

THE EFFECT OF VARYING LEVELS OF NET INCOMES FOR DIFFERENT
ENTERPRISES ON THE RESOURCE ORGANIZATION OF A CERTIFIED
SEED WHEAT FARM IN KANSAS

by

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INTRODUCTION

During the past several decades, the problem of allocating resources has been recognized as one of the major problems facing agricultural producers. Although the problem has only recently been recognized by researchers, resource allocation problems have been of concern to man ever since he first began experiencing the scarcity of some of the resources used in his everyday life. For example, the pre-Columbian American Indian faced the problem of using fish as food for immediate consumption, or using the fish as fertilizer to increase the years' corn crop. The nineteenth century homesteader had the choice of planting all of his 160 acres to crops, almost assured that he would be unable to care for them adequately with his near primitive equipment or concentrating on a smaller acreage and caring for it better.

Recently, however, problems of resource allocation on United States farms have become more complex than ever in the history of agriculture. In addition to the basic quantitative problems faced by his predecessors, the modern farmer has had to be concerned with qualitative differences in resources, as well as rapidly changing technological and institutional factors.

With the nearly continual rise in the cost of agricultural inputs during the past several decades, the farmer of today could not afford to mis-allocate valuable resources if he was to show a profit from his labor.¹ Even though the absolute number of

1. Historical Supplement to the Federal Reserve Chart Book On Financial and Business Statistics, September 1960, Board of Governors of the Federal Reserve System, p. 112-113.

farmers in Kansas have declined in the past half-century, land was frequently believed to be the most limiting resource by farmers.^{1,2} Under these conditions, the farmer's income could only be maintained or increased by using the available resources more efficiently, by vertical integration or specialization of some phase of production. This study was an inquiry into the latter of these three alternatives and specifically was concerned with determining the economic feasibility of a specialized wheat cropping program on a Kansas farm.

The Problem and Objectives of the Study

The basic problem of any firm has been the maximization of profits by combining the available resources most efficiently. Frequently one or more of the available resources has been limited to the extent that the entire production process had to be centered on making the most efficient use of the limited resource rather than of all resources. This has occurred on many farms when the operator believed land to be the most limited resource. In reality, labor and capital, rather than land may have been the most limiting resources, since many farm situations had the alternative of highly intensive farming. However, this author believed that the average farm operator (in Kansas) has preferred a more extensive operation. This conclusion was

1. United States Department of Commerce, "1954 Census of Agriculture, Kansas," Vol. I, Part 13, p. 17.

2. For additional comments on this conclusion, see page 2, paragraph 2 of this study.

justified from the fact that there has been relatively less physical labor involved on the part of the operator in extensive farm operations than on highly intensive operations. Assuming that most Kansas farmers have preferred extensive rather than intensive farm organizations, it was therefore conceivable that land could well be the limiting resource.

When this situation has existed a farm operator has had no choice but to utilize the land in the most efficient manner. In Kansas agriculture, relatively few cropping alternatives have existed.¹ The Kansas farmer has had to choose from wheat, barley, grain sorghum, corn, oats, alfalfa, native or domestic grasses, silage sorghum, soybeans, rye, sweetclover, sugar beets, and lespedesa. These have been considered to be the standard crops although there has recently been some interest in castor beans and safflower.²

Due to limited rainfall even fewer alternatives have been available to the farmer in Central and Western Kansas.³ With the exception of irrigated acreage in this area, the farmer has had to be satisfied with growing wheat, barley, oats, grain sorghum, silage sorghum, and alfalfa. In most cases on non-irrigated farm land, wheat has been grown as it was well suited to the area and has been relatively higher priced than other grain or forage crops.⁴

1. Kansas State Board of Agr., Farm Facts, 1960-1961, p. 3.

2. For further information on this see the Master Development Report of Reno County, Development Association, Reno County, Kansas published by Doane Agricultural Service, St. Louis, Missouri.

3. Farm Facts, op. cit. pp. 13-66.

4. Ibid., p. 89.

This left only the cropland which was not allotted to wheat on which to grow other crops. What has been grown on the remaining cropland has depended upon three variables: the yields, the costs of production, and the relative unit prices of the alternative crops.

Per acre net income for any crop was determined to be a function of price, yield and cost of production. This implied that in order to maximize per acre net income, the farm operator had to be constantly alert to any long run change in these three variables. Frequently a significant change of one of the variables has occurred. This has been witnessed in the past when technological or institutional factors brought about a change in one or all of the variables. Hybrid grain sorghums, increased use of commercial fertilizers, government programs, and new tillage methods have been excellent examples of factors responsible for bringing about changes in the three variables noted above. The problem of how to determine which crop or crops were to be grown when dynamic factors were continually changing was the basis for this study.

The principal objective of this study was to provide a framework of analysis by which a practical solution could be found by a farm operator for his available resources when crop yields, prices, or costs of production and/or resources changed.

In addition to this primary objective there was one lesser objective; the determination of the economic conditions under which specialized certified seed wheat production was feasible on Kansas farms.

Problems Involved in Attaining Objectives

Any method used to determine the optimum use of agricultural resources had one major disadvantage. This disadvantage was that regardless of the time, effort, or expense spent in careful preparation of the data used in the study, the analysis would be practically valueless if one of the major elements in the data changed because of the passage of time. In other words if given yields, prices, or costs were used to determine optimum resource allocation and one of the elements changed because of new technology, institutional factors, or other reasons, the resource plan would be rendered useless.

The problem can be stated more simply. If, for example, an optimum resource plan used prices, yields and costs that were presently appropriate, this plan would be relevant only as long as these variables were constant. Should any one or all of these factors vary for any reason, the plan would be no longer useful, and another plan would have to be developed.¹ In short, no method allowed for variable prices, yields or costs and for this reason any plan developed was static, and useful at only a given point in time.

The ideal, of course, was to develop some method by which important variables were allowed to change so that the plan would be relevant to all price, cost, and yield situations. In order to accomplish such an ideal required that all practical price

1. This plan would be useful, however, if all of variables changed proportionally in the same direction.

cost and yield situations be determined prior to actual changes, so that the optimizing plan would be dynamic should any change in the elements result.

This posed an extraordinary problem. The possibilities were infinite and as of now man has been incapable of solving infinite problems. For instance, if the prices of only three activities such as wheat, barley and grain sorghum were allowed to vary in three steps, i.e., wheat at \$1.50 per bushel, wheat at \$1.60 per bushel, wheat at \$1.70 per bushel and similarly with barley and grain sorghum, 3^3 or 27 different combinations were possible. If twelve activities, each at ten different prices were considered, 12^{10} or 743,008,370,688 different combinations existed. Clearly, the ideal was practically impossible and if it were accomplished the results would be so cumbersome that it would take most farm operators a lifetime to determine which combination was relevant to their specific situation.

However, under practical rather than theoretical conditions, it was unnecessary to consider all possible combinations. The researcher was aware that certain historical relationships as well as possible future trends existed and the problem was scaled down to a workable magnitude. For instance, it was highly unlikely that per bushel barley or grain sorghum prices would ever exceed the price of wheat even if wheat were to be used as a feed grain.

Likewise, it can be generally stated that yields of various crops as well as costs of different inputs maintain some degree

of relationship over time. With this in mind the researcher could design a dynamic optimizing resource plan that would be practical for a farm operator. It was the specific purpose of this study to design and present a dynamic solution for conditions of variable prices, yields, and costs on the selected farm.

Review of Economic Literature

One of the basic assumptions in this study was changes in prices, yields, or costs of production influence the use that farmers make of their resources. Of course, this shift in resource use was applicable only to those firms that have exhibited some degree of diversification in enterprises. Bortfeld acknowledged: "some farms have such greater comparative advantage in the production of one particular commodity that unrealistic price adjustments would have to occur before their resources could be economically used for the production of a different commodity or commodities."¹

Economic literature abounded with examples which demonstrated farm response to changes in prices and price relationships, but practically no work has been done on changes in yields or costs of production. Since these two variables acted upon the net income structure in identically the same manner as did price changes, all price-supply response literature was appropriate to this study.

1. G.F. Bortfeld, "Production Alternatives in Response to Price Changes for a 320 Acre Wheat-Beef Farm in South Central Kansas, unpublished Ph.D. dissertation, Department of Agricultural Economics, University of Minnesota 1958, p. 1, of section entitled "Review of Economic Literature."

Some of the first research to be done in this area was reported by J.D. Black as being performed by H.L. Moore for cotton in 1917.¹ Seven years later Black wrote a journal article entitled "Elasticity of Supply of Farm Products."² In this article he discussed, along with other things, response of resource use to changes in prices. Also, in the same article, Black called attention to other difficulties encountered when considering only changes of price relationships. It appeared pertinent to bring out some of these difficulties and acknowledge the existence of them in a study of this kind.

There are a number of difficulties involved in the statistical attack. Chief of these is the large number of variables in the problem. The wheat acreage may have decreased for many reasons other than a relative decline in price, such, for example, as the following: Increasing damage from pests and disease, increase in price of competing crops, improvements in varieties or adaptability of competing crops, increasing wages for harvest labor and improvements in machinery for handling competing crops.³

It was noted that all of these problems could be put in terms of changes in the prices, yields or costs of production of alternative enterprises, but the complexity of such an inclusive study was for practical purposes, overwhelming, unless the three aforementioned variables were combined into one, i.e., net income.

Since these two pioneering studies, much of economic literature has been devoted to studying price-supply response in relation to resource use. Some of the leading work was a

1. John D. Black, Introduction to Economics for Agriculture, p. 247.

2. John D. Black, "Elasticity of Supply of Farm Products," Journal of Farm Economics, Vol. VI, No. 2, April 1924.

3. Loc. cit.

general study done by L.H. Bean in his article "The Farmers' Response to Price."¹ Bean summarized his studies on farmers' response to price in this way:

1. There appears to be a general type of production response to price, common to each of the cases analyzed.

2. In each case the price received for the production of the preceding season is the dominant factor in the change in production in any given year. In most cases, the price received during the season two years preceding is also an important factor, particularly if the price has been low.

3. Although there is a general similarity in the nature of the response of production to price one year preceding, the extent of that response for different prices differs by regions and by commodities, some showing a greater response to high prices; others, to low prices.

4. The response to price two years preceding does not follow a general type, but differs markedly for several of the commodities.

5. For each commodity the analysis reveals that there is under ordinary conditions a definite national average price which tends to maintain acreage unchanged from that of the preceding year. For any one commodity there are different regional prices which tend to maintain acreage unchanged in the different areas. Where competing crops are involved, these equilibrium prices tend to vary with the prices of the competing crops.

6. Prices only moderately above or below this equilibrium price (plus or minus 10 percent) tend to be followed by about the same percentage increase or decrease in acreage, but very high prices bring forth no materially greater increase in acreage than do moderately high prices.

7. In some cases the effect of high prices on subsequent production lasts only one season, in other, at least two seasons.

8. Changes in livestock (hog) numbers on farms show the same general type of response to antecedent prices received by producers as do changes in crop acreages.

1. L.H. Bean, "The Farmers' Response to Price," Journal of Farm Economics, Vol. XI, No. 3, July 1929, pp. 369-370.

John D. Black in his book, Agricultural Reform in the United States pointed out response of resource use to price changes.¹ "Time response will vary for different commodities. The acreage of an annual cash crop that requires little special equipment or skill can be increased quickly. The response may be in terms of greater intensity in cultural practices."

Schultz also indicated the use of prices in guiding farm production:²

It is through price and technical expectation that changes in taste, technique and resources are transmitted to the firm--the expectations accordingly act as a barometer of all the economic changes which impinge upon the actions of the firm from without. The farmer as an entrepreneur must do two things. He must formulate the price and technical rates that he expects. He must then develop a production plan based on his expectations which will give him an optimum use of his resource.

Wilcox and Cochrane pointed out the well established fact of the slowing of resource response to price change by habit or custom.³ They indicated, however, something of the overall response of resources to price change by stating:

If from 5 to 10 percent of the farmers involved change their production plans in response to change in price relationships, that is enough to keep the allocation process in motion. And studies indicate that just this happens. A small percentage of the producers affected by a price change, usually those who can most easily shift into alternative enterprises, modify their production plans and this gives us, in most cases but not all cases,

1. John D. Black, Agricultural Reform in the United States, pp. 113.

2. T.W. Schultz, "Theory of the Firm and Farm Management," Journal of Farm Economics, August, 1939, Vol. XXI, No. 3, part I.

