A STUDY OF THE RELATIONSHIP OF MONTHLY GOVERNMENT CONDITION FIGURES TO YIELDS, ABANDONMENT, AND PRODUCTION OF WINTER WHEAT AND THE ACCURACY OF GOVERNMENT AND PRIVATE FORECASTS OF WINTER WHEAT PRODUCTION

by

CHARLES PEAIRS WILSON

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TABLE OF CONTENTS

INTRODUCTION

Forecasts of future crop production are useful to many people. Information as to the probable total quantity of grain to be marketed is of vital importance to farmers, business men, and those providing marketing services for these groups. With this information, farmers are in a better position to judge the time to market, the quantity to market, and the probable income they will receive from their crop. Millers and elevator operators use the forecasts in planning their operations. Railroads use the information to determine the approximate number of cars necessary to move the crop. Crop forecasts are useful to bankers in estimating the loans they will be called upon to furnish for harvesting and marketing the crop. Those business men who sell goods and services to farmers and others in agricultural communities use crop forecasts to get an idea of the probable demand for their products and services. Prospects of production are one of the principal factors affecting grain prices as the harvest season approaches. Those individuals making price forecasts for farmers or for private industry find crop forecasts of great assistance to them in their work. To produce and market grain efficiently, crop forecasts are indispensable.

Crop forecasts are made by two types of agencies. First, are those individuals employed by private business enterprises to collect information on crop condition and to forecast production. Second, is the government crop reporting service. The forecasts of both agencies are regularly published in grain trade papers. The government forecasts are also published in various governmental publications.

In considering crop forecasts, it is important to realize that the extent to which future conditions will affect yields is not known. A forecast usually is made on the basis of conditions existing at the time the forecast is made. Normal conditions are assumed for the future. But normal conditions are not always the case, and any deviation from normal will add to or subtract from prospects as they were at the time the forecast was made. The earlier in the season a forecast is made, the greater is the possibility for improvement or deterioration of a crop. But even after the crop has reached maturity, unfavorable weather may cause the loss of a portion of the crop or favorable weather may enable farmers to save a larger proportion of the crop than usual. Even though existing conditions are accurately interpreted, changes in conditions affecting the crop can easily cause relatively large errors in crop forecasts.

Accuracy, of course, is of primary importance in any forecast and is the goal of those making crop forecasts. In making accurate forecasts, two problems are involvod. First is the problem of accuratoly estimating the acreage; and second is the problom of accurately forecasting yiolds. Yield multiplied by acreage indicates total production, which is the important factor so far as the market is concerned.

Condition figures, as reported by crop correspondents, are used by the government crop reporting service as a basis for forecasting yields and, to some extent, in estimating abandonment and indirectly in forecasting total production. Most persons using crop forecasts have little basis for judging the degree of accuracy that has been attained. If the degree of accuracy of forecasts in the past is known, those persons using crop forecasts should be in a better position to interpret and use this type of information intelligently in the future.

The purpose of this study was twofold: (1) To determine the relationship of government condition figures to yields, abandonment, and production of winter wheat in the United States and in Kansas; and (2) to determine the accuracy of government forecasts of winter wheat production in the United States and in Kansas, of private forecasts of winter wheat production in the United States, and of forecasts of winter wheat production in Kansas based on fall rainfall.

REVIEW OF LITERATURE

Most of the information published in regard to crop forecasts is a description of the methods used by the government crop reporting service. A few studies of the relative accuracy of government and private forecasts have been made. Little has been published on the relationship of government condition figures to yields or on the measurement of the accuracy of forecasts.

The importance of accuracy was emphasized by most writers concerned with orop forecasts. "The nearest approach to accuracy attainable is the goal of the Crop Reporting Service," is a statement from Miscellaneous Publication No. 171 (5). Clark and Weld (4) stated, in referring to crop reports, "It is, consequently, important that the information which is dispersed shall be accurate." Schoenfeld (25) stated that "To be of value to those interested in a certain crop, estimates and forecasts of production must be accurate in addition to being honestly and efficiently prepared."

Government forecasts of crop production are based largely on condition as reported by voluntary crop reporters. "During the growing season forecasts of the probable yield per acre are made on the basis of the condition of the crop in percent of normal, actually on appearance, as reported by the regular crop correspondents. The relationship of condition to final yield per acre as a basis of forecasting is supplemented by weather and yield relationships," according to Sarle (21). Becker and Harlan (2) stated, "The studies that have been carried on during this period (referring to the period 1930-39) have shown the need of monthly estimates of probable abandonment as a factor influencing the current forecast of production, particularly since reporters, after several months, tend to forget the loss of planted acreage and tend to confine their reports of condition and yield per acre to the acreage remaining for harvest or actually harvested. In recent years, through the use of reported condition, including the reports of failure, it has been possible to approximate the probable abandonment and to prepare forecasts of yield per acre that carry an allowance for this important factor."

In the description of the government crop reporting service in Miscellaneous Publication No. 171 (5), some of the characteristics of condition figures were discussed.

"The crop reporters are asked to report on the condition of the growing crop in percentage of a normal or full crop... The normal may be described as a condition of perfect healthfulness, unimpaired by drouth, hail, insects or other injurious agency and with such growth and development as may be reasonably looked for under these favorable conditions.

"...it has been found that the crop reporter does have a well defined judgment of what constitutes a normal for his locality. Representing the mass judgment of a multitude of observers, it adjusts itself to any actual trends as might arise from the development of improved strains of higher yielding seed or the introduction of plant pests like the bollweevil." In the same publication it was pointed out that the same condition in two different areas does not indicate the same yield. A normal yield for one area is not a normal yield for another. Neither does the same condition in the same area in two different months indicate the same yield. There seems to be a tendency for the condition figure, on the average, to decline as the season progresses.

In presenting an example of the type of material and method used by the government crop reporting service, the relationship of condition to yields of corn in Minnesota was discussed. Dot charts of the relationship were shown with regression lines plotted and the coefficients of correlation indicated. The following data were taken from those charts.

Table 1. The coefficient of correlation for monthly condition figures and yields of corn in Minnesota for the periods 1920-1929 and 1899-1930 (5).

Factors		Coefficient of correlation	
X	Y	1920-1929	1899-1930
July 1 condition and yield		+.765	+.554
August 1 condition and yield		+.866	+.684
September 1 condition and yield		+.848	+.596
October 1 condition and yield		+.963	+.770

In regard to these figures it was stated, "Condition and yield data for corn in Minnesota have been selected not to show the best or worst examples of the data from which forecasts of yield must be made but rather a fair sample of a moderately good relationship between condition and yield."

In the same publication it was stated that the coefficient of correlation for condition on September 1 to corn yield in Kansas for a period of 25 years was +.984.

"The accuracy of forecasts made early in the season must necessarily be judged by the crop prospects at that time rather than by the harvest three or four months later."

The following statement also appeared. "The fundamental problem and duty of the crop reporting board is to make as accurate a forecast of what the final yield per acre is most likely to be as is humanly possible at that time of season." These statements hardly seem compatable. If the purpose is to forecast final yield, then it would seem that that is the standard by which accuracy should be measured.

Schoenfeld (25) made a study of the accuracy of government and private forecasts of cotton production. For private forecasts, he used an average of several private forecasts. He compared the percentage error of the government forecasts each year with the percentage error of the average of private forecasts. Table 2 was taken from his study.

He concluded that "It will be seen that on the whole government forecasts more nearly approximate final ginnings than do private forecasts. If one were to examine the forecasts of certain private agencies, it would be seen that they are as accurate as those of the government. The averages of all private agencies are, however, pulled down by agencies whose forecasting organizations are limited and methods employed empirical."

Clark and Weld (4) stated that "News gathered by the government is not always so timely as that obtained by large

Table 2. United States government and private agency cotton production forecasts* - Percentage relation of December 1 forecast/1 to final ginnings/2.

Crop year	Government forecast	Averages of private forecasts
1915	-0.3	+2.6
1916	+0.5	-0.1
1917	-3.2	-4.2
1918	-2.8	-3.9
1919	-3.4	-8.2
1920	-3.4	-6.1
1921	+4.8	-0.4
1922	+2.0	+0.9
1923	-0.6	-3.7
1924	-3.5	-3.3
1925	-3.2	-4.5

* Sources: Commerce and Finance, New York. Pearsell's News Bureau, New York, and Cotton Gazette, London.

/1 As issued by the U.S. Dept. Agr. in December.

/2 As reported by the U.S. Dept. Comm. in March following harvest of crop.

individual firms, so that these are often in possession of essential facts somo time before those who depend on the government. On the other hand, news gathered by governments is likely to be much more extensive and accurate. This is partly due to the greater resources which may be made available to cover the expense involved, and sometimes, due to a feeling that governmental agencies are disinterested, to the greater spirit of cooperation which is likely to prevail among those with facts to contribute."

Schoenfeld (25) quoted the following statements from a study of the accuracy of government and private forecasts of cotton production which was made by the Chamber of Commerce of the United States. "There is no way of determining whether the government or private forecasts more accurately reflected actual conditions during the growing season, although the magnitude of the governmental statistical organization would seem to give an advantage to the latter's forecast. Some of the private forecasting agencies have good records but none of them surpassed the record of the Department of Agriculture in its December estimates for the 10 year period."

Some of the shortcomings of the present method of forecasting were recognized. King (15) stated that "The present methods of estimating and forecasting are not fully satisfactory; first, because we must depend on the returns from volunteer crop correspondents rather than on samples selected according to rigid specifications and, second, because the observations themselves are highly subjective in that the statements of the farmer may be both inaccurate and biased." According to Sarle (22), "The extent to which crop yields can be predicted is definitely limited but the reported condition of a crop serves as a fairly adequate basis for such a forecast. Naturally the late season forecasts are usually more accurate than are early season forecasts, and the condition figure is a much more satisfactory measure of the probable yield per acre for some crops than it is for other crops...One of the fundamental difficulties in using the reported condition of the crop as a basis of forecasting yield lies in the subjective nature of the sample data."

Schoenfeld (25) said that "Early in the season estimates of production must assume that weather will continue normal until the end of the growing season."

Sarle (22) mentioned that the crop is always subject to improvement or deterioration due to weather, insects and diseases. Consequently, early season condition figures may not be satisfactory as a basis for actual forecasting. He also stated that "...the reported condition as of the first of a particular month may not reflect the full influence of weather that has prevailed up to that time. A deficiency of subsoil moisture accompanied by adequate surface soil moisture may give a temporary high condition for a crop at a given date. If rains are ample and well distributed, a good yield may result, but normal or light rains may not furnish sufficient moisture to carry the crop through to good yield."

Sarle (22) continued with "The reported condition or appearance of the growing crop apparently tends to reflect the vegetative more than the reproductive aspects of the cotton plant."

He suggested methods of improving crop yield forecasts. "If accurate forecasts of yield per acre are to be made early in the season it will be necessary (1) to know the relationship between weather and yield per acre and (2) to know how to forecast the weather or at least the extremes of weather several months in advance...Obviously it is essential that more precise methods be developed for forecasting yield per acre in advance of harvest. The experience gained in making boll counts on cotton and the results obtained in studies of the relationship of yields to weather indicate three lines of development: (1) methods involving the use of weather data along with condition in forecasting yield, (2) methods based on the relation of yield to structural counts and measurements of plant characteristics associated with yield from representative samples of the growing crops and (3) methods involving the use of the direct and indirect influence of weather on crop yields."

Sarle (24) commented on attempts to forecast yields from weather data: "In a number of states, studies of the relationship of weather factors to yield per acre of several important crops have been made. In these studies monthly averages of weather data and average yields for the entire state were used. Although some of these studies have shown a high relationship for the period of years covered, the forecasting formulas developed seldom have proved satisfactory when actually used for predicting in seasons not included in the original study."

Several studies of the relationship of moisture to wheat production in the southern Great Plains area, particularly in central and western Kansas have been made. Call and Hallsted (3) stated, "In western Kansas moisture is the limiting factor in production of wheat." Their data were obtained from experimental plots at Hays, Kansas, for the years 1910-1913, inclusive. They reported, "As an average of four years, the yield of grain secured was in direct proportion to the supply of available moisture in the soil at seeding time."

Hallsted and Coles (10) reported a close relationship between the moisture content of the upper three feet of soil at seeding time and yield of winter wheat at Hays, Kansas. Measurements of soil moisture were taken between September 15 and October 1 for the period 1910-1928. The coefficient of correlation between moisture content of the soil and yield of wheat following wheat in the cropping system was +.807.

Henney (13) reported a study of the relationship of winter wheat production and weather factors in 14 south central Kansas counties. As the dependent variable he used wheat production in percent of the secular trend from 1916 to 1929. Independent variables were August to October rainfall and March to June rainfall one year prior to harvest. He found an index of correlation of .9275.

A study of the relationship of winter wheat production in each of the nine crop reporting districts of Kansas was published by Henney (12). In each district, rainfall during those fall months which gave the best relationship to yield was used as the independent variable. Yield per seeded acre was used as the dependent variable. For the six western crop reporting districts, the index of correlation varied from .536 to .872.

Hallsted and Mathews (11) reported a close relationship between the depth of soil moisture at seeding time and yields of winter wheat at Hays, Garden City, and Colby, Kansas. They pointed out that the possibilities of obtaining a paying crop by seeding in dry soil were remote. As the depth of soil moisture increased, the possibilities of obtaining high yields were greater. Normal rainfall from seeding time to harvest was not sufficient to produce a crop in central and western Kansas. A reserve of moisture in the soil at seeding time usually was necessary to obtain high yields.

Mathews and Brown (17) were of the opinion that precipitation, evaporation, relative humidity, and temperature affected wheat yields in western Kansas. The interrelationship of these factors accounted for the fact that any one of them gave a high degree of relationship with yield.

Pallesen/3 determined the relationship of rainfall to yields of winter wheat in western Kansas by five-day periods beginning with the harvest of the preceding crop and continuing until the harvest of the current crop. He found that the rainfall from seeding time to December 1 was the most important in determining yields. Spring rainfall was relatively unimportant in determining final yield.

Sarle (23) made a study of the possibility of making forecasts earlier in the season of wheat yields in Canada by combining the preseason rainfall and condition. He reported, "It would appear from this investigation that reasonably dependable forecasts of yield per acre of wheat could be made for all three provinces one month earlier than the first official estimates are now being issued by the Canadian government."

Montgomery (19) suggested the possibility of using weather data for forecasting purposes. "When more information is obtained about the relationship between moisture in the soil at seeding, and yield under field conditions, and when data become more complete and cover a longer period of years, it is probable that for areas similar to Western Kansas forecasts of production on a statistical basis will

/3 Pallesen, J. E. Unpublished; Influence of the amount and distribution of seasonal rainfall on winter wheat plot yields, 1939.

be used to supplement the present observational methods of crop forecasting. Statistical forecasts for winter wheat give promise of providing an indication of production early in the season before the observational method can be applied."

SCOPE AND METHOD OF PROCEDURE

This study was limited to winter wheat crop forecasts for the United States and for Kansas. The first part of the study deals with government condition figures and forecasts for the United States. Condition figures were related to yield per seeded acre, yield per harvested acre, abandonment, and production. The accuracy of the monthly forecasts by the government and by private forecasters was determined and compared.

The second part of the study deals with government condition figures and forecasts for Kansas. Condition figures were related to yield per seeded acre, yield per harvested acre, abandonment, and production. The accuracy of government forecasts and of forecasts based on fall rainfall was determined and compared.

The period under consideration is the 19-year period from 1921 to 1939, inclusive, with the following exceptions:

Condition figures for Kansas were not published for April, May, June, or July in 1938 and 1939; consequently, in these cases the 17-year period 1921 to 1937 was used. The forecasts for Kansas based on fall rainfall cover the 18-year period 1922 to 1939.

Condition figures and government forecasts of production as prepared by the United States Department of Agriculture were taken from the 1939 Almanac number of the Northwestern Miller (20). The series of private forecasts used is an arithmetic average of the individual forecasts that were obtained from the Kansas City Grain Market Review published by the Kansas City Board of Trade (14). Data on United States production and acreage were taken from the Agricultural Statistics for 1939, published by the United States Department of Agriculture (1). Abandonment and yields were calculated from these data.

For Kansas, condition and government forecasts were taken from Crops and Markets (6), Weather Crops and Markets (27), and Market Reporter (16), published by the United States Department of Agriculture. Production and acreage data for Kansas were taken from General Crop Revisions (9), crop years 1924-1935, published by the United States Department of Agriculture, June, 1936, supplemented by data from the Yearbooks of the United States Department of Agriculture (28) and current crop reports. Abandonment and yields were calculated from these data. Forecasts for Kansas based on fall rainfall were taken from the files of the Department of Agricultural Economics, Kansas Agricultural Experiment Station. These forecasts had not been published but were used as a basis for wheat price forecasts in recent years.

The correlation method of determining the relationships of condition to yields, abandonment, and production was used. Coefficients of correlation, probable errors of the coefficients of correlation, and standard errors of the estimate were calculated. All the relationships were plotted and a straight line regression and standard error of the estimate was plotted in each case, to help visualize these relationships.

The accuracy of forecasts was determined by calculating the error of each forecast in terms of bushels and in terms of percent. The average error of each series of forecasts was calculated. The coefficient of correlation, probable error of the coefficient of correlation, and standard error of the estimate of each series of forecasts and production also were calculated as a measure of accuracy. The production was plotted against each forecast and the regression line and standard error of the estimate were plotted.

No consideration was given to the accuracy of acreage estimates in this study.

LIMITATIONS OF THE STUDY

Several limitations to this study were recognized. To measure the accuracy of a forecast, a standard with which to compare the forecast must be used. Actual production would be the most desirable standard. Strictly speaking, actual production is never known. The number of bushels of wheat produced cannot be enumerated. The amount of wheat produced must be estimated; this involves some error. King (15) stated, "The accuracy of samples now being gathered by the Bureau of Agricultural Economics for estimating crop yields is generally being tested by a correlation of the samples with the Bureau's estimated yield, and the estimates are in turn based upon sample data. The danger in this procedure lies in the fact that in many cases the Crop Reporting Board does not have an accurate basis for checking all the estimates, and, since the estimates are made to agree with sample indications, the degree of correlation can be misleading as to the accuracy of either the indications or the estimates." The final revised estimates of production were used as the basis for comparison in this study.

There was a lack of complete homogeneity of data in the series on production. Estimates of production made at the end of the crop year are revised when census data become available. In the data used in this study, the data on production up to 1935 were revised on that basis. For the years since 1935 no revisions were made because census data were not available. It was necessary to use unrevised estimates of production for the years 1936 to 1939, inclusive.

The small number of years under consideration limited the significance of the relationships and of the measures of accuracy. Due to the small number of years under observation, any one year had a great deal of influence on the results obtained. Consideration of the probable error of the coefficient of correlation enables a person to judge the validity of these measures of relationship and accuracy.

In all cases where the correlation method was used, two assumptions were made; namely, a normal distribution and a straight line relationship.

DEFINITION OF TERMS

1. Forecast: "Estimates of crop production made prior to harvest are called forecasts." (5).

2. Estimate: "Estimates (of crop production) made at harvest time or later." (5).

3. Production: The final estimate of production made by the government crop reporting service.

4. Yield per seeded acre: Production divided by the seeded acreage.

5. Yield per harvested acre: Production divided by the harvested acreage.

6. Abandonment: The percentage of the seeded acreage that was not harvested.

7. Condition: A figure expressing the condition of the crop in percentage of normal. "The normal may be described as a condition of perfect healthfulness, unimpaired by drouth, hail, insects, or other injurious agency, and with such growth and development as may reasonably be looked for under these favorable conditions." (5).

8. Government forecast: The forecast of crop production regularly prepared and published by the crop reporting service for the United States Department of Agriculture.

9. Private forecasts: The arithmetic average of the forecasts of individuals employed by private business enterprises. (14).

10. Coefficient of correlation (r): "An abstract measure of the degree to which the average relationship (connecting two variables) actually holds in practice." (Mills, 18).

11. Standard error of the estimate (Sy): A measure of "the variation, in absolute terms, about the line of relationship." Mills (18). Approximately 68 percent of the observations should fall within the range described by the standard error of the estimate.

12. Probable error of the coefficient of correlation (PEr): If successive drawings were made of n correlative items from the statistical universe from which the original observations were taken, in the resulting normal distribution of coefficients of correlation, according to the laws of chance, the coefficient of correlation already discovered would represent the mean; and there would be an even chance that the real coefficient of correlation is within the limits of one probable error plus and minus the coefficient already calculated. (Davies and Yoder, 7).

13. Average error: The arithmetic average, disregarding algebraic signs, of the difference between each forecast and production in the series.

14. Significant coefficient of correlation: If, according to the laws of chance, there are less than five chances out of 100 that a coefficient of correlation equally as high could have resulted from non-correlated data, the coefficient of correlation is significant. In this study, 17, 18, and 19 pairs of observations were used. The minimum coefficient of correlation for significance would be .482, .468, and .456, respectively. (Snedecor, 26).

15. Highly significant coefficient of correlation: If, according to the laws of chance, there is less than one chance out of 100 that a coefficient of correlation equally as high could not have resulted from non-correlated data, the coefficient of correlation is highly significant. For 17 pairs of observations the minimum coefficient of correlation to be highly significant is .606; for 18 pairs, .590; and for 19 pairs, .575. (Snedecor, 26).

DESCRIPTION OF METHODS USED IN CROP FORECASTING

A complete description of the government crop reporting service was given in Miscellaneous Publication No. 171 (5). Only a brief description is given here.

Information for the basis of crop forecasts is obtained on schedules covering condition of the growing crop from voluntary crop correspondents located in producing areas. There are several hundred thousand voluntary crop correspondents but only a portion of these report on condition of winter wheat. The schedules are returned by the crop correspondents to the branch offices located in the states. A trained statistician in the state office summarizes the reports on condition by districts. The state statistician also obtains information on weather conditions, changes in crop conditions, and other factors from personal observation and from interviews with well-informed men to supplement the information obtained from the schedules of the crop correspondents. This information is then transferred to the crop reporting board in Washington, D. C., where the condition figures are officially determined for each state and for the United States. The reports are made as of the first of the month and are published about the tenth of that month. The method of forecasting production is to establish, in graphical form, the relationship of condition to yield over a period of years. A line of best fit is calculated or drawn in freehand. The weighted average condition figure for each state is applied to the chart and yield is read from it, assuming that past relationships will hold for the future. Often, factors other than condition enter into the forecast of yield, and multiple correlation is used in some cases.

A questionnaire was sent to several private forecasters to obtain information on methods used in forecasting crop production. There was considerable variation in the methods used but apparently the data used in forecasting were almost entirely subjective. Most of the basic information was obtained from crop correspondents in producing areas. Farmers, elevator operators, and millers furnished most of this information. The number of reports received by private forecasters, of course, was much smaller than the number used by the government crop reporting service. Private crop forecasters apparently spent considerably more time in personal observation of the growing crop and in making personal interviews than was possible for the state statisticians of the government crop reporting service to do. The crop correspondents in some cases reported a forecast of yield directly and some reported a condition figure which is interpreted by the forecaster in terms of yield. Some of the private forecasters used the government acreage figure while others made their own estimate of acreage. The government crop reporting districts were used by some private forecasters but some had set up districts on a different basis.

Based upon the fundamental research of the relation of soil moisture at seeding time and wheat yields in central and western Kansas, a method of forecasting wheat production in Kansas from rainfall was developed in the Department of

Agricultural Economics in the Kansas Agricultural Experiment Station. In the absence of soil moisture data over wide areas, rainfall data were used. Rainfall data for one station in each county as reported by the Weather Bureau were used. The relationship of fall rainfall to yields in each county were tested. A satisfactory relationship for 53 counties was found. These 53 counties were the principal wheat producing counties in the state. Those months or combinations of months from August to November for which precipitation data gave the best relationship to yields per seeded acre for each county were chosen. This relationship was plotted for each county. A freehand curve to fit the data was drawn in in each case. When the rainfall data became available by counties they were applied to the charts and county yields were estimated. After the government estimates of seeded acreage were available in December, a forecast of production for each of the 53 counties could be calculated. As there was little or no relationship between precipitation and yield in the remaining 52 out of the total of 105 counties in Kansas, the 10-year average county yield was applied to the reported seeded acreage to obtain an indicated production for those areas of the state. The summation of the estimated production by counties gave a forecast of production for Kansas.

STUDY OF WINTER WHEAT CROP FORECASTS FOR THE UNITED STATES

Relationship of Condition to Yields, Abandonment, and Production of Winter Wheat

The 19-year series of government condition figures, yield per seeded acre, yield per harvested acre, abandonment, and production are shown in Table 3. Crop correspondents reported condition on the acreage seeded in December and April and on the acreage remaining for harvest in May, June, and July. Total production divided by seeded acreage indicated yield per seeded acre. Total production divided by the harvested acreage indicated the yield per harvested acre. The percent of the seeded acreage not harvested was the percent abandoned.

The average condition by months was as follows: December, 80.15; April, 77.10; May, 77.20; June, 72.62; and July, 74.32. There appeared to be a definite tendency for condition to decline, on the average, as the season advanced.

