A STUDY OF THE PRODUCTIVITY OF SELECTED SOILS IN WESTERN KANSAS

by

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INTRODUCTION

The recent drought in the Great Plains, causing severe dust storms, crop failures, and low incomes, has focused public attention to the problems of this region. Particular emphasis has been directed to the dust bowl area of western Oklahoma, western Kansas, eastern Colorado and the Texas Panhandle. Opinions have been widespread concerning the feasibility of crop production in this section, some holding the belief that a large portion should be reseeded to grass as was done in the 1930's. The conservation reserve of the Soil Bank program is a step in this direction.

The Great Plains is distinctive because of its topography, climate and natural resources. Geographically, it is normally described as an area from Texas to the Canadian border, with its eastern boundary along a line from the eastern edge of North Dakota through the middle portion of Kansas, and west to the Rocky Mountains. In early maps it was described as the Great American Desert. The climate of most of the region is that of semi-arid, with annual rainfall ranging from 8 to 30 inches. With the exception of a few island-like mountain groups, the topography is level to rolling prairie land. The high variation in precipitation from year to year in the area is a distinctive factor and makes successful crop production extremely variable. Associated with this variability of rainfall are low average yields and as a result, low per acre

returns. Most areas throughout the country are faced with variable prices, irregular yields and changing costs of the factors of production. This fluctuation of income is greater in western Kansas than in more humid areas.[1]

Most of the settlers in the Great Plains came from areas of higher precipitation and were not acquainted with dry land farming techniques. The size of the farm which was limited partly by the Homestead Act, along with the natural hazards of drought, wind, and insects, forced many of the early settlers to abandon this region.

These natural hazards experienced by the settlers are factors which plague the area today. Reference to Table 1 will indicate the variation in both agricultural production and income. The year 1947 represents above average rainfall and farm income, whereas 1954 represents the opposite. These cycles of high and low rainfall and income are not of the same duration and usually are not predictable.

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[1] Emery N. Castle, Adapting Western Kansas Farms to Uncertain Prices and Yields, Kansas Agricultural Experiment Station Technical Bulletin 75, February, 1954.

Table 1. A comparison of agricultural production and income for Kansas type-of-farming area 10b, (nine counties in southwest portion of the state) for the years 1947 and 1954.

Item	1947	1954
Acres seeded, wheat	2,078,000	1,467,000
Acres harvested, wheat	2,022,000	962,000
Yield per acre harvested	20.7	8.2
Farm value wheat crop	$93,784,000	$17,384,400
Total value of crops	$104,393,130	$35,301,060
Total value livestock and livestock products	$18,585,050	$13,137,510
Total value crops, livestock and livestock products	$122,978,180	$48,438,570

Source: Calculated from data in Thirty Sixth Biennial Report, Kansas State Board of Agriculture and Report of Kansas State Board of Agriculture, 1954-1955.

The Problem

Research effort has increased and governmental programs to improve the economic welfare of the people in the Great Plains have been enacted. The emergency hay and grain program, soil bank payments, the Great Plains program, and emergency tillage payments are examples of activities which have provided assistance to the farmers of this region. How beneficial are the present programs, are they adequate, what are the economic results, what institutional arrangements are needed and how

should the cost and benefits be shared? Answers to these and many other related questions suggest that some framework is needed to analyze and evaluate both present and future assistance. Several outlines could be developed, but in general they would need to include most of the following items. What are the goals of the activities and what entities are involved--persons or aggregations, public or private? What are the physical requirements and consequences of the activities and what are their economic results in costs and returns? What institutional arrangements are necessary to attain the goal or goals? These arrangements may be in the form of controls, regulations, credit and taxation.

The analysis and evaluation of activities or programs require a knowledge of the productivity of the land. Land can be differentiated into classes and soil types. The productivity of each soil type must be known, to properly evaluate the productivity of the area. This phase of determining the productivity of soil types in western Kansas has not yet been done. A major portion of the study will be devoted to physical returns (yields), and the availability and means of obtaining this necessary information.

The second part of the problem is to determine the economic productivity of the selected soils, after the physical returns are known. This problem can be viewed by observing the average returns during a given period and/or the variability of

returns. In this study only average returns will be used for analyzing the economic productivity of soils.

The determination of physical and economic productivity is part of the framework suggested for analyzing activities--the physical requirements and consequences and the economic results in costs and benefits. More specifically, the productivity of soil types can be used to determine the most profitable treatment for different levels of management, to make recommendations regarding cropping sequences and the evaluation of conservation practices. Additional uses of this productivity could be made in the correlation of soil fertility tests and crop yield response, in the economic classification and evaluation of land and in the planning of soil, water and plant conservation measures.

In this study, reference will be made to physical and/or economic productivity. The term physical is used to express quantity, such as yields in bushels per acre, where as the term economic refers to quantity times price or value.

Economic Principles

Production of farm commodities involves numerous relations between resources and commodities.[1] The production function

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[1]Earl O. Heady, Economics of Agricultural Production and Resource Use, p. 21.

indicates the relationship of the input of resources to output of product or products. How resources should be used will depend to a great extent on this functional relationship and market prices. Additional forces such as uncertainty, risk, leasing arrangements and other man made institutions will condition the use of farm resources.

Assuming that an individual farmer's motive is profit maximization, then marginal returns and marginal costs should be equated. This maximization can be obtained only if resources are allocated to the point where values of marginal products are equal for all enterprises, i.e. no other combination of resource use will give a greater return.

The use of marginal analysis is essential in a basic problem of determining how resources should be used to attain the greatest returns. The data available for this study is insufficient to enable derivation of production functions and the use of marginal analysis. The only variable being considered is crop yields, from a fixed unit (an acre of land). Since the inputs associated with these yields were not obtained, the relationship or production function of the input of resources to output of product cannot be determined. The yields in this case represent points on different production functions, and maybe in an area of either increasing or decreasing returns.

In this study, total costs and total returns per crop acre are used as an alternative analysis. This technique of TC and

TR will provide a basis of comparison for the soil types under present farming methods and use of resources.

It is recognized that many farmers reporting yields for this study had not extended resource use to a point where maximum profits were realized. Often the farmer has not been able to reach this point of profit maximization because (1) he has not operated under perfect knowledge of relevant input-output relationships and cost structures, (2) he has been faced with uncertain future prices and yields, and (3) he usually has been limited in the amount of capital available to him.[1]

HYPOTHESIS

There is no significant difference between the selected soil types in western Kansas as to physical or economic productivity, or the data available for determining the productivity of the selected soil types in western Kansas is inadequate.

TESTS OF HYPOTHESIS

Procedure for Collecting Yield Data from Farmers

A study of the productivity of soils in western Kansas may be divided into two major parts, crop yields and soil types.

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[1]Earl O. Heady, op. cit., p. 115.

Crop yields are the result of numerous factors including precipitation, temperature, variety, date of planting, method of tillage, preceding crops, fertilizer and other factors. Soil types are the result of parent materials and climatic conditions. No attempt is being made to relate yields to rainfall, temperature and other climatic conditions, assuming that these variations are related to the area in which the soil types were developed. The other factors of production, non-climatic, are assumed to be constant among soil types. The period of study is 1930 to 1956 inclusive. This period includes the dry cycles of the middle 30's and early 50's and the wet cycle of the 40's.

A classification of soil types was needed to initiate the collection of yield data from farmers. This soil classification was done by the Soil Conservation Service, USDA. The SCS was undertaking a similar project and because of their interest in the physical returns to different soil types, they provided the basic information. Their contributions consisted of aiding in the organization of the survey, mapping the soils, locating farmers who possessed records, collecting yields from these farmers, and recording the results for use in the study.