3. Walter W. Wilcox and Williard W. Cochrane, Economics of American Agriculture, p. 407.

the desired change in output. The total output of a particular product expands a little in response to a price rise and contracts a little in response to a price decline.

By this means, farmers are prevented from going from one extreme to the other which helps guard against an explosive type of behavior when all resources are first devoted to the output of one commodity, and then are all shifted into the production of another.

One of the most recent and comprehensive studies was done at Kansas State University by Bortfeld.¹ In this study, budgeting was used as a tool to determine resource changes that occurred on south central Kansas wheat-beef farms when price relationships changed. It was concluded that discrete shifts in resource allocation should occur with changes in commodity price levels.

Numerous other studies have been done and could be noted. These that have been given somewhat indicate the interest and attention that has been given the subject.

Review of Methodological Literature

The six decades of this century have seen many new developments in economic methodology. One of the most important has been the development of linear programming analysis in the past ten to fifteen years. Agricultural economists have long used an informal type of programming analysis known as the "budget method" to find profitable adjustments in farm management, but as usually practiced, it was not a very systematic or sophisticated method. It has been well known that budget analysis has strongly relied on the judgement and intuition of the researcher

1. Bortfeld, op. cit.

and there was no guarantee that the most profitable combination of enterprises would be discovered.¹

Stigler, in 1945, used a more systematic method of budgeting in an attempt to find the minimum-cost human diet which met stated specifications.² But Stigler did not actually discover the principles of linear programming and therefore was unable to quite find the minimum-cost diet.

It was difficult to trace precisely the history of the development of linear programming. It appears that many lines of development culminated in the present form. The first application of the method appears to have been made by George B. Dantzig in 1947.³ However, it was not until 1951, that Dantzig published his work. In the same volume that published Dantzig's work, there appeared an article by Hildreth and Reiter making application of the method to an agricultural problem--that of selecting an optimum crop rotation.⁴ Later in the same year F.V. Waugh of the United States Department of Agriculture made an application to a cost minimization problem in agriculture--that

1. Budgeting and linear programming analysis are similar in the type of data used, although budgeting has the disadvantage that due to time limitations and the magnitude of some problems not all possible resource combinations can be considered.

2. George J. Stigler, "The Cost of Subsistence," Journal of Farm Economics, May 1945, Vol. XXVII, No. 2, pp. 303-314.

3. George B. Dantzig, "Maximization of a Linear Function of Variables Subject to Linear Inequalities," Ch. 21 in T.C. Koopmans (Editor) Activity Analysis of Production and Allocation.

4. Clifford Hildreth and Stanley Reiter, "On the Choice of a Crop Rotation Plan," Ch. 11 in Koopmans, ibid.

of selecting a minimum cost feed.¹

Since 1951, there have appeared scores of articles on the technique itself and hundreds of reports of research employing the method. No attempt has been made in this study to trace the general development of linear programming in research studies, but reference will be made to a particular refinement of the technique--that of variable pricing.

The first study involving linear programming under different price conditions appears to have been made by W.D. Fisher and L.W. Schruben.² Their study was concerned with varying the price of feed ingredients and determining the minimum-cost feed. At the time of publication, the study was quite revolutionary, but with the advent of automatic computers, variable pricing has become a somewhat more widely used technique.

Wilfred Candler and Earl O. Heady have made significant contributions to the technique of variable price linear programming.³ In their book, *Linear Programming Methods*, an entire chapter is devoted to the subject. It was here they recognized the extreme complexity of dealing with more than two or three activities with varying prices. In the same book, however, they stated that: "the

1. Frederick V. Waugh, "The Minimum-Cost Dairy Feed" *Journal of Farm Economics*, August, 1951, Vol. XXXIII, No. 3, pp. 299-310.

2. Walter D. Fisher and Leonard W. Schruben, "Linear Programming Applied to Feed Mixing Under Different Price Conditions," *Journal of Farm Economics*, November, 1952, Vol. XXXIV, No. 4.

3. Wilfred Candler and Earl O. Heady, *Linear Programming Methods*.

same general methods used for two-price-variable programming could be used to vary three or more prices...(although) representation and interpretation of results when more than two prices are varied is difficult, and most people will prefer to confine themselves to problems where only two prices vary."

It should be pointed out that until now no feasible or practical solution has been found by which more than three variables could be represented. So long as three or fewer variables were dealt with, price mapping could be used to represent and determine the optimum plan of operation. When one more variable was added, graphical presentations were of no value.

The limited amount of literature dealing with variable price linear programming can be primarily explained because of the only recent application of automatic computers to the method. Formerly linear programming had to be performed by clerical help on desk calculators and the relative complexity of variable pricing virtually made large problems impossible. Not until recently has variable pricing even been feasible on automatic computers. This difficulty was observed by computer program writers and it resulted in an incorporation of variable pricing sub-programs in already existing or newly written linear programming programs.

The Department of Statistics at Iowa State University has led the field in new developments and refinements in linear programming. One of the most widely used programs has been the

Grosvenor-Hartley program designed for the IBM 650.¹ This program included four modes of operation--two general linear programming operations, a variable resource operation and a variable pricing operation. It was this last operation that was utilized in this study.

DESCRIPTION OF THE STUDY

The study was concerned with using linear programming analysis on a specific farm situation in order to develop a tool by which farmers would be able to determine their optimum resource organization should any change occur in the prices, yields or costs of production of cropping enterprises. The farm selected for study was a 960 acre farm located in Reno County Kansas. The farm was one of several in Kansas that have been specializing in the production of certified seed wheat for the past few years.

The selected farm was clearly an above average Kansas farm in respect to resource quality and quantity. However, the author believed that such a study was justified on the basis that for the most part agricultural economic research has been concerned with non-existent hypothetical "average" farms rather than actual farm situations.

A further comment may be in order at this point. In reviewing literature concerned with budgeting or linear programming analysis of farms, it has been noticed that most studies deal with a representative farm of a particular area. This representative

1. D.D. Grosvenor and H.O. Hartley, Linear Programming Program, No. 10.1.001, Iowa State University, 1960.

farm has been frequently spoken of as hypothetical farm possessing typical characteristics of farms of the area.¹ Certainly such a farm does not in reality exist, but can exist only in the mind of the researcher who is unable to prevent subjectivity from entering into the thought processes used in creating the representative farm. Upon completion of such a study the practical value is questionable, as no existing farms have resources identical to those of the hypothetical farm.

On the other hand, by selecting a specific farm and thoroughly studying it, these disadvantages can be eliminated. Any final plan obtained will be useful to the one studied. While the study of a representative farm cannot be used directly by any farm, the study of a specific farm can be of use to at least one farm, and it seems logical that the latter should be preferred over the former.²

The case method of study was appraised in Marshall's words "as the intensive study of all the details" of a few carefully

1. Cochrane and Butz commented on the representative farm as a unit of study in an article, "Output Responses of Farm Firms," Journal of Farm Economics, November 1951. They stated: "Thus, our firm does not actually exist and never did exist, but it is representative of single enterprise dairy farms in the area. If dropped from the sky into Northeastern Pennsylvania, it would be described as a typical single enterprise unit as regards size, organization and practices."

Also see F.E. Elliott, "The Representative Firm Idea Applied," Journal of Farm Economics, October 1928.

2. The study of a representative farm can be justified if the deviation from the average is very slight. However, in an agricultural area such as Kansas, the deviation from the mean is generally large as evidenced by the size of Kansas Farm Management Association farms when compared to other farms in the same area.

chosen cases.¹ "At its best, it is the best (method) of all..."

"Leonard Salter stated in his book:²

The case method has been fought over bitterly in the wars of social science methodology. Even its strongest foes, however, favor it with high praise. If a case is an acting unit and if the interaction and sequences in its experience are preserved with the unit, than it has strong testing force. Insofar as the interaction and sequential gaps among the facts of the unit of action's experience are closed in a case study and as far as these facts are relevant to the experienced problem under study, to that extent a case study has the quality of testing relations in the place where they have meaning. In this form the case method can prepare evidence that carries exceedingly great weight as a test.

Although distinct advantages were evident in selecting a specific farm for study, these advantages were of doubtful significance unless care was used by the researcher. Subjectivity could enter unless carefully kept records of yields, prices, costs, and etc. were available. After researching such records, no compensation was made because of abnormalities in any production process. This author believed every farm has abnormalities in any production process. Every farm has abnormalities of some type: yields may be higher or lower than the "average," prices received or products sold may deviate from the accepted norm, or input-output ratios may differ from those thought commonly the case. In fact when dealing with farms in an area such as Kansas it was possible that abnormalities could be the rule rather than the exception.

In this study the selected farm has several abnormalities. First, the yields of wheat, grain sorghum, silage sorghum, and

1. Alfred Marshall, Principles of Economics, p. 116.

2. Leonard A. Salter, A Critical Review of Research in Land Economics, pp. 71-72.

barley were considerably above the county average, while the yield of alfalfa was somewhat below the county average. Second, input-output ratios differed from the accepted norm of the area because the acreage of the farm was larger than the county average thus allowing for larger equipment to be used on the farm. Third, the farm specialized in certified seed wheat production which called for better than average management as well as increasing summer labor requirements. Fourth, fertilizer, fuel, oil and repair costs were lower because of quantity and wholesale buying of these products.

In determining input-output ratios, past Kansas Farm Management Association records for the farm were used so that subjectivity on the part of the researcher was minimized.

Characteristics of Reno County

Reno County lies in the Arkansas River valley in about the center of the state east and west and just to the south of the center north and south.¹ It is one of eight counties comprising type of farming area 6b.² The agriculture of the county is highly diversified. Although it is one of the largest wheat producing counties in the state, it also ranks in the top

1. United States Department of Agriculture, Soil Conservation Service and the Kansas Agricultural Experiment Station, Manhattan, Kansas, Physical Land Conditions Affecting Use, Conservation and Management of Land Resources, Reno County Kansas, October 1954, p. 1.

2. For a detailed description of farming area 6b, see J.A. Hodges, F.F. Elliott and W.E. Grimes, "Types of Farming in Kansas," Kansas Agricultural Experiment Station Bulletin 251, August, 1930. Also see Leo N. Hoover "Kansas Agriculture After 100 Years," Kansas Agricultural Experiment Station Bulletin 392, August, 1957.

ten counties of the state in the production of barley, grain sorghum, silage sorghum and alfalfa hay.

Hutchinson, the county seat of approximately 40,000 is one of the leading grain storage centers in the state and is a large flour manufacturing center. The only important non-agricultural industry is the salt industry which includes three major salt mines.

The soils of the county are favorable for the production of moderate to high yields of adapted farm crops. In general, the land is level to gently rolling with natural drainage being excellent in most areas of the county.

The climate has also been favorable to the production of crops commonly grown in that section of Kansas. The mean annual temperature for the county has been 56.6 degrees.¹ Summer temperatures of over 100 degrees occur as do sub-zero temperatures in the winter but their duration has usually been brief.² The mean annual precipitation has been 27.6 inches with the largest amount occurring in May.³ Over the past 50 years this has averaged 4.63 inches.⁴ The precipitation has varied from a minimum of 16 inches in one year to a maximum of 39 inches in another.⁵ During the average of these years 72 percent of the rainfall came during the growing season which averaged 183 days.⁶ The growing season has varied from extremes

1. Kansas State Board of Agriculture Climate of Kansas, Vol. LXVII, June, 1948, No. 285.

2. Loc. cit.

3. Loc. cit.

4. Loc. cit.

5. Loc. cit.

6. Loc. cit.

of 145 days to 223 days.¹ The latest date in the spring on which a killing frost was recorded was on May 15, while the earliest date of a killing frost in the fall was September 20.²

Since 1911, the yields of all crops grown in Reno County were 103 percent of the state average yields.³ During the past five years the average yields of individual crops in the county were: wheat, 21.4 bushels per acre; barley, 21.9 bushels per acre; oats, 20.1 bushels per acre; grain sorghum, 25.4 bushels per acre; silage sorghum, 8.3 tons per acre; alfalfa, 2.0 tons per acre and alfalfa seed, 101 pounds per acre.⁴ The year to year fluctuations in yield have been 21 percent less than average fluctuations for the state.⁵

Characteristics of the Farm and Management

The farm selected for study was located in central Reno County, about six miles southwest of Hutchinson. The farm consists of 1,000 acres of which 960 acres were used for cultivated crops. The remaining 40 acres consisted of native pasture, grassed waterways and the farmstead. The farmstead was situated at one corner of 400 acres of land owned by the operator. Of the remaining 600 acres, 440 were owned by the operator. The rest was rented on a 1/3-2/3 rent share basis.