In observing the month-to-month trend in condition during each year, it was noted that April condition was the same as or higher than December condition in eight years and lower in 11 years. May condition was higher than April condition in 13 years and lower in six years. For the 19

Table 3. Government condition figure by months, yield per seeded acre, yield per harvested acre, production, and percent abandonment of winter wheat in the United States, 1921-1939, inclusive.

Year	Condition/4					Yield per seeded acre/5	Yield per harvested acre/6	Production Millions of bushels/6	Percent abandonment/5
	Previous December	April	May	June	July				
1921	88.5	91.8	88.0	77.9	77.2	13.3	14.0	603	5.1
1922	76.0	78.4	83.5	81.9	77.0	12.1	13.7	571	12.2
1923	79.5	75.2	80.1	76.3	76.8	12.2	14.3	555	14.7
1924	88.0	83.0	84.8	74.0	77.9	14.8	16.2	574	8.3
1925	81.0	68.7	77.0	66.5	85.2	9.8	12.5	401	21.9
1926	82.7	84.1	84.0	76.5	77.6	15.6	16.8	632	7.4
1927	81.8	84.5	85.6	72.2	75.0	12.4	14.4	548	13.5
1928	86.0	68.8	74.9	73.6	88.7	12.0	15.7	579	23.9
1929	84.4	82.7	83.6	79.6	86.7	13.3	14.2	586	6.3
1930	86.0	77.4	76.7	71.7	73.8	14.1	15.4	634	8.8
1931	86.3	88.8	90.3	84.3	82.3	18.1	19.0	825	4.8
1932	79.4	75.8	75.1	64.7	64.7	11.3	13.6	492	16.9
1933	68.9	59.4	66.7	64.0	57.8	8.5	12.4	377	31.9
1934	74.3	74.3	70.9	55.3	57.2	9.8	12.6	439	22.3
1935	77.8	69.8	75.3	74.2	73.0	9.9	13.9	465	29.0
1936	78.2	68.5	67.0	66.7	66.3	10.4	13.8	520	24.3
1937	75.8	73.8	77.4	71.5	71.0	11.9	14.6	686	18.5
1938	76.0	82.0	85.0	81.0	75.0	12.2	13.8	687	11.7
1939	72.2	78.0	79.0	68.0	69.0	12.2/7	14.9/8	563/8	18.5/7

Sources: /4 Northwestern Miller. /5 Calculated from 1939 Agricultural Statistics. /6 1939 Agricultural Statistics. /7 Calculated from December, 1939, Crop Report. /8 December, 1939, Crop Report.

years under observation, June condition was never higher than May condition. July condition was the same as or higher than June condition in 11 years and lower in eight years.

There seemed to be a definite tendency for crop correspondents to lower their opinions of the crop after May 1. The winter wheat crop usually shows at its best about May 1. It is growing rapidly, and insects, rust, and hot, dry weather usually have not had an opportunity to cause much damage. By June 1 some of these factors have had an opportunity to cause deterioration of the crop.

Yield per seeded acre is always lower than yield per harvested acre. Yield per seeded acre also varies more from year to year than yield per harvested acre. For the 19 years under observation the average yield per seeded acre was 12.3 bushels. The standard deviation was 2.2 bushels and the range from 8.5 to 18.1 bushels or 9.6 bushels. The yield per harvested acre for the same period was 14.5 bushels, with a standard deviation of 1.6 bushels and a range from 12.4 bushels to 19.0 bushels--6.6 bushels.

The condition figure for April showed a closer relationship with yield per seeded acre than for any other month. Since condition was reported on the acreage remaining for harvest after April, this result seemed logical. The coefficients of correlation, standard errors of the estimate, and probable errors of the coefficient of correlation for December, April, May, June, and July condition are shown in Table 4. The relationships are plotted in Figs. 1 to 5. It may be seen that the difference between the coefficient of correlation for condition in April and May was within the probable error. The coefficient of correlation was slightly higher for condition in December than in June or July.

The regression equation shows that considerable variation in yield would be indicated by a given condition figure in the different months. For example, a condition of 80 would indicate a yield per seeded acre of 12.27 bushels in December, 12.95 bushels in April, 11.52 bushels in May, 13.86 bushels in June, and 13.11 bushels in July. In other words, a lower condition in June than in May did not necessarily indicate a lower yield.

There was little difference in the relationship of condition by months to yield per harvested acre. December, May, and June condition figures gave almost identical coefficients of correlation. April and July condition gave slightly lower coefficients of correlation (Table 5 and

Table 4. Coefficient of correlation, probable error of the coefficient of correlation, and standard error of the estimate for condition by months and yield per seeded acre for the United States winter wheat crop, 1921-1939.

Factors X	Factors Y	r	PEr	Sy (In bu.)
December condition	and yield per seeded acre	+.683	±.082	±1.62
April condition	and yield per seeded acre	+.794	±.057	±1.37
May condition	and yield per seeded acre	+.779	±.090	±1.40
June condition	and yield per seeded acre	+.672	±.084	±1.65
July condition	and yield per seeded acre	+.518	±.113	±1.87

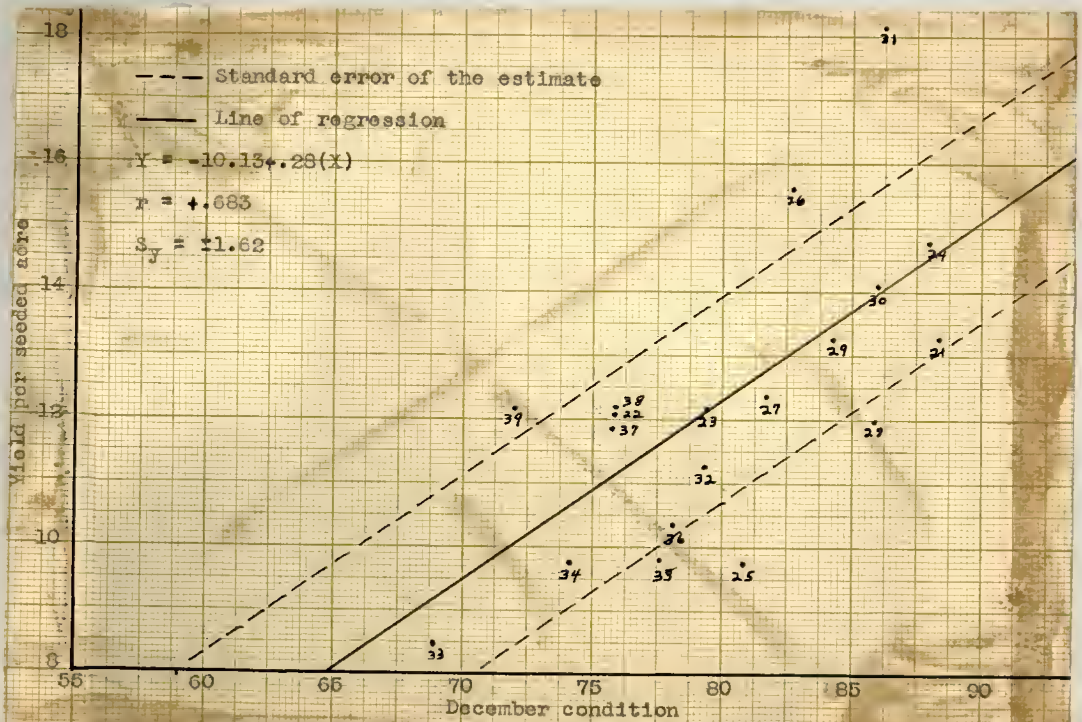

Fig. 1. Relationship of December condition of winter wheat to yield per seeded acre in the United States.

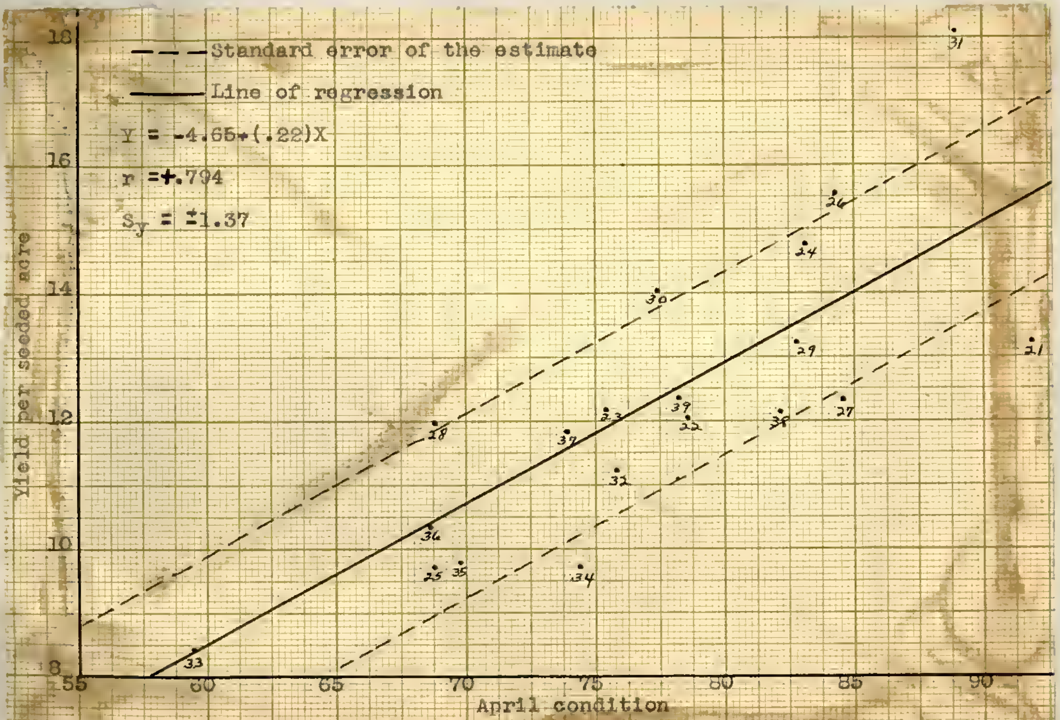

Fig. 2. Relationship of April condition of winter wheat to yield per seeded acre in the United States.

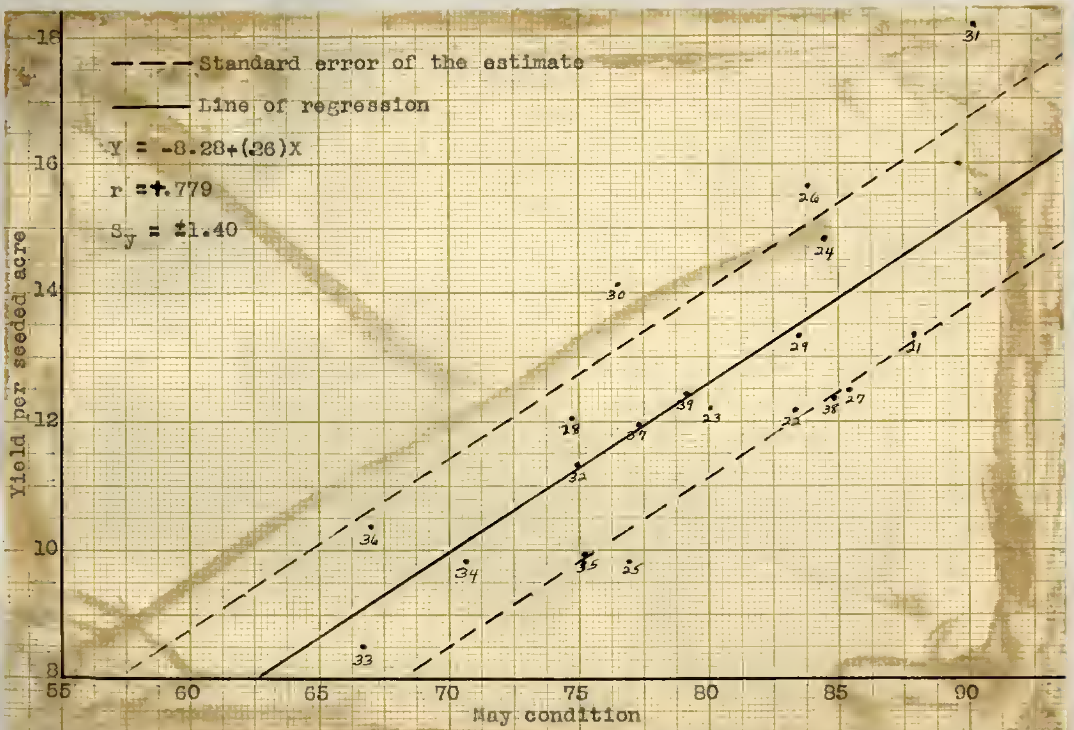

Fig. 3. Relationship of May condition of winter wheat to yield per seeded acre in the United States.

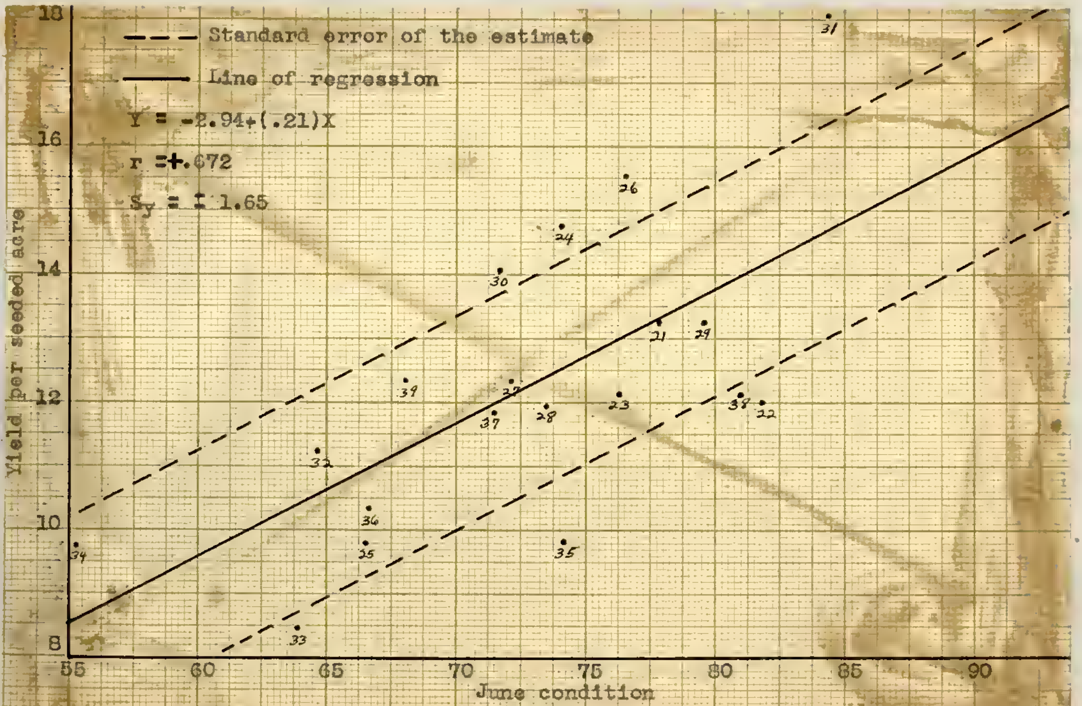

Fig. 4. Relationship of June condition of winter wheat to yield per seeded acre in the United States.

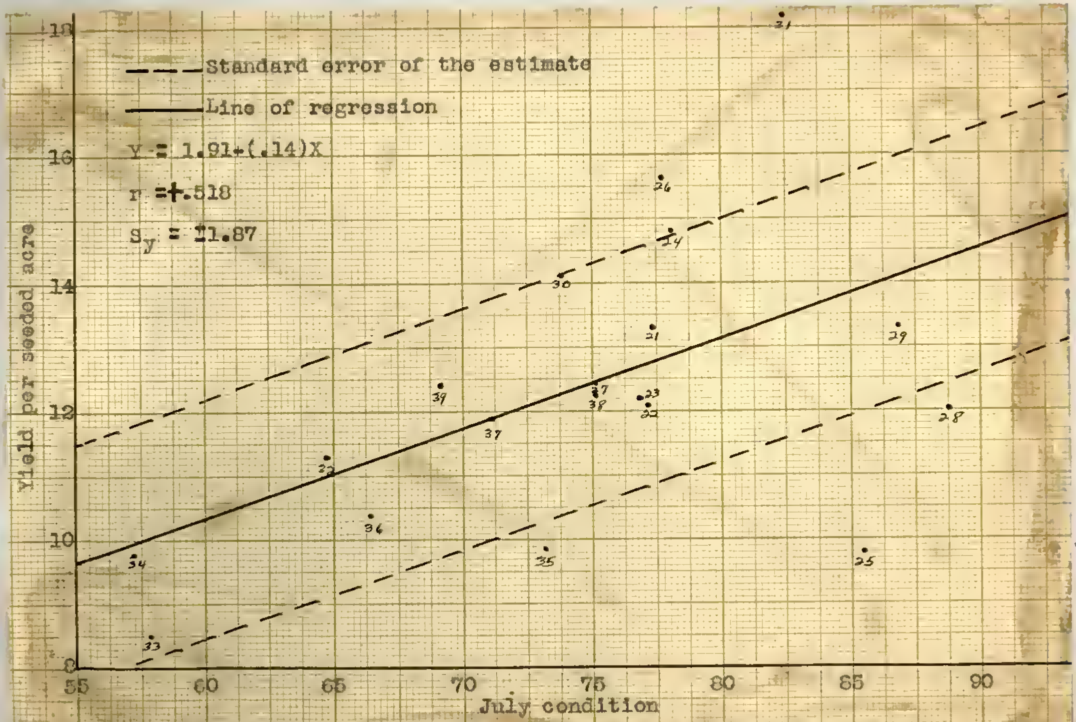

Fig. 5. Relationship of July condition of winter wheat to yield per seeded acre in the United States.

Figs. 6 to 10). The differences in the coefficients of correlation all lie within the probable error. It would be expected that the relationship would improve as the crop became more mature. This was not the case for the 19-year period included. In fact, the July condition seemed to give the poorest relationship of all.

A condition of 80 would indicate a yield per harvested acre in December of 13.50 bushels; in April, 14.81 bushels; in May, 14.62 bushels; in June, 15.55 bushels; and in July, 14.97 bushels.

In comparing the relationships of condition to yield per seeded acre and yield per harvested acre, it may be observed that significantly closer relationships exist in the case of yield per seeded acre. The failure of the relationship to improve in May, June, and July with yield per harvested acre indicates the difficulty that crop correspondents have in reporting on the acreage remaining for harvest. This may be due to the fact that farmers either think in terms of seeded acreage when reporting condition or have difficulty in estimating abandonment. As a matter of fact, in May and June, they probably are reporting on neither the acreage seeded nor the acreage remaining for harvest, but somewhere between these two. Presumably, it should be

Table 5. Coefficient of correlation, probable error of the coefficient of correlation, and standard error of the estimate for condition by months and yield per harvested acre for the United States winter wheat crop, 1921-1939.

Factors		r	PEr	Sy
X	Y			(In bu.)
December condition and yield per harvested acre		+.555	±.107	±1.23
April condition and yield per harvested acre		+.537	±.110	±1.30
May condition and yield per harvested acre		+.553	±.107	±1.29
June condition and yield per harvested acre		+.554	±.107	±1.24
July condition and yield per harvested acre		+.457	±.122	±1.38

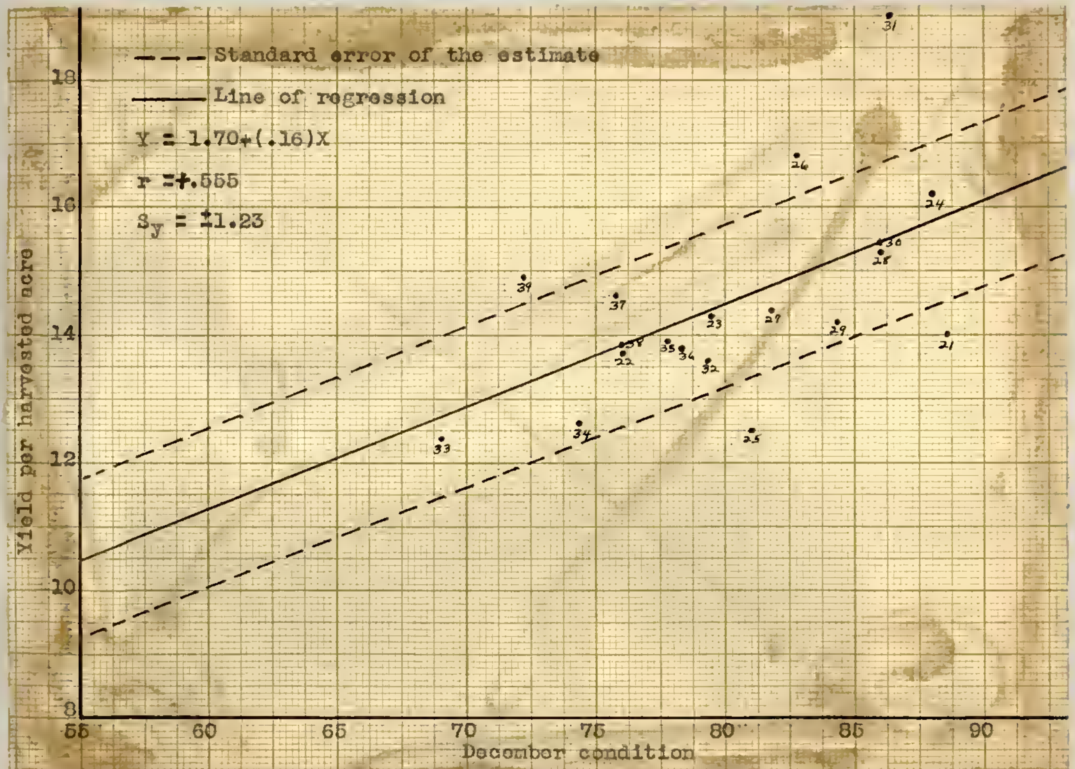

Fig. 6. Relationship of December condition of winter wheat to yield per harvested acre in the United States.

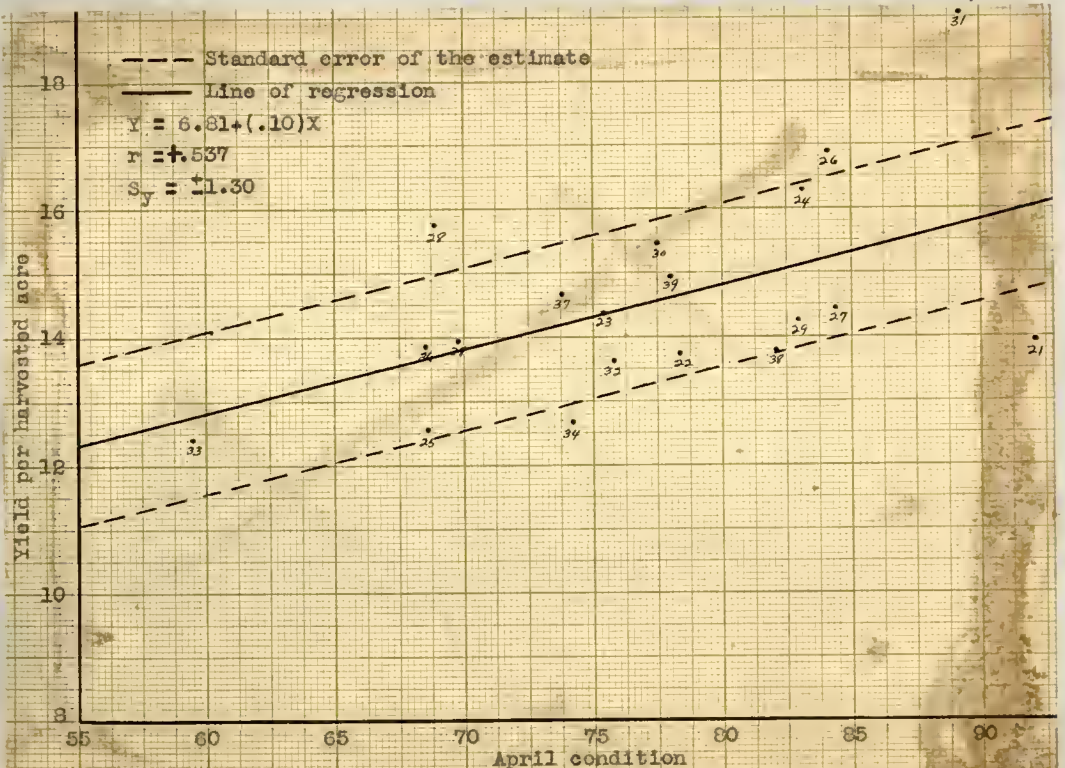

Fig. 7. Relationship of April condition of winter wheat to yield per harvested acre in the United States.

