407	310	377	317	397	350	425	242	285
9-	356	416	492	470	312	317	355	400	392	325	247	380	418	367	375	460	332	400	392	427	362	370
10-	324	392	325	432	370	378	265	364	370	370	331	327	375	395	387	326	365	367	335	365	342	285
11-	360	367	460	313	389	375	427	385	377	346	320	386	365	385	420	357	397	333	362	401	390	320
12-	377	399	390	543	452	331	380	382	332	430	312	305	325	371	398	340	331	313	407	335	375	330
13-	324	262	320	365	332	352	335	455	287	305	300	315	302	290	340	382	352	382	382	325	275	331
14-	265	323	315	350	323	340	355	427	382	375	305	345	287	352	357	350	425	382	398	352	360	366
15-	380	366	402	385	435	385	435	342	332	450	307	307	477	370	305	412	315	370	379	395	425	377
16-	345	350	322	281	382	305	380	342	350	272	287	412	365	335	465	335	332	380	357	332	370	277
17-	314	332	322	408	462	355	320	497	407	331	385	347	307	372	347	262	495	437	327	337	400	285

Appendix.

Hill Number.

Row Number.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20,	21	22
18-	247	325	412	360	315	385	335	342	357	307	280	307	307	305	375	322	342	385	237	353	270	320
19-	337	276	330	345	356	400	345	346	337	390	250	287	277	395	362	280	346	300	290	337	282	342
20-	218	325	330	417	427	310	357	325	366	317	285	425	322	412	302	286	305	375	318	352	316	380
21-	300	360	381	364	390	416	362	372	385	385	295	271	357	232	337	318	337	362	301	427	398	370
22-	218	375	375	420	208	430	302	370	270	420	285	360	306	325	367	335	350	325	431	355	301	265
23-	275	457	382	372	402	325	390	340	378	432	315	355	435	304	399	420	432	342	330	387	387	407
24-	297	357	381	377	373	390	310	356	340	467	310	327	270	365	342	340	340	347	320	390	75	89
25-	286	266	330	321	259	292	320	350	225	355	135	246	382	346	320	305	280	375	320	305	408	320
26-	280	265	347	370	382	370	360	355	382	410	305	347	343	325	375	307	325	340	380	410	332	310
27-	322	420	427	402	412	410	370	412	400	465	347	412	315	365	405	321	301	412	338	380	326	390
28-	270	315	367	370	386	467	350	402	377	317	366	390	345	370	310	325	385	315	387	327	410	395
29-	362	336	266	326	380	398	372	352	315	360	278	360	366	440	305	340	492	390	562	415	422	372
30-	350	506	399	387	377	422	337	410	370	427	282	328	325	330	412	377	315	342	330	332	335	325
31-	332	280	371	342	358	430	392	410	407	392	367	372	370	340	480	350	440	293	375	425	342	403
32-	280	320	447	358	378	382	315	445	387	460	247	373	325	314	400	375	360	415	599	321	437	517
33-	282	382	320	403	405	390	340	420	387	398	390	480	325	332	405	335	365	325	435	405	347	420
34-	287	307	399	421	432	380	430	440	500	386	368	360	410	415	397	397	405	370	335	420	527	405

Appendix.

Appendix.

Hill Number.

Row Number.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
35-	303	307	377	406	426	390	407	332	442	415	370	415	377	505	420	378	340	325	446	435	383	482
36-	335	345	412	405	352	552	385	367	487	437	415	380	387	400	360	425	365	336	382	410	317	480
37-	273	285	332	415	357	320	415	424	387	355	305	385	307	382	346	547	336	434	280	377	395	316
38-	262	415	310	357	402	382	450	415	388	367	382	312	338	305	403	385	396	420	435	380	300	530
39-	372	362	410	402	432	345	415	441	380	367	550	425	411	365	400	360	392	455	380	371	485	407
40-	408	370	358	385	335	347	523	457	395	384	387	392	345	355	357	470	340	420	370	454	440	340
41-	350	366	380	452	372	435	392	385	365	425	330	382	377	405	437	432	395	315	330	386	350	360
42-	350	391	372	357	520	380	410	412	430	397	457	337	345	495	465	450	410	335	375	407	301	420
43-	363	402	320	325	410	440	352	430	390	373	415	387	317	410	345	327	352	390	322	325	440	332
44-	430	355	402	425	430	385	420	440	385	400	392	410	365	362	439	410	390	357	420	450	445	340
45-	355	382	405	435	305	352	440	375	400	367	367	402	403	470	480	370	380	397	402	475	355	390
46-	399	385	412	382	390	430	410	380	372	280	457	320	395	315	377	420	425	397	367	500	402	360
47-	321	357	395	517	485	398	365	462	357	400	395	400	402	350	480	420	377	385	375	445	367	395
48-	385	385	372	435	315	402	410	425	363	407	445	380	380	425	420	335	380	407	345	380	365	377
49-	367	380	350	323	301	377	375	342	415	335	340	395	321	387	305	315	370	402	382	332	450	310
50-	375	435	432	345	380	362	342	365	367	377	362	400	332	360	327	445	400	455	480	347	407	465
51-	330	417	425	415	390	390	352	430	440	395	402	403	445	365	402	445	350	320	437	403	367	315