Prior to the start of this study, the SCS had begun the complete mapping of four western Kansas counties. Soil scientists had been assigned to these areas and their services were made available for this project. The four counties were Logan, Hamilton, Stevens and Ford, (Fig. 1). Other counties could

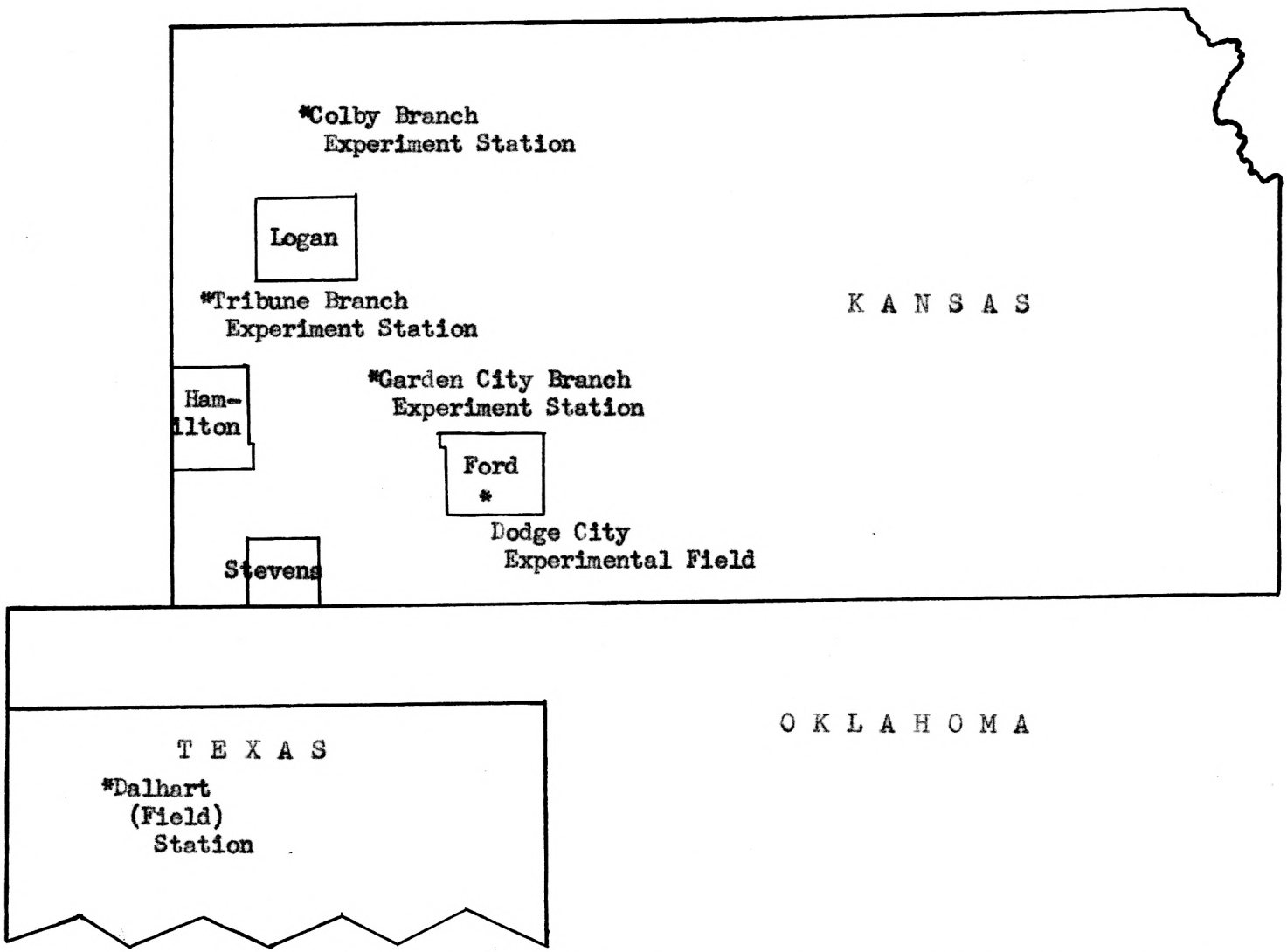

Fig. 1. Location of counties, experiment stations and fields that were included in the study of the productivity of selected soils in western Kansas.

have been selected but the services of the soil scientist would have been limited and the project would have been lengthened considerably.

By previous agreement, the writer was to outline the problem, establish procedures, test and summarize the data, with the SCS doing the field work. Three personal contacts were made with the soil scientists and work unit personnel in these counties to coordinate and supervise the collection of data.

Previous forms which had been used for collecting yields in northeastern Kansas were reviewed.[1] The nature of the area being studied and the number of years observed presented a different situation and necessitated a new form, but many of the previous items were included, (Exhibit A). An accompanying instruction sheet was used to supplement the oral comments given at the first meeting, (Exhibit B). These comments were that yield data should be taken from records and that if yields from memory were included, an evaluation of the reliability should be made. A quarter section was suggested as the size of the field to be used to standardize the sample in each county. It is desirable to have the entire field all of one soil type, but in some localities this presented a major

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[1]Cooperative study of conservation practices by the Agricultural Research Service and the Kansas Agricultural Experiment Station, Manhattan, Kansas.

Exhibit A. Form used for collecting yield data from farmers for the study of the productivity of selected soils in western Kansas.

County:_____ PRACTICE AND YIELD REPORT Soil Type:_____

Farm Operator:_____ Address:_____

Legal Description of Field | Size of Field | Photo Number

Item	19__	19__	19__	19__	19__
Crop Planted					
Acres Planted					
Acres Harvested					
Production - total or per acre					
Crop Planted					
Acres Planted					
Acres Harvested					
Production - total or per acre					
Misc. Crops - Acres					
Summer Fallow - Acres					
Terraced Yes - No					
Crop Damage: Kind					
Crop Damage: Extent					

Indicate any pertinent comments on back of this card

Exhibit B. Supplemental instructions to the county SCS offices in regard to the use of the form for collecting yield data.

I am forwarding under separate cover forms for the collection of yield data in your county. The card has been reorganized, incorporating your suggestions for gathering and recording the data.

Following are a few questions, which I anticipate might arise when using the card. The identification section should not present any major problems. If a farmer wishes to remain anonymous, assign a number or letter on all cards which include data from the selected fields. The size of the field, I believe, should be a quarter section, however an eighty or a half section would suffice.

When recording the yield data, one point will need to be carefully noted, that is, whether production was from fallow or continuous crop. We will consider only the two major crops, wheat and milo. Any other crop will be included in the miscellaneous section. The total acreage of crops planted, miscellaneous crops and summer fallow should equal the size of the field as shown in the identification section.

If the yield was from summer fallow, identify by the letters S.F. and continuous crop the letter C. Since there are only two sections on the card where the crop planted may be recorded, it may be necessary to divide the line or use an additional card. This case will arise if the farmer had yields of wheat from both continuous cropping and summer fallow and milo from either continuous or summer fallow, all in one field. Three line entries would be necessary to record this illustration.

The item entitled crop damage and extent refers to hail, fire, and any other damage which affected isolated farms. Yields for this study should be restricted to dry land farms. If a farmer is now irrigating but has good records of preceding years on dry land farming, record these yields up to the time he started irrigating.

obstacle. In these cases, yields were taken as long as the major soil type included 75 per cent of the size of the field.

Major Soils in Western Kansas

The designation of the soil type and the collection of the yield data was performed by the soil scientists and work unit personnel. The soils included in this study are Keith, Colby, and Ulysses in Logan County; Richfield and Colby in Hamilton County; Dalhart, Vona and Richfield in Stevens County; and Hastings-like in Ford County. The characteristics of these soils and the acreage in each county is presented in Tables 2 and 3.

Results of the Sampling Procedure

Different means were employed by the counties in locating individual farmers who had farm records, who were located on the soil types being studied, and who were willing to cooperate. In Logan County, 225,000 acres had been previously mapped for farm and ranch planning and for a standard survey. These acreages were reviewed and those areas which had at least 75 per cent of the major soil types being considered in this project were screened out. Landlords and tenants involved were recorded and contacts were made. Approximately 50 per cent of this group were absentee farmers and the other 50 per cent did not possess sufficient farm records. This procedure was deemed inadequate. Other activities considered were the

Table 2. Some characteristics of selected soil types in western Kansas.

