METHODS OF FORECASTING NEW ENGLAND POTATO YIELDS

The Relationship of Yields To Reported Condition and Weather Data

Introduction

In forecasting crop yields at the first of each month during the growing season the statisticians of the Division of Crop and Livestock Estimates have relied in the past almost entirely on farmers' reports of crop condition in per cent of normal. This reported condition has been interpreted by the "par method" which assumes that a one per cent change in reported condition is likely to be accompanied by a corresponding change in the same direction in probable yield. In practice, however, the statistician is not limited to a purely mechanical averaging and interpreting of condition data. Condition figures have been modified in many ways. They are subject to editing in varying degrees and in some instances published condition figures have been modified materially by the statistician in order to effect yield forecasts justified by other observations. Allowance has also been made in many instances for the fact that condition figures are notably inelastic, and fail to measure accurately extremes, such as bumper yields and crop failure.

It is apparent that the crop statistician is not limited in making forecasts of yield to a mechanical analysis of reported condition interpreted by the par method. In fact, he is expected and required to use considerable judgment in arriving at his forecasts. But unless his judgment be based on a careful analysis of the various factors which enter into the situation it may result in little, if any, improvement in the forecasts. Such an analysis can be made only after a good deal of research has been done. This research may be along many lines. It may be studies

of the actual relationship which has existed between reported condition and finally published yields, or it may be studies of the influence of weather conditions, the sale of fertilizer, prices during the previous year, or other factors to yields. The object of this research is to discover the actual relationship of yields in past years to certain factors which are known before harvest, and to determine the relative accuracy and reliability of these different factors as indications of probable yields. Where this is done the crop statistician no longer needs to rely on one indication, such as reported condition, but can use all available information in making his forecast.

Use of Weather Data In Forecasting New England Potato Yields in 1928

During the 1928 season studies were made of the relation between potato yields in New England and weather conditions. These studies were used in making the yield forecasts for July 1, August 1, September 1 and October 1. These forecasts were not, however, based entirely on the studies of weather factors. They took into consideration any other indications which might be available, but in forming his judgment as to probable yields the statistician gave considerably more weight to the rainfall indications since they offer a reliable explanation of variations in yields during the past fifteen years.

The following table shows the average yields in the six New England States as forecast by this method compared with the average yields which would have been forecast from reported condition and par.

New England Potato Yields
Forecast Using Weather Data and Indicated by Condition

Months	Indicated Yields		Per Cent Error	
	Forecast Largely from Rainfall and Trend	Indicated by Condition and Par	Forecast Largely from Rainfall and Trend	Indicated by Condition and Par
	Bushels	Bushels	Per cent	Per cent
July 1	199.7	224.5	+ 2.5	+ 15.2
August 1	197.7	253.9	+1.5	+ 30.3
Sept 1	194.2	235.1	- .3	+ 20.7
October 1	195.4	222.7	+ .3	+14.3

Final Yield 194.8

It is apparent that the New England potato yield forecasts in 1928 were decidedly improved by the use of weather data. The following summary will indicate how these forecasts were made. It will also show the relative accuracy of various methods of forecasting yields and will suggest possible methods of further improving the forecasts from weather data.

The Accuracy of Past Forecasts

The first step in studying yield data with the purpose of improving forecasts is to examine the forecasts which have been actually made in past years. If these forecasts have been accurate there is obviously no need for further study. The final estimates of potato yield in the six New England States will be found in Table I. When these final yields were compared with the yields indicated by the production forecasts during the early months of the same years, it was found that the July 1 and August 1 forecasts had been decidedly unreliable.

Figure 1 for example, shows how the August 1 forecast of yield for each state compares with the finally published yield. It is evident

that the August first forecasts of yield have, in many cases, been decidedly inaccurate. In 1921, for example, the yield as forecast on August 1 for Maine was 169 - the lowest forecast for the period - while the finally published yield was 298, or the second highest yield in the period. The error in this forecast was 129 bushels, or 76 per cent. Although this is an extreme case it shows that occasionally the August 1 forecasts have been very unreliable.

We are interested, however, not so much in extreme cases as in the average reliability of the forecasts. The following table shows the standard errors in the August 1 forecasts compared with the standard deviations of yields in the six New England States.

Comparison Of Standard Error Of August 1 Potato Yield Forecasts With Standard Deviation Of Final Yields

States	Standard Error of Forecasts 1914 - 1927	Standard Deviation of Yields 1913 - 1927
	Bushels	Bushels
Maine	56.7	50.0
New Hampshire	29.5	28.1
Vermont	31.1	27.2
Massachusetts	31.6	26.6
Rhode Island	29.1	25.4
Connecticut	29.6	24.5

Re-examination of Basic Data Necessary

Since the potato yield forecasts in New England during the early months of the growing season, during past years, have been unreliable it is important to examine in a critical manner the basic data from which the yield was calculated. Such an examination has been made in order to discover, first, whether these data, (reported condition figures), could

have been interpreted better by some other method than the par method, and, second, whether or not reported condition in the early months was related closely enough to final yields to provide a reliable basis for forecasting by any method which could be found. That is, after discovering that the early forecasts have been inaccurate the statistician should determine whether the fault is with the basic data used in making the forecasts, or whether it is with the method of interpreting these data. If it is the former, it is especially important to study weather data or any other factors which may affect crop yields. If it is the latter, the basic data already gathered should be further studied in order to find an interpretation which will provide a more reliable forecast.

With this and in view the original reports on the condition of potatoes in New England were tabulated for July 1, August 1, September 1 and October 1 of the years 1913 to 1927. The data tabulated in Table III represent the average of the field aid and township reports for the years 1913 to 1927. The relation of these data to final yields in each state were then studied.

Relation of Reported Condition to Final Yield

The relation of reported condition to final yields was analyzed by multiple correlation methods, using final yields as the dependent factor and reported condition on the first of each month and trend, (numbering the years as 1, 2, 3, etc.), as the independent factors. The results of this analysis will be found in Tables V, VI, and VII.

A study of these tables and of Figures 2 and 3 brings out the following significant facts:

1. The relationship of final potato yields to condition and trend is only fair in most of the New England States on July 1 and on August 1

as shown by the coefficients of correlation ($R_{1.23}$), by the standard errors of estimates ($S_{1.23}$) and graphically by the spread of the dots around the regression lines plotted in Figures 2 and 3.

2. The larger part of this relationship on July 1 and on August 1 in most states may be attributed to a gradual trend upward in yields. Condition is not a good indication of yields in these months in most states. This is shown by the determination coefficients, $d_{12.3}$.

3. The regression lines showing the actual relationship which has existed during the past fifteen years between condition and final yield on July 1 and on August 1 in most cases have a slope decidedly different from the "par line". These regression lines showing the relation between final yields and July 1 condition in New Hampshire and Vermont and August 1 condition in Maine and Vermont, all have downward slopes as shown by the regression coefficients ($b_{12.3}$), and by the plotted regression lines in Figures 2 and 3. In these cases yields have varied inversely with reported condition and high reported condition has been associated with low yields, which is opposite to the assumptions of the par method of forecasting.

4. The relationship of final potato yields to reported condition and trend was fairly high in all states on September 1 and October 1. Reported condition in these months is evidently a fairly satisfactory basis for forecasting yields. This is shown by the correlation coefficients, ($R_{1.23}$), and by the standard errors of estimate, ($S_{1.23}$). The standard errors of estimate are considerably below the standard deviations of the final yields, which indicates that yields can, on these dates, be estimated from condition and trend more accurately than from the mean.

5. The standard errors of estimate indicate, however, that even on September 1 and October 1 a fairly large part of the variation in yields is not anticipated correctly by condition. Since these dates are just before and after digging time and later weather does not seriously influence average yields, the results indicate that farmers are unable even when the crop is practically mature to judge the condition of the crop with any great accuracy.

6. The low determination of reported condition on July 1 and August 1 ($d_{12.3}$), indicates either that the farmer's judgment of crop prospects on these dates is unreliable, or that weather conditions later in the season have been responsible for decided changes in the condition of the crop during the remainder of the season. In this connection it should be noted that the minus regression coefficients ($b_{12.3}$), for some states in the early months show that the reporter's estimates of condition have been commonly in the wrong direction. That is, he has usually anticipated a small crop when prospects were actually the best and vica versa. It is probable that the majority of reporters are guided by the appearance of tops and are without any satisfactory indication of tuber development. In the early months, therefore, condition as reported in these states is a useful indicator of probable yields only if farmers misjudge prospects with enough regularity to make it possible to forecast that yields will vary in the opposite direction from that anticipated by the growers.

7. The regression line is decidedly better than the "par line" for use in interpreting reported condition figures, as shown by the improvement in the standard errors of estimate.

Further Study Of Condition Desirable

This analysis of reported condition might well be carried one step further to test the curvilinearity of the relationships. Such a study would be particularly desirable in the case of September 1 and October 1 condition since these data appear to afford a fairly satisfactory basis of forecasting. This has not yet been done, but it is probable that such a study might reveal a tendency for yields to increase more and more sharply as reported condition approaches 100, and also to decrease more sharply as reported condition approaches low levels. This would result in an S-shaped curve, which might increase the accuracy of interpreting condition.

Preliminary Study of Weather Data

Obviously, the yields of potatoes are related to weather conditions. Since it was found that reported condition during the early months of the growing season did not provide a satisfactory basis of forecasting, weather data were obtained for the last fifteen years and the relationship of rainfall and temperature to yields was studied. Dot charts and simple correlations failed to show any usable degree of relationship between yields and temperature. Monthly mean temperature and the means of the daily high and daily low temperature were studied without success. But a high correlation between rainfall and yields was apparent from the start. A study of any data on rainfall by months or as totals for the growing season showed a decided tendency for large yields on years of light rainfall and small yields on years of heavy rainfall. Almost no data were available on other weather factors such as humidity and percentage of possible sunshine.

Results Of Study of Rainfall Data

For that reason a complete record of monthly average rainfall by states was obtained from 1913 to 1927 and was analyzed by multiple correlation methods. The first set of correlations calculated used final yields as the dependent factor and rainfall from May 1 to July 1, August 1, etc., and trend, (tabulated 1, 2, 3, etc.), for the independent factors. The rainfall data used will be found in Table IV and the results of the analysis in Tables V, VI, and VIII.

These statistical results might be summarized as follows:

1. Total rainfall from May 1 to the date of the forecast together with trend provides a much more reliable basis for estimating probable yields than do reported condition and trend except in Connecticut. In Connecticut the straight line correlation using rainfall does not improve the estimates but the improvement is marked in the other states. This is shown by the correlation coefficients, ($R_{1.23}$), and the standard errors of estimate, ($S_{1.23}$).

2. In the four northern states the yield estimated from rainfall up to July 1 and trend is more accurate than the yields estimated from condition and trend on September 1, and in Rhode Island it is more accurate than the yields estimated from condition and trend on August 1.

3. May 1 to August 1 rainfall is even more closely related with final yields. Using this factor and trend as the independent factors produces correlation coefficients of over .80 in three states; over ..70 in two states, and only .56 in Connecticut.

4. When total rainfall for the growing season is used, without weighting by months, the addition of rainfall after August 1 does not add to the accuracy of the yield estimates in the three northern states, but for some unexplained reason seems to be more important in southern New England. The opposite conclusions might have been anticipated, since the season is perhaps two weeks earlier in southern New England.

