# ASSESSING PRODUCTIVITY OF KANSAS SOILS

by

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# INTRODUCTION

Soil scientists in many states estimate crop productivity values for soils found within their borders. These values can be used to help farmers maximize their production and profit. Extansion personnel utilize yield information to assess and recommend management practices, and investors gain a clearer picture of costs and returns by knowing the productivity of soils. Use-value taxation, utilized in several states, is more valid if it is based on soil productivity information.

This study was designed to assess the productivity and establish yield figures for the soils of Kansas. This proved to be no easy task. The many factors affecting yields and the rapid changes in production technology make yield estimation difficult. Add to this the lack of yield information on the many soils of the state, and one gains an appreciation for the states which have established productivity estimates.

The study begins by reviewing the various concepts in rating soil productivity and components common to all rating approaches. These components are applied to estimate the productivity of Kansas soils. A study to determine if real estate sale prices are affected by the productivity of soils is also initiated.

The results of the study show differences between soil series yields and trends in crop yields across the state. Factors affecting the sale price of real estate in a four-county area are also discussed.

The potential uses of accurate soil productivity figures in the state are many. The results and conclusions of the study show the process of obtaining productivity ratings for Kansas is not complete, but hopefully set in motion.

# CHAPTER I
# REVIEW OF LITERATURE

## Approaches To Soil Ratings

Many systems have been devised to rate soil productivity. Most systems use selected soil and nonsoil components such as rainfall and temperature. Rating detail varies from a few to a large number of classes and complex indices. Some systems apply to a limited geographical area, others to entire nations.

In general, however, most systems follow one of three approaches. One approach categorizes soils by management limitations or difficulty of placing land into production. A second rates productivity by soil profile physical and/or morphological characteristics. A third major approach uses actual yield information.

These approaches also may be used for special-purpose rating systems. Common examples of special systems are establishing real estate taxes, cattle carrying capacities, or the economic productivity of certain land areas.

## Management Limitations

The first approach, classifying a soil by management limitations, groups soils into different land-use purposes. The most widely used rating system of this type is the Land Capability Class System of the United States Department of Agriculture Soil Conservation Service (S.C.S.) (32).

Eight classes are used, with Class One having no important limitations for sustained production while Class Eight is considered useful only for recreation, wildlife habitat, water supply, or esthetic purposes. Subdivisions of classes two through eight recognize the limiting factors of erosion, excess water, soil limitations or climatic limitation.

The Land Capability System is the rating most often used for farm planning. But, when considered a measure of soil productivity, Smith and Atkinson (53) point out several assumptions in the classification which must be remembered:

1. Capability is assessed under good management practices and not present management.
2. Each class may include different kinds of soils, often requiring different management. This indicates only the management limitations, not the soil's ability to produce.
3. Soils considered suitable for improvement are classified as if they were already improved. Major land reclamation could therefore change a soil class.
4. Physical limitations are considered more than chemical limitations. This is based on the assumption that chemical problems are easier to correct, although either may be the limiting factor on yields.

## Physical Properties

The second approach to rating soils, that of evaluating the profile physical and/or morphological characteristics, has the advantage of attempting to estimate productivity directly. In the 1930's Storie developed the most well-known index of this type to rate California soils (57). With slight modifications the Storie Index has been applied to other areas. The system consists of three factors: a) the character of the soil profile such as texture, structure, and fertility, b) topography, and c) other modifying characteristics such as climate, erosion, stoniness, and salinity problems. The three factors are given a value between 1 and 100 with 100 representing the most favorable or ideal conditions for plant growth. Progressively larger subtractions are made as conditions become less favorable. These three values, when multiplied together, form the final index.

The factors limiting production and the points to be subtracted are at the discretion of the person making the rating, and must vary from area to area. Although this makes the Storie Index somewhat subjective, it has the advantage of alerting managers or buyers to potential problems when a low rating is observed. Very little work has been done, however, to correlate Storie Index values with actual historic yields.

At about the same time Storie was developing his index, Clarke developed an index for rating English soils easily in the field (12). Clarke's index is defined as: Profile value = Texture rating x Depth x Drainage factor. Since that time Clarke has shown that his index correlates well with actual crop yields (13).

To rate soils in Iowa, Fenton collected corn yield estimates for major soil series and interpolated yield figures for less extensive soils (22). The yield figures, modified by eleven yield-affecting factors such as wetness and erosion, form a Corn Suitability Rating. The Corn Suitability Rating ranks soils from 1 to 100, with the value 100 assigned to the most productive soil in the state. Yields for crops other than corn are found by multiplying the corn yield by a percentage factor for each crop.

Walker devised a similar corn yield model in Indiana by assigning corn yields to index soils (Walker, C. F. 1976. A Model to Estimate Corn Yields For Indiana Soils. M.S. Thesis, Purdue Univ. West Lafayette, Ind.). One index soil was chosen for each family texture located in the state. From these base yields, bushel figures were either added to or subtracted for 14 different profile characteristics. This depends on whether the factor was considered better or worse for corn production than the same factor in the base yield soil.

Allgood and Gray (3) developed two models to estimate wheat, grain sorghum and cotton productivity ratings for soils in southwest Oklahoma. For the first model, entitled the Soil-Properties Model, they collected eight laboratory determinations for each soil. These determinations served as independent variables to predict yields collected over ten years on 16 soil series.

Their second model, named the Soil-Classification Model, analyzed the same soils based on finding a "normal soil" for the study area. The normal soil was given a dummy variable value of 0 for 19 diagnostic characteristics as defined in Soil Taxonomy (55). All other soils were compared to the normal soil by a dummy variable 1 representing a particular diagnostic characteristic common to both soils. A 0 value would represent a characteristic of the normal soil not found in the soil being evaluated. Linear regression procedures regressed the dummy variables against the same yields used as dependent variables in the Soil-Properties Model.

Allgood and Gray concluded that either model could be used in predicting yields, but extensive laboratory data must be available for each soil in the Soil-Properties Model.

## Yield Information

The third method of rating productivity involves collecting actual yield information. This is perhaps a more credible approach as results are based on actual historic yields rather than estimation. These systems evaluate actual and not potential yields as do the other approaches.

Several studies of this type have occurred in Kansas. Shortly after World War II Pine collected yields from farmers and personal plots in Geary and Riley Counties to determine physical and economic productivity of the soils (Pine, W. H. 1948. Methods of Classifying Kansas Land According to Economic Productivity. Ph.D. Thesis, Univ. of Minnesota, Minneapolis). Pine showed that yields should be analyzed by management applied, and at least the profile, slope, and erosion of the soil. Lack of data to be analyzed, he further concluded, was the greatest obstacle to land classification in the state.

Ten years later Fritschen and Pine (24) collected wheat and grain sorghum yields from farmers and experiment stations in western Kansas. Fields mapped as at least 75 percent one soil series were included as representative of that series. Yield differences between the six soil series were not significant. Yield variations due to year to year changes in weather and a lack of analytical data were cited for the inability to show series yield differences.

Many Kansas soils have yield figures based on historical yields collected for the S.C.S. county soil surveys (1). These values are based on actual yields from farmers and state experiment stations and fields as well as estimates from farmers, county and state officials. Although beginning with actual yields, the final yield figures for all soils in a county are not solely based on historical yields. Yield estimates are made for soil series for which there are known crop yields and interpolations and extrapolations are made for soils for which no information is available

Yield estimates are made for crops commonly grown on all soils found within the county. In addition to the soil, the estimates consider the effects of climate, erosion and management on yields. In many reports yields for two levels of management are estimated. The first, or average level, assumes management practices in use by the majority of farmers in the county. The second management level requires improved practices applied by only a few of the most efficient managers. Yield estimates are expected averages for a five to ten year period. Index A describes the two management levels (36).

Another example of Kansas yields partially based on actual yield information are those compiled by the North Central Regional Technical Committee 3 on Soil Survey (37). For the years 1954-1963, personnel from the agricultural experiment stations made estimates for the more extensive soil series based on the knowledge of cooperating individuals.

## Special Rating Systems

In the search for equitable assessment of rural land, an increasing number of states is considering use-value taxation. Therefore, many studies have attempted to establish soil-productivity ratings for tax purposes.

The Taylor County, Iowa soil survey was completed in 1946 and Scholtes and Riecken (49) used the soil information for reassessment. The Corn Suitability Ratings for the soils in each 40-acre tract were area-weighted, with a dollar value assigned to each rating. From the tract value calculated by the Corn Suitability Ratings, deductions were made for wetness, gullies, and wasteland.

Since that time, Iowa has built adjustments into the assessment for temperature and precipitation deviations, artificial drainage, flooding, timbered areas, and problems with isolated spots (21). Fifty percent of the assessed value is determined by soil productivity, the remainder by fair market value.

Illinois has collected yield estimates, but applies them differently for assessment (20,39). Each soil's productivity in bushels per acre of corn, soybeans, wheat, and oats is estimated. These estimates, when weighted by the percentage of time each crop is grown on the soil, results in a Soil-Productivity Index.

The Soil-Productivity Index and the percentage of each soil series found in the soil survey are used to calculate an area-weighted Tract-Productivity Index. The Tract-Productivity Index, when compared with the sale price of other tracts with similar index value, form the basis of the assessed value (40).

For Illinois counties lacking complete detailed soil surveys, Eberle devised a method of preparing soil landscape maps relying heavily on visual and stereoscopic interpretations of aerial photographs and a minimum of actual in-the-field mapping (Eberle, W. M. 1973. Soil-Landscape Maps for Farmland Valuation in Woodford County, Illinois. Ph.D. Thesis. Univ. of Illinois, Urbana.). The soil landscape map is less detailed than soil surveys, with up to two soils and two slope classes combined into a single mapping unit. This method required far less time and expense to complete than the standard soil survey, and the values were shown to be highly correlated with actual real estate sales values in the study area.

Minnesota's variety of crops, soils, and soil productivity led Rust and Hanson (47) to convert physical productivity figures into an economic index. This index, called the Crop Equivalent Rating, is based on physical yield estimates for all major crops grown on each soil series. Calculating the percent of time each crop is grown on the series gives a percent land use for crops on all soils.

The percent land use and the current market price for each crop allow the calculation of gross income per acre. Subtracting expenses incurred in producing the crops from the gross income results in a net return per acre for each soil series in the state. The soil with the highest net income per acre is assigned a Crop Equivalent Rating of 100. All other series's net income figures are weighted by this ratio.

South Dakota utilizes an economic index to equate land values where much of the land is in native grass. The estimated yield of grass is multiplied by a percentage of crop production to give all soils a relative economic value of crop production (Westin, F. C. 1977. Report to North Central Regional Technical Committee 3 on Soil Survey. St. Louis, Missouri.).

Timber is another native crop which poses special problems in evaluation. In West Virginia Weitzman and Trimble (63) devised a Forest Land Capability Class System with four classes. The most important soil factor in determining productivity was depth to bedrock. But allowances also had to be made for coarse textures, impeded drainage, and special problems with some soil series.

Soil productivity indices can be calculated for almost any special purpose, limited only by the researcher's imagination. Yahner and Srinivasan (65) fed soil information, including maps and productivity figures for the mapping units, into a computer. Given the location of a farm, the computer retrieves the soil information and calculates an average productivity index for the farm or any field on the farm.

As additional research reveals the increasing importance of soils and knowledge of their productivity, new refinements and approaches to soil productivity ratings are undoubtedly forthcoming.

## Components of Productivity Models

All soil productivity models must allow for factors which have a universal effect on yields, including management, erosion, accuracy of soil mapping, time period, crop varieties, weather, and future yield trends.

### Management

One of the most obvious factors affecting yields is management. Rehm and Sorensen (44) tested the effects of fertilization, row spacing, and plant populations of corn on the yields of soybeans grown the following year. Even soybeans, which are considered generally unresponsive to fertilizers (64), showed yield influences from prior fertilization. Thus proper management not only is important in obtaining optimum short-run yields, but also has a building effect over time.

As discussed earlier, the S.C.S. considers management important enough to make soil yield estimates for two management levels (36). The S.C.S. further has stated that management plays such an important role on soil productivity that one can not define "natural soil productivity" (54). Any measure of soil productivity exists only in a cultural setting with an assumed level of management. A "productive" soil is one which gives good yields of a specific crop or crop sequence in relation to inputs of materials and labor.

Erosion

A factor closely tied to management, and equally as important in the long run, is erosion. Swanson and Maccallum (58) studied the effects of various soil conservation measures on income received from three Illinois soils. The soil loss was calculated for a number of alternative conservation plans and converted to yield reductions. The annual costs and returns for each plan were estimated, and the annual net returns were discounted and summed into a present value of the plan.

Their results showed little economic incentive to establish conservation measures on the three deep loessial soils. Profit maximization would require a minimum of conservation measures but an increased use of fertilizers as soil losses increased over a 50-year period.

Not all soils, however, have permeable subsoils capable of sustaining high yields with additional fertilizer. Odell (38) found that shallow soils in the same area of Illinois were more adversely affected by soil losses than deeper soils.

Iowa research revealed an increasing use of fertilizers would recoup soil losses in some years, but not in others, depending on the weather (19). To maintain high yields, however, heavy fertilization, especially of nitrogen, had to be maintained (18).

In general, the effect of erosional losses on yields depends on the original soil, the weather, use of fertilizers, and time period involved.

## Purity of Soil Mapping

To associate crop yields with soils the purity of the soil mapping units must be defined. The areal percentage of a soil mapping unit for which the estimate is made may vary from 50 to 100 percent (16,45).

Not only does the percent of mapping units vary, but some errors occur in mapping. The S.C.S. claims 85% accuracy in soil survey mapping (54). Some have said that the figure is too low, others, too high. Stephens (56) considered describing an area containing only 85% one soil series as too tolerant of inaccuracy. On the other hand, the late Robert Sloan, superintendent of the Cornbelt Experiment Field for 14 years, stated in a personal interview with me that he could detect no yield differences between the various mapping units of the Grundy series located on the experiment field.

Soils form a continuum, yet a soil scientist is forced to draw a distinct line to separate mapping units (9). Also, soil properties vary within a series (11).

Few fields contain a high percentage of any one soil series. Most researchers therefore accept a low percentage of any one soil series on the fields from which they collect yield information. As the required percentage of one soil series decreases, however, so does the researcher's ability to relate the yields to specific soil properties.

## Weather

The factor with perhaps the greatest effect on yields and certainly the factor over which man has the least control is weather. Rust and Odell (48) showed that weather changes affect corn yields in Illinois more than any other factor. Thompson (59) showed similar results for wheat yields in Kansas, Nebraska, South Dakota, North Dakota, and Oklahoma. Consequently, most crop-yield estimates for soils assume "average" weather (6).

There is growing speculation as to what the term "average" or "normal" weather means. Shapley (51) and others believe that weather in recent years has been abnormally good. Poorer years, they believe, will come soon. Thompson's yield models (59) show recent weather to be better than average, but getting worse. The Central Intelligence Agency (10) noted the possibility of a major climatic change which will decrease yields on many soils.

Regardless of future forecasts, Thompson (60) has shown that year to year variations in weather have a larger effect on soil yield potential than climatic change. Although gaining in popularity in recent years, theories of worsening weather are not fully accepted. Most rating systems ignore future weather theories and consider only past weather patterns to establish yield estimates. One study was completed in 1966 to project yields for soils in nine Missouri River Basin states to the year 2020. The report by almost 100 scientists from nine states made no mention of weather (37).

Many people question that series yields can be used in real estate tax assessment when unusual weather, such as heavy rain or hail, seem to strike some fields more often than others. Soils are formed by five factors, one of which is climate (8). Longtime climate variation produces a different soil which would therefore be mapped differently.

Occurrences of hailstorms in Kansas, for example, can be directly correlated with elevation (23). Hail insurance rates in the state are determined by allowing a weight of 25% to township experience, 25% to county experience, and 50% to elevation. Soil series also vary with distance and elevation.

## Future Yield Trends

The uncertainty of weather makes soil productivity estimates for the future difficult. Illinois's original soil rating system assigned values from 1 to 10 to the state's soil series, with the value 1 representing the most productive soil (52). It soon became apparent that increasing yields on many of the soil series did not fit into the rating system. The rating was revised to range from 1 to 100, with 100 assigned to the most productive soil in the state (62). The new system was "open ended" to include new soil series or to allow for increases in series estimates.

Researchers in Illinois now believe that yields on their soils will continue to increase, with no limiting factors in sight (20). Jensen (30) believes, however, that even if the weather remains favorable for crop growth, the favorable mix of genetics and technology enjoyed in the past soon will hit absolute yield ceilings. The U.S.D.A. cites increased topsoil erosion and constraints in the use of fertilizers, pesticides, energy, and water as potentially decreasing soil productivity (33). These opposing theories make future yield estimation highly speculative.

Time Period

For productivity rating systems based on actual yield information, the length of the past time period must be carefully chosen. The period must reflect the crop varieties, technology, and weather desired.

Rust and Odell (48) estimated yields based on a ten year period, as did the North Central Regional Technical Committee on Soil Survey (37). Most studies consider a ten year period as adequate to obtain stable yield data, although some studies make estimates from as little as three years information (6).

## Crop Varieties

Genetic improvements in crop varieties have contributed to increasing yields on all soil series. Jensen (30) has shown that 49% of wheat yield increases in New York since 1925 have been due to genetic improvements. Buntley and Bell (6) listed crop genetic potential as one of the four major factors influencing yields.

Therefore, most yield models include adoption of new varieties in soil yield estimates, although varietal improvements can be taken out (30,59).

# CHAPTER II
# METHODOLOGY

## Collecting Yield Information

To obtain crop yields from specific soil series in Kansas I asked fieldmen from the Kansas Farm Management Association to find members who would provide yield and soil information. Association members keep records and tend to be the better producers in the state. It was felt that they could therefore provide the best yield information. The limited response from association fieldmen, however, produced only three farms with useable soil and crop yield information.

I then collected both crop yield and soil series information from 16 Kansas Agricultural Experiment Stations and Fields. The yields were taken from annual reports for facilities located at Belleville, Colby, Garden City, Hays, Hesston, Hutchinson, Mankato, Manhattan, Minneola, Newton, Ottawa, Powhattan, Rossville, St. John, Topeka and Tribune.

The experiment station reports are on file with the Kansas Agricultural Experiment Station and the Experiment Field reports are kept by the Agronomy Department, both located at Kansas State University. I collected information for the years 1955 through 1977 on performance and variety trials of all major crops.

To correlate the crop yields with soils, S.C.S. Soil Surveys show soil series for 12 of the 16 locations (2,4,14,17,25,27,28,29,34,46). Franklin, Stafford, and

Thomas Counties, in which are found the East Central Experiment Field, Sandy land Experiment Field, and the Colby Branch Experiment Station, respectively, did not have published soil surveys. Fortunately, the counties are presently being mapped, and the S.C.S. Soil Scientists in charge of mapping the counties graciously mapped the fields and supplied the necessary soil series information.

In addition to the soil information supplied in the Greeley County Soil Survey, a more detailed map of the Tribune Branch Experiment Station can be found in Making the Most of Soil, Water, Climate in West-Central Kansas Through Research at Tribune Branch Experiment Station (26). The map in this publication was used instead of the less detailed county survey.

The Southeast Kansas Branch Experiment Station, with fields located at Mound Valley, Parsons, and Columbus, has no published soil maps. The only yields included in the study from the Southeast fields are those published in Kansas Sorghum Performance Tests (61) on soils known to be Parsons silt loam on the Parsons field.

Likewise, the Mankato field in Jewell County is unmapped, but the soil on the station has been determined to be Crete silt loam.

Locating the other stations' experiment plots on the soil survey maps showed soil series for individual plots. Plots on a soil series border were carefully checked with a grid overlay to determine percentages of each soil series in the plot. When the surface area of a plot did not consist of at least 90 percent of one soil series, the plot was omitted from the study. But experiment plots are so small that only two stations had plots requiring areal measurement. All other plots were clearly either 100 percent one soil series or clearly much less than 90 percent of any one soil series. Table 1 shows the soil series and locations for which information was collected.

I averaged yields for a particular plot and crop using all variety data supplied by the annual report. Since 1955, many tests have been moved and/or changed, leaving gaps in the record. Appendix B contains the yield figures for all crops and locations.

## Separating Series Differences

The first step in analyzing the yields was to determine if differences existed between soil series yields. The location, soil series, year and yield figures were entered on computer cards. Using the General Linear Models Procedure of the Statistical Analysis System (SAS), the F value was calculated for the variables year, soil series, and the year and series together in an analysis of variance procedure.

