IRRIGATION PRACTICES AND COSTS IN SOUTHEASTERN MISSOURI - 1959

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PREFACE

This study was designed to help farmers make decisions concerning the place of irrigation in their farming operations. They need two types of information for this purpose. The first deals with the amount of investment required for the equipment; the second with returns in relation to the costs. Since capital is limited on most farms, the expected returns from alternative investment opportunities also must be considered. Investment in irrigation equipment should be made only after the operator has decided that expected returns over a period of years will be equal to or greater than those expected from other investment opportunities.

The need for and the response from irrigation in a humid region are likely to be intermittent. Since fixed costs have to be borne regardless of annual use, the attention of the farmer, who has purchased equipment must be centered upon variable costs. He must compare expected returns from applying water to his crop in a given year with what he reasonably would get if he used the money for another purpose, and irrigate when he expects the returns to be equal to or larger than income from other uses of the money. In the years when the equipment is not used the fixed cost can be regarded as crop insurance.

The analysis presented here is designed to help farmers in both areas of decision making. The 65 farms studied in the Delta Cotton Corn Area owned or controlled irrigation equipment in 1959. Data were obtained that made it possible to determine the cost of installing and operating different types of irrigation systems. The estimated yield response and the variable costs of irrigating corn, cotton, and soybeans also were available. From this information, it was possible to determine the effect of field irrigation on net farm income.

Random weather variations have considerable influence on the responses of crops to irrigation and on the costs of applying water in a given year. The data presented in this study represent irrigation costs and estimated yield responses from 65 farms in one year. This is not sufficient time to justify firm conclusions as to the feasibility of using supplemental irrigation under all price and weather conditions, but the analysis does establish "bench marks" that can be used as a guide in deciding whether or not to invest in irrigating equipment.

CHAPTER I

INTRODUCTION

Farmers as well as extension and research personnel of the Land Grant Colleges and the United States Department of Agriculture have become increasingly interested in irrigation in the humid areas of the United States. The primary reason has been reductions in crop yields in extremely dry years. Periodic shortages of natural moisture have encouraged the use of supplemental irrigation in an effort to maintain satisfactory levels of income where water has been available. Furthermore, the technological advances, which have been made in crop varieties, in the use of fertilizers, and in irrigation equipment, have lowered the cost of applying irrigation water per unit of output and stimulated a persistent demand for information related to the use of supplemental irrigation for reducing the risk and uncertainty of crop production.

As the interest in irrigation increased, the need for basic data concerning its use also increased. The information desired included specific data on response of different crops, most satisfactory types of equipment to use, amount of investment required and factors influencing costs in relation to returns. Most farm operators have limited capital to invest in their businesses. If it is put into irrigation equipment, alternative uses must be postponed for the present time or indefinitely.

Whether or not to irrigate land is a managerial decision that must be made by each farm operator. Several types of information are needed. They include: (1) the quantity and quality of water available; (2) the cost of installing equipment and distributing water on the land; (3) the additional yield that can reasonably be expected from each type of crop; (4) frequency of need for supplemental water, and (5) additional returns in relation to costs. This information was not available for Missouri farmers, yet many of them had acquired and were using irrigation equipment. In order to take advantage of the experiences of these farmers, this and several other studies were initiated.

I. OBJECTIVES OF THE STUDY

The investigations in Missouri were guided by the following objectives:

1. To determine the costs of installing and operating various types of irrigation systems.
2. To determine the changes in yield and quality of product obtained from various quantities of water applied to specific types of crops.
3. To determine the effects of irrigation on farm

income.

Need for the Study

For several years, the farmers of Missouri have used supplemental irrigation as a means of increasing production, stabilizing yields, improving the quality of their products, and reducing the risk and uncertainty incident to variable weather conditions. Natural moisture conditions fail to meet optimum requirements for crops at some time during the growing season in most years. According to the 1954 U. S. Census of Agriculture, Missouri farmers applied water to 1,113 acres in 1944 and 33,314 acres in 1954. Additional reports indicated that irrigation continued to expand within the state up to 1956. After that date, the total irrigated acreage and the number of farmers applying water to their crop declined. The primary reason for the decline was a more nearly uniform distribution of rainfall throughout the growing season.

The investigation reported in this manuscript covers the second part of a two-phase study. The first was concerned with the nature and extent of irrigation in Missouri.[1] During the initial phase, information was

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[1]Ted L. Jones and Frank Miller, Nature and Extent of Irrigation in Missouri, University of Missouri Agricultural Experiment Station Research Bulletin 735, April 1960.

obtained by mail questionnaire to indicate the types of crops receiving water and the acreages irrigated in the various areas of the state, sources of supply, and types of distribution systems used. Information was obtained for the years 1954 to 1958.