5. The failure of August and September rainfall to add to the accuracy of the yield estimates does not necessarily mean that rainfall during these months is not an important factor to be considered. On the other hand it means that rainfall during this period is not related to yields in the same manner as is rainfall during the first part of the growing season. There are two possible methods of discovering the true relationship of late rainfall to yields. One is a multiple correlation using separate data on early and late rainfall together with trend as dependent factors. The other is a "regression surface" which will indicate the joint relationship of early and late rainfall on yields. Such studies have not yet been completed for all states, but the joint relationship of early and late rainfall to yields in Maine has been determined and will be discussed later in this paper.

6. Since total state average rainfall from May 1 to the date of the first four yield forecasts has, during the past fifteen years, been related more closely to final potato yields than has reported condition on the same dates the statistician should rely strongly on rainfall as a basis of his forecasts. This does not necessarily mean that he should give no weight to reported condition. He should consider

all indications which may have any value. However, the very low degree of relationship between July 1 and August 1 condition and final yields makes it advisable in many states to disregard this indication entirely and to base the forecasts on the yields indicated from rainfall plus any other information which seems reliable such as personal inspection of potato fields and the advice of potato experts.

Further Studies Of Rainfall Data

The results obtained from this simple, rather mechanical study of state average rainfall data suggest that an even more accurate explanation of the variation in potato yields might be obtained from a more refined statistical analysis. Several possible refinements in the analysis of rainfall data suggest themselves.

These refinements have not all been worked out in detail, but certain examples will be discussed in the next few pages to show how rainfall data can be used to further improve the basis of forecasting. These examples include studies of (1) the curvilinearity of the rainfall - yield relationship, (2) the use of station rainfall data instead of state average data, (3) weighting rainfall by months, (4) the use of rainfall data earlier than May 1, and (5) the joint influence of early and late rainfall on yields.

The Curvilinearity Of The Rainfall-Yield Relationship

First, it is likely that the true relation between rainfall and yields is not linear. It is apparent, for example, that decreasing amounts of rainfall will not continue to increase yields indefinitely, and we know that we could not possibly have a minus yield. Both of these would be

possible if the relationship between rainfall and yields were linear. It is, therefore, desirable to study the curvilinearity of these relationships.

Figures 4 and 5 show the results of a multiple curvilinear correlation analysis of May 1 to August 1 rainfall and trend in each state. These particular months were chosen for presentation here because a greater improvement in the yield forecasts by the use of rainfall data is possible on August 1 than on any of the other dates of forecasting. Somewhat higher correlations can be obtained by including in the analysis August and September rainfall, but, since reported condition on September 1 and on October 1 provide a fairly good indication of probable yields, the improvement made by forecasting yields from rainfall is likely to be less marked.

The results of the curvilinear analysis are shown in Figures 4 and 5 and in Table XII (a). The results are:

1. The relationship between rainfall and yields is decidedly curvilinear, and the curves in the six states are similar in shape. All of the curves show a steeper slope towards the left side of the charts, indicating that a difference of one inch in rainfall causes a larger difference in yield in a relatively dry year than in a relatively wet year. The optimum rainfall cannot be accurately determined in any of the New England States. It appears that no year since 1913 was dry enough to cause a decrease in yields.

2. The curves present a considerably more accurate explanation of past yields than do the straight line equations. The spread of the dots around the curves shows the amount of error in esti-

estimating yields from May 1 to August 1 rainfall. A comparison of this spread in Figures 4 and 5 with the spread of the dots around the lines in Figures 2 and 3 will give a good idea of the relative accuracy of explaining yields by May 1 to August 1 rainfall and by August 1 reported condition. The standard errors of estimate, ($S_{1.23}$), and the correlation indices, ($P_{1.23}$), in Table XII (a) provide a measure of the accuracy of these estimates.

3. The relative accuracy of estimating past yields from the rainfall-yield curve as compared with reported condition indicates more strongly than ever that the statistician should base his August 1 forecasts largely on rainfall except possibly in the case of Connecticut.

The Use Of Maine Station Rainfall Data

In case rainfall varies considerably in different parts of the state the state average rainfall data may not accurately reflect growing conditions in the specialized potato sections. This is especially true in Maine where roughly seventy-five per cent of the potato production is in the extreme northeastern cornar of the state, Aroostook County. For this reason the original station rainfall data for Maine were tabulated and analyzed.

Tables IX and X show the monthly average rainfall as reported by certain stations in Maine. These data were averaged to make a new rainfall series. This average was computed by weighting the rainfall reported from each station by the acreage of potatoes in the districts around the station. Using this new rainfall series a new set of correlations were computed for Maine, the results of

which are shown in Table XI and in Figure 6. These results were:

1. The correlation coefficients and standard errors in Table XII (b) show a considerable improvement over those in Table XII (a), indicating that the use of station data makes possible more accurate forecasts of yields in Maine than can be obtained from state average data.

2. The rainfall-yield curve in Figure 6 presents a remarkably accurate estimate of yields during the past years from data available on August 1, as shown by $P_{1.23} = .921$ and $S_{1.23} = 19.5$ bushels.

Weighting By Months

An additional refinement in analysis can be made by weighting the rainfall during the season by the relative importance of rainfall during the different months, or by a multiple correlation analysis treating the rainfall during the various months separately. The second of these methods requires the use of too great a number of dependent factors. If we include five monthly figures for rainfall and also trend in a correlation analysis of fifteen observations we are likely to get a large degree of spurious correlation. It is, therefore, preferable to treat rainfall as one, or possibly two factors if the months can be properly combined to make an average or total figure. But, in making a straight, unweighted, addition of the monthly rainfall data we assume that one inch increase or decrease in rainfall has the same influence on yields whether it occurs in May, June, July, August, or September. This is, of course, possible but not probable.

A preliminary study of the Maine rainfall data indicated that an additional inch of rainfall during July tended to cause roughly

twice as much damage as did an extra inch during the other months. The Maine monthly station average data were, therefore, re-totaled using the following weights: May, 1; June, 1; July, 2; August,1; and September,1. Using this new rainfall series for Maine together with trend in a multiple correlation analysis produced the results shown in Table XII (b) and in Figure 6, which may be summarized thus:

1. Weighting by the relative importance of months produces a small, but worthwhile improvement in the accuracy of the results.

2. The curvilinear correlation, ($P_{1.23}$ - .937), and the standard error of estimate, ($S_{1.23}$ - 17.5), of the August 1 curve shown in Figure 6 indicate that these refinements have made possible the explanation of a large portion of the variation in yields during the past fifteen years.

The Use of Rainfall Data Earlier Than May 1.

The tendency of this study to indicate that rainfall affects the character of plant growth for a material time after it has fallen led to the study of the effect of April rainfall or rainfall prior to potato planting which begins in most parts of New England about May 1. When studied on the basis of Maine monthly station rainfall data to August, weighting April, 1; May, 1; June, 1; and July, 2; the addition of April rainfall materially improves the multiple correlation with trend as shown by the summary of results in Table XII. The improvement, however, does not extend to the curvilinear relationship.

It seems probable that April rainfall has an influence on yields which is worthy of further study, especially on a basis for the July 1 and August 1 yield forecasts.

The Influence of Joint Early and Late Rainfall and Trend

It has been noticed that the addition of August and September rainfall in the correlation analysis in many cases adds little or nothing to the explanation of past yields, and it has been remarked that this probably does not mean that rainfall during these months is unimportant, but rather that the true relationship of late rainfall to yields is not brought out in such an analysis. For that reason the Maine station rainfall data were again re-analyzed, using a "three dimension correlation" to find the joint influence of early and late rainfall on yields.

The technique of such an analysis will not be described here, but the method used was a modification of the method proposed by Dr. Mordecai Ezekiel. (Determination Of Curvilinear Regression "Surfaces" In the Presence Of Other Variables. Journal of the American Statistical Association, September, 1926.)

The results of this analysis are shown in Figure 8. This chart will not be difficult for anyone to understand if he is acquainted with contour maps. The dots on the chart represent average yields in Maine during the last fifteen years adjusted to allow for trend. The location of these dots depends on the amount of rainfall, (weighted by months), which occurred from May 1 to July 31 and from August 1 to September 15, and is measured from the X and Y axes. The adjusted yield is written beside each dot. These yields may be thought of as elevations on a map. The problem of determining the regression "surface" is that of smoothing the surface described by these elevations. The contour lines drawn across the chart are the result of such a smoothing process. These contour lines if calculated from a multiple linear correlation analysis would be straight

lines and would be parallel and equidistant, and the surface described would be a tilted plane. The location of the dots, however, shows a decided tendency for a warping or twisting of the surface, the high point being in the upper, left hand corner, and the low point in the upper, right hand corner. The contour lines drawn on the chart reflect this warped surface. The results are summarized as follows:

1. Early and late rainfall when studied jointly and when an allowance is made for trend offer an almost perfect explanation in the variation of potato yields in Maine from 1913 to 1927, as shown by the correlation coefficient. .985 and the standard error of 8.1 bushels.

2. While the average relation of late rainfall to yields is minus, the highest yields have resulted from a dry early season followed by a moderately wet season after August 1. This suggests that blight, which usually begins to be noticed about the middle of August, is probably related to moisture conditions in July or in previous months. It has been commonly assumed that blight infestation is likely to be most serious in years when August is wet and warm. This analysis suggests, however, that temperature has little influence on yields, and that wet weather during August does not cause serious damage unless the ground is already wet from heavy rains early in the season. Excessive rains in both the early and late periods have had a cumulative effect which is disastrous to yields.

3. Although the data for forecasting from this analysis are not complete until October 1, it is possible as early as August 1 to use the results. Knowing the rainfall from May 1 to July 31

it is possible to forecast probable yields assuming normal rainfall during the next two months, and also to get some idea of the range of error which may be caused by unusual rainfall during the latter part of the season.

Summary Of The Study Of Rainfall

This study to date has been limited to an analysis of methods of forecasting New England potato yields from reported condition and to a consideration of one weather factor - rainfall - as an additional basis of making forecasts. It has been shown that there has been a high degree of relationship between rainfall and yields. While this does not establish a causal relationship, the similarity of the rainfall-yield curves in the various states as well as the judgment of potato experts that yields in New England are closely related to rainfall add confidence to the use of this analysis as a basis of forecasting yields. There are other details which might be studied in regard to the single factor of rainfall. The results explained here are not complete for all months and all states, but rather are given as examples of the types of analysis which was used in making the 1928 forecasts. It is perhaps improbable that forecasts in the coming years based on rainfall will result in errors as low as those in 1928, but it now seems certain that the high errors in previous forecasts can be definitely eliminated.

Further Fields of Study

While rainfall seems to be the outstanding factor which influences potato yields in New England there are many other minor factors which are worthy of some analysis. Prices received by farmers for previous

crops probably influences somewhat the expenditures of money and time on the next crop, and, therefore infbuences yields. Fertilizer consumption also is likely to cause some variation in yields from year to year. Variation in acreage from year to year with poorer lands going into and coming out of potatoes may also explain some of the yield variations.