Crops included in the evaluation were irrigated and non-irrigated wheat, grain sorghum, soybeans, corn, winter barley, and forage sorghum, as well as non-irrigated spring oats and alfalfa and irrigated cornsilage. Crops dropped from the analysis due to small sample size included

TABLE 1

SOILS AND THEIR LOCATIONS

| Soil | Station | County | Slope% |
|---|---|---|---|
| Butler silt loam | North Central | Republic | 0-1 |
| Carwile fine sandy loam | Sandy land | Stafford | 0-1 |
| Cawker silt loam | Fort Hays | Ellis | 0-1 |
| Clark-Ost (complex) | South Central | Reno | 0-1 |
| Crete silty clay loam | Fort Hays | Ellis | 0-1 |
| Crete silt loam | Mankato | Jewell | 0-1 |
| Crete silt loam | Belleville | Republic | 0-1 |
| Eudora silt loam | Ashland | Riley | 0-1 |
| Eudora silt loam | Rossville | Shawnee | 0-1 |
| Eudora silt loam | Topeka | Shawnee | 0-1 |
| Eudora-Kimo (complex) | Topeka | Shawnee | 0-1 |
| Farnum fine sandy loam | Sandy land | Stafford | 0-1 |
| Goessel silty clay loam | Newton | Harvey | 0-1 |
| Grundy silty clay loam | Cornbelt | Brown | 0-1 |
| Harney silt loam | Fort Hays | Ellis | 0-1 |
| Harney silt loam | Southwest | Ford | 0-1 |
| Ivan silt loam | Manhattan | Riley | 1-3 |
| Kahola silt loam | Manhattan | Riley | 0-1 |
| Keith silt loam | Colby | Thomas | 0-1 |
| Keith loam | Garden City | Finney | 0-1 |
| Kenoma silt loam | East Central | Franklin | 1-3 |
| Ladysmith silty clay loam | Newton | Harvey | 0-1 |
| Muir silt loam | Ashland | Riley | 0-1 |
| Naron fine sandy loam | Sandy land | Stafford | 0-1 |
| Parsons silt loam | Parsons | Labette | 0-1 |
| Reading silt loam | Manhattan | Riley | 1-3 |
| Richfield silt loam | Tribune | Greeley | 0-1 |
| Smolan silt loam | Manhattan | Riley | 1-4 |
| Tabler fine sandy loam | Sandy land | Stafford | 0-1 |
| Ulysses silt loam | Colby | Thomas | 0-1 |
| Ulysses silt loam | Tribune | Greeley | 0-1 |
| Ulysses silt loam | Garden City | Finney | 0-1 |
| Ulysses silt loam | Garden City | Finney | 1-3 |

Table 1, Cont.

| Soil | Station | County | Slope% |
|---|---|---|---|
| Ulysses-Colby (complex) | Garden City | Finney | 1-3 |
| Ulysses-Richfield (complex) | Garden City | Finney | Leveled |
| Ulysses-Richfield (complex) | Garden City | Finney | 0-1 |
| Woodson silt loam | East Central | Franklin | 0-1 |
| Wymore silty clay loam | Manhattan | Riley | 1-4 |

irrigated spring oats, winter oats, spring barley, rye, alfalfa, and sugarbeets as well as non-irrigated winter oats, spring oats, rye and cornsilage.

This analysis showed differences between series yields for non-irrigated wheat, grain sorghum, winter barley, and soybeans. Winter barley was dropped from further analysis because of small sample size and its lack of popularity in the state.

Using the General Linear Models Procedure to calculate the least squares means matrix of the series yields showed which series yields differed for the three remaining crops. Another method that illustrated series yield differences consisted of subtracting the yields for each year on one soil series from the same year's yields on all other series. Running a one-way analysis of variance test on the differences illustrated the diversity in series yields.

In an attempt to separate the effect of soil on yields from the effects of other factors, "problem" yields of wheat and irrigated wheat were removed. Annual reports were consulted to determine if insect, disease or weather problems were encountered during the production of any wheat yields that appeared by visual examination to be much lower than other yields in the series. These problem yields were compared with other non-affected plots and if a difference occurred the observation was dropped from the analysis. Appendix C lists the yields which were removed.

To separate other yield-affecting factors from the effect of soils, predicted wheat yields from a model developed by Dr. Arlin M. Feyerherm were used. Dr. Feyerherm's model estimates wheat yields for the U. S. using fertilization, varietal improvement, cropping patterns, temperature, and rainfall as independent variables.

I subtracted my observed yields from Dr. Feyerherm's predicted yields for each year from 1956 through 1974. Differences were calculated for soil series located at Mankato, Garden City, Colby, Hutchinson, and for two series at Hays. A one-way analysis of variance test on the differences showed series yield differences due primarily to soils.

## Yield Trends

The yield data I collected revealed that yields were increasing over time. Both linear and curvilinear regression equations were fitted against non-irrigated wheat, grain sorghum, and soybean yields to evaluate the trends. The Stepwise Regression Procedure of SAS was used to determine the curvilinear model with the highest $R^2$. These procedures also were run on individual series yields.

The Kansas Crop and Livestock Reporting Service collects wheat and grain sorghum yields on a county and statewide basis (31). I compared their statewide trends in farmers' yields with the yields from the experiment stations for 1955 through 1977.

Since crops other than non-irrigated wheat, grain sorghum, soybeans and winter barley showed no significant differences between soil series yields, only statewide trends were evaluated. Both linear and curvilinear models were fitted against their yields.

## Real Estate Sales Analysis

Many factors influence the price paid for agricultural land. One factor may be the productivity of soils in the sale tracts. To test this theory, rural real estate sales were analyzed for Riley, Geary, Morris and Chase Counties for 1975 and 1976.

Most of the information on the sale tracts was collected by local individuals (Kansas Society of Farm Managers and Rural Appraisers Farmland Sales Project. 1975 and 1976. Department of Agricultural Economics, Kansas State University, Manhattan.). Information for each tract included the legal description, date of sale, total acres in the tract, sale price per acre, improvements, miles to town, cropland acres, and type of road bordering the tract. Only verified sales were included in the analysis. A verified sale is one for which there is reasonable proof of sale and not reported from hearsay.

From the legal description of the sale, the tract was located in a soil survey (5,15,29,36). In some cases the soil survey provided information missing in the sales project's records, making the sale useable for analysis. In all cases the soil survey provided information on the soil series found in the sale tract.

The area of each soil mapping unit was measured on each sale tract with a planimeter. This enabled the percent of each mapping unit to be calculated.

The county soil survey reports contain yield estimates for crops commonly grown on soil mapping units found within the county. The reports for the four counties in the study area unfortunately were published at different times. The Morris County report contains yield estimates for 1969, Riley County for 1968, Chase County for 1967, and Geary County for 1958. As yields have been increasing since those years, the yields were projected to 1975 in order to be relative to each other.

The yields I collected from the experiment station trials have increased an average of 1.2 bushels per acre per year for non-irrigated wheat and grain sorghum. Yields from the county soil surveys were raised by 1.2 bushels per acre per year for each year from the date of estimation to 1975.

Some soil mapping units occurred in more than one county, so small differences arose in the 1975 yield estimates for those units. The majority of differences were one or two bushels, with the largest difference being four bushels per acre. When differences occurred, the average of the 1975 projected yields from all counties containing the mapping unit was taken, resulting in one yield figure being used for each mapping unit for all counties.

A few mapping units found on the sale tracts have no yield estimates in the soil survey reports as estimates are given for soil series on which crops are commonly grown. Many of the sale tracts contained mapping units in native grass which usually are not cultivated.

The mapping units without crop production figures have values which must be accounted for in the analysis. Data were taken from Cash Farm Rental Rates in Kansas (42) to arrive at productivity figures for all mapping units. This publication gives the average cash rent per acre for cropland and for pasture or grazing land for each year and crop reporting district.

Cash rent for grassland was 68% of cash rent for cropland in the East Central Crop Reporting District in 1975. This percentage of the average crop yields for the available mapping units gave values of 31 bushels per acre for wheat and 47 bushels per acre for grain sorghum on the remaining uncultivated mapping units. A list of the mapping units and their estimated yields can be found in Appendix D.

The Capability Class Units from the soil survey also were area-weighted for each sale tract by the percent of each mapping unit in the tract.

The multiple linear regression option of SAS analyzed the following model:

$$Y = \beta_0 + \beta_1 X_{10} + \beta_2 X_{20} + \beta_3 X_{21} + \beta_4 X_{30} + \beta_5 X_{40} + \beta_6 X_{50} + \beta_7 X_{51} + \beta_8 X_{60} + \beta_9 X_{70} + \beta_{10} X_{71} + \beta_{11} X_{72} + \beta_{12} X_{80} + \beta_{13} X_{90} + \beta_{14} X_{91} + E$$

Where

$Y$ = Sale price per acre

$X_{10}$ = Total acres in sale tract

$X_{20}$ = Full improvements

$X_{21}$ = Partial improvements

$X_{30}$ = Miles to town

$X_{40}$ = Bordering hardsurface road

$X_{50}$ = Wheat yield estimate

$X_{51}$ = Grain sorghum yield estimate

$X_{60}$ = Year sold

$X_{70}$ = Geary County tract

$X_{71}$ = Morris County tract

$X_{72}$ = Chase County tract

$X_{80}$ = Percent cropland

$X_{90}$ = Capability Class Four

$X_{91}$ = Capability Class Five

$\beta$ = The parameters of the model

$E$ = Random error term

Real Estate Model Variables

The improvements were described in the Society's records as either unimproved, partly improved, or fully improved. Multicollinearity was avoided by including only two of the three variables in the model. Dummy variables with values 0 or 1 represented full and partial improvements, respectively, while a zero for both full and partial indicated an unimproved tract.

Three classifications of roads were used; dirt, gravel, and hardsurface. Since too few tracts contained dirt roads to make a valid comparison, all sale tracts with dirt roads were not analyzed. Multicollinearity was avoided by including only one dummy variable representing the relationship of hardsurface to gravel roads.

The date of sale was represented by a dummy variable indicating a 1975 or 1976 purchase. Dummy variables also represented the counties with Riley County excluded for comparison.

Few tracts contained soils averaging Capability Class One, Two, Six, Seven, and Eight, so only Classes Three, Four, and Five were analyzed. Variables representing Classes Four and Five were included for a comparison with Class Three.

The percent cropland was determined by dividing the cultivated acres by the total acres in the tract, and multiplying by 100 to obtain percentage.

# CHAPTER III
# RESULTS AND DISCUSSION

## Data Collection

State Experiment Stations and Fields proved to be the best source of crop yield information. The facilities have annual reports which provide accurate yield information for each year's operation. Another advantage of using experiment station yields as opposed to farmers' yields is the consistently high level of management applied at all experiment stations and fields. All stations and fields are assumed to operate under the top or B level of management as defined by the S.C.S. in Appendix A. This proved a great advantage over farmers' yields which would have required an assessment of the management applied by each operator.

The 90% area figure was chosen to obtain yields from fields consisting predominantly of one soil series. Any plot which had less than 90% of any one soil series was not included in the analysis. This percentage is much higher than most studies require. I felt this purity was needed, however, as most soil series were located at only one experiment facility. The single location therefore would represent the series for the entire state.

Choosing the 90% figure assured that at least 77% of each plot was one soil series even if the S.C.S. mapping was off the full 15% and the plot percentage off the full 10%. In actuality the plots were much higher than 77% one soil series. Most plots were clearly 100% one soil series or much less than 90% any one series. For plots that were close to the 90% proportion, a grid overlay was used to find the percentage of each soil series. The plots which required the most areal measurement were located in the irrigated borders at Colby and on the dryland field at Tribune. Determining the proportion of soils in these plots was aided by obtaining soil maps for the stations which were in greater detail than the county survey maps for which the S.C.S. claims 85% accuracy. The Tribune map is found in an experiment station bulletin (26) and the map of the Colby Station was made by the S.C.S. soil scientists mapping Thomas County but was more detailed with a scale of 7.5 inches to the mile.

I collected yields from only variety and performance trials in order to be consistent with farmers' fields and yields from other stations. Stations grow registered seed and have many other experiments, but only variety and performance tests were consistent between stations. Also, variety and performance tests consisted of varieties grown, or soon to be grown, by farmers in the area. Test yields increased due to varietal improvement as the varieties changed from year to year.

Ten years is considered the maximum time period necessary to observe yield trends in most studies. Ted Walter, agronomist in charge of variety testing at

Kansas State University, stated in a personal interview that few varietal and technological improvements in grain sorghum production have occurred since 1955. Since then there have been continual but gradual improvements in wheat production. A 23-year period beginning in 1955 was selected for this analysis to utilize the longest time period possible without major breakthroughs in plant breeding or technology. The longer the time period the greater the probability of averaging out the effects of adverse weather, poor management decisions, and other factors on soil yield estimates.

## Yield Differences by Crop

The first step in analyzing the data was to determine which crops showed differences in soil series yields. The General Linear Models Procedure computed a two-way analysis of variance test on statewide yields for each crop. Table 2 shows the crop, total number of observations, and the probabilities of a greater F value for the variables series, year, and series and year together.

Table 2 reveals that the year in which the crop was grown had a non-zero effect on the yield more often than soil series for most crops. Ten crops showed yield differences for the year grown at a 10% significance level. Only four crops showed a difference in soil series, while year and/or series combined to show significant differences for ten series.

TABLE 2

THE EFFECTS OF SOIL SERIES AND YEAR ON CROP YIELDS

| CROP | TOTAL OBSERVATIONS | PROBABILITY OF GREATER F | | |
|---|---|---|---|---|
| | | SERIES | YEAR | MODEL |
| Alfalfa | 34 | 0.20 | 0.61 | 0.46 |
| Spring barley | 34 | 0.25 | 0.12 | 0.14 |
| Winter barley | 73 | 0.01* | 0.00* | 0.00* |
| Irr. winter barley | 27 | 0.85 | 0.59 | 0.53 |
| Corn | 40 | 0.41 | 0.16 | 0.13 |
| Irr. corn | 76 | 0.24 | 0.02* | 0.01* |
| Irr. corn silage | 31 | 0.70 | 0.74 | 0.67 |
| Forage sorghum | 56 | 0.16 | 0.01* | 0.00* |
| Irr. forage sorghum | 28 | 0.16 | 0.02* | 0.03* |
| Grain sorghum | 160 | 0.00* | 0.00* | 0.00* |
| Irr. grain sorghum | 56 | 0.53 | 0.07* | 0.13 |
| Spring oats | 71 | 0.22 | 0.05* | 0.02* |
| Soybeans | 68 | 0.00* | 0.02* | 0.00* |
| Irr. soybeans | 55 | 0.30 | 0.06* | 0.04* |
| Wheat | 174 | 0.00* | 0.00* | 0.00* |
| Irr. wheat | 42 | 0.11 | 0.72 | 0.10* |

*Significant at the 10% level or higher.

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The study's purpose was to determine soil differences. The four crops which showed a series difference were therefore chosen for further analysis. These crops were non-irrigated wheat, grain sorghum, soybeans and winter barley. These four crops also showed highly significant differences for the variable year. Large sample sizes for these crops may have contributed to the model's ability to detect their series yield differ-ences. Other than spring oats and irrigated corn, the four crops had the largest sample sizes in the study.

Perhaps a greater reason for the distinction of these four crops would be their suitability to Kansas's soils and climate. They are therefore the most popular dryland crops in the state, hence more variety and performance tests were made for these crops.

All four of the crops were non-irrigated. Irrigated grain sorghum, soybeans, wheat and winter barley failed to show series differences. When a crop is irrigated, physical limitations to crop yields are less pronounced. Some soil productivity indices rate soils primarily on their ability to supply water to a crop (7). Roy Gwin, Jr., superintendent of the Tribune Branch Experiment Station, stated in a personal interview that series yield differences were observed on the dryland field, but not on the irrigated field.

## Series Yield Differences

Series differences were sought for yields of wheat, soybeans and grain sorghum. Winter barley was dropped from further analysis because of declining popularity among producers in the state (31). Of the 73 winter barley yields, only 12 were grown since 1968.

A least squares means matrix was found by the General Linear Models Procedure to distinguish differences in series's yields of grain sorghum, wheat and soybeans. Table 3 contains the least-squares means and their standard errors for grain sorghum.

TABLE 3

GRAIN SORGHUM LEAST-SQUARES MEANS

| SERIES | LEAST-SQUARES MEAN | STANDARD ERROR OF THE MEAN |
|---|---|---|
| Woodson | 104.2 | 15.9 |
| Grundy | 93.8 | 5.3 |
| Parsons | 78.8 | 7.0 |
| Farnum | 66.5 | 13.1 |
| Crete (Mankato) | 65.9 | 7.0 |
| Crete (Belleville) | 60.2 | 6.1 |
| Ladysmith | 59.3 | 22.3 |
| Kenoma | 58.8 | 22.4 |
| Keith (Colby) | 57.1 | 4.5 |
| Clark-Ost | 56.3 | 4.5 |
| Ulysses (Garden City) | 56.2 | 9.2 |
| Harney (Minneola) | 50.9 | 4.5 |
| Harney (Hays) | 50.2 | 6.1 |
| Keith (Garden City) | 48.1 | 9.1 |
| Crete (Hays) | 47.4 | 8.5 |
| Richfield | 36.4 | 15.8 |
| Carwile | 29.9 | 16.1 |

Least-squares means are nearly equal to the arithmetic means of the series yields. The least-squares mean is affected more by exceptionally high or low yields because the differences are squared. Therefore, least-squares means tend to be slightly lower than arithmetic means because years with exceptionally low yields are encountered more often than are years with exceptionally high yields.

Table 4 gives the probability of the least-squares mean on one series grain sorghum yields equaling the least-squares mean of other series. This information is arranged in order of highest yield in Graph 1. The graph shows that the majority of grain sorghum yield differences occurred between the series located in the northern and eastern portions of the state and series located elsewhere. The two most productive series were located at Ottawa and Powhattan and differed from all but three other series. The lowest yielding series was found on the St. John field and failed to differ from 10 of the 16 other series.

One reason many of the series showed no yield differences may be the small sample sizes collected from many of the series. All of the soils' least squares mean standard errors greater than eight had sample sizes equal to or less than ten. Only series with at least six observations appear in Graph 1.

A similar procedure was completed for soybeans. Table 5 contains each soil series, its least-squares mean and the standard error of the least-squares mean. All series met the 10% significance level and were included in Table 6 which shows the probability of the least-squares mean of one series equaling the means of the other series. Graph 2 contains this information for series having at least six observations.

As with grain sorghum, the higher yielding series were located in the northern and eastern sections of the state and had larger sample sizes. Kenoma, Ladysmith and Tabler contained the smallest sample sizes and

TABLE 4

SERIES DIFFERENCE PROBABILITIES FOR GRAIN SORGHUM

The probability of a greater t value in testing if the least-squares mean of one series equals the mean of another series.

| | Crete (Belleville) | Carwile | Keith (Colby) | Clark-Ost | Farnum | Keith (Garden City) |
|---|---|---|---|---|---|---|
| Crete (Belleville) | . | | | | | |
| Carwile | 0.081* | . | | | | |
| Keith (Colby) | 0.684 | 0.106 | . | | | |
| Clark-Ost | 0.616 | 0.116 | 0.906 | . | | |
| Farnum | 0.664 | 0.082* | 0.503 | 0.466 | . | |
| Keith (Garden City) | 0.270 | 0.311 | 0.378 | 0.418 | 0.249 | . |
| Ulysses (Garden City) | 0.723 | 0.162 | 0.931 | 0.990 | 0.519 | 0.533 |
| Grundy | 0.000* | 0.000* | 0.000* | 0.000* | 0.055* | 0.000* |
| Crete (Hays) | 0.232 | 0.341 | 0.314 | 0.353 | 0.230 | 0.957 |
| Harney (Hays) | 0.252 | 0.241 | 0.365 | 0.421 | 0.260 | 0.849 |
| Kenoma | 0.954 | 0.299 | 0.940 | 0.913 | 0.771 | 0.659 |
| Ladysmith | 0.969 | 0.290 | 0.924 | 0.897 | 0.783 | 0.644 |
| Harney (Minneola) | 0.225 | 0.211 | 0.334 | 0.393 | 0.262 | 0.784 |

*Significant at 10% level.

Table 4, Cont.

| | Ulysses (Garden City) | Grundy | Crete (Hays) | Harney (Hays) | Kenoma | Ladysmith |
|---|---|---|---|---|---|---|
| Grundy | 0.000* | . | | | | |
| Crete (Hays) | 0.474 | 0.000* | . | | | |
| Harney (Hays) | 0.574 | 0.000* | 0.788 | . | | |
| Kenoma | 0.912 | 0.131 | 0.630 | 0.708 | . | |
| Ladysmith | 0.899 | 0.134 | 0.616 | 0.693 | 0.989 | . |
| Harney (Minneola) | 0.602 | 0.000* | 0.718 | 0.926 | 0.729 | 0.713 |
| Crete (Mankato) | 0.417 | 0.002* | 0.103 | 0.103 | 0.767 | 0.778 |
| Parsons | 0.046* | 0.085* | 0.004* | 0.002* | 0.392 | 0.402 |
| Richfield | 0.281 | 0.001* | 0.528 | 0.412 | 0.414 | 0.403 |
| Woodson | 0.010* | 0.531 | 0.002* | 0.002* | 0.101 | 0.091* |

| | Crete (Belleville) | Carwile | Keith (Colby) | Clark-Ost | Farnum | Keith (Garden City) |
|---|---|---|---|---|---|---|
| Crete (Mankato) | 0.535 | 0.042* | 0.295 | 0.256 | 0.969 | 0.124 |
| Parsons | 0.051* | 0.007* | 0.010* | 0.008* | 0.413 | 0.008* |
| Richfield | 0.164 | 0.776 | 0.209 | 0.226 | 0.148 | 0.518 |
| Woodson | 0.012* | 0.001* | 0.005* | 0.004* | 0.071* | 0.003* |

*Significant at 10% level.

Table 4, Cont.

| | Harney (Minneola) | Crete (Mankato) | Parsons | Richfield |
|---|---|---|---|---|
| Crete (Mankato) | 0.075* | . | | |
| Parsons | 0.001* | 0.204 | . | |
| Richfield | 0.378 | 0.094* | 0.014* | . |
| Woodson | 0.002* | 0.029* | 0.139 | 0.002* |

*Significant at 10% level.

TABLE 5

SOYBEAN LEAST-SQUARES MEANS

| Series | Least-Squares Mean | Standard Error of Mean |
|---|---|---|
| Tabler | 36.8 | 9.3 |
| Grundy | 36.1 | 2.1 |
| Woodson | 32.8 | 2.9 |
| Ladysmith | 28.2 | 9.8 |
| Crete (Belleville) | 22.6 | 2.5 |
| Kenoma | 22.1 | 11.8 |
| Clark-Ost | 16.8 | 3.9 |
| Crete (Mankato) | 14.9 | 3.0 |
| Keith (Colby) | 13.8 | 3.9 |

GRAPH 1
SERIES YIELD DIFFERENCES
FOR GRAIN SORGHUM

A shaded square indicates a significant difference at 10%. For example, Clark-Ost differs from Grundy and from Parsons.