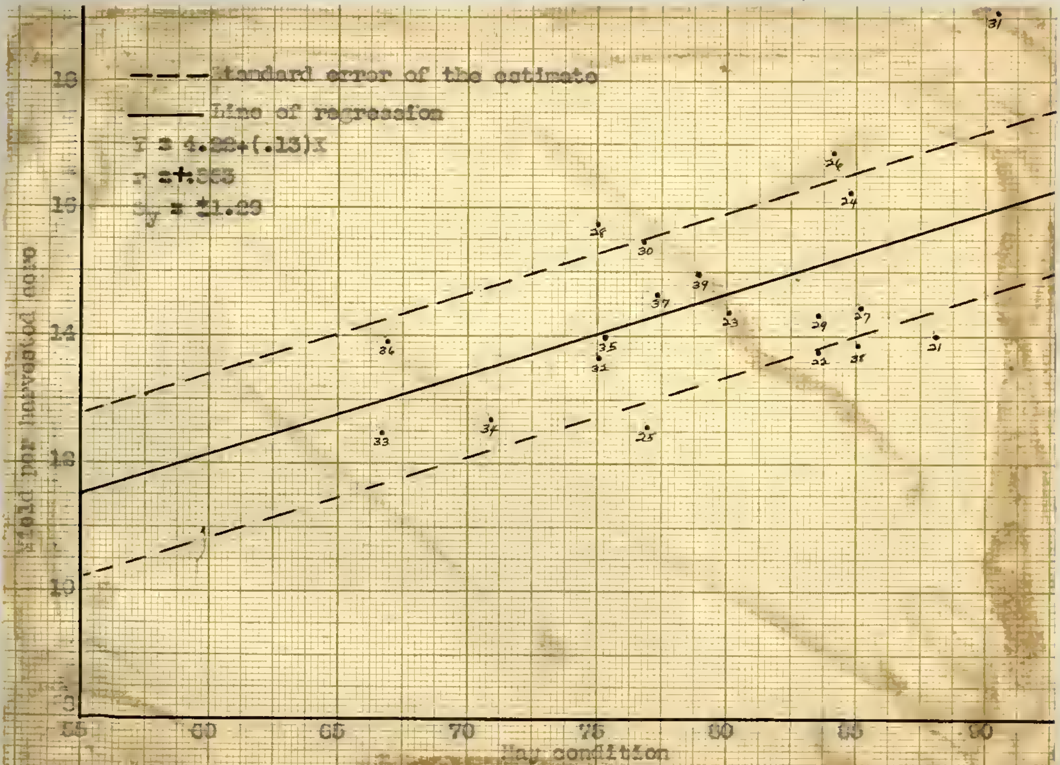

Fig. . Relationship of May condition of winter wheat to yield per harvested acre in the United States.

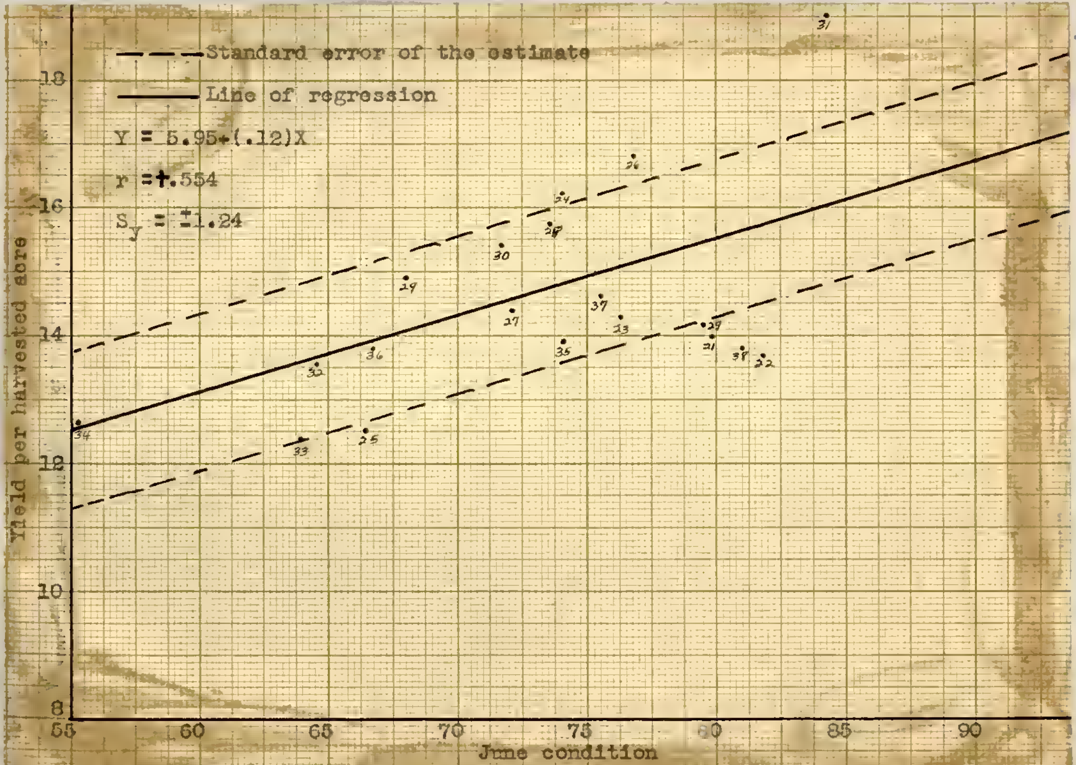

Fig. 9. Relationship of June condition of winter wheat to yield per harvested acre in the United States.

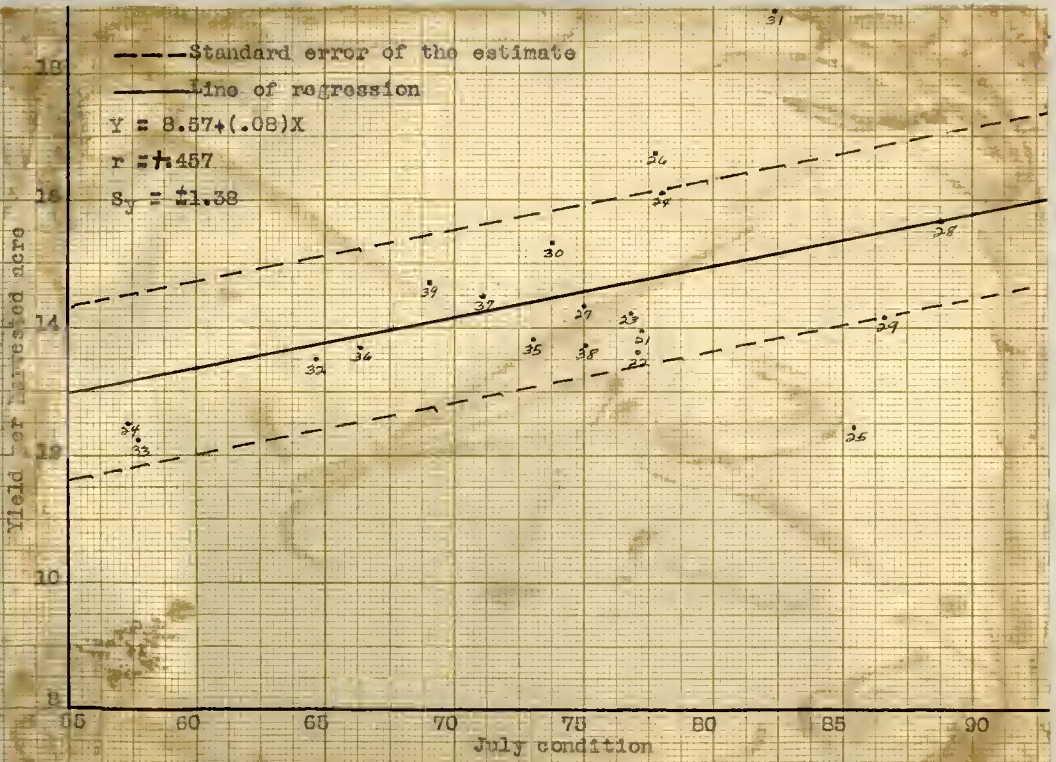

Fig. 10. Relationship of July condition of winter wheat to yield per harvested acre in the United States.

nearer the harvested acreage basis; but, according to these results, it apparently is nearer the seeded acreage basis.

The smaller standard error of the estimate for the yield per harvested acre basis may be explained by the smaller range in yields than for yield per seeded acre.

A close relationship existed between condition, particularly in April and May, and abandonment (Table 6 and Figs. 11 to 14). April condition gave a higher coefficient of correlation than May condition, but the difference between the two was less than the probable error. December condition gave a highly significant coefficient of correlation and was a fairly satisfactory early season indicator of abandonment.

Table 6. Coefficient of correlation, probable error of the coefficient of correlation, and standard error of the estimate for condition and percent of winter wheat acreage abandoned in the United States, 1921-1939.

Factors X	Factors Y	r	PEr	Sy
December condition	and abandonment	-.561	±.105	±7.82
April condition	and abandonment	-.756	±.066	±6.14
May condition	and abandonment	-.702	±.078	±6.66
June condition	and abandonment	-.533	±.111	±7.98

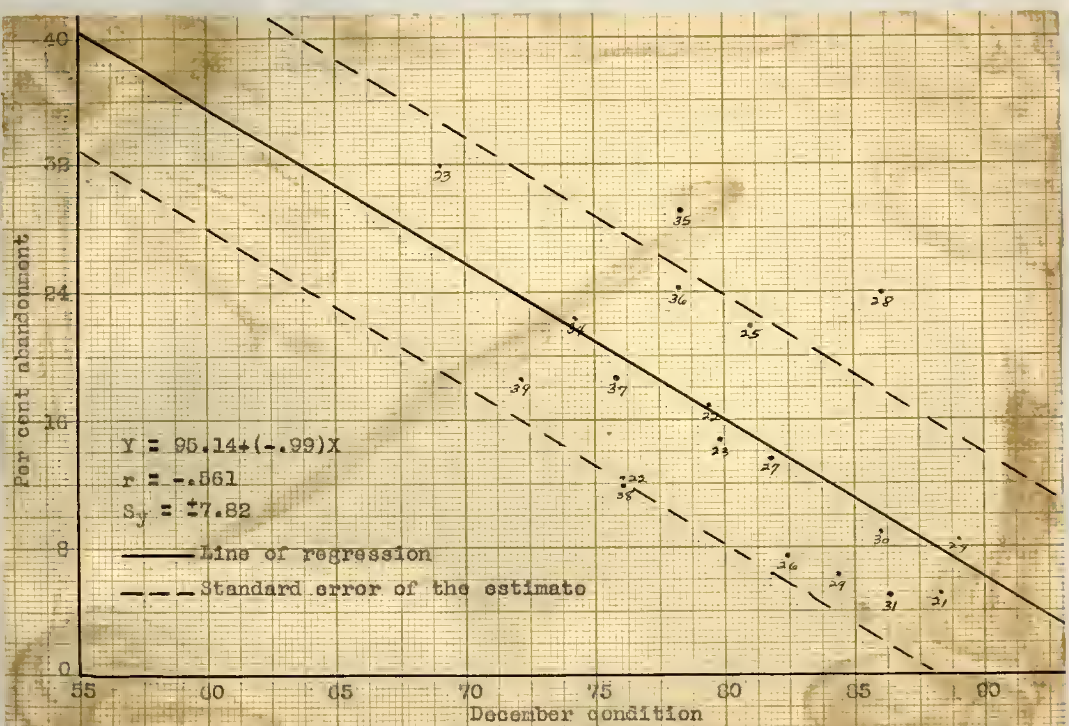

Fig. 11. Relationship of December condition of winter wheat to per cent of the seeded acreage abandoned in the United States.

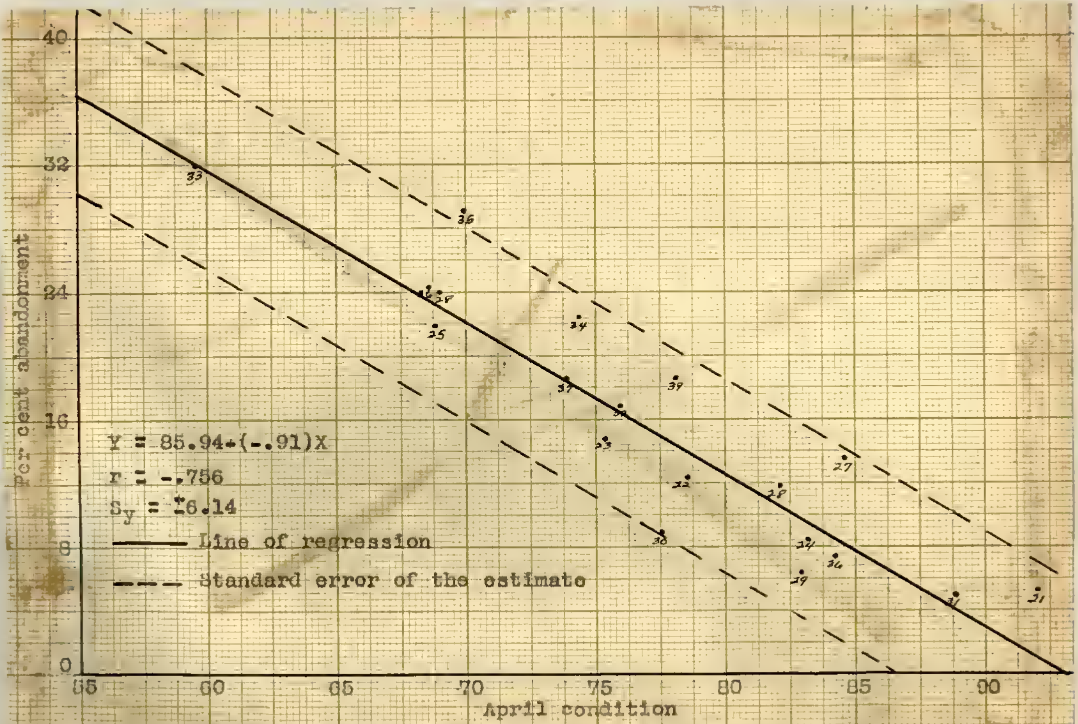

Fig. 12. Relationship of April condition of winter wheat to per cent of the seeded acreage abandoned in the United States.

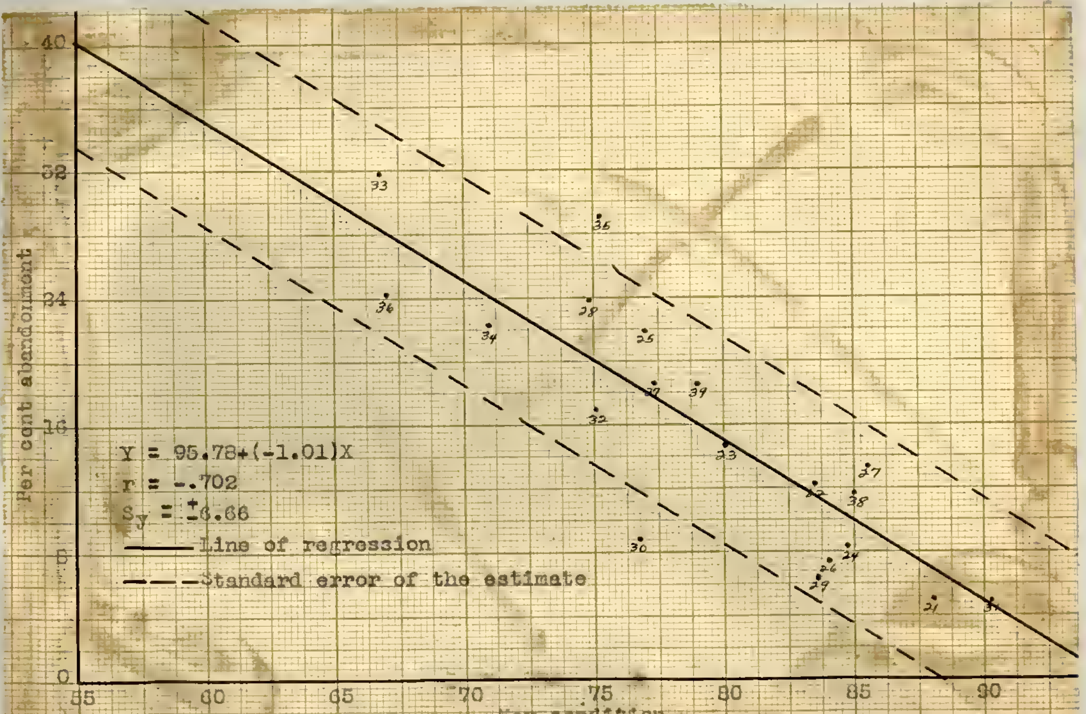

Fig. 13. Relationship of May condition of winter wheat to per cent of the seeded acreage abandoned in the United States.

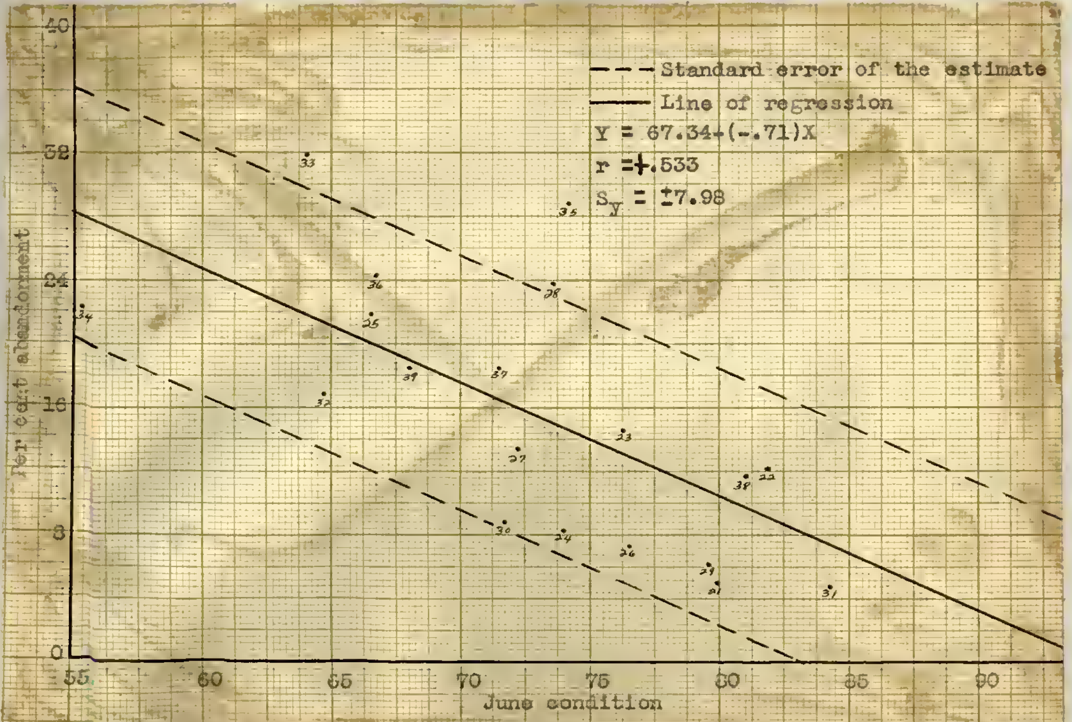

Fig. 14. Relationship of June condition of winter wheat to per cent of the seeded acreage abandoned in the United States.

The relationship of condition to total production improved as the season advanced until July. June condition gave a higher coefficient of correlation than for any of the other months, although the differences between the coefficients of correlation for April, May, and June all lie within the probable error. The relationships of condition and production are shown in Table 7 and Figs. 15 to 19.

Table 7. Coefficient of correlation, probable error of the coefficient of correlation, and standard error of the estimate for condition and total production of winter wheat in the United States, 1921-1939.

Factors		r	PEr	Sy
X	Y			
December condition and production		+.449	±.123	±92.77
April condition and production		+.681	± .082	±75.86
May condition and production		+.687	± .082	±75.49
June condition and production		+.723	± .074	±71.66
July condition and production		+.436	± .125	±93.44

In considering the value of each monthly condition figure for forecasting purposes, it may be observed that the December condition gave a highly significant coefficient of correlation with yield per seeded acre, yield per

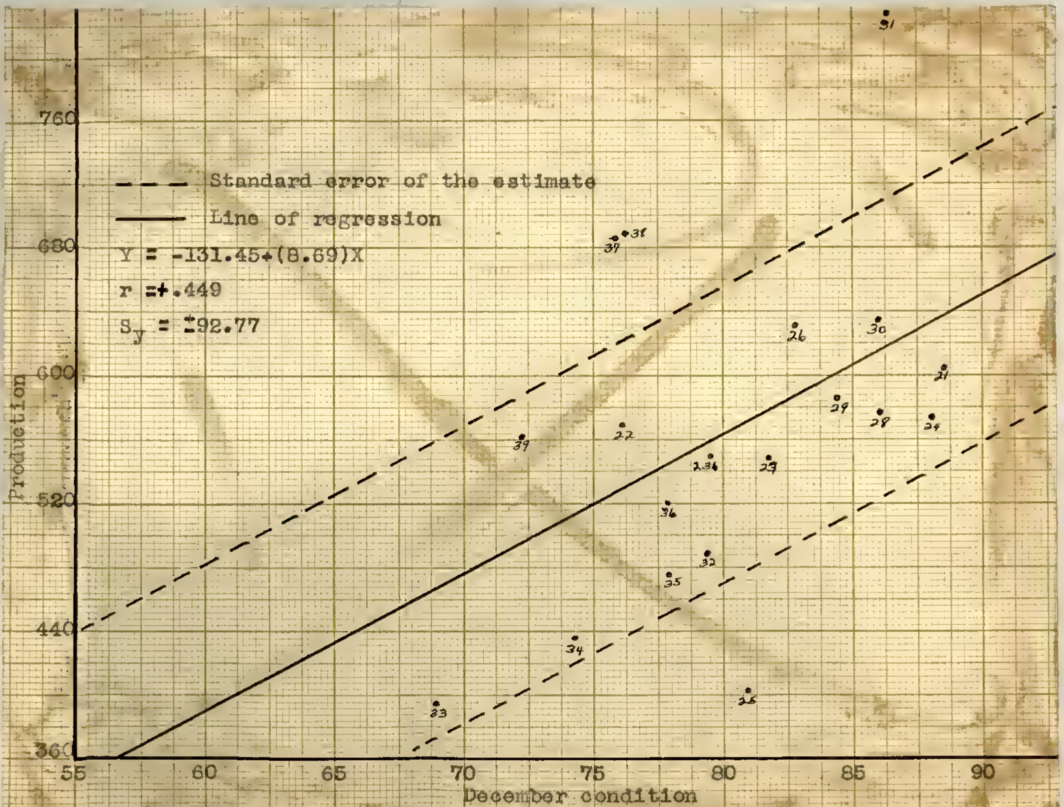

Fig. 15. Relationship of December condition of winter wheat to total production in the United States.

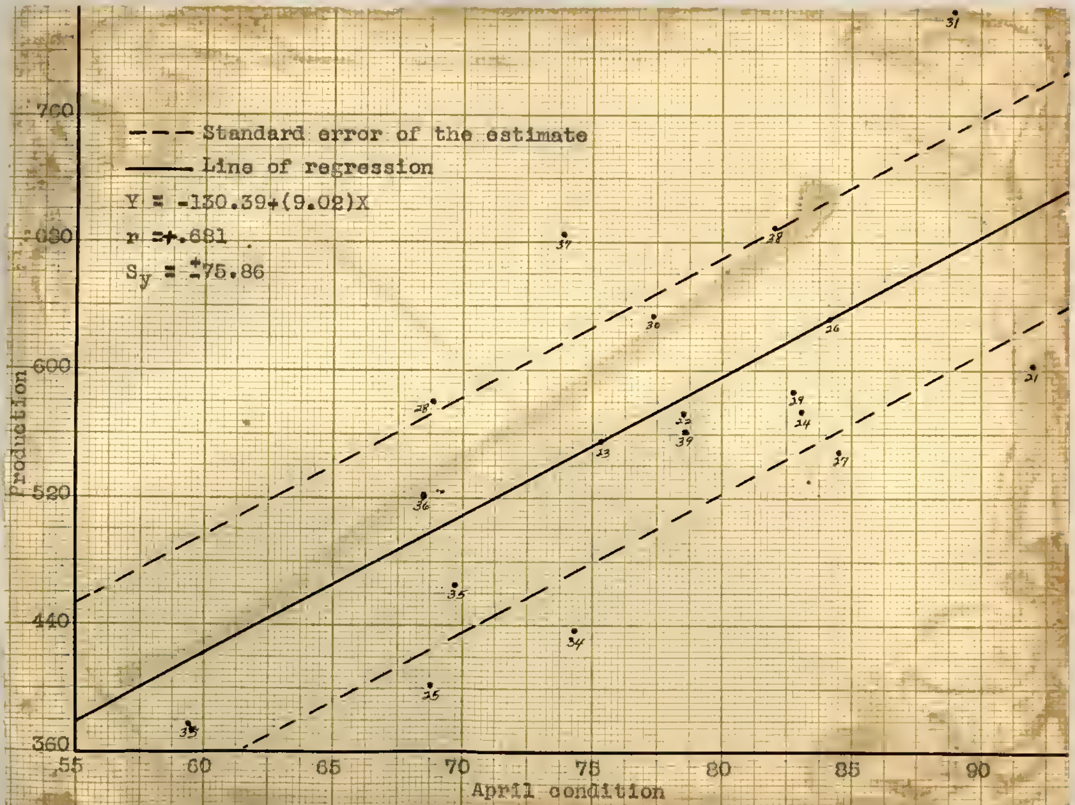

Fig. 16. Relationship of April condition of winter wheat to total production in the United States.

