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VALIDITY OF THE SURVEY METHOD OF RESEARCH.

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CONTENTS.

INTRODUCTION.

The distinguishing feature of farm-management investigations is the application of the inductive method of reasoning to farm practice. In practically all farming communities can be found examples of successful and of unsuccessful farms. It is assumed that a careful analysis of the methods and business system of a large number of farmers, all working under essentially similar soil, climatic, and economic conditions, may be made to reveal the reasons for the success of one and the failure of another. The essential difference between the farm-management method and the laboratory method of investigation lies in the fact that the laboratory investigator varies his causes and studies the resulting variation in the effects produced. The farm-management investigator has his experimental results already produced for him. He merely collects the results of farm experience, arranges them in such manner as to display the variations of a causal factor, and then studies the resulting variations in the effects produced. Suppose, for example, it is desired to know what degree of soil fertility will result in the greatest profit to the farmer under the conditions prevailing in a given locality. Having analyzed the business of a large number of farms in the locality, the farms are first grouped on the basis of their yields per acre, with enough farms in each group to give reliable averages. The average profit made by the farms in each group is then determined. Table I shows this relation for a group of 378 farms in southeastern Pennsylvania. The results indicate that under the conditions prevailing in this locality, and with the methods practiced by local farmers, the point of diminishing returns is reached when the yield on a given farm reaches about 40 per cent above the general average of the community. Yields higher than this appear to be obtained at an expense greater than the increase in income due to the increased yields. The figures would naturally differ for different regions.

TABLE I.—*Relation of crop yield to labor income.*

	Groups of farms based on yield per acre.				
Average yields expressed in percentage of the community average	84 and less.	85–99	100–114	115–139	140 and over.
Average labor income expressed in percentage of the community average	49	74	108	153	130

HOW FARM RECORDS ARE OBTAINED.

Knowledge of the details of farm practice and of the results arising from this practice may be obtained in two ways. First, careful records may be kept of the details of the farm work and the business transactions of the farmer. Second, such details may be obtained by interviewing farmers who give them as accurately as may be from memory, or from such desultory records as may have been made of the farm operations. The first of these methods involves years of labor and enormous expense; the second gives an enormous amount of data in a short while and at a nominal expense. The question is as to the relative accuracy of these two methods.

When farm management investigations first began it was supposed that the only way to get at the facts of farm practice with a degree of accuracy sufficient for investigational purposes was by means of carefully made records. Accordingly, cost-accounting records were begun on a large number of farms. It was soon perceived, however, that the cost of such records and the time required for their accumulation were serious obstacles. Furthermore, practice differs so widely in different regions, on different farms in the same locality, and even on the same farm from year to year, that it would be an interminable task to collect sufficient data in this manner to solve the numerous problems which the study of farm practice had revealed. Because of the amount of time involved the results would frequently be out of date before the work could be finished. Finally it was decided to give the second method a trial. At first many students of farm management had misgivings as to the validity of data obtained from farmers who keep few or no records. Accordingly, in order to test this point a number of investigations were undertaken. These were of necessity limited to data which were either already available in reliable records or of which such records could be secured by instituting a system of cost accounting. The results of these investigations are given below.

INVESTIGATIONS BY F. E. ROBERTSON.

Where a community of farmers sell all their milk to local creameries it is possible to get an accurate record from the creameries of the amount of milk sold by each patron and the receipts for the same. In a dairy community in southern New Hampshire 135 farmers were found who sold all their milk to local creameries. These farmers were asked to give an estimate of the amount received for milk during the preceding year. Many of them at first professed to be unable to do this, but a little questioning as to the number of cows kept, the amount of the monthly milk check, etc., finally elicited an estimate from each of them. Later the precise amounts were copied from the books at the creameries. The results are shown in Table II. The error in these estimates, taking all farms together, was $346, or slightly less than one-third of 1 per cent of the total.