Hill Number

Row Number.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
52-	392	392	405	452	385	455	410	377	550	368	407	355	342	375	407	435	335	377	402	480	420	377
53-	260	340	405	346	372	375	367	347	450	320	380	375	392	277	452	375	425	317	367	377	440	325
54-	312	384	412	455	435	395	440	345	447	390	385	411	375	417	287	445	385	387	365	415	345	420
55-	358	395	335	352	305	365	375	390	492	397	390	385	370	435	300	412	337	350	425	412	325	325
56-	215	372	405	365	395	395	415	340	360	477	320	402	455	385	360	415	420	430	425	301	425	327
57-	357	435	400	372	455	390	312	367	435	515	390	405	385	412	412	355	335	382	450	501	370	415
58-	345	312	415	415	342	425	380	370	495	390	420	405	392	392	375	402	455	325	415	377	450	422
59-	332	435	365	320	392	410	420	312	410	445	365	302	400	375	357	302	465	432	390	342	320	335
60-	361	350	322	445	365	445	487	387	420	342	400	420	335	492	475	390	387	445	430	425	550	417
61-	320	372	415	520	360	350	512	365	344	405	412	335	335	280	325	372	372	325	307	385	220	360
62-	265	332	457	367	450	330	397	355	450	376	285	390	387	440	420	385	320	385	382	440	320	293
63-	315	335	461	468	405	322	460	445	425	340	410	425	337	374	432	450	410	365	375	377	380	307
64-	305	400	342	402	282	382	387	394	375	405	370	382	360	485	395	390	495	322	395	367	395	440
65-	340	350	396	485	405	397	360	450	450	427	360	412	350	410	477	460	397	337	287	440	362	320
66-	282	380	425	350	458	435	340	307	395	470	425	395	370	425	275	360	390	350	387	395	420	340
67-	315	385	347	375	380	345	495	397	415	410	387	395	374	310	454	335	350	365	320	382	385	415
68-	295	362	415	397	358	425	364	375	387	366	325	400	345	357	345	377	330	320	375	367	340	362

Appendix.

Appendix.

Hill Number.

Row Number.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
69-	325	519	385	370	305	335	365	502	455	395	352	425	330	405	380	380	420	405	385	360	327	370
70-	282	330	360	435	325	345	355	467	392	420	347	327	400	355	410	305	332	420	370	367	347	340
71-	420	360	413	350	350	390	340	430	410	455	402	327	377	465	320	370	350	325	355	405	415	300
72-	320	455	280	320	367	392	417	380	360	450	300	270	345	375	432	450	315	445	387	462	375	440
73-	310	320	385	397	365	430	385	450	365	382	401	370	355	352	397	392	290	365	340	307	367	450
74-	347	360	372	445	355	312	401	301	450	387	332	295	300	510	392	370	260	380	377	345	380	270
75-	412	477	435	427	462	362	402	432	340	455	415	490	405	335	461	347	382	325	380	355	430	245
76-	312	290	450	425	490	415	455	330	375	377	287	375	467	360	424	425	510	462	350	415	360	355
77-	397	362	415	450	430	240	337	427	377	425	382	315	422	385	547	310	395	300	340	375	475	337
78-	370	397	320	435	337	450	495	335	342	465	305	387	330	375	395	360	392	352	397	355	330	420
79-	342	500	422	390	440	370	385	305	395	372	140	385	380	342	340	440	320	440	380	335	350	390
80-	255	235	465	357	360	397	307	387	410	420	355	412	317	415	440	305	380	380	390	345	367	385
81-	227	440	385	377	407	305	365	390	420	410	327	515	400	340	385	395	320	350	435	472	350	440
82-	400	412	403	400	370	450	451	367	432	395	330	415	415	375	335	340	280	445	445	385	380	480
83-	310	390	400	350	417	350	350	372	380	435	350	412	375	395	350	350	492	420	484	510	450	450
84-	352	466	342	357	407	400	335	490	395	392	345	400	380	382	357	400	360	301	315	415	375	425
85-	280	382	440	427	375	390	425	335	325	420	445	277	397	407	315	210	342	301	355	340	480	355