Only limited information was available concerning costs and returns that could be expected when water was applied to crops and no effort was made to get data of this type in the first round of inquiry. The study reported here deals with costs and returns in the southeastern delta area where most of the irrigation water is used.

II. THE ECONOMICS OF IRRIGATION

Field crops have been produced commercially in the humid areas of the United States for many years without the use of irrigation. In a static economy, irrigation probably would never have been introduced. The tremendous technological changes that have taken place in the production and marketing of agricultural products within the last 40 years have increased the investments in farm businesses greatly and brought on a diligent search for methods that can be used to reduce unit costs and stabilize farm incomes. Farm tractors and other machinery, commercial fertilizer, superior crop varieties, and portable irrigation equipment are only a few innovations that have been introduced. Naturally, questions have arisen as the specific conditions under which these new practices and devices profitably can be used.

In this study, the assumption is made that farm operators act rationally in the economic sense. Therefore, the maximization of family satisfaction is the goal toward which they are working. The desire for increased farm income is consistent with this assumption. Total family satisfaction will increase as farm income increases up to the point where the efforts expended become less satisfying than leisure. If the assumption is made that most farm families have not attained a flow of income so great that further efforts to increase it would conflict with maximization of satisfaction through other activities or through no effort at all (leisure vs. work), then the conclusion is logical that the adoption of such innovations as irrigation, is an attempt to increase earnings.

Irrigation requires relatively large investments, regardless of the type of system used. Consequently, the annual fixed cost is high. In addition, the use of an irrigation system leads to variable costs such as wages for labor, fuel, and repairs.

Since most farm operators do not have unlimited capital, a choice must be made between two or more alternative uses. Here opportunity costs become the guide.

Before the decision is made to invest in irrigation equipment, the income that might be obtained by putting the money into some alternative use needs to be considered. The choice to buy the equipment should be based on rejection of the second best available alternative use of the funds. After the decision has been reached and the capital investment has been made, the capital is fixed or sunk for a given period of time. Where a well is used as a source of water, its cost can be recovered only through use or sale of the land at a higher price, because the well is there ready for use. Moveable equipment can be sold. If the assumption is made that the fixed capital cannot be recovered for a given period of time, then only the variable costs should be considered. The opportunity cost after acquisition of the water distributing system is the amount of farm income that will be foregone if the value or amount of variable costs needed is placed in uses other than with the fixed capital investment in the irrigation equipment.

Irrigation in the humid areas may not be required every year due to fluctuations in the amount and distribution of rainfall. Because of this fact, yield response will vary from year to year. Fixed costs will be an annual charge, while variable costs will be incurred only when the irrigation system is used. If, over time, investments in irrigation are to be profitable, the yield response in dollar terms during the years of use must exceed the fixed and variable costs incurred throughout the total period, including the years when water is not applied to crops.

Farm operators who irrigate crops in humid regions face difficult managerial decisions. They must decide what crop will receive the water, when, and how much will be applied. In a given year, the guide is marginal cost and marginal returns. Water should be applied up to the point where the cost of an additional unit (acre inch) is equal to the value of the additional output of product resulting from use of the water. The stand of the crop, the level of plant nutrients in the soil, the presence or absence of weeds, temperature, relative humidity, subsequent rainfall and many other factors influence response. No method or technique is known which will inform the operator when the equimargin is reached. However, the farm operator must act as if he has perfect knowledge of all these factors.

III. METHOD OF INVESTIGATION

Data for this analysis were obtained from farmers who owned or controlled irrigation equipment in Dunklin, Pemiscot, New Madrid, and Mississippi Counties. An earlier study had shown that the greatest concentration of irrigation was in this region. A list of 186 farmers who owned or controlled irrigation equipment was compiled from information furnished by County Agents, Soil Conservation personnel, well-drillers, and irrigation equipment dealers. Each farmer was given an identification number and 65 drawn from the list with the aid of tables of random numbers. Each farm operator chosen by this procedure was interviewed three times during 1959. The first interview was made in May and June. The investment in irrigation equipment, and other basic information was obtained during this interview. The second interview was conducted in August and September and operating costs obtained. The third and final interview was made in December to secure estimated yield responses.

IV. SUMMARY OF RELATED RESEARCH

Thorfinnson and others obtained irrigation data from 76 farmers in the Blue River Watershed Area of Nebraska for the 1952 season.[2] The report of findings included a brief description of 3 systems of water distribution, but it dealt specifically with the relative cost of operating them. The average investment in irrigation equipment per acre irrigated was $11.00 for the siphon tube method,

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[2] T. S. Thorfinnson, Meryl Hunt and A. W. Epp, Cost of Distribution of Irrigation Water by Different Methods, University of Nebraska College of Agriculture Experiment Station Bulletin 432, August 1955, pp. 3, 5-6.