1. Loc. cit.

2. Bark, Dean L. When to Expect Late-spring and Early-fall Freezes in Kansas. Kansas Agricultural Experiment Station Bulletin 415, December 1959.

3. Farm Facts, 1960-1961, op. cit. pp. 21-54.

4. Ibid.

5. Ibid.

All of the outlying land was located within six miles of the farmstead, making it relatively convenient to transport necessary machinery to the fields, but quite difficult to use the land for any type of livestock enterprise. The farm was situated on well-drained, level upland and the soil has been some of the most productive in the county. The dominant soil type was Pratt loam which is a dark reddish soil with moderately sandy surface soil and loamy to friable clayey subsoil.¹ It has been very well adapted to growing winter cereal crops, but the relatively low moisture retention of the soil has made it less desirable for the raising of sorghum crops. Since the farm was broken from native sod in the late 1890's, most of the land has been devoted to wheat production, with occasional rotations of grain sorghum, alfalfa, barley, oats and forage sorghum. Although the soil was inherently fertile, almost continual wheat production has diminished natural fertility making commercial fertilizer use an annual necessity.

Since the re-establishment of government wheat allotments in 1951, most of the acreage has been devoted to wheat and barley with about 40 acres of alfalfa and approximately 20 acres of forage sorghum grown annually. The wheat allotment was 480 acres which has been used for the production of certified seed wheat.

The present operator started farming in the early 1930's

1. O.W. Bidwell, Major Soils of Kansas, Kansas Agricultural Experiment Station Circular 336.

on 240 acres of the presently owned 800 acres of land. Since then he has expanded the acreage to the present 1,000 acres by inheriting, buying and renting additional land. He has been a member of the Kansas Farm Management Association since 1934 and has been considered by the Association fieldman as being an above average manager, when compared to other Association managers. Through his managerial practices, he has been able to maintain better than county average for nearly all of the crops grown on the farm, particularly those of wheat and barley.

He is skilled mechanic and a natural innovator; this being evidenced by various machines that have been made in the farm's shop and used in the daily operation of the farm. The operator engages in the daily farm work and has been assisted by a hired laborer throughout the year and by family help during the summer months.

History and Importance of Certified Seed Production

The Kansas Crop Improvement Association traces its beginning back to the Kansas Corn Breeders Association which was organized in 1902.¹ In 1914, the name was changed to the Kansas Crop Improvement Association as interest in other crops grew.² The first certification was performed in 1917 in cooperation with Kansas State Agricultural College; this involved Kanred wheat which was released that year and distributed to

1. Kansas Crop Improvement Association, Mimeographed Material entitled "Seed Certification," p.2.

2. Ibid. p. 2.

selected Association members for increase.¹ Since that time many Kansas farmers have participated in the certification service.

In 1961, approximately 400 farmers in 90 counties were association members producing certified wheat, barley, oats, rye, sorghum, soybeans, domestic grasses, alfalfa and sweet clover.² Wheat has been the most important single crop involved in the service, with nearly 10,000 acres of certified seed wheat produced in Kansas in 1960.

The seed certification program has followed two general trends.³ The first of these being the program in which foundation seed has been furnished by the plant breeders to a few selected growers who produced very elite seed in limited quantities and under strict supervision to be distributed to more farmers the following year.

The second trend has been one in which numerous growers were encouraged to produce many bushels of superior quality seed under adequate supervision. The association preferred the latter course as the most good has been done for agriculture in that more farmers were able to obtain the benefits of superior seed.

The Kansas Crop Improvement Association has defined certified seed as "seed of known superior heredity and quality, verified

1. Ibid. p. 2.

2. Kansas Certified Seed Directory, Fall, 1961, Kansas Crop Improvement Association, Manhattan, Kansas.

3. Seed Certification, op. cit., p. 3.

by and traceable through the periodic inspection and records of an impartial and officially recognized agency."¹ The Association further states:

When analyzing the definition: "known superior heredity" is justification for certification. It is the heredity that makes a variety or hybrid superior. Certification identifies seed which is not merely superior in physical characteristics, but is fundamentally superior in the very germplasm. "And quality," Federal and state laws offer minimum protection on important quality factors. These laws prohibit sale of agricultural seed containing seed of certain noxious weeds; they prohibit sale of improperly labeled seed, leaving it to the buyer to determine whether the seed suits him. State laws require report of purity, germination, weed seed content and other crop information. Certification regulations set minimum standards for these several things, thus assuring high quality plus superior germplasm in the seed.

In the past many farmers have realized the value of planting certified seed, although the additional cost incurred has tended to discourage large scale use of certified seed, with the result being that relatively few acres of Kansas wheat were devoted to specialized seed production.

With the advent of wheat allotments in the early 1950's, farmers in the wheat producing areas of the United States began to pay more attention to the quality of the wheat seed they planted each fall. The demand for certified seed wheat increased with a very marked increase noted in the demand by neighboring states to the east of Kansas.

The increase in demand by neighboring states brought about specialized seed production on many farms which had formerly devoted

1. Seed Certification, op. cit. p. 1.

small acreages to certified seed wheat for local sale. The major seed producing area tended to be concentrated in Central Kansas, with Reno County leading all other Kansas Counties in certified seed wheat production.

By 1955, the number of farmers in Reno County producing certified seed wheat had diminished until there were four major producers who had firmly established their product with seed buyers.¹ These four individuals devoted their entire wheat allotment to certified seed wheat which was shipped to seed companies, farmer cooperatives, and private grain elevators in Missouri, Illinois, Iowa, and Arkansas.

This study was concerned with one of these farms which has been producing certified seed wheat on a commercial scale since 1951.

Special Problems of Certified Seed Production

Success in growing and marketing certified seed wheat has depended in a large part upon four major factors: (1) Producing a clean seed under compliance with certification standards; (2) growing varieties adapted to the growing conditions of the area; (3) production of those varieties which were in greatest demand by major buyers; and (4) production in sufficient volume to attract buyers. There has been little question that the production of high quality certified seed wheat calls for a better than average manager. The farmer must be sincerely interested in producing a

1. Kansas Certified Seed Directory, Spring and Fall, 1950 to 1961. Kansas Crop Improvement Association, Manhattan, Kansas.

quality product as well as being an efficient marketer.

In addition to other problems certified seed wheat production has called for additional labor and equipment when compared to market wheat production. Each field required roguing to eliminate natural mutations, non-varietal plants, weeds and other undesirable plants. Extra care had to be taken to assure that machinery used in the various operations would not contaminate fields used for seed production with weed seeds or other crops. If the production of seed has been on a relatively large scale basis, these problems have been magnified, particularly the problem of cleaning and processing the seed.¹ In order to clean, and bag the seed from several hundred acres, it has been necessary for the producer to own the equipment. In addition to cleaner, bag sewing machine, and grain handling equipment, there has to be sufficient warehouse space to accomodate several hundred bushels of bagged grain so that trucks can be loaded without having to wait until the seed is processed.

In short, the growing, processing, and selling of certified seed wheat has not been a feasible enterprise for the average farmer, but had to be left to those who were willing to specialize and observe rigid production procedures to guarantee pure seed production.

1. This does not necessarily mean economics of scale are absent, but rather managerial problems are frequently intensified by large scale production as compared to limited production of certified seed wheat.

Table 1. Prices, yields, production costs, net and gross incomes of selected enterprises, by acres.¹

	: P18 : P19 : P20 : P21 : P22 : P23 : P24 : P25 : P26 : P27 : P28 : P29														
	owned : owned : rented : owned : rented : owned : rented : owned : rented : owned : rented : owned : rented : owned : rented	market : seed : market : seed : winter : winter : spring : spring : grain : grain : silage : alfalfa : wheat : wheat : wheat : wheat	barley : barley : barley : barley : sorgh. : sorgh. : sorgh. : sorgh. : hay : hay : seed												
Unit of production	1A. 1A. 1A. 1A. 1A. 1A. 1A. 1A. 1A. 1A. 1A. 1A. 1A. 1A. 1A.	30bu. 30bu. 30bu. 30bu. 45bu. 45bu. 45bu. 45bu. 21cwt. 21cwt. 14ton 1ton 80#													
Yield per acre	30bu. 30bu. 30bu. 30bu. 45bu. 45bu. 45bu. 45bu. 21cwt. 21cwt. 14ton 1ton 80#														
Price per unit (\$)	1.80 2.40 1.80 2.40 .90 .90 .90 .90 1.90 1.90 6.00 13.00 .30														
Gross income (\$)	54.00 72.00 35.00 48.00 40.50 27.00 40.50 27.00 39.90 25.60 84.00 42.00														
Production costs/A.															
Taxes, interest ²	17.40 17.40														
Labor	1.78 3.16	1.78	2.70	1.94	1.94	1.94	1.94	1.94	1.91	1.91	17.40	17.40	17.40	17.40	
Storage	1.50	1.00													
Chemicals															
Certification	.10 .90	.10	.90	.10	.10	.10	.10	.10	.10	.10					
Insurance	.15 .15	.15	.15	.15	.15	.15	.15	.15	.15	.15					
Loss	1.00		.75												
Marketing ³	.25 6.00	.25	4.00	.25	.25	.25	.25	.25	.25	.25					
Seed	2.20 2.20	2.20	2.20	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.00	1.00	1.00	.60	
Machinery ⁴	3.78 3.78	3.78	3.78	4.72	4.72	4.72	4.72	4.72	4.01	14.27	14.27	14.27	14.27	14.13	
Total expenses	31.06 41.49	11.86	19.08	31.96	12.76	31.96	12.76	31.96	12.76	34.72	15.52	80.77	38.10		
Net Income	22.94 30.51	24.14	28.92	8.54	14.24	8.54	14.24	5.18	11.08	3.23	3.90				

1. Data in this table computed from table 2.

2. Interest includes opportunity interest.

3. Marketing expenses also include cleaning and processing charges.

4. Machinery expenses include fuel and oil.

ANALYSIS OF THE PROBLEM

Enterprises Selected for Analysis

Twelve different cropping enterprises, or activities as they are commonly known in linear programming studies, were selected for the optimizing farm plan. These enterprises were those common to the area and to the farm.¹ Although twelve different activities were considered, this involved only six different crops, as a separate activity was used for growing these crops on rented land. Included in these activities were: Owned market wheat, owned certified seed wheat, rented market wheat, rented certified seed wheat, owned winter barley, rented winter barley, owned spring barley, rented spring barley, owned grain sorghum, rented grain sorghum, owned silage sorghum, and owned alfalfa. A brief discussion of these activities follow.

Owned and Rented Market Wheat. These two activities were identical with the exception that 1/3 of the rented market wheat was the landlord's share. All production coefficients were identical, however net cost to the operator was reduced on the rented land as the landlord paid 1/3 of the fertilizer expense as well as the property tax on the land. It was assumed the market wheat was hauled directly to an elevator, so there were no storage costs attributed to these activities.

It may be noticed in table 1, a small charge for certification was attributed to the market wheat activities. This resulted from the certification of a small seed patch for the coming year's seed. The operator desired certified seed always be planted so

1. Farm Facts, op. cit. pp. 21-54.

there would be a maximum amount of flexibility should the production of certified seed be profitable in the next year.

Using the yields, prices and production costs from table 1 a net income of \$22.94 per acre resulted from owned market wheat and \$24.14 per acre from rented market wheat.

Owned and Rented Certified Seed Wheat. As with the above market wheat activities, a $1/3-2/3$ rental arrangement was assumed. All production coefficients were identical except those involving cleaning and processing of the seed. It was considered that the landlord's share was disposed of elsewhere leaving the operator only his share to be processed. Although the renter realized only $2/3$ of the crop yield, it was assumed that per acre certification costs were the same as for owned certified seed wheat. This was realistic from the standpoint of most rent-share arrangements. The renter has been unable to divide the field into his share and the landlord's share, so the entire field of wheat had to be certified. This, of course, resulted in an increased per bushel certification cost to the renter.

Due to the higher price received for certified seed wheat, the net incomes of this specialized crop were higher than those of market wheat although labor, processing and marketing costs were also increased. Table 1 shows a net income of \$30.51 per acre resulting from owned certified seed wheat and \$28.94 per acre from the rented certified seed wheat.