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Row Number.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
86-	325	430	380	430	385	405	362	350	355	499	310	377	480	472	315	405	370	455	372	455	360	255
87-	332	355	465	410	362	395	327	440	392	417	340	360	387	280	420	270	477	422	427	402	457	340
88-	305	365	380	495	455	315	390	405	437	411	365	455	367	380	372	375	395	492	377	365	415	350
89-	302	420	362	485	415	392	350	455	425	372	355	415	385	387	325	402	330	352	455	350	335	420
90-	250	360	407	360	412	425	320	302	472	360	390	357	410	325	315	345	505	365	410	345	420	432
91-	400	353	387	330	397	355	367	310	445	322	352	360	390	387	325	275	387	417	340	375	350	412
92-	255	345	312	445	452	380	364	392	405	360	295	340	370	430	400	325	230	430	370	400	382	410
93-	395	353	430	400	370	382	377	370	425	412	342	365	437	343	375	325	337	385	410	407	325	405
94-	332	397	440	310	480	365	340	317	395	390	302	317	360	345	405	492	332	380	255	365	340	405
95-	277	317	415	310	360	332	375	365	355	415	390	390	415	372	347	450	370	450	340	330	325	325
96-	275	335	265	385	320	420	410	425	325	415	392	360	382	340	400	320	360	310	380	312	382	540
97-	262	357	367	395	415	412	350	410	352	365	310	380	385	315	280	300	395	315	352	382	337	355
98-	322	255	385	377	342	435	422	399	372	402	405	380	290	315	315	320	347	452	310	430	367	435
99-	232	372	450	395	337	392	350	382	372	437	347	355	370	397	355	362	330	472	380	357	335	380
100-	330	390	375	372	360	370	327	445	365	407	390	327	410	460	310	350	450	400	345	280	455	370
101-	335	371	400	415	390	355	480	395	377	382	340	367	425	385	430	365	352	360	350	357	325	402
102-	321	322	357	361	362	402	400	390	387	395	287	380	405	362	342	345	325	335	410	385	467	357

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Row Number.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
103-	287	265	435	365	341	380	395	392	315	360	285	365	345	420	337	270	330	301	370	320	250	280
104-	275	320	305	360	355	480	400	395	427	390	310	365	390	380	400	370	322	442	400	375	365	295
105-	305	404	375	262	382	415	345	440	360	532	365	462	380	435	405	390	442	340	370	335	410	350
106-	312	325	415	381	380	395	320	480	352	365	385	402	382	357	352	330	370	360	430	482	235	465
107-	377	302	430	435	335	375	320	365	347	395	430	335	377	415	437	352	392	385	350	320	385	432
108-	301	331	332	445	442	367	440	360	505	385	362	310	330	302	352	355	360	405	340	442	387	360
109-	277	423	340	457	400	315	367	305	352	342	265	341	255	362	285	352	362	367	255	405	360	345
110-	324	285	417	405	390	440	450	390	442	335	257	386	360	375	300	395	477	315	345	390	312	415
111-	370	350	335	422	337	395	350	350	445	432	380	405	382	445	427	385	387	422	417	410	362	340
112-	340	415	375	360	315	365	390	430	380	364	410	370	385	400	325	395	365	335	400	315	410	520
113-	397	350	360	400	395	301	430	360	460	365	375	375	380	242	230	345	416	382	527	355	345	305
114-	285	375	395	430	365	330	335	412	322	360	450	325	257	435	417	375	377	352	423	335	382	372
115-	340	340	370	350	325	352	360	435	360	357	320	410	382	396	435	300	360	370	362	300	362	315
116-	330	322	345	301	322	285	357	365	355	335	382	430	420	387	385	430	340	385	305	312	372	342
117-	309	420	375	430	390	327	421	335	390	360	301	457	380	310	300	415	412	377	355	411	400	360
118-	301	300	372	387	290	387	387	410	335	482	400	335	390	317	385	340	340	350	350	492	302	400
119-	332	477	410	300	430	425	390	362	325	410	295	370	395	355	350	532	372	417	390	355	410	447