TABLE II.—*Comparison of farmers' estimates and creamery records of annual receipts for milk on 135 New Hampshire dairy farms.*

Estimated value of milk sold, all farms	$106,183
Actual value of milk sold, all farms	105,837
Error in estimates	346

Before this investigation was finished it occurred to the investigator to include also the amount of milk sold. Accordingly, the remaining farmers, 79 in number, were asked to estimate this item. These farmers were in the habit of thinking in terms of dollars and cents but not in terms of pounds or gallons of milk. They found it more difficult to estimate quantity than value of milk sold. The results are given in Table III. In this case the error in the total for all the farms was nine-tenths of 1 per cent.

TABLE III.—*Comparison of farmers' estimates and creamery records of pounds of milk sold annually on 79 New Hampshire farms.*

Estimated pounds of milk sold, all farms	3,518,816
Actual pounds of milk sold, all farms	3,487,320
Error in estimates (pounds)	31,496

INVESTIGATIONS BY A. D. McNAIR.

An investigation was made at Belton, S. C., of the pounds of seed cotton per bale from estimates of seven farmers and from gin records of 400 bales. The average for the 400 bales, according to the gin records, was 1,362 pounds of seed cotton per bale. The average of the seven farmers' estimates was 1,369 pounds, the difference being about one-half of 1 per cent of the gin record.

The same investigator obtained the percentage of lint to seed cotton from gin records of 1,192 bales of cotton at Atkins, Ark., and from farmers' estimates on 151 bales in the same locality. According to the gin records, the average turnout of lint cotton was 32.5 per cent; the average of the farmers' estimates was 33.1 per cent. He made a similar investigation at Dermott, Ark., the gin results being 31.75 per cent (on 907 bales) and the farmers' estimates being 31.2 per cent (on 65 bales).

Records kept on 15 farms in an Arkansas community on the amount of cotton picked per day per man gave an average of 140.4 pounds. The average of the estimates of 50 farmers in the same locality was 140.3 pounds per day.

On 23 plantations in Coahoma County, Miss., on which were 9,326 acres of share croppers' cotton and 1,509 acres of share croppers' corn, the number of days of labor on these crops as shown by planters' estimates was 129,347. Each planter also estimated the number of days of "outside labor" performed, and this amounted to 14,018, or a grand total 143,365 days of labor for the share croppers and their families. On the same plantations each owner was asked to estimate the gross yearly value of the labor of the share croppers and their families, and the total for the 23 plantations was $144,007. This sum of money is equal to a daily wage of $1.004 for each of the 143,365 days of labor performed, which is a close approximation to the current wage of $1 per day.

From the above data it appears that in the case of important items of the farmer's business he has knowledge which is quite accurate. Matters of less importance are usually not kept in mind so accurately. In the matter of the amount of labor done in producing a crop, which involves a knowledge of an average day's work at plowing, harrowing, seeding, cultivating, etc., the farmer's knowledge is based on experience usually covering many years, and the answers he gives to such questions are averages rather than figures applicable to any one year. Because of differences in the preceding crop, amount of rainfall from year to year, variations in temperature, etc., the work done on an acre of corn, for instance, may in any one year depart quite widely from the average. It is therefore impossible to test adequately the accuracy of the farmer's estimates of items of this character by comparison with actual records for any one year.

In order to show the variations that may occur between estimates based on many years' experience and accurate records for a single season, the following data relating to a group of 29 farms at Conway, Ark., are given. Each of these farmers was asked to estimate the amount of man and horse labor required by an acre of cotton and an acre of corn, in both cases up to the time the cultivation of the crop is finished. The questions asked the farmer related not to the total amount of this labor but to the various operations usually performed and rate of work per day for each operation. That is, the questions were asked in the terms in which the farmer thinks. Later these same farmers were induced to keep accurate records of all the labor on their farms for a year. Table IV shows the results in comparison. Because of the variation from year to year of the actual amount of work done per acre on a given crop even on the same farm it is impossible to tell whether the actual work done during the season for which records were made on these farms is more accurate than the farmers' estimates. In any case the differences are seen to be relatively small when compared, for instance, with the differences in yield on duplicate plots in field experiments on the yield of crops.