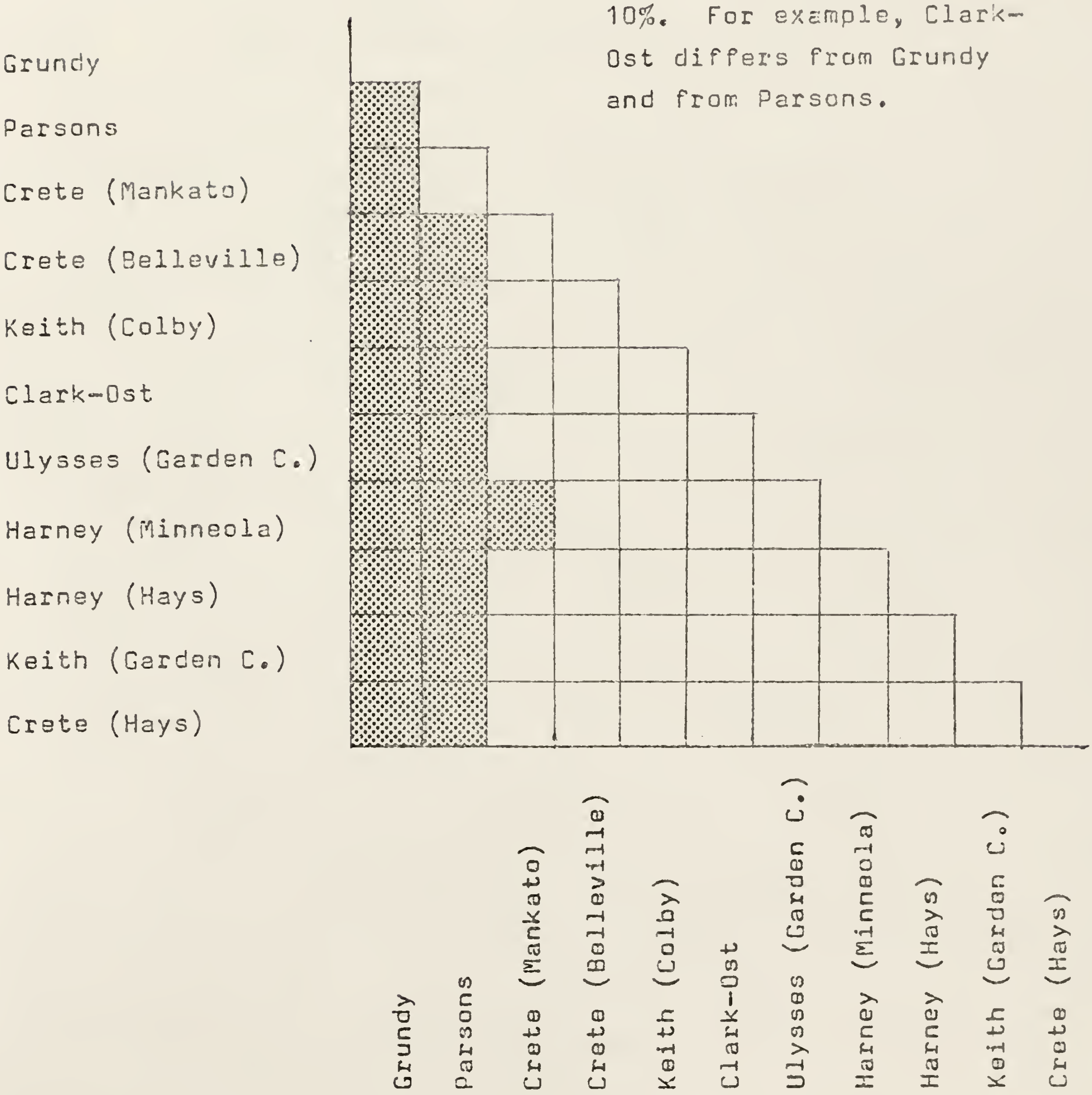


TABLE 6

SERIES DIFFERENCE PROBABILITIES FOR SOYBEANS

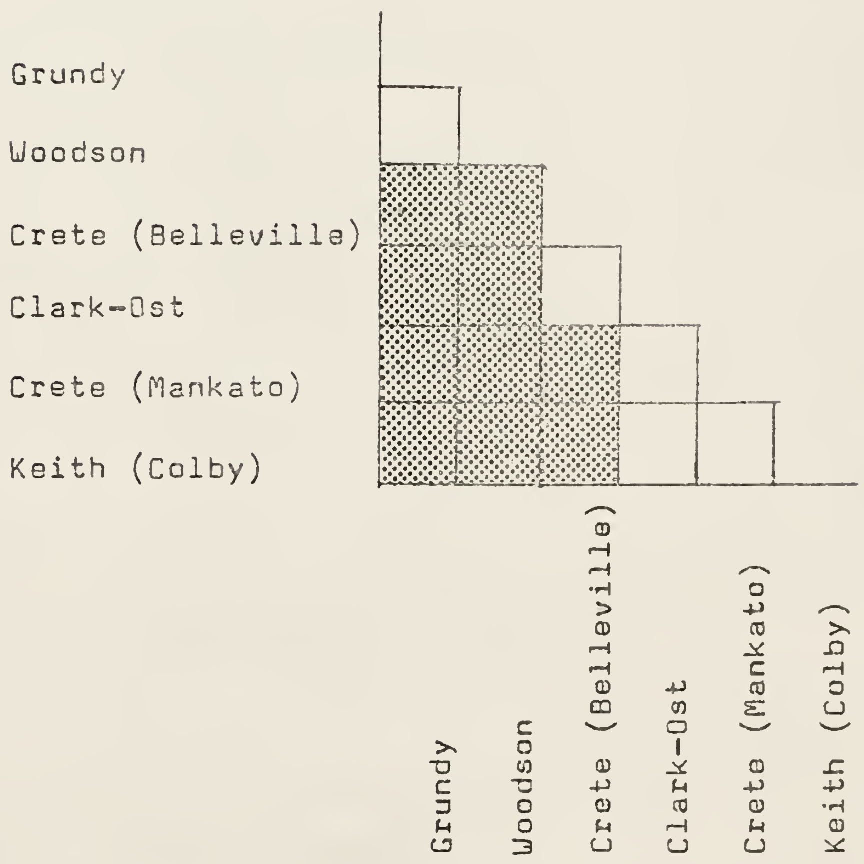
The probability of a greater t value in testing if the least-squares mean of one series equals the mean of another series.

| | Crete (Belleville) | Keith (Colby) | Clark-Ost | Grundy | Kenoma | Lady-smith | Crete (Mankato) | Tabler |
|---|---|---|---|---|---|---|---|---|
| Crete (Belleville) | . | | | | | | | |
| Keith (Colby) | 0.061* | . | | | | | | |
| Clark-Ost | 0.193 | 0.571 | . | | | | | |
| Grundy | 0.000* | 0.000* | 0.000* | . | | | | |
| Kenoma | 0.964 | 0.517 | 0.678 | 0.248 | . | | | |
| Ladysmith | 0.583 | 0.179 | 0.281 | 0.437 | 0.694 | . | | |
| Crete (Mankato) | 0.041* | 0.817 | 0.686 | 0.000* | 0.568 | 0.189 | . | |
| Tabler | 0.144 | 0.028* | 0.046* | 0.937 | 0.340 | 0.528 | 0.028* | . |
| Woodson | 0.007* | 0.000* | 0.001* | 0.372 | 0.395 | 0.652 | 0.000* | 0.676 |

*Significant at 10% level.

GRAPH 2
SERIES YIELD DIFFERENCES
FOR SOYBEANS

A shaded square indicates a significant difference at 10%. For example, the Crete series at Belleville differs from the Grundy, Woodson, Crete at Mankato and Keith at Colby.



therefore the largest standard errors. Most stations growing non-irrigated soybeans are in the northern and eastern portions of the state, so less variation occurred among soybean yields.

Table 7 contains the least squares means information to differentiate series wheat yields. All series met the 10% significance criteria, and appear in Table 8 showing the probability of series yield differences. A simplified form of Table 8 can be found in Graph 3. I excluded the series Cawker, Farnum, Goessel, Kahola, Ladysmith, Wymore and Ulysses because they contained less than six observations. These series also had the highest standard errors, as shown in Table 7.

The higher yielding series for wheat differed from more series than did the lower yielding series. Highest wheat yields also occurred on series located in the northeast portion of the state although the tendency was less noticeable than for grain sorghum.

A second method to determine soil series yield differences is subtracting series yields from each other. Table 9 contains grain sorghum yield differences from the Harney series located at Minneola. The Harney yield was subtracted from yields of other series for the same year, and a one-way analysis of variance was run on the differences. Table 9 also shows the 10% LSD value for each comparison. Only series with a minimum of six observations were included.

TABLE 7

WHEAT LEAST SQUARES MEANS

| Series | Least-Squares Mean | Standard Error of Mean |
|---|---|---|
| Ulysses (Garden City) | 45.5 | 7.2 |
| Grundy | 44.6 | 2.3 |
| Crete (Belleville) | 41.6 | 2.3 |
| Kahola | 39.5 | 10.0 |
| Clark-Ost | 38.3 | 2.1 |
| Keith (Garden City) | 35.0 | 4.1 |
| Wymore | 34.9 | 10.0 |
| Crete (Mankato) | 34.7 | 2.4 |
| Farnum | 33.5 | 5.8 |
| Smolan | 32.9 | 3.8 |
| Woodson | 32.8 | 3.3 |
| Carwile | 31.6 | 3.2 |
| Keith (Colby) | 31.0 | 2.6 |
| Cawker | 30.7 | 10.0 |
| Crete (Hays) | 27.6 | 3.6 |
| Harney (Hays) | 27.0 | 2.6 |
| Harney (Minneola) | 26.8 | 2.1 |
| Goessel | 26.1 | 10.2 |
| Ladysmith | 23.1 | 10.2 |

TABLE 8

SERIES DIFFERENCE PROBABILITIES FOR WHEAT

The probability of a greater t value in testing if the least-squares mean of one series equals the mean of another series.

| | Crete (Belleville) | Carwile | Cawker | Keith (Colby) | Clark-Ost | Farnum | Keith (G. C.) | Ulysses (G. C.) | Goessel |
|---|---|---|---|---|---|---|---|---|---|
| Carwile | 0.010* | . | | | | | | | |
| Cawker | 0.295 | 0.937 | . | | | | | | |
| Keith (Colby) | 0.003* | 0.892 | 0.979 | . | | | | | |
| Clark-Ost | 0.291 | 0.077* | 0.462 | 0.034* | . | | | | |
| Farnum | 0.195 | 0.768 | 0.810 | 0.694 | 0.438 | . | | | |
| Keith (Garden City) | 0.160 | 0.501 | 0.696 | 0.414 | 0.472 | 0.835 | . | | |
| Ulysses (Garden City) | 0.614 | 0.076* | 0.240 | 0.064* | 0.345 | 0.191 | 0.215 | . | |
| Goessel | 0.141 | 0.614 | 0.749 | 0.643 | 0.249 | 0.532 | 0.424 | 0.128 | . |
| Grundy | 0.330 | 0.001* | 0.174 | 0.000* | 0.039* | 0.073* | 0.038* | 0.932 | 0.077* |

*Significant at 10% level.

Table 8, Cont.

| | Crete (Belleville) | Carwile | Cawker | Keith (Colby) | Clark-Ost | Farnum | Keith (G. C.) | Ulysses (G. C.) | Goessel |
|---|---|---|---|---|---|---|---|---|---|
| Crete (Hays) | 0.001* | 0.413 | 0.762 | 0.428 | 0.012* | 0.374 | 0.178 | 0.030* | 0.895 |
| Harney (Hays) | 0.000* | 0.280 | 0.717 | 0.272 | 0.001* | 0.304 | 0.106 | 0.019* | 0.936 |
| Kahola | 0.837 | 0.454 | 0.538 | 0.412 | 0.907 | 0.607 | 0.680 | 0.634 | 0.353 |
| Ladysmith | 0.079* | 0.434 | 0.598 | 0.454 | 0.151 | 0.380 | 0.286 | 0.079* | 0.823 |
| Harney (Minneola) | 0.000* | 0.207 | 0.704 | 0.215 | 0.000* | 0.276 | 0.076* | 0.014* | 0.947 |
| Crete (Mankato) | 0.037* | 0.414 | 0.698 | 0.298 | 0.258 | 0.845 | 0.955 | 0.159 | 0.416 |
| Smolan | 0.052* | 0.794 | 0.840 | 0.684 | 0.210 | 0.925 | 0.702 | 0.130 | 0.539 |
| Woodson | 0.032* | 0.795 | 0.843 | 0.667 | 0.172 | 0.915 | 0.684 | 0.120 | 0.536 |
| Wymore | 0.513 | 0.753 | 0.770 | 0.708 | 0.740 | 0.903 | 0.993 | 0.396 | 0.541 |

*Significant at 10% level.

Table 8, Cont.

| | Grundy | Crete (Hays) | Harney (Hays) | Kahola | Lady-smith | Harney (Minn.) | Crete (Mankato) | Smolan | Woodson |
|---|---|---|---|---|---|---|---|---|---|
| Crete (Hays) | 0.000* | . | | | | | | | |
| Harney (Hays) | 0.000* | 0.896 | . | | | | | | |
| Kahola | 0.608 | 0.264 | 0.227 | . | | | | | |
| Ladysmith | 0.040* | 0.680 | 0.714 | 0.256 | . | | | | |
| Harney (Minneola) | 0.000* | 0.864 | 0.964 | 0.218 | 0.724 | . | | | |
| Crete (Mankato) | 0.002* | 0.099* | 0.031 | 0.643 | 0.274 | 0.012* | . | | |
| Smolan | 0.007* | 0.306 | 0.192 | 0.538 | 0.375 | 0.160 | 0.674 | . | |
| Woodson | 0.004* | 0.260 | 0.158 | 0.524 | 0.371 | 0.134 | 0.642 | 0.990 | . |
| Wymore | 0.336 | 0.484 | 0.443 | 0.746 | 0.413 | 0.430 | 0.987 | 0.850 | 0.842 |

*Significant at 10% level.

GRAPH 3

SERIES YIELD DIFFERENCES FOR WHEAT

A shaded square indicates a difference at 10%. For example, Carwile differs from Grundy, Clark-Ost, and the Crete at Belleville.

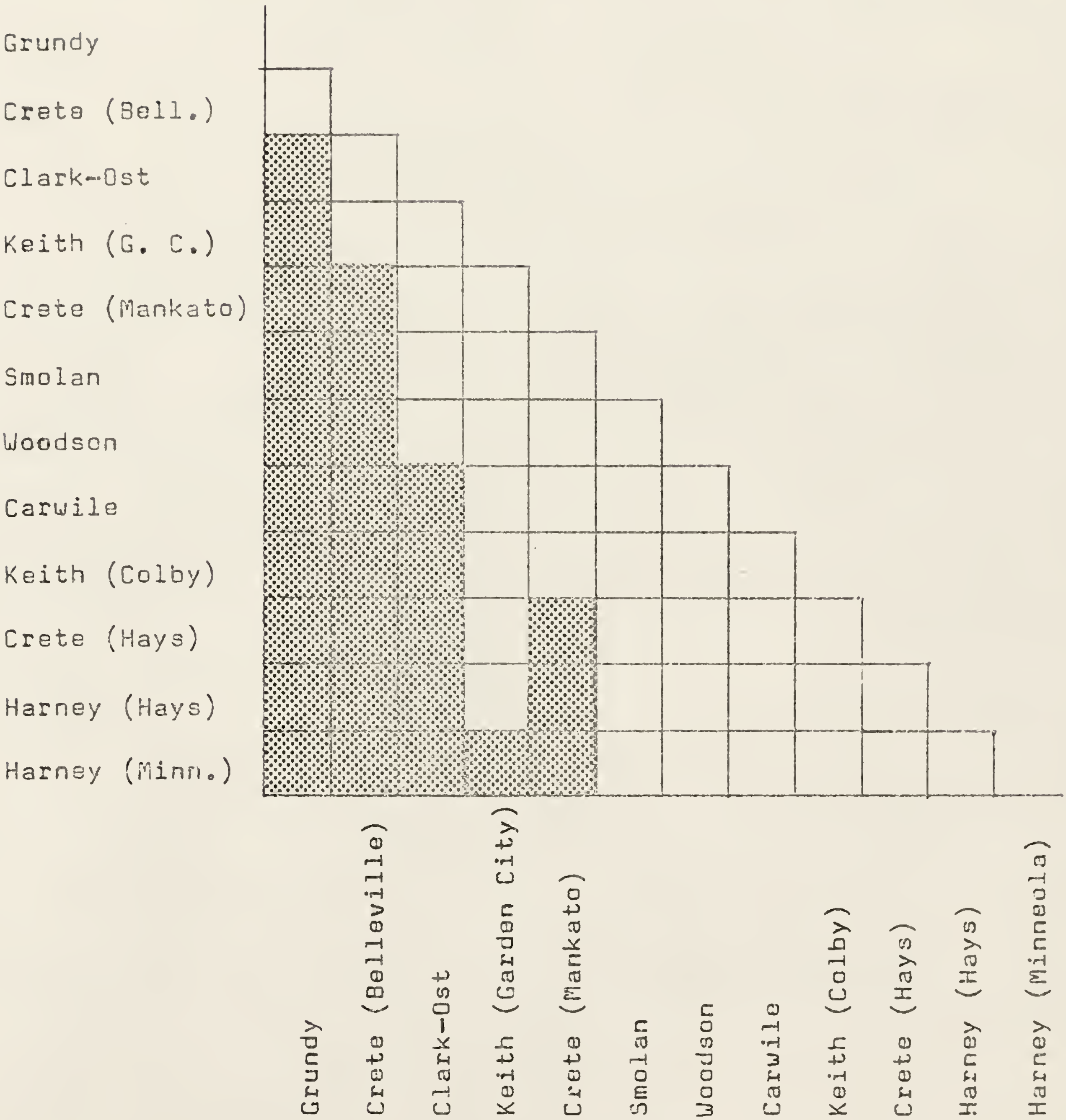


TABLE 9

GRAIN SORGHUM YIELD DIFFERENCES FROM THE HARNEY SERIES AT MINNEOLA

| Series | Mean | | Crete (Hays) | Harney (Minneola) | Ulysses (G. C.) | Harney (Hays) | Keith (G. C.) |
|---|---|---|---|---|---|---|---|
| Grundy | 41.6 | Mean difference | 54.4* | 41.6* | 39.8* | 38.6* | 37.1* |
| | | LSD | 20.4 | 14.7 | 21.6 | 17.1 | 21.6 |
| Parsons | 28.5 | Mean difference | 41.2* | 28.5* | 26.7* | 25.4* | 24.0* |
| | | LSD | 22.4 | 17.3 | 23.4 | 19.4 | 23.4 |
| Crete (Mankato) | 22.8 | Mean difference | 35.5* | 22.8* | 21.0 | 19.7* | 18.3 |
| | | LSD | 22.4 | 17.3 | 23.4 | 19.4 | 23.4 |
| Crete (Belleville) | 11.7 | Mean difference | 24.4* | 11.7 | 9.8 | 8.6 | 7.2 |
| | | LSD | 21.6 | 16.3 | 22.7 | 18.5 | 22.7 |
| Keith (Colby) | 7.8 | Mean difference | 20.6* | 7.8 | 6.0 | 4.8 | 3.4 |
| | | LSD | 19.9 | 14.0 | 21.1 | 16.6 | 21.1 |
| Clark-Ost | 5.5 | Mean difference | 18.2 | 5.5 | 3.6 | 2.3 | 1.0 |
| | | LSD | 19.7 | 13.7 | 20.9 | 16.3 | 20.9 |
| Keith (Garden City) | 4.5 | Mean difference | 17.2 | 4.5 | 2.7 | 1.4 | . |
| | | LSD | 25.3 | 20.9 | 26.2 | 22.7 | |

*Significant at LSD = 10%
Includes the years 1955–1977.

Table 9, Cont.

| Series | Mean | | Clark-Ost | Keith (Colby) | Crete (Bell.) | Crete (Mkt.) | Parsons |
|---|---|---|---|---|---|---|---|
| Grundy | 41.6 | Mean difference | 36.2* | 33.8* | 30.0* | 18.8* | 13.1 |
| | | LSD | 14.7 | 15.0 | 17.1 | 18.1 | 18.1 |
| Parsons | 28.5 | Mean difference | 23.0* | 20.6* | 16.8 | 5.7 | . |
| | | LSD | 17.3 | 17.6 | 19.4 | 20.3 | |
| Crete (Mankato) | 22.8 | Mean difference | 17.3* | 15.0 | 11.1 | . | |
| | | LSD | 17.3 | 17.6 | 19.4 | | |
| Crete (Belleville) | 11.7 | Mean difference | 6.2 | 3.8 | . | | |
| | | LSD | 16.3 | 16.6 | | | |
| Keith (Colby) | 7.8 | Mean difference | 2.4 | . | | | |
| | | LSD | 14.0 | | | | |

*Significant at LSD = 10%

Includes the years 1955–1977.