Soil type	Description*			Soil, slope	Subsoil permeability	Erosion
	General	Surface	Subsoil			
Colby	Deep, light colored, friable, loess soil, with limy surface	Light grayish brown, silt loam	Light grayish brown, silt loam	Level to undulating upland	Moderate	Wind, water severe on steep slopes
Dalhart	Deep, brown, friable, aeolian sand	Brown, fine sandy loam	Brown, sandy clay loam	Nearly level to gently sloping upland	Moderate	Wind, highly susceptible
Hastings-like	Deep, moderately light colored, friable, loess soil	Light grayish brown, silt loam	Light grayish brown, silty clay loam	Level to gently undulating upland	Moderately slow	Wind, water moderate
Keith	Deep, moderately light colored, friable, loess soil	Grayish brown, silt loam	Grayish brown, silty clay loam	Nearly level to gently rolling upland	Moderate	Wind, water moderate
Richfield	Deep, moderately dark colored, moderately friable, loess soil	Dark grayish brown, silt loam	Brown, heavy silty clay loam	Nearly level upland	Moderately slow	Wind, water slight

Table 2 continued.

Table 2 (concl.)

Soil type	Description*			Soil, slope	Subsoil permeability	Erosion
	General	Surface	Subsoil			
Ulysses	Deep, moderately dark colored, friable, loess soil	Dark grayish brown, silt loam	Brown, friable silty clay loam	Nearly level to gently undulating upland	Moderate to rapid	Wind, water moderate
Vona	Deep, brown, friable, aeolian sand	Brown, fine sandy loam	Light yellowish brown, fine sandy loam	Undulating upland	Rapid	Wind, highly susceptible

*Dry color.

Source: National Cooperative Soil Survey Series Description, USDA, Kansas Agricultural Experiment Station.

Table 3. Some area characteristics and percentage of Keith, Ulysses, Colby, Richfield, Hastings-like, Dalhart and Vona soil types in Logan, Hamilton, Ford and Stevens counties in western, Kansas.

Item	Logan	Hamilton	Ford	Stevens
Total acres[a]	686,720	634,880	693,120	466,560
Cropland acres[b]	353,619	442,078	510,210	375,310
Grassland acres[b]	318,046	177,760	155,000	78,951
Other[b]	15,055	15,042	27,900	11,899
Number of farms[a]	345	406	1,146	436
Soil types (in per cent)[c]				
Keith	17			
Ulysses	68		5	
Colby	15	45		
Richfield		45		15
Hastings-like			80	
Dalhart				40
Vona				17
Others[d]		10	15	28

[a]Census

[b]Soil Conservation Service

[c]Expressed as per cent of total acres except in Logan County, which represents per cent of cropland.

[d]May include some of the above soils which were not considered dominant for the county.

Source: 1. Kansas, Counties and State Economic Areas, 1954 Census of Agriculture, U. S. Dept. of Commerce, Bureau of the Census, Washington, 1956.
2. Soil Conservation Service in Logan, Hamilton, Ford and Stevens counties.

Farm Management Association, Veteran's On-farm Training Classes, Agricultural Stabilization and Conservation Office, and the USDA crop reporters. These too, failed to provide sufficient data. The township assessors were then contacted and because of their acquaintance with farmers in the district were able to provide names of two to four farmers who had records and who were willing to cooperate. Most of the 49 cases submitted from Logan County were individuals mentioned by the assessors.

The county SCS personnel expressed the feeling that crop yields taken from records and weight tickets were satisfactory. There is a possibility where an individual farmer, with several quarters may be in error as to yields derived from different fields. When records were not available and the farmer gave yields from memory, it was felt that only the past two or three years should be used and that the reliability would be from 75 to 100 per cent.

Individuals collecting data in the other counties encountered similar problems. The main obstacle was locating farmers who had kept records for several years. Only one case was discovered where an individual had started and maintained his yield records from 1926. Several farmers have yield data from 1947 through 1956, but the majority were only two to three years. This failure to locate yield records was only part of the problem. Due to changes in the ownership

and/or operators, many cases were found where the present operator had records but had only farmed the particular field for a short time. These two factors which limited the data obtained for this study, also suggest that a purely random sample of a small number would not provide sufficient data.

The county SCS personnel began sampling December 1, 1956 and the data obtained was collected on April 1, 1957. Approximately 125 cases were received with an average of about eight individual yields and three summer fallowed periods. Most of these yields were from 1952 to 1956 inclusive. An example of one of the completed forms received is shown in Exhibit C. The yields were then tabulated into the form shown in Table 4. Although approximately 1,000 separate yield items were obtained, the number per soil per crop per year is rather small. Yields were obtained from both continuous and summer fallowed wheat and milo for most of the soil types. From observation of arrayed data only two rotations had sufficient yields for a five year period to justify statistical analyses. The two observations are summer fallowed wheat on Keith, Richfield, Ulysses and Hastings-like soil types and continuous milo on Dalhart and Vona, (Tables 5 and 6). Although the Colby soil type was included in the study, sufficient yields were not obtained to make a comparison.

Exhibit C. Sample of a completed form received from county SCS personnel.

County: Logan PRACTICE AND YIELD REPORT Soil Type: Ulysses

Farm Operator: x x x x x x x x Address: x x x x x x x x

x x x x x x x x x x x x x x
Legal Description of Field

320
Size of Field

2 P - 31
Photo Number

Item	1954	1953	1952	1951	1950
Crop Planted	wheat	wheat	wheat		wheat
Acres Planted	120	160	60		160
Acres Harvested	120	160	60		160
Production - total or per acre	12[SF]	17[SF]	30[a]		12[SF]
Crop Planted	milo			milo	
Acres Planted	160 40			183	
Acres Harvested	160 40			183	
Production - total or per acre	12.5[C] 33[SF]			62[b]	
Misc. Crops - Acres			100	100	30
Summer Fallow - Acres		160	160	37	130
Terraced Yes -(No)					
Crop Damage: Kind					Hail - wheat
Crop Damage: Extent					65%

Indicate any pertinent comments on back of this card
"a" 37 ac SF "b" 130 ac SF
23 ac C 53 ac C

Table 4. Sample of yield data for wheat on fallow from Richfield soil type, 1930-1956.

	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956
Hamilton County average Kansas State Board of Agriculture	13	20	10	6	5	2	5	3	8	5	7	11	22	17	17	30	10	25	22	12	9	10	22	7	6	11	
Tribune Experiment Station Variety Test	40	22	0	0	8	0	0	3	27	17	10	30	26	49	0	48	18	58	68	0	24	0.0[a]	23	17	9	29	0
Test plots on farms, Kansas State College Agronomy Department Hamilton Co.									0	0		54	40	34	27	0.0[a]	34	40 0 28	50	19 12 0	20	21 14	32 33	34			
Farmer's yields collected by SCS Hamilton County									12	12	30			52	43	40 39 36 36 39 25 26	40 34 29 35 36 32 32 29	30 7 16 20	40 6 13 12	9	10 5 17 10 9 13 11	33 30 30 33 32 30 29 30 29 27 26 23	8 16 19 19 7 16 13 9 8 3	14 14 11 11 11 18 5	28 20 20 22 14 14 16 17 18 16	7 0 0 6 12 13 4 6 7 2
Farmer's yields collected by SCS Stevens County																		18	24 20 21	12	3 10 12	9 12	14 12				

[a]Hail

Table 5. Average annual yields per acre seeded (bushels) for wheat on fallow for Keith, Ulysses, Richfield and Hastings-like soil types in western Kansas, computed from yields of farmers, 1952-1956, and their statistical analysis.

Year	Keith Logan Co.		Ulysses Logan Co.		Richfield Hamilton & Stevens Co.		Hastings-like Ford Co.	
	Acres	Unweighted[a] mean	Acres	Unweighted[a] mean	Acres	Unweighted[a] mean	Acres	Unweighted[a] mean
1952	1,000	22.1	512	28.2	2,860	29.3	462	29.3
1953	1,331	11.7	567	9.6	2,300	10.3	293	8.7
1954	1,598	10.6	584	9.4	1,820	11.5	1,052	13.6
1955	2,174	12.6	353	11.2	1,946	15.7	609	10.6
1956	2,256	8.8	831	9.5	1,417	3.4	600	14.1

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Soil types	3	12.10	4.03	.47 (n.s.)
Years	4	902.61	225.65	26.53**
Interaction	12	110.92	9.24	1.09 (n.s.)
Error	162		8.51	

**Significant at .01 level of probability.

[a]No significant correlation was found between the acreage and the yield per acre, so all analyses were conducted on a yield per acre basis.