TABLE IV.—*Comparison of 29 farmers' estimates with actual records for a single season of labor on cotton and corn to "laying by."*

Crop.	Man-days per acre.		Horse-days per acre.	
	Estimates.	Records.	Estimates.	Records.
Cotton	10.14	9.80	5.76	6.05
Corn	4.44	4.78	5.22	6.39

INVESTIGATIONS BY M. B. OATES.

Investigations of a similar nature were conducted in northwestern Louisiana. The results are given in Table V. The figures given are averages of 10 records and 11 estimates on cotton, 13 records and 13 estimates on corn, and 11 records and 10 estimates on peanuts. Ordinarily these numbers are too small to give reliable averages, yet the agreement between estimates and records is fairly satisfactory.

TABLE V.—*Comparison of records and estimates of man and horse labor on cotton, corn, and peanuts in Louisiana.*

Crop.	Man hours per acre.		Horse hours per acre.	
	Estimates.	Records.	Estimates.	Records.
Cotton	47.0	47.7	34.9	34.4
Corn	32.3	27.2	38.1	33.1
Peanuts	23.1	29.4	30.2	30.0

Estimates were also secured from 10 farmers of the number of days available for field work during the year. This number naturally varies with the character of the weather from year to year. Later these same farmers kept records of the actual days available for such work on their farms for a year. Table VI gives a comparison of the estimate and the record on each of the 10 farms.

TABLE VI.—*Days per year available for field work.*

Farm No.	1	2	3	4	5	6	7	8	9	10
By record	225	208	220	215	203	207	205	202	212	218
By estimate	221	203	216	221	212	182	203	212	216	206

The average of the 10 estimates is 209 days and of the 10 records 212 days, a difference of only 1½ per cent of the total. Considering the fact that the quantity here under consideration actually varies considerably from year to year and that the records are for a single year, the agreement between the estimates and the records must be regarded as very satisfactory.

INVESTIGATIONS BY C. M. HENNIS.

In cooperation with the North Dakota Experiment Station the Office of Farm Management secured the data given in Table VII.

TABLE VII.—*Acres plowed per day.*

Number of horses.	Records.		Estimates.	
	Number of records.	Average.	Number of estimates.	Average.
		Acres.		*Acres.*
3	15	2.81	1	2.73
4	32	3.83	16	4.26
5	60	5.02	37	5.17
6	15	5.55	10	5.61

When it is remembered that the numbers averaged are in most cases very small and that the farmers making the records were not the same as those giving the estimates, but were located in the same general region, it must be admitted that it is possible to get just about as reliable results from farmers' estimates as it is from the most careful records provided the questions asked the farmer are within the range of his experience and thinking and provided the number of estimates is large enough to permit the proper working of the law of averages.

CASE OF A GEORGIA FARM.

In a farm management survey it happened that one enumerator obtained the record of a certain farm from the overseer at the farm, while another enumerator obtained the record of the same farm from the manager at his office in town. In both cases the record was given from memory. The record from the manager gave a labor income of $3,688, that from the overseer $3,656, a difference of $32, which is less than 1 per cent of the quantity involved. It should be remembered that records of this kind are used only in averages, so that errors in them are for the most part eliminated by the law of averages. (See p. 9.)

ACCURACY OF THE FARMER'S KNOWLEDGE.

The opinion prevails quite widely, even among farmers themselves, that the average farmer knows very little of the details of his business. The results given in the foregoing pages indicate that this opinion is not consistent with facts. During the past decade the Office of Farm Management has analyzed the business of nearly 20,000 farms. The experience gained in this work indicates that the average farmer does know the details of his business with a fair degree of accuracy, the discrepancy in his knowledge being relatively small in the case of the larger and more important items, but increasing as the importance of the items decreases. One reason for this is the fact that in a year's business on the average farm there are relatively few business transactions, most of them being fairly large items. The principal product of the farm is, in many cases, disposed of in a single sale, and the farmer remembers the details of this sale quite accurately until the corresponding figures for a new year replace them in his mind. In many other cases a product, such as eggs, milk, etc., is sold in fairly regular quantities from month to month, and the farmer remembers with a fair degree of accuracy the usual monthly income from such sales, as well as the variations in this income.