Table 9, Cont.

| Series | Mean | | Crete (Hays) | Harney (Minn.) | Ulysses (G. C.) |
|---|---|---|---|---|---|
| Harney (Hays) | 3.1 | Mean difference | 15.8 | 3.1 | 1.2 |
| | | LSD | 21.6 | 16.3 | 22.7 |
| Ulysses (Garden City) | 1.8 | Mean difference | 14.5 | 1.8 | . |
| | | LSD | 25.3 | 20.9 | |
| Harney (Minneola) | 0.0 | Mean difference | 12.7 | . | |
| | | LSD | 19.7 | | |
| Crete (Hays) | -12.7 | | | | |

*Significant at LSD = 10%

Includes the years 1955-1977.

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This method differs little statistically from the previous tests, but was run on a sequence of years where the series tested had few missing observations. If, for example, yields for one series were obtained during a period of favorable weather while those of another series were collected from years having abnormally bad weather or disease, a valid comparison of their yield potential is unlikely. Grouping yields from the same years overcomes this problem.

In actuality, few differences arise in the results of the two tests. Table 9 shows three series differences not shown in Graph 1. In Table 10 the Keith soil at Colby is used for base yields. Table 10 and Graph 1 both

TABLE 10

GRAIN SORGHUM YIELD DIFFERENCES FROM THE KEITH SERIES AT COLBY

| Series | Mean | | Crete (Hays) | Harney (Hays) | Harney (Minn.) | Keith (G. C.) | Clark-Ost |
|---|---|---|---|---|---|---|---|
| Grundy | 33.4 | Mean difference | 50.1* | 40.2* | 40.1* | 37.2* | 34.6* |
| | | LSD | 17.5 | 15.2 | 12.8 | 18.5 | 12.8 |
| Parsons | 18.7 | Mean difference | 35.4* | 25.5* | 25.4* | 22.5* | 20.0* |
| | | LSD | 19.1 | 16.9 | 14.9 | 20.0 | 14.9 |
| Crete (Mankato) | 13.7 | Mean difference | 30.4* | 20.5* | 20.4* | 17.5 | 14.9* |
| | | LSD | 19.1 | 16.9 | 14.9 | 20.0 | 14.9 |
| Crete (Belleville) | 7.1 | Mean difference | 23.8* | 13.9 | 13.8* | 10.9 | 8.3 |
| | | LSD | 18.2 | 15.9 | 13.7 | 19.1 | 13.7 |
| Keith (Colby) | 0.0 | Mean difference | 16.7 | 6.8 | 6.7 | 3.8 | 1.2 |
| | | LSD | 16.8 | 14.3 | 11.8 | 17.8 | 11.8 |
| Clark-Ost | -1.2 | Mean difference | 15.5 | 5.6 | 5.5 | 2.6 | . |
| | | LSD | 16.9 | 14.4 | 12.0 | 17.9 | |
| Keith (Garden City) | -3.8 | Mean difference | 12.9 | 3.0 | 2.9 | . | |
| | | LSD | 21.5 | 19.6 | 17.9 | | |

*Significant at LSD = 10%
Includes the years 1955-1977 except 1965.

Table 10, Cont.

| Series | Mean | | Keith (Colby) | Crete (Bell.) | Crete (Mankato) | Parsons |
|---|---|---|---|---|---|---|
| Grundy | 33.4 | Mean difference | 33.4* | 26.3* | 19.7* | 14.7 |
| | | LSD | 12.7 | 14.5 | 15.6 | 15.6 |
| Parsons | 18.7 | Mean difference | 18.7* | 11.6 | 5.0 | . |
| | | LSD | 14.8 | 16.3 | 17.3 | |
| Crete (Mankato) | 13.7 | Mean difference | 13.7 | 6.6 | . | |
| | | LSD | 14.8 | 16.3 | | |
| Crete (Bell.) | 7.1 | Mean difference | 7.1 | . | | |
| | | LSD | 13.5 | | | |

*Significant at LSD = 10%

Includes the years 1955–1977 except 1965.

Table 10, Cont.

| Series | Mean | | Crete (Hays) | Harney (Hays) |
|---|---|---|---|---|
| Harney (Minneola) | -6.7 | Mean difference | 10.0 | 0.1 |
| | | LSD | 16.9 | 14.4 |
| Harney (Hays) | -6.8 | Mean difference | 9.9 | . |
| | | LSD | 18.7 | |
| Crete (Hays) | -16.7 | | | |

*Significant at LSD = 10%

Includes the years 1955-1977 except 1965.

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have 19 differences, although the differences are not all on the same comparisons.

Table 11 and Table 12 show the differences in soybean yields using the Crete soil at Belleville and the Woodson series at Ottawa for base yields. Obtaining series with at least six observations for the period of time considered reduces the data avialable for analysis. Fewer differences appear in Tables 11 and 12 than in Graph 2 as the Keith series was dropped from the two tables.

Differences in wheat yields from the Grundy series at Powhattan and the Harney series located at Minneola are found in Tables 13 and 14. Comparisons between the one-way analysis of variance test and the least squares means test described earlier can be found in Table 15.

TABLE 11

SOYBEAN YIELD DIFFERENCES FROM THE

CRETE SERIES AT BELLEVILLE

| Series | Mean | | Crete (Mankato) | Clark-Ost | Crete (Bell.) | Woodson |
|---|---|---|---|---|---|---|
| Grundy | 13.1 | Mean difference | 19.4* | 18.9* | 13.1* | 3.3 |
| | | LSD | 7.0 | 8.4 | 6.3 | 7.0 |
| Woodson | 9.8 | Mean difference | 16.1* | 15.6* | 9.8* | . |
| | | LSD | 7.2 | 8.6 | 6.6 | |
| Crete (Belleville) | 0.0 | Mean difference | 6.3 | 5.8 | . | |
| | | LSD | 6.6 | 8.0 | | |
| Clark-Ost | -5.8 | Mean difference | 0.5 | . | | |
| | | LSD | 8.6 | | | |
| Crete (Mankato) | -6.3 | | | | | |

*Significant at LSD = 10%

Includes the years 1962-1977 except 1966, 1972 and 1973.

TABLE 12

SOYBEAN YIELD DIFFERENCES
FROM THE WOODSON SERIES

| Series | Mean | | Clark-Ost | Crete (Mankato) | Crete (Bell.) | Grundy |
|---|---|---|---|---|---|---|
| Woodson | 0.0 | Mean difference | 22.0* | 21.0* | 8.3 | 0.3 |
| | | LSD | 11.5 | 10.8 | 9.6 | 9.6 |
| Grundy | -0.3 | Mean difference | 21.7* | 20.7* | 8.0 | . |
| | | LSD | 11.9 | 11.2 | 10.0 | |
| Crete (Belleville) | -8.3 | Mean difference | 13.7* | 12.7* | . | |
| | | LSD | 11.9 | 11.2 | | |
| Crete (Mankato) | -21.0 | Mean difference | 1.0 | . | | |
| | | LSD | 12.9 | | | |
| Clark-Ost | -22.0 | | | | | |

*Significant at LSD = 10%

Includes the years 1966-1977 except 1972.

TABLE 13

WHEAT YIELD DIFFERENCES FROM THE GRUNDY SERIES

| Series | Mean | | Crete (Hays) | Harney (Hays) | Harney (Minn.) | Keith (Colby) | Woodson |
|---|---|---|---|---|---|---|---|
| Grundy | 0.0 | Mean difference | 20.3* | 19.6* | 19.0* | 18.6* | 15.6* |
| | | LSD | 8.5 | 6.8 | 6.0 | 7.1 | 8.1 |
| Crete (Belleville) | -0.9 | Mean difference | 19.4* | 18.7* | 18.1* | 17.7* | 14.6* |
| | | LSD | 8.9 | 7.2 | 6.6 | 7.6 | 8.5 |
| Clark-Ost | -6.6 | Mean difference | 13.7* | 13.0* | 12.4* | 12.0* | 9.0* |
| | | LSD | 8.6 | 6.8 | 6.1 | 7.2 | 8.1 |
| Carwile | -7.4 | Mean difference | 12.9* | 12.1* | 11.6* | 11.2* | 8.1 |
| | | LSD | 10.1 | 8.6 | 8.1 | 8.9 | 9.7 |
| Crete (Mankato) | -8.6 | Mean difference | 11.8* | 11.0* | 10.4* | 10.0* | 7.0 |
| | | LSD | 8.8 | 7.1 | 6.4 | 7.5 | 8.4 |
| Smolan | -11.1 | Mean difference | 9.2 | 8.4 | 7.9 | 7.5 | 4.4 |
| | | LSD | 10.1 | 8.6 | 8.1 | 8.9 | 9.7 |
| Woodson | -15.6 | Mean difference | 4.7 | 4.0 | 3.4 | 3.0 | . |
| | | LSD | 10.1 | 8.6 | 8.1 | 8.9 | |

*Significant at LSD = 10%.
Includes the years 1957-1975 except 1962.

Table 13, Cont.

| Series | Mean | | Smolan | Crete (Mankato) | Carwile | Clark-Ost | Crete (Bell.) |
|---|---|---|---|---|---|---|---|
| Grundy | 0.0 | Mean difference | 11.1* | 8.6* | 7.4 | 6.6* | 0.9 |
| | | LSD | 8.1 | 6.4 | 8.1 | 6.1 | 6.6 |
| Crete (Belleville) | -0.9 | Mean difference | 10.2* | 7.6* | 6.5 | 5.7 | . |
| | | LSD | 8.5 | 7.0 | 8.5 | 6.7 | |
| Clark-Ost | -6.6 | Mean difference | 4.6 | 2.0 | 0.8 | . | |
| | | LSD | 8.1 | 6.5 | 8.1 | | |
| Carwile | -7.4 | Mean difference | 3.7 | 1.1 | . | | |
| | | LSD | 9.7 | 8.4 | | | |
| Crete (Mankato) | -8.6 | Mean difference | 2.5 | . | | | |
| | | LSD | 8.4 | | | | |

*Significant at LSD = 10%

Includes the years 1957-1975 except 1962.

Table 13, Cont.

| Series | Mean | | Crete (Hays) | Harney (Hays) | Harney (Minneola) |
|---|---|---|---|---|---|
| Keith (Colby) | -18.6 | Mean difference | 1.7 | 1.0 | 0.4 |
| | | LSD | 9.4 | 7.8 | 7.1 |
| Harney (Minneola) | -19.0 | Mean difference | 1.3 | 0.6 | . |
| | | LSD | 8.5 | 6.8 | |
| Harney (Hays) | -19.6 | Mean difference | 0.8 | . | |
| | | LSD | 9.0 | | |
| Crete (Hays) | -20.3 | | | | |

*Significant difference at LSD = 10%

Includes the years 1957-1975 except 1962.

TABLE 14

| Series | Mean | | Crete (Hays) | Harney (Minn.) | Carwile | Harney (Hays) | Keith (Colby) |
|---|---|---|---|---|---|---|---|
| Grundy | 17.8 | Mean difference | 20.7* | 17.8* | 15.3* | 14.8* | 14.2* |
| | | LSD | 9.6 | 6.5 | 7.8 | 7.6 | 7.6 |
| Crete (Belleville) | 15.6 | Mean difference | 18.4* | 15.6* | 13.0* | 12.6* | 11.9* |
| | | LSD | 10.0 | 7.1 | 8.3 | 8.1 | 8.1 |
| Clark-Ost | 12.4 | Mean difference | 15.2* | 12.4* | 9.8* | 9.4* | 8.7* |
| | | LSD | 9.5 | 6.3 | 7.6 | 7.4 | 7.4 |
| Woodson | 8.8 | Mean difference | 11.7 | 8.8 | 6.3 | 5.8 | 5.2 |
| | | LSD | 11.9 | 9.5 | 10.4 | 10.3 | 10.3 |
| Crete (Mankato) | 7.4 | Mean difference | 10.2* | 7.4* | 4.9 | 4.4 | 3.7 |
| | | LSD | 9.8 | 6.7 | 7.9 | 7.7 | 7.7 |
| Keith (G. C.) | 5.8 | Mean difference | 8.7 | 5.8 | 3.2 | 2.8 | 2.2 |
| | | LSD | 11.8 | 9.5 | 10.4 | 10.3 | 10.3 |
| Smolan | 5.1 | Mean difference | 7.9 | 5.1 | 2.6 | 2.1 | 1.5 |
| | | LSD | 11.4 | 9.0 | 9.9 | 9.8 | 9.8 |

*Significant at LSD = 10%

Includes the years 1955–1975.

Table 14, Cont.

| Series | Mean | | Smolan | Keith (G. C.) | Crete (Mankato) | Woodson | Clark-Ost |
|---|---|---|---|---|---|---|---|
| Grundy | 17.8 | Mean difference | 12.7* | 12.0* | 10.4* | 9.0 | 5.4 |
| | | LSD | 9.1 | 9.6 | 6.8 | 9.6 | 6.5 |
| Crete (Belleville) | 15.6 | Mean difference | 10.4* | 9.7 | 8.2* | 6.7 | 3.2 |
| | | LSD | 9.5 | 10.0 | 7.4 | 10.0 | 7.1 |
| Clark-Ost | 12.4 | Mean difference | 7.2 | 6.5 | 5.0 | 3.5 | . |
| | | LSD | 9.0 | 9.5 | 6.7 | 9.5 | |
| Woodson | 8.8 | Mean difference | 3.7 | 3.0 | 1.4 | . | |
| | | LSD | 11.4 | 11.9 | 9.8 | | |
| Crete (Mankato) | 7.4 | Mean difference | 2.3 | 1.6 | . | | |
| | | LSD | 9.2 | 9.8 | | | |
| Keith (Garden City) | 5.8 | Mean difference | 0.7 | . | | | |
| | | LSD | 11.4 | | | | |

*Significant at LSD = 10%

Includes the years 1955–1975.

Table 14, Cont.

| Series | Mean | | Crete (Hays) | Harney (Minn.) | Carwile | Harney (Hays) | Crete (Bell.) |
|---|---|---|---|---|---|---|---|
| Keith (Colby) | 3.7 | Mean difference | 6.5 | 3.7 | 1.1 | 0.7 | |
| | | LSD | 10.3 | 7.4 | 8.6 | 8.4 | |
| Harney (Hays) | 3.0 | Mean difference | 5.8 | 3.0 | 0.5 | . | |
| | | LSD | 10.3 | 7.4 | 8.6 | | |
| Carwile | 2.5 | Mean difference | 5.4 | 2.5 | . | | |
| | | LSD | 10.4 | 7.6 | | | |
| Harney (Minneola) | 0.0 | Mean difference | 2.8 | . | | | |
| | | LSD | 9.5 | | | | |
| Grundy | 17.8 | Mean difference | | | | | 2.3 |
| | | LSD | | | | | 7.2 |

*Significant at LSD = 10%

Includes the years 1955–1975.

TABLE 15

NUMBER OF SERIES DIFFERENCES IN TESTS

| Crop | Series | One-Way Analysis Of Variance | Least Squares Means Test |
|---|---|---|---|
| Grain Sorghum | Keith (Colby) | 20 | 19 |
| | Harney (Minneola) | 22 | 19 |
| Wheat | Grundy | 28 | 28 |
| | Harney (Minneola) | 22 | 28 |
| Soybeans | Woodson | 6 | 10 |
| | Crete (Belleville) | 6 | 10 |

In general, fewer differences are found in the one-way test because smaller sample sizes were used, resulting in larger standard errors and fewer differences between series.

In addition to small sample size, other factors may have combined to minimize series yield differences. Variety and performance plots are generally small in size. Therefore disease or adverse weather such as hail would affect the plot yields more than yields obtained from the averaged size farm field.

As stated earlier, comparison of yields from different years may have added variability not due to soils. Assumptions of correct mapping and classification of the small plots and consistent management of the stations also are necessary to differentiate series yields.

## Isolating the Effect of Soil on Yields

The estimated yields from a model developed by Dr. Arlin M. Feyerherm were subtracted from wheat yields on six series to remove effects of varietal improvement, rainfall, temperature, fertilization, cropping patterns, disease, insect and weather problems from the effect of the soil on yields. A one-way analysis of variance was computed for the differences, with the results appearing in Table 16. If Dr. Feyerherm's model removes the effects of the above variables, then the differences noted in Table 16 should be due primarily to the soil.

Several theoretical and practical problems arose in this approach, however. Predicted values were available for the years 1956 through 1974 at the five locations listed in Table 16. Only 45 collected yields met the criteria and were avialable for comparison with the model's predicted yields. Also, under the present concept of soil classification, a soil must be considered _in situ_. Removing the variation in temperature and rainfall, for example, removes part of the differences in the soils themselves (8).

TABLE 16

MODEL TO REMOVE NON-SOIL EFFECTS

| Series | Mean | | Crete (Hays) | Harney (Hays) | Keith (Colby) | Crete (Mankato) | Clark-Ost |
|---|---|---|---|---|---|---|---|
| Keith (Garden City) | 8.2 | Mean difference | 12.2* | 11.1* | 9.7* | 5.9 | 4.3 |
| | | LSD | 9.9 | 8.6 | 8.4 | 10.7 | 7.8 |
| Clark-Ost | 3.9 | Mean difference | 7.9* | 6.8* | 5.4 | 1.6 | • |
| | | LSD | 7.8 | 6.0 | 5.8 | 8.8 | |
| Crete (Mankato) | 2.3 | Mean difference | 6.3 | 5.2 | 4.8 | • | |
| | | LSD | 10.7 | 9.5 | 9.3 | | |
| Keith (Colby) | -1.4 | Mean difference | 1.4 | 2.6 | • | | |
| | | LSD | 8.4 | 6.8 | | | |
| Harney (Hays) | -2.9 | Mean difference | 1.1 | • | | | |
| | | LSD | 8.6 | | | | |
| Crete (Hays) | -4.0 | | | | | | |

*Significant at LSD = 10%

Includes the years 1956-1974..

To avoid these problems, annual reports for all stations were consulted when any yield of wheat or irrigated wheat was observed to be below average for the series. If the reports noted insect, disease or weather problems, the yields were dropped from the analysis. Thirty-three of the 174 observations for non-irrigated wheat showed problems. Deleting those observations raised the mean yield from 35.3 bushels to 38.9 bushels per acre, and the $R^2$ from 0.62 to 0.69. The F value also increased from 6.22 to 6.66.

Removing the problem yields from irrigated wheat yields showed more improvement over the original model. Nine yields were removed from the 42 original irrigated yields. This increased the $R^2$ from 0.65 to 0.80 and the probability of a greater F value from 0.30 to 0.10. The probability of a greater F value for the variable series in the revised model was 0.56, so series differences were still not determined for irrigated wheat. Appendix C lists the yields which were removed from the analysis for wheat and irrigated wheat.

## Increasing Yield Trends

Data from the Kansas Crop and Livestock Reporting Service (35) show that yields have increased during the study period for all major crops in the state. The trends on experiment stations were evaluated by regressing wheat, grain sorghum and soybean yields against time. Graph 4 plots the regression line for non-irrigated

GRAPH 4

REGRESSION OF STATEWIDE

NON-IRRIGATED WHEAT YIELDS

Least-squares equation where Y=yield and X=last two digits of year:

$$Y = -41.53 + 1.16X$$

wheat yields from all locations across the state.

The probability of a greater F value was only 1 in 10,000, but the $R^2$ value was quite low. A low $R^2$ would be expected when obtaining yields from such a wide variety of locations and soils. Yields from each location of each series were regressed against time to measure the trends of individual series. Graph 5 shows the least squares trend line for wheat on the Grundy series.

Regression equations were calculated for all series having a probability of a greater F value of less than 0.10 for the model. These equations and their standard errors appear in Table 17. To test for curvilinear trends in wheat yields the stepwise regression procedure searched for higher $R^2$ values using exponents on the variable year in the model. No curvilinear trends were found as the linear models had higher $R^2$ values for each series and for the state as a whole.

Statewide trends for grain sorghum are illustrated in Graph 6. As the first equation in Table 18 illustrates, a linear equation explains the variation very poorly for statewide grain sorghum yields. Other equations in Table 18 show poor results for grain sorghum yields on individual series as well. Only the two series listed in Table 18 had significant regression equations, both with very low $R^2$ values.