All these factors and others are worthy of some attention and can be studied in a rough way by comparing the data on these factors each year with the residual which represents the portion of the yields which is not explained by rainfall and trend. For the present, however, this study is being limited to the analysis of rainfall data since it has been demonstrated conclusively that the major part of the variation in yields can be attributed to that factor.

TABLE 1

Potatoes: Yield Per Acre (Final Estimates) By States

Year	Maine	N. H.	Vermont	Mass.	R. I.	Conn.
1913	220	122	127	105	130	92
1914	260	159	163	155	165	140
1915	179	95	108	120	110	95
1916	204	120	112	91	74	95
1917	125	107	100	115	135	110
1918	200	140	130	133	130	95
1919	230	102	100	90	100	75
1920	177	127	130	125	110	115
1921	298	160	150	115	115	103
1922	187	100	120	90	90	140
1923	258	190	200	180	165	160
1924	315	170	160	150	140	130
1925	250	145	125	140	140	135
1926	290	165	155	155	150	155
1927	232	150	155	100	110	109

TABLE 11

Yields Indicated By Monthly Forecasts From Condition and Par

Years	Maine				New Hampshire				Vermont			
	July	Aug.	Sept	Oct.	July	Aug.	Sept.	Oct.	July	Aug.	Sept.	Oct.
1914	212	226	238	240	126	146	155	160	126	146	147	155
1915	226	219	177	150	132	142	113	98	140	154	128	106
1916	221	224	206	196	113	135	130	117	117	138	120	124
1917	190	214	161	135	125	140	141	108	133	144	137	123
1918	207	216	206	216	113	124	130	138	112	123	114	118
1919	187	196	202	214	135	125	124	130	126	120	121	120
1920	200	203	197	196	129	142	147	142	129	141	138	136
1921	184	169	191	254	122	120	118	144	123	112	108	124
1922	189	182	168	159	124	111	116	97	126	124	130	109
1923	217	210	221	252	131	130	133	159	126	130	126	150
1924	225	218	232	260	135	140	136	153	132	140	151	148
1925	258	254	239	242	152	150	136	133	147	147	124	119
1926	244	271	269	282	135	135	145	140	133	133	152	144
1927	260	285	246	227	162	169	162	146	148	153	156	131

Years	Massachusetts				Rhode Island				Connecticut			
	July	Aug.	Sept.	Oct.	July	Aug.	Sept	Oct.	July	Aug.	Sept.	Oct.
1914	120	132	141	145	132	149	157	159	109	126	137	136
1915	123	138	116	102	132	146	116	114	114	130	109	102
1916	116	120	116	103	123	128	99	91	107	116	117	104
1917	128	136	133	126	132	150	154	144	113	124	125	120
1918	121	113	120	131	132	114	128	136	110	92	97	104
1919	122	122	126	91	132	128	121	88	100	108	111	71
1920	112	126	130	128	113	120	120	124	101	112	120	126
1921	112	108	109	117	127	123	118	115	102	104	96	101
1922	118	116	112	91	128	122	118	90	106	112	114	100
1923	115	107	120	139	113	122	128	142	103	98	102	117
1924	118	110	116	141	117	112	118	134	107	90	95	107
1925	123	126	115	117	118	120	128	135	111	114	111	116
1926	122	122	138	137	115	115	129	124	113	113	126	136
1927	135	139	130	86	138	136	128	101	135	134	132	94

TABLE 111

Monthly Condition (Mean Field Aid and Township) By States

Years	Maine				New Hampshire				Vermont			
	July	Aug.	Sept.	Oct.	July	Aug.	Sept.	Oct.	July	Aug.	Sept.	Oct.
1913	93.5	94.5	92.0	91.0	89.5	80.0	74.0	70.0	90.5	91.5	80.5	81.0
1914	93.0	93.0	94.5	96.0	90.0	97.0	96.5	98.0	90.5	96.0	94.5	97.0
1915	94.0	92.0	74.5	61.0	89.5	89.0	72.0	56.0	93.5	98.5	79.0	65.0
1916	89.5	93.0	82.0	76.5	79.5	86.0	81.0	73.0	84.0	90.5	76.0	74.0
1917	83.0	88.5	68.0	53.0	85.0	96.5	89.0	66.0	91.5	98.0	88.5	72.0
1918	91.5	93.0	85.5	86.0	81.0	86.5	82.5	86.0	88.0	83.5	77.0	75.0
1919	93.5	87.0	84.0	84.5	93.0	88.0	79.5	77.0	91.0	85.0	80.0	77.0
1920	91.0	92.5	88.5	84.0	90.0	97.5	96.5	88.5	91.5	98.0	92.5	88.5
1921	84.0	76.0	84.5	90.5	83.0	86.5	77.0	86.5	87.0	80.5	73.0	88.5
1922	82.5	83.5	69.5	60.5	83.0	75.5	74.5	57.5	89.5	86.0	83.5	73.5
1923	91.0	83.0	89.0	94.0	86.5	88.0	81.5	95.0	88.5	90.0	79.0	90.5
1924	91.0	86.0	89.0	90.5	86.0	90.5	85.5	89.5	88.0	92.5	92.5	87.5
1925	94.0	89.5	80.0	81.0	95.0	94.0	79.0	77.5	92.5	92.5	73.0	70.0
1926	83.5	86.5	81.5	89.5	81.5	86.5	82.5	78.0	82.5	89.5	86.0	85.0
1927	88.0	89.0	78.0	71.0	91.0	94.0	83.0	66.0	89.0	93.0	90.0	73.0

Years	Massachusetts				Rhode Island				Connecticut			
	July	Aug.	Sept.	Oct.	July	Aug.	Sept	Oct.	July	Aug.	Sept.	Oct.
1913	89.0	77.0	70.5	77.0	87.0	81.0	74.0	75.5	85.0	86.5	68.0	71.5
1914	90.0	96.0	95.5	95.5	93.5	96.0	96.5	93.5	90.0	97.0	97.0	95.0
1915	92.0	95.0	75.0	69.0	93.0	93.0	69.0	70.0	91.5	94.0	75.0	70.5
1916	84.5	82.0	76.5	68.0	85.5	77.0	65.5	55.5	86.0	84.0	80.5	71.5
1917	91.5	95.5	87.0	81.5	95.5	98.5	96.0	91.5	93.0	94.5	92.0	87.5
1918	90.0	81.5	80.5	85.0	91.5	79.0	82.0	88.0	91.5	70.0	71.0	72.5
1919	88.5	87.5	85.0	59.0	85.0	85.5	77.0	56.0	87.0	88.0	82.0	52.5
1920	85.5	90.5	89.0	87.0	81.5	82.0	79.0	81.0	83.0	90.5	92.5	93.5
1921	86.5	80.0	76.5	78.5	91.5	88.0	80.0	79.5	89.5	83.0	72.0	74.0
1922	89.0	86.0	77.5	62.5	90.5	87.0	79.0	58.0	92.5	90.5	86.5	75.0
1923	89.0	82.0	86.0	91.0	86.0	89.5	88.0	94.5	94.5	82.5	79.0	90.5
1924	88.0	78.5	79.5	86.0	89.5	83.0	79.5	89.0	89.5	70.5	70.0	77.0
1925	91.5	90.5	79.0	78.5	89.0	90.5	89.0	85.0	89.5	89.0	81.5	82.5
1926	81.5	85.0	84.0	83.0	83.5	78.5	84.0	80.0	80.5	80.5	81.5	85.0
1927	87.0	88.0	79.0	51.0	90.0	86.0	80.0	58.0	87.0	81.0	71.0	57.0

TABLE IV

Rainfall in Inches: State Averages
From May 1 to July 1, Aug. 1, Sept. 1 and October 1.

Years:	Maine				New Hampshire				Vermont			
	Jul 1	Aug 1	Sept 1	Oct 1	Jul 1	Aug 1	Sept 1	Oct 1	Jul 1	Aug 1	Sept 1	Oct 1
1913	4.51	7.58	10.31	13.55	4.54	7.09	9.83	12.32	4.73	8.88	10.87	13.06
1914	4.83	8.40	12.05	13.64	3.86	7.21	11.79	12.49	3.86	7.97	12.45	14.57
1915	4.69	12.18	16.80	18.82	3.40	13.34	19.13	20.69	4.11	11.71	16.43	18.75
1916	8.76	12.99	16.70	20.26	10.39	14.72	17.88	23.03	8.01	11.28	13.79	18.57
1917	12.44	15.62	21.26	22.54	10.17	12.21	16.25	17.12	7.00	10.11	14.79	16.44
1918	6.00	11.29	14.20	21.06	6.52	9.21	13.28	20.52	7.56	10.37	13.70	20.51
1919	6.34	9.35	11.68	16.00	6.83	9.12	12.41	17.30	7.18	9.61	13.20	17.63
1920	4.55	8.30	12.09	18.98	5.73	9.74	13.94	20.54	4.99	9.54	12.72	18.08
1921	3.22	5.94	9.92	12.49	5.08	9.36	12.30	14.81	4.82	8.70	11.83	13.97
1922	12.45	15.15	20.12	21.98	13.10	15.82	20.33	22.64	11.01	13.01	17.71	19.78
1923	4.32	7.78	10.01	12.15	4.15	7.44	9.83	12.63	5.26	8.73	11.06	14.55
1924	5.82	8.33	12.73	17.67	4.90	7.77	11.40	18.09	6.18	9.76	13.39	19.72
1925	6.02	9.72	11.20	15.91	6.63	11.58	13.61	17.74	7.61	12.78	14.87	20.07
1926	4.73	7.50	10.93	14.22	4.59	8.30	11.48	14.29	5.49	9.37	12.63	15.53
1927	7.38	11.31	15.90	18.01	5.82	10.42	14.44	16.80	5.72	10.78	15.03	16.58

Years:	Massachusetts				Rhode Island				Connecticut			
	Jul 1	Aug 1	Sept 1	Oct 1	Jul 1	Aug 1	Sept 1	Oct 1	Jul 1	Aug 1	Sept 1	Oct 1
1913	4.57	6.71	10.16	13.74	3.24	5.53	8.35	11.31	4.96	6.85	10.55	14.10
1914	4.54	8.01	11.77	12.34	3.78	7.90	10.93	11.70	5.19	9.78	12.35	12.73
1915	4.26	12.19	18.17	19.53	4.01	6.86	12.46	14.20	3.86	10.17	17.47	19.30
1916	8.86	14.97	17.29	20.08	8.22	17.54	18.95	20.07	8.91	14.82	17.59	20.73
1917	9.37	11.09	16.11	17.83	8.14	9.87	13.47	16.59	8.28	11.19	16.17	17.96
1918	5.38	8.71	11.01	18.15	6.09	8.82	11.32	16.65	7.80	11.14	13.90	20.60
1919	6.96	11.29	15.69	21.03	7.82	12.59	18.79	24.73	7.91	12.24	17.41	23.15
1920	9.84	12.55	15.36	19.51	11.09	13.94	16.87	18.94	10.58	15.41	19.73	26.01
1921	6.41	13.77	15.76	17.78	6.89	11.64	14.18	15.42	6.85	11.77	13.96	17.44
1922	12.89	16.99	22.54	25.63	10.48	14.61	23.99	25.85	11.82	16.64	22.11	24.86
1923	4.44	7.13	9.19	10.58	3.99	6.35	7.96	10.51	5.47	8.38	10.58	13.43
1924	5.05	7.39	12.60	17.75	5.31	6.26	12.76	17.78	7.03	8.24	13.44	18.08
1925	6.20	10.27	12.53	15.96	5.27	7.92	10.40	13.24	6.81	13.35	16.21	19.56
1926	4.80	8.24	11.97	13.52	5.39	8.84	12.86	14.21	3.90	7.31	11.75	14.49
1927	6.09	10.41	18.36	21.51	6.61	10.75	21.04	24.26	7.73	12.88	20.68	22.47