But though the farmer does know fairly well the details of his business, he is not always aware of this fact; and it requires no slight skill on the part of the investigator to reduce his questions to the terms in which the farmer carries the information in his head. Unless this is done, the answers given by the farmer are mere guesses and are of small value. Thus, if we ask a farmer how much profit he made on a certain field of corn he will usually not even hazard a guess at the answer, because he realizes he does not know; but if we analyze the cost and income from this field into its elements we find the farmer has very definite knowledge of these elements. He knows the operations, such as plowing, harrowing, planting, etc., done in raising the crop. He knows the amount and value of the fertilizers applied. He knows how much corn was secured and its market value. The trouble is not that the farmer does not know the facts necessary to arrive at the profit made from the field, for he does know them; but he does not know how to use these facts in calculating the profit, because his knowledge of cost accounting methods is meager. The investigator, if he is competent, supplies the deficiency in the farmer's knowledge of bookkeeping, and together the two of them are able to arrive at an approximately correct solution of the problem.

Similarly with the profits from the entire farm. The farmer knows the facts necessary to calculate these profits, even though he may not know how to make the calculations.

It should also be rememembered that the farmer's less accurate memory for small details is not a matter of great importance, for the smaller the item the less influence an error in it has on the final result.

ACCURACY OF COST-ACCOUNTING METHODS.

Those having even the most elementary knowledge of the principles of cost accounting are aware that such work always involves estimates, no matter how accurately it may be done, and these estimates not infrequently constitute an important proportion of the cost. Consider, for instance, the cost of a day of horse labor. This is the annual cost of keeping the horse divided by the number of days' work the horse does in the year. It is possible to arrive at a fairly accurate valuation of the feed the horse consumes and of the man labor required in caring for the horse, though the latter item itself is based partly on estimates (especially of the cost of the man's keep). Even then the variation in feeding practice from farm to farm and in the eating capacity of individual animals make the actual cost of feed a highly variable quantity, so that a single so-called "accurate" record is of little, if any, more value than an intelligent estimate of an experienced horseman. Another item in the cost of keeping the horse is interest on investment. To arrive at this we must estimate the market value of the animal. Depreciation is also an important element. In arriving at this we must not only assume a value for the horse, but we must make a guess at how long he will last. Barn rent is another item. To arrive at this we must estimate the value of the barn, the length of time it will last, the cost of future repairs, and the relative value of the space occupied by the horse, as compared to that used as a shelter for machinery, etc. We must also estimate the cost of harness required in order that the horse may do its work. The animal must also be credited with the value of his manure, another estimate.

The above facts suffice to show that on the farm even cost accounting is at best largely a matter of estimates. It is merely a question of the dependability of the estimates. It has been shown above that in matters in which farmers have had extended experience their estimates are so sufficiently reliable that when large numbers of them are averaged the results possess a very satisfactory degree of accuracy. However, it is not possible to overestimate the importance of making questions submitted to farmers conform to the terms in which the farmer's knowledge exists. When this is done a proper study of data furnished by farmers may reveal numerous important facts never suspected either by the farmer or his questioner. For instance, if in the farm-management survey made some years ago in Lenawee County, Mich., the farmer had been asked directly what the manure of a horse or cow was worth to him, he probably would not have hazarded a reply. If he had it would have been little more than a guess, not an estimate. But when the question was broken up into its elements and he was asked to state the acreage and yields of his various crops, the prices at which his products were sold, the number and kinds of animals kept on the place, he answered readily enough. By taking these data from many farms and comparing those having relatively little stock with those having many, the actual increment in crop values due to the manure of a single animal was easily calculated.[1]

LAW OF ERROR.

The law of error, frequently called the law of averages, may be stated in many different ways. Perhaps as comprehensive a statement of it as any is this: "Errors of measurement or observation tend, in the absence of 'bias,' to group themselves about the true value of the quantity measured in such manner as to eliminate each other in the final average."

