CROP INCOME IN WESTERN KANSAS FOR 1917-1957 AS AFFECTED BY LAND ALLOCATION, PRICES AND RAINFALL

by

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INTRODUCTION

Farm income is derived primarily from two sources; crops on the one hand and livestock on the other. This study is concerned only with that part of the farm income which is derived directly from crops. For years farmers have been faced with problems of adjustment in distributing their cropland among the various crops available, in order to realize the highest possible income from their resources.

As farm surpluses have become more and more apparent, resulting in lower prices, much concern has been voiced in regard to decreasing farm incomes. Consequently, farmers are specializing in certain crops and have developed an interest in seeking alternatives in other crops and enterprises. However, the alternatives are often limited because of area conditions, certain crops being more adaptable in some areas than they are in others.

Decisions regarding land allocation are complicated by a complexity of factors, not all of which are measurable. Since the decisions reached concerning land allocation have such impact on the incomes of the farm operators involved, there is considerable interest in investigating the relationships among some of these factors.

This study was designed to arrive at conclusions which would (1) provide the farmers in this area with a measure of relative desirabilities of various practices and (2) provide a better basis for certain policy recommendations. This involved the investigation of the factors and their interrelationships which seemed to have major effect on farm incomes. The factors studied were crop distribution, rainfall and prices. It is hoped that this study will provide a basis for further studies dealing with

evaluation of resource use and their effects on optimum cropping and livestock plans.

Problem

In recent years a majority of the farmers have been faced with a price-cost squeeze and consequently with falling net incomes. Their primary crops are being produced in quantities which, with given prices, exceed the demand, and as a result government regulations, hoping to improve the balance of production, are forcing reductions of acreages in many instances. This necessitates a change in the pattern of land use. In many areas the change of crops being produced is already underway, and has been for some time. The problem of how to allocate the land available in order to comply with the government regulations and yet maintain income remains acute in most areas.

A study such as this is complicated by factors far more complex than the ordinary measurable inches of rainfall, dollars or capital, and acres of land. How can the management ability of farmers be measured? By years of experience? Perhaps one man is a better manager with five years of experience than another man with ten. Does the amount of education measure the ability of a man to manage a farm? How high an I. Q. should a farmer have to be capable of good management? These are questions which research workers cannot answer as yet.

Other variables may be equally hard to measure. There has been no reliable method devised to measure the effects of government policies and programs on the allocation of resources. Acres of land which may be planted to different crops are known, but the feelings of the farmers toward the government programs affect what the farmers will actually do.

Farmers customs and habits also affect the allocation of their resources. Varying amounts of industriousness or laziness are important in resource allocation. Most people are influenced in their actions by the actions of other people around them, but how much and in what way is difficult to ascertain.

These are some of the factors which are difficult or impossible to measure accurately. It is for this reason that they, and others like them, have not been included in this study.

A need exists for some means of finding the optimum allocation of crops which can be grown in most areas. Farmers are constantly required to make decisions concerning the amounts of different crops to plant, amounts of land to fallow and new crops and varieties to use. They are hindered in their management practices by uncertainties of weather, prices, governmental policies and programs, and relative efficiencies of various crops. In many cases, their crop income is a major part of their total income, making these problems of utmost importance to them.

To alleviate the problems of resource allocation requires a knowledge of the relationships among various pertinent factors involved. This knowledge is available only from a study of the historical consequences of different policies and practices followed by the farmers themselves. There is a need for a better understanding of the relationships among factors which affect farm income derived from different crops. This understanding must be based on conditions of areas comprising representative samples of the situations facing farmers.

In a study by Kaldor and Heady,[1] it was found that most farmers' price predictions were in error. Their errors of two different years had little or no correlation to one another, which would indicate that crop diversification was not an adequate means of compensation for the uncertainties of price and production, at least as far as the individual prediction abilities were concerned. Being unable to predict prices causes a misallocation of land to various crops, which concerns us here. The farmer faced with price uncertainty will allocate land according to his own forecasts. If his forecast is not accurate, as the probabilities would suggest, his allocation will also be in error.

Scope of Study

This study was restricted to a geographic area comprising, roughly, the western one-third of Kansas. This restriction of the area reduces some of the heterogeneity of conditions which would have entered had a larger area been included. This does not mean that the area selected is entirely homogeneous, but that the degree of heterogeneity is smaller than it would have been had, for instance, the state as a whole been included.

This area is primarily a wheat producing area, with few other opportunities available for land use. Rainfall is limited, keeping the area out of competition with other areas in the production of most other crops. For convenience, the area was divided into four parts.

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1. D. R. Kaldor and Earl O. Heady, An Exploratory Study of Expectations, Uncertainty, and Farm Plans in Southern Iowa Agriculture, Iowa State Agricultural Experiment Station Research Bulletin 408.

These parts are four established types of farming areas.[1] The four areas selected, and the counties they included were:

Area 10a	Area 10b	Area 11	Area 12
Finney	Ford	Cheyenne	Greeley
Gove	Grant	Decatur	Hamilton
Hodgeman	Gray	Graham	Kearny
Lane	Haskell	Rawlins	Logan
Ness	Meade	Sheridan	Scott
Trego	Morton	Sherman	Wallace
	Seward	Thomas	Wichita
	Stanton		
	Stevens		

The time period chosen for study was the years 1917 through 1957. This period includes a large variety of situations which have posed problems of a managerial nature. Learning what solutions farmers had tried and which had been most successful, provided a background for the study.

The scope of this study of factor relationships was limited to include only three major factors affecting crop incomes. These three factors were crop distribution, rainfall and prices. Many other important factors exist, but to consider more in this study would have been impractical. The crop distribution study was limited to five crops which have historically occupied the major portion of the land in the area studied. Thus the scope of this study was limited to a level which could provide valuable information with some degree of practicality.

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1. J. A. Hodges, Types of Farming Areas, Kansas Agricultural Experiment Station Bul. 251, August 1930.

Factors Affecting Crop Income

The factors chosen for study all exhibited a substantial effect on crop incomes. As would be expected, certain factors showed a more pronounced effect than others, and in their individual importance they varied according to the conditions of the situation.

Crops. Wheat, corn, oats, barley and grain sorghums were chosen as the crops to be studied. They are the predominant crops grown in the areas considered, thus they have had and still have a large effect on the incomes derived from crops. While individual emphasis has varied in different situations, taken collectively, they have remained the five most important crops.

Prices. Showing a large degree of variation in different years, prices have proven to be one of the major determinants of crop income. Any study involving income must consider prices.

Rainfall. This was an obvious choice of a factor for study. Crop production, and therefore crop income is strongly dependent upon moisture, which is subject to extreme variations in Western Kansas.

Procedure

One of the more accurate and comprehensible indicators of the income from crops is the value of crops produced, adjusted to some base period of time. This adjustment relates all years under observation to one period, which makes accurate cause and effect analyses between the base period and the observation periods possible. It also relates one observed year to another so that accurate analyses may be made of the relationships involved therein.

Gathering the Data. Yearly evaluations of crop production are presented by individual crops and counties in the Kansas State Board of Agriculture Biennial Reports.[1] These values are based on the dollar prices of the year considered. To obtain the figures necessary for this study, the yearly values of the crops considered were obtained by county. In each year, the values of each crop were totaled for all counties in each area. For each area, totals were taken of values of food grains, feed grains, and other crops. These were divided by price indexes based on the 1910-14 time period and totaled, giving the adjusted value of crops produced for each area and year measured in constant dollars.

Rainfall amounts were obtained by quarters for the years 1916 through 1957.[2] These quarter totals were necessary in order to show accurately the effects of rainfall on crop incomes. For instance, income from wheat depends primarily on the rainfall in the third and fourth quarters of the year previous to harvest, and the first two quarters of the year of harvest. For other crops, other quarters of rainfall were more applicable.

Relevant prices used were the yearly "Food Grain" price indexes which applied to wheat, "Feed Grain" indexes applied to corn, oats, barley and grain sorghums, and the "All Crops" index applied to other crops.[3] All price indexes were based on a 1910-1914 period.[4]

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1. Kansas State Board of Agriculture Biennial Report, Reports 20 through 38, 1916-1952, and Farm Facts, 1953-1957.

2. U.S.D.A. Weather Bureau, Climatological Data, 1917-1957, vols. 31-71. (1940 and after this was taken over by the U. S. Department of Commerce.)

3. "Other crops" included rye, all tame hay and soybeans.

4. Kansas State Board of Agriculture Report, June 1957, Price Patterns, p. 20.

Percent of total harvested acres in any area occupied by "other crops", denoted by X_6, soon proved to have a sufficiently small effect on the value of crops produced to justify its being dropped from the study. This justified dropping the "All Crops" price index (X_{14}) also, since X_6 was the only factor to which X_{14} was applied.

As a guide to the relative emphasis which historically has been placed on each of the crops included, as well as to make such information more easily handled in the regression equation, the annual harvested acres of each crop in each county were divided by the annual total harvested crop acres for that county to obtain percents of the annual total harvested crop acres occupied by each crop from 1917-1957. These county percentages were totaled by areas, and may be seen in tables 1, 2, 3 and 4.

Processing the Data. This study utilized a single equation multiple regression analysis method. The classification of variables was as follows:

Y = annual value of crop production from cropland including the value of all crops sold, stored or used on the farm measured in constant dollars;

X_1 = crop acreage of wheat in percent;

X_2 = crop acreage of corn in percent;

X_3 = crop acreage of oats in percent;

X_4 = crop acreage of barley in percent;

X_5 = crop acreage of grain sorghums in percent;

X_6 = crop acreage of other crops in percent;

X_7 = 3rd quarter rainfall in year t-1;

X_8 = 4th quarter rainfall in year t-1;

X_9 = 1st quarter rainfall in year t;

X_{10} = 2nd quarter rainfall in year t;

X_{11} = 3rd quarter rainfall in year t;

X_{12} = Food grain index (1910-14 base);

X_{13} = Feed grain index (1910-14 base);

X_{14} = All crops index (1910-14 base).