TABLE V

Means and Standard Deviation Squared

X_1 = Final Yields X_2 = Condition and Rainfall X_3 = Trend

Date	X_2 = Condition		X_2 = Rainfall		X_1 = Final Yield	
	Mean	σ^2	Mean	σ^2	Mean	σ^2
			Maine			
July 1	89,5333	17,0215	6,4040	7,3246	228,3333	2497.0374
Aug. 1	88,4667	23,3430	10,0960	7,8200	"	"
Sept 1	82,7000	56,0267	13,7267	12,3801	"	"
Oct. 1	80,6000	167,6733	17,1520	11,9531	"	"
			New Hampshire			
July 1	86,9000	20,4067	6,3807	7,1527	136.8000	787,2267
Aug 1	89,0333	35,8548	10.2220	7.1112	"	"
Sept 1	82.2667	49.5901	13.8600	9.6845	"	"
Oct 1	77.6333	156.5540	17.4007	11.9762	"	"
			Vermont			
July 1	89.1667	8.4496	6.2353	3.2553	136.0000	739.7333
Aug. 1	91.0000	27.9333	10.1733	2.0776	"	"
Sept 1	83.0000	48.9000	13.6313	3.3532	"	"
Oct 1	79.8333	78.3942	17.1873	5.5144	"	"
			Massachusetts			
July 1	88.2333	7.6681	6.6440	5.9357	124.2667	705.7873
Aug 1	86.3333	36.1946	10.6480	8.6975	"	"
Sept 1	81.3667	37.8434	14.5673	12.5088	"	"
Oct. 1	76.8333	146.5940	17.6627	14.4383	"	"
			Rhode Island			
July 1	88.8333	14.7948	6.4225	5.2754	124.2667	642.8540
Aug 1	86.3000	38.5267	9.9613	11.4811	"	"
Sept 1	81.2333	69.9343	14.2887	20.4850	"	"
Oct 1	77.0000	188.3667	17.0307	22.6456	"	"
			Connecticut			
July 1	88.6667	14.1496	7.1400	4.8233	116.6000	599.7067
Aug 1	85.4333	58.8680	11.3447	8.1865	"	"
Sept 1	79.9667	75.7436	15.5933	12.2014	"	"
Oct 1	77.0333	141.2874	18.9940	15.8499	"	"

Mean of X_3 = 8.0 and standard deviation squared of X_3 = 18.6667 in all cases.

TABLE VI

Product Moments

Final Yields, Condition, Rainfall and Trend

X_1 = Final Yields X_2 = (Condition / Rainfall) X_3 = Trend

Date	X_2 = Condition P_{12}	P_{23}	P_{13}	X_2 = Rainfall P_{12}	P_{23}
			Maine		
July 1	13.5329	- 6.1883	100.2669	- 81.0778	- .0134
August 1	-111.2337	- 10.9669	"	- 106.9090	- 1.9627
September 1	207.7360	- 5.9333	"	- 127.0171	- 2.3429
October 1	486.4693	3.6667	"	- 122.3174	- 1.5367
			New Hampshire		
July 1	- 12.5867	.7667	60.6000	- 39.6278	.0584
August 1	36.8779	1.9336	"	- 49.4456	- .5067
September 1	57.6821	- .6003	"	- 61.9600	-1.8920
October 1	263.7645	4.3336	"	- 56.7711	- .2715
			Vermont		
July 1	- 26.4379	- 3.8336	48.3333	- 20.4348	1.7476
August 1	- 12.8333	- 4.9333	"	- 20.2615	1.4136
September 1	45.5667	1.9333	"	- 25.5395	1.0843
October 1	174.7379	18.6003	"	- 27.1382	2.0543
			Massachusetts		
July 1	1.5057	- 4.3331	28.9997	- 37.2646	.4227
August 1	2.0790	- 4.2997	"	- 53.1685	- .3653
September 1	76.1954	.3331	"	- 68.5790	.9343
October 1	259.2127	- 8.9664	"	- 80.1234	1.6171
			Rhode Island		
July 1	15.6123	- 4.4664	13.9331	- 38.2709	1.5500
August 1	54.3171	- 4.4667	"	- 68.4339	.1623
September 1	159.3726	6.4003	"	- 90.5606	4.6364
October 1	301.2641	- 1.4667	"	- 90.6569	5.5064
			Connecticut		
July 1	10.8961	- 2.0003	54.4667	- 7.6113	1.1620
August 1	- 1.1227	- 14.4331	"	- 13.0634	1.2711
September 1	69.2823	- 6.6336	"	- 22.0983	2.7076
October 1	198.4505	- 2.9331	"	- 37.7704	3.2713

Note: σ_3^2 = 18.6667 in all cases; σ_1^2 and σ_2^2 are given in other tables.

TABLE VII

Factors Influencing Potato Yields

(Coefficients of Regression, Determination, etc.)

X_1 = Final Yield X_2 = Condition (1st of month) X_3 = Trend

Condition on 1st of month	K	$b_{12.3}$	$b_{13.2}$	$d_{12.3}$	$d_{13.2}$	$R_{1.23}$	$S_{1.23}$
			Maine				
July 1	-102.67	3.12446	6.40724	.01693	.04790	.25462	48.3
August 1	473.83	-3.09622	3.55237	.13783	.02656	.40557	45.7
September 1	-420.22	4.42561	6.77813	.36318	.05067	.64719	38.1
October 1	- 35.59	2.79584	4.82224	.54468	.03605	.76206	32.4
			New Hampshire				
July 1	174.88	- .73991	3.27681	.01183	.25234	.51397	24.1
August 1	35.13	.85825	3.15752	.04020	.24306	.53222	23.8
Sept 1	11.56	1.20294	3.28511	.08814	.25288	.58397	22.8
October 1	- 10.81	1.60527	2.87375	.53785	.22122	.87125	13.8
			Vermont				
July 1	310.97	-2.15492	2.14672	.07702	.14026	.46613	24.1
August 1	115.49	- .00224	2.58869	.00004	.16914	.41131	24.8
Sept 1	46.85	.83288	2.50302	.05130	.16354	.46351	24.1
October 1	- 36.67	2.11453	.48227	.49949	.03151	.72870	18.6
			Massachusetts				
July 1	.45	1.23642	1.84056	.00264	.07563	.27941	25.5
August 1	89.90	.24880	1.61086	.00073	.06619	.25869	25.7
Sept. 1	-50.62	2.00008	1.51786	.21592	.06237	.52753	22.6
October 1	-43.03	1.91966	2.47564	.70503	.10172	.89819	11.7
			Rhode Island				
July 1	6.96	1.38031	1.07568	.03352	.02334	.23845	24.2
August 1	-17.47	1.53909	1.11470	.13004	.02416	.39268	23.3
Sept 1	-60.83	2.28219	.03605	.56579	-.00078	.75167	16.7
October 1	- 6.39	1.60614	.87261	.75269	.01891	.87841	12.1
			Connecticut				
July 1	-14.24	1.20075	3.04651	.02182	.27669	.54636	20.5
August 1	14.54	.85920	3.58219	-.00161	.32534	.56897	20.1
Sept 1	- 6.76	1.20784	3.34708	.13954	.30399	.66598	18.3
October 1	-21.27	1.46996	3.14883	.48643	.28598	.87887	11.7

TABLE V111

Factors Influencing Potato Yields
(Coefficients of Regression, Determination, etc.)

X_1 = Final Yield X_2 = Total Rainfall (1st of month) X_3 = Trend

Rainfall From May 1 to Date	K	$b_{12.3}$	$b_{13.2}$	$d_{12.3}$	$d_{13.2}$	$R_{1.23}$	$S_{1.23}$
			Maine				
July 1	256.25	-11.05943	5.36354	.35910	.21537	.75793	32.6
August 1	323.79	-12.65707	4.04168	.54190	.16229	.83916	27.6
Sept. 1	324.83	- 9.46815	4.18306	.48162	.16797	.80597	29.6
October 1	357.14	- 9.64463	4.57747	.47244	.18381	.81075	29.3
			New Hampshire				
July 1	146.59	- 5.58292	3.22918	.28104	.24856	.72775	19.2
August 1	181.14	- 6.73492	3.06362	.42302	.23584	.81170	16.4
Sept 1	197.09	- 5.88005	2.65045	.46280	.20403	.81660	16.2
October 1	192.64	- 4.66836	3.17461	.33667	.24438	.76226	18.2
			Vermont				
July 1	159.58	- 8.07321	3.34510	.22302	.21857	.66452	20.3
August 1	231.43	-12.13960	3.50859	.33251	.22925	.74950	18.0
Sept 1	228.72	- 8.61556	3.08973	.29746	.20188	.70664	19.2
October 1	215.37	- 6.13756	3.26473	.22517	.21331	.66218	20.4
			Massachusetts				
July 1	153.19	- 6.39900	1.69846	.33736	.06979	.63847	20.4
August 1	177.23	- 6.05259	1.43511	.45595	.05397	.71758	18.5
Sept 1	191.45	- 5.61950	1.33428	.54603	.07537	.73829	16.4
October 1	209.91	- 5.77944	2.05423	.65610	.08441	.86053	13.5
			Rhode Island				
July 1	162.41	- 7.66083	1.33254	.45607	.02996	.69716	18.2
August 1	177.37	- 5.97186	.79834	.63572	.01730	.80810	14.9
Sept 1	178.12	- 4.86315	1.95431	.68509	.04236	.85291	13.2
October 1	184.43	- 4.50814	2.07625	.63575	.04500	.82508	14.3
			Connecticut				
July 1	108.64	- 2.31571	3.06201	.02939	.27810	.55452	20.4
August 1	115.62	- 2.07069	3.05886	.04511	.27781	.56826	20.2
Sept 1	129.92	- 2.54044	3.28634	.07630	.29847	.61218	19.4
October 1	147.74	- 3.09725	3.46064	.19507	.31430	.71370	17.1