The manner in which such errors group themselves about the true average will be discussed in some detail a little later.

Absolute accuracy is not obtainable in any kind of measurements. In any case it is merely a question of degree of accuracy.

The accuracy of any average depends on three things. First, and most important of all, is freedom from "bias"; that is, entire absence of any tendency to make each measurement too high or too low. In general, we have found bias singularly absent in practically all our field studies of farm practice. It is true that some farmers deliberately overestimate, but fortunately there seem to be about as many who deliberately underestimate. These over and under estimates tend to cancel each other and thus to reduce their effect on the resulting averages.

Second in importance is the number of items on which an average depends. The larger the number the more reliable the average. The reason for this lies in the fact that when a number of items is averaged the larger the number the better the chance that any error will be canceled by a similar error in the opposite direction.

Since no measurement of any kind is absolutely accurate, every measurement represents an error of greater or less magnitude.

[1] See Dept. Agr. Bul. 341, Table LX, p. 98.

Abundant study of the law of error has shown that large errors occur less often than small ones, and if bias is absent plus errors of any magnitude occur just about as often as minus errors of similar magnitude. This is well illustrated in Table VIII, which shows the distribution of errors in 354 separate measurements of an area.

TABLE VIII.—*Distribution of errors.*

Magnitude of error.	Number of plus errors.	Number of minus errors.
0 to 0.3	89	93
.31 to .6	51	55
.61 to .9	26	22
.91 to 1.2	8	8
1.21 to 1.5	2	0
Total number	176	+178=354

In these measurements there were in all 176 plus and 178 minus errors. Furthermore, of the errors of any given magnitude there are about as many plus as minus.

In so far as we have been able to test the matter, the errors arising in securing data from farm experience distribute themselves about the true value in approximately the manner above illustrated. It is therefore possible, by securing large numbers of estimates, to get averages of a very satisfactory degree of accuracy.

The third factor governing the accuracy of an average is the accuracy of the individual items averaged. Inaccuracies in these items, if bias is absent, tend to eliminate each other because of the manner in which errors group themselves about the true mean, provided the number of items is large enough. For this reason inaccuracies in the original measurements are less important than either absence of bias or number of items averaged.

Pearl and others have shown by actual count that an average is more accurate than the data on which it is based. This fact has indeed long been known. The relation of the accuracy of an average to that of the items averaged is given by the well-known formula $E=\frac{e}{\sqrt{n}}$, where E is the probable error of the mean, e the probable error of a single observation, and n the number of observations averaged. Thus it might be said that an average based on, say, 40 observations of a variable quantity is twice as reliable as one based on 10, and an average based on 100 observations is 10 times as trustworthy as a single observation. Even if the probable error of the individual estimates is as much as 25 per cent, the probable error of the average of 100 such estimates is only $2\frac{1}{2}$ per cent. Hence, even if the farmer's knowledge of the details of his business were even less definite than experience has shown it to be it would still be possible to get fairly reliable results by securing large numbers of estimates and using only averages of them. This principle is taken advantage of in the study of farm practice, and there is reason to believe that, within the proper limits of use of the results obtained, studies of this kind are entitled to at least as much consideration from the standpoint of accuracy as are those involving experimental work conducted under the most favorable field conditions. Indeed it is believed that when carefully conducted by those properly trained both in the collection of data and in the interpretation of these data, the results of such studies approach in accuracy those obtained in laboratory investigations.

The so-called law of averages is merely one manifestation of the laws of probability, or chance. It is not feasible here to discuss these laws in detail. They are fully treated in standard texts, with which every experimentalist should be familiar. In fact, the interpretation of experimental results which does not take into account the law of error is nearly as apt to be wrong as it is to be right. A little consideration will show that in a highly variable quantity, such as the yield of a given plot treated in a given way, six duplicate plots is far too small a number to insure with any degree of certainty that the action of the law of averages will eliminate the departures from the true average. In general, the average of six such yields, no matter how accurately each yield is measured, is far less reliable than would be the average of 60 estimates of farmers based on years of experience with a given field. Sixty such estimates give a chance for the law of averages to eliminate a large proportion of the errors in the individual estimates, and these errors are in general no larger than those in plot yields, no matter how accurately these yields are measured.