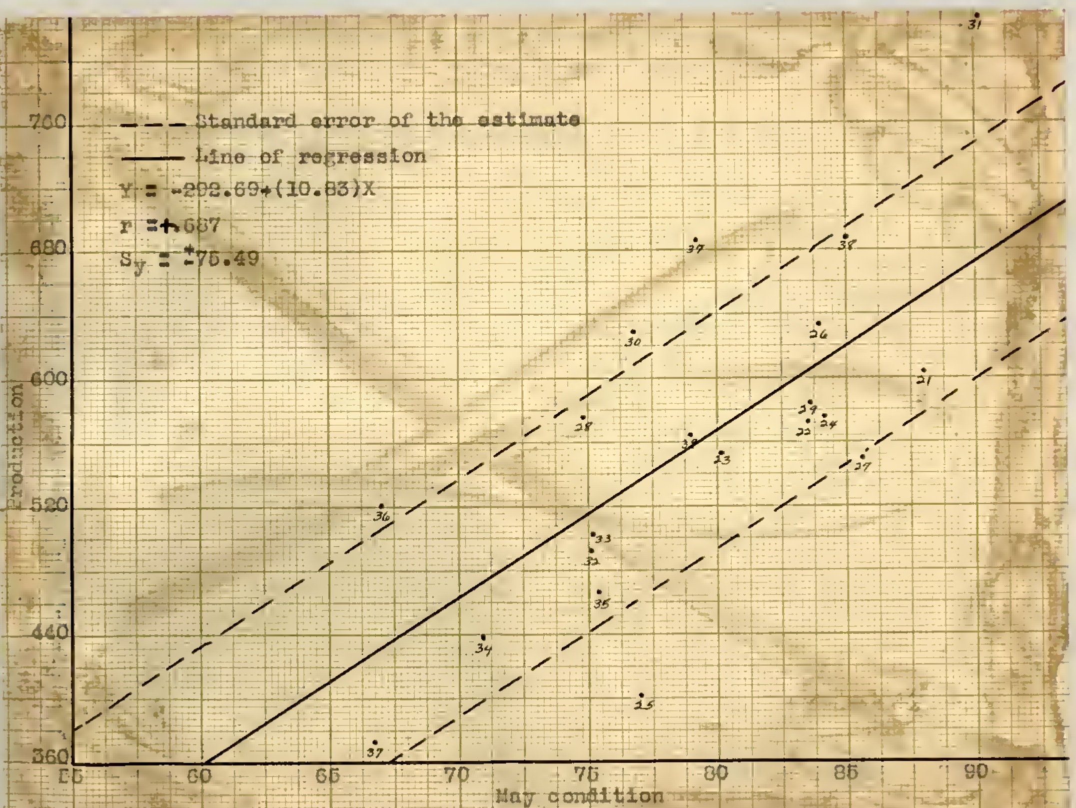

Fig. 17. Relationship of May condition of winter wheat to total production in the United States.

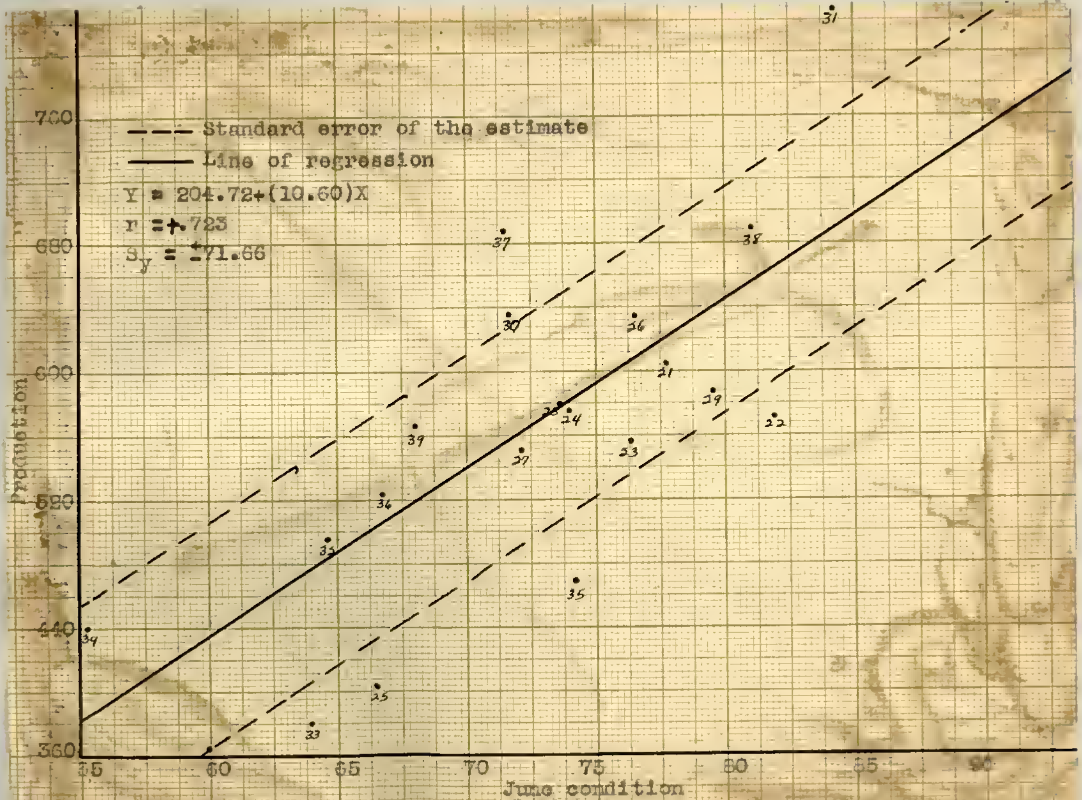

Fig. 13. Relationship of June condition of winter wheat to total production in the United States.

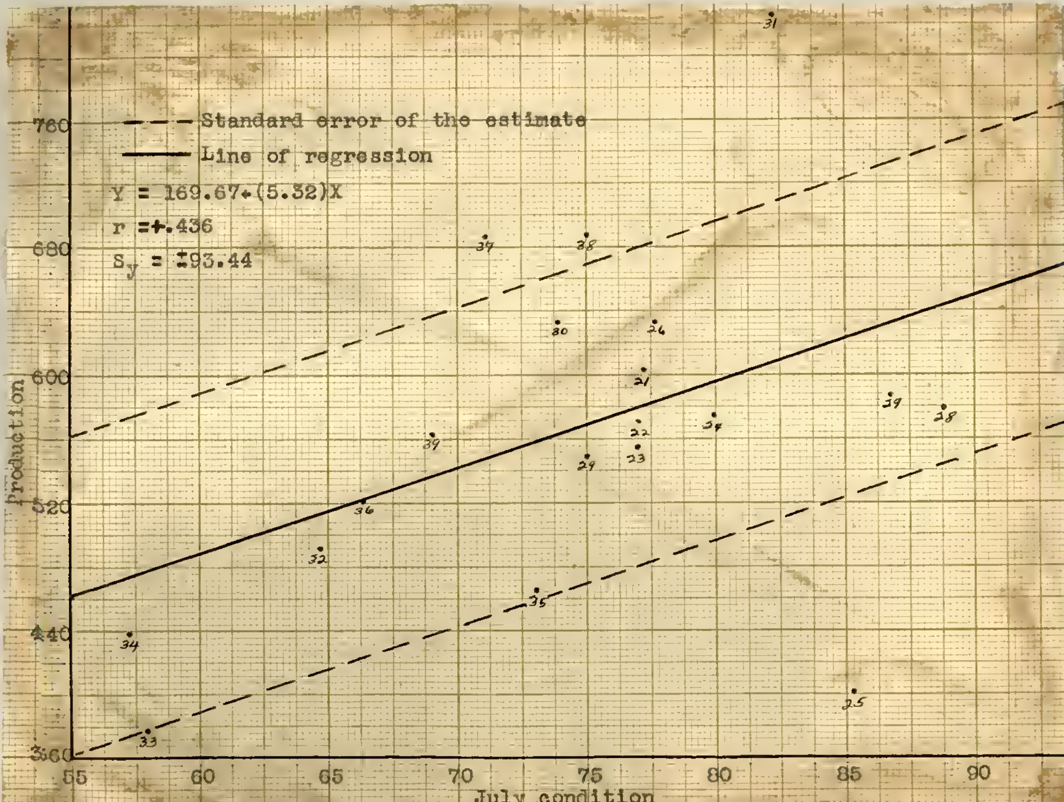

Fig. 19. - Relationship of July condition of winter wheat to total production in the United States.

harvested acre, abandonment, and production. April condition gave the best coefficient of correlation with yield per seeded acre and abandonment, of any monthly condition figure. June condition gave the highest coefficient of correlation with total production. The July condition figure showed a relatively poor relationship with yields and production.

Condition figures are used as an aid in forecasting yields and have little significance in themselves. The ultimate purpose is to forecast total production.

Accuracy of Government Forecasts of Winter Wheat Production

Forecasts of winter wheat production are made regularly by the government crop reporting service and by private forecasters as of the first of April, May, June, and July. These forecasts and production for the period 1921 to 1939 are shown in Table 8.

The averages of the government forecasts by months were April, 545 million bushels; May, 541 million bushels; June, 531 million bushels; and July, 531 million bushels. The month-to-month change in each year was: The May forecast was higher than the April forecast in 10 years and lower in

Table 8. Government forecasts and the average of private forecasts by months and production for winter wheat in the United States in millions of bushels, 1921-1939.

Year	Government Forecasts/9				Private Forecasts/10				Production/11
	April	May	June	July	April	May	June	July	
1921	621	629	578	573	652	642	601	576	603
1922	573	584	607	569	573	575	606	563	571
1923	572	578	581	586	585	565	592	583	555
1924	549	553	509	543	556	560	549	528	574
1925	474	445	407	404	519	442	423	396	401
1926	530/13	549	543	568	572	565	561	562	632
1927	568/13	594	537	579	582	597	560	561	548
1928	536/13	486	512	544	534	472	513	519	579
1929	575/13	595	622	582	573	618	632	599	586
1930	574/13	525	532	558	574	543	543	551	634
1931	644	653	649	713	619	658	681	695	825
1932	458	441	411	432	500	463	427	421	492
1933	334	337	341	336	371	350	357	323	377
1934	492	461	400	394	506	486	421	408	438
1935	435	432	441	458	490	449	469	451	465
1936	493	464	482	512	536	486	501	497	520
1937	656	654	649	664	655	649	660	637	686
1938	726	754	760	715	710	741	810	715	687
1939	549/12	544/12	523/12	538/12	540	535	515	526	563

Sources: /9 Northwestern Miller. /10 Calculated from data taken from Kansas City Grain Market Review. /11 Taken from 1939 Agricultural Statistics. /12 Taken from current crop reports. /13 Taken from Crops and Markets.

nine years; the June forecast was higher than the May forecast in nine years and lower in 10 years; the July forecast was higher than the June forecast in 12 years and lower in seven years. There seemed to be a tendency for the June forecast to be slightly lower than for the other months.

The opinion is sometimes expressed that the government crop reporting service is a detriment to the farmer because the size of the crop usually is overestimated. Data indicate that this is not true (Table 8). Of the 76 government crop forecasts made in the last 19 years, 24 were larger than production and 52 were smaller.

The percentage error of each government forecast and the average error in percent of average production are shown in Table 9. The July forecasts showed the smallest average error. This would be expected because at least a part of the crop is harvested by July 1 and observers can see how the crop is "turning out". The April forecasts appeared to be more nearly accurate than the May or June forecasts. The June forecasts had the largest average error.

The coefficients of correlation, standard errors of the estimates, and probable errors of the coefficients of correlation for the monthly forecasts and production are shown in Table 10. The data are plotted in Figs. 20 to 23. The

Table 9. Percentage error of each monthly forecast and average error in percent of average production for the government forecasts.

Year	April	May	June	July
1921	+ 2.9	+ 4.3	- 4.2	- 5.0
1922	+ 0.3	+ 2.2	+ 6.3	- 0.4
1923	+ 3.0	+ 4.1	+ 4.6	+ 5.5
1924	- 4.4	- 3.7	-11.4	- 5.5
1925	+18.2	+10.9	+ 1.4	+ 0.7
1926	-16.2	-13.2	-14.1	-10.2
1927	+ 3.6	+ 8.3	- 2.1	+ 5.6
1928	- 7.5	-16.1	-11.6	- 6.1
1929	- 1.9	+ 1.5	+ 6.1	- 0.7
1930	- 9.5	-17.2	-16.1	-12.0
1931	-22.0	-20.9	-21.4	-13.6
1932	- 7.0	-10.4	-16.5	-12.2
1933	-11.5	-10.7	- 9.6	-10.9
1934	+12.3	+ 5.2	- 8.7	-10.1
1935	- 6.5	- 7.1	- 5.2	- 1.6
1936	- 5.2	-10.8	- 7.4	- 1.6
1937	- 4.4	- 4.7	- 5.4	- 3.3
1938	+ 5.6	+ 9.7	+10.6	+ 4.0
1939	- 2.5	- 3.4	- 7.2	- 4.5
Average error in percent of average production	7.6	8.9	9.3	6.0

results of this method of measuring accuracy did not agree entirely with the results as shown by the average error. The reason for this is that the correlation method gave greater weight to the largest errors. The correlation method showed the July forecast to be the most nearly accurate, the June forecast being more nearly accurate than the forecast for April or May. The differences between the coefficient of correlation for April, May, and June are within the probable error, so the differences probably are insignificant.

Table 10. Coefficient of correlation, probable error of the coefficient of correlation, and standard error of the estimate for the government forecasts of production and production of winter wheat in the United States, 1929-1939.

Factors X	Factors Y	r	PEr	Sy
April forecast	and production	+.846	±.044	±55.68
May forecast	and production	+.827	±.049	±58.55
June forecast	and production	+.851	±.042	±54.07
July forecast	and production	+.937	±.018	±37.04

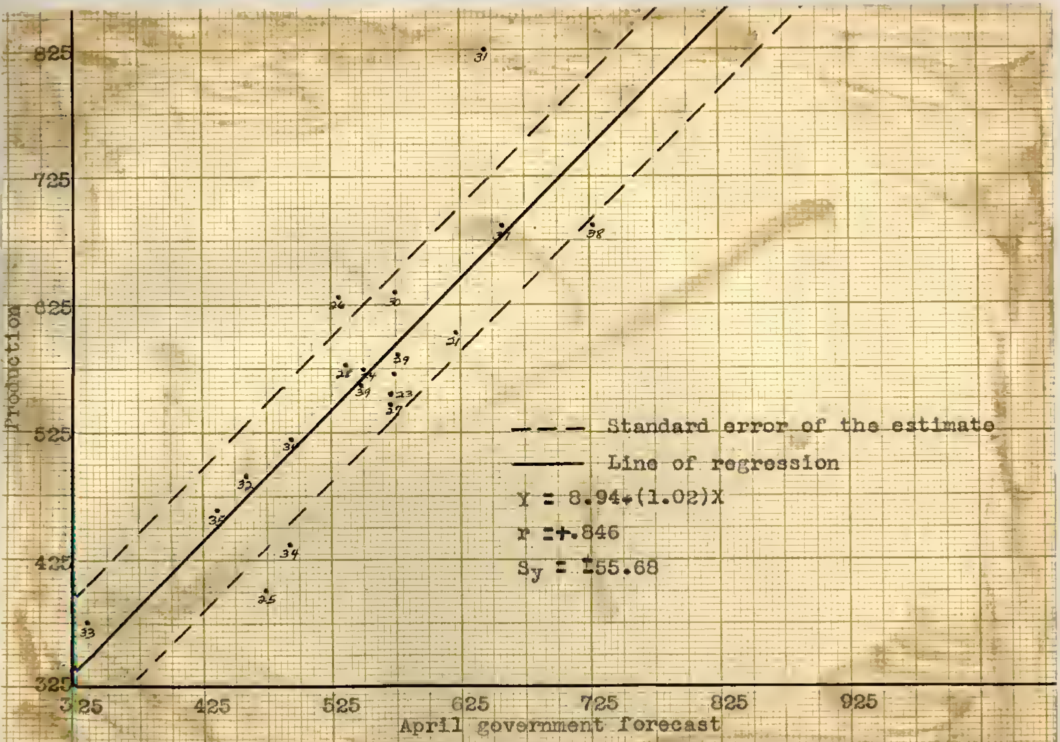

Fig. 20. Relationship of the April government forecast of winter wheat production to production in the United States.

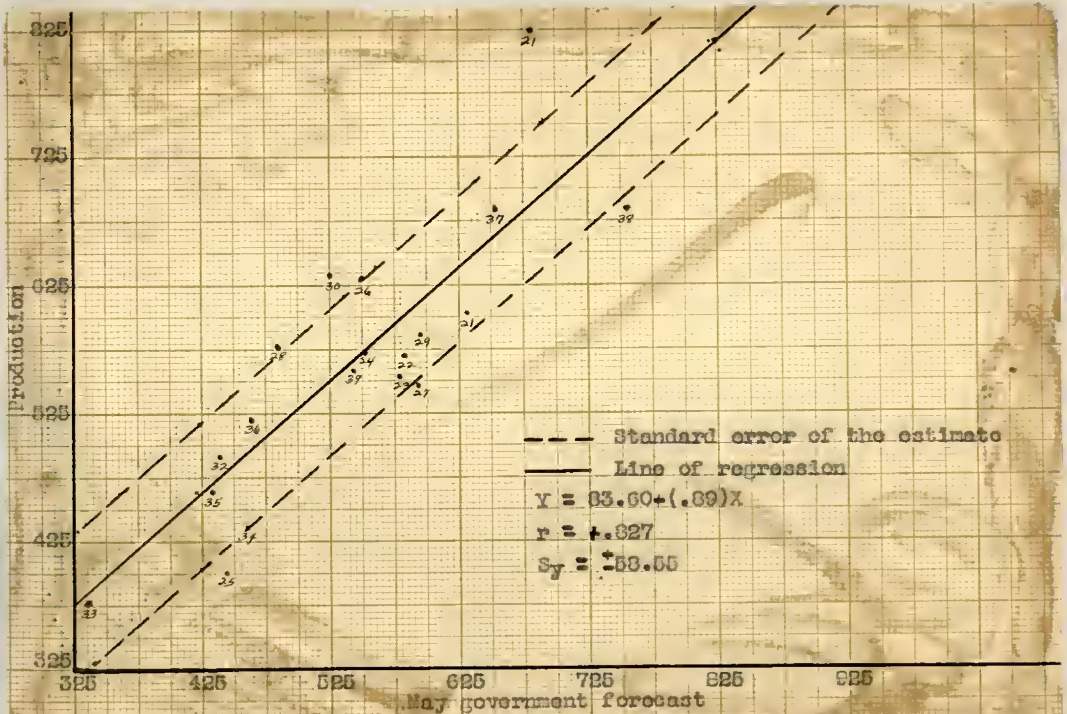

Fig. 21. Relationship of the May government forecast of winter wheat production to production in the United States.

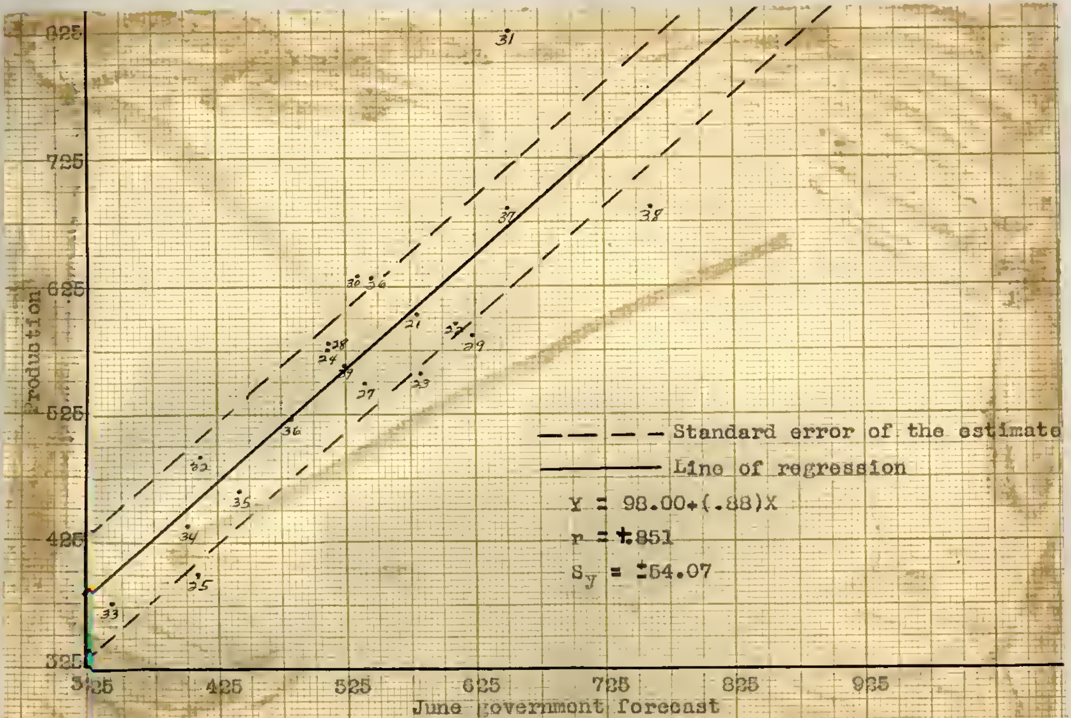

Fig. 22. Relationship of the June government forecast of winter wheat production to production in the United States.

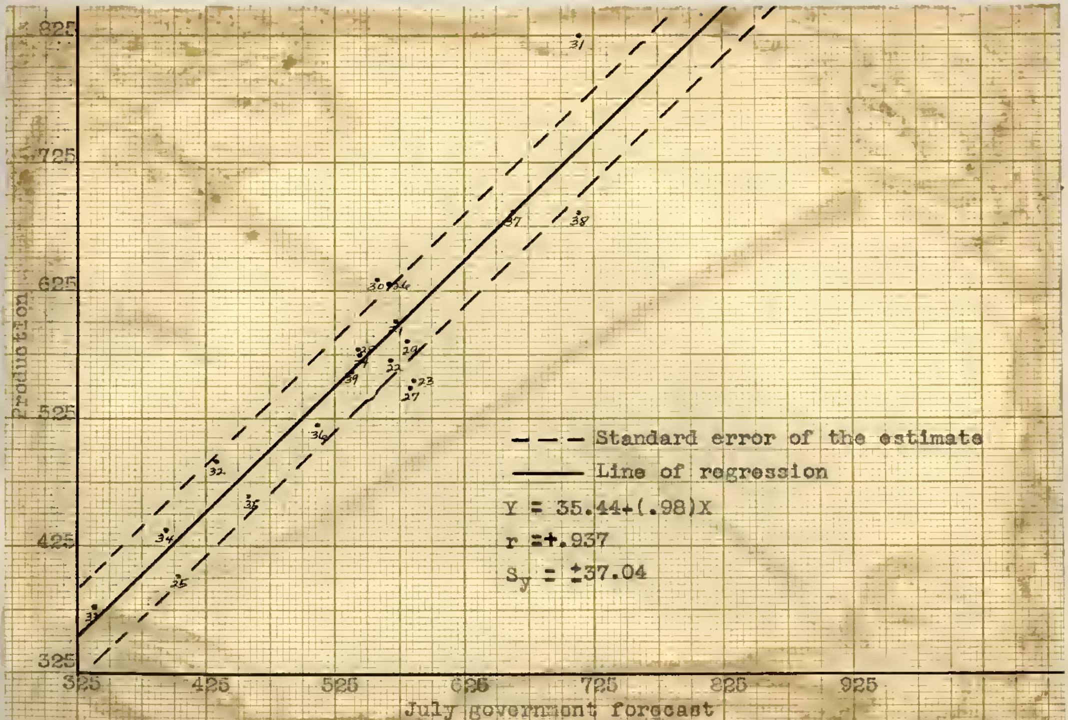

Fig. 23.—Relationship of the July government forecast of winter wheat production to production in the United States.

Accuracy of Private Forecasts of
Winter Wheat Production

The average of private forecasts by months for the 19-year period were: April, 561 million bushels; May, 546 million bushels; June, 549 million bushels; and July, 532 million bushels. In six years the May forecast averaged larger than the April forecasts and in 13 years they were smaller. The June forecasts averaged larger than the May forecasts in 11 years and smaller in eight years. The July forecasts averaged larger than the June forecasts in six years and smaller in 13 years. These data indicate a tendency for the size of the private forecasts to decline as the season advances. There were 29 times when private forecasts averaged more than production and 47 times when they averaged less than production.

The degree of accuracy of the private forecasts is shown in Table 11. The average error was the smallest for the July forecasts but April forecasts had only a slightly larger average error. The May and June forecasts were somewhat less accurate.

The accuracy of the private forecasts as measured by the correlation method is shown in Table 12 and Figs. 24 to

Table 11. Percentage of error of each monthly forecast and average error in percent of average production for the average forecasts of the private reporters.