Table 6. Average annual yields per acre seeded (bushels) for milo on continuous cropping for Dalhart and Vona soil types in western Kansas, computed from yields of farmers, 1952-1956, and their statistical analysis.

Year	Dalhart Stevens Co.		Vona Stevens Co.	
	Acres	Unweighted[a] means	Acres	Unweighted[a] means
1952	1,666	14.7	2,086	8.5
1953	1,636	18.4	2,614	13.8
1954	1,906	23.3	2,969	20.1
1955	1,764	19.3	2,799	17.6
1956	1,569	4.4	2,869	7.3

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Soil types	1	16.69	16.69	5.00*
Years	4	305.87	76.47	22.92**
Interaction	4	23.90	5.98	1.79 (n.s.)
Error	130		3.34	

* Significant at .05 level of probability.

**Significant at .01 level of probability.

[a]No significant correlation was found between the acreage and the yield per acre, so all analyses were conducted on a yield per acre basis.

Yield Data from Other Sources

The period of years to be observed in this study is from 1930 to 1956, as was previously mentioned. It was recognized that yields from farmers would not be adequate for a period of this length. Additional data to supplement the farmers' yields were necessary. Other sources were experimental test plots on individual farms, off-site investigations by the experiment stations, experiment station results and the Kansas State Board of Agriculture county yield estimates. An example of yields from these sources is shown in Table 4, along with farmers' data. By referring to Fig. 1, the experiment stations as shown are Colby, Garden City, Tribune, Kansas and Dalhart, Texas, and the Dodge City Kansas Experiment Field. These stations are not located in the counties in which yield data from the farmers were obtained. A transition to these other localities was made to continue this study. The Keith soil type observed in Logan County is found at the Colby station, the Richfield in Hamilton County at the Tribune station, the Ulysses in Logan County at the Garden City station, the Hastings-like in Ford County at the Dodge City field and the Dalhart in Stevens County at Dalhart station, Texas. The experiment station located at Goodwill, Oklahoma is closer to the area of study than Dalhart, Texas, but the soils found there are of a finer texture and the data are not applicable to the Dalhart soil type.

The data obtained from these other non-farm sources have certain limitations. The variety plots located on individual farms were not repeated yearly on all the soil types. In most cases, reference was made only to the county and the farmer with no accompanying legal description. The off-site investigations of sandy textured soils conducted by the Garden City Experiment Station have been in operation only a few years. Yields reported by Kansas State Board of Agriculture are county averages and are not separated according to soil types. The experiment stations were the only applicable sources of data for the study, and the following procedure was adopted.

Comparison are made of the soil types, Keith, Ulysses, Richfield and Hastings-like by using the variety test plot results of the four Kansas stations and field. The Dodge City field was not established until 1938 which limits this comparison to a period of 1939 to 1956. Yields from Commanche wheat on one year fallow were used for the entire period at all locations, to eliminate the possibility that the observed yield differences were the result of variety rather than soil, (Table 7). For milo, the Colby variety was used and only during the period of 1943 to 1950 was the same variety grown at all the stations, (Table 8). To observe a longer period it was necessary to use yields which were from different varieties, (Table 9). Westland yields were observed at Garden City, Tribune, and Dodge City with Colby and Midland at the

Table 7. Yield per acre (bushels) of wheat on fallow for Keith, Ulysses, Richfield, and Hastings-like soil types in western Kansas, 1939-1956, and their statistical analysis.[1]

Year	Keith (Colby station)	Ulysses (Garden City station)	Richfield (Tribune station)	Hastings-like (Dodge City field)
1939	0.0	12.0	16.7	25.4
1940	0.0	10.6	10.2	27.2
1941	37.5	32.6	30.1	41.1
1942	49.3	14.3	25.0	27.7
1943	51.4	31.3	49.3	13.0
1944	54.3	40.3	0.0	27.7
1945	63.5	34.1	47.7	39.2
1946	39.4	23.1	17.5	35.9
1947	32.4	38.9	57.9	24.7
1948	31.7	37.0	67.9	23.1
1949	0.0[a]	35.9	0.0	29.6
1950	37.9	13.0	23.8	13.8
1951	0.0[b]	0.0	0.0[a]	00.0
1952	40.0	28.1	23.0	50.4
1953	0.0	0.0	17.4	8.6
1954	13.7	2.9	9.3	22.3
1955	31.9	35.1	28.9	13.0
1956	8.6	24.3	0.0	14.6
Mean	27.3	23.0	23.6	24.3

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Soils	3	199.65	66.55	.36 (n.s.)
Years	17	11,786.54	693.33	3.79**
Error	51	9,326.06	182.86	

**Significant at .01 level of probability.

[a]Hail

[b]Winter killed.

Source: 1. Unpublished annual reports, 1939-1956, Colby Experiment Station, Garden City Experiment Station, Tribune Experiment Station and Dodge City Experiment Field.

Table 8. Yield per acre (bushels) of milo on fallow for Keith, Ulysses, Richfield, and Hastings-like soil types in western Kansas, 1943-1950, and their statistical analysis.[1]

Year	Keith (Colby station)	Ulysses (Garden City station)	Richfield (Tribune station)	Hastings-like (Dodge City field)
1943	21.7	50.2	10.3	24.4
1944	33.9	60.5	25.3	40.5
1945	15.4	40.2	12.6	28.2
1946	0.0[a]	28.0	20.2[b]	10.7
1947	0.0[a]	36.9	46.2	32.9
1948	37.1	23.1	44.9	28.8
1949	48.7	33.1	38.9	35.0
1950	24.1	10.5	22.1	48.8
Mean	22.6	35.3	27.6	31.2

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Soils	3	698.28	232.76	1.17 (n.s.)
Years	7	1,922.49	274.64	1.39 (n.s.)
Error	21	4,161.05	198.14	

[a] Too wet.

[b] Interpolated

Source: 1. Unpublished annual reports, 1943-1950, Colby Experiment Station, Garden City Experiment Station, Tribune Experiment Station and Dodge City Experiment Field.

Table 9. Yield per acre (bushels) of milo on fallow for Keith, Ulysses, Richfield and Hastings-like soil types in western Kansas, 1943-1956, and their statistical analysis.[1]

Year	Keith (Colby station)	Ulysses (Garden City station)	Richfield (Tribune station)	Hastings-like (Dodge City field)
1943	21.7	30.9	8.4	20.9
1944	33.9	68.9	33.7	50.2
1945	15.4	45.5	4.2	31.7
1946	0.0[a]	13.8	0.0[b]	16.8
1947	0.0[a]	32.3	42.0	27.3
1948	37.1	54.1	53.9	21.5
1949	30.5	52.8	34.9	51.1
1950	22.5	34.4	8.4	62.8
1951	22.4	51.2	0.0[c]	38.5
1952	40.1	12.5	28.9	22.9
1953	42.0	16.8	23.4	27.7
1954	27.2	24.8	27.3	20.9[b]
1955	28.2	17.8	0.0	27.0
1956	5.0	28.0	0.0	9.2
Mean	23.3	34.6	18.9	30.6

Least significant difference 10.33

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Soils	3	2,083.99	694.66	3.81*
Years	13	6,567.82	505.22	2.77**
Error	39	7,111.81	182.35	

*Significant at .05 level of probability.
**Significant at .01 level of probability.

[a]Too wet.

[b]Interpolated.

[c]Hail.

Source: 1. Unpublished annual reports, 1943-1956, Colby Experiment Station, Garden City Experiment Station, Tribune Experiment Station and Dodge City Experiment Field.

Colby station. This raises the question whether yield differences were due to variety or soil type.

As was mentioned previously, the only yields available for the Dalhart soil were those from the station at Dalhart, Texas. The USDA had conducted experiments on dryland crop-rotations and tillage methods at three of the stations, Dalhart, Colby and Garden City. The project was started in the early 1900's and ran through 1950. The source of data available from the Dalhart station was printed in 1940 and gave yields up to and including 1938.[1] The period of years to be observed in this study are from 1930 to 1956 inclusive. Only eight years could have been compared with this limitation, therefore it was necessary to extend the period an additional 15 years to a starting date of 1915. Comparison of the soil types at these three stations is limited to milo, because it was the only crop grown at the Dalhart station, (Tables 10 and 11.)