Owned and Rented Winter and Spring Barley: All of the four barley enterprises were identical in respect to yields, prices and production costs, with the exception that labor requirements

for winter barley occurred during the summer months while the major labor requirements for spring barley occurred during the winter months. Again, the same rental share as with the wheat activities was assumed.

The inclusion of two different types of barley was justified from the standpoint of labor requirements. It was considered that an inadequate quantity of summer labor could act as a restriction to the growing of winter barley. Both types of barley were included in the analysis so that labor would be less of a restrictive factor, enabling a barley enterprise to enter a maximizing plan if the net income per acre was sufficient.

It should be noted in table 1 that the net income from the rented barley enterprises exceeded that of the owned barley enterprises. This can frequently occur as it did in this case when the taxes on owned land exceed the value of the landlord's share of the crop on the rented land. For owned winter and spring barley a net income of \$8.54 per acre was derived; from rented winter and spring barley the net income was \$14.24 per acre.

Owned and Rented Grain Sorghum. The two activities were identical with the exception of the aforementioned rental arrangement. It may be noted that the net income resulting from grain sorghum was less than that from the barley enterprises. This was due to two major reasons. First, although labor requirements were lower for the grain sorghum enterprises than for the barley activities, total production costs were higher. This was attributed to the \$5.00 per acre charge for chemicals.

The specific compound used was a relatively new and expensive chemical commonly known as "atrazine." Although the chemical cost exceeded the cost of machine cultivation, the operator preferred this method as it completely eliminated all broad-leaf weeds and grasses. This method had another distinct advantage in that it freed one or two laborers from the time consuming job of cultivation when their labor was needed elsewhere such as in the wheat harvesting operation. Although the analysis showed surplus labor existed in the wheat harvesting months, the successful cultivation of grain sorghum was, timewise an extremely critical operation. It was the operators feeling that grain sorghum would not be grown on the farm unless a chemical weed killer were to be used.

The second reason that the per acre net income of grain sorghum enterprises was reduced was in comparison to barley yields, the grain sorghum yields were somewhat lower. The situation has been frequently experienced by the operator and the only valid reason for this was the moisture retention abilities of the sub-soil of the farm were relatively low. Unless frequent rainfall was received during the summer months grain sorghum would wither, resulting in a lowered yield,

Although the farm's subsoil was unsuited to better than average grain sorghum yields, this did not also mean that the soil was unsuited to the production of cereal grains. Due to rainfall characteristics of the area, this region has been known as one of the highest yielding wheat and barley areas of the state.

In regard to the net income derived from the two grain sorghum enterprises, it will again be noticed net income per acre from rented grain sorghum exceeded that of the owned grain sorghum. This was due to the same conditions prevailing in the barley enterprises. Owned grain sorghum netted \$5.18 per acre while rented grain sorghum netted \$11.08.

Owned Silage Sorghum. Only one silage sorghum activity was considered--that grown on owned land. In the western half of Kansas most rented land has been used only for the production of cash grain crops rather than for forage crops. The primary reason for this has been for the most part, cash grain crops yield a higher return to the landlord than do forage crops. The low net income of the silage sorghum enterprise has not been unusual in Kansas even though the yield has been considerably above the average yields of the area. The extremely high storage costs accounted for one-third of the gross income from the crop although labor and machine costs were also higher than other crops. Increased fertilizer application and chemical weed killers also added to production costs.

It may be questioned why such an obviously low income crop was one of the enterprises selected for study. This is a question that cannot be answered using economic criteria but must be dealt with in other terms. Frequently silage sorghum cannot be purchased by the farmer at any price because of the limited supply in the area. However, there have been times that silage has been relatively inexpensive due to an oversupply in the area. Under these conditions many farmers preferred to grow their own silage

sorghum for use in a livestock enterprise, knowing that the crop was a low income enterprise but also aware that silage may have been unavailable if they did not grow the crop themselves. For these reasons silage sorghum was included as a possible entering enterprise although the net income was only \$3.23 per acre.

Owned Alfalfa Hay and Seed. Again, as with the silage sorghum activity, alfalfa was grown only on owned land. Alfalfa was included in the study for essentially the same reasons the silage sorghum enterprise was included.

It was considered one planting of alfalfa would be used for five years before establishing a new field. The production coefficients assumed did not include the cost of initial establishment of the alfalfa enterprise with the exception that the seed cost was normalized over a period of five years. This was realistic in many cases because frequently ground prepared for some other crop has been devoted to alfalfa if the season was favorable to the establishment of a good stand.

The yield of hay from the enterprise was considerably below the county average. This can be explained by the fact that the second crop of alfalfa was allowed to seed. It was assumed a normal alfalfa crop would consist of two cuttings of hay and one seed crop. The net income from the seed and hay from table 1 was \$3.90 per acre.

The selected activities included all of the crops common to the area except oats. This crop was eliminated because the normal price of oats has been less than barley and average yields

of oats have been below those of barley.

Corn and soybeans were excluded from the study because of their extremely low yields under dryland conditions. Recently some interest has developed in the growing of castor beans and safflower in the area. Insufficient evidence that these two crops were suited to the area as well as uncertain potential prices, yields and production costs eliminated these activities from serious consideration.

Prices, Yields and Costs Used in Study

Although absolute prices, yields and production costs were relatively meaningless in this study, the problem was approached with as much realism as possible. All preliminary programming used the data shown on table 1. During the development of the optimizing solutions, absolute prices, yields and costs, yielded to relative figures among the variables.

All prices used were those currently existing. No attempt was made to develop price relationships from historical data or trend studies. Table 2 shows the prices used in the preliminary analysis.

Yields were taken from the farm's Kansas Farm Management Association account records. These yields were averages from the past six years. Although weather conditions have been very favorable during this time, this short period of years was chosen for two major reasons. First, the operator began using commercial fertilizer during the first of this period and second, complimenting fertilization was the introduction of a new tillage method-chisel

Table 2. Product and resource prices used in study.

Item	Unit	Price (\$)	¹
Products sold			
Market wheat	bu.	1.80	
Certified seed wheat	bu.	2.40	
Barley	bu.	.90	
Grain sorghum	cwt.	1.90	
Alfalfa hay	ton	18.00	
Alfalfa seed	lb.	.30	
Silage sorghum	ton	6.00	
Resources purchased			
Anhydrous ammonia (82.5% N)	ton	94.00	
Super phosphate (48% P ₂ O ₅)	ton	74.00	
Atrazine (chemical weed killer)	lb.	2.50	
L.P. gas (fuel)	gal.	.07	
Oil	gal.	.65	
Wheat bags	bag	.16	
Grease	lb.	.15	
Labor	hr.	1.25	
Certification	acre	.80	
Certification	field	10.00	
Certification tags	tag	.01	
Crop insurance	\$1,000	2.30	
Wheat seed	bu.	2.20	
Barley seed	bu.	1.00	
Grain sorghum seed	lb.	.20	
Silage sorghum seed	lb.	.10	
Alfalfa seed	lb.	.30	

1. Calculated from Kansas State Board of Agriculture, Farm Facts 1960-61; Kansas Farm Management Account book, farm No. 6, Assoc. No. 2; Personal interviews: 1961 dealer prices, Manhattan, Kansas

plowing. Considering the introduction of these two important techniques, it was believed that the use of a longer time period to compute yields would not take into consideration recent technological advance.

Production costs used in this study were gathered from several sources. The selected farm enjoyed some economies of quantity buying, primarily in fertilizer, fuel and oil purchases. These costs were calculated from personal interviews with the operator.

Property tax figures were obtained from the operator's personal property tax receipts of the past year. Interest charges were based on a 6 percent charge on \$250 per acre. This was determined to be a fairly realistic figure, based on the recent average sale value of similar land in the immediate area.

Labor was assigned a flat charge of \$1.25 per hour. This was extremely difficult to justify, but this figure has been the approximate cost of hiring labor in the area.

Storage costs were based on studies by the University of Illinois.¹ Only four enterprises were subjected to farm storage costs. These included both certified seed wheat activities and the two forage activities--silage sorghum and alfalfa hay.

Chemical charges were based on currently existing prices and recommended spraying quantities for the various crops. Only four enterprises, owned and rented grain sorghum, silage sorghum

1. "Costs of Storing Farm Products on the Farm." Mimeographed material, Illinois Agricultural Experiment Station.

and alfalfa had chemical costs, as seed treating chemicals were included in the cost of the seed.

Certification costs were taken from the Fall, 1961, Kansas Certified Seed Directory.¹ These charges included a \$10.00 per field charge, plus \$.80 per acre inspection charge, but did not include any processing charges.

Insurance charges were based on costs currently existing for fire insurance on an estimated \$75.00 per acre crop value.² The operator has always taken out fire insurance on cereal crops, but has never taken out hail insurance or any other type of crop insurance.

Loss occurred in both certified seed wheat activities. This loss resulted from the cracked, shriveled, or other damaged grain cleaned from the seed. Although this by-product had value for market grain blending or for livestock feed, some loss resulted because of the lowered price of grain sold for this purpose.

All barley and wheat activities were subjected to marketing, cleaning and processing charges. In the case of the certified seed wheat enterprises, this charge included the labor cost of cleaning, bagging, handling as well as the materials used in the operation. A small cost of certification was attributed to the market cereal crops as a small seed patch was grown each year for the coming years' seed.

Seed costs were based on the price for which the certified bulk seed of that crop could have been sold. Usually this amounted

1. Kansas Certified Seed Directory, op. cit., p. 40.

2. Verified by phone interview with Farm Bureau Mutual Insurance Co., Manhattan, Kansas.

to approximately \$.20 a bushel less than the cost of bagged seed.

The last item included in the production cost analysis was that of machine, fuel and oil expense. Data taken from the farm's account books was unsatisfactory for estimating machine cost per acre. The best alternative method was using information published by the Department of Agricultural Engineering at Kansas State University.¹ This study made it possible to determine annual depreciation, interest, insurance, repairs and tax costs by using a percentage of the initial machine cost. To this relatively fixed cost was added the costs of operation, based in part on the aforementioned study and in part on personal interviews with the farm operator. Fuel and oil costs were calculated from per hour fuel and oil use determined by personal interviews with the farm operator. All annual and per hour costs were put in terms of per acre costs, so that a uniform unit of study could be maintained for all enterprises.

Determination of Labor and Machine Coefficients

Table 3 shows the labor and machinery requirements for the selected enterprises. These two types of coefficients for field operations were identical in respect to the number of hours used per acre. Some studies have made allowances for time that labor was used during field operations when the machinery was idle. This occurred when minor repairs, adjustments or greasing was performed by the operator while the machinery was unused.

1. G.H. Larson, G.E. Fairbanks and F.C. Fenton, "What it costs to Use Farm Machinery," Kansas Agricultural Experiment Station Bulletin 417, April 1960.

Table 3. Total per acre labor and machine requirements for specified enterprises.

Crop	: Power hours ¹	: Labor hours ²
Owned market wheat	1.425	1.425
Owned certified wheat	1.425	2.525
Rented market wheat	1.425	1.425
Rented certified wheat	1.425	2.195
Owned winter barley	1.550	1.550
Rented winter barley	1.550	1.550
Owned spring barley	1.550	1.550
Rented spring barley	1.550	1.550
Owned grain sorghum	1.525	1.525
Rented grain sorghum	1.525	1.525
Owned silage sorghum	4.025	5.025
Owned alfalfa hay and seed	2.875	2.875

1. One hour for one 4-5 plow tractor.

2. Derived by totaling number of hours needed to perform each operation.

Table 4. Labor resources available by months.

Period	: Total hours ¹
January 1--January 31	240
February 1--February 28	220
March 1--March 31	255
April 1--April 30	275
May 1--May 31	250
June 1--June 30	720
July 1--July 31	564
August 1--August 31	600
September 1--September 30	286
October 1--October 31	286
November 1--November 30	250
December 1--December 31	220

1. Computed by halving total hours available each month.
See footnote, page

Table 5. Land and labor resources used by specified enterprises by acres and hours.