Year	April	May	June	July
1921	+ 3.6	+ 6.4	- 0.4	- 4.5
1922	+ 0.3	+ 0.7	+ 0.7	- 1.5
1923	+ 5.4	+ 1.8	+ 1.8	+ 5.0
1924	- 3.2	- 2.5	- 2.5	- 8.1
1925	+29.4	+10.2	+10.2	- 1.3
1926	- 9.5	-10.7	-10.7	-11.1
1927	+ 6.2	+ 8.9	+ 8.9	+ 2.3
1928	- 7.5	-18.7	-18.5	-10.4
1929	- 1.9	+ 5.4	+ 5.4	+ 2.2
1930	- 9.5	-14.4	-14.3	-13.1
1931	-25.0	-20.3	-20.3	-15.8
1932	+ 1.2	- 6.4	- 5.9	-14.5
1933	0	- 7.5	- 7.2	-14.9
1934	+15.5	+10.7	+10.9	- 6.9
1935	+ 5.3	- 3.5	- 3.5	- 3.1
1936	+ 3.0	+ 6.6	- 6.6	- 4.5
1937	- 4.6	- 5.0	- 4.3	- 6.5
1938	+ 4.3	+ 5.6	+ 7.8	+ 4.2
1939	- 4.3	- 4.5	- 8.4	- 6.8
Average error in percent of average production	7.4	8.1	8.0	7.3

27. The July forecast was the most nearly accurate by this method. The April forecast appeared to be the least nearly accurate. Again, the results did not entirely agree with those shown by the average error. The differences between the coefficients of correlation for April, May, and June are less than the probable error.

Table 12. Coefficient of correlation, probable error of the coefficient of correlation, and standard error of the estimate for the average of private forecasts of winter wheat production and production, 1921-1939.

Factors X Y	r	PEr	Sy
April forecast and production	+.794	±.057	±59.12
May forecast and production	+.837	±.046	±56.85
June forecast and production	+.839	±.045	±54.03
July forecast and production	+.924	±.022	±39.18

Comparison of the Accuracy of Government and Private Forecasts of Winter Wheat Production

In comparing the degree of accuracy of the government and private forecasts, it appeared that there was little difference. The government forecasts appeared to be somewhat more nearly accurate in July. Private forecasts appeared to be slightly more nearly accurate in May. The

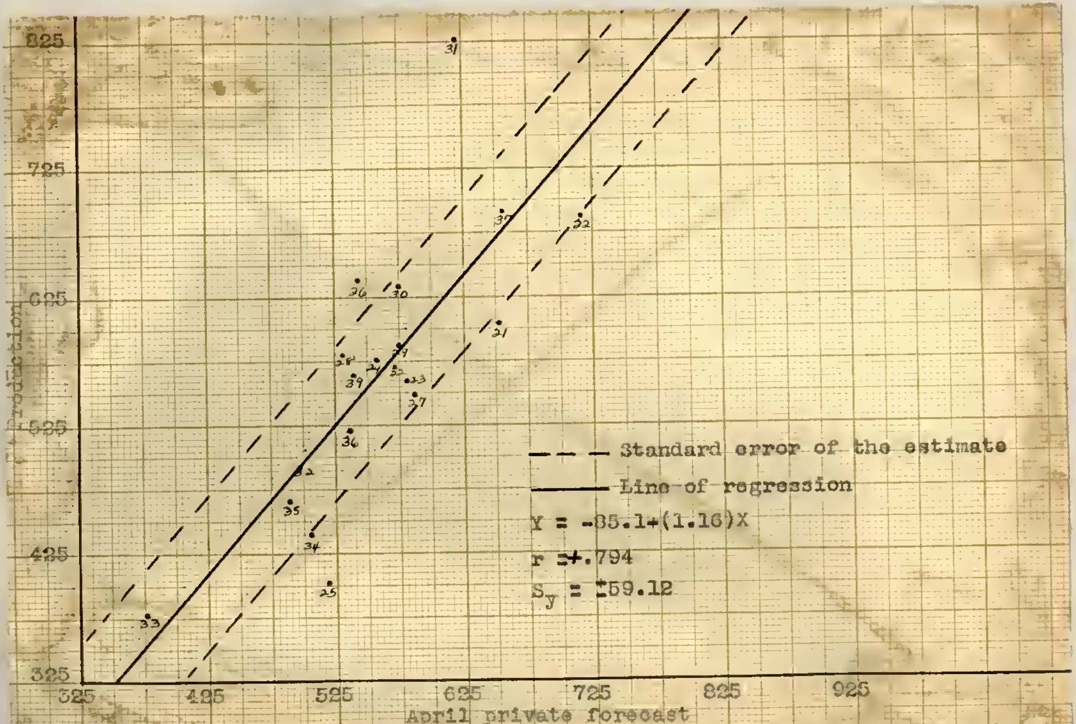

Fig. 24. The relationship of the April private forecast of winter wheat production to production in the United States.

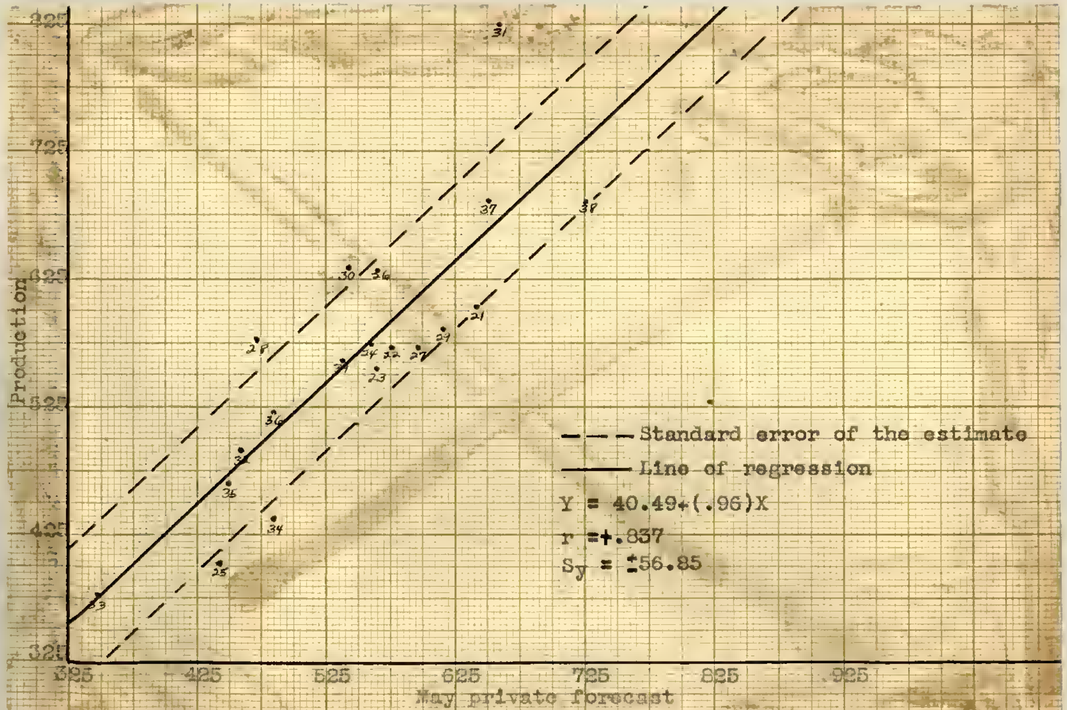

Fig. 25. The relationship of the May private forecast of winter wheat production to production in the United States.

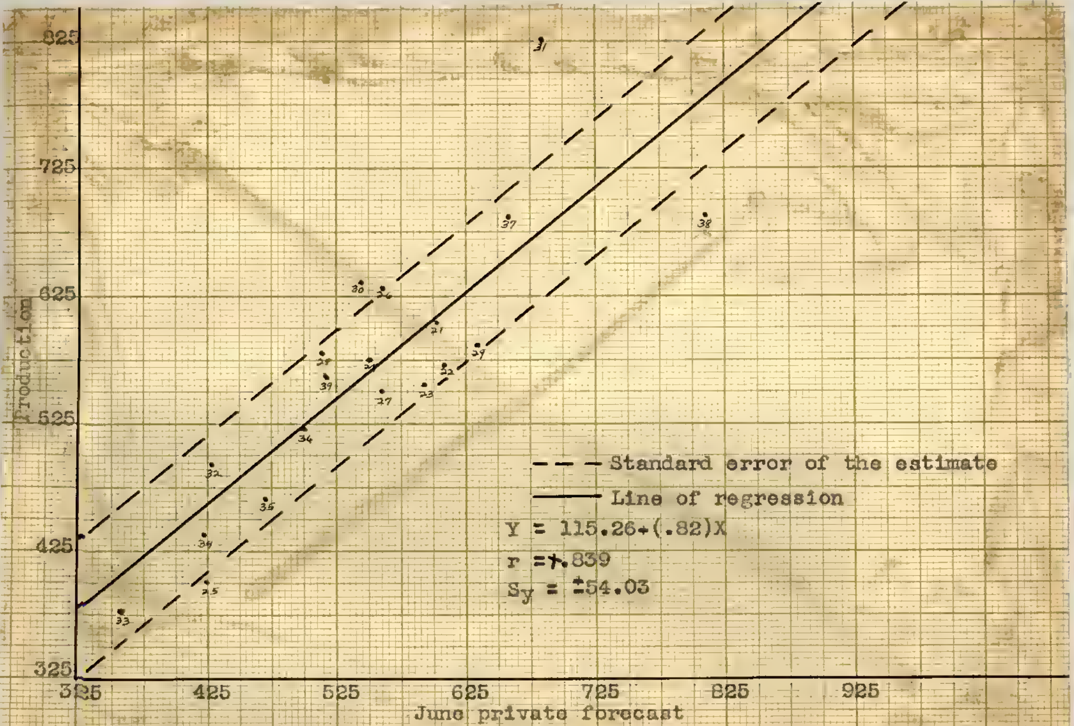

Fig. 26. The relationship of the June private forecast of winter wheat production to production in the United States.

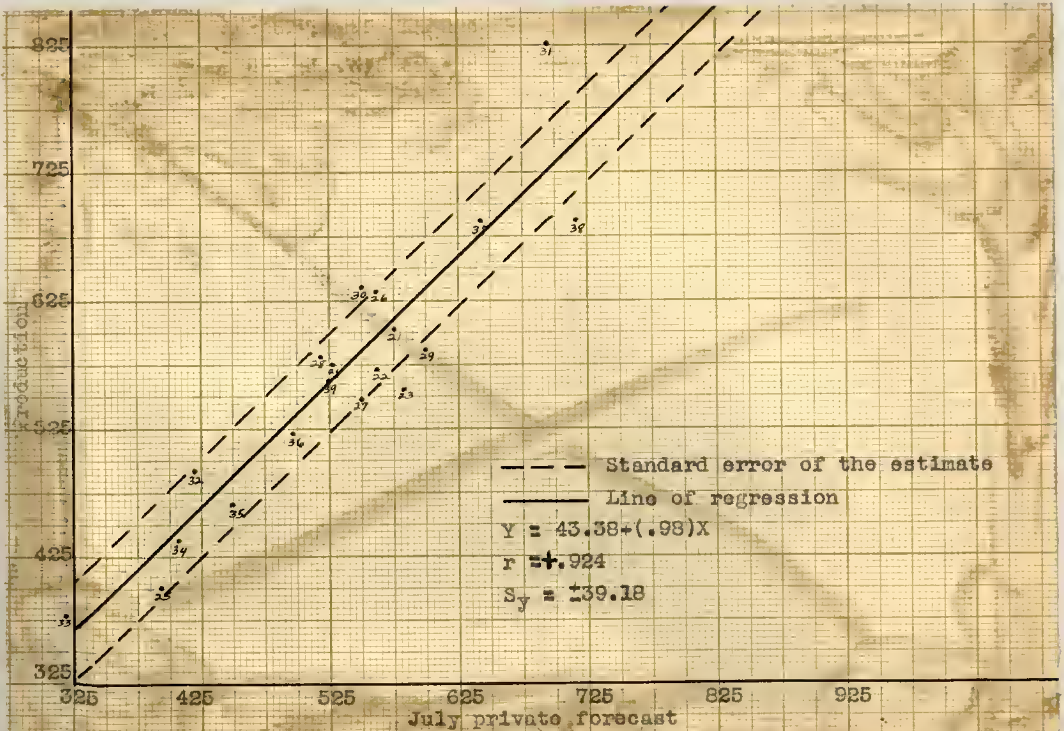

Fig. 27. The relationship of the July private forecast of winter wheat production to production in the United States.

relative accuracy for the other two months depended on the method of measurement used. The correlation method gave the advantage to the government forecasts and the average error method gave the advantage to the private forecasts. The different results given by the two methods were due to the greater relative weight given to the larger errors by the correlation method.

An exceptionally high degree of correlation existed between each monthly forecast for the government and for the private forecasters (Table 13 and Figs. 28 to 31). This indicated that both types of forecasting agencies agreed closely on the probable production at a given time. Apparently the private forecasts and the government forecast were furthest apart in April and gradually agreed more closely as the season progressed. The close agreement between the two types of forecasting agencies indicated that the changes in condition following the time the forecast is made cause the greatest errors in forecasts. Both types of agencies interpreted the conditions existing at a given time in about the same way.

Table 13. Coefficient of correlation, probable error of the coefficient of correlation, and standard error of the estimate for the average of private forecasts and the government forecasts of winter wheat production, 1921-1939.

Factors		r	PEr	Sy
X	Y			
April private forecast	and government forecast	+.976	±.007	±18.03
May private forecast	and government forecast	+.987	±.003	±15.63
June private forecast	and government forecast	+.992	±.002	±13.34
July private forecast	and government forecast	+.993	±.002	±10.22

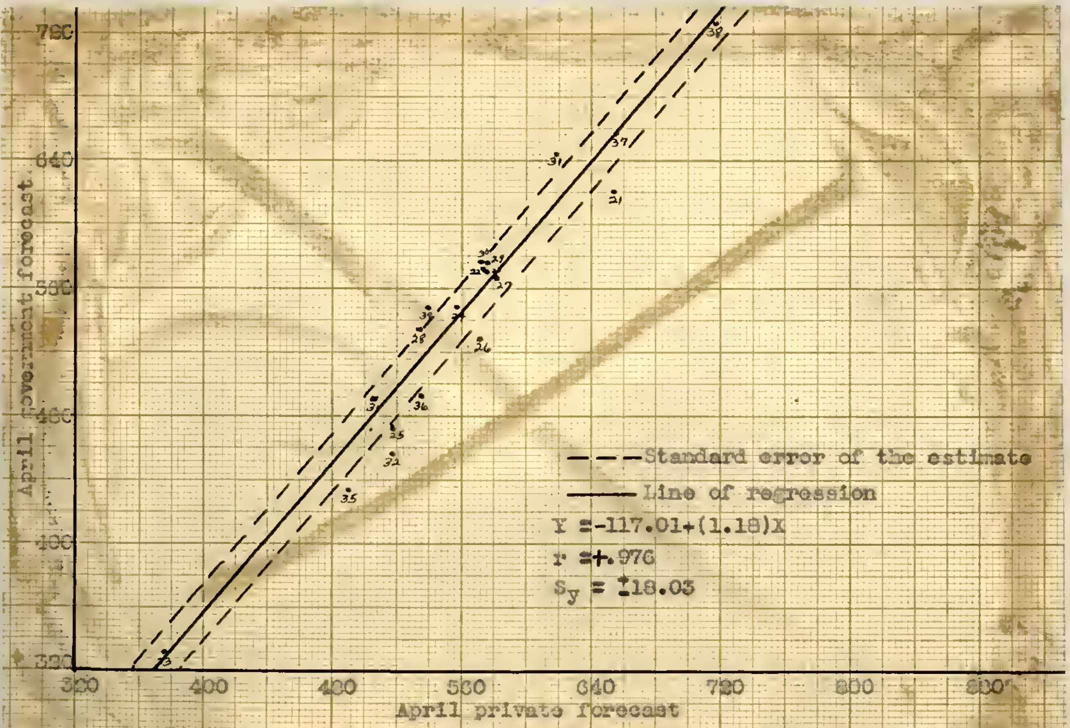

Fig. 28. Relationship of the April government forecast of winter wheat production to the April private forecast of production in the United States.

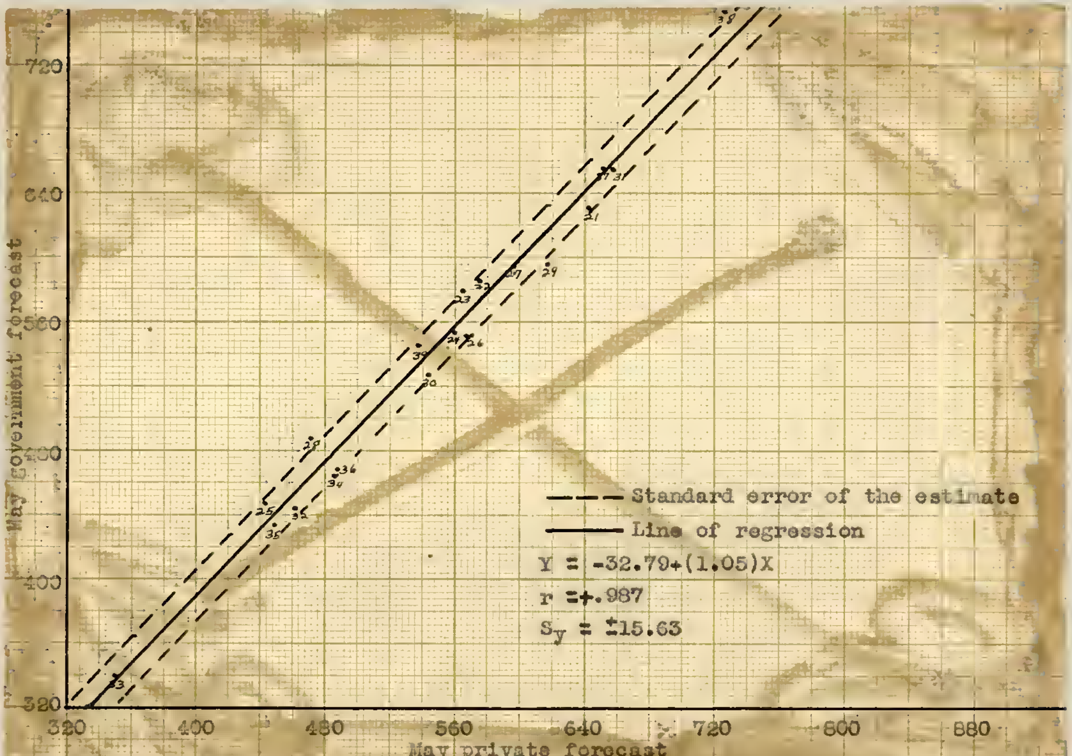

Fig. 23. Relationship of the May government forecast of winter wheat production to the May private forecast of production in the United States.

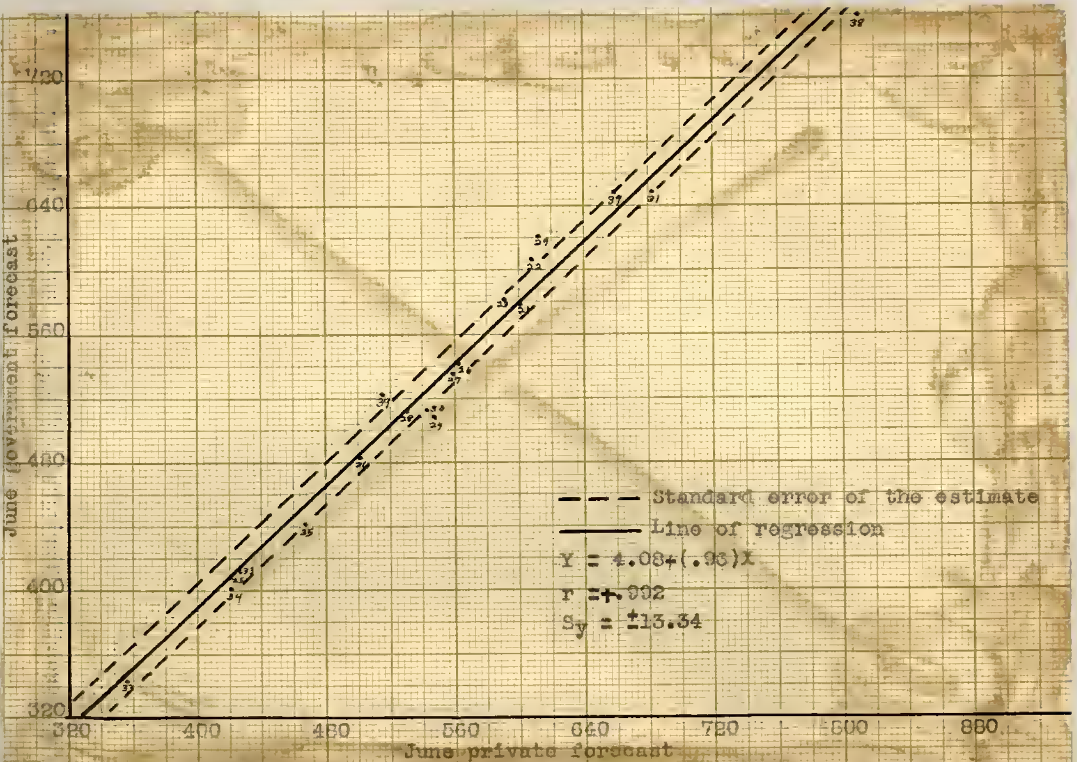

Fig. 30. Relationship of the June government forecast of winter wheat production to the June private forecast of production in the United States.

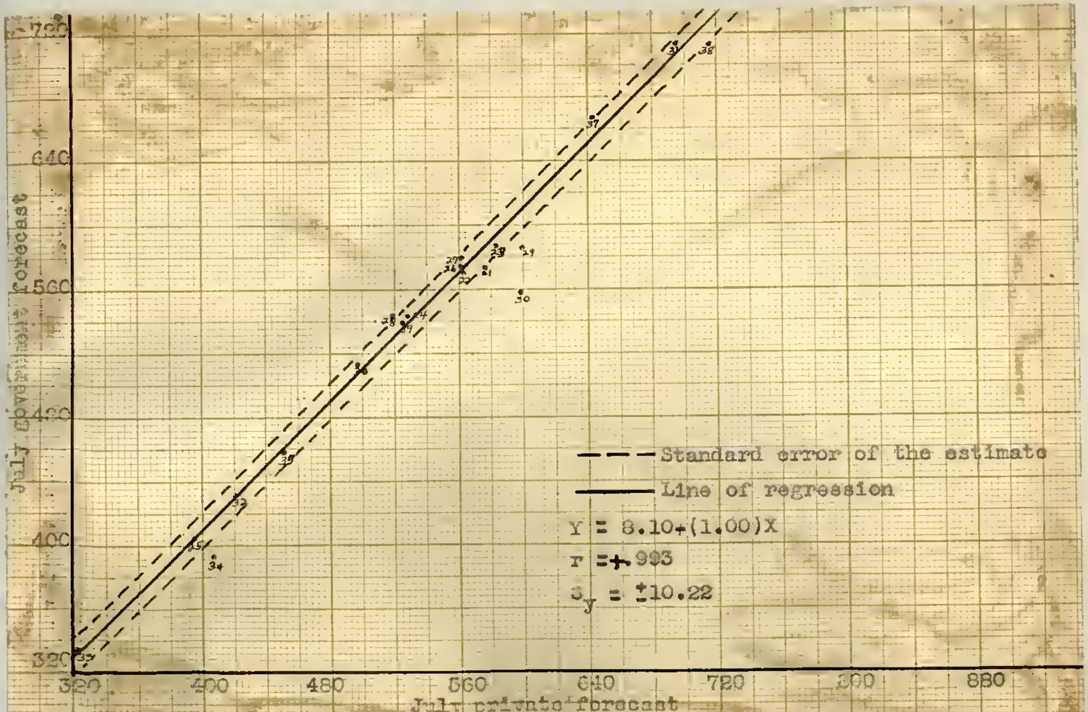

Fig. 31. Relationship of the July government forecast of winter wheat production to the July private forecast of production in the United States.

STUDY OF WINTER WHEAT CROP FORECASTS FOR KANSAS

Relationship of Condition to Yields, Abandonment, and Production of Winter Wheat

The series of condition figures, yield per seeded acre, yield per harvested acre, abandonment, and production for Kansas are shown in Table 14. These data cover the period 1921 to 1939 except that condition figures for April, May, June, and July were not published in 1938 and 1939.

For the 17-year period in which direct comparisons of conditions by months could be made, the averages were: December, 72.94; April, 71.65; May, 74.76; June, 64.71; and July, 65.88. Crop correspondents tended to rate the condition of the crop high in May and much lower in June and July. The month-to-month trend of condition each year was further evidence of this fact. The April condition was higher than the December condition in six years and lower in 11 years. May condition was higher than April condition in 11 years and lower in six years. In four years June condition was higher than May condition and lower in 13 years. July condition was higher than June condition in 11 years and lower in six years.

July condition showed the closest relation of any monthly condition figure to yield per seeded acre. April

Table 14. Government condition figure by months, yield per seeded acre, yield per harvested acre, production and percent abandonment of winter wheat in Kansas, 1921-1939.