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Row Number.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
120-	385	300	360	373	325	475	300	340	452	437	365	375	380	402	360	425	315	344	402	322	382	362
121-	370	390	322	342	345	345	302	312	450	375	315	300	305	320	322	342	355	365	382	364	290	277
122-	325	385	355	370	375	357	345	302	330	335	382	317	345	360	433	375	345	380	325	415	372	382
123-	382	355	442	385	335	375	425	380	492	385	385	383	402	493	375	377	382	355	390	417	390	322
124-	405	380	380	315	383	367	380	342	420	332	360	397	310	345	390	400	450	377	370	372	300	300
125-	417	340	340	370	522	450	400	387	320	415	360	382	385	425	435	355	410	270	360	452	375	345
126-	387	360	492	435	330	245	377	455	357	527	370	335	390	380	370	340	325	335	315	370	300	352
127-	460	340	350	380	380	373	400	360	355	370	352	363	375	332	445	280	302	362	420	380	302	347
128-	435	325	307	367	385	442	400	472	375	345	385	440	417	365	330	420	372	377	442	462	415	430
129-	393	390	410	472	315	420	380	425	375	390	555	335	300	400	385	420	360	360	395	412	417	430
130-	397	450	335	400	347	415	375	335	380	352	292	362	300	440	375	301	395	400	435	340	370	442
131-	425	401	395	350	360	410	390	360	370	585	392	315	395	430	400	367	375	350	432	307	390	430
132-	330	370	302	352	400	373	300	457	325	435	345	386	325	380	380	312	392	390	450	380	390	425
133-	377	300	360	315	430	322	360	405	340	345	392	252	322	292	350	385	317	415	372	375	420	387
134-	437	340	340	366	435	450	405	375	377	430	390	430	385	345	520	375	322	415	300	385	377	435
135-	394	325	400	487	337	425	430	425	390	360	423	352	410	310	345	377	342	385	440	330	462	302
136-	312	380	357	366	400	372	345	340	382	472	360	350	400	347	365	430	350	396	460	410	330	385

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Hill Number.

Row Number.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
137-	442	340	376	390	370	395	405	382	345	335	336	410	469	430	360	335	395	385	385	385	397	355
138-	382	330	400	325	327	415	450	340	305	356	345	300	325	350	395	365	395	440	402	320	360	425
139-	262	390	430	370	400	320	315	425	397	395	300	290	452	283	327	265	362	370	418	350	315	257
140-	410	385	280	365	392	410	322	340	345	487	345	355	302	350	370	355	387	435	390	400	385	330
141-	310	315	320	392	420	440	227	330	330	307	437	360	275	350	325	300	350	377	330	435	200	425
142-	320	347	432	367	325	398	385	365	350	380	360	417	355	305	415	382	430	300	362	315	360	410
143-	355	362	370	340	375	360	325	362	360	410	361	365	343	395	255	402	370	350	420	402	370	362
144-	315	340	345	315	370	395	360	360	375	301	375	370	330	363	347	322	375	351	360	370	425	365
145-	300	315	345	195	315	370	390	332	310	335	350	280	230	325	270	345	302	377	305	370	180	335
146-	315	347	305	302	410	300	320	360	320	331	277	275	335	357	380	360	337	300	360	390	430	265
147-	365	395	394	385	396	330	380	360	385	367	350	320	410	370	332	347	375	459	345	382	365	332
148-	330	307	377	330	356	320	315	390	370	360	373	315	400	325	435	337	312	362	335	305	301	412
149-	300	227	367	300	302	335	385	305	420	335	245	455	390	365	267	345	422	407	425	312	385	280
150-	275	357	345	365	270	415	315	350	340	382	360	273	330	272	385	300	365	350	405	363	315	275
151-	320	220	300	270	312	447	360	370	305	370	330	175	257	290	350	280	302	350	325	335	325	330
152-	265	312	352	312	310	305	300	390	250	300	283	330	453	372	260	382	360	355	370	395	300	457
153-	225	330	360	460	365	270	292	420	400	370	335	345	225	247	232	355	357	437	370	301	360	347
154-	182	220	320	300	387	230	197	302	193	260	235	180	270	150	241	132	205	205	232	332	365	280

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