TABLE IX

Monthly Rainfall by Stations in Maine 1913 - 1928

Years	May					June				
	Van Buren	Presque Isle	Houlton	Orono of Oldtown	Lewiston	Van Buren	Presque Isle	Houlton	Orono of Oldtown	Lewiston
1913	3.86	3.53	1.83	3.15	4.22	2.37	1.20	1.21	1.38	1.20
1914	2.19	2.74	1.20	1.58	2.44	5.15	4.80	4.05	3.92	2.92
1915	5.14	4.05	4.19	4.97	1.81	1.08	1.95	1.32	2.47	1.89
1916	4.85	3.44	1.09	4.42	6.46	2.25	2.17	2.62	4.99	4.65
1917	2.18	3.90	1.90	4.43	2.88	7.86	7.67	6.91	7.92	11.16
1918	3.57	4.00	.39	1.97	2.55	5.41	3.74	2.00	2.54	3.83
1919	2.55	3.32	3.26	4.43	4.78	3.08	1.26	1.87	1.19	.93
1920	1.26	.91	.48	2.01	2.04	2.81	6.08	.60	2.14	2.19
1921	.86	1.63	1.43	.88	1.87	2.02	1.58	1.36	1.12	2.47
1922	1.94	1.55	1.50	1.99	5.69	10.45	11.10	8.30	10.05	8.71
1923	2.40	1.58	.90	1.78	2.01	.77	.82	1.20	2.64	2.43
1924	4.03	3.03	2.34	3.63	6.12	2.28	.76	1.28	2.57	1.21
1925	2.15	2.32	1.29	1.91	1.52	2.51	3.21	5.64	4.39	5.02
1926	2.32	1.86	3.07	1.92	1.45	2.70	1.84	2.08	2.87	2.45
1927	3.65	2.08	5.00	4.60	5.35	4.43	3.42	3.36	3.05	2.39
1928	3.57	5.59	2.19	4.16	4.87	3.12	3.06	2.42	2.73	2.84

Years	July					August				
	Van Buren	Presque Isle	Houlton	Orono or Oldtown	Lewiston	Van Buren	Presque Isle	Houlton	Orono or Oldtown	Lewiston
1913	3.53	5.18	1.64	5.86	1.53	2.71	3.01	1.70	3.15	2.27
1914	2.63	2.23	1.31	2.84	3.00	4.16	2.35	1.01	3.05	4.54
1915	4.36	3.40	4.03	6.67	9.52	2.99	3.50	2.17	4.67	4.25
1916	7.36	3.68	4.32	4.39	3.35	1.69	1.70	1.57	2.27	2.69
1917	2.76	2.56	3.69	3.94	4.34	6.02	5.32	4.89	3.26	4.45
1918	3.73	6.78	2.86	6.44	6.86	.71	1.62	1.51	2.42	4.95
1919	3.82	3.80	1.57	5.23	2.85	2.08	1.75	.46	1.61	1.94
1920	4.53	4.28	3.00	4.46	3.58	4.28	3.62	2.91	2.48	2.71
1921	3.15	2.49	2.32	1.80	1.68	5.32	5.43	4.29	2.90	2.38
1922	2.19	1.50	2.20	2.91	3.33	4.23	3.88	5.65	6.64	3.00
1923	2.23	4.32	3.65	3.86	4.12	3.23	2.33	2.80	1.65	.98
1924	2.90	2.09	1.44	2.31	2.59	4.79	3.07	2.70	4.15	5.25
1925	2.97	2.45	2.09	3.42	4.59	2.86	3.09	2.20	1.31	.62
1926	2.09	2.10	2.79	5.13	2.71	3.97	3.71	3.96	4.13	1.93
1927	6.15	2.94	5.39	2.08	3.10	4.46	5.25	5.99	4.21	3.85
1928	4.91	4.62	2.70	2.37	3.43	3.19	3.30	3.74	4.04	3.84

TABLE 1X (Continued)

Monthly Rainfall by Stations in Maine 1913 - 1928

Years	September					September 1 to September 15				
	Van Buren	Presque Isle	Houlton	Orono or Oldtown	Lewiston	Van Buren	Presque Isle	Houlton	Orono or Oldtown	Lewiston
1913	2.72	2.01	2.10	a 4.42	4.02	.79	.32	.20	a 2.73	.49
1914	4.07	2.10	1.35	a 3.03	0.53	2.47	1.45	1.03	a .79	.32
1915	4.75	3.25	2.37	a 1.19	1.13	1.49	.60	.37	a .08	.13
1916	3.33	4.04	1.42	a 4.60	2.99	1.66	2.29	.80	a 1.94	1.69
1917	1.77	1.41	1.97	1.44	0.62	.88	.71	.07	.84	.20
1918	4.53	4.70	5.15	6.38	7.70	1.80	1.72	1.75	2.40	1.33
1919	4.64	4.56	4.48	3.97	4.65	3.98	3.91	3.84	3.15	3.91
1920	5.50	5.21	7.96	5.21	9.27	4.36	4.02	5.60	3.83	4.01
1921	3.55	3.15	2.35	2.52	2.33	1.73	1.77	1.14	.86	.97
1922	0.78	1.05	.65	2.50	2.01	.54	.52	.10	1.34	1.21
1923	2.54	2.98	2.48	a 2.15	3.07	.77	1.01	.84	a 2.46	1.44
1924	2.84	3.34	3.59	3.51	5.81	1.50	2.42	2.96	2.70	4.23
1925	3.97	4.18	4.75	7.14	4.85	1.93	2.26	3.06	3.77	2.86
1926	4.00	3.30	3.18	4.15	2.92	2.69	1.97	1.41	1.72	1.22
1927	3.23	1.36	1.37	1.38	1.25	2.53	.77	.94	.75	.63

a - Orono

TABLE X

Station Data Weighted by Acreage

Years	Months						Totals May 1 to				
	May	June	July	Aug.	Sept.	Sept. 15	July 1	Aug. 1	Sept. 1	Sept. 15	Oct. 1
1913	3.38	1.37	4.21	2.75	2.91	.91	4.75	8.96	11.71	12.62	14.62
1914	2.22	4.31	2.40	2.85	2.21	1.23	6.53	8.93	11.78	13.01	13.99
1915	4.08	1.86	5.01	3.60	2.66	.52	5.94	10.95	14.55	15.07	17.21
1916	3.84	3.04	4.29	1.90	3.59	1.87	6.88	11.17	13.07	14.94	16.66
1917	3.38	8.05	3.17	4.92	1.44	.61	11.43	14.60	19.52	20.13	20.96
1918	2.97	3.54	5.79	1.97	5.42	1.90	6.51	12.30	14.27	16.17	19.59
1919	3.51	1.54	3.60	1.61	4.49	3.80	5.05	8.65	10.26	14.06	14.75
1920	1.16	3.95	4.09	3.36	6.04	4.26	5.11	9.20	12.56	16.82	18.60
1921	1.41	1.63	2.39	4.63	2.93	1.48	3.04	5.43	10.06	11.54	12.99
1922	2.03	10.25	2.06	4.48	1.25	.64	12.28	14.34	18.82	19.46	20.07
1923	1.66	1.25	3.85	2.32	2.74	1.19	2.91	6.76	9.08	10.27	11.82
1924	3.40	1.34	2.18	3.58	3.53	2.55	4.74	6.92	10.50	13.05	14.03
1925	2.03	3.76	2.78	2.49	4.70	2.89	5.79	8.57	11.06	13.95	15.76
1926	2.07	2.19	2.67	3.70	3.47	1.90	4.26	6.93	10.63	12.53	14.10
1927	3.32	3.42	3.62	4.99	1.62	1.03	6.74	10.36	15.35	16.38	16.97

TABLE XI

Maine Rainfall (Station Data) Trend and Yields

	Mean	σ^2	P_{12}	P_{23}	P_{13}
Str. Totals					
July 1	6.1307	6.4502	- 86.5737	- 1.6689	100.2669
Aug.1	9.6047	6.8240	- 112.1428	- 3.5843	"
Sept.1	12.8813	9.0147	- 117.0357	- 2.1044	"
Oct. 1	16.1413	6.9973	- 111.2703	- 1.9251	"
(a) Wt'd Totals					
Aug. 1	13.0787	9.4260	- 137.7120	- 5.4996	"
Sept.1	16.3553	10.6565	- 142.6049	- 4.0197	"
Oct. 1	19.6153	9.7266	- 136.8395	- 3.8404	"
Aug. 1 to Sept. 15	5.0620	1.3167	4.9261	2.5680	"

	K	$b_{12.3}$	$b_{13.2}$	$d_{12.3}$	$d_{13.2}$	$R_{1.23}$	$S_{1.23}$
Str.Totals							
July 1	269.68	-12.317001	4.270229	.427037	.171468	.773631	31.7
Aug 1	354.02	-15.139124	2.464475	.679903	.098959	.882532	23.5
Sept 1	351.39	-12.045858	4.013447	.564527	.161157	.851906	26.2
Oct 1	437.23	-14.845312	3.840426	.661521	.154210	.903178	21.4
(a) Wt'd Totals							
Aug 1	399.27	-13.857980	1.288582	.764270	.051642	.903280	21.4
Sept 1	439.02	-13.381964	1.022176	.705863	.108813	.902594	21.5
Oct 1	461.84	-13.004100	2.696025	.712634	.108257	.906030	21.1
(b) Early and Late Rainfall							
May to July X_2	(-12.897356			.711291)			
with	438.48				.117854	.896567	22.1
Aug to Sept 15, X_3		-12.830652	2.935037	-.025312)			
Trend X_4							

(a) Weighted on basis of May - 1, June - 1, July - 2, Aug. - 1, and September -1.
(b) Three independent factors; Rainfall May 1 to July 31 = X_1, August 1 to September 15 = X_2, and trend = X_3

Note: Mean of yields X_1 = 228.3333; σ^2 of X_1 = 2497.0374; mean of trend X_3 = 8.0; σ^2 of trend = 18.6667.

TABLE XII

Summary of Results

(a) Studies of State Average Data

Months	Standard Errors of Estimates (In Bushels)					Coefficients of Correlation		
	σ of Yields	Actual Forecasts 1914 to 1927	Estimates From Condition and Trend	Estimates From State Average Rainfall and Trend: Str. Line	Estimates From State Average Rainfall and Trend: Curve	Condition and Trend	State Average Rainfall and Trend: Str. Line	State Average Rainfall and Trend: Curve
Maine								
July 1	50.0	51.6	48.3	32.6		.255	.758	
Aug 1	50.0	56.7	45.7	27.6	22.8	.406	.839	.890
Sept 1	50.0	41.3	38.1	29.6		.647	.806	
Oct 1	50.0	24.2	32.4	29.3		.762	.811	
New Hampshire								
July 1	28.1	29.8	24.1	19.2		.514	.728	
Aug 1	28.1	29.5	23.8	16.4	13.9	.532	.812	.869
Sept 1	28.1	26.2	22.8	16.2		.584	.817	
Oct 1	28.1	15.4	13.8	18.2		.871	.762	
Vermont								
July 1	27.2	30.4	24.1	20.3		.466	.664	
Aug 1	27.2	31.1	24.8	18.0	9.9	.411	.750	.931
Sept 1	27.2	27.4	24.1	19.2		.464	.707	
Oct 1	27.2	20.0	18.6	20.4		.729	.662	
Massachusetts								
July 1	26.6	29.3	25.5	20.4		.279	.638	
Aug 1	26.6	31.6	25.7	18.5	14.2	.259	.718	.845
Sept 1	26.6	26.4	22.6	16.4		.528	.788	
Oct 1	26.6	16.0	11.7	13.5		.898	.861	
Rhode Island								
July 1	25.4	29.7	24.2	18.2		.238	.697	
Aug 1	25.4	29.1	23.3	14.9	13.2	.393	.808	.853
Sept 1	25.4	19.2	16.7	13.2		.752	.853	
Oct 1	25.4	12.3	12.1	14.3		.878	.825	
Connecticut								
July 1	24.5	27.4	20.5	20.4		.546	.555	
Aug 1	24.5	29.6	20.1	20.2	14.9	.569	.568	.792
Sept 1	24.5	24.7	18.3	19.4		.666	.612	
Oct 1	24.5	19.6	11.7	17.1		.879	.714	