Year	Condition/14					Yield/15		Production/16 in millions of bushels	Percent abandonment/15
	Previous December	April	May	June	July	Per seeded acre	Per harvested acre		
1921	88	88	84	60	70	11.6	12.7	134	8.2
1922	60	65	74	75	72	10.1	12.8	125	20.7
1923	73	64	77	65	61	7.3	10.2	84	27.8
1924	84	87	88	68	79	15.4	16.0	157	4.0
1925	76	63	75	59	53	7.4	9.2	80	20.0
1926	84	87	83	70	73	13.2	14.8	154	11.0
1927	80	79	86	58	67	9.0	11.2	114	20.0
1928	81	77	80	81	84	13.6	16.3	173	16.7
1929	82	77	81	78	69	11.8	12.4	155	4.5
1930	92	78	73	69	72	13.6	14.2	186	4.1
1931	90	93	92	83	87	18.1	18.5	252	2.0
1932	70	64	65	50	54	9.3	11.6	120	20.1
1933	57	37	55	50	43	5.1	9.1	67	44.0
1934	64	70	60	47	49	6.6	9.8	84	32.2
1935	71	47	57	58	58	4.8	9.3	64	48.8
1936	81	66	66	70	68	8.4	11.5	120	26.6
1937	80	76	75	59	61	9.2	12.0	158	23.0
1938	73	/17	/17	/17	/17	9.0	10.5	152	14.4
1939	61	/17	/17	/17	/17	8.0	11.5	112	30.1

Sources: /14 Crops and Markets, Weather Crops and Markets and Market Reporter. /15 1921-1923 calculated from U.S.D.A. Yearbooks. 1924-1935 calculated from General Crop Revisions, June, 1936. 1936-1939 calculated from current Crop Reports. /16 1921-1923, U.S.D.A. Yearbooks. 1924-1935, Crop Revisions. 1936-1939 Current Crop Reports. /17 Not published.

condition gave the next best relationship to yield per seeded acre. June condition gave a low coefficient of correlation compared with April, May, and July conditions and only slightly higher than December condition. It seemed significant that there was no improvement in the relationship after April until July when the relationship improved materially. The relationships of condition to yield per seeded acre are shown in Table 15 and Figs. 32 to 36.

A given condition figure would indicate a much higher yield in June or July than in December, April, or May. For example, a condition of 80 would indicate a yield of 11.04 bushels per acre in December, 12.01 bushels in April, 11.68 bushels in May, 14.08 bushels in June, and 14.07 bushels in July.

July condition was the best indicator of yield per harvested acre of any monthly condition figure. This would be expected because the crop usually is ready to harvest by July 1. April condition gave a higher coefficient of correlation with yield per harvested acre than May or June condition. However, the differences between the coefficient of correlation for the April, May, and June condition figure were less than the probable error. December condition showed the poorest relationship with yield per harvested

Table 15. Coefficient of correlation, probable error of the coefficient of correlation, and standard error of the estimate for condition by months and yield per seeded acre for the Kansas winter wheat crop (1921-1939 for December; 1921-1937 for April, May, June, and July).

Factors		r	PEr	Sy
X	Y			
December condition and yield per seeded acre		+.729	±.072	±2.34
April condition and yield per seeded acre		+.851	±.043	±1.95
May condition and yield per seeded acre		+.807	±.056	±2.12
June condition and yield per seeded acre		+.738	±.074	±2.44
July condition and yield per seeded acre		+.889	±.034	±1.68

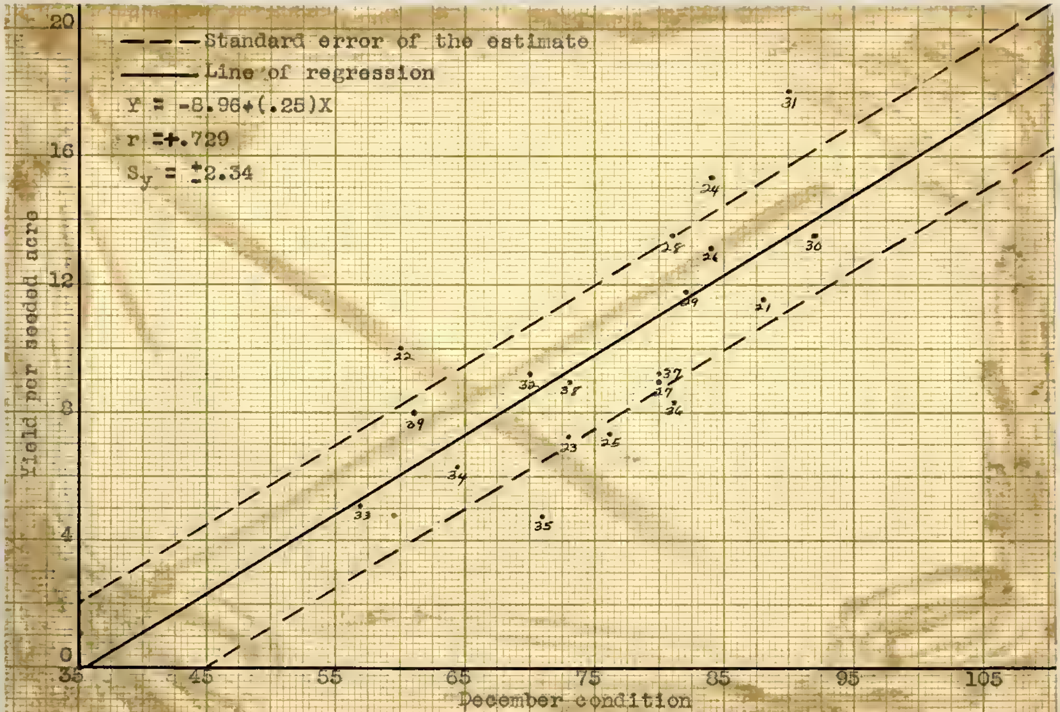

Fig. 32. Relationship of December condition of winter wheat to yield per seeded acre in Kansas.

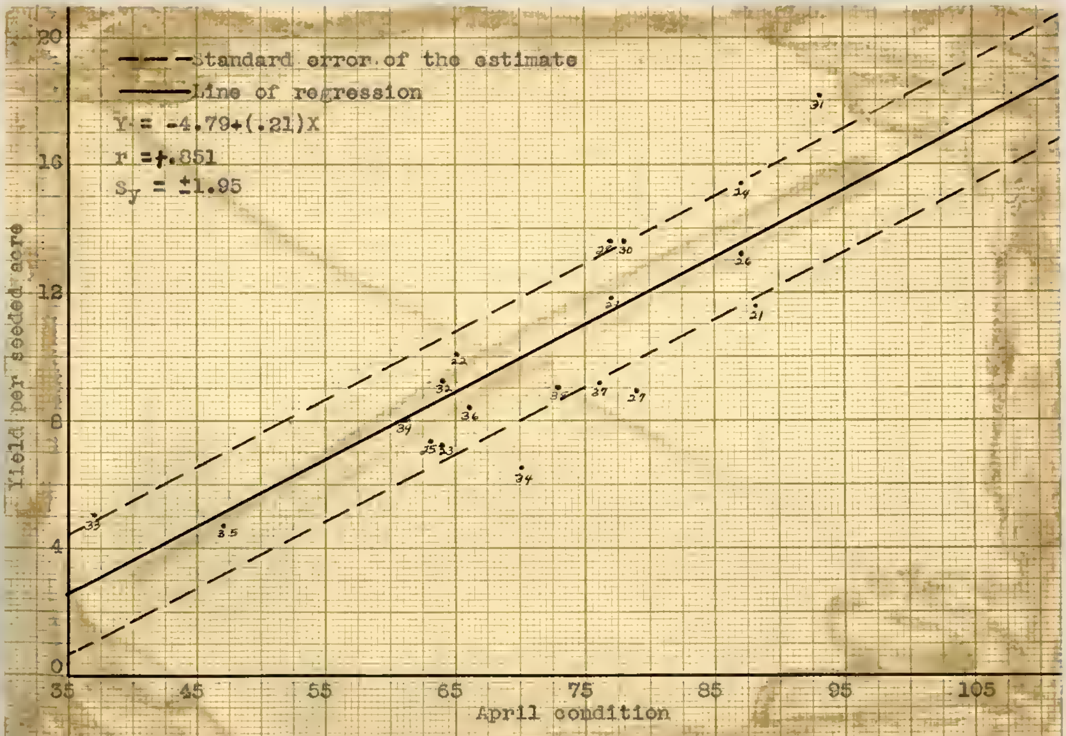

Fig. 33. Relationship of April condition of winter wheat to yield per seeded acre in Kansas.

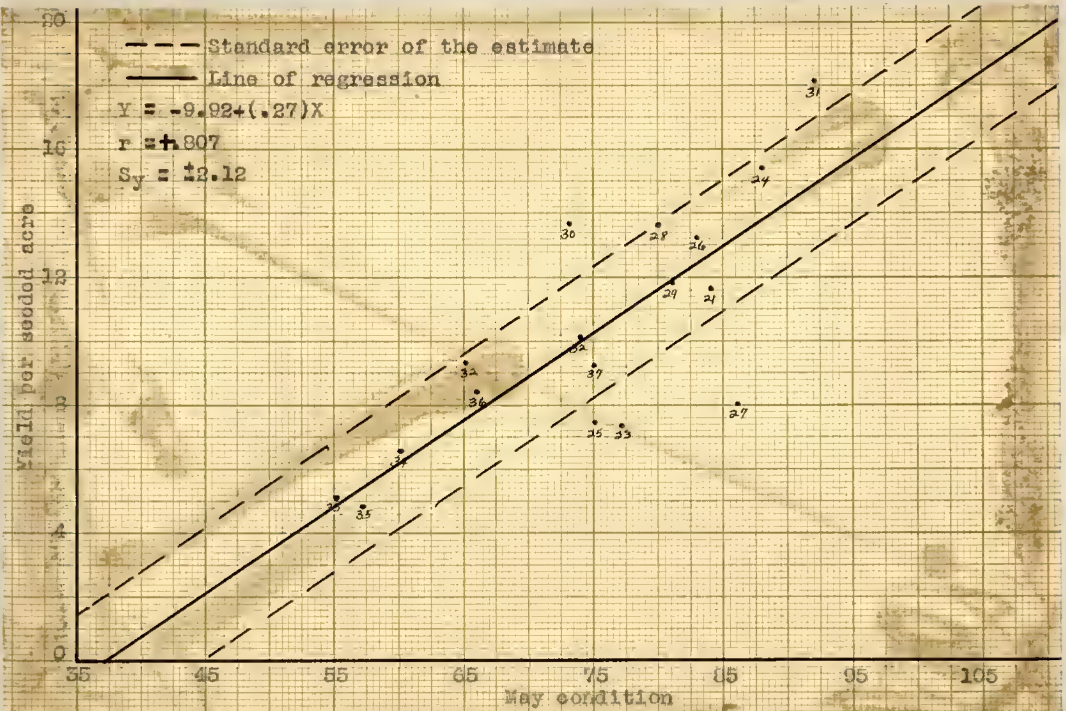

Fig. 34. Relationship of May condition of winter wheat to yield per seeded acre in Kansas.

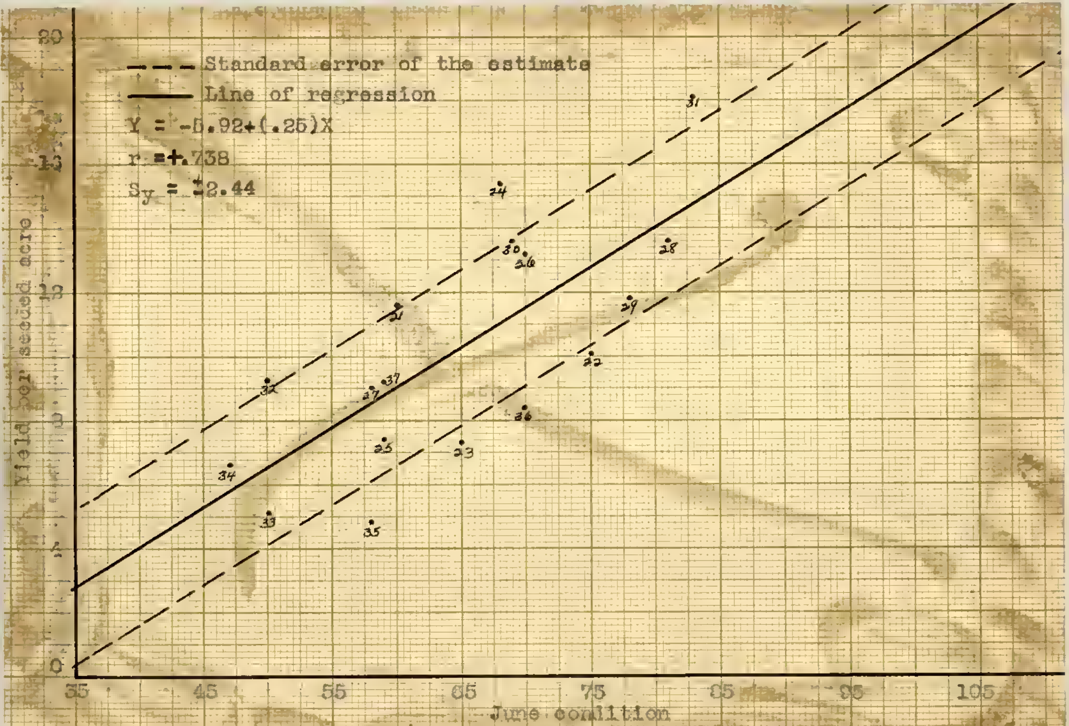

Fig. 35. Relationship of June condition of winter wheat to yield per seeded acre in Kansas.

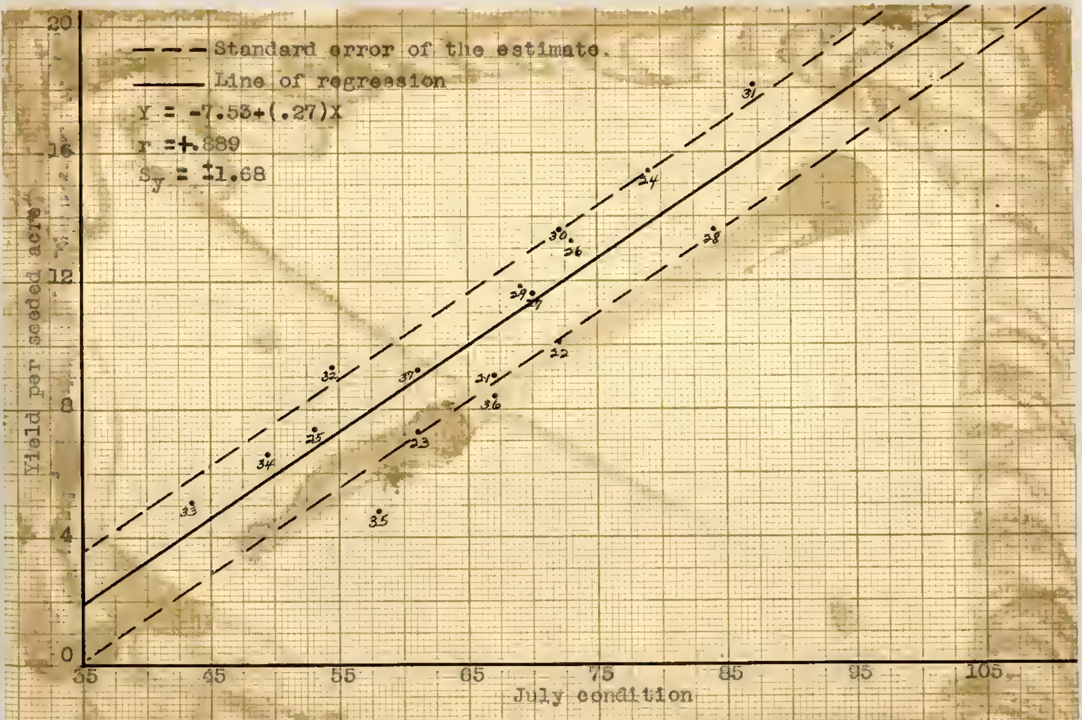

Fig. 36. Relationship of July condition of winter wheat to yield per seeded acre in Kansas.

acre, as would be expected (Table 16 and Figs. 37 to 41).

A condition of 80 would indicate a yield per harvested acre of 12.90 bushels in December, 13.69 bushels in April, 13.38 bushels in May, 15.39 bushels in June, and 15.41 bushels in July.

In general, condition showed a closer relationship to yield per seeded acre in December, April, and May and to yield per harvested acre in June and July. These results would be expected, except for May when crop correspondents are supposed to be reporting condition on the acreage remaining for harvest. Apparently the abandonment after May 1 limited the relationship of May condition to yield per harvested acre.

April condition gave an exceptionally high coefficient of correlation with abandonment. May condition showed a slightly lower relationship. December condition, with a coefficient of correlation of -.736, was a satisfactory indicator of abandonment early in the season (Table 17 and Figs. 42 to 45).

Table 16. Coefficient of correlation, probable error of the coefficient of correlation, and standard error of the estimate for condition by months and yield per harvested acre for the Kansas winter wheat crop (1921-1939 for December; 1921-1937 for April, May, June, and July).

Factors X	Factors Y	r	PEr	Sy
December condition	and yield per harvested acre	+.682	±.032	±2.00
April condition	and yield per harvested acre	+.773	±.065	±1.65
May condition	and yield per harvested acre	+.723	±.078	±1.86
June condition	and yield per harvested acre	+.756	±.069	±1.74
July condition	and yield per harvested acre	+.912	±.027	±1.03

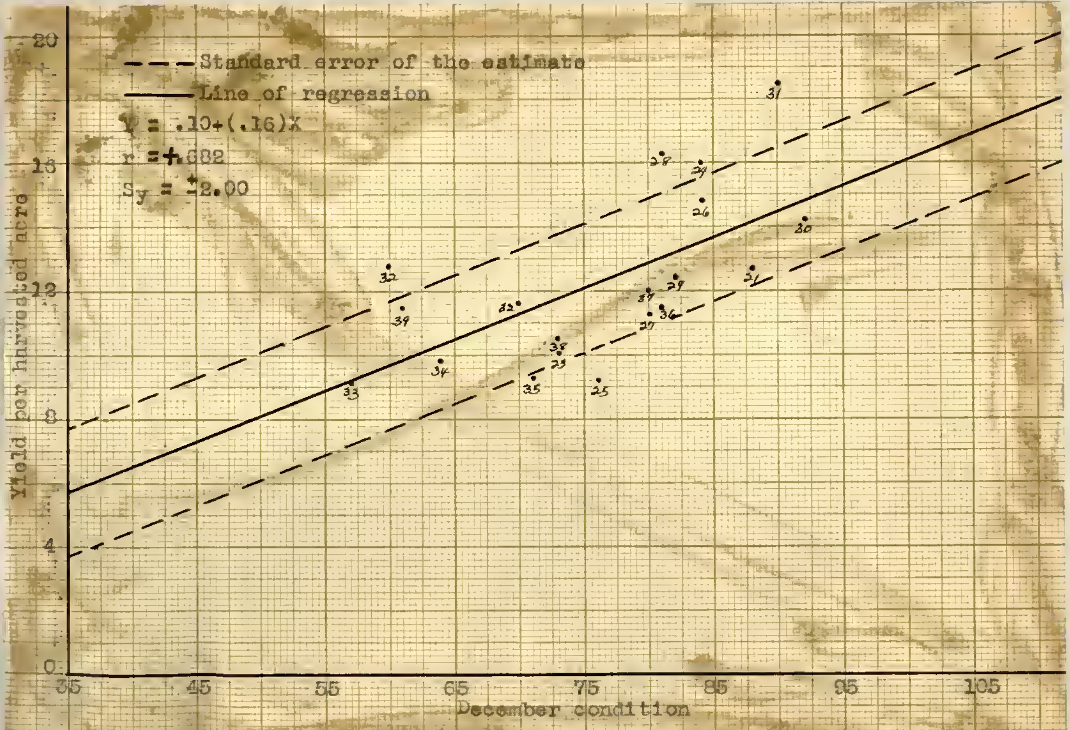

Fig. 37. Relationship of December condition of winter wheat to yield per harvested acre in Kansas.

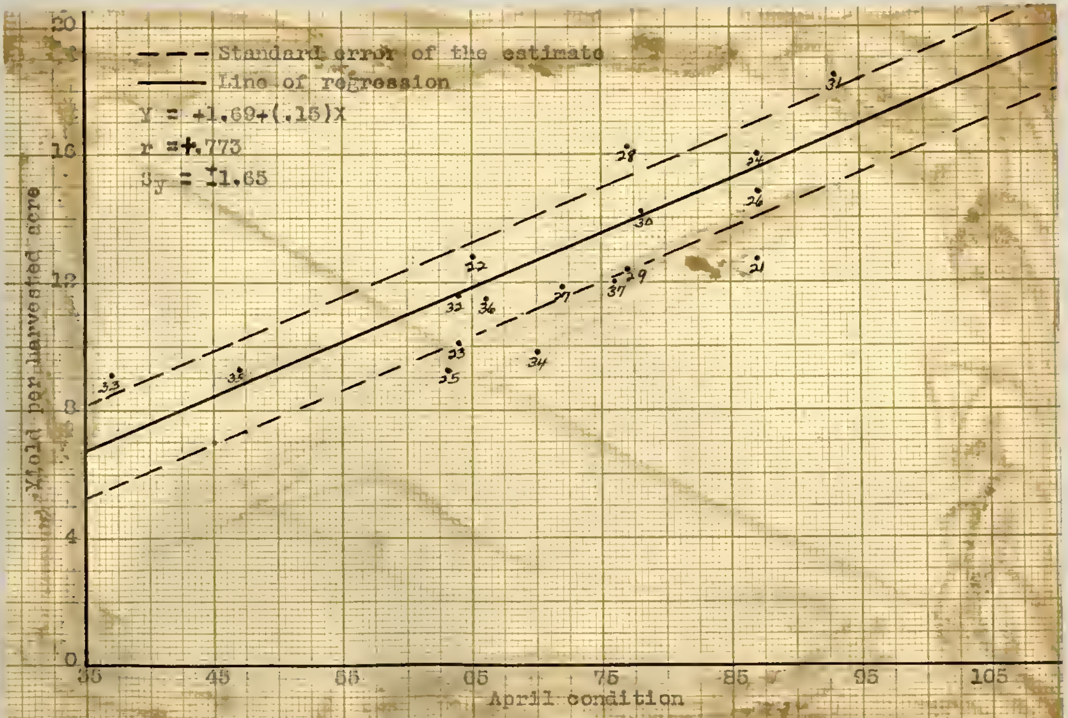

Fig. 38. Relationship of April condition of winter wheat to yield per harvested acre in Kansas.

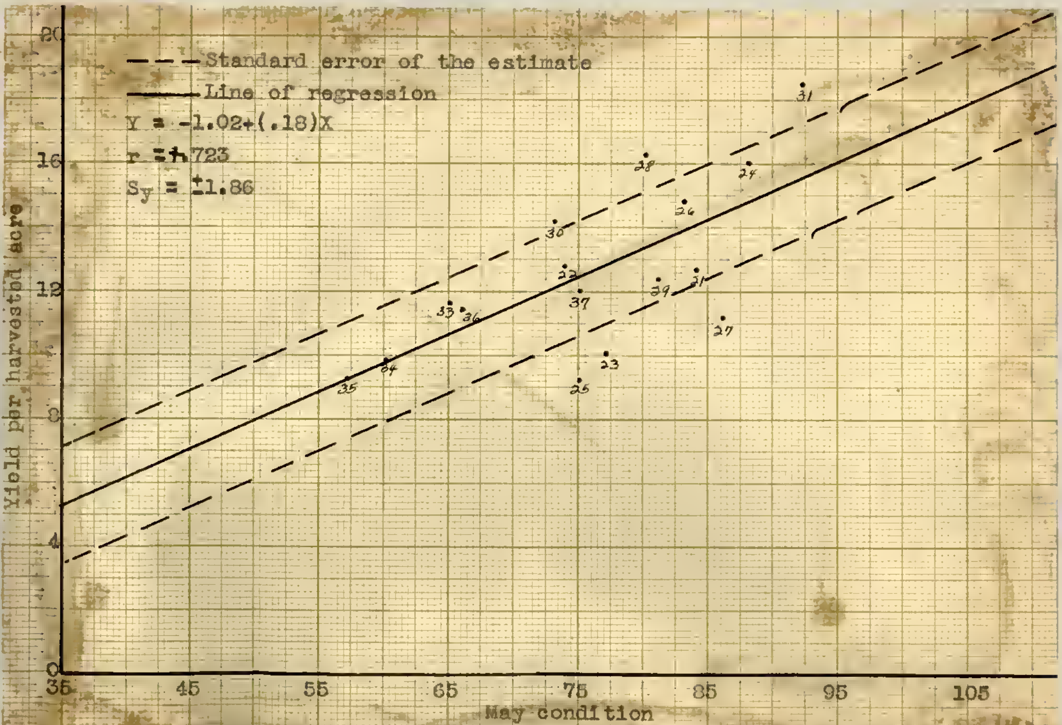

Fig. 39. Relationship of May condition of winter wheat to yield per harvested acre in Kansas.