The above variables were fitted to different algebraic equations to determine the type of equation most suitable for describing the relationships between the dependent variable (Y) and independent variables (X's). It was at this stage of analysis that the factors X_6 and X_{14} were omitted, for the reason mentioned above, from the rest of the study. The following functional relationships were selected for final analysis:

$$Y = a + b_1X_1 + b_2X_1 (X_7 + X_8 + X_9 + X_{10}) + b_3X_1 (X_{12}) +$$
$$+ b_4X_2 + b_5X_2 (X_9 + X_{10} + X_{11}) + b_6X_2 (X_{13}) +$$
$$+ b_7X_3 + b_8X_3 (X_9 + X_{10}) + b_9X_3 (X_{13}) +$$
$$+ b_{10}X_4 + b_{11}X_4 (X_7 + X_8 + X_9 + X_{10}) + b_{12}X_4 (X_{13}) +$$
$$+ b_{13}X_5 + b_{14}X_5 (X_9 + X_{10} + X_{11}) + b_{15}X_5 (X_{13})$$

This model is descriptive. It specifies interdependent functional relationships and employs realized data for estimating the parameters. It provides an average description of the way the structure of land use in conjunction with rainfall and pertinent prices operated in the past.

HISTORICAL LAND USE BY CROPS

Before proceeding with the analysis of the relationships among factors affecting crop income, some attention should be given to the historical use of land by various crops. This will help to provide a better understanding

of the relationships among factors and their relative importance when they are analyzed.

Technological improvements in various crops, changes in demand along with weather and price changes have caused constant changes in the amounts of various crops grown in these areas. In addition, government programs for conservation and surplus control also affected the pattern of land use by different crops. Some of these changes have forced farmers to invest more capital in land and equipment. While expanding, the farmer has been faced with lower prices relative to his costs, making it more necessary for him to be cautious in choosing the crops and the amounts of each he will grow. The changes in the amounts of crops grown, when viewed yearly, show the effects of a complexity of factors, not all of which are easily ascertained.

Wheat

In the years from 1917-1957 there were some rather large and abrupt changes in the percentage of harvested acres occupied by wheat. In the year 1917 itself, when the United States entered World War I, wheat in area 10a, as an example, occupied only 5.5 percent of the total harvested acres, corn being far more widely grown. Under the conditions of a world war and relatively good years for crops from the standpoint of moisture, this percentage increased to 59.9 percent in 1919. Later in the postwar years, 1921 hit a peak of 62.7 percent of harvested cropland occupied by wheat. An index of prices received by farmers for food grains for these years shows indexes of 250, 234, 250, 251 and 132 respectively for the years

1917 through 1921.[1] This rather abrupt price drop in 1921 was echoed by the drop in wheat acres the next two years. From 62.7 percent of harvested cropland occupied in 1921, the figure dropped to 46.9 percent in 1922 and 13.4 percent in 1923.

Area 10a is included in the 18-22 inch rainfall band. In the 1922 cropyear rainfall totaled 24.8 inches and in 1923 it totaled 26.1 in this area.[2] This would suggest that the acreage reduction was largely due to the corresponding price fluctuation. This price fluctuation is caused by decreased demand for wheat following the crisis of a world war. Tastes were also changing. Migration from farm to city, during the war, to man the defense plants in the period of stepped up industrial production had increased incomes, allowing people to buy less of the staple foods and more fancier foods such as fruits and vegetables. As people did less manual labor, they demanded less fatty meats and less starchy foods. This in turn, decreased the demand for the cereal grains and other feed grains used in producing fatty meat, such as pork.

In general, wheat production in the 1920's increased in all areas. Prices increased gradually until 1927, then dropped off slightly in the latter 1920's. This was accompanied by a corresponding increase in wheat acreage until 1927, then an acreage decrease in 1928 and 1929. Population was growing, especially urban population, and times were generally better than they had been previous to World War I.

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1. Period of 1910-1914 taken as a base with index of prices received of 100.

2. Cropyear rainfall computed on the basis of the third and fourth quarters of the year previous to harvest and the first two quarters of the harvest year.

The 1930's saw a general decline in wheat acres for the first five years, with a recovery during the last five. The former was a period of serious world depression and prices were low. From 1930-35 the prices in all areas covered by this study were below those of 1910-14, increasing some in the last five years of the decade. The crop year rainfall in this period ranged at or below average. For crop years 1937-1939, wheat occupied a relatively large percentage of harvested crop acres, decreasing slightly in 1940. Price also decreased in 1939 and 1940; it began to increase again in 1941 on the entry of the United States into World War II.

The war years of 1941-45 fail to show any large increases in the percentage of cropland occupied by wheat, but acres of cropland harvested increased rather rapidly in this period. There was a relatively rapid increase in percent of harvested crop acres occupied by wheat at the end of the war when prices reached new peaks. In 1947 the wheat price index reached its highest point in the 41 year period studied with an index of 276. (1910-14 = 100) Rainfall conditions were fairly favorable through this period from 1940-1950.

Prices remained relatively steady during the 1950's, while dry weather prevailed. The percent of harvested cropland occupied dropped from 83.7 percent in 1952 to 53 percent in 1953 in area 10a. This would appear to be the first period in the 41 years in which the rainfall influenced the percentage of harvested crop acres occupied by wheat more than prices. In 1956, with the advent of the soil bank program, three out of the four areas involved in this study showed increases in the percent of harvested acres occupied by wheat. In 1957 all four areas showed rather large decreases in this percentage.

Area 10a, for instance, showed 70.5 percent of harvested acres occupied by wheat in 1956, and only 9.8 percent in 1957. There was a slight decrease in price between 1956 and 1957, and an increase in moisture. Most of this moisture came in the second and third quarters of 1957. Rainfall amounts were extremely low in the last two quarters of 1956, giving a very poor outlook for wheat producers the next year. The government extended an opportunity for farmers to put additional land into the soil bank in the spring of 1957 because of this poor outlook. For the same reason, farmers refrained from planting wheat in the fall of 1956 and waited for sorghum planting time in the spring of 1957, at which time the moisture was much more favorable. For purposes of comparison, the percentage of harvested crop acres occupied by grain sorghums in area 10a increased from 6.9 percent in 1956 to 68.9 percent in 1957. The direction of this change was opposite that of wheat, and in almost equal proportions.

For the area covered by this study, wheat acres explained 36.6 percent of the variation in crop income for the years 1917-1957.

Corn

In an overall sense, corn has played a decreasing role in farmers operations over the 41 year period from 1917-57. In 1917, corn occupied a larger percentage of harvested crop acres than any of the other crops considered, (wheat, oats, barley, and grain sorghum), in three of the four areas considered. This percentage decreased until about 1923, when wheat decreased in importance and corn helped fill the vacant acres which resulted from the abstinence of wheat planting. As wheat recovered somewhat

in 1924, corn decreased in importance in most areas. In area 12, however, both wheat and corn increased in percent of harvested acres occupied, through most of the twenties.

In the early thirties corn increased slightly in importance, relative to wheat. About 1937, the percentage of harvested acres occupied by corn began to decrease. In 1940, three of the four areas showed a percentage of 2 percent or less of harvested acres occupied by corn. In these same three areas, this percentage remained below 2 percent for the remainder of the period covered by this study, not even showing much reaction to the boom periods of World War II and the years immediately following. The one area which had a percentage of harvested acres occupied by corn above 2 percent in 1940, showed some increase during the war years. In 1940 this area, area 11, had 11.8 percent of its harvested acres occupied by corn, and in 1944, it showed 13.1 percent. Following that it dropped rather abruptly, until the early fifties. In 1956, area 11 had a percentage of 1.6. A slight increase in all areas was shown in 1957, probably due to the rather sharp decrease in wheat acres and an increase in irrigation.

Taking the entire area covered by the study, corn acres explained 1.2 percent of the variation in crop income for the years 1917-57. It is this high only because of area 11. In this area, corn acres explained 0.8 percent of the variation in crop income.

Oats

In the four areas covered by this study, oats has been of only minor importance in the years 1917-57. A more accurate statement could be that oats approach insignificance. In only one area does the percent of harvested

acres occupied by oats exceed 7 percent. In area 11, in one isolated year, this crop percentage reached 7.1 percent. In all the areas combined, this crop accounted for only about 0.2 percent of all variation in crop income, making it appear to be of very little value to this study.

Barley

Another relatively unimportant crop in these four areas from 1917-57, has been barley. Acres of this crop accounted for only 1.2 percent of the variation in crop income in those years, for the area studied, with the highest percent being in area 10a. In this area, barley explained 1.5 percent of the variation in crop income, even that having a very little importance to the study when compared to wheat. The largest percent of total harvested areas occupied by barley at any time in the period covered in this study, occurred in area 12 in 1936, when barley occupied 57.8 percent of harvested acres. More commonly this percentage was below 10 percent. In general, the changes in barley acres followed those of corn. Barley occupied a smaller percent of the total harvested acres than corn in nearly all cases, but the changes were in the same direction, even though on a smaller scale.

Grain Sorghums

Including all sorghums grown for grain, this classification was shown to be one of the major crops grown in terms of acres of cropland occupied. However, in the years included in this study, a relatively small percent of the crop income has been explained by the acres of this crop grown. The percent of harvested acres occupied by this crop has varied from a percentage too small to be measured practically, (less than 0.1 percent),

to as high as 78.8 percent. The variations in the relative importance of this crop are not dependent on any one other variable. Some increases in percent of harvested crop acres occupied by this crop, such as occurred in 1954 and 1955 in all areas, are caused by a shortage of moisture for other crops. The greater relative hardiness and lower moisture requirement of sorghums allow this crop to be grown where other crops fail to survive.

The rather large increases in the percentage of cropland devoted to grain sorghum in 1957 over that of 1956 almost offsets the sudden decrease in wheat acreage of the same year, brought about by a poor outlook for wheat. Sorghum occupied relatively small percentages of harvested crop acres during the depression and drouth of the thirties. This was before sorghum became popular as a drouth resistant crop. Probably the most important factor in its lack of popularity in the thirties however, was that the price was relatively low. In the ten years from 1930 through 1939, the price index was 100 or below for six years, and reached a level of more than 150 in only one year. Percent of total crop acres occupied by grain sorghums was relatively low during World War II. At this time the demand for wheat was high and all available acres were being devoted to it. Many acres of grassland in these four areas were plowed up during this time for the purpose of wheat production. It is primarily since World War II, and even more specifically, since the advent of the soil bank program in 1956, that sorghums have gained their greatest popularity in this area of the state. As farmers are forced to withdraw acres formerly used for wheat production, they are finding grain sorghums a good replacement crop. Most of the land in these four areas is fitted to the production of grain sorghums, and a good market is provided in most years by the livestock producing areas. So much

grain sorghum has been grown for these reasons, that some people predict that the nation will soon be faced with a surplus of sorghums as well as wheat.