Table 12 gives the wheat yields on fallow at the Colby and Garden City stations. Yields from experiment stations for the Colby and Vona soil types could not be found.

From the arrayed date of yields reported by farmers two types of rotations were predominate, wheat on fallow for the Keith and Ulysses soil types and continuous milo on the Dalhart

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[1] R. O. Mathews and B. F. Barnes, Dry Land Crops at the Dalhart (Texas) Field Station, United States Department of Agriculture Circular No. 56, Washington, D. C., November, 1940.

Table 10. Yield per acre (bushels) of milo on fallow for Keith, Ulysses and Dalhart soil types in western, Kansas, 1921-1938 and their statistical analysis.[1]

Year	Keith (Colby station)	Ulysses (Garden City station)	Dalhart (Dalhart field station)
1921	48.0	52.4	34.5
1922	38.0	34.8	35.5
1923	67.1	39.1	46.7
1924	39.5	69.7	27.8
1925	24.7	40.3	49.1
1926	0.0	20.7	43.6
1927	13.4	34.5	42.1
1928	19.7	70.2	64.5
1929	21.6	47.2	76.4
1930	42.5	22.8	49.1
1931	49.4	67.2	42.4
1932	55.3	34.7	28.1
1933	28.5	29.7	0.0
1934	0.0	0.0	3.3
1935	0.0	0.0	34.5
1936	0.0	1.3	4.0
1937	0.0	0.0	29.8
1938	13.7	0.0	4.8
Mean	25.6	31.4	34.2

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Soils	2	690.29	345.14	1.34 (n.s.)
Years	17	16,836.13	990.36	3.85**
Error	34	8,743.02	257.15	

**Significant at .01 level of probability.

Source: 1. Dryland crop-rotation and tillage experiments at the Colby (Kansas) Branch Experiment Station, U. S. Department of Agriculture in cooperation with the Kansas Agricultural Experiment Station Circular No. 979, pp. 84-85. June 1956.

Dryland crops at the Dalhart (Texas) Field Station, U. S. Department of Agriculture Circular No. 564, pp. 54-56, November 1940.

Unpublished data, Garden City Experiment Station, Garden City, Kansas.

Table 11. Yield per acre (bushels) of milo on continuous cropping for Keith, Ulysses, and Dalhart soil types in western Kansas, 1915-1938, and their statistical analysis.[1]

Years	Keith (Colby station)	Ulysses (Garden City station)	Dalhart (Dalhart field station)
1915	12.6	38.2	35.3
1916	0.0	2.7[a]	16.0
1917	3.1	0.0	0.0
1918	9.1	1.6	5.7
1919	28.8	38.9	48.7
1920	20.7	34.0	35.7
1921	15.9	17.4	28.9
1922	12.3	9.8	32.1
1923	44.8	38.8	24.1
1924	6.7	32.9	24.3
1925	1.6	2.6	37.3
1926	0.0	0.0	24.0
1927	7.9	6.0	33.4
1928	11.7	45.2	38.8
1929	1.4	7.2	45.5
1930	27.2	0.0	40.9
1931	14.5	19.0	19.3
1932	0.0	0.0	19.5
1933	2.1	12.4	0.0
1934	0.0	0.0	4.1
1935	0.0	0.0	9.3
1936	0.0	0.0	0.0
1937	0.0	0.0	4.1
1938	7.4	0.0	0.0
Mean	9.5	12.8	22.0

Least significant difference 5.87

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Soils	2	2,003.86	1,001.93	9.835**
Years	23	10,037.99	436.43	4.28**
Error	46	4,685.85	101.87	

**Significant at .01 level of probability.

[a] Interpolated.

Source: 1. Colby Experiment Station, Dalhart Field Station, Garden City Experiment Station, op. cit., (Table 10).

Table 12. Yield per acre (bushels) of wheat on fallowed for Keith, and Ulysses soil types in western Kansas, 1922-1950, and their statistical analysis.[1]

Year	Keith (Colby station)	Ulysses (Garden City station)	Year	Keith (Colby station)	Ulysses (Garden City station)
1922	31.8	0.0	1937	6.5	10.5
1923	1.7	2.8	1938	8.2	1.0
1924	47.5	23.3	1939	5.5	0.0
1925	19.2	18.3	1940	0.0	30.3
1926	9.5	11.5	1941	19.3	26.7
1927	0.5	0.0	1942	16.7	8.3
1928	33.2	0.0[a]	1943	30.8	16.6
1929	13.2	35.5	1944	28.2	30.8
1930	35.3	34.5	1945	44.8	17.3
1931	34.2	33.0	1946	8.3	11.8
1932	35.3	40.3	1947	35.8	44.8
1933	0.0	5.7	1948	28.8	38.5
1934	3.2	4.3	1949	0.0[a]	22.7
1935	0.0	0.0	1950	24.0	3.5
1936	0.0	0.0			
Mean				18.0	16.3

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Soils	1	42.25	42.25	.37 (n.s.)
Years	28	9,434.98	336.96	2.94**
Error	28	3,203.99	114.43	

**Significant at the .01 level of probability.

[a]Hail.

Source: 1. Colby Experiment Station, and Garden City Experiment Station, op. cit., (Table 10).

soil type. A comparison of these three soils by converting quantity (bushels) to gross returns is shown in Table 13. Prices of $2.06 per bushel for wheat and $1.26 per bushel for milo was used to determine the value per acre. These figures were derived by averaging the prices Kansas farmers received for the 5-year period of 1952 to 1956, as given by the Kansas State Board of Agriculture. Table 14 shows the comparison of yields reported by farmers in terms of gross income. Each yield observation was converted to a gross value by using the prices Kansas farmers received for that year. The yields use were wheat on fallow for the Keith, Ulysses, Richfield and Hastings-like soil types and yields from continuous milo for the Dalhart and Vona soil types.

Statistical Tests Used[1]

The data shown in Tables 7 through 13 obtained from variety tests and dry land experiments conducted at the stations and fields represent only one observation per year. To test the hypothesis that the selected soils in this study are the same as to productivity, a statistical technique, the analysis of variance for two-way experiments was used.[2]

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[1]The statistical tests used in this study were suggested and supervised by Stanley Wearden, Assistant Statistician. Calculations used in the tests were computed by the writer, and he assumes the responsibility for accuracy.

[2]George W. Snedecor, Statistical Methods Applied to Experiments in Agriculture and Biology, p. 291-293.

Table 13. Yield per acre (bushels) of wheat on fallowed for Keith and Ulysses, yield per acre (bushels) of milo on continuous cropping for Dalhart and annual gross income per acre for Keith, Ulysses and Dalhart soil types in western Kansas and the statistical analysis for gross returns, 1922-1938.

Year	Keith (Colby station)	Gross income[2]	Ulysses (Garden City station)	Gross income[2]	Dalhart (Dalhart field station)	Gross income[2]
1922	31.8	32.75	0.0	0.00	32.1	40.45
1923	1.7	1.65	2.8	2.88	24.1	30.37
1924	47.5	49.03	23.2	23.90	24.3	30.62
1925	19.2	19.78	18.3	18.95	37.3	47.00
1926	9.5	9.89	11.5	11.95	24.0	30.24
1927	0.5	0.41	0.0	0.00	33.4	42.08
1928	33.2	34.20	0.0[a]	0.00	38.8	48.89
1929	13.2	13.60	35.5	36.67	45.5	57.33
1930	35.3	36.26	34.5	35.43	40.9	51.53
1931	34.2	35.23	33.0	33.99	19.3	24.32
1932	35.3	36.26	40.3	41.61	19.5	24.57
1933	0.0	0.00	5.7	5.77	0.0	0.00
1934	3.2	3.30	4.3	4.53	4.1	5.17
1935	0.0	0.00	0.0	0.00	9.3	11.72
1936	0.0	0.00	0.0	0.00	0.0	0.00
1937	6.5	6.59	10.5	10.71	4.1	5.17
1938	8.2	8.45	1.0	1.03	0.0	0.00
Mean		16.91		13.37		26.44

Least significant difference 8.68

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Soils	2	1,552.21	776.10	5.02*
Years	16	9,437.65	589.85	3.82**
Error	32	4,943.80	154.49	

* Significant at the .05 level of probability.
**Significant at the .01 level of probability.