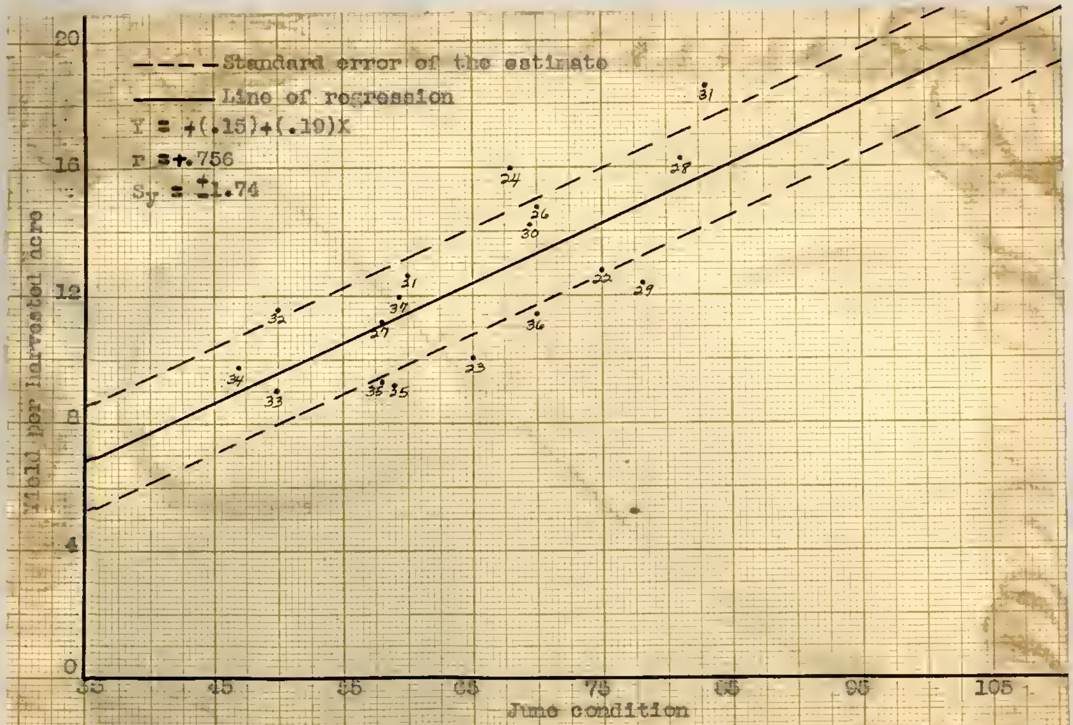

Fig. 40. Relationship of June condition of winter wheat to yield per harvested acre in Kansas.

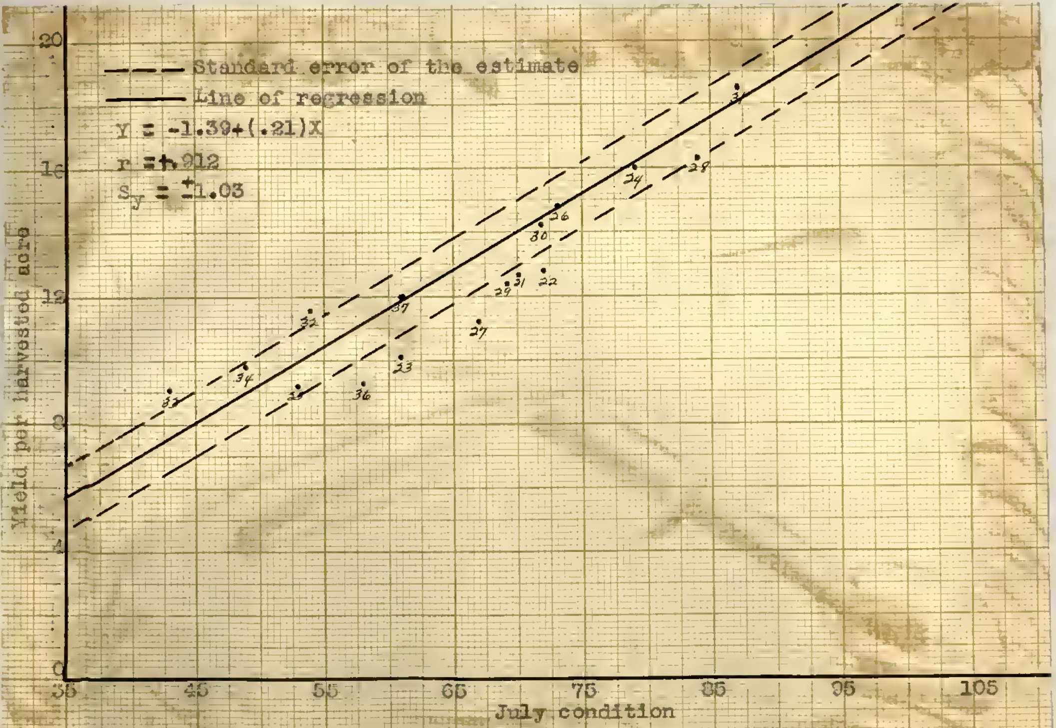

Fig. 41. Relationship of July condition of winter wheat to yield per harvested acre in Kansas.

Table 17. Coefficient of correlation, probable error of the coefficient of correlation, and standard error of the estimate for condition by months and percent of winter wheat acreage abandoned in Kansas (1921-1939 for December; 1921-1937 for April, May, June, and July).

Factors X	Factors Y	r	PEr	Sy
December condition	and abandonment	-.736	±.071	± 8.56
April condition	and abandonment	-.905	±.029	± 5.93
May condition	and abandonment	-.863	±.041	± 6.99
June condition	and abandonment	-.635	±.097	±10.34

July condition showed the best relationship of any monthly condition figure with production. The coefficient of correlation for April condition was somewhat lower, the difference between the coefficient of correlation for July and April conditions being about equal to the probable error. May and December condition gave a relatively low coefficient of correlation compared with the other months (Table 18 and Figs. 46 to 50).

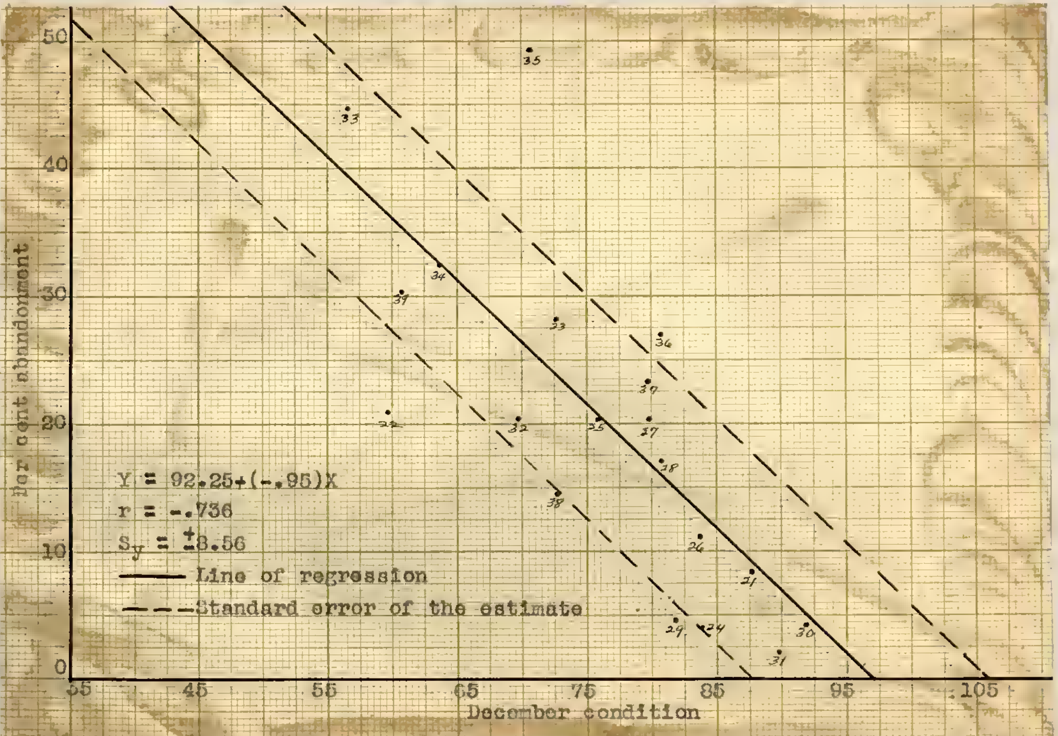

Fig. 42. Relationship of December condition of winter wheat to per cent of the seeded acreage abandoned in Kansas.

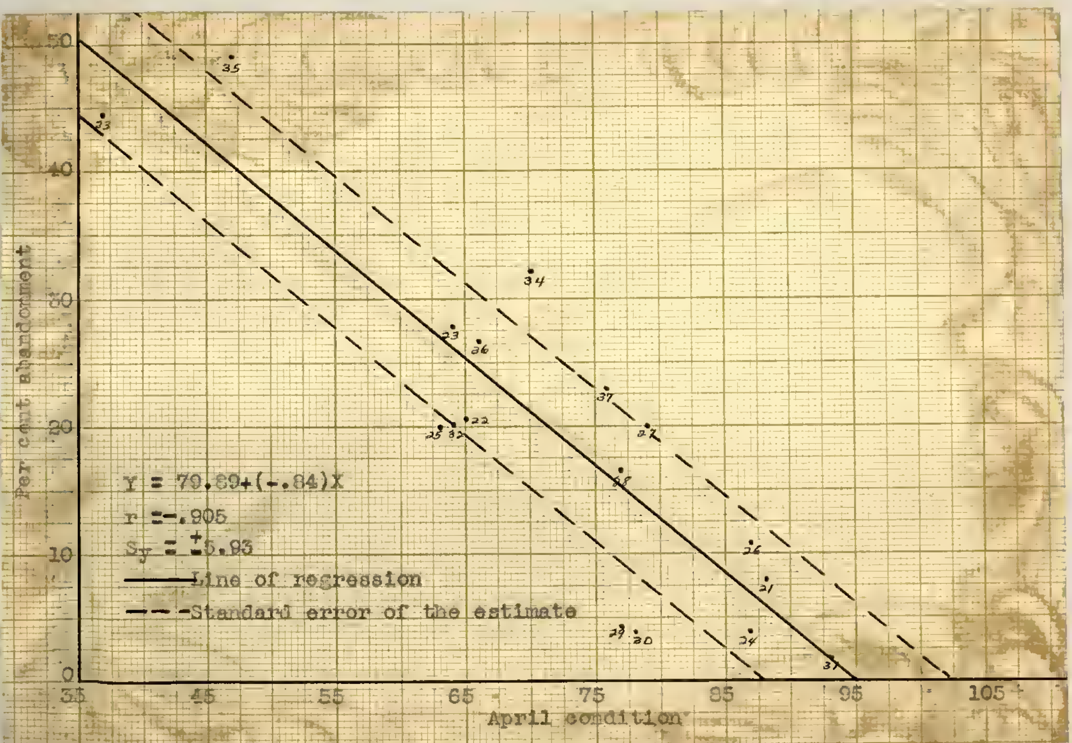

Fig. 43. Relationship of April condition of winter wheat to per cent of the seeded acreage abandoned in Kansas.

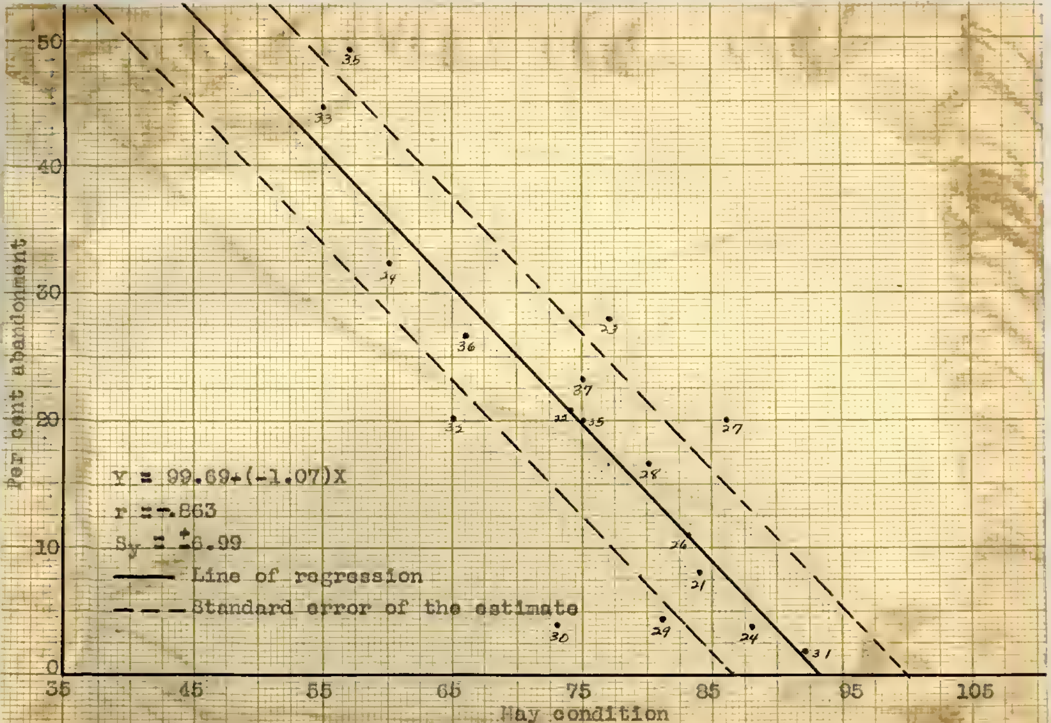

Fig. 44. Relationship of May condition of winter wheat to per cent of the seeded acreage abandoned in Kansas.

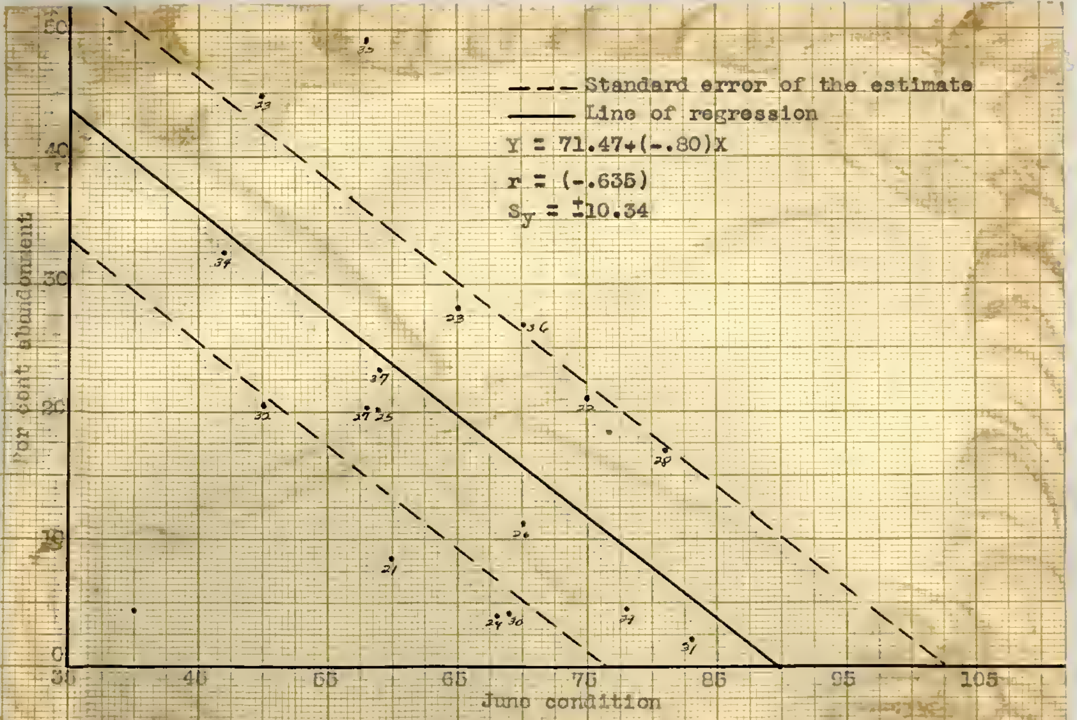

Fig. 25. Relationship of June condition of winter wheat to per cent of the seeded acreage abandoned in Kansas.

Table 18. Coefficient of correlation, probable error of the coefficient of correlation, and standard error of the estimate for condition by months for condition and total production of winter wheat in Kansas (1921-1939 for December; 1921-1937 for April, May, June, and July).

Factors X	Factors Y	r	PEr	Sy
December condition	and production	+.694	±.080	±32.57
April condition	and production	+.787	±.062	±29.22
May condition	and production	+.697	±.084	±34.40
June condition	and production	+.725	±.078	±32.63
July condition	and production	+.831	±.051	±26.32

In summarizing the relationships of the monthly condition figures to yields, abandonment, and production, it may be noted that July condition gave the closest relationship to yield per seeded acre, yield per harvested acre, and production. April condition gave the highest coefficient of correlation with abandonment and second highest with yield per seeded acre, yield per harvested acre, and production. There seemed to be no improvement in the relationships after April until July. December condition gave a highly significant coefficient of correlation in all cases.

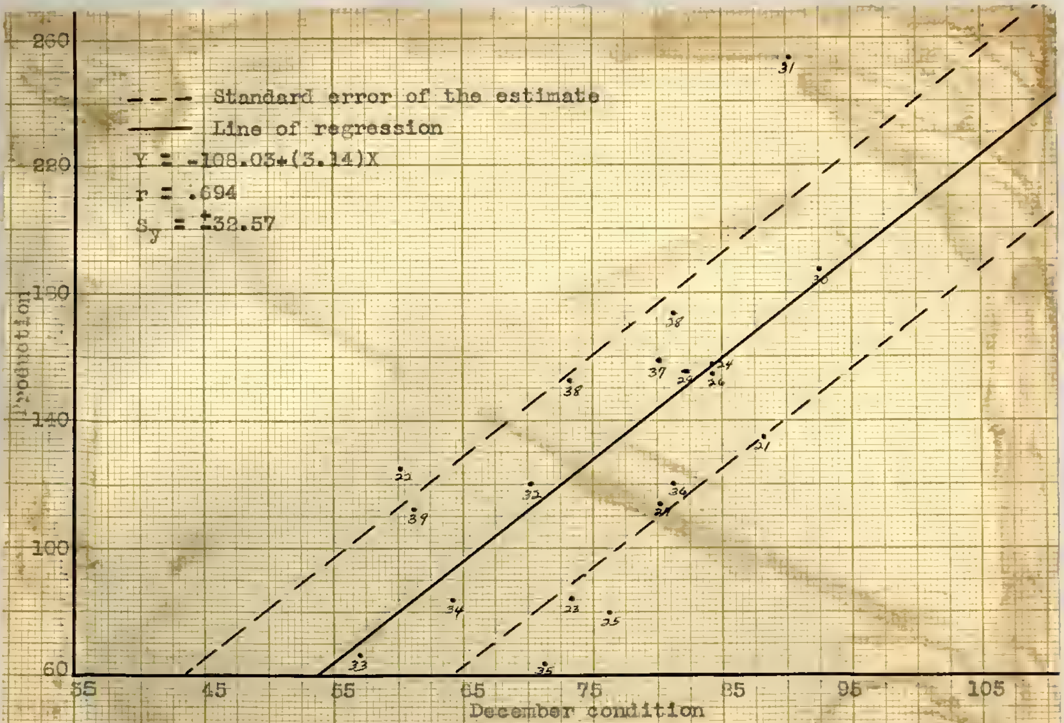

Fig. 46. Relationship of December condition of winter wheat to total production in Kansas.

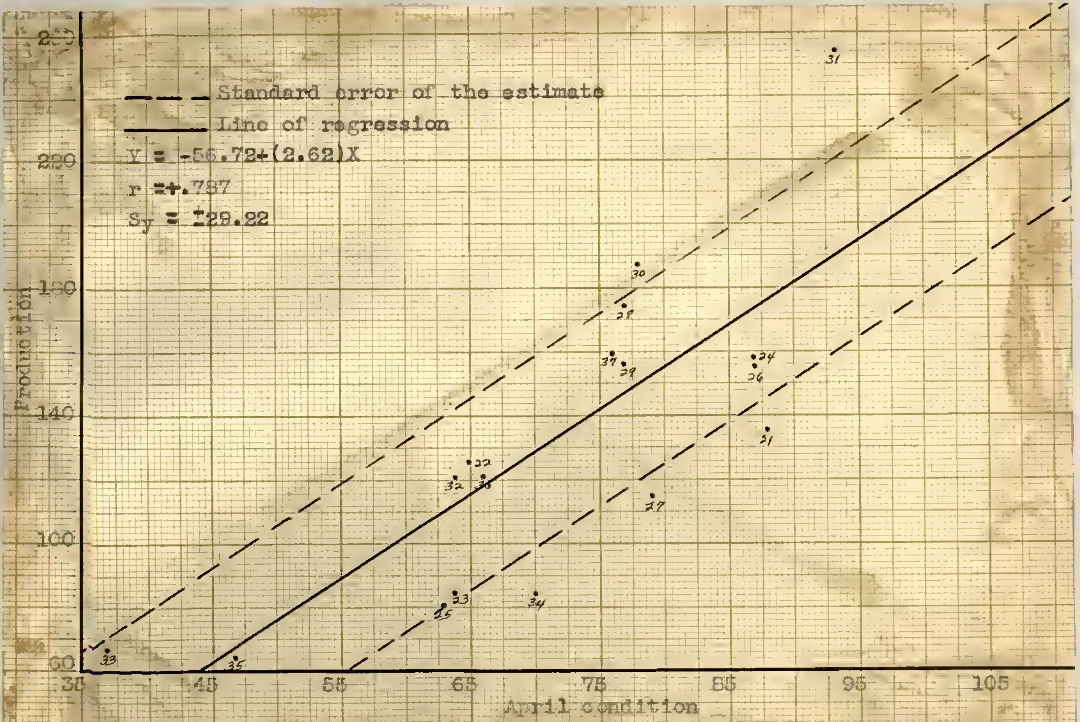

Fig. 47. Relationship of April condition of winter wheat to total production in Kansas.

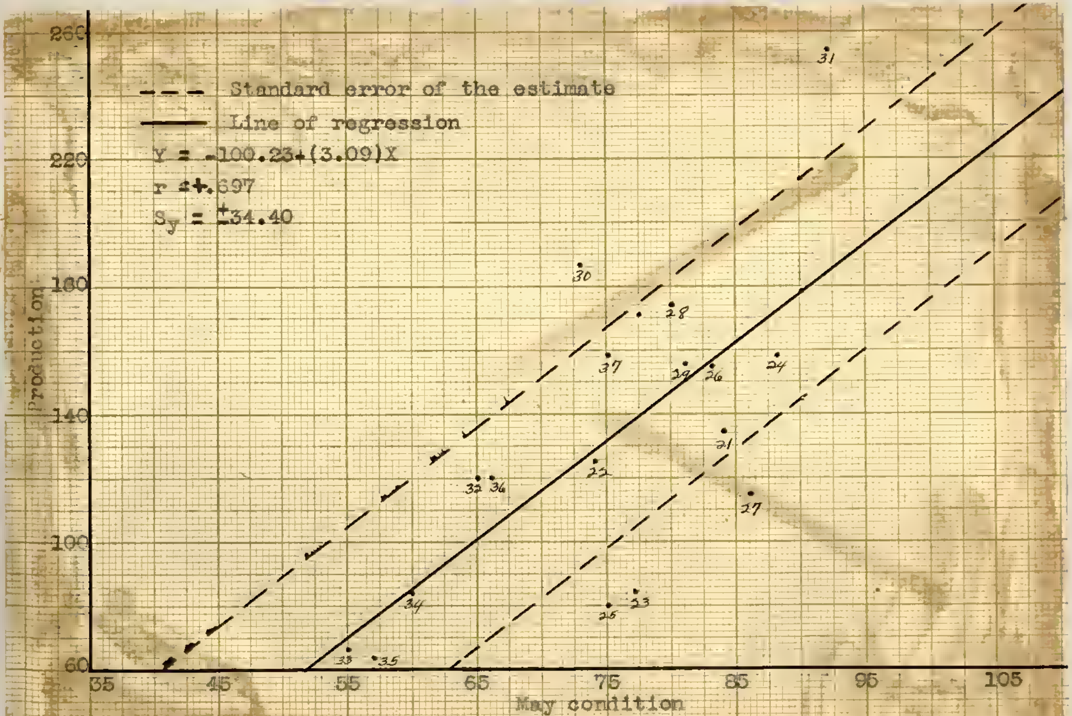

Fig. 48. Relationship of May condition of winter wheat to total production in Kansas.