ESTIMATED RELATIONSHIPS AMONG FACTORS AND THEIR EFFECTS ON CROP INCOME

The relationships among the factors affecting crop income were estimated for each economic area separately and for the area of the study as a whole. The method of estimating the relationships was the least-square method of linear regression. The estimated regression coefficients and coefficients of determination are shown in Table 5. The coefficients of determination are presented in partial form in Table 6, giving the percents of variation in crop income explained by each segment of the regression equation. To test the significance of the regression coefficients, the t values in Table 7 were obtained. The significance levels of the corresponding regression coefficients are shown in the same table, directly under the t values.

The marginal returns realized from each of the crops considered in the years 1917-57 are presented in Tables 8, 9, 10 and 11. These values were ranked by years and the frequencies with which each crop attained each rank were totaled. These ranks and rank frequencies are presented in Tables 12 through 16.

These major classifications of information provide the basis for inferences applicable to the area under study and were approached for discussion by individual economic areas.

Economic Area 10a

The coefficient of determination (R^2) applicable to the economic area 10a reveals that 66 percent of the variation in crop income was explained or accounted for by the regression equation; that is, the factors included in the study and their interrelationships were responsible for 66 percent of the variability of crop incomes in economic area 10a in the years 1917-57. In order to gain insight into the relative importance of each factor and its relationship with other factors, the coefficient of determination was expressed in its partial form.

Through the years 1917-57, the partial coefficients of determination reveal that the percent of total cropland occupied by wheat in area 10a accounted for 30.8 percent of the variation in crop income. The inches of rainfall applicable to wheat accounted for an additional 20.4 percent of the variation in crop income in that area and time period when they were added to the acreage effects. The added consideration of the price level of wheat accounted for an additional 5.8 percent. The three factors, the percentage of cropland occupied by wheat, the rainfall and prices received for wheat, explained a total of 57 percent of the total variation in crop income in area 10a for the years 1917-57. Wheat has been the major cash crop in this area, which makes this high degree of determination expected.

The percent of total cropland occupied by corn explained an additional one-tenth of one percent of the variation in crop income. Adding the effects of rainfall relevant to corn explained one percent more of the variation in crop income. With the price level of corn also considered, an additional six-tenths of one percent of the variation in crop income was

explained. The total acres of wheat and corn, their relevant rainfall amounts and the price levels of each, explained a total of 58.7 percent of the variation in crop incomes in area 10a in the time period studied.

The percents of crop acres occupied by oats, barley and grain sorghums, the rainfall amounts relevant to these crops, and their price levels, explained a total of 7.3 percent of the total variation in crop income, making a total of 66 percent of the variation in crop income explained by the regression equation for area 10a.

This study included a relatively large number of variables as compared with the number of observations. With the consequent small number of degrees of freedom, coupled with relatively large standard errors, very few of the regression coefficients were significant at upper levels. In area 10a, with 41 observations and 25 degrees of freedom, only one regression coefficient, the one corresponding to the wheat acres-rainfall factor combination, was significant at the five percent level. Others were significant at lower levels and some of them can, for practical purposes, be considered as non-significant.

Marginal returns, according to the derived descriptive-predictive equation, of the various crops studied provide insight into the actual historical importance these crops have played in this area and show some reasons why land has been distributed among different crops as it has. These marginal returns are presented in Tables 8, 9, 10 and 11 and were obtained by taking a partial derivative of Y (crop income) with respect to each of the crops individually. The acres of each crop are in terms of a percent of total harvested acres occupied, and returns are in terms of 1910-14 dollars. The marginal returns refer to the increase or decrease

in the number of 1910-14 dollars which would have been realized by devoting one additional percent of total harvested cropland to the crop in question.

The marginal returns relevant to wheat in area 10a show a high degree of stability, reaching above 200 in only four of the 41 years, and below 100 only during the depression period of 1932 through 1940. This means that in 28 years out of 41, an additional one percent of harvested acres devoted to wheat would have increased returns from wheat by $100,000 and $200,000. This stability makes wheat a popular crop in this area because it means that in any year, with average price and rainfall conditions, the farmer may expect a positive return from an investment in wheat. This does not mean that it is impossible to lose money on wheat. Natural disasters such as hail, flood or wind, which ruin a crop, cause a loss, but considering the most probably price and rainfall situations and holding other factors constant, returns from wheat may be expected to be positive in economic area 10a. Marginal returns from wheat failed to rank first, or highest, of the crops considered in any year studied. However, they ranked second or third consistently and were never negative. The average rank of marginal returns from wheat in this area and time period was roughly three.

The marginal returns from corn in economic area 10a have not been so encouraging to farmers in this area. While marginal returns from this crop reached a higher level in some years than the marginal returns from wheat reached in any year, they showed a high degree of variation. This makes expectations of returns from corn very uncertain. In 23 of the 41 years studied, marginal returns from corn in this area were negative. In most of these years, either price or rainfall was low. Marginal returns from corn show a high degree of dependence on rainfall.

In economic area 10a, oats showed the highest degree of variation in marginal returns of all the crops studied. From a low of -6,160.9 in 1951, this figure reached a high for the period of 2,276.2 in 1956. This means that in the period studied, the returns for devoting one additional percent of harvested cropland to oats in this economic area ranged from a loss of $6,160.90 to a gain of $2,276,20. Oats showed negative marginal returns in 27 of the 41 years studied, and ranked either fourth or fifth in level of marginal returns in 31 of the 41 years.

In economic area 10a, barley showed positive returns in every year studied. The level of these returns was higher than those from wheat in all but two years, 1917 and 1956. The marginal returns from barley reached their highest points in many of the same years as did the returns from wheat. The consistency with which barley has maintained relatively large positive marginal returns would suggest that barley production could be carried on profitably at a slightly greater rate. Barley ranked first or second in level of marginal returns in 39 of the years covered by this study. Its rank in the other years was third, being below wheat and oats both years.

Grain sorghums suffered negative marginal returns in only three years in the period studied. The general level of these returns was the same as those for wheat, but showed a slightly higher range of variation. For area 10a, over the time period studied, grain sorghums appeared to be the third best crop.

For area 10a in general, the crops appear to rank themselves by level of marginal returns in a manner very closely approximating that which might be expected. Marginal returns from barley are higher in many cases than those from wheat, making barley the first crop to be put into a cropping plan. Wheat would follow barley in making a choice of crops, but would

very likely be produced to a much larger extent. Grain sorghums would be the third choice, followed by corn and oats in that order. This does not mean that more of a higher ranked crop should be produced than of a lower ranked crop. These marginal returns figures were arrived at on the basis of the amounts of each crop which were actually produced in the past in this economic area. The choice of barley over wheat refers only to the reliability of positive returns from barley at the level at which it has been produced, as compared with the reliability of positive returns from wheat at its level of past production. Similar comparisons apply to the other crops in the choice of their rank in preference.

Economic Area 10b

The coefficient of determination for economic area 10b was 0.79. This shows an increase of 0.13 over the R^2 for economic area 10a. The combined effects of the three wheat factors and their interrelationships accounted for a total of 75.1 percent of the variation in crop income in economic area 10b.[1] This was an increase of 18.1 percent over the amount explained by the same factors in area 10a. The three corn factors showed a decrease of 1.4 percent in total variation in crop income explained, while the combined factors of grain sorghum, oats and barley showed decreases in variation determination of 0.4 percent, 0.6 percent and 2.3 percent respectively. As might be expected, wheat proved to be the most important crop in determining crop income which justifies its position as the major cash crop throughout the period.

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1. The three factors of a crop refer to the percent of total harvested acres occupied by that crop, the quarters of rainfall applicable to that crop and the price level of that crop.

Like economic area 10a, this area had only one regression coefficient significant at an upper level. The coefficient corresponding to the factor combination of wheat acres and rainfall was significant to the factor combination of wheat acres and rainfall was significant at the one percent level. All others were significant at lower levels.

Table 9 presents the marginal returns relevant to the crops in economic area 10b. These figures again are according to the derived predictive-descriptive equation and were obtained by taking a partial derivative of crop income with respect to each crop. Wheat was the most stable, followed by grain sorghum, corn, barley, and oats in that order. Wheat and grain sorghums had no negative marginal returns during the 41 year period. Corn showed negative marginal returns in only two years and barley in only four. Barley revealed rather large marginal returns in several years but the negative returns in some years made expectations of positive returns uncertain relative to wheat and grain sorghums. Corn was also somewhat uncertain because of the two years with negative returns. Oats maintained an undisputed last place consideration in this area because of the large number of years in which the crop revealed negative marginal returns. Oats ranked fifth in level of marginal returns in 31 years and had negative marginal returns in 30 years of the 41 year period covered by this study.

For economic area 10b, in general, the crop preference would place wheat first as would be expected. Grain sorghums would be second and corn third, primarily because of the uncertainty brought about by the two years of negative returns from corn. Barley, with four years of negative returns, would occupy fourth place in preference with oats ranked as a poor fifth.

Economic Area 11

The three wheat factors and their interrelationships accounted for 51.6 percent of the variation in crop income in economic area 11. Price level of wheat in this economic area had a smaller effect on crop income than in either area 10a or 10b, explaining only an additional 1.0 percent of variation; wheat acres and rainfall relative to wheat accounted for 50.6 percent of variation in crop income. Corn, oats, barley and grain sorghum all showed larger effects on crop income than in area 10a or 10b. These increases make up for most of the loss in determination attributable to wheat factors when the aggregate coefficient of determination is considered. This coefficient showed that the crops, their rainfalls and prices accounted for 74 percent of the variation in crop income in economic area 11. Thus, this coefficient explained 8 percent of variation in crop income more than the corresponding coefficient for area 10a and explained only 5 percent of variation less than that for area 10b. Wheat factors in area 11 explained 5.4 percent and 23.5 percent less of crop income variation than in area 10a and 10b respectively.

Three regression coefficients for economic area 11 had t values which were significant at the 5 percent level, two of them beyond the 5 percent level. The regression coefficient of the factor combination of wheat acres and rainfall had a t value which was significant at the 5 percent level. The regression coefficient corresponding to the corn acres-rainfall factor combination showed a t value which was significant beyond the 5 percent level. The regression coefficient corresponding to the grain sorghum acres-rainfall factor combination also showed a t value which was significant beyond the 5 percent level.