	P18	P19	P20	P21	P22	P23	P24	P25	P26	P27	P28	P29
Land												
Owned cropland	1.0	1.0	-	-	1.0	-	1.0	-	1.0	-	1.0	1.0
Owned allotment	1.0	1.0	-	-	-	-	-	-	-	-	-	-
Rented cropland	-	-	1.0	1.0	-	1.0	-	1.0	-	1.0	-	-
Rented allotment	-	-	1.0	1.0	-	-	-	-	-	-	-	-
Labor												
Jan. 1-- Jan. 31	-	-	-	-	-	-	.10	.10	.20	.20	.20	-
Feb. 1-- Feb. 28	-	-	-	-	-	-	.10	.10	.20	.20	.20	.25
Mar. 1-- Mar. 31	-	-	-	-	-	-	.125	.125	.10	.10	.10	-
Apr. 1-- Apr. 30	-	-	-	-	-	-	-	-	.10	.10	.10	-
May 1-- May 31	-	.10	-	.10	-	-	-	-	.10	.10	.10	.125
June 1-- June 30	.50	.50	.50	.50	.625	.625	.625	.625	.125	.125	.125	.125
July 1-- July 31	.40	.65	.40	.57	.40	.40	.20	.20	-	-	-	1.000
Aug. 1-- Aug. 31	.30	.30	.30	.63	.30	.30	.20	.20	-	-	-	.25
Sep. 1-- Sep. 30	.10	.35	.10	.27	.10	.10	.20	.20	-	-	4.000	1.125
Oct. 1-- Oct. 31	.125	.125	.125	.125	.125	.125	-	-	.25	.25	-	-
Nov. 1-- Nov. 30	-	-	-	-	-	-	-	-	.25	.25	-	-
Dec. 1-- Dec. 31	-	-	-	-	-	-	-	-	.25	.25	.20	-
Total labor	1.425	2.525	1.425	2.195	1.550	1.550	1.550	1.550	1.525	1.525	5.025	2.875

Source: Computed from input-output data taken from Kansas Farm Mgt. Assoc. Account Book, farm No. 6, Assoc. No. 2; personal interviews; previous research. Also see footnote, page 41 of this study.

Because of the extreme difficulty of estimating this time period, and the relatively minor importance of this time difference, this study treated time used by labor and machinery as being equal.

Labor and machine coefficients were determined by three different methods. First, personal interviews with the farm operator; second, by the researchers' own knowledge of the time requirements; and third, by standards based on previous research in Kansas and surrounding states.¹ The figures obtained by interview and by the researchers personal knowledge were checked for accuracy by comparing them with recent research and, for the most part, they were nearly identical to those of previous studies.

It was assumed that the labor supply consisted of the operator, a year around hired man and additional family help consisting of one man during the summer months of June, July and August. A five and one half day work week was assumed for all months except during June, September and October. During June, the harvest month, a seven day week was assumed and during September and October, a six day work week was assumed. An allowance for inclement weather was made by halving the number

1. See the following bulletins for additional information, O.J. Scoville and J.A. Hodges, "Practices and Costs on Wheat Farms in Western Kansas, 1947, Agricultural Experiment Station Circular 268, December 1950.

Norman R. Collins, "Income Advantage to the Specialized Grain Producing Firm from Flexible Compared with Inflexible Use of Resources," Kansas Agricultural Experiment Station Technical Bulletin 87, September 1956.

James S. Plaxico and Daniel Capstick, "Optimum Wheat Beef Farming Systems in North Central Oklahoma," Oklahoma Agricultural Experiment Station Bulletin B-532, August 1959.

of available work hours of each month.¹ Table 4 shows the number of work hours available for each month.

Description of Land Resources

The farm consisted of 960 acres of land of which 160 acres were rented on a 1/3-2/3 rent-share basis. The land was divided into four different resource categories: owned cropland consisting of 800 acres, owned wheat allotment of 400 acres, rented cropland of 160 acres and rented wheat allotment of 80 acres.

This method of allocation was chosen so that any crop except wheat could occupy all of the cropland, but wheat would be restricted to the allotted 480 acres. All land both rented and owned, was assumed to be identical in respect to production possibilities. Table 5 shows the land resources used by the selected enterprises.

Method of Analysis Used in Study

The optimum organization of enterprises under different net income conditions was determined by linear programming analysis.² Linear programming represents a refinement of the budgeting techniques long used to show the return that may be

1. This system can be justified only partially, as no data is available showing how many field work days on farms can be expected. This figure was computed by determining the number of rainy days during each month and adding approximately two days to each rainy day so as to allow for drying of the fields.

2. For more detailed discussion on linear programming analysis, see Linear Programming Methods by Heady and Candler.

expected when a given set of farm resources are utilized in a certain manner. In contrast to the budgeting technique, linear programming offers certain advantages. It can be used to evaluate more alternatives and also provides a way for determining the optimum use of resources that meet conditions outlined by the economic theory of the firm. Linear Programming rests on the basic economic principle of equimarginality as stated by Knight:¹

Economic theory is concerned with the allocative aspects of economic behavior. Its entire argument comes under the single "economic principle" that a total result is maximized through allocating means among alternative channels of use (each subject to a law of diminishing effectiveness) in such a way that equal increments of means yield equal increments of end in all modes of use.

For this reason, linear programming was ideally suited to solving problems dealing with the allocation of scarce or limited resources to maximize the attainment of some predetermined end.

Linear programming also has certain advantages over traditional marginal analysis. Most of the physical input-output data are in a form more adaptable to linear programming analysis than to marginal analysis. While the contribution of marginal analysis cannot be belittled in economic theory, linear programming is in closer harmony to the usual way in which farmers make decisions. Marginal analysis considers infinitesimal variations

1. Frank H. Knight, "Economic Science in Recent Discussion," American Economic Review, June, 1934, p. 229.

while linear programming generally deals with larger changes in resource allocation.

Basically all linear programming problems have three components. These are: (1) the objective, (2) the alternative methods or processes and (3) resource restrictions.¹ In this study the objective was to maximize the income under various net income per enterprise situations. The alternative processes included the twelve selected cropping activities and the restrictions were land and labor. No capital restriction was assumed.

Linear programming is formally defined as a technique involving the minimization or maximization (in this study) of a linear function, subject to linear inequalities. The inequalities allow selection of a plan which lets some quantity of one or more resources to go unused. Also, inequalities are required to guarantee that a solution to a problem will exist. With many resources and many activities it will probably be impossible to find a plan which just exactly exhausts the supply of all resources. In this study land and labor were allowed to be in surplus if such a solution were necessary.

Several assumptions are used in linear programming analysis. These are listed and discussed in the following paragraphs.²

Additivity and Linearity. All activities must be additive in the sense that when two or more are used, their total product must be equal to the sum of their individual products. Heady and

1. Candler and Heady, op. cit. pp. 17-18.

2. Loc. cit.

Candler worded the concept by stating: "The total amount of resources used by several enterprises must be equal to the sum of the resources used by each individual enterprise." Similarly, increasing returns to scale for any single process is not allowed, since linear programming applies only to situations in which input-output ratios are linear.

Divisibility. It is assumed that factors can be used and products can be produced in quantities which are fractional units. Resources and products are considered to be continuous and to be infinitely divisible.

Finiteness. It is assumed that there are a finite number of alternate activities as well as a finite number of resources restrictions. Linear programming is always used on problems which have a limited number of alternate processes.

Single Valued Expectations. Linear programming methods assume that resource supplies, input-output coefficients, prices, yields, and productions costs are known with certainty. Although this is unrealistic in most everyday situations this same assumption is used in most other research techniques. In this regard, linear programming provides solutions which are as realistic as those from other methods which employ the same assumptions.

Programming Procedure

The specific program used for this study was program number 10.1.001, I.S.U., written for the IBM 650 by D.D. Grosvenor and H.O. Hartley.¹ As stated on page 15 of this study operation

1. Grosvenor, Hartley, op. cit.

variable pricing, mode 4 was used to determine the optimum plans. It should again be pointed out that in reality it was not variable pricing, but rather net incomes of each enterprise that were varied. It was entirely possible that new incomes of farm enterprises could vary for reasons other than price variations. This study allowed for variations in not only price but enterprise yields and costs of production. This further pointed to the basic thesis of this study--resource allocation does not respond to changes in prices alone, but also to changes in yields and costs of production of alternative enterprises.

After all data were collected and tabulated the maximization problem was set up. This involved sixteen different equations, actually inequations until the disposal activities were introduced. These equations were tabulated on input cards which were used by the IBM 650 to maximize the linear profit equation.

The first operation solved for the optimum solution with the given net incomes. All succeeding operations solved for optimum plans while the net income of one enterprise was varied. In all, thirteen different and separate solutions were obtained, i.e., twelve variable net income solutions and one given net income solution. Although this involved the programming of some activities already in solution, it was believed that a clearer picture could be obtained from this procedure. The results from the programming analysis were satisfactory, although due to the form of output data from the 650, some discretion on the part of the researcher had to be used in interpreting the different solutions.

Formulation of the Problem

The problem was to find the solution for 28 variables, of which sixteen were slack variables and twelve were real variables. The linear programming problem involved sixteen equations plus the linear maximizing function. Each variable was assigned a P with a numerical subscript for formulation purposes. The variables and their coded P numerical subscripts are identified in Table 6.

The linear maximizing function can be written as follows:

$$\begin{aligned} Z = & 22.94 P_{18} + 30.51 P_{19} + 24.14 P_{20} + 28.94 P_{21} \\ & + 8.54 P_{22} + 14.24 P_{23} + 8.54 P_{24} + 14.24 P_{25} \\ & + 5.18 P_{26} + 11.08 P_{27} + 8.23 P_{28} + 3.90 P_{29} \end{aligned}$$

The numerical coefficients represent the absolute net income of each activity on a per acre basis.

The linear equation system resulting from the introduction of the slack variables can be written as:

- (1) $1P_{18} + 1P_{19} + 1P_{22} + 1P_{24} + 1P_{26} + 1P_{28} + 1P_{29} + 1P_2 = 800$
- (2) $1P_{18} + 1P_{19} + 1P_3 = 400$
- (3) $1P_{20} + 1P_{21} + 1P_{23} + 1P_{25} + 1P_{27} + 1P_4 = 160$
- (4) $1P_{20} + 1P_{21} + 1P_5 = 80$
- (5) $.1P_{24} + .1P_{25} + .2P_{26} + .2P_{27} + .2P_{28} + 1P_6 = 240$
- (6) $.1P_{24} + .1P_{25} + .2P_{26} + .2P_{27} + .2P_{28} + 1P_7 = 220$
- (7) $.125P_{24} + .125P_{25} + .1P_{26} + .1P_{26} + .1P_{27} + .1P_{28} + 1P_8 = 255$
- (8) $.1P_{26} + .1P_{27} + .1P_{28} + 1P_9 = 225$
- (9) $.1P_{19} + .1P_{21} + .125P_{26} + .125P_{27} + .125P_{28} + .125P_{29} + 1P_{10} = 250$

Table 6. Identification of coded real and disposal activities.

Coded Subscript ¹	Activity
Disposal activities ²	
P ₂ -----	Owned cropland disposal activity
P ₃ -----	Owned wheat allotment disposal activity
P ₄ -----	Rented cropland disposal activity
P ₅ -----	Rented wheat allotment disposal activity
P ₆ -----	Jan. 1--Jan. 31 disposal activity
P ₇ -----	Feb. 1--Feb. 28 disposal activity
P ₈ -----	Mar. 1--Mar. 31 disposal activity
P ₉ -----	Apr. 1--Apr. 30 disposal activity
P ₁₀ -----	May 1--May 31 disposal activity
P ₁₁ -----	June 1--June 30 disposal activity
P ₁₂ -----	July 1--July 31 disposal activity
P ₁₃ -----	Aug. 1--Aug. 31 disposal activity
P ₁₄ -----	Sep. 1--Sep. 30 disposal activity
P ₁₅ -----	Oct. 1--Oct. 31 disposal activity
P ₁₆ -----	Nov. 1--Nov. 30 disposal activity
P ₁₇ -----	Dec. 1--Dec. 31 disposal activity
Real activities	
P ₁₈ -----	Owned market wheat
P ₁₉ -----	Owned certified seed wheat
P ₂₀ -----	Rented market wheat
P ₂₁ -----	Rented certified seed wheat
P ₂₂ -----	Owned winter barley
P ₂₃ -----	Rented winter barley
P ₂₄ -----	Owned spring barley
P ₂₅ -----	Rented spring barley
P ₂₆ -----	Owned grain sorghum
P ₂₇ -----	Rented grain sorghum
P ₂₈ -----	Owned silage sorghum
P ₂₉ -----	Owned alfalfa hay and seed

1. The coded subscript was used in linear programming analysis.
 See page 47 for equations used in the analysis.
2. P₁ was the zj-cj objective row in the analysis.