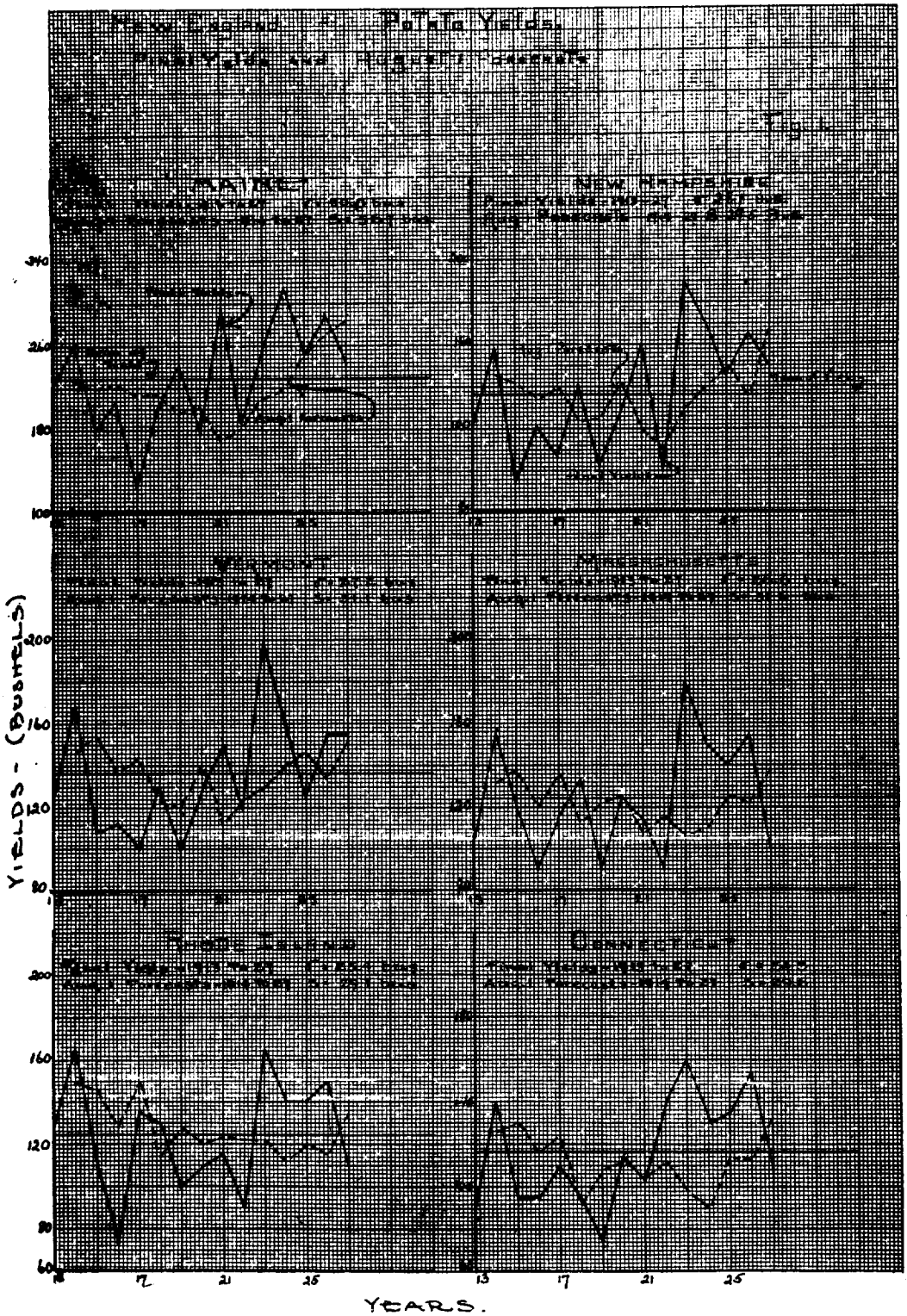
TABLE XII (cont'd)