[a]Hail.

Source: 1. Colby Experiment Station, Dalhart Field Station, Garden City Experiment Station op. cit., (Table 10).
2. Calculated by using prices Kansas farmers received for 5 year period of 1952-1956 from Reports of Kansas State Board of Agriculture.

Table 14. Average yearly returns per crop acre (gross) for wheat from fallow on Keith, Ulysses, Richfield and Hastings-like soil types and for milo from continuous cropping on the Dalhart and Vona soil types and the statistical analysis for gross returns. Computed from yields reported by farmers, 1952-1956.[1]

Years	Keith Logan Co.	Ulysses Logan Co.	Richfield Hamilton Co.	Hastings-like Ford Co.	Dalhart Stevens Co.	Vona Stevens Co.
1952	23.44	29.94	31.03	31.09	21.66	12.50
1953	11.73	9.60	10.30	8.67	23.55	17.71
1954	11.07	9.78	11.96	14.11	29.14	25.10
1955	12.99	11.59	16.14	10.89	22.23	20.24
1956	8.77	9.50	3.44	14.14	5.14	8.43
Mean	16.30	14.08	14.57	15.78	20.34	16.79

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Soil types	5	154.5570	30.9114	3.82**
Years	4	880.7538	220.1884	27.19**
Interaction	20	797.8012	39.8901	4.93**
Error	292		8.0983	

**Significant at .01 level of probability.

[1]Calculated from average yields presented in Tables 5 and 6. Prices received by Kansas farmers for five year period of 1952 to 1956--wheat $2.06 and milo $1.26. Each average yield observation was converted to a gross value by using the prices Kansas farmers received for that year.

The statistical test employed for data in Tables 5, 6, and 14 was the analysis of variance for sample sizes of unequal numbers.[1] The sources of variation in yields are soils, years and discrepancy (error). Implicit in the variation ascribed to "years" are major weather variations.

Interpretations of Statistical Tests

The year to year variation in all observations was large, and in most cases one soil type was not consistently better than another. Rather there was a reversal between soil types, one being the lowest during one period and the highest the next. This interchange of positions among the soil types may have accounted for F-values which were not significant unless the differences between soil types was very large. The F-values derived from the analysis of variance for the yield data in Tables 5 through 14 are applicable only to the periods shown in each table. Had shorter or longer periods been observed in which different climatic conditions were present, then the conclusions reached may not have been the same.

Table 5 - average annual yields per acre seeded for wheat on fallow for Keith, Ulysses, Richfield and Hastings-like soil types in western Kansas, computed from yields of farmers 1952-1956. The analysis of variance for this example

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[1] Ibid., op. cit., p. 33.

resulted in a F-value which was not significant and supported the null hypothesis.

Table 6 - average annual yields per acre seeded for milo on continuous cropping for Dalhart and Vona soil types in western Kansas computed from yields of farmers 1952-1956. A comparison of these soil types resulted in a significant F-test and a rejection of the null hypothesis.

Table 7 - yield per acre of wheat on fallow for Keith, Ulysses, Richfield and Hastings-like soil types in western Kansas, 1939-1956. In the analysis of variance, the resultant F-value was non-significant.

Table 8 - yield per acre of milo on fallow for Keith, Ulysses, Richfield, and Hastings-like soil types in western Kansas 1943-1950. The F-value was non-significant and the null hypothesis was accepted.

Table 9 - yield per acre of milo on fallow for Keith, Ulysses, Richfield and Hastings-like soil types in western Kansas 1943-1956. In this example the null hypothesis was rejected.

Table 10 - yield per acre of milo on fallow for Keith, Ulysses, and Dalhart soil types in western Kansas, 1921-1938. The analysis of variance and the resultant F-value supported the null hypothesis.

Table 11 - yield per acre of milo on continuous cropping for Keith, Ulysses, and Dalhart soil types in western Kansas, 1915-1938. A highly significant difference was derived in this case.

Table 12 - yield per acre of wheat on fallowed for Keith and Ulysses soil types in western Kansas, 1922-1950. In this example no significant difference was observed.

Table 13 - yield per acre of wheat on fallowed for Keith and Ulysses, yield per acre of milo on continuous cropping for Dalhart, and annual gross income per acre for Keith, Ulysses and Dalhart soil types in western Kansas, 1922-1938. The analysis of variance calculated from the gross income figures led to the rejection of the null hypothesis.

Table 14 - average yearly returns per crop acre (gross) for wheat from fallow on Keith, Ulysses, Richfield and Hastings-like soil types and for milo from continuous cropping on the Dalhart and Vona soil types, computed from yields reported by farmers, 1952-1956. The analysis of variance calculated from the gross income figures showed a significant difference between soil types but due to significant interaction one soil type was not the best under all conditions.

In conclusion, three of the above cases were for wheat on fallow and no significant difference resulted in all cases. Five of the cases involved milo on either fallow or continuous, three observations resulted in a significant difference and two did not. These results suggest that a general conclusion about the soil types when milo production is observed cannot be made with these limited data. A comparison of soil types, by converting yields to gross returns, resulted in a rejection

of the null hypothesis in one case and the other case soil types were significant but due to significant interaction one soil type was not the best under all conditions.

Net Income

Having tested the hypothesis that there is no significance difference between soil types in western Kansas, the second part of the problem can be considered; what is the economic productivity? By using the yield data presented in the preceding tables and the cost of production as shown in Tables 19, 20 and 21 in the Appendix, a determination of net income can be made. The average prices received by Kansas farmers for the period of 1952 to 1956 inclusive will again be used (Table 18 in Appendix). The cost of production was estimated by the Soil Conservation Service personnel in the four counties in which the study was conducted. The number and kinds of inputs were based on average climatic conditions and average crops. The input costs as given by the SCS personnel are very similar to the 1955 custom rates for farm operations in western Kansas.[1]

The yields reported by farmers for wheat on fallow for soil types, Keith, Ulysses, Richfield and Hastings-like, were

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[1] C. L. Ahrens, C. F. Bortfeld and J. A. Hodges, 1955 Custom Rates for Farm Operations in Western Kansas, Kansas Agricultural Experiment Station Report No. 74, August, 1956.

used to compute the average annual net income per acre as shown in Table 15. The yields used in the computation are averages per acre seeded, and reflect losses from drought, hail, insects and other factors. The returns were $7.60, $8.08, $9.05 and $10.06 for the soil types Keith, Ulysses, Richfield and Hastings-like respectively, (Table 15). On the Keith soil type in Logan County heavy hail damage occurred during the period 1952-1954. Only one observation showed a net loss for the 5-year period. The average net returns for milo from continuous cropping computed in the same manner was $10.59 for Dalhart soil type and $7.05 for Vona soil type, (Table 15). Negative returns resulted in the year 1956 for both soil types.

The analysis of the yields reported by farmers are only for five years and represent for the most part a dry cycle. Experiment stations yields from variety test plots can be used to obtain a longer average. It is recognized that the value per year should be computed by using prices and cost of production for the year in which the yield was derived. The kind and amount of input going back to the year 1938 would be difficult to obtain. As an alternative, the average yearly prices received by Kansas farmers for the period 1952-1956 will be used. For wheat, this figure is $2.06 per bushel and milo $1.26 per bushel. The cost of input associated with this period are those shown in Tables 19 and 20, Appendix. Using

Table 15. Average yearly returns per crop acre (net) computed from yields of farmers for wheat from fallow on Keith, Ulysses, Richfield, and Hastings-like soil types and for milo from continuous cropping on the Dalhart and Vona soil types in western Kansas, 1952-1956.