To try to explain more of the variation the stepwise regression technique picked the best variables

GRAPH 5

REGRESSION OF GRUNDY SERIES

NON-IRRIGATED WHEAT YIELDS

Least-squares equation where Y=yield and X=last two digits of year:

Y = -66.76 + 1.71X

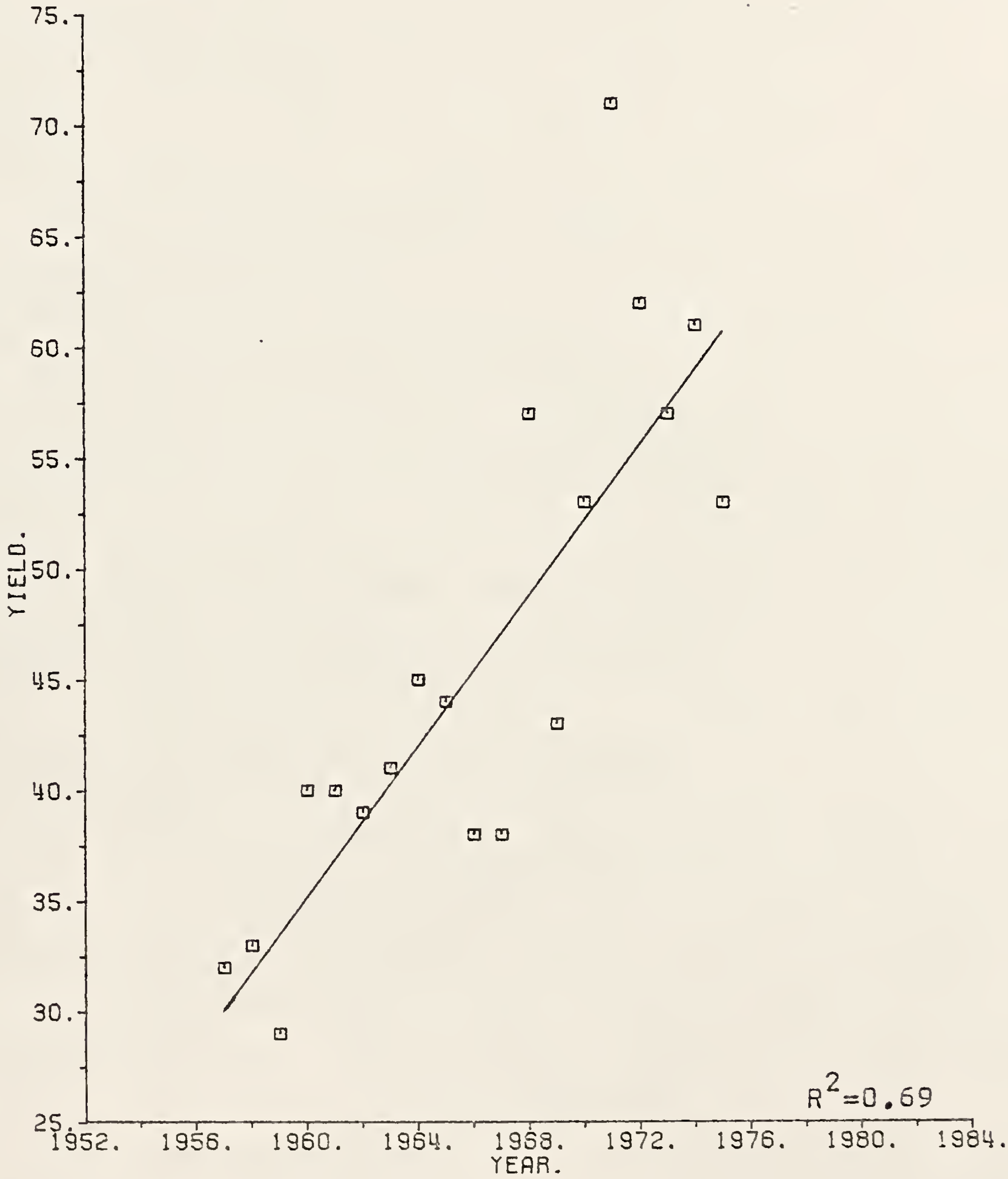

TABLE 17

WHEAT REGRESSION EQUATIONS

Y = Yield in bushels per acre X = Last two digits of year

Statewide

$Y = -41.53 + 1.16X$
9.88 0.15 (Standard Errors)

Probability of a greater F = 0.0001

$R^2$ = 0.26 Observations = 174

Grundy

$Y = -66.76 + 1.71X$
18.91 0.28

Probability of a greater F = 0.0001

$R^2$ = 0.69 Observations = 18

Crete (Mankato)

$Y = -77.50 + 1.75X$
30.39 0.47

Probability of a greater F = 0.0021

$R^2$ = 0.48 Observations = 17

Harney (Minneola)

$Y = -71.23 + 1.50X$
27.80 0.43

Probability of a greater F = 0.0023

$R^2$ = 0.39 Observations = 21

Keith (Colby)

$Y = -86.06 + 1.72X$
37.64 0.56

Probability of a greater F = 0.0092

$R^2$ = 0.45 Observations = 14

Table 17, Cont.

Carwile

$$Y = -111.94 + 2.27X$$
$$\quad 44.17 \quad 0.73$$

Probability of a greater F = 0.0141

$R^2$ = 0.55   Observations = 10

Clark-Ost

$$Y = -26.82 + 0.99X$$
$$\quad 26.12 \quad 0.40$$

Probability of a greater F = 0.0248

$R^2$ = 0.25   Observations = 20

Harney (Hays)

$$Y = -80.14 + 1.60X$$
$$\quad 51.79 \quad 0.73$$

Probability of a greater F = 0.0500

$R^2$ = 0.28   Observations = 14

Crete (Belleville)

$$Y = -15.82 + 0.87X$$
$$\quad 30.28 \quad 0.46$$

Probability of a greater F = 0.0801

$R^2$ = 0.18   Observations = 18

Smolan

$$Y = -95.12 + 1.91X$$
$$\quad 62.22 \quad 0.92$$

Probability of a greater F = 0.0918

$R^2$ = 0.46   Observations = 7

GRAPH 6

REGRESSION OF STATEWIDE
NON-IRRIGATED GRAIN SORGHUM YIELDS

Least-squares equation where Y = Yield and X = last two digits of year:

$Y = -18.60 + 1.19X$

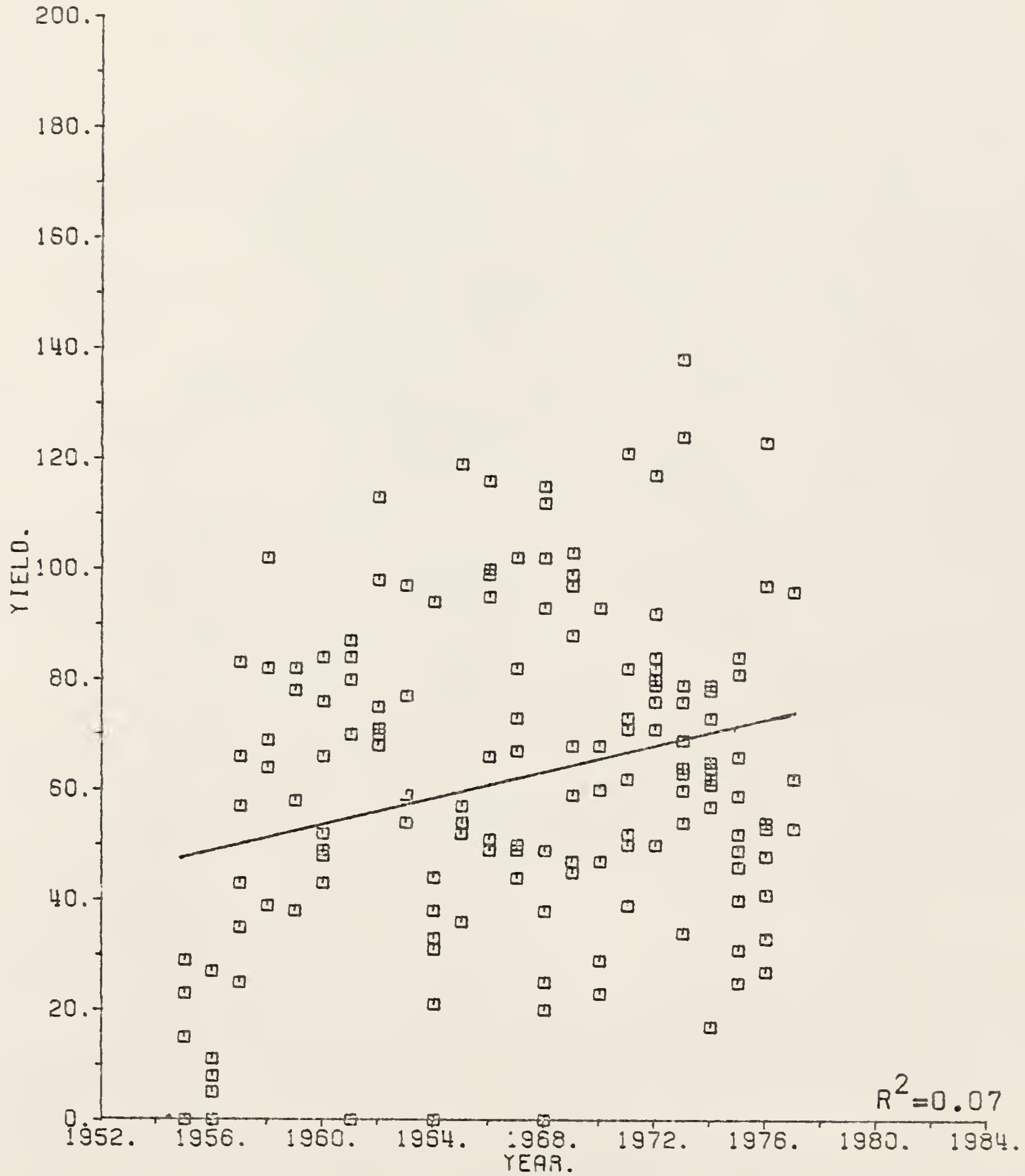

TABLE 18

GRAIN SORGHUM LINEAR REGRESSION EQUATIONS

Y = Yield in bushels per acre    X = Last two digits of year

Statewide

$$Y = -18.60 + 1.19X$$
$$\quad\quad 23.68 \quad 0.35$$

Probability of a greater F = 0.0009

$R^2$ = 0.07    Observations = 160

Keith (Colby)

$$Y = -38.74 + 1.45X$$
$$\quad\quad 40.83 \quad 0.61$$

Probability of a greater F = 0.0286

$R^2$ = 0.22    Observations = 22

Harney (Minneola)

$$Y = -29.47 + 1.22X$$
$$\quad\quad 44.97 \quad 0.68$$

Probability of a greater F = 0.0901

$R^2$ = 0.14    Observations = 22

---

for curvilinear prediction equations. Graph 7 and the first equation in Table 19 show the fit for statewide grain sorghum yields. Although an improvement on the linear model, the equation was useless for prediction. The shaded squares in Graph 7 are yields from the Parsons, Powhattan and Ottawa stations. These stations receive more rainfall than other stations and have the highest grain sorghum yield means, as illustrated in Table 3.

GRAPH 7

CURVILINEAR TREND OF STATEWIDE

GRAIN SORGHUM YIELDS

Least-squares equation where Y = Yield and X = Last two digits of year:

$$Y = -86319.64 + 5184.24X - 116.43X^2 + 1.16X^3 - 4.32\times10^{-3}X^4$$

Equation applies to years 1955–1974.
For 1975–1977, Y = 70.

Shaded squares indicate yields from the Parsons, Powhattan or Ottawa stations.

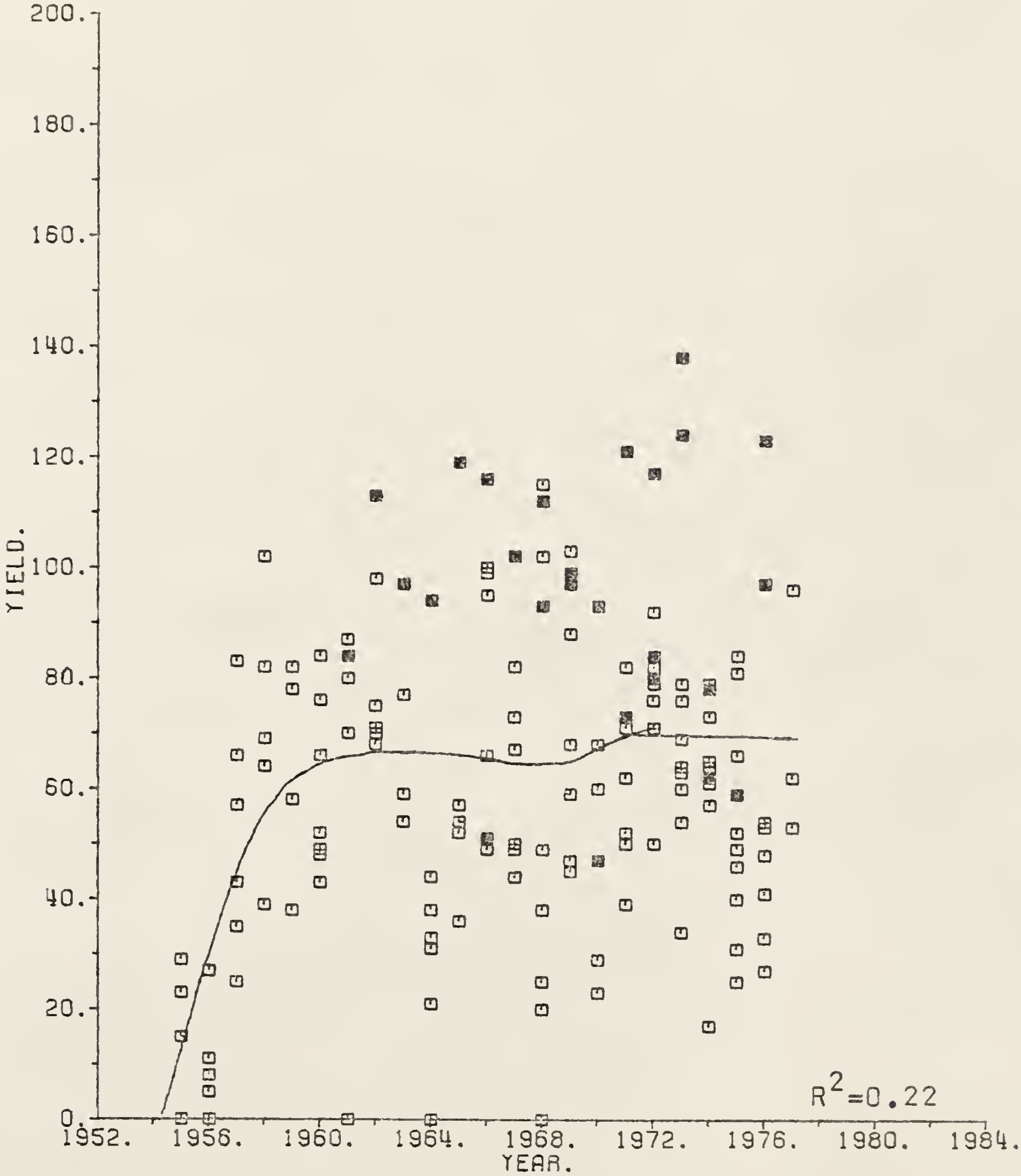

TABLE 19

GRAIN SORGHUM CURVILINEAR REGRESSION EQUATIONS

Y = Yield in bushels per acre    X = Last two digits of year

Statewide

$$Y = -86319.64 + \underset{2013.65}{5184.24X} - \underset{46.09}{116.43X^2} + \underset{0.47}{1.16X^3} - \underset{0.0017}{0.0043X^4}$$

Equation applies to years 1955–1974.
For 1975–1977, Y = 70.

Probability of a greater F = 0.0001

$R^2 = 0.22$    Observations = 160

Crete (Belleville)

$$Y = -2349.18 + \underset{29.01}{71.96X} - \underset{0.22}{0.53X^2}$$

Probability of a greater F = 0.0517

$R^2 = 0.45$    Observations = 13

Keith (Colby)

$$Y = -990.81 + \underset{12.84}{30.62X} - \underset{0.10}{0.22X^2}$$

Probability of a greater F = 0.0098

$R^2 = 0.39$    Observations = 22

---

Only four of the shaded yields fall below the least-squares line, indicating much of the variation may be due to yield differences among soil series. Curvilinear trends in individual soil series, also listed in Table 19, show a slight improvement on the Keith equation and a sizeable increase in the $R^2$ of the Crete. The Harney series at Minneola was described best by a linear trend.

The pooled soybean yields from across the state failed to show a significant linear or curvilinear trend. The best fit obtained was a linear relationship with 0.80 probability of a greater F value and an extremely low $R^2$ of 0.0009. The yields were divided into series to see if statewide yields were hiding trends in individual series yields. The two series with significant trends and their equations can be found in Table 20.

Neither of the equations in Table 20 is useful, however. The first shows soybean yields decreasing on the Woodson series. The trend for the Keith series leveled off and had a high $R^2$, but was based on only six observations. All other series failed to show any trends in soybean yields. Small sample sizes may be responsible for the failure to show any trends in soybean yields. Both grain sorghum and wheat had well over twice the sample size of soybeans.

Additionally, Dr. Cecil D. Nickell, soybean breeder at Kansas State University, stated in a personal interview that soybean yields were highly dependent on the amount of water supplied to the plants. The large year to year fluctuations in yields therefore mask any small yield increases over time.

The leveling out of grain sorghum yields may be possible if, as stated earlier, few improvements in grain sorghum production have occurred since 1955. Kansas Crop and Livestock Reporting Service (K.C.L.R.S.)

TABLE 20

SOYBEAN REGRESSION EAUATIONS

Y = Yield in bushels per acre    X = Last two digits of year

Woodson

$$Y = 71.70 - \underset{6.7\times10^{-7}}{1.48\times10^{-6}}X^4$$

Probability of a greater F = 0.0548

$R^2 = 0.35$    Observations = 11

Keith (Colby)

$$Y = 28706.02 - \underset{269.50}{919.70X} + \underset{0.07}{0.23X^3} - \underset{0.0005}{0.002X^4}$$

Probability of a greater F = 0.0341

$R^2 = 0.98$    Observations = 6

---

data indicate a substantial increase in grain sorghum yields during the period, however. Assuming linear trends, its statewide grain sorghum farm yields has increased 1.46 bushels per acre per year. This study of experiment stations gave a 1.2 bushel increase.

The average farm yields approach experiment station yields in the two equations. This may result from the time lag in farmers applying technology used by experiment station personnel. This time lag has shortened considerably during the study period, as has the difference in management applied. Table 21 compares the equations for linear trends in wheat and grain sorghum in this study and in yearly state averages of farm yields estimated

TABLE 21

COMPARISON WITH K.C.L.R.S. TRENDS

Y = Yield in bushels per acre     X = Last two digits of year

Wheat

My Equation

$$\underset{9.88}{Y = -41.53} + \underset{0.15}{1.16X}$$

Probability of a greater F = 0.0001

$R^2 = 0.26$

K.C.L.R.S. Equation

$$\underset{8.90}{Y = -15.59} + \underset{0.13}{0.63X}$$

Probability of a greater F = 0.0001

$R^2 = 0.51$

Grain Sorghum

My Equation (Linear)

$$\underset{23.68}{Y = -18.60} + \underset{0.35}{1.19X}$$

Probability of a greater F = 0.0009

$R^2 = 0.07$

K.C.L.R.S. Equation

$$\underset{17.83}{Y = -54.87} + \underset{0.27}{1.46X}$$

Probability of a greater F = 0.0001

$R^2 = 0.58$

by the K.C.L.R.S.

Wheat yields in the two trends are diverging. Yields from experiment stations are rising nearly twice as fast as farm yields. The estimated 1.2 bushel per year increase in experiment station yields may be larger than the actual increase, influenced by a small sample size and increased yields in the north-eastern corner of the state. Increased use of nitrogen fertilizer during the study period produced dramatic yield increases at Manhattan, Powhattan and Mankato. Elsewhere dramatic yield increases from nitrogen fertilization were not observed. Since that is where the majority of wheat is grown the K.C.L.R.S. yields would have been less affected by the yield increases in the north-eastern section of the state. Trends from individual stations also showed that the average bushel per acre per year yield decreased 0.07 for every additional observation from the station. Therefore larger sample sizes may have lowered the 1.2 bushel increase.

## Yield Trends in Minor Crops

Many of the crops which failed to show series yield differences revealed trends when yields were pooled for all experiment stations and fields. Table 22 gives the equations for winter barley, irrigated wheat, and other crops for which information was collected. Corn, irrigated grain sorghum, irrigated winter barley, and irrigated forage sorghum failed to show any

TABLE 22

YIELD TRENDS IN MINOR CROPS

Y = Yield in bushels per acre  X = Last two digits of year

Winter Barley

$$Y = 16.50 + \underset{3.7\times10^{-7}}{1.04\times10^{-6}}X^4$$

Probability of a greater F = 0.0069

$R^2$ = 0.10  Observations = 73

Irrigated Wheat

$$Y = -38.76 + \underset{0.38}{1.33}X$$

Probability of a greater F = 0.0012

$R^2$ = 0.23  Observations = 42

Irrigated Soybeans

$$Y = -578.64 + \underset{8.58}{17.76}X - \underset{0.06}{0.13}X^2$$

Probability of a greater F = 0.0269

$R^2$ = 0.13  Observations = 55

Irrigated Corn

$$Y = -720.38 + \underset{12.43}{23.49}X - \underset{0.09}{0.16}X^2$$

Probability of a greater F = 0.0003

$R^2$ = 0.20  Observations = 76

Spring Oats

$$Y = -16.36 + \underset{0.42}{0.94}X$$

Probability of a greater F = 0.0262

$R^2$ = 0.07  Observations = 71

Table 22, Cont.

<u>Spring Barley</u>

$$Y = -62.71 + \underset{0.47}{1.45X}$$

Probability of a greater F = 0.0043

$R^2$ = 0.23     Observations = 34

<u>Forage Sorghum</u>

$$Y_{(Tons/Acre)} = -1797.28 + \underset{32.13}{70.41X} - \underset{0.37}{0.77X^2} + \underset{1.42\times10^{-5}}{2.64\times10^{-5}X^4}$$

Probability of a greater F = 0.0001

$R^2$ = 0.35     Observations = 56

<u>Irrigated Corn Silage</u>

$$Y_{(Tons/Acre)} = 14.12 + \underset{1.8\times10^{-7}}{4.3\times10^{-7}X^4}$$

Probability of a greater F = 0.0254

$R^2$ = 0.16     Observations = 31

---

significant trends.

Real Estate Sales Analysis

The taxable value of Kansas agricultural land is theoretically assessed by market value. We must assume that the sale price of land used purely for agricultural purposes reflects the potential productivity of the soil if Kansas is to follow some other states in adopting use-value taxation.

I regressed soil and non-soil components of real estate sales data against sale price per acre to test this assumption. Multiple regression analysis was chosen because of its advantages over single factor analysis in real estate studies (16).

The variables used to predict sale price per acre included: total acres in the tract, full improvements, partial improvements, miles to town, bordering hard-surface road, wheat yield estimate, grain sorghum yield estimate, year sold, Geary County tract, Morris County tract, Chase County tract, percent cropland, Capability Class 4 and Capability Class 5.