Marginal returns from the five crops in economic area 11 fall into a pattern similar to areas 10a and 10b. Wheat again yielded positive marginal returns in every year of the period studied, with grain sorghums showing negative marginal returns in only one. Barley yielded negative marginal returns in 10 of the 41 years with oats and corn following at 13 and 20 years respectively showing negative marginal returns. From 1941 through 1957, oats showed large positive marginal returns. This accounts for its record of ranking first among the crops studied in level of marginal returns for 28 of the 41 years studied. In all the remaining 13 years however, oats ranked fifth in level of marginal returns. The years in which oats ranked first were years when oats occupied a small percentage of the total harvested acres. Years when oats occupied larger percentages of harvested acres were those in which the crop ranked fifth in level of marginal returns. This would suggest that oats should have been produced to a slightly larger extent from 1941-1957.

Grain sorghum in economic area 11 showed steadily positive, though relatively low marginal returns, which means that grain sorghum would have been second only to wheat in safety of investment. Barley would have been third choice with negative marginal returns in 10 of 41 years, and relatively low returns when they were positive. Oats would probably be fourth choice as a crop to grow because of its lack of dependability in yielding positive returns. Corn, with negative marginal returns in 20 of the 41 years, would be fifth choice. The marginal returns from this crop are relatively large when negative and rather small when positive. Corn yielded negative marginal returns in every year from 1943-1957, approximately the same period in which oats yielded a series of large positive returns.

Economic Area 12

The coefficient of determination relevant to economic area 12 showed the largest percent of variation in crop income explained by the regression formula of all areas considered. The R^2 in this area shows 83 percent of the variation in crop income explained by the regression equation. The three wheat factors explain 75.2 percent of the changes in crop income themselves, with only 8 percent explained by the other crop factors. This would be expected from the importance wheat has had in the allocation of land in this area in the past.

This area is unique from the standpoint of significance of the regression coefficients. None of the regression coefficients in this area were significant at an upper level. Most of them could be considered non-significant for all practical purposes.

From the standpoint of marginal returns, wheat again proves to be the most desirable crop to grow. In each of the 41 years included in the study, wheat yielded positive returns at a relatively stable level. Grain sorghums, with two years of negative returns, would be second in rank of preference. Barley would be the third crop to be included in the cropping program on the basis of marginal returns. This crop yielded negative marginal returns in 10 of the 41 years. Oats and corn, with negative return in 18 and 19 years respectively, would be the last two crops to be included in cropping plans in this area on the basis of marginal returns. Corn would probably take preference over oats despite the lower positive returns, because its negative returns are also lower and only slightly more probable.

All Areas

A coefficient of determination was derived for a combination of all four of the economic areas in conjunction. This shows that a total of 64 percent of the variation in total crop income for the area of the study as a whole was explained by the factors considered in the regression. As in each of the individual economic areas, the three wheat factors accounted for the major part of the variation in crop income. In this case they explained 55.9 percent of the variation in total crop income for the area of the study as a whole. The next combination of crop factors by level of determination was the combination of corn factors with 3.1 percent of the variation in crop income explained.

The aggregate estimation of regression coefficients indicated that three of them were significant at upper levels. The coefficient corresponding to the wheat acres-rainfall factor combination was significant at the one percent level. The coefficient corresponding to the wheat acres-price factor combination was significant between the 5 percent and 1 percent level, as was the coefficient corresponding to the corn acres-rainfall factor combination.

Marginal returns were not derived for the area as a whole because it was felt that any inferences which could have been drawn from them would have been too general in nature to be applicable.

LIMITATIONS OF RESULTS

The results of this study are limited in applicability by several unavoidable consequences. In no way does this prevent the study from being useful providing these limitations are realized and considered.

The prices and values in this study are based on a period of 1910-14, and should be properly adjusted before comparisons with data based on other base periods, such as another popular period of years, 1947-49.

Value of crops produced is only an estimate of crop income. Income figures were not available in sufficient quantities for the area studied and in the event they should become available, would be preferable for use in a study of this type, than value of crops produced.

Accuracy of estimation was reduced in this study by the small number of observations relative to the number of variables. Had better data been available for more observations, this accuracy could have been increased somewhat.

This study has been conducted in a manner which includes technology as it has changed through time. To base predictions for the future on this study, however, would not be inclusive of future changes in technology. Such predictions, therefore, would need to be adjusted accordingly.

Government programs have a substantial impact on farming operations in this area, especially as they effect allowable acreages of crops and the prices. Anything which causes a change in the price levels of these crops will effect the applicability of this study.

The dependent variable (Y) was measured in constant, gross dollars. The cost of producing the individual crops was not deducted from the value of crops produced. Thus, all of the estimated marginal returns would be lower and more of them could be negative if the costs of production were taken into consideration. However, the omission of production costs should not detract from the applicability of findings since production costs are similar for all of the crops considered except corn. The relative

positions of crops would probably remain the same even if the production costs were considered.

The main source of data for this study were county yield figures. Because of the variation in soils, climatic conditions and natural hazards within a county, variations of average county yields tend to be less, because of the greater acreage and the chance for a low yield in one part of the county to be offset by a high yield in another part of the county. This means that the results and inferences obtained from this study are more applicable to individual economic areas than to individual farms.

SUMMARY AND CONCLUSIONS

This study was designed to investigate factors affecting crop income. Its' primary aims were (1) to provide the farmers in this area with a measure of relative desirabilities of various practices and (2) to develop a background of factual information for extension farm planning and to provide a better basis for certain policy recommendations.

This study was restricted to a geographic area comprising approximately the western one-third of Kansas. This area includes type of farming areas 10a, 10b, 11 and 12, which are primarily wheat producing areas characterized by low rainfall. The study included land allocation by crops, rainfall and prices in a 41 year time period covering the years 1917 through 1957.

The crops considered in this study were wheat, corn, oats, barley and grain sorghums. Prices were included in the study and were expressed in terms of indexes based on 1910-14 = 100. Rainfall, another independent variable, was expressed in quarterly amounts as it was recorded at various rainfall measuring stations in the area.

Value of crops produced, including all crops sold, used on the farm or stored, was included as an indicator of crop income, the dependent variable. These data were obtained from Kansas State Board of Agriculture Biennial Reports and Farm Facts. All values were adjusted to a base period of 1910-14 and then divided by 1,000 for ease of handling.

Quarters of rainfall most relevant to each crop were summed.

Prices used were indexes based on 1910-14 = 100. The indexes used were obtained from the Kansas State Board of Agriculture Price Patterns report of 1957. The "Food Grain" index was used for wheat, the "Feed Grains" index for corn, oats, barley and grain sorghum and the "All Crops" index for "Other Crops."

The data were analyzed with the aid of a single equation multiple regression method. After experimenting with several equation forms, the one selected for use was

$$Y = a + b_1X_1 + b_2X_1 (X_7 + X_8 + X_9 + X_{10}) + b_3X_1 (X_{12}) +$$
$$+ b_4X_2 + b_5X_2 (X_9 + X_{10} + X_{11}) + b_6X_2 (X_{13}) +$$
$$+ b_7X_3 + b_8X_3 (X_9 + X_{10}) + b_9X_3 (X_{13}) +$$
$$+ b_{10}X_4 + b_{11}X_4 (X_7 + X_8 + X_9 + X_{10}) + b_{12}X_4 (X_{13}) +$$
$$+ b_{13}X_5 + b_{14}X_5 (X_9 + X_{10} + X_{11}) + b_{15}X_5 (X_{13})$$

where individual independent factors or variables were used alone and in combination. These factors were classified as follows:

X_1 = crop acreage of wheat in percent;

X_2 = crop acreage of corn in percent;

X_3 = crop acreage of oats in percent;

X_4 = crop acreage of barley in percent;

X_5 = crop acreage of grain sorghums in percent;

X_6 = crop acreage of other crops in percent;

X_7 = 3rd quarter rainfall in year t-1;

X_8 = 4th quarter rainfall in year t-1;

X_9 = 1st quarter rainfall in year t;

X_{10} = 2nd quarter rainfall in year t;

X_{11} = 3rd quarter rainfall in year t;

X_{12} = Food grain index (1910-14 base);

X_{13} = Feed Grain index (1910-14 base);

X_{14} = All crops index (1910-14 base).

"Other Crops" variable has shown in the preliminary analysis that its effect on value of crops produced was very small and it was omitted from the study in the final analysis. The omission of the "Other Crops" variable made the price index for "All Crops" unnecessary also.

Historical land use by crops was investigated to provide understanding of the importance various crops have had in the past. This importance was expressed in terms of the percents of total harvested acres occupied by each of the various crops in the past.

Wheat was the most important crop in this area from the standpoint of acres grown. Grain sorghum ranks second in land allocation with corn, oats and barley being relatively less important.

Coefficients of determination (R^2) showed that 66, 79, 51.6 and 83 percent of the variation in value of crops produced in type of farming areas 10a, 10b, 11 and 12 respectively was explained by the factors considered in regression. The coefficient of determination derived for the area of the study as a whole, indicated that 64 percent of the variation in value of crops produced was explained by the factors considered in regression analysis.

The partial coefficients of determination in all individual economic areas showed wheat along with quarterly rainfall to be the major source of variation in value of crops produced.

Marginal returns from each crop were estimated for every one of the 41 years. These were derived by taking a partial derivative of Y with respect to each crop. Wheat was the most stable crop of the five considered. Barley and grain sorghum indicated very low or even negative marginal returns in some years, making them less desirable crops in which to invest time, labor and equipment. Corn and oats both showed negative marginal returns in several years, making them the least dependable crops to grow.

The major limitations of this study were caused by situations which were unavoidable. True crop income figures were not available, and the value of crops produced figures were used. Costs of producing the crops are difficult to obtain. Had they been considered, the marginal returns would have been lower.

The restrictions placed upon the production of certain crops by government programs have a detrimental effect on the ability of farmers to make decisions concerning land allocation. For maximum income in the area covered by this study, the optimum cropping plan would appear to include the maximum legal acreage of wheat with the remainder of the land allocated primarily to barley and grain sorghums. Until more crop varieties are developed which are adaptable to this area, these three will probably remain the major factors in determining crop income.

Policy recommendations based on the needs of this area alone would most certainly be aimed at easing restrictions on the acreages of wheat which farmers were allowed to grow. In an aggregate sense, however, this

area loses some significance. A possibility would be to eliminate the production of wheat in other areas, giving wheat production to the area where wheat is most adaptable.