While we may not here consider the laws of chance in detail, a few illustrations of them may serve to show that such laws actually exist.

In flipping a penny it is an even chance whether heads or tails turn up at any particular throw. Now, it has been proven by abundant experiment that as the number of times the penny is thrown increases, the tendency for the total number of heads to equal the total number of tails increases. In other words, where the chance is even the event will, on the average, turn out in one of two possible ways as often as it does in the other.

In throwing a single die there are six possible results, all equally likely to occur. There is thus a tendency, when a die is thrown many times, for any one of the six faces to turn up one time in six on the average.

An excellent illustration of the workings of the laws of chance was recently found in tabulating the replies to a circular letter sent out by the Office of Farm Management. The latter contained a list of implements, and the farmers to whom it was sent were asked to state in connection with each item whether he owned the implement named and whether he recommended its purchase by farmers. The particular tabulation with which we are concerned here included only those farmers recommending the purchase, the object being to ascertain what proportion of them had acted on their own recommendations. The blanks used in tabulating the replies had spaces for entering 700 replies relating to a particular implement. The replies when entered in several cases filled two or more pages of the blank. After the answers had all been recorded, it was noticed that where the replies relating to a particular implement filled more than one page, the proportion of farmers owning the implement among those recommending its purchase was nearly the same on each separate page. Table IX has been constructed to show this interesting operation of the laws of chance. Take, for instance, the figures relating to the emery wheel (see Table IX). Of the 1,400 replies relating to it 976 were from farmers owning this implement. It happened that in tabulating the replies, exactly half of the owners were recorded on each of the two pages. Since this fact was not noticed until the tabulations had been completed, and since the replies were handled without any thought of the matter here under discussion, this perfectly even distribution of the 976 owners between the two arbitrary groups of 700 can only be ascribed to pure chance, or as nearly pure chance as can be imagined. It was an even chance whether any particular owner's reply should be recorded on the first page of the blank or on the second; hence half fell on one page and half on the other.

That this result is not wholly capricious but is really due to the operation of a law is shown by every other case where two full pages of the blank were filled. There are nine such cases in the table. In no case where an even chance existed does the number of owners recorded on a page exceed 52 per cent or fall below 48 per cent of the total number of owners on the two pages.

The figures relating to the set of stocks and dies are an excellent illustration of the importance of numbers in arriving at an average. The replies in this case filled slightly more than two pages. On the first page, containing 700 replies, 52.71 per cent were from farmers owning a set of stocks and dies. On the second page the percentage is 52.43, or practically the same. But on the third page, where there are only six replies, 83⅓ per cent are from owners. Six is too small a number to give a reliable average in such a case.

In the case of most of the implements of the list there was one page of the tabulating blank only partially filled. In all these cases, excepting only the one just mentioned, the proportion of owners is nearly the same as on the corresponding full pages. Thus, in the case of the drill press the third page contains only 44 replies, but the percentage of owners among them is nearly the same as on the preceding full page. Even here the number of replies is sufficient to permit the law of chance to make itself evident.

TABLE IX.—*Illustrating operation of law of chance.*

Implement.	Page No.	Number of farms having.	Percentage of owners on two pages.	Number of farms recommending.	Per cent of those recommending having.
Carborundum or emery wheel	1	488	50.00	700	69.71
	2	488	50.00	700	69.71
Set of stocks and dies	1	369	50.14	700	52.71
	2	367	49.86	700	52.43
	3	5	....	6	....
Gasoline blowtorch	1	205	....	700	29.28
	2	105	....	426	24.64
Wrecking tool	1	537	50.3	700	76.71
	2	532	49.7	700	76.00
	3	133	....	180	73.88
Pinch bar	1	612	50.5	700	87.43
	2	598	49.5	700	85.43
	3	87	....	104	83.65
Hack saw	1	478	51.5	700	68.28
	2	450	48.5	700	64.28
	3	38	....	53	71.69
Small hoist	1	520	50.1	700	74.28
	2	519	49.9	700	74.14
	3	148	....	220	67.27
Drill press, or breast drill	1	454	52.0	700	64.85
	2	420	48.0	700	60.00
	3	26	....	44	59.09
Combination vise, drill, and anvil	1	370	....	700	52.85
	2	345	....	654	52.75
Combination pliers	1	638	50.15	700	91.14
	2	634	49.85	700	90.57
	3	190	....	216	87.96
Expansion bit	1	349	....	700	49.86
	2	296	....	568	52.11
Combination bevel square	1	375	....	700	53.57
	2	274	....	494	55.46
Heavy shears, or tinner's snips	1	448	51.32	700	64.00
	2	425	48.68	700	60.71
	3	53	....	86	61.62