Years	Keith Logan Co.	Ulysses Logan Co.	Richfield Hamilton Co.	Hastings-like Ford Co.	Dalhart Stevens Co.	Vona Stevens Co.
1952	$17.44	$23.94	$25.51	$25.37	17.91	2.75
1953	5.73	3.60	4.78	2.95	13.80	7.96
1954	5.07	3.78	6.44	8.39	19.39	15.35
1955	6.99	5.59	10.62	5.17	12.48	10.49
1956	2.77	3.50	- 2.08	8.42	- 4.61	- 1.32
Mean	7.60	8.08	9.05	10.06	10.59	7.05

Source: Computed from data in Tables 5, 6, 18, 19 and 21. Prices received were $2.06 for wheat and $1.26 for milo, for five year period of 1952-1956. Each average yield observation was converted to a gross value by using the prices Kansas farmers received for that year. Net returns were derived by substracting the production cost from the gross value.

these figures the net returns per acre seeded for wheat on fallow and milo on fallow are shown in Tables 16 and 17. For a period of 1938 to 1956, wheat on fallow resulted in a net return of $22.13, $17.66, $18.78 and $19.30 for soil types Keith, Ulysses, Richfield and Hastings-like respectively.

The average net returns from milo on fallow for a similar period 1943 to 1956 showed a much smaller return. For Keith, $7.52, Ulysses, $14.62, Richfield $5.75, and Hastings-like $12.53 were computed from the yields observed by the experiment stations.

In both the above examples several years of zero yields were reported by the experiment stations. The cost of inputs for these years are shown and were substracted from the totals before computing the 14 and 18 year averages. The inputs used include combining and hauling, but no deduction was made for these two items; because no additional charge was made for above average crops and unusual weather conditions. On this basis it was felt that the low and high costs of production associated with below and above average yields would compensate each other.

The yields reported by experiment stations on the average may be larger than those obtained by the average farmer. The kind of measurement which could be used in determining this difference is variable. Individuals who have some knowledge of the situation feel that these experimental yields are from 20 to 35 per cent higher than those obtained by the average

Table 16. Average yearly returns per crop acre (net) computed from yields of experiment stations for wheat from fallow on Keith, Ulysses, Richfield, and Hastings-like soil types, 1939-1956.

Years	Keith Logan Co.	Ulysses Logan Co.	Richfield Hamilton Co.	Hastings-like Ford Co.
1939	$-6.00	$ 6.36	$11.68	$20.44
1940	-6.00	4.92	4.99	22.30
1941	32.62	27.59	25.48	36.61
1942	44.78	8.73	20.23	22.81
1943	46.94	26.24	45.26	7.67
1944	49.93	35.51	-5.52	22.81
1945	59.41	29.12	43.61	34.66
1946	34.58	17.79	12.50	31.26
1947	27.37	34.01	54.12	19.72
1948	26.65	32.11	64.42	18.07
1949	-6.00	30.98	-5.52	24.77
1950	33.04	7.39	18.99	8.50
1951	-6.00	-6.00	-5.52	-5.72
1952	35.20	22.04	18.17	46.19
1953	-6.00	-6.00	12.40	3.14
1954	8.11	-3.01	4.06	17.25
1955	26.86	30.15	24.25	7.67
1956	2.86	19.03	-5.52	9.32
Mean	$22.13	$17.66	$18.78	$19.30

Source: Computed from data in Tables 7, 18, and 19, used average price of $2.06 for wheat and $1.26 for milo.

Table 17. Average yearly returns per crop acre (net) computed from yields of experiment stations for milo from fallow on Keith, Ulysses, Richfield, and Hastings-like soil types, 1943-1956.

Years	Keith Logan Co.	Ulysses Logan Co.	Richfield Hamilton Co.	Hastings-like Ford Co.
1943	$ 6.52	$12.32	$- .91	$ 6.42
1944	14.21	36.26	15.30	24.88
1945	2.55	21.51	-3.55	13.22
1946	-7.15	1.54	-6.20	3.83
1947	-7.15	13.20	20.26	10.45
1948	16.22	26.93	27.76	6.79
1949	12.07	26.11	15.79	25.44
1950	7.03	14.52	- .91	32.81
1951	6.96	25.11	-6.20	17.51
1952	18.11	.73	12.01	7.68
1953	19.31	3.43	8.54	10.70
1954	9.99	8.47	11.00	6.42
1955	10.62	4.06	-6.20	10.26
1956	-4.00	10.49	-6.20	- .95
Mean	7.52	14.62	5.75	12.53

Source: Computed from data in Tables 9, 18, 20 used average price of $1.26 for milo.

farmer. Milo stands are thinned to a desired number of plants and because of this practice, higher yields are normally derived. If this assumption is true, then the average net returns computed from yields of the experiment stations should be adjusted by this amount.

SUMMARY AND CONCLUSIONS

The basic problem was to determine significant differences, if any, between the selected soil types in western Kansas as to physical or economic productivity. The study was conducted in Logan, Hamilton, Stevens and Ford counties. The major soil types of these counties were Keith, Ulysses and Colby, in Logan County; Richfield and Colby in Hamilton County; Dalhart, Vona and Richfield in Stevens County; and Hastings-like in Ford County. The basic data which included soil classification, obtaining yields from farmers and the cost of inputs was performed by the Soil Conservation Service personnel in the four counties. To supplement these data, yields reported by the Colby, Garden City and Tribune Experiment Stations, Dodge City Experiment Field and Dalhart (Texas) Field Station were used. These yields were obtained from variety test plots and the dryland crop-rotation and tillage experiments.

The study included the period of 1930 to 1956, to obtain several climatic cycles. The soil types were compared by using yields derived from wheat and milo on fallow and continuous

cropping, non-irrigated. Wheat on fallow is the primary crop grown on the Keith, Ulysses, Richfield and Hastings-like soil types. Continuous milo is the principle crop for the Dalhart and Vona soils. Yields were converted to gross values so that a comparison of all the soil types could be made. Net income per acre was calculated to derive a value for the return to land and entrepreneur.

The statistical test used was the analysis of variance for two-way experiments and sample sizes of unequal number. For wheat on fallow from Keith, Ulysses, Richfield, and Hastings-like soils and the gross values of crops from these same soils plus Dalhart and Vona, calculated from yields reported by farmers, no significant difference was observed. Farmers' yields for continuous milo from Dalhart and Vona soils and the experiment stations results when computed to gross values showed a significant difference, (P .05). In all cases a significant difference was noted for the years as was expected. Interaction and reversal of high and low yields among the soil types were important factors. Unless there was a large yield difference between soils, which more than offset this interaction, it would be difficult to detect a true difference.

The Colby soil type was dropped from the analysis and the period of 1930 to 1956 was expanded to a beginning date of 1915 because of the limitation of data.

The major obstacle in determining the productivity of land was finding sufficient and reliable yield data. Most of the farmers surveyed in the four counties included in this study had not maintained records of yields and cropping sequences. The reliability of data from any other source than records is questionable if more than two or three years are needed. A random sample due to these limitations, would not provide sufficient data for a study of this nature. To obtain data, it was necessary to locate and collect yieldsfrom those farmers who possess records. This procedure was time consuming and did not result in sufficient yield data to determine the productivity of soils in all cases. This selected group of farmers may have derived higher yields than the average farmer on the same soil type. As a general conclusion data for the determination of productivity of the soil types from records of farmers are inadequate.

The climatic variations associated with this area suggest that from 15 to 20 years of observation should be a minimum. Experiment stations yield data, in most cases, are available for a period of 20 to 35 years and would meet this criterion. However, station results represent only a single location per soil type per year. Yields derived from experimental test plots normally would not be the same as those obtainable from scale of operations of farm size. The cost of input associated with these yields is different than farmers would normally incur. Derivation of production functions would enable the

use of marginal analysis and a determination of the area of production, whether rational or irrational.

The net returns computed from yields of experiment stations and farmers were not analyzed statistically because of the limitation of data. It is recognized that net returns would be advantageous for the comparison of soils, because the cost of input associated with crops and soils types are different. As a general conclusion the net returns to four soil types were about the same when yields of wheat from fallow were observed and were quite different when milo from fallow was observed.