$46.00 for gated pipe, and $67.00 for sprinkler equipment. The number of man hours of labor required for one irrigation per acre of corn was 0.90 for siphon tubes, 0.71 for gated pipe, and 1.41 for sprinklers. Operating costs were least for siphon tubes and most for sprinklers when only labor, repairs for equipment, and power needs were considered. When depreciation, interest, and taxes were included, the total cost was $1.29 per acre for one irrigation with siphon tubes, $2.56 with gated pipe, and $7.70 for sprinklers.

Puterbaugh and Kottke[3] studied 167 irrigating units in Connecticut in 1957. They found the greatest interest in additional irrigation was among dairy farmers. When a budgeting analysis of costs and returns from irrigating hay and pasture on a typical dairy farm was made, supplemental irrigation in combination with other good farming practices was found to be profitable over a period of years. Water was obtained from a stream. The analysis, which included no costs for developing a source of water, led to the following conclusions:

1. Variable costs of operating an irrigation system

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[3]Horace L. Puterbaugh and Marvin W. Kottke, Technical and Economic Characteristics of Irrigation on Connecticut Farms, University of Connecticut Storrs Agricultural Experiment Station Bulletin 340, March 1959, pp. 1-2.

in a given year make up a relatively small part of the total costs, especially when additional labor is not hired.

2. Yield responses from irrigation in a given year need not be substantial to permit greater additional returns than variable costs.

3. Yield responses would probably have to be greater than 0.5 ton of hay equivalent per acre for the additional returns to exceed the fixed costs of equipment as well as the variable costs of applying the water.

4. Variations in rainfall reduce the need for irrigation in some years and lead to the need for intensive use of water in other years. The yield response of forage crops probably will have to be as much as 1.5 tons per acre in the years of intensive irrigation to offset losses from fixed costs in the years when irrigation is not needed.

Davis[4] found that adequate rainfall in 1957 and 1958 reduced the average acreages of irrigated field crops from

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[4] Velmar W. Davis, Irrigation in Illinois, 1954 to 1958, University of Illinois College of Agriculture in Cooperation with Farm Economics Research Division, Agricultural Research Service, United States Department of Agriculture AERR-33, July 1960, pp. 1-2.

45 in 1956 to 33 in 1957 and to 6 in 1958. Only 13 of 77 field crop irrigators used their systems in 1958. The adequate rainfall in 1958 not only caused fewer farmers to use irrigation, but generally fewer irrigations per crop were made and smaller quantities of water applied per irrigation. Estimated yield response of corn from irrigation decreased from 38 bushels in 1957 to 21 bushels in 1958.

Forty field crop irrigators[5] reported an average investment of $7,433 per farm, or $86 per acre based on 86 acres irrigated per farm. The $86 per acre included the following items: distribution system, $51; pump and power unit, $23, and water source, $12. Pipe, fittings, and sprinklers were the chief items of capital investment on nearly all farms. The average investment per farm was $4,406 in distribution equipment; $1,976 in pump and power unit, and $1,051 in source of water.

One hundred and thirty-two central Nebraska farmers had an average investment in well, pump, power unit, and sprinkler equipment of $11,265 per farm and $9,822 per well in 1957.[6] Approximately one-half of the investment

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[5]Ibid.

[6]T. S. Thorfinnson, Norris P. Swanson and A. W. Epp, Cost of Distributing Irrigation Water by the Sprinkler Method, University of Nebraska Agricultural Experiment Station Bulletin SB455, March 1960, pp. 3-4.

was for sprinkler equipment, including main lines, sprinkler lines, risers, nozzles, fuel tanks, gas lines, booster pumps, and booster engines. The other one-half was invested in wells, pumps, and power units.

The cost per irrigated acre averaged $12.95 for all crops.[7] For milo, on which 6.7 acre inches of water were applied, the cost was $11.04 per acre; on corn, $15.40 per acre with 8.7 inches applied, and on alfalfa, $13.81 with an average of 9 inches applied. From 40 to 50 per cent of the total was made up of depreciation, taxes, and interest. The remainder was variable costs such as fuel, repairs on equipment, and wages to labor used in moving the equipment.

The cost of distributing water varied widely among farms. Many factors were responsible. Among them were the number of acres irrigated, the quantity of water applied during the season, the kind of fuel used in the power unit, efficiency of the pumping plant, design of the sprinkler system and the extent of irrigation as related to the capacity of the plant.[8]

Two hundred and six farm records covering the 1956-1958 growing seasons in three Delaware counties were

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[7]<u>Ibid</u>.