The final model is:

$$Y = -115.42 + 85.91X_{40} + 7.13X_{51} + 62.48X_{60} + 1.40X_{80} - 54.41X_{90}$$

| Variable | Std. Error | Prob. of a Greater F |
|---|---|---|
| $Y$ = Sale price per acre | | |
| $X_{40}$ = Bordering hardsurface road | 36.03 | 0.0209 |
| $X_{51}$ = Grain sorghum yield est. | 2.25 | 0.0026 |
| $X_{60}$ = Year sold | 26.47 | 0.0221 |
| $X_{80}$ = Percent cropland | 0.44 | 0.0027 |
| $X_{90}$ = Capability Class 4 | 26.46 | 0.0449 |
| Model | | 0.0001 |

$R^2 = 0.59$

As the above figures show, all variables are significant at the 10% level. The positive value of hardsurface roads over gravel roads is understandable, but the value of $85.91 per acre seems quite large. However, in a similar multiple factor analysis of Morris, Chase, Pottawatomie, Wabaunsee and Lyon Counties for 1957 and 1958 (16), the ratio of the value of hard-surface over gravel roads per acre to sale price per acre ranged from 0.26 to 0.37. The $85.91, when divided by the average sale price per acre of $375.45, results in a ratio of only 0.23 for this study. So, although the buyers probably did not consider a bordering hard-surface road worth $85.91 an acre, this large value is not relatively as high as those obtained in the past. Hardsurface roads may be closely correlated with distance to town and bottomlands, increasing the value of hardsurface roads in the model beyond their actual value.

A $7.13 increase occurs for each additional bushel of grain sorghum. Plotting the estimated grain sorghum and wheat yields against price per acre results in a probability of a greater F value of 0.0001 for both crops. Therefore, as predictors of sale price when taken by themselves, each crop has a definite correlation with sale price. In the multiple regression equation, however, wheat fares much poorer as a predictor, and is dropped from the model, probably because of correlation with grain sorghum yields, capability class ratings, and percent cropland.

The variable for date of sale showed a $62.48 increase per acre from 1975 to 1976. This increase does not seem out of line when compared to past increases in land values (41).

The $1.40 increase for each additional percent of cropland is within reason, assuming cropland is of higher value than grassland. Having more management limitations, Class 4 being worth $54.41 less than Class 3 also seems plausible.

# CHAPTER IV
# CONCLUSIONS

The results of the real estate sale analysis support the theory that market price reflects soil productivity for agricultural land. Several shortcomings of the model must be considered when interpreting the results of the analysis, however.

First of all, only 57 real estate sales were available for analysis in the four-county area. This totaled 17,217 acres out of a total of over 1,594,000 acres, or slightly over 1% of the study area.

Some of the variables supplied by the Society of Farm Managers and Rural Appraisers can be considered little more than estimates for the tracts. Improvements, for example, were lumped together into three classes, and were evaluated independently by different society members.

The estimated crop yields for the 71 soil mapping units listed in Appendix D also contain many assumptions. The original soil survey yields are only estimates made by federal, state, and county officials. From these estimates, the assumption that crop yields are directly related to cash rent must be made. The study area includes two large and growing cities as well as three large reservoirs, which may have removed some of the sales from strictly agricultural use.

Time also limits the interpretation of the results. The sale data were collected for 1975 and 1976. The trend of $61.84 increase per acre per year can not be applied to other years or areas, as economic factors controlling purchasing decisions change.

The study also failed to include many factors which influence the price a purchaser is willing to pay. Seldin (50) lists other factors influencing sale price as: facilities (mail delivery, telephone, electricity, etc.), schools, churches, community (makeup and growth), zoning, recreation, health services, taxes, easements, rental rates in the locality, topography, drainage, and conservation measures taken and needed.

No attempt was made to assess the sale tract's distance from a buyer's home or base of operation, or whether the buyer was even a farmer. Today macro-economic factors such as income, foreign markets and inflation cause lawyers, doctors, and Arabs to frequent land auctions as well.

Each real estate sale is unique in itself with a different set of assets and liabilities, known and unknown, to each potential buyer. A myriad of the above factors and others, such as the low price of a sale to a son or son-in-law, make this study a general one. When two of the five factors determining sale price in the model are directly related to soils, namely the grain sorghum yield and Capability Class 4, one must assume that soil productivity is considered by real estate purchasers.

Use-value taxation is based on the above theory.

Rural land is assessed by the use value and urban land by market value. Then use value and market value must be closely correlated for agricultural land to obtain equitable assessment.

Analyzing the productivity of the state's soil series showed that series located on experiment stations and fields had different yield potentials. Most of the differences occurred between the series located in the northern and eastern portions of the state when compared with series located elsewhere. The Grundy series, for example, yielded so much more than most series located elsewhere that significant differences occurred. Series located in more uniform parent material and climate in other portions of the state naturally showed fewer yield differences among themselves.

The increasing trend for wheat may be slightly high at 1.2 bushels per acre per year, but the linear trends in both individual series and statewide yields adds credibility to the equations. The leveling off of grain-sorghum yields is harder to explain, but may be influenced by the lack of advancements in its breeding and production during the study period. Soybeans probably failed to show trends in yields because of small sample size. The ability to show series differences was limited by the smaller area of the state which grows non-irrigated soybeans. In a smaller area there are fewer soil differences. The three crops above and winter barley were the only crops to show series yield differences because they are most adapted to Kansas's soils and climate and therefore also had larger sample sizes.

Many of the differences in series yields may be reasoned away by changes in rainfall and temperature rather than soils. This study attempted to measure yields grown on soil in situ. Any soil removed from its climate ceases to be the original soil. The two models which tried to remove effects of variables other than soils were hampered by small sample sizes and generalized data.

In short, I believe the greatest shortcoming of the study was the lack of yields from known soil series to analyze. The missing observations collected in Appendix B suggest that not enough information was available, and that perhaps requiring tracts of 90% of one soil series and only variety and performance data was too limiting in obtaining yields. Having only one yearly yield created too much variability about the trend line to project yield estimates for series with any degree of confidence. The high F values indicate that trends and differences exist, but the low $R^2$ values limit their quantification.

It seems odd that we in agriculture in Kansas have studied and quantified nearly every facet of the state's agriculture except what its soil series will produce. It is hoped that this study will lay the groundwork for additional research to estimate and quantify the productivity of Kansas soils.

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# LITERATURE CITED


1. Ableiter, J. K. 1940. Productivity rating of soil types. Missouri Agric. Exp. Stn. Bull. 421.

2. Abmeyer, W., and H. V. Campbell. 1970. Soil survey of Shawnee County, Kansas. USDA Soil Cons. Serv. in coop. with Kans. Agric. Exp. Stn.

3. Allgood, F. P., and F. Gray. 1978. Utilization of soil characteristics in computing productivity ratings of Oklahoma soils. Soil Sci. 125:361-367.

4. Atkinson, C. H., and D. A. Gier. 1967. Soil survey of Republic County, Kansas. USDA Soil Cons. Serv. in coop. with Kans. Agric. Exp. Stn.

5. Barker, W. L. 1974. Soil survey of Morris County, Kansas. USDA Soil Cons. Serv. in coop. with Kans. Agric. Exp. Stn.

6. Buntley, G. J., and F. F. Bell. 1976. Yield estimates for the major crops grown on the soils of west Tennessee. Univ. of Tenn. Agric. Exp. Stn. Bull. 561.

7. Buntley, G. J., and F. F. Bell. 1977. Estimating crop yields for soils. Better Crops With Plant Food. 61:29-31. Potash/Phosphate Inst. Atlanta Ga.

8. Buol, S. W., F. D. Hole, and R. J. McCracken. 1973. Soil genisis and classification. Iowa St. Univ. Press. Ames, Iowa.

9. Campbell, J. B. 1977. Variation of selected properties across a soil boundary. Soil Sci. Soc. of Am. J. 41:578-582.

10. Central Intelligence Agency. 1974. Potential implications of trends in world population, food production, and climate. C.I.A. Directorate of Intelligence, Office of Political Research. Document Expediting Project, Exchange and Gift Division, Library of Congress, Washington, D.C.

11. Cipra, J. E., O. W. Bidwell, D. A. Whitney, and A. M. Feyerherm. 1972. Variations with distance in selected fertility measurements of pedons of western Kansas Ustoll. Soil Sci. Soc. of Am. Proc. 36:111-115.

12. Clarke, G. R. 1950. Productivity ratings. Trans. Internat'l Congr. Soil Sci. 1:345-352.

13. Clarke, G. R. 1971. The study of soil in the field. Clarendon Press. Oxford.

14. Dodge, D. A., B. I. Tomasu, R. L. Haberman, W. E. Roth, and J. B. Baumann. 1965. Soil survey of Ford County, Kansas. USDA Soil Cons. Serv. in coop with Kans. Agric. Exp. Stn.

15. Dunmire, R. G., and O. W. Bidwell. 1960. Soil survey of Geary County, Kansas. USDA Soil Cons. Serv. in coop. with Kans. Agric. Exp. Stn.

16. Edwards, J. D., W. H. Pine, and A. M. Feyerherm. 1964. Effects of roads and other factors on farm real estate values in Kansas. Kans. Agric. Exp. Stn. Bull. No. 469. Manhattan, Kans.

17. Eikleberry, R. W., and E. H. Templin. 1960. Soil survey of Brown County, Kansas. USDA Soil Cons. Serv. in coop. with Kans. Agric. Exp. Stn.

18. Engelstad, O. P., and W. D. Shrader. 1961. The effect of surface soil thickness on corn yields: II. As determined by an experiment using normal surface soil and artificially-exposed subsoil. Soil Sci. Soc. of Am. Proc. 25:497-499.

19. Engelstad, O. P., W. D. Shrader, and L. C. Duminel. 1961. The effect of surface soil thickness on corn yields: I. As determined by a series of field experiments in farmer-operated fields. Soil Sci. Soc. of Am. Proc. 25:494-497.

20. Fehrenbacher, J. B., R. A. Pope, I. J. Jansen, J. D. Alexander, and B. W. Ray. 1978. Soil productivity in Illinois. Univ. of Ill. Coll. of Agric. Coop. Ext. Serv. Circ. 1156. Urbana, Ill.

21. Fenton, T. E. 1975. Use of soil productivity ratings in evaluating Iowa agricultural land. J. of Soil and Water Cons. 30:237-240.

22. Fenton, T. E., E. R. Duncan, W. D. Shrader, and L. C. Duminel. 1971. Productivity levels of some Iowa soils. Agric. and Home Econ. Exp. Stn. Special Rpt. No. 66. Ames, Iowa.

23. Flora, S. D. 1956. Hailstorms of the United States. Univ. of Okla. Press. Norman, Okla.

24. Fritschen, J. F., and W. H. Pine. 1958. A study of the productivity of selected soils in western Kansas. Kans. St. Coll. of Agric. and App. Sci. Rpt. of Progress No. 24. Manhattan, Kans.

25. Glover, R. K., L. D. Zavesky, W. R. Swafford, and Q. L. Markley. 1975. Soil survey of Ellis County, Kansas. USDA Soil Cons. Serv. in coop. with Kans. Agric. Exp. Stn.

26. Gwin, R. E., O. W. Bidwell, R. C. Angell, and G. Muilenburg. 1974. Making the most of soil, water, climate in west-central Kansas through research at Tribune Branch Experiment Station. Kans. Agric. Exp. Stn. Bull. 577. Manhattan, Kans.

27. Harner, R. F., R. C. Angell, M. A. Lobmeyer, and D. R. Jantz. 1965. Soil survey of Finney County, Kansas. USDA Soil Cons. Serv. in coop. with Kans. Agric. Exp. Stn.

28. Hoffman, B. R., and L. W. Dowd. 1974. Soil Survey of Harvey County, Kansas. USDA Soil Cons. Serv. in coop. with Kans. Agric. Exp. Stn.

29. Jantz, D. R., R. F. Harner, H. T. Rowland, and D. A. Gier. 1975. Soil survey of Riley County and part of Geary County, Kansas. USDA Soil Cons. Serv. in coop. with Kans. Agric. Exp. Stn.

30. Jensen, N. F. 1978. Limits to growth in world food production. Science 201:317-320.

31. Kansas State Board of Agriculture. 1978. 61st annual report and farm facts. Topeka, Kans.

32. Klingebiel, A. A., and P. H. Montgomery. 1961. Land capability classification. USDA Handbook No. 210.

33. Lee, L. K. 1978. A perspective on cropland availability. USDA Econ., Stat., and Coop. Serv. Econ. Rpt. No. 406. Washington, D.C.

34. McBee, C. W., E. L. Fleming, K. H. Sallee, and V. L. Hamilton. 1961. Soil survey of Greeley County, Kansas. USDA Soil Cons. Serv. in coop. with Kans. Agric. Exp. Stn.

35. McGinnis, C., and R. L. Schulte. 1974. Planting, development and harvest of major Kansas crops. Kansas Crop and Livestock Reporting Service. Topeka Kans.

36. Neill, J. T. 1975. Soil survey of Chase County, Kansas. USDA Soil Cons. Serv. in coop. with Kans. Agric. Exp. Stn.

37. North Central Regional Technical Committee 3 on Soil Survey. 1965. Productivity of soils in the north central region. Univ. of Ill. Agric. Exp. Stn. Bull. 710. Urbana, Ill.

38. Odell, R. T. 1950. Measurement of the productivity of soils under various enviornmental conditions. Agron. J. 42:282-292.

39. Odell, R. T., and W. R. Oschwald. 1970. Productivity of Illinois soils. Univ. of Ill. Coop. Ext. Serv. Circ. 1016. Urbana, Ill.

40. Oschwald, W. R. 1971. Suggested procedure for utilizing soil surveys in tax assessment of agricultural lands. Agronomy Facts Special Pub. 32 (rev.). Dept. of Agron., Univ. of Ill. Urbana, Ill.

41. Pine, W. H., and R. R. Hancock. 1974. Trends in land values in Kansas. Kans. Agric. Exp. Stn. Bull. No. 581. Manhattan, Kans.

42. Pine, W. H., and R. R. Hancock. 1976. Cash farm rental rates in Kansas. Kans. Exp. Stn. Bull. No. 594. Manhattan, Kans.

43. Ad Hoc Regional Technical Committee on Missouri Basin Projections. 1966. Projections of crop yields land resource regions 1980-2000-2020 Missouri River Basin states. Univ. of Neb. Coll. of Agric. and Home Econ. Agric. Exp. Stn. Misc. Pub. 22. Lincoln Neb.

44. Rehm, G. W., and R. C. Sorensen. 1977. Soybean yields on a silt loam soil as influenced by prior fertilization, row spacings, and plant populations for corn. Soil Sci. 124:235-240.

45. Rennie, D. A., and J. S. Clayton. 1960. The significance of local soil types to soil fertility studies. Can. J. of Soil Sci. 40:146-156.

46. Rockers, J. J., I. Ratcliff, L. W. Dowd, and E. F. Bouse. 1966. Soil survey of Reno County, Kansas. USDA Soil Cons. Serv. in coop. with Kans. Agric. Exp. Stn.

47. Rust, R. H., and L. D. Hanson. 1975. Crop equivalent rating guide for soils of Minnesota. Univ. of Minn. Agric. Exp. Stn. Misc. Rpt. 132. Minneapolis, Minn.

48. Rust, R. H., and R. T. Odell. 1957. Methods used in evaluating productivity of Illinois soils. Soil Sci. Soc. of Am. Proc. 21:171-175.

49. Scholtes, W. H., and F. F. Riecken. 1952. Use of soil information for tax assessment in Taylor County, Iowa. Soil Sci. Soc. of Am. Proc. 16:270-273.

50. Seldin, M. 1975. Land investment. Dow Jones-Irwin. Homewood, Ill. pp. 41-51.

51. Shapley, D. 1976. Crops and climatic change: U.S.D.A.'s forecasts criticized. Science 193:1222-1224.

52. Smith, G. D., and R. S. Smith. 1939. A study of crop yield records by soil type and soil rating. Soil Sci. Soc. of Am. Proc. 4:375-377.

53. Smith, R. T., and K. Atkinson. 1975. Techniques in pedology. The Gresham Press. Old Woking, Surrey.

54. Soil Survey Staff. 1951. Soil survey manual. USDA Handb. No. 18. U.S. Gov. Printing Off. Washington D.C.

55. Soil Survey Staff. 1975. Soil taxonomy. USDA Handb. No. 436. U.S. Gov. Printing Off. Washington D.C.

56. Stephens, C. G. 1963. The 7th approximation: its application in Australia. Soil Sci. 96:40-48.

57. Storie, R. E. 1950. Rating of soils for agriculture, grazing and forest use. Trans. Internat'l Congr. Soil Sci. 1:336-339.

58. Swanson, E. R., and D. E. Maccallum. 1969. Income effects of rainfall erosion control. J. of Soil and Water Cons. 24:56-59.

59. Thompson, L. M. 1962. Evaluation of weather factors in the production of wheat. J. of Soil and Water Cons. 17:149-156.

60. Thompson, L. M. 1975. Weather variability, climatic change, and grain production. Science 188:535-541.

61. Walter, T. L. 1978. 1977 Kansas sorghum performance tests. Kans. Agric. Exp. Stn. Rpt. of Progress 321. Manhattan, Kans.

62. Wascher, H. L., J. B. Fehrenbacher, and R. T. Odell. 1950. Illinois soil type descriptions. Dept. of Agron. AG-1443. Univ. of Ill. Urbana, Ill.

63. Weitzman, S., and G. R. Trimble, Jr. 1955. A capability classification for forest land. J. of Soil and Water Cons. 10:228-232.

64. Welch, L. F., L. V. Boone, C. G. Chambliss, A. T. Christiansen, D. L. Mulvaney, M. G. Oldham, and J. W. Pendleton. 1973. Soybean yields with direct and residual nitrogen fertilization. Agron. J. 65:547-551.

65. Yahner, J., and G. Srinivasan. 1975. Using the soil survey for land assessment. A computer model. Purdue Univ. Agric. Exp. Stn. Bull. No. 93. West Lafayette, Ind.

APPENDIX

# APPENDIX A
## CRITERIA FOR S.C.S. MANAGEMENT LEVELS (36)

The average system or A level of management consists of:

1) Use of recommended crop varieties.
2) Proper seeding rates, dates, methods of planting and harvesting.
3) Some use of weed-, disease-, and insect-control practices.
4) Use of starter fertilizer.

The improved system or B level of management includes the practices listed above for the average level plus:

1) A well planned fertility program that provides for the optimum use of fertilizer and lime required to obtain the best crop yields.
2) Use of such soil- and water-conserving practices as terraces, contour farming, and grassed waterways.
3) Maximum use of crop residue to aid in control of soil blowing and water erosion, to increase water intake, and to enhance seeding emergence.
4) Use of surface drainage where needed to remove excess water.
5) Use of a well-planned cropping system that fits the operator's needs and maintains the soil in good physical condition.
6) Timely tillage operations.
7) Full and timely use of weed, disease, and insect control practices.

# APPENDIX B
## YIELD DATA FROM EXPERIMENT STATIONS AND FIELDS

### Alfalfa (Tons/Acre)

| Series | Crete | Crete | Clark-Ost | Farnum |
|---|---|---|---|---|
| Station | Belleville | Mankato | Hutchinson | St. John |
| Year | | | | |
| 1972 | . | . | 2.6 | . |
| 1971 | . | . | 2.9 | . |
| 1970 | . | . | 3.1 | . |
| 1969 | . | . | 4.0 | . |
| 1968 | . | . | 2.0 | . |
| 1967 | 2.4 | 4.8 | . | . |
| 1966 | . | 3.2 | . | . |
| 1965 | 4.1 | 2.7 | . | . |
| 1964 | 2.5 | 1.3 | . | . |
| 1963 | 5.0 | . | 2.4 | . |
| 1962 | 5.5 | 3.5 | 2.9 | . |
| 1961 | 5.3 | 3.3 | 3.4 | . |
| 1960 | . | 3.4 | 2.7 | 3.8 |
| 1959 | . | 2.2 | 2.9 | 4.0 |
| 1958 | . | 4.3 | . | 5.7 |

Appendix B, Cont.

| | Alfalfa (Tons/Acre) | Irrigated Alfalfa (Tons/Acre) | Irrigated Spring Barley |
|---|---|---|---|
| Series | Ladysmith | Farnum | Keith |
| Station | Newton | St. John | Colby |
| Year | | | |
| 1976 | . | . | 53 |
| 1975 | . | . | 41 |
| 1974 | 3.5 | . | 27 |
| 1973 | 4.4 | . | 47 |
| 1972 | 4.3 | . | 48 |
| 1971 | 5.4 | 7.7 | 49 |
| 1970 | 2.1 | 4.2 | 47 |
| 1969 | 3.3 | . | 62 |
| 1968 | . | . | 0 |
| 1967 | . | . | 45 |
| 1966 | . | . | 34 |
| 1965 | . | . | 38 |
| 1964 | . | . | 40 |

Appendix B, Cont.

Spring Barley

| Series | Crete | Keith | Ulysses | Crete |
|---|---|---|---|---|
| Station | Belleville | Colby | Garden City | Mankato |
| Year | | | | |
| 1977 | . | 50 | . | . |
| 1976 | . | . | . | . |
| 1975 | . | 39 | . | . |
| 1974 | . | 37 | . | . |
| 1973 | . | 48 | . | . |
| 1972 | . | . | . | . |
| 1971 | . | 50 | . | . |
| 1970 | . | . | . | . |
| 1969 | . | 28 | . | . |
| 1968 | . | 9 | . | . |
| 1967 | . | 66 | . | . |
| 1966 | . | 25 | . | . |
| 1965 | . | 39 | . | 23 |
| 1964 | . | 15 | . | 23 |
| 1963 | . | . | . | 42 |
| 1962 | . | . | . | 43 |
| 1961 | 49 | 4 | 17 | 40 |
| 1960 | . | 43 | . | 60 |
| 1959 | 39 | 23 | . | 31 |
| 1958 | 0 | 0 | . | 32 |
| 1957 | 36 | 0 | . | . |
| 1956 | 4 | . | . | 0 |
| 1955 | 7 | 33 | . | 9 |

Appendix B, Cont.