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APPENDIX

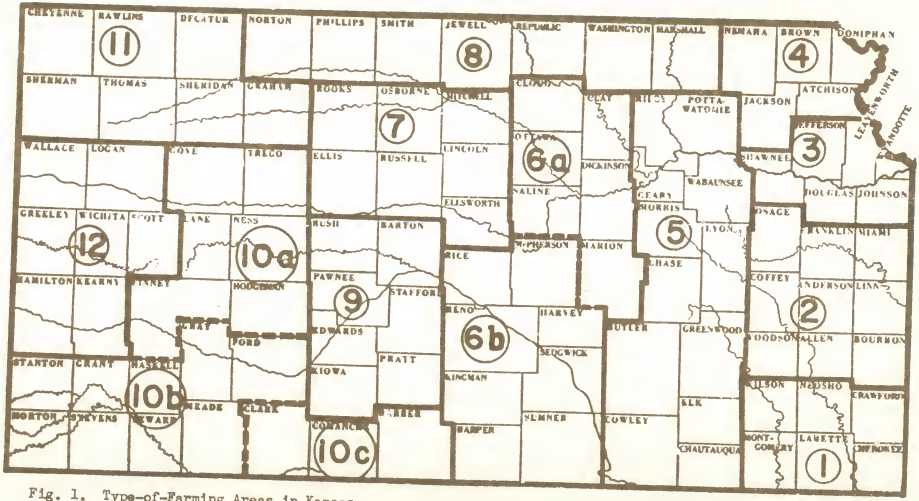

Fig. 1. Type-of-Farming Areas in Kansas.

Table 1. Percentage of total harvested acres occupied by individual crops, area 10a, 1917-57.

Year	Wheat	Corn	Oats	Barley	Gr. Sorg.
1917	5.48	31.95	6.32	13.89	21.35
1918	22.42	20.03	6.97	8.15	17.51
1919	59.85	8.12	3.29	6.77	6.92
1920	59.46	6.18	2.67	7.82	7.48
1921	62.70	6.84	3.34	9.16	5.58
1922	46.98	10.48	4.79	12.72	9.42
1923	13.40	20.24	5.68	18.70	21.06
1924	59.11	9.12	2.04	9.62	7.91
1925	64.06	8.04	2.15	7.88	6.48
1926	65.65	7.40	2.04	6.78	7.73
1927	47.08	17.32	2.46	7.77	12.06
1928	55.28	14.91	1.77	7.83	8.17
1929	70.79	8.37	1.36	6.61	5.10
1930	75.34	6.39	.97	4.90	4.36
1931	76.69	6.18	1.07	4.12	3.20
1932	56.20	12.58	2.14	8.58	6.23
1933	30.84	19.40	1.50	13.13	11.38
1934	61.20	5.08	1.24	7.27	—
1935	11.30	19.41	.85	4.10	14.22
1936	62.29	4.63	1.15	3.20	—
1937	80.00	1.53	.41	1.48	10.03
1938	78.57	.31	.84	3.09	8.38
1939	71.60	.40	1.00	4.70	8.50
1940	51.00	1.10	2.80	13.50	15.10
1941	70.70	0.80	1.80	11.10	5.20
1942	77.70	0.90	1.20	6.90	2.80
1943	64.70	1.50	1.20	5.40	3.80
1944	64.30	1.30	1.70	11.50	9.70
1945	82.10	0.40	0.90	3.30	3.60
1946	83.20	0.30	0.90	3.20	3.00
1947	81.60	0.10	0.80	2.80	2.70
1948	76.90	0.20	1.50	4.90	7.60
1949	82.50	0.20	0.90	2.40	5.80
1950	77.30	0.20	1.00	0.80	10.40
1951	46.00	0.60	1.00	2.10	33.20
1952	83.70	0.40	0.80	0.90	4.60
1953	53.00	0.60	1.40	1.70	23.10
1954	50.50	0.50	0.80	2.20	31.30
1955	55.00	0.10	0.70	1.20	18.90
1956	70.50	0.10	0.30	0.60	6.90
1957	9.80	0.60	1.20	2.50	68.90

Table 2. Percentage of total harvested acres occupied by individual crops, area 10b, 1917-1957.

Year	Wheat	Corn	Oats	Barley	Gr. Sorg.
1917	5.74	15.46	4.97	9.17	44.67
1918	9.78	10.46	5.86	4.10	45.71
1919	38.12	5.46	2.14	5.72	33.15
1920	32.19	7.27	2.43	6.73	33.76
1921	46.06	10.64	1.97	8.37	21.37
1922	43.93	10.78	2.56	9.71	21.93
1923	5.55	16.68	3.24	9.69	47.93
1924	49.88	8.32	1.11	5.63	22.98
1925	53.47	7.87	0.75	4.19	21.88
1926	64.36	5.78	0.57	2.05	18.66
1927	39.27	12.68	0.41	3.05	32.57
1928	59.52	10.28	0.41	2.60	18.18
1929	69.88	8.37	0.24	2.42	11.67
1930	71.37	8.96	0.21	2.13	9.91
1931	78.79	6.18	0.26	0.88	8.29
1932	45.89	18.72	1.18	3.93	14.70
1933	15.16	20.48	0.56	6.92	25.29
1934	61.31	5.57	0.39	2.69	--
1935	28.35	9.25	0.87	1.95	19.49
1936	43.90	5.33	0.97	0.45	--
1937	58.01	1.92	0.25	0.47	26.57
1938	61.34	0.34	0.39	1.36	31.15
1939	76.40	0.20	0.20	2.90	13.90
1940	54.30	0.60	1.10	6.20	24.10
1941	65.50	0.60	1.00	5.80	17.20
1942	71.80	1.00	0.30	4.30	10.00
1943	56.80	1.00	0.20	2.10	9.60
1944	59.40	0.40	0.40	4.80	24.40
1945	74.90	0.20	0.20	1.90	12.20
1946	77.90	0.10	0.10	0.90	10.50
1947	82.30	0.10	0.10	1.00	11.10
1948	80.70	0.03	0.20	0.90	11.80
1949	79.40	0.03	0.10	0.60	13.80
1950	68.10	0.03	0.02	0.02	23.30
1951	38.10	0.40	0.20	1.20	46.40
1952	74.20	0.20	0.10	0.60	17.70
1953	66.90	0.20	0.10	0.40	19.80
1954	47.30	0.10	0.10	1.30	38.50
1955	31.70	0.03	0.10	0.40	66.80
1956	61.60	0.20	0.10	0.30	21.50
1957	8.40	0.40	0.50	1.90	78.80

Table 3. Percentage of total harvested acres occupied by individual crops, area 11, 1917-1957.

Year	Wheat	Corn	Oats	Barley	Gr. Sorg.
1917	17.46	37.41	3.50	20.74	7.19
1918	32.97	28.79	3.22	15.40	5.42
1919	59.04	16.62	1.00	10.40	2.12
1920	58.60	16.91	0.86	11.56	1.88
1921	64.66	14.65	0.90	9.41	1.55
1922	56.86	20.40	1.24	9.22	2.72
1923	39.36	30.96	1.86	13.30	5.25
1924	50.09	27.67	1.32	10.63	1.81
1925	52.37	27.50	0.95	8.43	1.47
1926	51.94	29.22	1.03	7.05	1.90
1927	37.77	38.28	2.44	9.07	3.64
1928	26.77	49.16	1.17	14.00	1.82
1929	50.95	27.94	0.99	12.87	1.07
1930	57.71	25.23	0.96	9.02	1.03
1931	51.81	30.72	1.01	9.65	0.88
1932	34.85	43.68	1.61	10.69	1.06
1933	15.80	46.76	2.53	20.14	2.61
1934	36.87	33.49	1.23	12.97	—
1935	12.78	26.95	1.26	10.84	4.57
1936	44.70	30.13	1.38	9.22	—
1937	69.95	12.37	0.65	4.10	4.64
1938	71.90	9.20	0.76	5.57	4.76
1939	53.20	8.50	1.50	10.80	12.60
1940	42.10	11.80	1.70	16.60	13.30
1941	56.10	11.70	1.40	13.60	6.30
1942	65.50	13.30	7.10	8.30	2.80
1943	64.30	12.20	1.20	9.30	2.00
1944	56.60	13.10	2.70	9.40	5.30
1945	73.70	7.30	1.10	4.50	3.50
1946	76.50	5.80	1.20	4.10	2.00
1947	81.70	3.90	1.00	3.20	1.50
1948	76.20	4.10	1.60	4.80	3.80
1949	77.70	4.10	1.10	2.70	4.80
1950	78.10	4.30	0.80	1.90	5.00
1951	57.30	7.90	0.90	1.10	16.40
1952	79.60	5.40	1.00	0.60	4.10
1953	68.80	6.20	1.30	1.30	11.60
1954	58.70	6.30	1.00	2.60	18.30
1955	63.20	2.50	0.70	2.60	5.70
1956	62.30	1.60	0.20	1.60	7.00
1957	36.70	5.30	0.90	3.30	38.20

Table 4. Percentage of total harvested acres occupied by individual crops, area 12, 1917-1957.

Year	Wheat	Corn	Oats	Barley	Gr. Sorg.
1917	2.08	19.58	2.18	13.47	16.79
1918	3.31	17.72	2.20	12.25	18.44
1919	13.64	14.41	1.41	15.57	16.30
1920	15.65	15.50	1.62	15.54	15.61
1921	30.38	16.20	1.62	16.47	11.09
1922	31.07	16.27	1.54	13.95	11.96
1923	14.50	19.27	1.38	14.66	19.92
1924	27.26	20.64	0.92	15.39	13.84
1925	26.81	24.80	0.92	14.73	10.04
1926	27.49	25.32	0.78	15.31	11.46
1927	20.88	27.47	0.59	12.24	19.54
1928	19.44	29.74	0.66	15.02	16.23
1929	33.95	24.18	0.52	18.25	9.97
1930	43.37	19.08	0.44	16.45	7.31
1931	58.73	14.77	0.35	10.90	4.45
1932	29.88	24.46	0.66	17.87	10.76
1933	7.40	25.05	0.31	38.06	14.61
1934	37.57	13.18	0.18	17.83	—
1935	1.14	23.57	0.11	10.33	13.02
1936	37.10	13.48	0.50	57.79	—
1937	51.74	4.58	0.70	4.81	22.75
1938	56.34	2.31	0.13	4.92	20.41
1939	58.90	1.00	0.10	8.00	17.00
1940	32.00	2.00	0.30	13.60	29.90
1941	50.50	1.50	0.40	14.60	16.30
1942	65.90	2.90	0.40	7.50	8.80
1943	66.30	2.40	0.30	7.20	7.70
1944	39.30	2.70	0.60	12.50	27.30
1945	70.30	1.00	0.20	4.60	9.30
1946	80.40	0.80	0.10	2.70	3.90
1947	83.40	0.50	0.20	2.10	5.10
1948	78.80	0.40	0.30	2.60	8.90
1949	74.40	0.30	0.20	2.10	15.10
1950	71.80	0.30	0.10	0.60	15.60
1951	30.60	2.30	0.20	1.00	50.00
1952	84.30	0.70	0.20	0.80	6.80
1953	67.80	0.90	0.20	0.40	17.90
1954	41.40	0.80	0.20	1.90	42.70
1955	50.30	0.80	0.10	0.80	21.70
1956	50.80	1.30	0.10	0.60	12.30
1957	3.70	1.60	0.80	2.00	71.00

Table 5. Values of coefficients of determination (R^2) and regression (b).