- (10) $.5P_{18} + .5P_{19} + .5P_{20} + .5P_{21} + .625P_{22} + .625P_{23} + .625P_{24}$
 $+ .625P_{25} + .1P_{26} + .1P_{27} + .1P_{28} + .1P_{29} + .1P_{11} = 720$
- (11) $.4P_{18} + .65P_{19} + .P_{20} + .57P_{21} + .4P_{22} + .4P_{23} + .2P_{24}$
 $+ .2P_{25} + .125P_{29} + .1P_{12} = 564$
- (12) $.3P_{18} + .8P_{19} + .3P_{20} + .63P_{21} + .3P_{22} + .3P_{23} + .2P_{24}$
 $+ .2P_{25} + .25P_{29} + .1P_{13} = 600$
- (13) $.1P_{18} + .35P_{19} + .1P_{20} + .27P_{21} + .1P_{22} + .1P_{23} + .P_{24}$
 $+ .2P_{25} + .4P_{28} + .125P_{29} + .1P_{14} = 286$
- (14) $.125P_{18} + .125P_{19} + .125P_{20} + .125P_{21} + .125P_{22} + .125P_{23}$
 $+ .25P_{26} + .25P_{27} + .1P_{15} = 286$
- (15) $.25P_{26} + .25P_{27} + .1P_{16} = 240$
- (16) $.2P_{26} + .25P_{27} + .1P_{17} = 220$

All real and slack variables are subject to the constraint that they must be equal to or greater than zero. The numerical coefficients represent land and labor requirements, and the number on the right hand side of the equation represents the amount of the resource available in terms of acres or hours.

Results of the Analysis

The results of the linear programming analysis were presented in this section of the study. First, the optimum plan for the farm under a fixed net income per enterprise was shown. Second, optimum plans under variable net income situations were presented.

Optimum Organization With Fixed Net Income Enterprises.

Under a fixed net income situation, the analysis showed that there were six possible entering enterprises. Both P_{19} owned seed wheat

and P_{21} rented seed wheat, entered as contributing activities, but the analysis indicated that the solution was indeterminate between the two types of barley enterprises. Both winter or spring barley were equally contributing and could therefore be termed perfect substitutes in this analysis. Either P_{22} , owned winter barley, P_{23} , rented winter barley, P_{24} , owned spring barley, or P_{25} , rented spring barley could enter the solution with equal contribution to the net income of the farm. With this situation considerable flexibility was available to the farm operator. Should soil or moisture conditions be unfavorable to the planting of winter barley, the land could remain idle until spring when spring barley could be planted. If an extremely harsh winter should kill the barley planted in the fall, the operator has the opportunity to re-plant barley in the spring.

Regardless of the type of barley grown, the operator can be assured, according to this analysis, that an adequate amount of labor was available for both the growing of spring or winter barley. Although the two types of barley demand labor during different times of the year, the analysis showed a surplus of labor existed each month.

Using this plan it was determined that 400 acres of owned cropland could be devoted to seed wheat production and the remaining 400 acres would be utilized for barley production. The rented cropland would also be equally divided between seed wheat and barley production. Only the restriction of 50 percent of the total acreage kept the two seed wheat enterprises from being grown

on all of the 960 acres of farm land.

Optimum Organizations Under Variable Net Income Situations.

Analyzing optimum plans under variable enterprise net incomes were considerably more complex than the analysis using fixed net income assumptions. At best only certain relationships among enterprises could be considered, if net incomes of all activities were allowed to vary. In order to present the results of the analysis, price mapping was used. Because preliminary analysis indicated that P_{28} , owned alfalfa and P_{29} , owned silage sorghum would come into solution only at very unrealistic levels, the analysis dealt only with those enterprises which were economically feasible i.e., activities P_{18} , through P_{27} .

Figure 1 shows the economic relationship that existed between certified seed wheat production and market wheat production, grown on owned land. The modified production possibility curve indicates that the two enterprises were perfectly linearly competitive for land resources. The determination of which crop that was to be grown on owned land depended entirely upon the ratio of net incomes of the two enterprises. So long as the ratio of
$$\frac{\text{net income of certified seed wheat}}{\text{net income of market wheat}}$$
 was greater than unity, all 400 acres of owned land would be devoted to certified seed wheat production. If this ratio was less than unity, the owned wheat allotment would be devoted to market wheat. Should the condition occur that this net income ratio was equal to one, then the solution would be indeterminate. The operator could choose to produce all of either enterprise or any amount of the two activities, so long as the total acreage

of the two crops equaled 400 acres.

This same relationship was also shown by the use of price mapping as shown in figure 2. The net incomes of certified seed wheat are shown on the vertical axis and the horizontal axis shows the net incomes of market wheat. This map was constructed in the following manner: The line with a 45 degree slope passing through the origin, denotes equal net incomes for certified seed wheat and market wheat. Thus the boundary line connects all possible combinations of the two enterprises with a net income ratio of one. Therefore, any net income pair falling above this line represents a condition in which the certified seed wheat net income ratio is greater than one and optimum plan A should be used. Net Income ratios of less than 1 will fall in the "B" area and therefore plan B should be used. Table 7 indicates the alternative plans available to the farm operator.

Table 7. Alternative Plans Available to Farm Operator.

Plan A	owned wheat allotment devoted to certified wheat
Plan B	owned wheat allotment devoted to market wheat
Plan C	owned cropland devoted to barley
Plan D	owned cropland devoted to grain sorghum
Plan A'	rented wheat allotment devoted to certified wheat
Plan B'	rented wheat allotment devoted to market wheat
Plan C'	rented cropland devoted to barley
Plan D'	rented cropland devoted to grain sorghum

In this case plan A denotes that all of the 400 acres of wheat allotment should be devoted to certified seed production and plan B indicates that 400 acres of wheat allotment will be

used to produce market wheat.

Figures 5 and 6 show the same graphical analysis for certified seed wheat and market wheat grown on rented land. These graphs differ from those on page 54 in that 80 rather than 400 acres of land are considered.

The question of which wheat enterprises was to be grown can be determined by the use of figures 2 and 6. This exhausts the supply of the wheat allotment acreage leaving the remaining land to be devoted to the production of either winter barley, spring barley, or grain sorghum. This problem can be solved by the same method as used in the wheat analysis.

Figures 3 and 4 denote the net income relationships existing between spring and winter barley or grain sorghum. As in the wheat analysis the enterprise to be produced can be determined by the net income ratio of spring or winter barley and grain sorghum. If the $\frac{\text{barley}}{\text{grain sorghum}}$ net income ratio is greater than one, figure 3 indicates that 400 acres of cropland should be devoted to barley production. If the ratio is less than one, then the graph specifies that the land should be used for grain sorghum production.

By the use of figure 4 the optimum plan can be determined. If the $\frac{\text{barley}}{\text{grain sorghum}}$ ratio is greater than unity plan C will be used. If this ratio is less than one, plan D will be used.

Figures 7 and 8 show the same graphical analysis for barley and grain sorghum grown on rented land. These graphs differ from the figures on page 55 in that 80 rather than 400 acres of land are considered.

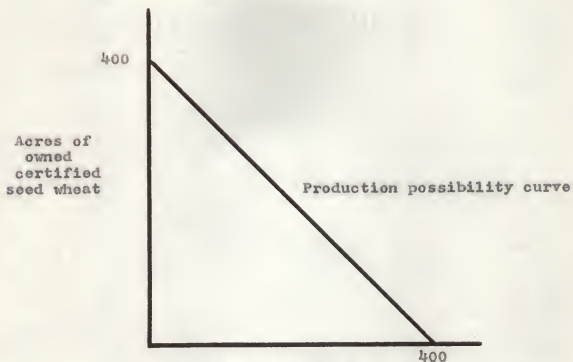


Fig. 1. Production possibilities for owned certified and market wheat.

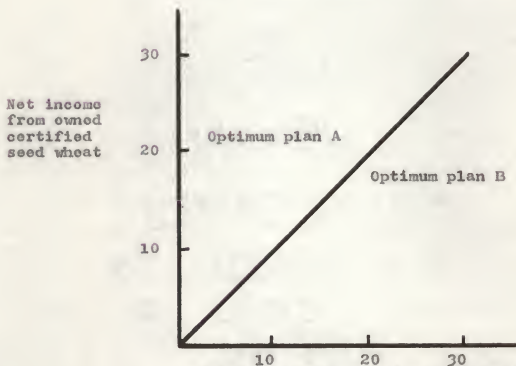


Fig. 2. Net income map for owned certified and market wheat.

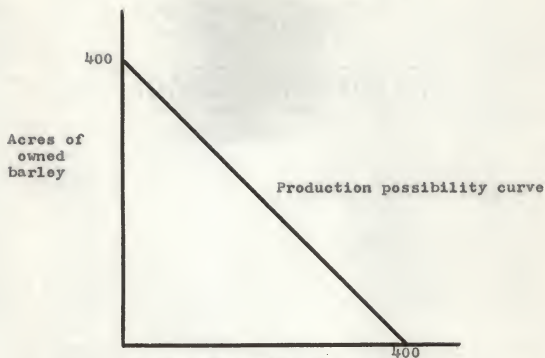


Fig. 3. Production possibilities for owned barley and grain sorghum.

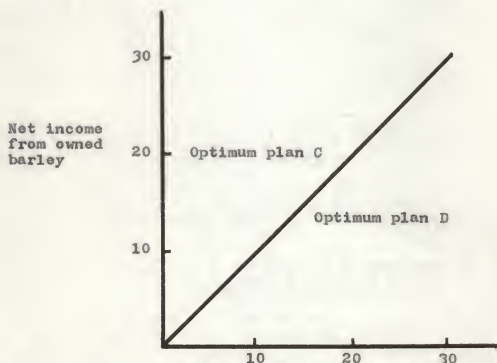
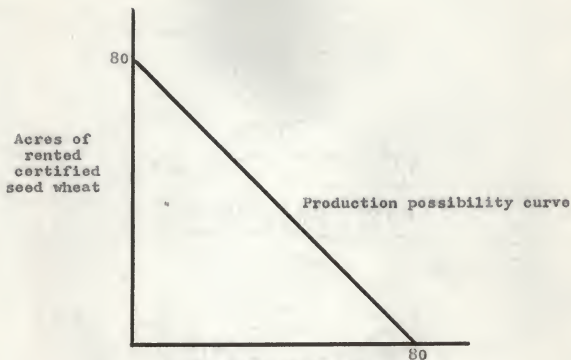
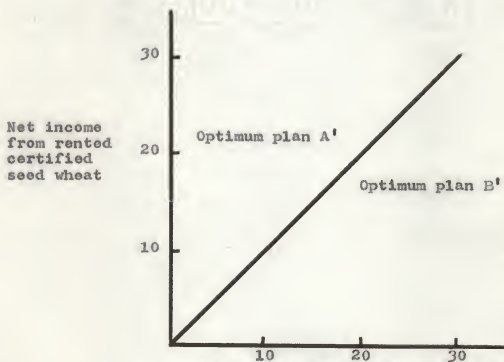


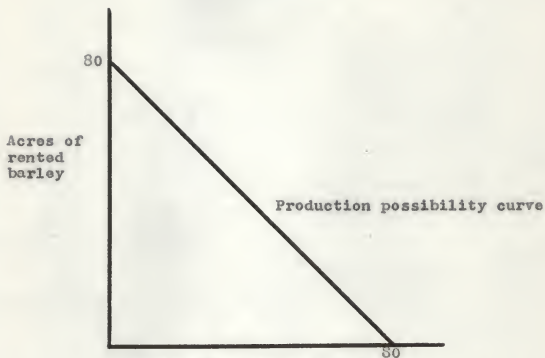
Fig. 4. Net income map for owned barley and grain sorghum.



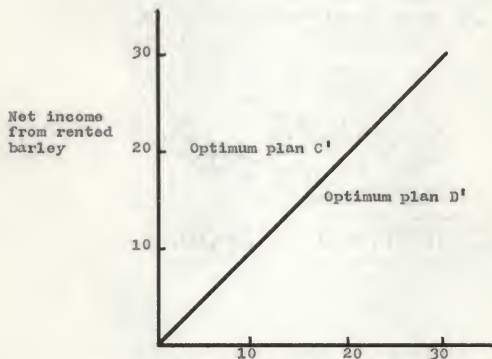
Acres of rented market wheat
Fig. 5. Production possibilities for rented certified and market wheat;



Net income from rented market wheat
Fig. 5. Net income map for rented certified and market wheat,



Acres of rented grain sorghum
 Fig. 7. Production possibilities for rented barley and grain sorghum.