Winter Barley

| Series | Crete | Crete | Ulysses-Colby | Keith |
|---|---|---|---|---|
| Station | Belleville | Mankato | Garden City | Colby |
| Year | | | | |
| 1976 | . | . | . | 42 |
| 1975 | . | . | . | 24 |
| 1974 | . | . | . | 43 |
| 1973 | . | . | . | . |
| 1972 | . | . | . | 73 |
| 1971 | . | . | . | . |
| 1970 | . | . | . | . |
| 1969 | . | . | . | . |
| 1968 | . | . | . | 0 |
| 1967 | . | 36 | . | 46 |
| 1966 | . | . | . | 35 |
| 1965 | . | 36 | . | 29 |
| 1964 | . | 27 | 15 | 4 |
| 1963 | . | 7 | . | 6 |
| 1962 | . | 21 | . | 30 |
| 1961 | 66 | 76 | . | . |
| 1960 | 6 | 13 | 17 | 31 |
| 1959 | 46 | 44 | . | . |
| 1958 | 70 | 66 | 49 | 50 |
| 1957 | 18 | . | . | . |
| 1956 | . | 6 | 13 | 0 |
| 1955 | . | 21 | . | 40 |

Appendix B, Cont.

Winter Barley

| Series | Keith | Clark-Ost | Harney | Smolan |
|---|---|---|---|---|
| Station | Garden City | Hutchinson | Minneola | Manhattan |
| Year | | | | |
| 1975 | . | . | . | 56 |
| 1974 | . | 48 | . | . |
| 1973 | . | 51 | . | 73 |
| 1972 | 30 | 68 | . | . |
| 1971 | . | . | . | . |
| 1970 | 44 | . | . | . |
| 1969 | . | . | . | . |
| 1968 | . | 46 | . | . |
| 1967 | . | 44 | 29 | . |
| 1966 | 5 | 14 | 5 | . |
| 1965 | . | 52 | 60 | . |
| 1964 | . | 62 | 15 | . |
| 1963 | . | 31 | . | . |
| 1962 | 27 | 42 | 30 | . |
| 1961 | . | 61 | 56 | . |
| 1960 | . | 49 | 23 | . |
| 1959 | . | 64 | 15 | . |
| 1958 | . | 41 | 37 | . |
| 1957 | . | 51 | 0 | . |
| 1956 | . | 24 | 0 | . |
| 1955 | . | 0 | 0 | . |

Appendix B, Cont.

| | Winter Barley | | Irr. Winter Barley | |
|---|---|---|---|---|
| Series | Ladysmith | Carwile | Keith | Ulysses-Richfield |
| Station | Newton | St. John | Colby | Garden City |
| Year | | | | |
| 1976 | . | . | 46 | . |
| 1975 | 60 | . | 41 | . |
| 1974 | . | . | 53 | . |
| 1973 | . | . | 38 | . |
| 1972 | . | . | . | 88 |
| 1971 | . | . | . | 73 |
| 1970 | . | . | . | 65 |
| 1969 | . | . | . | 75 |
| 1968 | . | . | 0 | 58 |
| 1967 | . | 37 | 82 | 42 |
| 1966 | . | . | 71 | 54 |
| 1965 | . | 27 | 44 | 30 |
| 1964 | . | . | 45 | 51 |
| 1963 | . | . | 20 | 51 |
| 1962 | . | . | 35 | 28 |
| 1961 | . | . | 0 | . |
| 1960 | . | . | 0 | . |
| 1959 | . | . | 62 | . |
| 1958 | . | . | 63 | . |
| 1957 | . | . | 44 | . |

Appendix B, Cont.

Corn

| Series | Woodson | Parsons | Grundy | Richfield |
|---|---|---|---|---|
| Station | Ottawa | Parsons | Powhattan | Tribune |
| Year | | | | |
| 1977 | 83 | . | . | . |
| 1976 | 54 | . | . | . |
| 1975 | 68 | 83 | 84 | 44 |
| 1974 | 14 | 0 | 17 | 28 |
| 1973 | 103 | 48 | 155 | . |
| 1972 | . | 94 | 153 | . |
| 1971 | . | 101 | 49 | . |
| 1970 | . | 56 | 45 | . |
| 1969 | . | 80 | 91 | . |
| 1968 | . | 51 | 120 | . |
| 1967 | . | 92 | 78 | . |
| 1966 | . | . | 65 | . |
| 1965 | . | . | 102 | . |
| 1964 | . | . | 73 | . |
| 1963 | . | . | 102 | . |
| 1962 | . | . | . | . |
| 1961 | . | . | 124 | . |
| 1960 | . | . | 93 | . |
| 1959 | . | . | 105 | . |
| 1958 | . | . | 67 | . |
| 1957 | . | . | 58 | . |

Appendix B, Cont.

| | Corn | | Irrigated Corn | |
|---|---|---|---|---|
| Series | Keith | Kahola | Crete | Keith |
| Station | Colby | Manhattan | Belleville | Colby |
| Year | | | | |
| 1977 | . | 76 | 132 | 76 |
| 1976 | . | 60 | 145 | 178 |
| 1975 | 51 | . | . | 143 |
| 1974 | . | . | 121 | . |
| 1973 | . | 113 | 156 | 85 |
| 1972 | . | . | 151 | 151 |
| 1971 | . | . | 132 | 172 |
| 1970 | . | . | 125 | 133 |
| 1969 | . | . | 134 | 160 |
| 1968 | . | . | . | 151 |
| 1967 | . | . | 165 | 171 |
| 1966 | . | . | 146 | 157 |
| 1965 | . | . | 149 | 135 |
| 1964 | . | . | 131 | 102 |
| 1963 | . | . | 121 | 126 |
| 1962 | . | . | 149 | 150 |
| 1961 | . | . | 110 | 91 |
| 1960 | . | . | 149 | 115 |
| 1959 | . | . | . | 100 |
| 1958 | . | . | . | 112 |

Appendix B, Cont.

Irrigated Corn

| Series | Keith | Ulysses | Carwile | Naron |
|---|---|---|---|---|
| Station | Garden City | Garden City | St. John | St. John |
| Year | | | | |
| 1976 | 152 | . | 153 | . |
| 1975 | 167 | . | 165 | . |
| 1974 | . | . | . | . |
| 1973 | . | . | . | . |
| 1972 | 153 | . | 165 | . |
| 1971 | 154 | . | 127 | . |
| 1970 | 134 | . | . | . |
| 1969 | . | . | . | . |
| 1968 | 132 | . | . | 73 |
| 1967 | . | . | . | . |
| 1966 | . | . | . | . |
| 1965 | 132 | . | . | . |
| 1964 | 113 | . | . | . |
| 1963 | 113 | . | . | . |
| 1962 | 153 | . | . | . |
| 1961 | . | 131 | . | . |
| 1960 | . | . | . | . |
| 1959 | . | 103 | . | . |
| 1958 | . | 122 | . | . |
| 1957 | . | 72 | . | . |
| 1956 | . | 74 | . | . |
| 1955 | . | 88 | . | . |

Appendix B, Cont.

| | Irrigated Corn | | | Irrigated Corn Silage |
|---|---|---|---|---|
| Series | Eudora | Eudora | Ulysses | Crete |
| Station | Topeka | Manhattan | Tribune | Belleville |
| Year | | | | |
| 1977 | 137 | . | . | . |
| 1976 | 154 | 115 | 192 | . |
| 1975 | 149 | 110 | 161 | . |
| 1974 | 153 | . | 128 | . |
| 1973 | 120 | . | . | . |
| 1972 | . | . | 160 | . |
| 1971 | . | . | 124 | . |
| 1970 | . | . | 151 | . |
| 1969 | . | . | 159 | . |
| 1968 | . | . | 156 | . |
| 1967 | . | . | 0 | 30.8 |
| 1966 | . | . | 158 | 26.9 |
| 1965 | . | . | 128 | 25.5 |
| 1964 | . | . | 126 | . |
| 1963 | . | . | 130 | 21.6 |
| 1962 | . | . | 148 | 24.9 |
| 1961 | . | . | 141 | 17.5 |
| 1960 | . | . | . | 21.9 |
| 1959 | . | . | . | 20.0 |

Appendix B, Cont.

Irrigated Corn Silage

| Series | Keith | Keith | Ulysses-Richfield | Ulysses |
|---|---|---|---|---|
| Station | Colby | Garden City | Garden City | Garden City |
| Year | | | | |
| 1976 | 27.9 | 28.0 | . | . |
| 1975 | 25.8 | 27.8 | . | . |
| 1974 | . | . | . | . |
| 1973 | . | . | . | . |
| 1972 | . | . | . | 26.5 |
| 1971 | . | . | . | 30.9 |
| 1970 | 24.5 | . | . | 25.8 |
| 1969 | . | . | . | 26.0 |
| 1968 | . | . | . | . |
| 1967 | . | 0.0 | . | . |
| 1966 | . | . | . | 26.7 |
| 1965 | . | 23.9 | . | . |
| 1964 | 0.0 | 22.9 | . | . |
| 1963 | 22.3 | . | . | 22.7 |
| 1962 | 24.4 | . | . | . |
| 1961 | 16.5 | . | 15.4 | . |
| 1960 | 18.2 | 22.5 | . | . |
| 1959 | 21.1 | . | . | 24.2 |
| 1958 | 21.2 | . | . | 24.2 |
| 1957 | . | . | . | . |
| 1956 | . | . | . | 15.1 |

Appendix B, Cont.

Forage Sorghum (Tons/Acre)

| Series | Keith | Keith | Ulysses-Colby | Ulysses |
|---|---|---|---|---|
| Station | Colby | Garden City | Garden City | Garden City |
| Year | | | | |
| 1977 | 18.5 | . | . | . |
| 1976 | 10.9 | . | . | 14.5 |
| 1975 | 12.0 | . | . | 9.0 |
| 1974 | . | . | . | . |
| 1973 | . | . | . | . |
| 1972 | . | . | . | . |
| 1971 | . | 16.2 | . | . |
| 1970 | . | . | . | . |
| 1969 | . | . | . | . |
| 1968 | . | . | . | . |
| 1967 | . | . | . | . |
| 1966 | . | . | 9.1 | . |
| 1965 | . | . | . | 14.4 |
| 1964 | 9.0 | 11.4 | . | 7.9 |
| 1963 | 15.5 | . | . | . |
| 1962 | 19.9 | . | 26.5 | . |
| 1961 | 14.2 | . | . | . |
| 1960 | 11.9 | . | 13.5 | . |
| 1959 | 8.7 | . | . | 14.9 |
| 1958 | 11.3 | . | 11.4 | . |
| 1957 | 7.3 | . | . | . |
| 1956 | . | . | . | . |
| 1955 | 5.2 | . | . | . |

Appendix B, Cont.

Forage Sorghum (Tons/Acre)

| Series | Carwile | Harney | Clark-Ost | Ivan |
|---|---|---|---|---|
| Station | St. John | Hays | Hutchinson | Manhattan |
| Year | | | | |
| 1976 | . | 9.6 | 8.5 | . |
| 1975 | . | 13.0 | 16.8 | 23.0 |
| 1974 | . | . | 17.6 | . |
| 1973 | . | . | . | . |
| 1972 | . | . | . | . |
| 1971 | . | . | 15.2 | . |
| 1970 | . | . | 11.6 | . |
| 1969 | . | . | 16.0 | . |
| 1968 | . | . | 12.6 | . |
| 1967 | . | . | 17.0 | . |
| 1966 | . | . | 19.5 | . |
| 1965 | . | . | 15.5 | . |
| 1964 | . | . | . | . |
| 1963 | . | . | 21.6 | . |
| 1962 | . | . | 21.9 | . |
| 1961 | . | . | 18.2 | . |
| 1960 | 6.7 | . | 5.8 | . |
| 1959 | 9.7 | . | 7.4 | . |
| 1958 | 6.8 | . | 8.0 | . |
| 1957 | . | . | 13.5 | . |
| 1956 | 6.7 | . | 2.7 | . |
| 1955 | 3.8 | . | 1.8 | . |

Appendix B, Cont.

| | Forage Sorghum | | Irrigated Forage Sorghum | |
|---|---|---|---|---|
| Series | Reading | Parsons | Crete | Keith |
| Station | Manhattan | Parsons | Belleville | Colby |
| Year | | | | |
| 1976 | 15.7 | . | . | 25.5 |
| 1975 | . | 21.0 | . | 22.1 |
| 1965 | . | . | 28.3 | . |
| 1964 | . | . | 34.1 | 23.2 |
| 1963 | . | . | 29.6 | 27.4 |
| 1962 | . | . | 30.2 | . |
| 1961 | . | . | 22.5 | 22.2 |
| 1960 | . | . | 19.4 | 23.7 |
| 1959 | . | . | 24.2 | 22.0 |
| 1958 | . | . | 23.3 | 6.1 |

Appendix B, Cont.

Irrigated Forage Sorghum (Tons/Acre)

| Series | Keith | Ulysses | Ulysses |
| --- | --- | --- | --- |
| Station | Garden City | Garden City | Tribune |
| Year | | | |
| 1976 | 40.4 | . | . |
| 1975 | 27.0 | . | . |
| 1974 | . | . | . |
| 1973 | . | . | . |
| 1972 | . | 21.5 | . |
| 1971 | . | 29.7 | . |
| 1970 | . | . | . |
| 1969 | 28.1 | . | . |
| 1968 | . | . | . |
| 1967 | 0.0 | . | . |
| 1966 | 31.8 | . | . |
| 1965 | 26.1 | . | . |
| 1964 | 26.2 | . | 27.7 |
| 1963 | . | . | 33.7 |
| 1962 | . | . | 29.7 |
| 1961 | 25.3 | . | 17.4 |
| 1960 | 25.9 | . | . |
| 1959 | 14.9 | . | . |

Appendix B, Cont.

Grain Sorghum

| Series | Crete | Crete | Crete | Keith |
|---|---|---|---|---|
| Station | Belleville | Hays | Mankato | Colby |
| Year | | | | |
| 1977 | 96 | . | . | 62 |
| 1976 | 27 | 48 | . | 54 |
| 1975 | 31 | 40 | . | 66 |
| 1974 | . | 64 | . | 65 |
| 1973 | . | 60 | 63 | 76 |
| 1972 | . | 71 | . | 76 |
| 1971 | . | 39 | . | 71 |
| 1970 | . | 29 | . | 60 |
| 1969 | 103 | . | . | 59 |
| 1968 | 112 | . | 102 | 25 |
| 1967 | 82 | . | 50 | 67 |
| 1966 | . | . | . | 99 |
| 1965 | . | . | . | . |
| 1964 | . | . | . | 44 |
| 1963 | . | . | . | 59 |
| 1962 | 98 | . | 70 | 75 |
| 1961 | 0 | . | . | 70 |
| 1960 | 84 | . | 76 | 48 |
| 1959 | . | . | 78 | 58 |
| 1958 | 64 | . | 102 | 69 |
| 1957 | 43 | . | 57 | 25 |
| 1956 | 0 | . | 0 | 5 |
| 1955 | 0 | . | 15 | 23 |

Appendix B, Cont.

Grain Sorghum

| Series | Keith | Ulysses | Harney | Harney |
|---|---|---|---|---|
| Station | Garden City | Garden City | Hays | Minneola |
| Year | | | | |
| 1977 | . | . | 53 | . |
| 1976 | . | 41 | 53 | 41 |
| 1975 | 25 | . | 52 | 46 |
| 1974 | . | . | 62 | 79 |
| 1973 | . | . | 54 | 64 |
| 1972 | . | 82 | 92 | 80 |
| 1971 | . | 82 | 52 | 62 |
| 1970 | . | . | . | 68 |
| 1969 | . | 88 | 68 | 47 |
| 1968 | 38 | . | 20 | 0 |
| 1967 | . | . | 44 | 49 |
| 1966 | . | 49 | 95 | 66 |
| 1965 | . | 54 | 36 | 52 |
| 1964 | 21 | . | 33 | 38 |
| 1963 | . | . | . | 54 |
| 1962 | . | . | . | 68 |
| 1961 | . | . | . | 87 |
| 1960 | 43 | . | . | 52 |
| 1959 | . | . | . | 38 |
| 1958 | . | . | . | 39 |
| 1957 | . | . | . | 35 |
| 1956 | 27 | . | . | 11 |
| 1955 | . | . | . | 29 |

Appendix B, Cont.

Grain Sorghum

| Series | Clark-Ost | Parsons | Grundy | Woodson |
|---|---|---|---|---|
| Station | Hutchinson | Parsons | Powhattan | Ottawa |
| Year | | | | |
| 1976 | 33 | 123 | 97 | . |
| 1975 | 81 | 84 | 59 | . |
| 1974 | 73 | 57 | 61 | 78 |
| 1973 | 34 | 79 | 124 | 138 |
| 1972 | 50 | 84 | 117 | . |
| 1971 | 50 | 121 | 73 | . |
| 1970 | 23 | 47 | 93 | . |
| 1969 | 45 | 99 | 97 | . |
| 1968 | 49 | 93 | 115 | . |
| 1967 | 67 | . | 102 | . |
| 1966 | 100 | 51 | 116 | . |
| 1965 | 57 | . | 119 | . |
| 1964 | 31 | . | 94 | . |
| 1963 | 77 | . | 97 | . |
| 1962 | 71 | . | 113 | . |
| 1961 | 80 | . | 84 | . |
| 1960 | 66 | . | . | . |
| 1959 | 82 | . | . | . |
| 1958 | 82 | . | . | . |
| 1957 | 66 | . | 83 | . |
| 1956 | 8 | . | . | . |
| 1955 | 0 | . | . | . |

Appendix B, Cont.

Grain Sorghum

| Series | Butler | Kenoma | Richfield | Ladysmith |
|---|---|---|---|---|
| Station | Belleville | Ottawa | Tribune | Newton |
| Year | | | | |
| 1975 | 34 | . | 49 | . |
| 1974 | . | . | 17 | . |
| 1973 | . | . | . | 69 |
| 1972 | . | 79 | . | . |

| Series | Carwile | Farnum |
|---|---|---|
| Station | St. John | St. John |
| Year | | |
| 1967 | . | 73 |
| 1966 | . | . |
| 1965 | . | 57 |
| 1964 | 0 | . |
| 1960 | 49 | . |
| 1956 | . | 27 |

Appendix B, Cont.

Irrigated Grain Sorghum

| Series | Crete | Keith | Keith | Carwile |
|---|---|---|---|---|
| Station | Belleville | Colby | Garden City | St. John |
| Year | | | | |
| 1977 | . | 63 | . | . |
| 1976 | . | . | 127 | . |
| 1975 | . | . | . | . |
| 1974 | . | 108 | . | . |
| 1973 | . | 126 | . | . |
| 1972 | . | 137 | 131 | . |
| 1971 | . | 143 | 133 | . |
| 1970 | . | 126 | . | . |
| 1969 | . | 141 | 131 | 102 |
| 1968 | . | 71 | 124 | . |
| 1967 | . | 87 | . | . |
| 1966 | . | 133 | 128 | . |
| 1965 | . | 100 | 123 | . |
| 1964 | . | . | 126 | . |
| 1963 | 117 | 107 | 120 | . |
| 1962 | 123 | 83 | 122 | . |
| 1961 | 0 | 89 | 127 | . |
| 1960 | 131 | . | 125 | . |
| 1959 | 116 | 100 | 114 | . |
| 1958 | 107 | 102 | . | . |
| 1957 | . | . | . | . |
| 1956 | . | . | 94 | . |

Appendix B, Cont.

| | Irrigated Grain Sorghum | | Irrigated Spring Oats |
|---|---|---|---|
| Series | Naron | Ulysses | Keith |
| Station | St. John | Tribune | Colby |
| Year | | | |
| 1976 | . | 125 | 72 |
| 1975 | . | 84 | 71 |
| 1974 | . | 43 | 42 |
| 1973 | . | 97 | 54 |
| 1972 | . | 140 | 35 |
| 1971 | . | 120 | 72 |
| 1970 | . | 135 | 55 |
| 1969 | . | 138 | 62 |
| 1968 | 101 | 135 | 0 |
| 1967 | . | 100 | 136 |
| 1966 | . | 101 | 57 |
| 1965 | . | 106 | 62 |
| 1964 | . | 128 | . |
| 1963 | . | 132 | . |
| 1962 | . | 116 | . |
| 1961 | . | 79 | . |

Appendix B, Cont.

Spring Oats

| Series | Crete | Keith | Ulysses | Clark-Ost |
|---|---|---|---|---|
| Station | Belleville | Colby | Garden City | Hutchinson |
| Year | | | | |
| 1977 | . | 54 | . | . |
| 1976 | . | . | . | . |
| 1975 | . | 57 | . | . |
| 1974 | . | 42 | . | . |
| 1973 | . | 59 | . | . |
| 1972 | . | . | . | . |
| 1971 | 7 | 63 | . | . |
| 1970 | . | . | . | . |
| 1969 | . | 39 | . | . |
| 1968 | . | 9 | . | 27 |
| 1967 | . | 96 | . | . |
| 1966 | . | 32 | . | . |
| 1965 | . | 47 | . | 42 |
| 1964 | . | . | . | 30 |
| 1963 | . | 30 | . | 20 |
| 1962 | . | . | . | 16 |
| 1961 | . | 18 | 34 | 39 |
| 1960 | . | 58 | . | . |
| 1959 | 61 | . | . | 15 |
| 1958 | 41 | 0 | . | . |
| 1957 | 64 | 57 | . | . |
| 1956 | 6 | . | . | . |
| 1955 | 15 | 41 | . | 15 |

Appendix B, Cont.