	Area 10a	Area 10b	Area 11	Area 12	All areas
R^2	0.66	0.79	0.74	0.80	0.64
b_1	-68.71	-57.52	-16.66	26.95	50.00
b_2	7.33	16.27	11.46	3.76	10.98
b_3	0.39	0.49	0.15	0.56	0.35
b_4	-827.0	1,040.12	-562.45	409.42	98.36
b_5	61.53	-41.69	40.80	-5.94	18.15
b_6	-1.88	-0.37	-0.46	-2.06	-0.77
b_7	3.875.32	-8,385.76	6,194.30	-8,448.54	677.21
b_8	-531.82	618.44	-513.50	449.78	-14.74
b_9	4.59	8.95	3.33	33.21	-4.44
b_{10}	-868.77	-404.90	-703.36	-115.74	-171.14
b_{11}	57.64	-2.81	43.67	2.78	-7.86
b_{12}	1.48	6.75	-1.16	0.62	1.97
b_{13}	152.87	76.91	489.54	99.86	194.46
b_{14}	4.86	-2.08	-64.35	1.86	-3.96
b_{15}	-0.82	0.38	1.80	-0.39	0.33

Table 6. Percent of variation in income derived from crops as explained by different independent variables.

	Area 10a	Area 10b	Area 11	Area 12	All areas
b_1	30.8	28.4	31.5	57.7	36.6
b_2	20.4	29.7	19.1	6.9	15.4
b_3	5.8	7.0	1.0	10.6	3.9
b_4	0.1	0.0	0.8	3.3	1.3
b_5	1.0	0.1	6.0	1.0	1.6
b_6	0.6	0.2	0.5	0.1	0.2
b_7	0.3	0.3	0.8	0.0	0.2
b_8	1.6	0.6	1.7	0.4	0.1
b_9	0.2	0.6	0.0	2.5	0.0
b_{10}	1.5	0.4	1.0	0.1	1.2
b_{11}	1.8	0.0	5.6	0.0	0.1
b_{12}	0.2	0.8	0.2	0.1	0.5
b_{13}	1.0	0.9	0.5	0.3	2.6
b_{14}	0.4	0.0	5.1	0.0	0.1
b_{15}	0.3	0.1	0.3	0.2	0.1

Table 7. t values and levels of significance for multiple regression coefficients.[1]

	Area 10a	Area 10b	Area 11	Area 12	All areas
b_1	0.42	0.34	0.07	0.25	0.78
	N.S.	N.S.	sN.S.	N.S.	0.45
b_2	2.02	3.31	2.25	1.26	5.91
	0.05	0.003	0.030	0.25	0.0001
b_3	1.39	1.39	0.35	2.17	2.45
	0.18	0.18	N.S.	0.37	0.020
b_4	0.80	1.03	1.29	1.01	0.50
	N.S.	0.34	0.22	0.32	N.S.
b_5	1.37	0.64	2.72	0.35	2.11
	0.19	N.S.	0.015	N.S.	0.045
b_6	0.52	0.07	0.24	0.65	0.75
	N.S.	N.S.	N.S.	N.S.	0.43
b_7	0.93	1.06	1.10	1.23	0.38
	0.36	0.33	0.31	0.27	N.S.
b_8	1.56	1.17	1.23	0.65	0.12
	0.15	0.29	0.255	N.S.	N.S.
b_9	0.40	0.39	0.17	1.78	0.80
	N.S.	N.S.	N.S.	0.098	0.41
b_{10}	0.70	0.19	0.63	0.24	0.57
	0.46	N.S.	N.S.	N.S.	N.S.
b_{11}	1.28	0.04	1.11	0.16	0.58
	0.24	N.S.	0.30	N.S.	N.S.
b_{12}	0.28	0.77	0.26	0.21	1.20
	N.S.	0.42	N.S.	N.S.	0.25
b_{13}	0.30	0.27	0.68	0.46	1.42
	N.S.	N.S.	N.S.	N.S.	0.175
b_{14}	0.44	0.17	2.27	0.26	0.85
	N.S.	N.S.	0.029	N.S.	0.41
b_{15}	0.44	0.32	0.50	0.50	0.68
	N.S.	N.S.	N.S.	N.S.	N.S.

1. Rows opposite b's refer to the t values, with the significance levels directly under them.

Table 8. Estimated marginal returns of wheat, corn, oats, barley and grain sorghums in area 10a, 1917-1957.

Year	Marginal Returns				
	Wheat	Corn	Oats	Barley	Grain Sorghum
1917	111.2	-477.3	1,835.1	93.8	33.5
1918	159.6	-308.0	- 89.2	551.3	33.4
1919	223.7	- 47.4	-1,569.0	1,003.6	52.9
1920	169.3	-269.4	563.9	509.9	64.3
1921	143.2	130.0	-1,139.1	468.4	186.3
1922	128.0	25.8	-1,969.6	411.8	167.7
1923	120.7	506.7	-3,457.1	435.5	183.3
1924	144.0	-217.3	746.1	597.5	117.8
1925	123.5	-168.2	752.7	288.6	113.3
1926	128.0	-242.6	180.1	338.6	128.1
1927	127.2	191.5	-2,109.2	395.4	155.6
1928	162.8	421.0	-4,028.3	704.9	174.5
1929	132.7	- 97.5	- 88.4	522.1	132.5
1930	151.2	315.1	-3,006.1	731.7	171.9
1931	128.6	2.8	- 399.2	605.1	176.8
1932	94.9	140.2	-1,427.4	340.0	205.3
1933	73.9	7.1	- 28.9	109.1	185.0
1934	91.7	-414.3	-1,334.1	237.2	120.9
1935	92.5	-120.9	-1,423.1	267.1	230.8
1936	92.4	-312.0	105.4	233.8	103.1
1937	71.2	-511.3	1,545.3	74.0	71.7
1938	94.6	89.2	-2,017.9	357.5	172.5
1939	69.7	-259.0	- 316.4	102.2	143.4
1940	73.3	63.5	-1,084.5	123.5	158.3
1941	171.4	454.3	-4,315.4	836.0	192.7
1942	147.3	132.4	-1,887.3	617.3	149.6
1943	130.4	-291.5	300.6	485.4	78.2
1944	185.4	409.6	-4,060.2	873.5	125.6
1945	177.0	-153.4	-1,065.7	780.9	85.9
1946	135.3	-219.5	129.8	442.7	47.6
1947	251.9	-525.2	- 522.9	1,222.8	-20.2
1948	164.7	-149.0	- 980.6	630.6	14.3
1949	236.6	271.9	-4,813.9	1,100.9	115.9
1950	125.1	25.8	1,733.9	227.6	87.9
1951	307.0	581.4	-6,160.9	1,637.0	105.6
1952	163.4	-790.4	1,934.7	666.3	-64.7
1953	119.7	-636.9	1,902.4	329.0	-33.7
1954	165.5	-504.7	1,393.2	543.3	26.2
1955	176.1	-123.8	-1,764.8	611.5	66.9
1956	104.4	-693.8	2,276.2	80.1	22.1
1957	193.1	448.3	-4,838.0	745.3	129.3

Table 9. Estimated marginal returns of wheat, corn, oats, barley and grain sorghums in area 10b, 1917-1957.

Year	Marginal Returns				
	Wheat	Corn	Oats	Barley	Gr. Sorgum
1917	256.6	348.8	-2,902.5	1,106.2	137.5
1918	335.0	348.8	-1,540.6	1,234.2	146.3
1919	416.3	318.8	- 904.6	1,235.2	145.6
1920	328.8	249.2	-1,985.1	944.3	54.0
1921	416.0	217.2	-1,305.2	- 26.1	63.2
1922	331.8	335.9	- 977.3	96.1	75.9
1923	294.7	213.5	200.0	339.7	84.4
1924	338.2	438.1	-2,723.4	414.9	100.8
1925	272.2	191.0	-3,287.9	519.3	93.4
1926	378.0	470.7	-2,830.6	281.8	94.4
1927	283.1	253.6	-2,609.1	376.7	88.1
1928	425.3	53.9	2,081.9	339.4	77.7
1929	339.0	353.7	-2,547.2	359.7	93.2
1930	262.5	445.3	-3,501.9	302.6	93.6
1931	323.3	580.4	-3,725.9	- 23.9	81.1
1932	235.8	416.1	-1,121.5	- 193.5	126.0
1933	154.2	497.7	-3,894.5	- 75.0	71.9
1934	273.6	633.1	-4,403.8	236.2	69.2
1935	274.7	486.7	-2,475.1	519.6	109.1
1936	238.5	454.5	-1,695.9	506.2	106.2
1937	226.0	615.9	-4,019.7	682.3	124.4
1938	235.3	315.5	-1,233.5	102.0	74.4
1939	289.2	552.4	-2,452.5	106.3	87.2
1940	299.6	349.2	-1,055.5	227.9	84.5
1941	366.9	38.4	1,744.6	183.5	66.8
1942	401.2	202.8	6.0	363.2	86.4
1943	296.2	475.6	-2,940.8	778.0	124.5
1944	416.6	- 4.9	3,297.0	847.4	105.8
1945	380.0	223.4	- 608.2	799.7	113.9
1946	335.8	290.5	- 772.7	1,156.6	138.7
1947	553.6	247.1	1,612.2	1,473.3	164.7
1948	356.8	108.1	812.5	1,564.6	154.7
1949	446.8	66.7	1,424.0	833.2	108.5
1950	305.8	265.9	-3,840.3	946.5	124.0
1951	572.7	- 54.9	3,636.2	1,181.4	125.1
1952	319.0	499.6	-1,834.9	1,864.0	192.5
1953	223.5	469.5	-2,711.4	1,681.9	178.8
1954	314.9	453.9	-2,954.9	1,150.3	146.1
1955	389.5	243.6	1,355.1	1,028.3	128.8
1956	197.6	673.5	-4,281.2	1,053.7	150.0
1957	365.1	112.2	2,360.5	854.6	111.3

Table 10. Estimated marginal returns of wheat, corn, oats, barley and grain sorghums in area 11, 1917-1957.