Net income from rented grain sorghum
 Fig. 8. Net income map for rented barley and grain sorghum.

As noted earlier in this section spring barley and winter barley are considered as perfect substitutes and the question of which enterprise will be produced will depend on extraneous conditions rather than economic considerations. Hence, only one set of graphs are used for the barley-grain sorghum analysis.

For a more detailed statement on the use of graphical analysis solving such problems, see the next section of this study, entitled "Practical Application of the Analysis."

There were a number of other results that were derived from the linear programming analysis. Basically, it was determined the farm's present organization, i.e., certified seed wheat production and barley production, was the most profitable with existing prices, yields and production costs. However, the organization of the farm's resources depended entirely upon the relationship of enterprise net incomes. Essentially it can be concluded that any enterprise, of those considered, could enter as a contributing activity providing its per acre net income exceeded the net income of some other enterprise, subject, of course, to the aforementioned constraints on the wheat acreage. For example, barley production was feasible only as long as its per acre net income exceeded that of grain sorghum. If the net income per acre of grain sorghum exceeded that from barley, then grain sorghum was the most feasible crop to be grown on the farm. If one of the two feed grain's per acre net income exceeded the per acre income from wheat, then it was most profitable to devote the entire acreage to the feed grain.

This conclusion was possible because only one resource--land was limited in the analysis. Labor was subject to the aforementioned limitations, but in the production of wheat, barley and grain sorghum it did not serve as a constraint. Capital was not limited so long as extensive operations were used on the farm. Although land was the limiting resource of the farm studied, it was limiting only until some other restriction was reached. The first restriction to be met after expansion of the farm's acreage would probably be a labor restriction, although it was possible that management could become the limiting factor.

The fact that land was the limiting resource indicated it would pay the operator to acquire more land through buying or renting. This further substantiated this author's conclusion discussed earlier in this study concerning farmer's views on land being the limited resource.

A further conclusion was that certified seed wheat production was shown to be a profitable enterprise if produced on a scale similar to the farm studied in this analysis. This, however, was subject to several qualifications, particularly those noted on page 25 of this study. Furthermore it is likely that the demand for certified seed wheat has been relatively inelastic, thus any extensive enlargement of certified seed production could cause a sizeable decline in the price. This problem was not explored in this study but it was fairly realistic to assume a relatively inelastic demand curve has existed for the commodity.

In concluding this section of the study, it should be noted that livestock enterprises were not mentioned. This study did not attempt to include a livestock enterprise as one of the activities, but did make provision for including such an enterprise by the inclusion of the two forage activities, silage sorghum and alfalfa hay. It was considered these two products were "sold" to a livestock enterprise. The primary objective of this study according to the section entitled "The Problem and Objectives of the Study," was to determine a practical solution for the farm operator when crop rather than livestock, yields, prices or costs of production and/or resources changed.

Practical Application of the Analysis

This section of the study was devoted to the presentation of a system by which a farm operator could determine his optimum farm plan when given data such as that given in this study. An attempt was made to present charts, graphs and procedural instructions so that information such as this could be applied to actual farm situations.

In applying the data given in this study three steps are used. These are:

1. Determine the net income for each enterprise considered.
2. Define the restrictions imposed on enterprises or resources.
3. Solve for the optimum enterprise organization.

In order to determine the net income for each of the enterprises considered, three variables must be considered: (1) the yield per acre of each crop, (2) the selling price of the enterprise and (3) the cost of producing one acre of the activity.

After these three variables are determined the net income can be found by the use of the following equation: $N.I. = (P \times Y) - C$, where N.I. denotes net income per acre, P indicates the per unit price, Y signifies the yield per acre and C designates the cost of producing one acre of the crop. A nomographic chart on page 67 substituted for the mathematical calculations needed to determine the net income per acre.¹

The nomograph (sometimes called an alignment chart) graphically solves mathematical equations by using a straight edge with it. To use the chart, first determine the gross income from the enterprise by laying a straight edge on the determined yield and the determined price. The gross income can then be read from the line entitled gross income. To determine the activities' net income, lay a straight edge on the determined cost of production and the calculated gross income. The net income of the enterprise can then be read from line N.I.

The nomograph can also be used to find any one of the three aforementioned variables if the net income of the enterprise is known. However, its primary purpose is to guide the farm operator in the calculation of enterprise net incomes under various conditions of yields, prices, and costs of production. For example a net income of \$30.00 per acre for wheat can be obtained by a 30 bushel per acre yield, a \$2.00 per bushel price and \$30.00 cost of production. Or the same net income can be obtained with a 20 bushel yield, a \$2.00 price and a \$10.00

1. The nomograph on page 67 was designed by this author. However basic ideas for the chart were taken from G.H. Larson, op. cit., pp. 33-43.

cost of production. This example considered only two possible solutions but an infinite number of other combinations of price, yield and cost will also produce a \$30.00 per acre net income.

After the net income has been found for each activity, the second step is to define and determine any restrictions imposed on enterprises or resources. These restrictions may be caused by institutional, personal or other factors. One common constraint is one imposed on wheat acreage by government allotment programs. Many restrictions can also be those of a personal nature. It may be that a farm operator would prefer not to grow barley because of an allergic condition or an operator may prefer not to grow grain sorghum because it is often quite cold when the harvesting operation is performed. Regardless of the reason, all restrictions must be noted before step three can be started.

Step three consists of solving, by the use of graphs, for an optimum farm plan. The logic in using these graphs consists of a step by step trial and error elimination method.

In order to determine which enterprises enter into the optimum plan, the following procedure is used. First, determine which enterprise has the highest net income per acre, then by using the figures on pages 68 through 73, determine whether this enterprise will eliminate all other activities. This will be shown by the enterprise consistently falling in the area of solution when compared to all other considered enterprises. Second, consider any restraints imposed on this activity. If it is wheat, the restraint will probably be on the acreage grown, because of government wheat allotment programs. Any acreage

restraint will leave remaining land on which other crops can be grown.

Third, repeat steps one and two until all land is devoted to one or more of the enterprises considered. At this point the optimum solution has been reached.

Although the solution for finding an optimum plan was relatively simple in this study where land was the only constraint, the same general procedure and graphical analysis can be used when labor or capital are the limiting resources. Such a situation would, of course, require more complicated charts and graphs, but the same steps could be used to determine the optimum solution.

In order to clarify the use of the charts on pages 67 through 73 the following example has been given. This example determines the optimum land organization for the farm analyzed in this study under different enterprise net income situations than those given in the fixed net income analysis.

Assuming that the yields, prices and production costs were those shown in table 8, the first step was to compute the net incomes of each enterprise.

This operation was performed in the manner described on page 61. For example, to determine the net income for owned market wheat a straight edge was first placed at 30 on the yield line and \$2.00 on the price line of figure 9. This step determined the gross income for market wheat. To determine the net income from market wheat, the straight edge was placed on

the computed gross income, which in this case was \$60.00 and on the production cost line which was \$30.00. The net income of \$30.00 was then read from the line entitled net income. This step was repeated for all enterprises and each enterprise net income was then tabulated in table 9.

Table 8. Yields, prices and production costs used in example.

Enterprises	: Yield	: Price(\$)	: Production Costs(\$)
Owmed market wheat	30	2.00	30.00
Owmed certified wheat	30	2.25	35.00
Rented market wheat	25	2.00	20.00
Rented certified wheat	25	2.25	35.00
Owmed barley	40	.75	25.00
Rented barley	40	.75	20.00
Owmed grain sorghum	45	1.00	30.00
Rented grain sorghum	45	1.00	25.00

Table 9. Net incomes of enterprises used in example.

Enterprises	Net Incomes(\$)
Owmed market wheat	30.00
Owmed certified wheat	32.50
Rented market wheat	30.00
Rented certified wheat	27.50
Owmed barley	5.00
Rented barley	10.00
Owmed grain sorghum	15.00
Rented grain sorghum	20.00

The second step was to define the restrictions for each enterprise. In this case it was assumed the only restriction applying to the enterprises considered was the government wheat allotment program which restricted the wheat acreage to 400

acres on owned land and to 80 acres on rented land.

The third step was to solve for optimum enterprise organization by the use of the charts on pages 68 through 73. A number of separate plans and combinations of plans were available to the farm operator. These plans are identified in the following table.

Table 10. Alternative plans available to the farm operator.

Plan	Explanation
Plan A--all owned land devoted to certified wheat	
Plan B--all owned land devoted to market wheat	
Plan C--all owned land devoted to barley	
Plan D--all owned land devoted to grain sorghum	
Plan A'--all rented land devoted to certified wheat	
Plan B'--all rented land devoted to market wheat	
Plan C'--all rented land devoted to barley	
Plan D'--all rented land devoted to grain sorghum	

As stated on page 62 of this study, the logic in using these graphs consisted of a step by step trial and error method of elimination. First, the enterprise which had the highest per acre net income was chosen to compare with all other activities. In this case it was owned certified seed wheat. The net income ratio of $\frac{\text{owned certified wheat}}{\text{owned market wheat}}$ was greater than 1, i.e., $\frac{22.50}{30.00}$ 1, so plan A was feasible in this comparison. The net income of owned certified seed wheat was then compared to the other enterprises, i.e., barley and grain sorghum. In this example plan A was always the optimum plan. However, it has to be remembered that wheat was allotted to only 400 acres of the 800 acres of owned cropland. Therefore, the remaining

400 acres of owned cropland must be devoted to the next best alternative.

The next best alternative for owned land was found by examining table 9 for the next highest net income of a non-wheat enterprise. In this example it was grain sorghum. As with the certified wheat enterprise, the net income ratios of the remaining enterprise, which was barley was compared by the use of figure 15. This indicated that plan D should be used for the remaining cropland.

This completed the analysis for determining the optimum use of land. The land in this example was equally divided into two cropping plans--plan A and plan D. This was the optimum plan for all owned land.

For rented land the same steps were repeated using figures 16 through 21 with the optimum plans being plan B' and plan D'.

SUMMARY AND CONCLUSIONS

The basic hypothesis of the study was farm resources respond not only to changes in enterprise prices, but also to changes in yields and production costs of alternative enterprises. To substantiate this hypothesis, a Reno County, Kansas, farm specializing in the production of certified seed wheat was analyzed by the use of linear programming.

First, the optimum farm organization was determined using existing prices, yields and production costs. This analysis showed that certified seed wheat and market barley were the two most profitable enterprises.

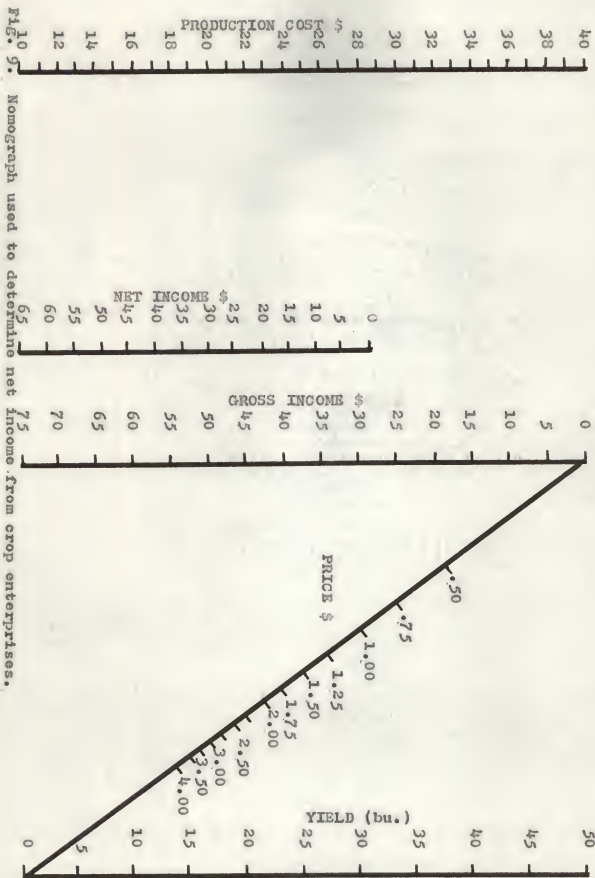


Fig. 9.