Spring Oats

| Series | Kahola | Smolan | Crete | Grundy |
|---|---|---|---|---|
| Station | Manhattan | Manhattan | Mankato | Powhattan |
| Year | | | | |
| 1975 | . | 41 | . | 70 |
| 1974 | . | 52 | . | 44 |
| 1973 | . | 78 | . | 50 |
| 1972 | . | . | . | . |
| 1971 | . | 51 | . | 46 |
| 1970 | 54 | . | . | 73 |
| 1969 | . | 67 | . | 70 |
| 1968 | 55 | . | . | 36 |
| 1967 | . | 49 | 47 | 51 |
| 1966 | . | 0 | . | 50 |
| 1965 | 48 | . | 38 | 42 |
| 1964 | . | 58 | 32 | 53 |
| 1963 | 50 | . | 60 | 36 |
| 1962 | . | . | 65 | . |
| 1961 | . | . | 78 | 63 |
| 1960 | . | . | 86 | 66 |
| 1959 | . | . | 40 | 32 |
| 1958 | . | . | 57 | 68 |
| 1957 | . | . | . | 63 |
| 1956 | . | . | 0 | . |
| 1955 | . | . | 17 | . |

Appendix B, Cont.

Winter Oats

| Series | Crete | Ulysses | Clark-Ost | Carwile |
|---|---|---|---|---|
| Station | Belleville | Colby | Hutchinson | St. John |
| Year | | | | |
| 1974 | . | . | 63 | . |
| 1973 | . | . | 80 | . |
| 1972 | . | . | 97 | . |
| 1971 | . | . | 30 | . |
| 1970 | . | . | 49 | . |
| 1969 | . | . | 42 | . |
| 1968 | . | . | 0 | . |
| 1967 | . | . | 34 | 54 |
| 1966 | . | . | 26 | . |
| 1965 | . | . | 0 | . |
| 1964 | . | . | 60 | . |
| 1963 | . | . | 18 | . |
| 1962 | . | 74 | 0 | . |
| 1961 | 12 | . | 71 | . |
| 1960 | 0 | . | 0 | . |
| 1959 | . | . | 89 | . |
| 1958 | . | . | 60 | . |
| 1957 | . | . | 39 | . |
| 1956 | . | . | 31 | . |
| 1955 | . | . | 0 | . |

Appendix B, Cont.

| | Rye | | Irrigated Rye | |
|---|---|---|---|---|
| Series | Crete | Keith | Keith | Ulysses-Richfield |
| Station | Belleville | Garden City | Garden City | Garden City |
| Year | | | | |
| 1972 | . | 34 | 66 | . |
| 1971 | 24 | . | . | 56 |
| 1970 | . | 30 | . | 40 |
| 1969 | . | 21 | . | 34 |
| 1966 | . | 6 | 24 | . |

Soybeans

| Series | Clark-Ost | Ladysmith | Tabler | Kenoma |
|---|---|---|---|---|
| Station | Hutchinson | Newton | St. John | Ottawa |
| Year | | | | |
| 1973 | . | 29 | . | . |
| 1972 | . | . | . | 43 |
| 1971 | 18 | . | . | . |
| 1970 | 9 | . | . | . |
| 1969 | 20 | . | 48 | . |
| 1968 | 22 | . | . | . |
| 1967 | . | . | . | . |
| 1966 | 30 | . | . | . |
| 1965 | 21 | . | . | . |

Appendix B, Cont.

Soybeans

| Series | Crete | Crete | Grundy | Woodson |
|---|---|---|---|---|
| Station | Belleville | Mankato | Powhattan | Ottawa |
| Year | | | | |
| 1977 | 42 | . | . | 27 |
| 1976 | 13 | . | . | 7 |
| 1975 | 6 | . | 31 | 23 |
| 1974 | 27 | . | 28 | 30 |
| 1973 | . | 17 | 41 | 28 |
| 1972 | . | . | 57 | . |
| 1971 | 16 | 13 | 20 | 52 |
| 1970 | 10 | 9 | 39 | 22 |
| 1969 | 38 | 34 | 36 | 51 |
| 1968 | 29 | 12 | 48 | 50 |
| 1967 | 24 | 23 | 34 | 33 |
| 1966 | . | . | 43 | 34 |
| 1965 | 26 | 10 | 43 | . |
| 1964 | 8 | 4 | 28 | . |
| 1963 | 30 | 29 | 38 | . |
| 1962 | 33 | 23 | . | . |
| 1961 | . | . | 31 | . |
| 1960 | 14 | . | 41 | . |
| 1959 | . | . | 31 | . |
| 1958 | . | . | 37 | . |
| 1957 | . | . | 25 | . |

Appendix B, Cont.

| | Soybeans | Irrigated Soybeans | | |
|---|---|---|---|---|
| Series | Keith | Crete | Keith | Ulysses-Richfield |
| Station | Colby | Belleville | Colby | Garden City |
| Year | | | | |
| 1977 | . | 43 | 0 | . |
| 1976 | . | . | 48 | . |
| 1975 | . | 52 | 41 | . |
| 1974 | . | 36 | 32 | . |
| 1973 | . | 45 | 46 | . |
| 1972 | . | . | 38 | . |
| 1971 | . | . | 49 | . |
| 1970 | . | . | 38 | . |
| 1969 | . | . | 50 | . |
| 1968 | 10 | 0 | 30 | . |
| 1967 | 21 | . | 42 | . |
| 1966 | 20 | 38 | 44 | . |
| 1965 | 21 | 27 | 32 | . |
| 1964 | 15 | 44 | 36 | . |
| 1963 | . | 52 | 42 | . |
| 1962 | . | 55 | 40 | 49 |
| 1961 | . | 25 | 34 | 53 |
| 1960 | . | 40 | 36 | 44 |
| 1959 | . | 44 | 33 | 0 |
| 1958 | 0 | . | 0 | . |

Appendix B, Cont.

Irrigated Soybeans

| Series | Muir | Naron | Eudora | Kenoma |
|---|---|---|---|---|
| Station | Manhattan | St. John | Topeka | Ottawa |
| Year | | | | |
| 1977 | . | . | 44 | . |
| 1976 | 44 | . | 54 | . |
| 1975 | . | . | 44 | . |
| 1974 | 41 | . | 35 | . |
| 1973 | . | . | . | . |
| 1972 | . | . | . | 79 |
| 1971 | . | . | . | . |
| 1970 | . | 43 | . | . |

| | Irrigated Soybeans | | Irrigated Sugarbeets (T/A) |
|---|---|---|---|
| Series | Ulysses | Eudora | Keith |
| Station | Garden City | Manhattan | Colby |
| Year | | | |
| 1977 | . | 52 | . |
| 1976 | . | . | 33.6 |
| 1975 | . | 49 | 23.1 |
| 1974 | . | . | 19.8 |
| 1973 | . | 52 | 27.8 |
| 1972 | . | 54 | . |
| 1971 | 44 | 56 | . |
| 1970 | . | 66 | . |
| 1969 | 45 | 60 | . |
| 1966 | 40 | . | . |
| 1965 | 40 | . | . |

Appendix B, Cont.

Wheat

| Series | Carwile | Clark-Ost | Crete | Crete |
|---|---|---|---|---|
| Station | St. John | Hutchinson | Belleville | Hays |
| Year | | | | |
| 1977 | . | . | 43 | 46 |
| 1976 | . | . | 21 | 34 |
| 1975 | . | . | 56 | 40 |
| 1974 | . | 41 | 54 | 22 |
| 1973 | . | 46 | . | 43 |
| 1972 | . | 44 | . | 33 |
| 1971 | . | 54 | 65 | 45 |
| 1970 | . | 46 | . | . |
| 1969 | . | 36 | . | 42 |
| 1968 | . | 45 | 75 | . |
| 1967 | 47 | 29 | 32 | . |
| 1966 | . | 16 | . | . |
| 1965 | 37 | 43 | 38 | . |
| 1964 | . | 38 | 43 | . |
| 1963 | 21 | 32 | 39 | . |
| 1962 | 17 | 36 | 32 | . |
| 1961 | 41 | 48 | 38 | . |
| 1960 | 24 | 39 | 24 | . |
| 1959 | 19 | 44 | 42 | . |
| 1958 | 24 | 38 | 45 | . |
| 1957 | . | 33 | 21 | . |
| 1956 | 12 | 27 | 34 | . |
| 1955 | 17 | 3 | 26 | . |

Appendix B, Cont.

Wheat

| Series | Crete | Farnum | Grundy | Harney |
|---|---|---|---|---|
| Station | Mankato | St. John | Powhattan | Hays |
| Year | | | | |
| 1977 | . | . | . | 53 |
| 1976 | . | . | . | 53 |
| 1975 | . | . | 53 | 52 |
| 1974 | . | . | 61 | 37 |
| 1973 | 61 | . | 57 | 44 |
| 1972 | 40 | . | 62 | 28 |
| 1971 | 63 | 48 | 71 | 38 |
| 1970 | 40 | . | 53 | 45 |
| 1969 | 41 | 49 | 43 | 30 |
| 1968 | 47 | . | 57 | 30 |
| 1967 | 18 | . | 38 | 24 |
| 1966 | . | . | 38 | 0 |
| 1965 | 21 | . | 44 | 36 |
| 1964 | 30 | . | 45 | 23 |
| 1963 | 36 | . | 41 | . |
| 1962 | 27 | . | . | . |
| 1961 | 46 | . | 40 | . |
| 1960 | 33 | . | 40 | . |
| 1959 | 24 | . | 29 | . |
| 1958 | 33 | . | 33 | . |
| 1957 | . | . | 32 | . |
| 1956 | 13 | 12 | . | . |
| 1955 | 18 | . | . | . |

Appendix B, Cont.

Wheat

| Series | Harney | Keith | Keith | Smolan |
|---|---|---|---|---|
| Station | Minneola | Colby | Garden City | Manhattan |
| Year | | | | |
| 1977 | . | 43 | . | . |
| 1976 | . | 51 | . | . |
| 1975 | 48 | 38 | . | . |
| 1974 | 34 | 39 | . | . |
| 1973 | 35 | . | . | 47 |
| 1972 | 45 | 39 | . | . |
| 1971 | 43 | . | . | . |
| 1970 | 29 | 60 | . | 41 |
| 1969 | 37 | . | 49 | 29 |
| 1968 | 10 | 0 | . | . |
| 1967 | 29 | 36 | . | 30 |
| 1966 | 3 | 24 | 5 | 30 |
| 1965 | 48 | . | . | 41 |
| 1964 | 24 | 20 | . | 22 |
| 1963 | 16 | . | . | . |
| 1962 | 29 | 26 | 14 | . |
| 1961 | 37 | . | 45 | . |
| 1960 | 30 | 37 | 48 | . |
| 1959 | 6 | . | . | . |
| 1958 | 21 | . | 31 | . |
| 1957 | 0 | 0 | . | . |
| 1956 | 15 | 9 | . | . |
| 1955 | 11 | . | . | . |

Appendix B, Cont.

Wheat

| Series | Kahola | Ladysmith | Cawker | Wymore |
|---|---|---|---|---|
| Station | Manhattan | Newton | Hays | Manhattan |
| Year | | | | |
| 1975 | . | 38 | . | . |
| 1973 | . | . | 45 | . |
| 1971 | . | . | . | 54 |
| 1968 | 43 | . | . | . |

| Series | Ulysses | Ulysses |
|---|---|---|
| Station | Colby | Garden City |
| Year | | |
| 1965 | 28 | . |
| 1956 | . | 24 |
| 1955 | 32 | 31 |

Appendix B, Cont.

| | Wheat | Irrigated Wheat | | |
|---|---|---|---|---|
| Series | Woodson | Keith | Ulysses-Richfield | Ulysses |
| Station | Ottawa | Colby | Garden City | Tribune |
| Year | | | | |
| 1977 | 39 | 54 | . | . |
| 1976 | 44 | 60 | . | 61 |
| 1975 | . | 47 | . | 59 |
| 1974 | 44 | 50 | . | 57 |
| 1973 | 46 | 66 | . | 53 |
| 1972 | 41 | 38 | 79 | 67 |
| 1971 | 52 | 52 | 65 | 40 |
| 1970 | 29 | 66 | 67 | 82 |
| 1969 | 42 | 63 | 58 | 54 |
| 1968 | 41 | 36 | 34 | 46 |
| 1967 | . | 54 | 58 | . |
| 1966 | . | 60 | 57 | . |
| 1965 | . | 61 | 24 | 57 |
| 1964 | . | 41 | 52 | 53 |
| 1963 | . | 45 | 34 | . |
| 1962 | . | 49 | 33 | . |
| 1961 | . | 14 | . | . |
| 1960 | . | 42 | . | . |
| 1959 | . | 37 | . | . |
| 1958 | . | 47 | . | . |

# APPENDIX C

## WHEAT YIELDS HAVING INSECT, DISEASE OR WEATHER PROBLEMS

<u>Non-irrigated wheat</u>

| | |
|---|---|
| Clark-Ost | 1955, 1966, 1967 |
| Crete (Belleville) | 1957, 1960, 1976 |
| Crete (Hays) | 1974 |
| Crete (Mankato) | 1956, 1959, 1962, 1965 |
| Harney (Hays) | 1964, 1966, 1974 |
| Harney (Minneola) | 1955, 1959, 1966, 1967, 1968 |
| Keith (Colby) | 1957, 1962, 1968 |
| Keith (Garden City) | 1962, 1966 |
| Smolan | 1966, 1969 |
| Woodson | 1970, 1977 |
| Ulysses (Colby) | 1965 |
| Ladysmith | 1975 |

<u>Irrigated wheat</u>

| | |
|---|---|
| Keith (Colby) | 1961, 1968, 1972 |
| Ulysses-Richfield (Garden City) | 1962, 1963, 1965, 1968 |
| Ulysses (Tribune) | 1968, 1971 |

# APPENDIX D

## MAPPING UNITS AND YIELD ESTIMATES FOR RILEY, GEARY, MORRIS, AND CHASE COUNTIES

| Mapping Unit and Slope | Wheat | Grain Sorghum | Capability Class |
|---|---|---|---|
| Alluvial and Reading | 31 | 47 | 6 |
| Benfield-Florence complex 5-20% | 31 | 47 | 6 |
| Breaks-Alluvial land complex | 31 | 47 | 6 |
| Chase silty clay loam | 52 | 94 | 2 |
| Clime-Sogn complex 5-20% | 31 | 47 | 6 |
| Crete silty clay loam 0-1% | 55 | 83 | 2 |
| Crete silty clay loam 4-8% | 52 | 78 | 3 |
| Crete soils, severely eroded | 45 | 68 | 4 |
| Dwight silty clay loam | 45 | 68 | 4 |
| Dwight silt loam 1-3% | 31 | 43 | 4 |
| Dwight-Irwin complex 1-4% | 38 | 62 | 3 |
| Dwight-Irwin complex 1-4%, eroded | 36 | 48 | 3 |
| Farnum fine sandy loam 0-1% | 31 | 47 | 4 |
| Florence cherty clay loam | 31 | 47 | 6 |
| Florence-Labette complex 2-12% | 31 | 47 | 6 |
| Florence-Matfield cherty silt loams | 31 | 47 | 6 |
| Geary silt loam 1-4% | 42 | 63 | 3 |
| Hastings silty clay loam 0-1% | 52 | 78 | 1 |
| Hastings silty clay loam 1-4% | 52 | 78 | 2 |
| Haynie very fine sandy loam | 47 | 57 | 1 |
| Humbarger clay loam and loam | 55 | 67 | 1 |
| Irwin silty clay loam | 45 | 68 | 3 |

Appendix D, Cont.

| Mapping Unit and Slope | Wheat | Grain Sorghum | Capability Class |
|---|---|---|---|
| Irwin silty clay loam 3-5% | 42 | 60 | 3 |
| Irwin silty clay loam 1-4%, eroded | 40 | 61 | 4 |
| Irwin silty clay loam 4-8% | 45 | 66 | 3 |
| Irwin silty clay loam 4-8%, eroded | 39 | 59 | 4 |
| Irwin soils 1-3%, eroded | 39 | 54 | 3 |
| Irwin soils 3-5%, eroded | 35 | 49 | 4 |
| Ivan silty clay loam | 41 | 59 | 2 |
| Ivan and Kennebec silt loams | 48 | 77 | 2 |
| Kahola silt loam | 60 | 110 | 1 |
| Kipson-Sogn complex 3-15% | 31 | 47 | 6 |
| Labette-Dwight complex 1-3% | 38 | 56 | 3 |
| Labette-Sogn complex 2-8% | 31 | 47 | 6 |
| Ladysmith silty clay loam 0-1% | 50 | 68 | 2 |
| Ladysmith silty clay loam 1-4% | 46 | 67 | 3 |
| Ladysmith silty clay loam 1-3% | 50 | 68 | 3 |
| Ladysmith silty clay loam 0-2% | 45 | 63 | 3 |
| Ladysmith silty clay loam 1-2%, eroded | 35 | 55 | 3 |
| Mason and Reading silt loams 0-1% | 57 | 101 | 1 |
| Mayberry clay loam 2-6% | 46 | 72 | 3 |
| Muir silty clay loam | 40 | 65 | 3 |
| Olpe-Smolan complex | 31 | 47 | 6 |
| Osage silty clay | 42 | 70 | 3 |

Appendix D, Cont.

| Mapping Unit and Slope | Wheat | Grain Sorghum | Capability Class |
|---|---|---|---|
| Reading silt loam 0-1% | 58 | 103 | 1 |
| Reading silt loam 1-3% | 53 | 90 | 2 |
| Shellabarger sandy loam 4-8% | 41 | 62 | 4 |
| Shellabarger sandy loam 8-20% | 31 | 47 | 6 |
| Smolan silty clay loam 4-8%, eroded | 40 | 72 | 3 |
| Sogn rocky clay loam | 31 | 47 | 7 |
| Sogn complex | 31 | 47 | 6 |
| Stony steep land | 40 | 68 | 7 |
| Sutphen silty clay | 40 | 68 | 3 |
| Tully silty clay loam 1-4% | 45 | 78 | 2 |
| Tully silty clay loam 4-8% | 44 | 68 | 3 |
| Tully silty clay loam 8-20% | 31 | 47 | 6 |
| Tully soils severely eroded | 38 | 58 | 4 |
| Tully silty clay loam 3-7% | 44 | 72 | 2 |
| Tully silty clay loam 3-7%, eroded | 37 | 63 | 3 |
| Tully silty clay loam 4-8%, eroded | 40 | 66 | 3 |
| Tully soils 5-15% | 31 | 47 | 6 |
| Wymore silty clay loam 0-1% | 50 | 84 | 2 |
| Wymore silty clay loam 1-4% | 48 | 78 | 2 |
| Wymore silty clay loam 1-4%, eroded | 42 | 70 | 3 |
| Wymore silty clay loam 4-8% | 44 | 72 | 3 |

Appendix D, Cont.

| Mapping Unit and Slope | Wheat | Grain Sorghum | Capability Class |
|---|---|---|---|
| Wymore silty clay loam 4-8%, eroded | 38 | 64 | 3 |
| Zaar silty clay 3-7% | 44 | 68 | 3 |
| Zaar-Dwight | 44 | 58 | 3 |

ASSESSING PRODUCTIVITY OF KANSAS SOILS

by

DAVID DEAN TERRY

B. S., Kansas State University, 1976

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

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Knowledge of the productivity of soils is necessary for farmers, extension personnel, and land investors. Some states, such as Iowa and Illinois, incorporate soil productivity information into their property assessment systems.

The purpose of this study was to collect and analyze yields from soil series across Kansas to estimate physical productivity for major crops. Real estate sale data from four counties in East-Central Kansas were analyzed to determine the effect of soil productivity on sale price.

Both soil and non-soil components of the sale tracts were regressed against sale price per acre for 57 sales within the study area. The study showed that hardsurface roads, date of sale, percent cropland, capability class, and adjusted grain sorghum yields from the Soil Conservation Service soil surveys had the greatest influence on sale price.

Yields were collected from 16 Kansas Agricultural Experiment Stations and Fields across the state to estimate the productivity of the state's soil series. Only yields from performance and variety tests were collected for the period 1955 through 1977. Differences in soil series yield potential were found by analyzing the differences between the means and between individual yearly yields on each series. Regression equations were fitted against the yields of each crop on each series to check for increasing trends in yields. The effects on yields of weather, management practices and disease were removed from the model to observe the effect of soils.

The study showed the soil series to have different yield potentials with the highest values occurring in the northeast where the yields were significantly different from all other soils.

Since 1955 yields slowly have increased in the variety and performance tests. Non-irrigated wheat yields increased linearly with a statewide average increase of almost 1.2 bushels per acre per year. Individual soil series yields showed a similar trend.

Non-irrigated grain sorghum yields showed less uniform change during the study period. Statewide, grain sorghum yields changed curvilinearly, increasing little over the last 15 years. Both linear and curvilinear trends can be observed in individual soil series grain sorghum yields.

The trend in increasing yields on individual series was not as noticeable for grain sorghum as for wheat, and no trends could be found for soybeans. Having only one yearly yield for each soil series greatly limited the ability to predict yields with accuracy, as weather, disease and other factors affecting the small test plots increased the variability about the trend line.

Additional yield information must be collected in order to assign specific potential yield figures to individual soil series in the state.