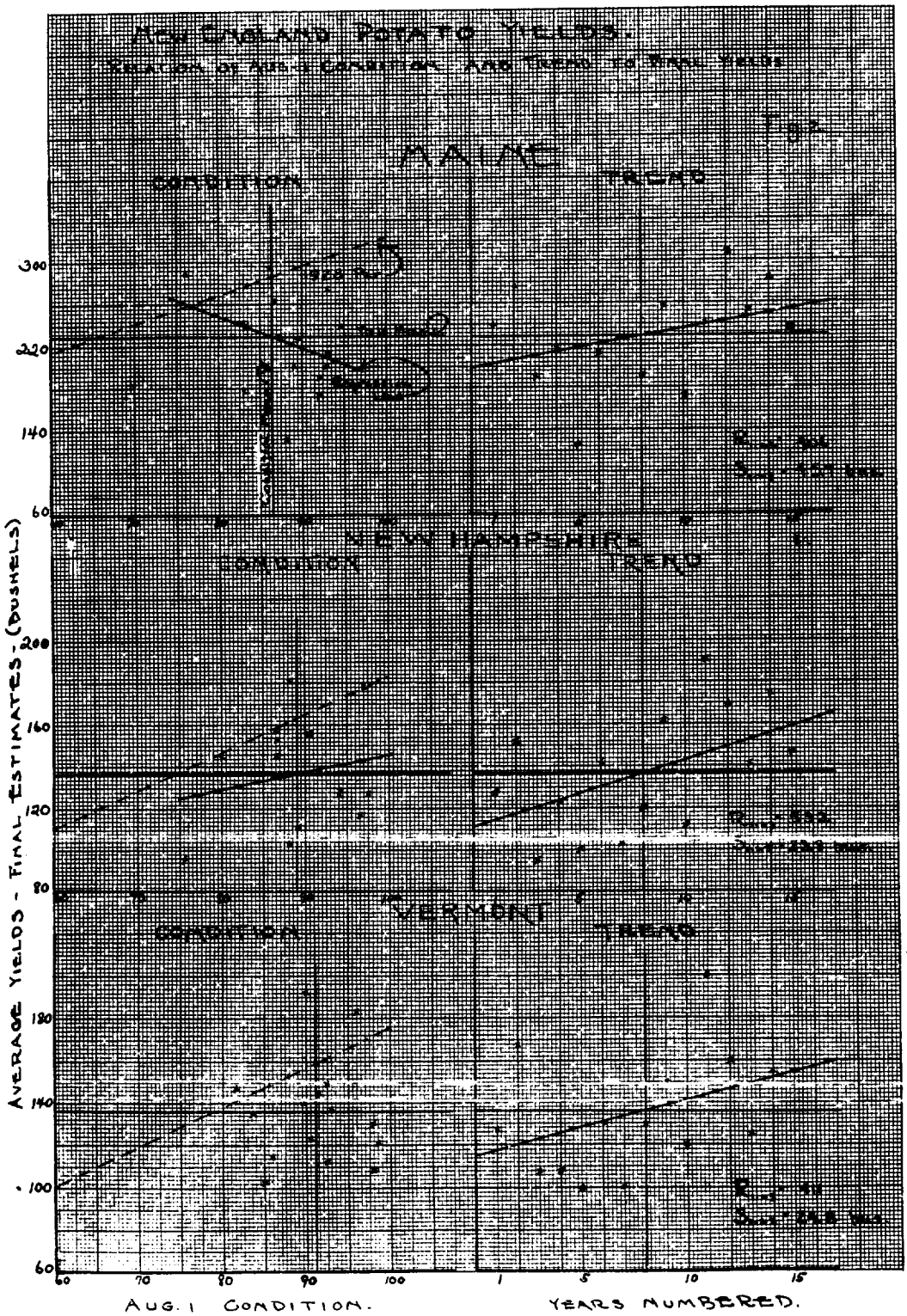
Summary of Results

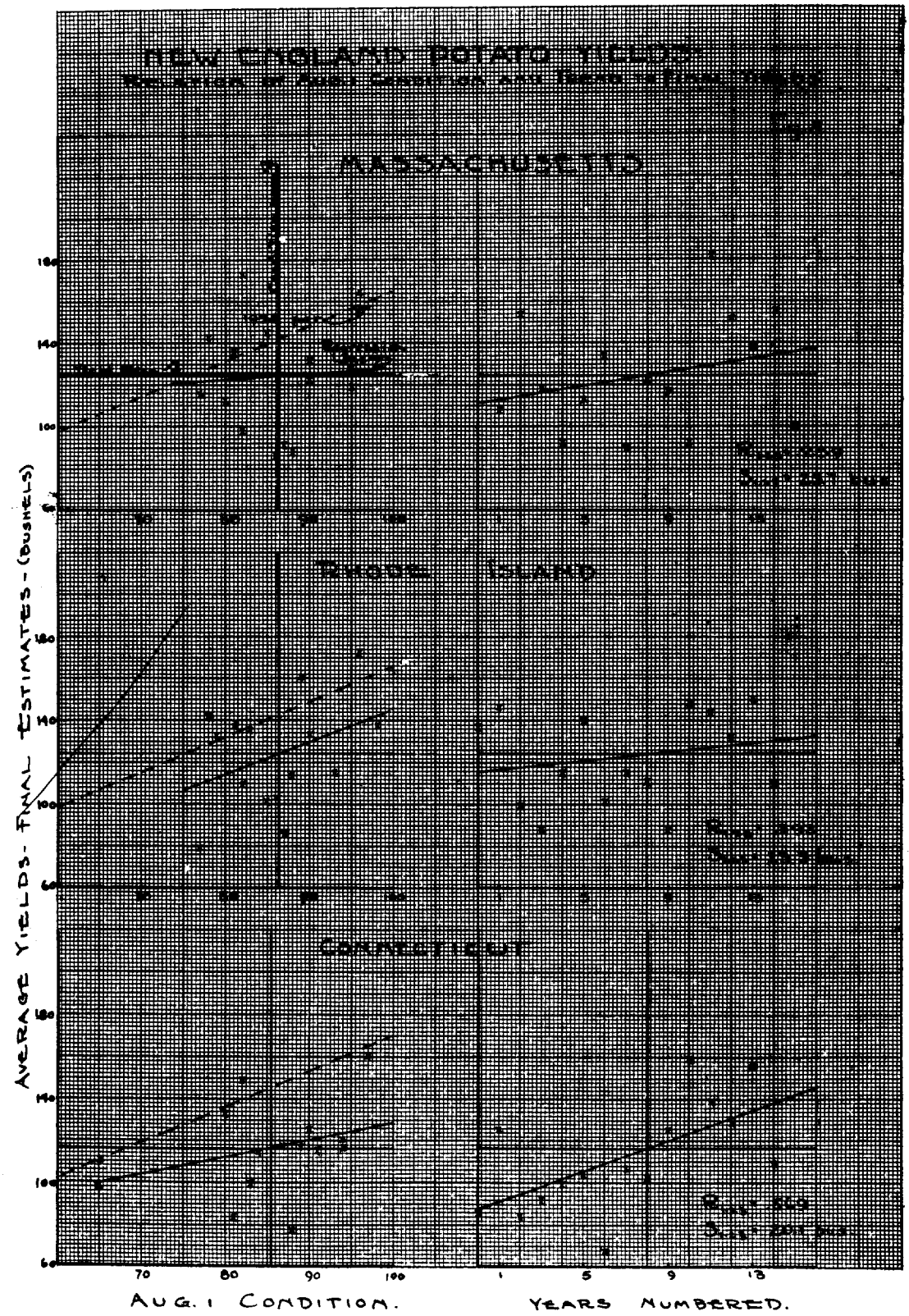
(b) Studies of Maine Station Data

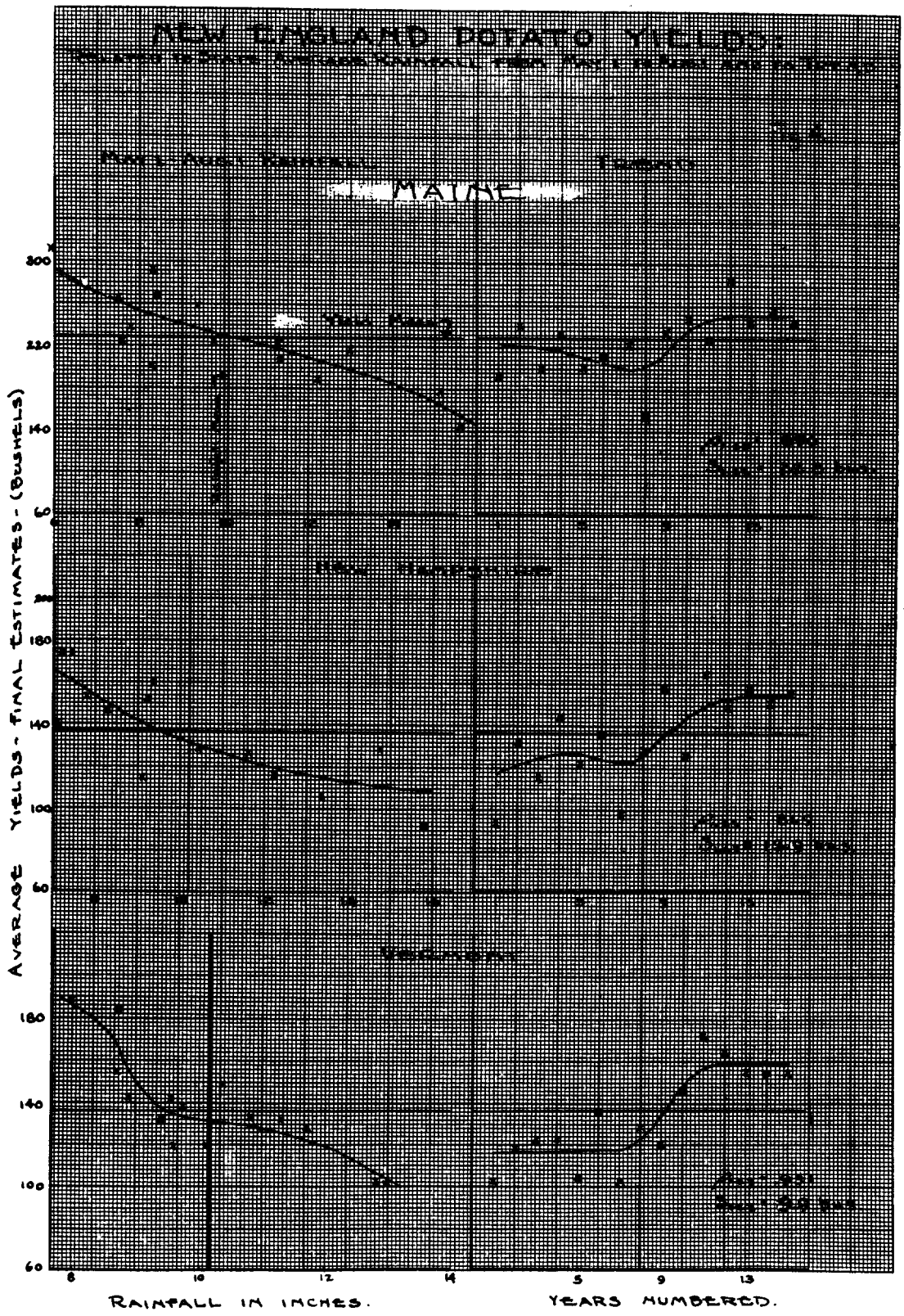
From Station Rainfall Data Weighted by Acreage

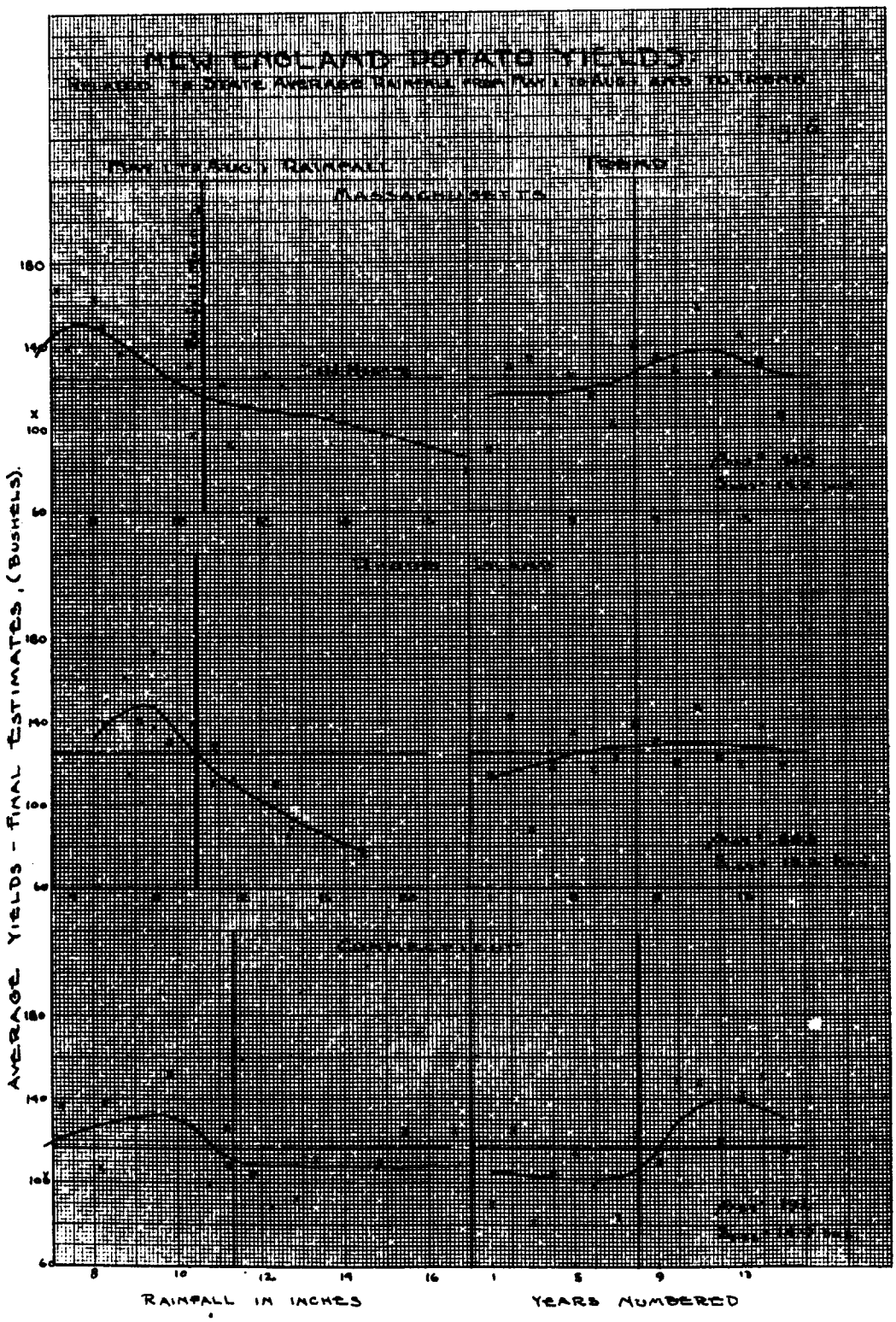
	Standard Error of Estimate		Coefficient of Correlation	
	Str. Line	Curve	Str. Line	Curve
Rainfall May 1 to July 1 and Trend	31.7		.774	
Rainfall May 1 to Aug. 1 and Trend	23.5	19.5	.883	.921
Rainfall May 1 to Sept. 1 and Trend	26.2		.852	
Rainfall May 1 to Oct. 1 and Trend	21.4		.903	
Doubling July Rainfall Data				
Rainfall April 1 to Aug. 1 and Trend	20.1	19.1	.916	.923
Rainfall May 1 to Aug. 1 and Trend	21.4	17.5	.903	.937
Rainfall May 1 to Sept.1 and Trend	21.5		.903	
Rainfall May 1 to Oct. 1 and Trend	21.1		.906	
Joint Relationship - May 1 to July 31 and Aug. 1 to Sept. 30 Rainfall - Three Dimension Correlation	-	8.1	-	.985