The fact that in each case it is page 1 that has the highest proportion of owners is of no significance, since the full pages were deliberately arranged in this order after the tabulation was completed, the original chance arrangement being thus lost.

MISTAKEN NOTIONS OF ACCURACY.

In the endeavor to find the average value of a variable quantity, such as annual rainfall, the yield per acre of a crop under given conditions, etc., there is such a thing as gross inaccuracy in the final result even where the individual measures are made with a high degree of precision. Suppose, for instance, it is desired to ascertain the average yield of winter wheat after summer fallow as compared with the yield after a preceding crop of small grain, under the soil and climatic conditions prevailing on a particular tract of uniform soil.

Suppose the actual average for summer fallowed land, as determined by the average of an indefinitely large number of trials extending over a series of years sufficient to give average climatic effects, is 30 bushels per acre and that in a particular experiment it is 20 bushels. Now there is in this latter figure an inherent error of 10 bushels, and this error can not be eliminated by any degree of accuracy in measuring the 20-bushel yield. The only way to eliminate errors of this kind is to get enough observations to allow the law of averages to operate on them; that is, to insure the elimination of errors in one direction by the occurrence of similar errors in the opposite direction.

The relatively small importance of accuracy in the items to be averaged as compared with the great importance of the number of these items is well illustrated by the following facts concerning rainfall at Penn Yan, N. Y. The annual precipitation at this station has been measured to the hundredth of an inch each year for a period of 60 years. The average of the 60 annual records is 29.113 inches. If instead of the actual rainfall for each year we use the nearest multiple of 10, thus recording 26.73 as 30, 23.87 as 20, and so on, we get an average of 28.667, which is in error 1.532 per cent, assuming 29.113 inches to be the true average. If now we divide the 60-year period into six periods of 10 years each, using the measurements to the hundredth of an inch, the averages of these six periods are in error to the extent of 3.24, 7.51, 2.95, 7.24, 2.94, and 3.52 per cent, respectively. That is, the 60-year average based on measurements made to the nearest multiple of 10 inches is more accurate than any one of the 10-year averages based on the most accurate measurements.

It is not intended here to convey the impression that accuracy in original data is a matter of small importance. Such accuracy is important. The main point to be made is that numbers of items to be averaged is still more important. Our studies lead to the conclusion that errors in the farmer's knowledge of the details of his business and of the work he does are in every way comparable to the departures from the true mean in field plot experimental work and that they distribute themselves about the true values in approximately the same manner. The fact that the survey method of investigation gives data sufficient to permit the law of averages to eliminate plus errors by the occurrence of similar minus errors while plot experiments ordinarily do not do this appears to justify the statement that the survey method is a more reliable means of arriving at those facts to which it is applicable than the field plot experimental method. It appears, in fact, to occupy a place intermediate between plot experiments on the one hand, where variations in other factors than that under observation occur and are not adequately eliminated, and laboratory studies on the other hand, in which variations in other factors are largely prevented. These variations due to factors other than that studied do occur in using the survey method, but the amount of data obtained by this method is sufficient to permit the elimination of such variations by the operation of the law of averages. The fact that there is such unanimity in the conclusions of investigators using the survey method in all parts of the country is, of itself, evidence of the general validity and great utility of this method of research.

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