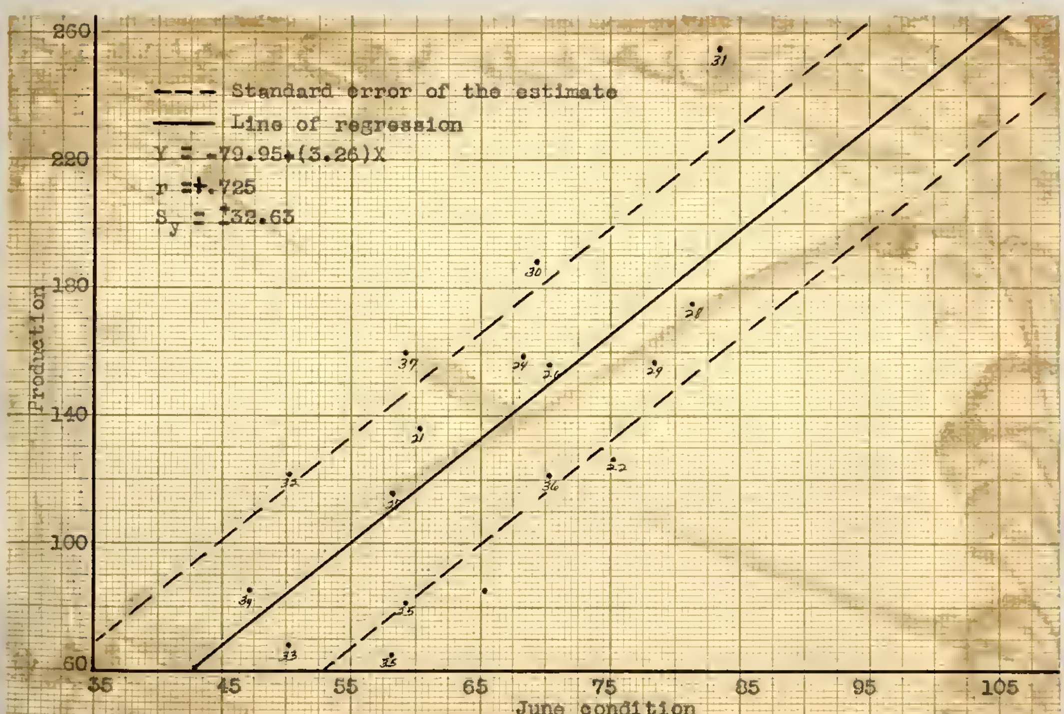

Fig. 49. Relationship of June condition of winter wheat to total production in Kansas.

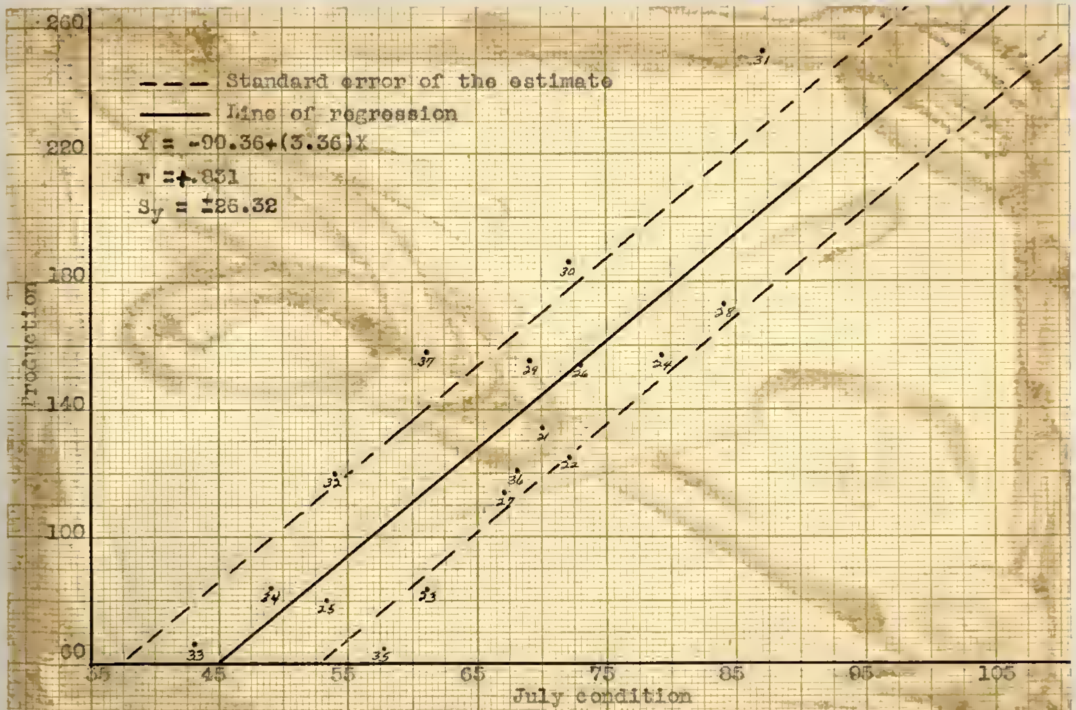

Fig. 50. Relationship of July condition of winter wheat to total production in Kansas.

In contrasting the relationship of condition to yields, abandonment, and production in Kansas, one outstanding difference may be noted. The July condition figure gave a much higher coefficient of correlation in all cases for Kansas than for the United States. In general, all the relationships were better for Kansas than for the United States. This was particularly true for condition and yield per harvested acre. The fact that production conditions were more nearly homogeneous for Kansas than for the United States may explain the closer relationships.

A point of similarity in the results for Kansas and the United States is that there apparently was little improvement in the relationships for May and June condition compared with April condition.

Accuracy of Government Forecasts of Winter Wheat Production

Forecasts of winter wheat production in Kansas were published by the government crop reporting service for the months of May, June, and July for the period under consideration. In recent years, forecasts were also made in April but the series did not include enough years for a reliable measurement of accuracy. An adequate series of private forecasts of winter wheat production in Kansas could not be obtained.

Forecasting winter wheat production in Kansas from rainfall has been studied in the Department of Agricultural Economics in the Kansas Agricultural Experiment Station since 1929. Unpublished forecasts based on fall rainfall have been made since 1934. Indicated production based on fall rainfall for the period 1922 to 1939 is shown in Table 19, along with government forecasts of production and production for Kansas.

The averages of the government forecasts for the 19-year period by months were: May, 124.74 million bushels; June, 117.58 million bushels; and July, 119.89 million bushels. An analysis of the month-to-month trend of the forecast for each year showed that in seven years the June forecast was the same as, or larger than, the May forecast and smaller in 12 years. The July forecast was the same as, or larger than, the June forecast in 13 years and smaller in six years. There seemed to be a tendency for the June forecast to be smaller than the forecast for the other months.

The May forecast was greater than production in 10 years and less in nine years. The June forecast was greater

Table 19. Government forecasts by months for Kansas, forecasts based on fall rainfall and production (1921-1939 for government forecasts and production; 1922-1929 for forecasts based on fall rainfall).

Year	Government Forecasts/18			Forecast based on fall rainfall/19	Production/20
	May	June	July		
1921	136	103	120	---	134
1922	106	117	109	92	125
1923	115	105	97	103	84
1924	134	113	130	150	157
1925	96	84	74	87	80
1926	142	133	140	145	154
1927	143	108	123	135	114
1928	143	158	168	137	173
1929	148	161	138	153	155
1930	135	137	147	180	186
1931	174	168	201	209	252
1932	87	72	82	107	120
1933	58	57	57	79	67
1934	99	80	80	97	84
1935	67	67	68	121	64
1936	115	130	131	141	120
1937	163	142	138	174	158
1938	193	193	164	154	152
1939	116	106	111	102	112

Sources: /18 Market Reporter, 1921; Weather Crops and Markets, 1922-1924; Crops and Markets, 1925-1938; Current Crop Reports, 1939. /19 Not published; taken from files of Dept. of Agr. Economics, Kansas Agr. Expt. Sta. /20 Yearbooks of Agriculture, 1921-1923; General Crop Revisions, 1924-1935; Agricultural Statistics, 1936-1938; Current Crop Report, 1939.

than production in six years and less in 13 years. In July the forecast was larger than production in five years and smaller in 14 years. Of the 57 monthly government forecasts, 20 were larger than production and 37 were smaller than production. The tendency was to underestimate the size of the crop.

The errors in each of the monthly forecasts are shown in Table 20. The July forecast had the smallest average error while the June forecast had the largest average error, indicating that the June forecast was the least nearly accurate and the July forecast the most nearly accurate. However, the difference in the accuracy of the May and June forecasts was relatively small.

The results of the correlation method are shown in Table 21 and Figs. 51 to 53. The July forecast gave the highest coefficient of correlation of the three monthly forecasts. The difference in the coefficient of correlation for May and June was only slight and well within the probable error, so the difference was not significant.

Table 20. Percentage error of each government forecast of winter wheat production for Kansas and the average error for each monthly forecast, 1921-1939.

Year	May	June	July
1921	+ 1.4	-23.2	-10.5
1922	-15.2	- 6.4	-12.8
1923	+36.9	+25.0	+15.4
1924	-14.7	-28.1	-17.2
1925	+20.0	+ 5.0	- 7.5
1926	- 7.8	-13.7	- 9.1
1927	+25.4	- 5.5	+ 7.4
1928	-17.4	- 8.7	- 2.9
1929	- 4.6	+ 3.8	-11.0
1930	-27.5	-26.4	-21.0
1931	-31.3	-33.6	-20.6
1932	-27.5	-40.0	-31.7
1933	-13.5	-15.0	-15.0
1934	+17.8	- 4.8	- 4.8
1935	+ 4.6	+ 4.6	+ 6.2
1936	- 4.2	+ 8.3	+ 9.1
1937	+ 3.1	-10.2	-12.7
1938	+26.9	+26.9	+ 7.8
1939	+ 3.5	- 5.4	- 0.9
Average error in percent of average production	16.6	17.2	12.5

Table 21. Coefficients of correlation, probable errors of the coefficient of correlation, and standard errors of the estimate for government forecasts of winter wheat production in Kansas, 1921-1939.

Factors X	Y	r	PEr	Sy
May forecast	and production	+.783	±.059	±28.13
June forecast	and production	+.790	±.058	±27.83
July forecast	and production	+.928	±.021	±16.77

Accuracy of Forecasts of Winter Wheat Production Based on Fall Rainfall

The accuracy of the forecasts each year based on fall rainfall are shown in Table 22. The average error in percent of average production was 13.38 percent.

The results of the correlation method are shown in Table 23 and Fig. 54. The high coefficient of correlation for this method of forecasting indicated a high degree of accuracy.

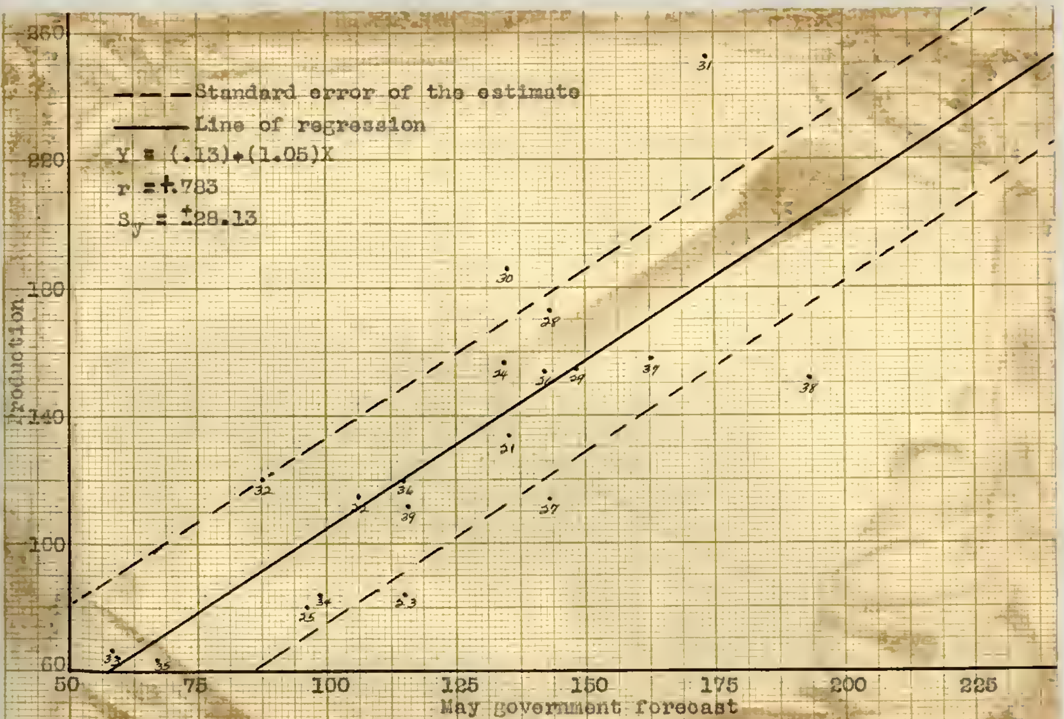

Fig. 51. Relationship of the May government forecast of winter wheat production to production in Kansas.

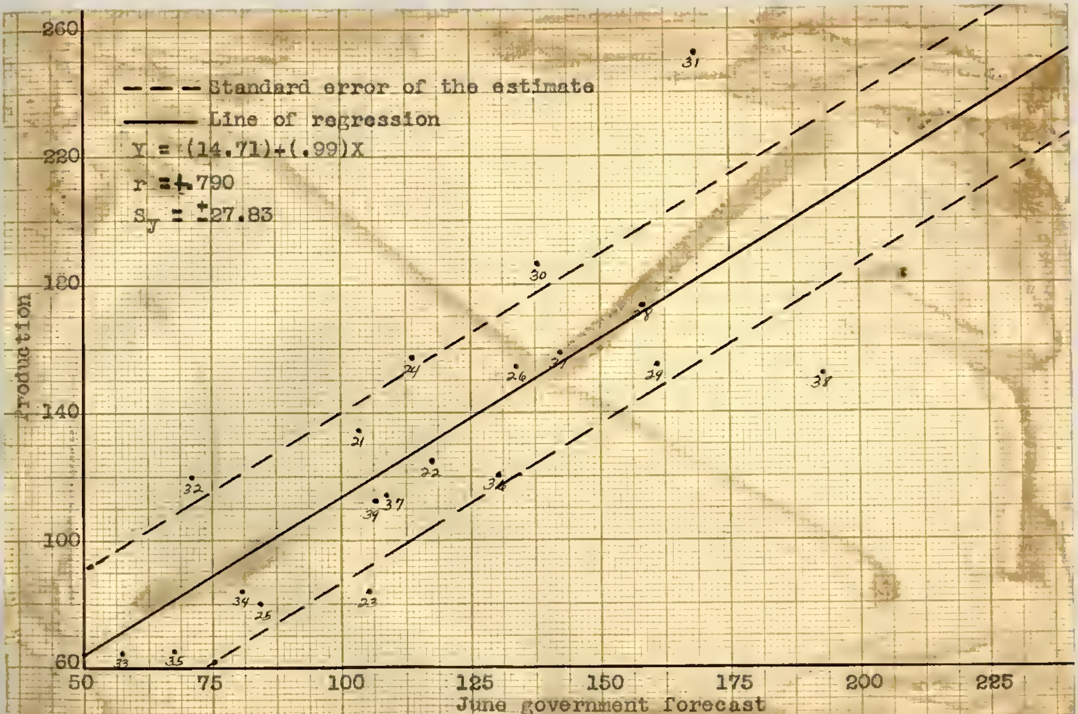

Fig. 52. Relationship of the June government forecast of winter wheat production to production in Kansas.

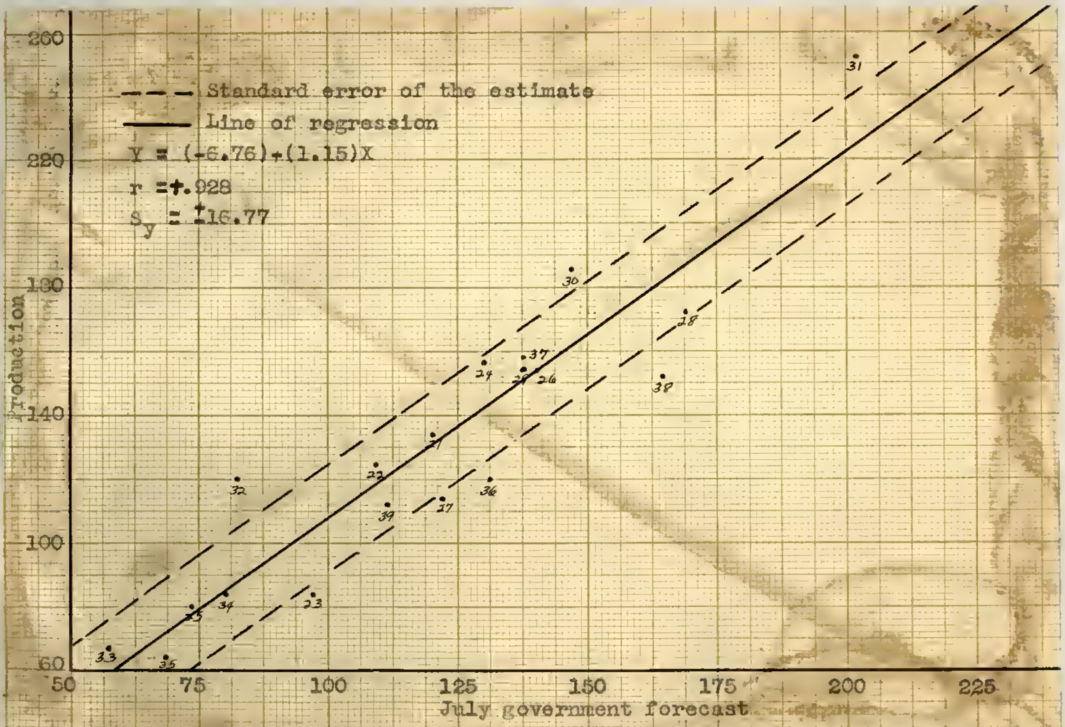

Fig. 53. Relationship of the July government forecast of winter wheat production to production in Kansas.

Table 22. Percentage error of each of the forecasts of winter wheat production in Kansas based on fall rainfall and average error in percent of average production, 1922 to 1939.

Year	Error
1922	-26.4
1923	+22.6
1924	- 4.5
1925	+ 8.7
1926	- 5.9
1927	+18.4
1928	-20.9
1929	- 1.3
1930	- 3.3
1931	-17.1
1932	-10.9
1933	+17.9
1934	+15.4
1935	+89.0
1936	+17.5
1937	+10.1
1938	+ 1.3
1939	- 9.0
Average error in percent of average production	13.88

Table 23. Coefficient of correlation, probable error of the coefficient of correlation, and standard error of the estimate for forecasts of winter wheat production in Kansas based on fall rainfall, 1922-1939.

Factors X	Factors Y	r	PEr	Sy
Forecast based on fall rainfall	and production	+.875	±.037	±19.13

Comparison of the Accuracy of Government Forecasts and Forecasts of Winter Wheat Production Based on Fall Rainfall

In comparing the accuracy of the forecasts based on fall rainfall with the government forecasts, it may be seen that the forecast based on fall rainfall compared favorably with the government forecasts in May and June but was less accurate than the government July forecast. Considering the fact that the forecast based on fall rainfall can be made in December and the high degree of accuracy of this method, it would seem to be of considerable value.

A large proportion of the hard winter wheat crop of the United States is produced in Kansas and in regions near to and similar in climate to central and western Kansas. It may be possible to forecast the winter wheat production in

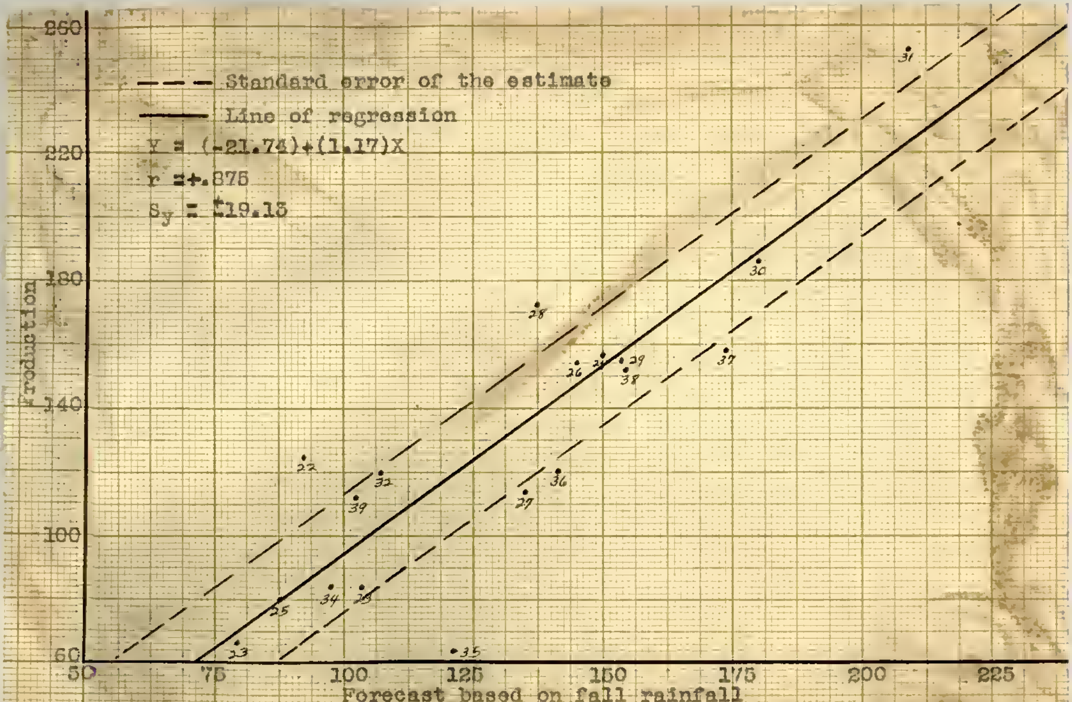

Fig. 54. Relationship of the forecast of winter wheat production in Kansas based on fall rainfall to production.

the more important winter wheat producing states by a similar method. During recent years the government has been measuring the depth of soil moisture at seeding time in Kansas and to some extent in other areas. When these data cover a longer period of years, they should furnish some valuable information that can be used in making earlier forecasts and more nearly accurate forecasts.

The five greatest errors in the government crop forecasts were in 1932, 1923, 1931, 1924, and 1938. The five greatest errors in the forecasts based on fall rainfall were in 1935, 1922, 1923, 1928, and 1927. The 1923 crop is the only one which appears in both groups. By combining the use of rainfall data and condition figures, it may be possible to avoid the extremely large errors which have been made in forecasting winter wheat production in Kansas. If there is inadequate subsoil moisture but adequate surface soil moisture for a short period of time, the crop may appear to be in better condition than subsoil moisture would justify and reported condition might indicate a yield which is too high. On the other hand, in years when the moisture supply is adequate for all purposes but there is extensive damage from insects, diseases, or late frost, a forecast based on fall rainfall might be in great error.

SUMMARY AND CONCLUSIONS

1. Crop reporters tended to lower their opinions of the condition of the winter wheat crop as it approached maturity.

2. Little or no improvement was made in the relationship of condition of the United States winter wheat crop to yields, abandonment, or production after April.

3. Condition of the United States winter wheat crop showed a closer relationship to yield per seeded acre than to yield per harvested acre.

4. In the months of May and June, condition was presumably reported on the acreage remaining for harvest. The total amount of abandonment is not known at that time and crop correspondents apparently are reporting on neither the seeded acreage nor the harvested acreage in these months but somewhere between the two.

5. July condition of the United States winter wheat crop showed a poor relationship to yields and production.

6. The government forecast was more nearly accurate in July than in any other month. Factors other than condition which were used by the crop reporting service in forecasting yield in July apparently improved the accuracy of that forecast.

7. Although the April government forecast showed a tendency for a slightly higher degree of accuracy than the May or June government forecasts, the difference in accuracy for the three forecasts was relatively slight.

8. The private forecasts were more nearly accurate in July than in any other month. Private forecasts were least nearly accurate in April.

9. The government forecast of winter wheat production in the United States was more nearly accurate than the private forecasts in July. Little difference in the relative accuracy of the government and private forecasts could be shown in the other months.

10. The government and private forecasts agreed closely on the production of the wheat crop at a given time. Apparently the greatest errors in forecasts were due to factors affecting the crop after the forecast was made rather than by misinterpretation of the conditions existing at a given time.

11. July condition was the most nearly accurate of any monthly condition figure as an indicator of yields and production for Kansas.

12. July condition showed a closer relationship to yields and production in Kansas than in the United States.

13. Little or no improvement in the relationship of condition to yields, abandonment, or production for Kansas was made in May or June compared with April.

14. April condition was an excellent indicator of abandonment in Kansas and, with the exception of July, showed the best relationship to yields and production.

15. In general, all the monthly condition figures showed a closer relationship to yields, abandonment, and production in Kansas than in the United States. The more homogeneous production conditions in Kansas than in the United States probably accounted for the better relationship.

16. The government forecast of winter wheat production for Kansas is more nearly accurate in July than in May or June. Little difference in the accuracy of the May and June forecasts was shown.

17. The forecast of winter wheat production in Kansas based on fall rainfall was more nearly accurate than the government forecast in May or June but was less nearly accurate than the July forecast.

18. The forecast based on fall rainfall can be made in December, which makes it quite useful.

19. Since a large proportion of the hard winter wheat crop is produced in central and western Kansas and in

neighboring areas of similar conditions, it is probable that a similar method of forecasting winter wheat production over a wider area would prove useful as an early season indicator of production over an important part of the hard winter wheat belt.

20. The possibility is also suggested of combining condition and fall rainfall to improve the accuracy of winter wheat crop forecasts in the Great Plains Area.

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