Nomograph used to determine net income from crop enterprises.

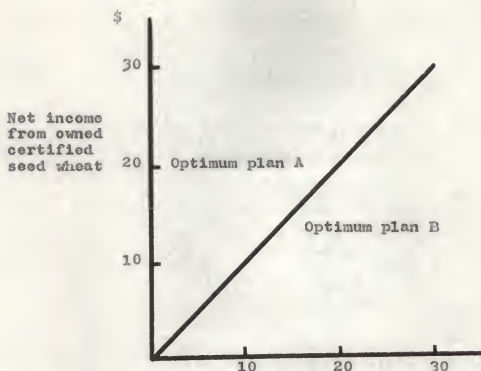


Fig. 10. Net income map for owned certified and market wheat

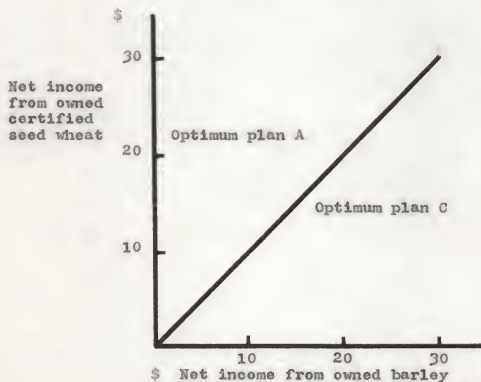


Fig. 11. Net income map for owned certified wheat and barley.

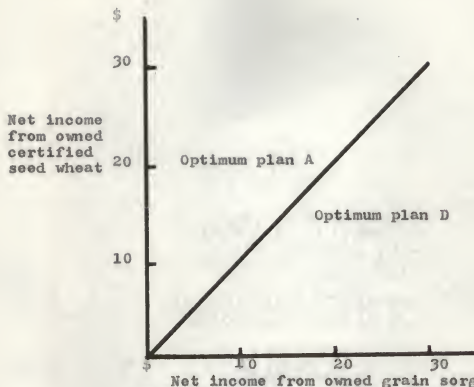


Fig. 12. Net income map for owned certified wheat and grain sorghum.

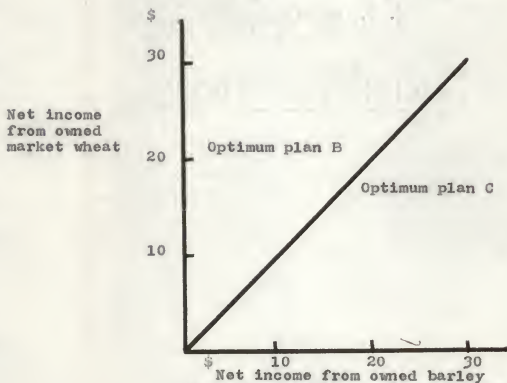


Fig. 13. Net income map for owned market wheat and barley.

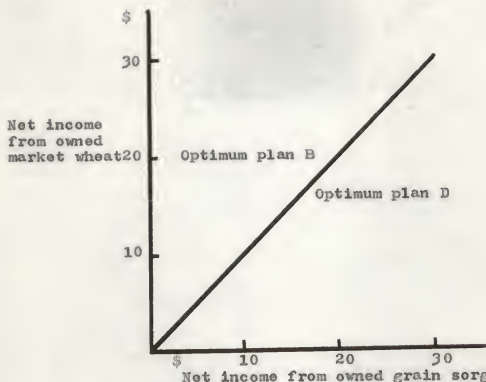


Fig. 14. Net income map for owned market wheat and grain sorghum.

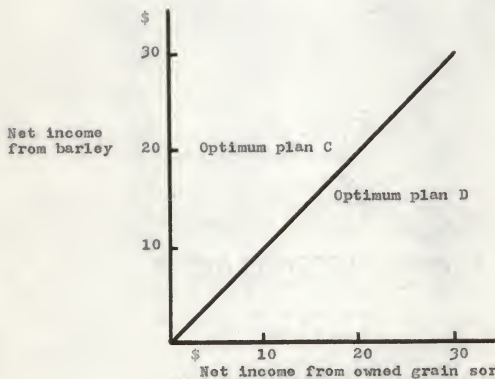


Fig. 15. Net income map for owned barley and grain sorghum.

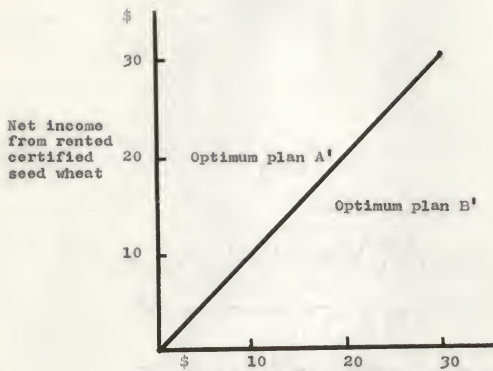


Fig. 16. Net income map for rented certified and market wheat.

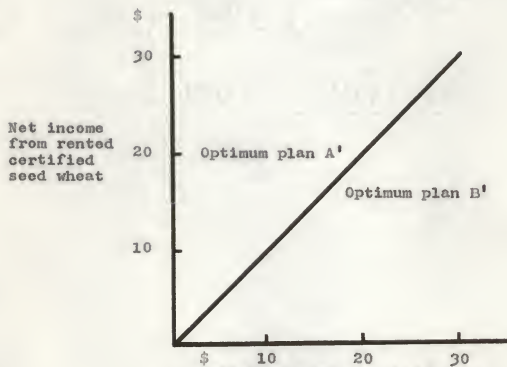


Fig. 17. Net income map for rented certified wheat and barley.

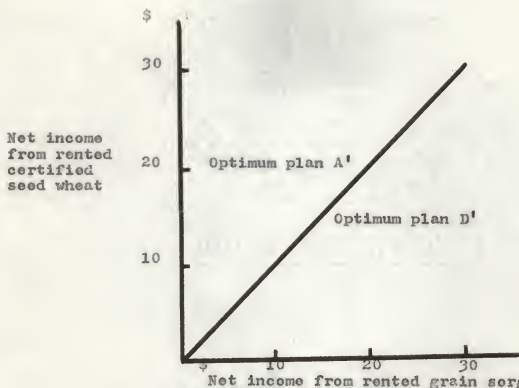


Fig. 18. Net income map for rented certified wheat and grain sorghum.

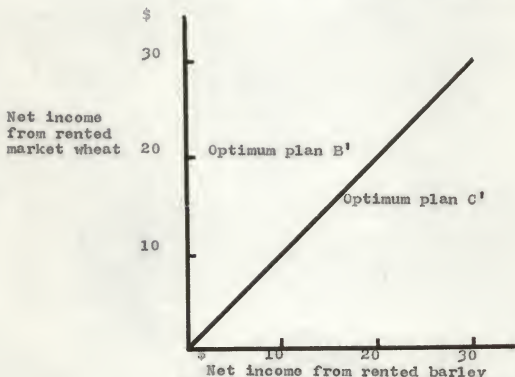


Fig. 19. Net income map for rented market wheat and barley.

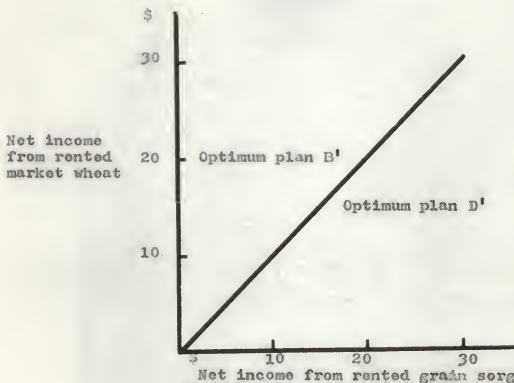


Fig. 20. Net income map for rented market wheat and grain sorghum.

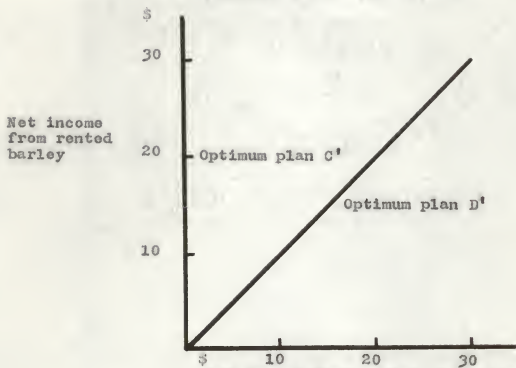


Fig. 21. Net income map for rented barley and grain sorghum.

The same data were then used to determine what changes were needed in the net incomes of the alternative enterprises to change the allocation of existing resources. Basically it was determined that all of the enterprises, except silage sorghum and alfalfa, would enter into an optimizing plan provided the per acre net income exceeded the per acre net income of other enterprises. This conclusion resulted because surplus labor existed in all months of the year and capital was not a limiting factor.

In order to determine which enterprise would enter into the optimizing plan, a series of charts were presented so that the farm operator could determine which crops would be most profitable. These charts made use of the analysis presented earlier in the study.

In addition to the conclusion noted above, there were a number of other conclusions that could be stated. Land was determined to be the limiting resource, therefore it would be feasible to expand the farm's acreage until some other restriction was reached. Labor and capital did not limit the size of the operation, however, had a more intensive operation been studied, these two resources could have become limiting.

A further conclusion of this study was for farms similar to the one analyzed, the production of certified seed wheat would be a profitable enterprise subject to the qualifications noted earlier in this study. It was also considered the demand curve facing the certified seed wheat producer was fairly inelastic, making limited production profitable, but sizable expansion of the industry was not recommended.

The introduction noted the farmer had three alternatives by which he could maintain or increase his farm income. These were (1) using the available resources more efficiently, (2) vertical integration of some phase of production and (3) specializing in the production of one or more enterprise. This study was an example of a farm combining the latter two alternatives and increasing the farm's income. Although this farm's speciality was the production of certified seed wheat, this does not indicate that all farms should attempt to raise incomes by producing certified seed. In fact, to do so would probably mean a drastic decline in the price of certified seed. However, it does point out the fact specialization of some type may be necessary for farmers to continue in business.

The farm operator can expect a continuation of rapid technological, institutional and economic changes--how his income will change will depend upon the adjustments made in resource use. This study attempted to determine what changes would occur when yields, prices and/or production costs changed due to technological, institutional or economic factors.

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THE EFFECT OF VARYING LEVELS OF NET INCOMES FOR DIFFERENT
ENTERPRISES ON THE RESOURCE ORGANIZATION OF A CERTIFIED
SEED WHEAT FARM IN KANSAS

by

Philip F. Warnken

B. S., Kansas State University, 1960

AN ABSTRACT OF A THESIS

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The basic hypothesis of this study was farm resources respond not only to changes in enterprise prices, but also to changes in yields and production costs of alternative enterprises. To substantiate this hypothesis, a Reno County, Kansas, farm specializing in the production of certified seed wheat was analyzed by the use of linear programming.

The two primary objectives of this study were: (1) to provide a framework of analysis by which a farm operator could determine the optimum use of his available resources when crop yields, prices, or costs of production and/or resources changed, and (2) to determine the economic conditions under which specialized certified seed wheat production was feasible on Kansas farms.

In order to simplify the analysis, the three variables; yields, prices, and production costs were aggregated into a single variable--net income. The study considered twelve different activities. These included certified seed wheat, market wheat, winter barley, spring barley, grain sorghum, silage sorghum and alfalfa grown on rented and owned land. The net income of each activity was allowed to vary to determine the changes needed in resource use to keep farm profits maximized.

In order to determine which activity would enter into an optimizing plan, a series of charts and graphs were presented. These figures enabled the farm operator to determine which crops would be the most profitable under conditions of variable prices, yields, and production costs.

It was determined that all of the activities except silage sorghum and alfalfa would enter into an optimizing plan provided the per acre net income exceeded the per acre net income of other enterprises. This conclusion resulted because land was the limiting resource. For the farm analyzed in this study, labor and capital did not limit the production of any activity except in the production of silage sorghum which met a labor restriction. Had a more intensive operation been utilized on the farm, labor and capital could have become limiting.

It was further determined with existing prices, yields, and costs, the most profitable enterprise for the farm was certified seed wheat. Because the government wheat allotment program limited the acreage to approximately 50 percent of the total acreage, the production of winter or spring barley was the next best alternative.