Year	Marginal Returns				
	Wheat	Corn	Oats	Barley	Gr. Sorghum
1917	220.7	-149.3	1,741.7	52.7	35.5
1918	234.7	-201.7	3,653.4	82.7	29.8
1919	267.1	-220.0	4,799.3	100.7	33.5
1920	251.3	-123.2	2,765.5	61.6	50.8
1921	178.8	178.8	-2,479.0	-22.6	103.1
1922	174.6	136.9	- 418.5	-10.8	99.4
1923	182.5	3.2	2,902.6	20.0	104.8
1924	181.7	58.3	-1,152.0	21.3	74.1
1925	198.9	28.0	- 585.5	17.9	69.9
1926	173.6	111.1	-2,637.5	-11.1	77.6
1927	190.5	45.1	1,101.2	14.6	87.0
1928	183.9	35.3	1,517.8	14.0	91.2
1929	171.6	64.5	518.0	12.6	80.8
1930	167.8	57.1	769.2	15.3	93.9
1931	145.4	193.8	-2,647.1	-12.0	99.4
1932	119.9	242.9	-2,643.9	-41.7	112.6
1933	118.0	189.5	-3,270.4	-46.9	113.7
1934	156.4	141.0	-2,204.8	- 1.9	78.7
1935	142.9	23.6	392.3	8.2	70.2
1936	147.1	46.4	- 831.8	5.5	66.1
1937	157.3	- 14.6	684.7	23.0	60.0
1938	146.5	139.6	- 406.1	-13.3	99.6
1939	133.7	154.9	-1,060.0	-20.0	92.5
1940	124.4	109.4	-1,631.8	-20.9	87.8
1941	184.4	36.7	2,115.4	14.1	116.6
1942	207.0	33.1	1,257.6	36.8	88.7
1943	192.2	- 54.5	1,653.9	48.3	54.5
1944	209.0	-143.7	4,784.3	60.1	69.2
1945	215.4	- 79.7	2,134.7	57.8	57.2
1946	218.0	-196.3	4,142.8	77.5	39.9
1947	302.0	-323.4	7,041.9	147.3	8.7
1948	241.6	-317.0	6,359.7	112.3	14.2
1949	256.2	-137.8	5,347.6	69.8	69.5
1950	225.6	-123.8	1,146.3	51.5	51.0
1951	271.1	-247.6	5,386.2	99.9	46.7
1952	254.4	-377.8	6,123.0	144.9	-12.5
1953	224.8	-328.7	1,876.7	112.3	2.9
1954	239.0	-147.8	2,457.1	73.2	26.4
1955	228.1	-124.2	2,420.7	56.9	36.1
1956	204.8	- 98.7	948.1	43.1	29.2
1957	207.0	- 56.1	612.9	31.5	42.1

Table 11. Estimated marginal returns of wheat, corn, oats, barley and grain sorghums in area 12, 1917-1957.

Year	Marginal Returns				
	Wheat	Corn	Oats	Barley	Gr. Sorghum
1917	215.4	-134.6	1,606.8	48.8	30.8
1918	218.3	-186.3	3,113.6	70.6	28.2
1919	241.6	-199.4	3,315.0	81.9	126.9
1920	238.8	-105.5	1,667.3	52.4	45.1
1921	179.9	181.1	-1,984,2	-21.8	102.4
1922	159.0	154.0	-1,677.9	-22.3	93.9
1923	166.6	14.4	1,283.3	8.3	101.2
1924	196.6	58.3	- 657.3	32.3	74.1
1925	186.0	38.6	-1,215.2	8.4	66.5
1926	182.4	107.6	-1,962.8	- 4.6	77.8
1927	173.4	53.8	- 518.0	2.0	84.2
1928	203.3	24.7	2,867.2	28.3	94.6
1929	160.6	69.2	- 698.0	4.5	79.2
1930	151.8	87.8	-1,030.0	3.5	84.0
1931	136.6	207.4	-3,141.9	-18.5	95.0
1932	121.1	231.7	-1,429.5	-40.8	116.3
1933	114.9	199.0	-3,135.5	-49.2	131.8
1934	148.8	143.9	-2,519.7	- 7.5	77.8
1935	137.9	40.1	- 282.4	4.5	64.9
1936	144.1	40.5	- 561.9	3.5	68.0
1937	148.2	5.4	- 484.8	16.3	53.5
1938	135.5	137.8	-1,216.3	-21.2	100.2
1939	128.0	179.6	-2,544.3	-24.2	84.6
1940	123.2	112.3	-1,406.9	-21.8	86.9
1941	168.1	100.4	856.0	2.1	96.1
1942	193.7	50.2	1,122.7	27.0	83.2
1943	180.8	- 39.1	574.4	39.9	49.5
1944	214.7	-129.6	5,459.0	64.3	64.7
1945	192.2	- 65.6	1,145.2	40.7	52.7
1946	215.3	-179.8	3,827.9	75.5	34.6
1947	291.8	-328.7	6,817.0	139.8	10.4
1948	240.1	-319.9	5,864.9	111.2	15.1
1949	256.9	-138.4	5,482.5	70.3	69.6
1950	218.0	-130.8	381.6	45.9	53.2
1951	303.8	-257.6	7,860.1	124.0	50.0
1952	235.4	-368.9	5,673.2	130.9	-15.4
1953	211.9	-308.6	4,440.6	103.5	- 3.6
1954	228.7	-141.3	1,332.6	65.6	24.3
1955	233.0	-125.4	2,780.5	60.5	36.4
1956	197.2	- 95.6	453.4	37.5	27.9
1957	238.1	-115.7	4,436.2	54.4	138.5

Table 12. Rank of marginal returns from individual crops in area 10a, 1917-1957.

	Wheat	Corn	Oats	Barley	Gr. Sorg.
1917	2	5	1	3	4
1918	2	5	4	1	3
1919	2	5	4	1	3
1920	3	5	1	2	4
1921	3	4	5	1	2
1922	3	4	5	1	2
1923	4	1	5	2	3
1924	3	5	1	2	4
1925	3	5	1	2	4
1926	4	5	2	1	3
1927	4	2	5	1	3
1928	4	2	5	1	3
1929	2	5	4	1	3
1930	4	2	5	1	3
1931	3	4	5	1	2
1932	4	3	5	1	2
1933	3	4	5	2	1
1934	3	4	5	1	2
1935	3	4	5	1	2
1936	4	5	2	1	3
1937	4	5	1	2	3
1938	3	4	5	1	2
1939	3	4	5	2	1
1940	3	4	5	2	1
1941	4	2	5	1	3
1942	3	4	5	1	2
1943	3	5	2	1	4
1944	3	2	5	1	4
1945	2	4	5	1	3
1946	2	5	3	1	4
1947	2	5	4	1	3
1948	2	4	5	1	3
1949	3	2	5	1	4
1950	3	5	1	2	4
1951	3	2	5	1	4
1952	3	5	1	2	4
1953	3	5	1	2	4
1954	3	5	1	2	4
1955	2	4	5	1	3
1956	2	5	1	3	4
1957	3	2	5	1	4

Table 13. Rank of marginal returns from individual crops in area 10b, 1917-1957.

	Wheat	Corn	Oats	Barley	Gr. Sorg.
1917	3	2	5	1	4
1918	3	2	5	1	4
1919	2	3	5	1	4
1920	2	3	5	1	4
1921	1	2	5	4	3
1922	2	1	5	3	4
1923	2	3	4	1	5
1924	3	1	5	2	4
1925	2	3	5	1	4
1926	2	1	5	3	4
1927	3	2	5	1	4
1928	2	5	1	3	4
1929	3	2	5	1	4
1930	3	1	5	2	4
1931	2	1	5	4	3
1932	2	1	5	4	3
1933	2	1	5	4	3
1934	2	1	5	3	4
1935	3	2	5	1	4
1936	3	2	5	1	4
1937	3	2	5	1	4
1938	2	1	5	3	4
1939	2	1	5	3	4
1940	2	1	5	3	4
1941	2	5	1	3	4
1942	1	3	5	2	4
1943	3	2	5	1	4
1944	3	5	1	2	4
1945	2	3	5	1	4
1946	2	3	5	1	4
1947	2	3	1	4	5
1948	3	5	2	1	4
1949	3	5	1	2	4
1950	2	3	5	1	4
1951	3	5	1	2	4
1952	3	2	5	1	4
1953	3	2	5	1	4
1954	3	2	5	1	4
1955	3	4	1	2	5
1956	3	2	5	1	4
1957	3	4	1	2	5

Table 14. Rank of marginal returns from individual crops in area 11, 1917-1957.

	Wheat	Corn	Oats	Barley	Gr. Sorg.
1917	2	5	1	3	4
1918	2	5	1	3	4
1919	2	5	1	3	4
1920	2	5	1	3	4
1921	1	2	5	4	3
1922	1	2	5	4	3
1923	2	5	1	4	3
1924	1	3	5	4	2
1925	1	3	5	4	2
1926	1	2	5	4	3
1927	2	4	1	5	3
1928	2	4	1	5	3
1929	2	4	1	5	3
1930	2	4	1	5	3
1931	2	1	5	4	3
1932	2	1	5	4	3
1933	2	1	5	4	3
1934	1	2	5	4	3
1935	2	4	1	5	3
1936	1	3	5	4	2
1937	2	5	1	4	3
1938	1	2	5	4	3
1939	2	1	5	4	3
1940	1	2	5	4	3
1941	2	4	1	5	3
1942	2	5	1	4	3
1943	2	5	1	4	3
1944	2	5	1	4	3
1945	2	5	1	3	4
1946	2	5	1	3	4
1947	2	5	1	3	4
1948	2	5	1	3	4
1949	2	5	1	3	4
1950	2	5	1	3	4
1951	2	5	1	3	4
1952	2	5	1	3	4
1953	2	5	1	3	4
1954	2	5	1	3	4
1955	2	5	1	3	4
1956	2	5	1	3	4
1957	2	5	1	4	3

Table 15. Rank of marginal returns from individual crops in area 12, 1917-1957.