A determination of productivity of the soil types in this area by historical data is not a satisfactory method. As a alternative, yearly yields could be collected and analyzed for each year and for a period of years. Methods for collecting the yield data could be accomplished by one or all the following means. Obtain yield data from well controlled management plots, or obtain yield data from farm account records. Harvest small plots on selected mapping units in farmer's fields or rely on the farmers to send in yield data following harvest. By collecting current yearly data, factors associated with the particular yield could be recorded, such as fertility, rainfall, mechanical and cultural conservation controls, and previous rotations.

The conclusions reached in this study coincide with a similar project, "Methods Used in Evaluating the Productivity of Some Illinois Soils."[1] Data for this study was obtained from detailed production records on approximately 700 farms and yields from 20,000 fields were used. Eight independent variables were used in estimating crop yields, such as temperature, precipitation, fertility, rotation and other factors. Their conclusions were that more yield variation was associated with the weather factors than with all others and that a 10 year period would appear to be a minimum from the standpoint of averaging weather variations.

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[1] R. H. Rust and R. T. Odell, "Methods Used in Evaluating the Productivity of Some Illinois Soils," Soil Science Society of American Proceedings, Volume 21, No. 2, (131-244) March-April, 1957.

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APPENDIX

Table 18. Average yearly prices received by Kansas farmers for wheat and grain sorghums (per bushel) 1952-1956.

Year	Wheat	Milo
1952	$2.13	$1.47
1953	2.01	1.28
1954	2.09	1.25
1955	2.06	1.15
1956	1.99	1.16
Mean	2.06	1.26

Source: Monthly releases of agriculture prices with index numbers, U. S. Department of Agriculture, Agriculture Marketing Service, Kansas State Board of Agriculture, Division of Statistics, Office of the Agricultural Statistician, Topeka, Kansas, 1952-1956.

Table 19. Estimated cost per acre for producing wheat on fallow for Keith, Ulysses, Richfield and Hastings-like soil types in western Kansas.

Input	Keith Logan Co.	Ulysses Logan Co.	Richfield Hamilton Co.	Hastings-like Ford Co.
Oneway			1.00	
Chisel	1.25	1.25	1.00	1.00[b]
Oneway	1.00	1.00	1.00	1.00[c]
Oneway	1.00	1.00	1.00	1.00
Duckfoot	1.00	1.00		
Rod weeder	.75[a]	.75[a]	.75	.75[d]
Rod weeder				.75[d]
Drill	1.00	1.00	1.00	1.00
Seed	1.50	1.50	.80	1.60
Rotary hoe				.50
Combine	3.00	3.00	3.00	3.00
Haul	1.50	1.50	1.50	.85
Total	12.00	12.00	11.05	11.45

[a]Rod weeder or springtooth harrow.

[b]Chisel or oneway.

[c]Oneway or sweeps.

[d]Rodweeder or oneway.

Source: Soil Conservation Service Personnel in Logan, Hamilton and Ford Counties. These estimates based on average climatic conditions and average production. The per acre cost for inputs are comparable to custom rates, as shown in Agricultural Economics Report No. 74, Kansas Agricultural Experiment Station, "1955 Custom Rates for Farm Operations in Western Kansas."

Table 20. Estimated cost per acre for producing milo on fallow for Keith, Ulysses, Richfield and Hastings-like soil types in western Kansas.

Input	Keith Logan Co.	Ulysses Logan Co.	Richfield Hamilton Co.	Hastings-like Ford Co.[b]
Chisel	1.25	1.25	1.00	--
Hoeme sweeps			1.00	--
Oneway	1.00	1.00	.75	--
Listing			1.25	--
Duckfoot	1.00	1.00		--
Duckfoot	1.00	1.00		--
Chisel	1.00[a]	1.00[a]	.75	--
Oneway	1.00	1.00	.75	--
Rodweeder	.75	.75		--
Drill	1.00	1.00	1.00	--
Seed	.40	.40	.10	--
Reseed	1.40	1.40	.55	--
Weed control			.75	--
Combine	3.00	3.00	3.00	--
Haul	1.50	1.50	1.50	--
Total	14.30	14.30	12.40	13.50

[a]Chisel (shovel type).

[b]Estimated by writer.

Source: Soil Conservation Service Personnel in Logan and Hamilton Counties: op. cit., Table 15.

Table 21. Estimated cost per acre for producing milo on continuous cropping for Keith and Vona soil types in western Kansas.

Input	Dalhart Stevens Co.	Vona Stevens Co.
Chisel	1.00	1.00
Oneway	1.00	1.00
List	1.25	1.25
Knife	.75	.75
Harrow or throw-in	.75	.75
Seed	.15	.15
Reseed	.75	.75
Combine	3.00	3.00
Haul	1.10	1.10
Total	9.75	9.75

Source: Soil Conservation Service Personnel in Stevens County, op. cit., Table 15.

A STUDY OF THE PRODUCTIVITY OF SELECTED SOILS IN WESTERN KANSAS

by

JOHN FRANCIS FRITSCHEN

B. S., Kansas State College
of Agriculture and Applied Science, 1950

AN ABSTRACT OF A THESIS

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requirements for the degree

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Department of Economics and Sociology

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1957

The determination of the productivity of soils in western Kansas and the sources and reliability of yield data was studied. A knowledge of the productivity of the land is needed to analyze and evaluate activities or programs. The productivity of soil types could be used in the correlation of soil fertility tests and crop yield responses, the economic classification and evaluation of land, the planning of soil, water and plant conservation measures and other uses.

The period of study was 1930 to 1956 which included the dry cycles of the middle 30's and 50's and the wet cycle of the 40's. The Soil Conservation Service was interested in the same general problem and provided the basic information. Their contribution consisted of aiding in the organization of the survey, mapping the soils, locating farmers who possessed records, collecting yields from these farmers, and recording the results for use in the study.

Four counties in which the major soil types of western Kansas are found were selected for the area of study. These counties were Logan, Hamilton, Stevens and Ford. The predominate soils are Keith, Colby, Ulysses, in Logan County; Richfield and Colby in Hamilton County; Dalhart, Vona and Richfield in Stevens County; and Hastings-like in Ford County. These soils were compared by using yields from wheat and milo on fallow and continuous cropping, non-irrigated. Wheat on fallow is the primary crop grown on the Keith, Ulysses,

Richfield and Hastings-like soil types. Continuous milo is the principle crop for the Dalhart and Vona soils.

Yield data were collected from farmers in the four counties and from the experiment stations and fields located in western Kansas and at Dalhart, Texas. The yield data obtained from the experiment stations were variety test and dryland crop-rotation and tillage experiments.

The analysis of the productivity of soil types was made by comparing physical returns(bushels) and gross returns. To compare soils on which different crops were grown, yields were converted to value or gross. The statistical test used was the analysis of variance for two-way experiments and sample sizes of unequal numbers. Interaction and reversal of high and low yields among the soil types were important factors. Unless there was a large yield difference between soils, which more than offset this interaction, it would be difficult to detect a true difference among soil types.

Ten comparisons were made of the soil types by using crop yields from wheat and milo on fallow and continuous. Three of these cases were for wheat on fallow and no significant differences among soil types were shown. Five of the cases involved milo on either fallow or continuous. Three of these observations resulted in a significant difference and two did not. A general conclusion about the soil types when milo production is observed cannot be made with the data

available. A comparison of soil types, by converting yields to gross returns, resulted in a rejection of the null hypothesis in one case and in the other case soil types were significant but due to significant interaction one soil type was not the best under all conditions.

The major obstacle in determining the productivity of land was finding sufficient and reliable yield data. Most of the farmers surveyed in the four counties included in this study had not maintained records of yields and cropping sequences. Experiment station data are available for a period of 20 to 35 years. However, the station results represent only a single location per soil type per year. Yields derived from experimental test plots normally would not be the same on those obtainable from a scale of operation of farm size.

Yield variations were associated more with weather factors than with all other factors, consequently a period of 15 to 20 years would be needed from the standpoint of averaging weather variations. A similar conclusion was reached by Rust and Odell in Illinois.[1]

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[1]R. H. Rust and R. T. Odell, "Methods Used in Evaluating the Productivity of Some Illinois Soils," Soil Science Society of American Proceedings, Volume 21, No. 2, (131-244) March-April 1957.