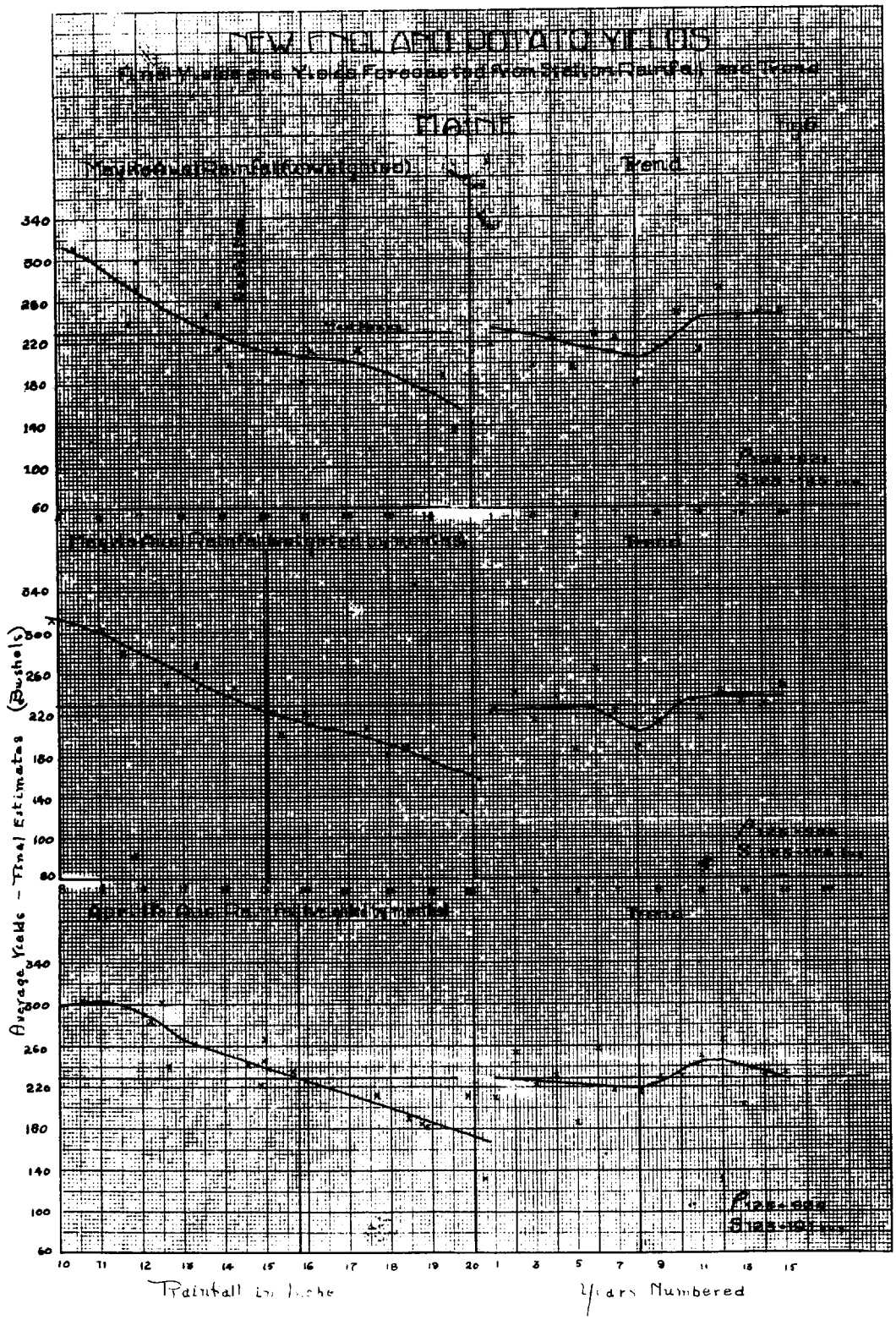

New England
Potato Yields
Fig. 1
Maine
New Hampshire
Vermont
Massachusetts
Connecticut
YIELDS - (BUSHELS)
YEARS.

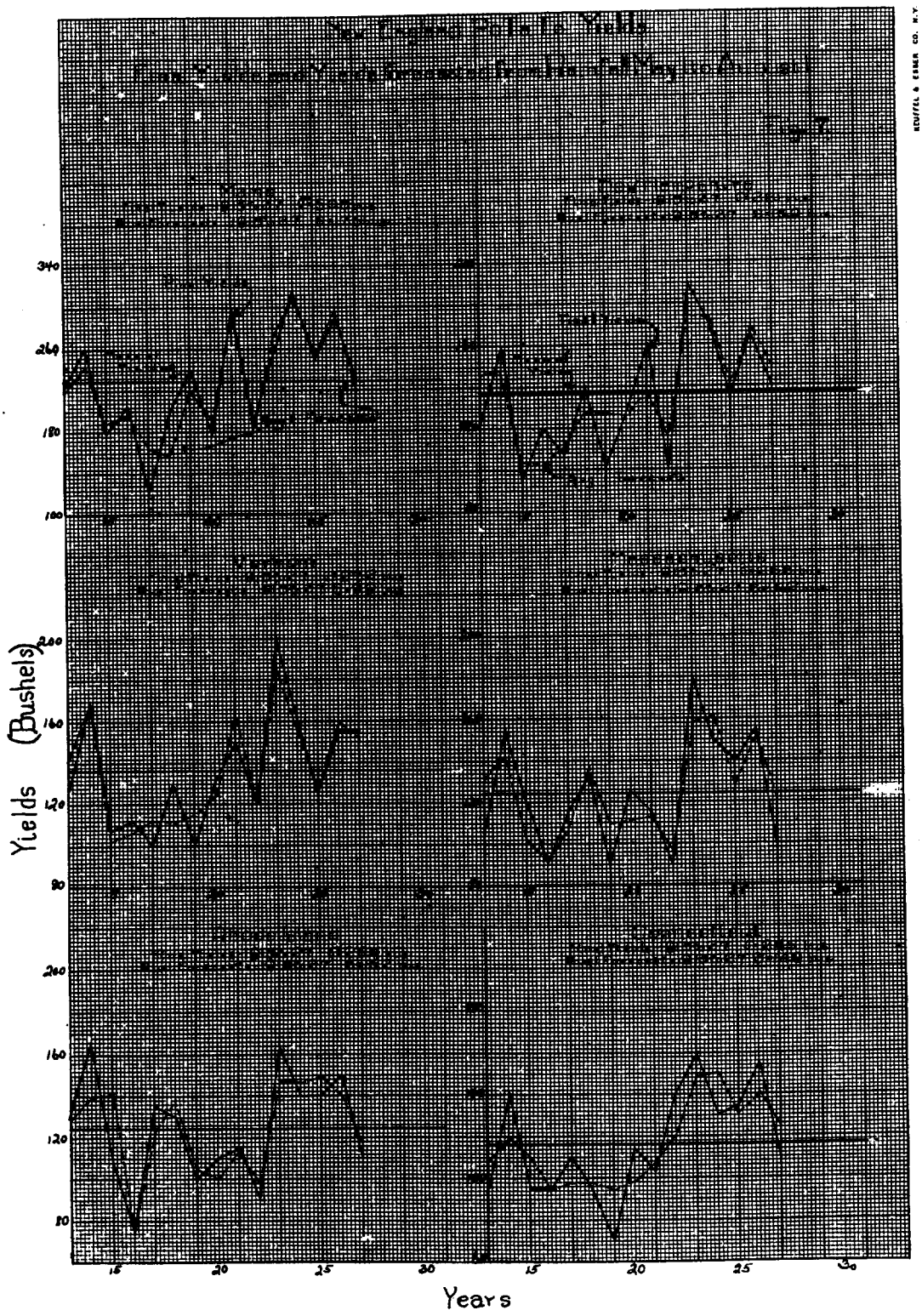

NEW ENGLAND POTATO YIELDS.
RELATION OF AUG. 1 CONDITION AND TREND TO FINAL YIELDS
MAINE
CONDITION
TREND
NEW HAMPSHIRE
CONDITION
TREND
VERMONT
CONDITION
TREND
AVERAGE YIELDS - FINAL ESTIMATES - (BUSHELS)
AUG. 1 CONDITION.
YEARS NUMBERED.
300
220
140
60
200
160
120
80
180
140
100
60
60
70
80
90
100
1
5
10
15

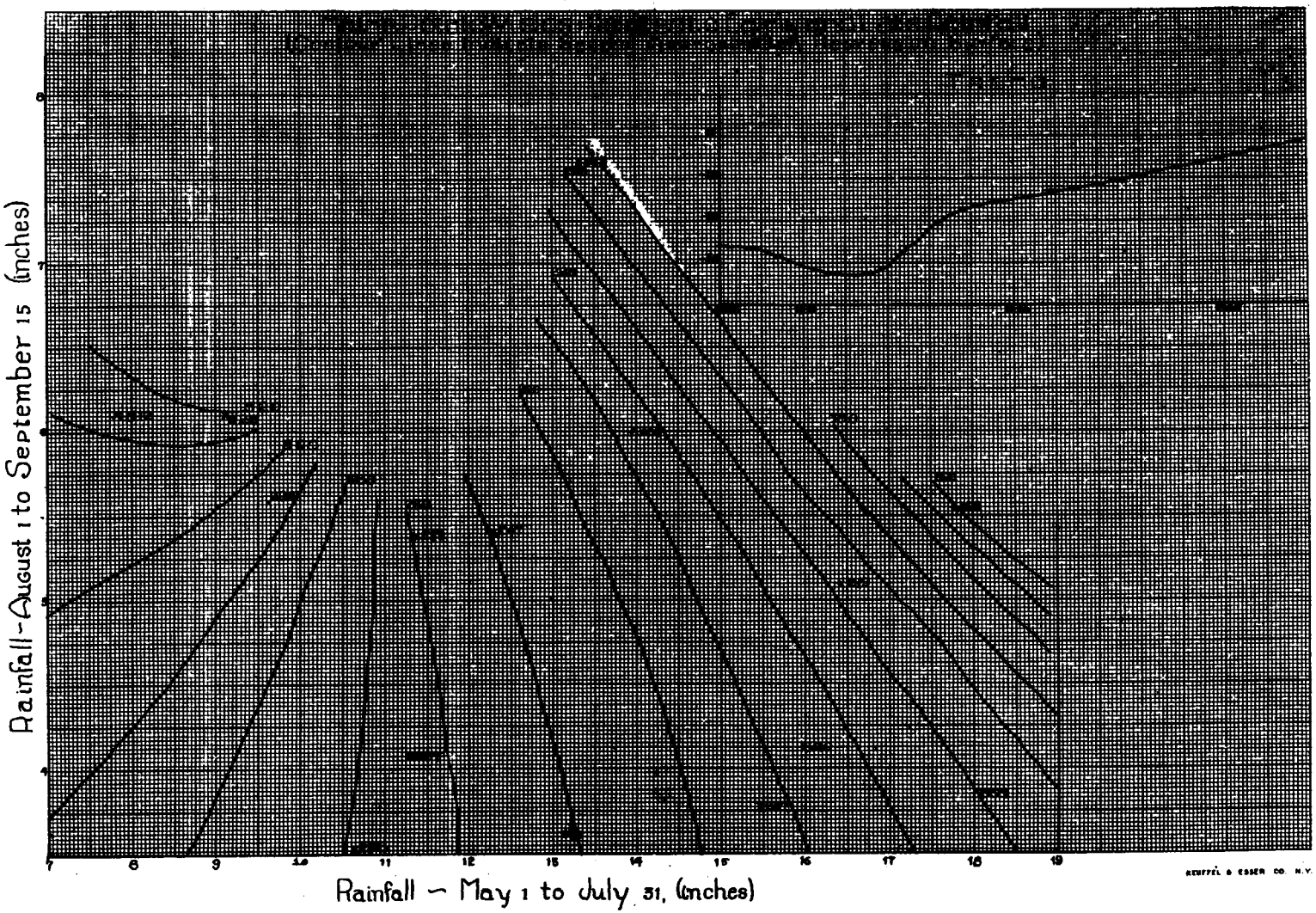

NEW ENGLAND POTATO YIELDS
MASSACHUSETTS
RHODE ISLAND
CONNECTICUT
AVERAGE YIELDS - FINAL ESTIMATES - (BUSHELS)
AUG. 1 CONDITION.
YEARS NUMBERED.


NEW ENGLAND POTATO YIELDS.
MAINE
AVERAGE YIELDS - FINAL ESTIMATES - (BUSHELS)
RAINFALL IN INCHES.
YEARS NUMBERED.


NEW ENGLAND POTATO YIELDS
AVERAGE YIELDS - FINAL ESTIMATES, (BUSHELS).
RAINFALL IN INCHES
YEARS NUMBERED


NEW ENGLAND POTATO YIELDS
Final Yields and Yields Forecasted from Station Rainfall and Trend
MAINE
Fig 6
Trend
Trend
Trend
Trend
Average Yields - Final Estimates (Bushels)
Rainfall in Inches
Years Numbered


Yields (Bushels)
340
260
180
100
200
160
120
80
240
160
120
80
15
20
25
30
15
20
25
30
Years


Rainfall-August 1 to September 15 (inches)
Rainfall – May 1 to July 31, (inches)
7
8
9
10
11
12
13
14
15
16
17
18
19