	Wheat	Corn	Oats	Barley	Gr. Sorg.
1917	2	5	1	3	4
1918	2	5	1	3	4
1919	2	5	1	4	3
1920	2	5	1	3	4
1921	2	1	5	4	3
1922	1	2	5	4	3
1923	2	4	1	5	3
1924	1	3	5	4	2
1925	1	3	5	4	2
1926	1	2	5	4	3
1927	1	3	5	4	2
1928	2	5	1	4	3
1929	1	3	5	4	2
1930	1	2	5	4	3
1931	2	1	5	4	3
1932	2	1	5	4	3
1933	3	1	5	4	2
1934	1	2	5	4	3
1935	1	3	5	4	2
1936	1	3	5	4	2
1937	1	4	5	3	2
1938	2	1	5	4	3
1939	2	1	5	4	3
1940	1	2	5	4	3
1941	2	3	1	5	4
1942	2	4	1	5	3
1943	2	5	1	4	3
1944	2	5	1	4	3
1945	2	5	1	4	3
1946	2	5	1	3	4
1947	2	5	1	3	4
1948	2	5	1	3	4
1949	2	5	1	3	4
1950	2	5	1	4	3
1951	2	5	1	3	4
1952	2	5	1	3	4
1953	2	5	1	3	4
1954	2	5	1	3	4
1955	2	5	1	3	4
1956	2	5	1	3	4
1957	2	5	1	4	3

Table 16. Number of years in which each crop attained each rank by level of marginal returns, 1917-1957.

Area and Crop	Rank Frequency					
	1	2	3	4	5	Total
Area 10a						
Wheat	0	10	22	9	0	41
Corn	1	8	1	13	18	41
Oats	10	3	1	4	23	41
Barley	27	12	2	0	0	41
Gr. Sorg.	3	8	15	15	0	41
Area 10b						
Wheat	2	19	20	0	0	41
Corn	11	13	9	4	6	41
Oats	8	1	0	1	31	41
Barley	20	8	8	5	0	41
Gr. Sorg.	0	0	4	33	4	41
Area 11						
Wheat	9	32	0	0	0	41
Corn	4	6	3	6	22	41
Oats	28	0	0	0	13	41
Barley	0	0	16	19	6	41
Gr. Sorg.	0	3	22	16	0	41
Area 12						
Wheat	13	27	1	0	0	41
Corn	6	6	6	3	20	41
Oats	23	0	0	0	18	41
Barley	0	0	14	25	2	41
Gr. Sorg.	0	8	20	13	0	41

Table 17. Value of crops produced in four economic areas in Western Kansas, 1917-1957, adjusted to a 1910-14 base.

Year	Area 10a	Area 10b	Area 11	Area 12
	(Thousands of Dollars)			
1917	1,906	3,130	3,751	887
1918	3,061	3,665	5,064	1,348
1919	7,151	9,204	16,505	2,048
1920	11,299	7,623	18,497	2,452
1921	7,234	10,256	9,763	2,038
1922	7,266	10,788	15,945	2,793
1923	8,451	6,953	16,847	3,749
1924	13,913	18,056	17,753	3,953
1925	6,859	7,190	12,742	2,107
1926	6,638	23,068	3,641	1,576
1927	5,680	8,584	12,563	2,595
1928	14,856	21,475	20,705	5,175
1929	14,462	27,118	20,429	5,125
1930	12,926	12,966	23,395	5,915
1931	20,782	24,967	17,754	8,974
1932	8,794	8,080	11,838	3,984
1933	5,316	3,857	9,373	2,217
1934	3,499	3,526	4,586	2,101
1935	838	1,863	3,276	338
1936	6,370	4,029	6,788	2,160
1937	3,147	2,993	5,486	2,189
1938	6,004	5,903	12,284	4,783
1939	2,194	5,006	5,159	2,416
1940	3,755	7,568	6,281	2,922
1941	16,513	19,364	19,000	8,595
1942	20,735	27,627	28,813	11,464
1943	12,501	15,597	22,515	12,249
1944	17,771	30,580	17,116	9,061
1945	19,679	27,198	27,771	17,837
1946	16,573	21,631	26,579	10,961
1947	26,538	36,622	29,525	23,919
1948	14,023	28,587	18,519	14,941
1949	13,124	22,023	12,510	10,413
1950	12,366	12,356	22,238	10,929
1951	10,646	16,009	12,658	8,498
1952	25,164	29,493	28,286	23,534
1953	5,901	7,595	15,941	7,050
1954	12,175	12,893	15,649	7,809
1955	12,116	11,413	15,773	8,126
1956	9,948	13,063	7,245	5,198
1957	9,640	13,549	16,279	8,472

Table 18. Index numbers of prices received by Kansas farmers, 1917-1957, inclusive.

Year	(1910-14-100)		
	Food Grains	Feed Grains	Other
1917	250	227	240
1918	234	248	235
1919	250	250	248
1920	251	205	235
1921	132	66	113
1922	120	82	109
1923	111	117	112
1924	123	129	124
1925	177	142	165
1926	157	110	143
1927	142	121	135
1928	131	120	126
1929	115	121	115
1930	89	111	94
1931	51	65	55
1932	39	38	39
1933	68	53	64
1934	94	100	96
1935	107	143	117
1936	116	140	117
1937	126	164	128
1938	77	81	77
1939	74	83	74
1940	85	101	86
1941	99	96	98
1942	122	123	121
1943	150	181	152
1944	169	194	170
1945	174	186	174
1946	203	237	204
1947	276	304	276
1948	245	297	249
1949	223	192	215
1950	231	205	224
1951	253	246	249
1952	251	340	261
1953	236	311	245
1954	245	235	242
1955	242	219	237
1956	233	218	229
1957	229	193	222

CROP INCOME IN WESTERN KANSAS FOR 1917-1957 AS AFFECTED BY LAND ALLOCATION, PRICES AND RAINFALL

by

LARRY MURPHY BOONE

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The primary aims of this study were (1) to provide the farmers in this area with a measure of relative importance of different crops; (2) to develop a background of factual information for extension farm planning, and (3) to provide a better basis for certain policy recommendations.

Geographically, this study includes four established type of farming areas which comprise approximately the western one-third of Kansas. This is primarily a wheat producing area characterized by low rainfall. It is also an area faced with an acute problem of how to allocate the available land among crops in order to comply with government regulations while maintaining income.

Value of crops produced, in constant dollars based on a 1910-14 time period, was used as an estimate of crop income, the dependent variable. These values were obtained from Kansas State Board of Agriculture Biennial Reports and Farm facts for all crops sold, used on the farm or stored. The independent variables included land allocation among wheat, corn, oats, barley and grain sorghum; rainfall, prices; and combinations of land allocation with rainfall and with prices.

Land allocation refers to the percent of the total harvested acres in this area which was occupied by each of the major crops in each year from 1917-1957. Rainfall refers to the quarters of rainfall recorded at various measuring stations in this area. Prices refer to price indexes obtained from the Kansas State Board of Agriculture Price Patterns report. The "Food Grains" index was applied to wheat; the "Feed Grains" index to corn, oats, barley and grain sorghum; and the "All Crops" index to the "Other Crops" variable.

The data were analyzed by a single equation multiple regression method. After experimentation, the equation form selected for use was,

$$Y = a + b_1X_1 + b_2X_1 (X_7 + X_8 + X_9 + X_{10}) + b_3X_1 (X_{12}) +$$
$$+ b_4X_2 + b_5X_2 (X_9 + X_{10} + X_{11}) + b_6X_2 (X_{13}) +$$
$$+ b_7X_3 + b_8X_3 (X_9 + X_{10}) + b_9X_3 (X_{13}) +$$
$$+ b_{10}X_4 + b_{11}X_4 (X_7 + X_8 + X_9 + X_{10}) + b_{12}X_4 (X_{13}) +$$
$$+ b_{13}X_5 + b_{14}X_5 (X_9 + X_{10} + X_{11}) + b_{15}X_5 (X_{13})$$

Y = annual value of crop production from cropland including the value of all crops sold, stored or used on the farm measured in constant dollars;

X_1 = crop acreage of wheat in percent;

X_2 = crop acreage of corn in percent;

X_3 = crop acreage of oats in percent;

X_4 = crop acreage of barley in percent;

X_5 = crop acreage of grain sorghums in percent;

X_6 = crop acreage of other crops in percent;

X_7 = 3rd quarter rainfall in year t-1;

X_8 = 4th quarter rainfall in year t-1;

X_9 = 1st quarter rainfall in year t;

X_{10} = 2nd quarter rainfall in year t;

X_{11} = 3rd quarter rainfall in year t;

X_{12} = Food grain index (1910-14 base);

X_{13} = Feed grain index (1910-14 base);

X_{14} = All crops index (1910-14 base).

"Other Crops" variable has shown in the preliminary analysis that its effect on values of crops produced was very small and it was omitted from the study in the final analysis. The omission of the "Other Crops" variable made the "All Crops" price index unnecessary also.

Wheat was the most important crop in this area from the standpoint of acres grown. Grain sorghum ranks second in land allocation with corn, oats and barley being relatively less important.

Coefficients of determination (R^2) showed that 66, 79, 51.6 and 83 percent of the variation in value of crops produced in type of farming areas 10a, 10b, 11 and 12 respectively was explained by the factors considered in regression. The coefficient of determination derived for the area of the study as a whole, indicated that 64 percent of the variation in value of crops produced was explained by the factors considered in the regression analysis.

The partial coefficients of determination in all individual economic areas showed wheat, along with rainfall, to be the major source of variation in value of crops produced.

Marginal returns from each crop were estimated for every one of the 41 years. These were derived by taking a partial derivative of Y with respect to each crop. Wheat was the most stable crop of the five considered. Barley and grain sorghum indicated relatively low or in some years even negative marginal returns, making them less desirable crops in which to invest time, labor and equipment. Corn and oats both showed negative marginal returns in several years, making them the least dependable crop to grow.

The major limitations of this study were caused by situations which were unaviodable. True crop income figures were not available, and the value of crops produced figures were used. Costs of producing the crops are difficult to obtain. Had then been considered, the marginal returns would have been lower.

The restrictions placed upon the production of certain crops by government programs have a detrimental effect on the ability of farmers to make decisions concerning land allocation. For maximum income in the area covered by this study, the optimum cropping plan would appear to include the maximum legal acreage of wheat with the remainder of the land allocated primarily to barley and grain sorghums. Until more crop varieties are developed which are adaptable to this area, these three will probably remain the major factors in determining crop income.

Policy recommendations based on the needs of this area alone would most certainly be aimed at easing restrictions on the acreage of wheat which farmers were allowed to grow. In an aggregate sense, however, this area loses some significance. A possibility would be to eliminate the production of wheat in other areas, giving wheat production to the area where wheat is most adaptable.