[8]<u>Ibid</u>.

analyzed.[9] The total investment in facilities, including source of water, ranged from $6,281 per farm ($481 per acre, on farms with less than 25 irrigated acres) to $21,096 per farm ($97 per acre on farms with 150 or more irrigated acres). As the number of irrigated acres increased, investment per acre decreased. Fixed cost per acre on farms with less than 25 acres irrigated averaged $51.18 per acre as compared to $8.84 on farms with 150 or more irrigated acres. Average variable costs ranged from $19.90 per acre for farms with less than 25 acres to $6.90 per acre for farms with 150 or more irrigated acres. Total irrigation costs per acre averaged from $71.08 per acre for farms with less than 25 irrigated acres to $15.74 per acre for farms with 150 or more irrigated acres.

The increased yield per acre that is necessary to pay for irrigation costs varies from year to year.[10] This situation exists because of variations in the following items: (1) number of acres irrigated per farm; (2) number of irrigations per year; (3) total amount of water applied; (4) price per unit of labor and supplies, and (5) price

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[9] W. G. Smith, W. E. McDaniel and E. N. Scarborough, Irrigation in Delaware, University of Delaware Experiment Station Technical Bulletin 335, July 1960, pp. 2-3, 7.

[10] Ibid.

received per unit for the crop produced. Farms having less than 25 irrigated acres required 19.30 cwt. of potatoes in 1956 and 50.78 cwt. in 1958 to pay for total costs of irrigation or a difference between years of 31.48 cwt. The difference in requirements for the same years for farms irrigating a total of 150 acre or more was only 5.73 cwt., (4.58 cwt. in 1956 and 10.31 cwt. in 1958).

Henderson stated that one ofthe most important factors determining the success of an irrigation enterprise was management. The management required for irrigated farming differed from that needed for dryland farming. It appeared that timing of operations and attention to details became much more important.[11] Careful attention had to be given to adequate fertilization, planting and cultivation methods, amount and variety of seed, and good distribution of water.

One of the principal advantages of irrigation, Henderson found, was that it required and permitted an operator to exercise managerial ability through the use of fertilizer, timing of water application, amount and variety of seed used, and other details that influence crop yields.

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[11]Philip A. Henderson, Will It Pay to Irrigate Corn?, University of Nebraska College of Agriculture Extension Service E. C. 57-805, August 1957, p. 3.

The dryland farmer may find that any efforts on his part to exercise managerial ability is completely overshadowed by the limitations imposed by lack of moisture.

Thomas and Slater[12] made a detailed study of sprinkler irrigation practices on 23 farms in 6 Southwestern Indiana counties in 1955. They found that fixed costs averaged 61 per cent and variable costs 39 per cent of the total irrigation costs. The total cost of applying an acre inch of water averaged $6.08. Fixed, variable, and total irrigation costs per acre inch of water applied decreased with increased use of the system.

Irrigating corn was profitable on 9 of the 23 farms when total costs were considered. Returns to irrigation exceeded variable costs on 16 farms. In general, unit irrigation costs tended to be lower on farms that used the system extensively, or that had systems requiring low capital investment and made relatively heavy applications per irrigation.[13]

V. IRRIGATION IN SOUTHEASTERN MISSOURI

The description of the area where data were obtained

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[12] D. Woods Thomas and G. R. Slater, Irrigation - Costs and Returns, Southwestern Indiana, 1955, Purdue University Agricultural Experiment Station Research Bulletin 668, August 1958, pp. 2-3.

[13] Ibid.

for this study is presented in Chapter II. It includes type of soil, climate, water supply, and economic characteristics. Chapter III covers the characteristics of the farms in the sample, including such items as size, tenure, types, capacities and fixed investment in irrigation equipment, sources of credit, kinds of crops irrigated, and number of irrigations. Chapter IV contains the costs and returns attributable to irrigation in 1959. The data are presented so costs and returns by different methods of applying water, and the effect of irrigation upon net farm income can be determined. The summary and conclusions are presented in Chapter V.

CHAPTER II

DESCRIPTION OF THE AREA

The records for this study were obtained from Dunklin, Pemiscot, New Madrid, and Mississippi Counties in the Delta Corn and Cotton Area of the state (Figure 1). The four counties encompass approximately 1,357,440 acres. New Madrid County is the largest with approximately 434,560 acres, of which 84.2 per cent was in farms in 1959. Dunklin is second with 347,520 total acres and 89.2 per cent in farms. Approximately 92.8 per cent of the 312,230 acres in Pemiscot County was in farms in 1959. The smallest of the four, Mississippi County, contains approximately 263,040 acres, of which 86.6 per cent was in farm land in 1959.[1] Crop production is the dominant enterprise in the area with cotton, soybeans, and corn the major crops produced.

Soils

The soils are of alluvial origin, but they show extreme variations in texture, profile and drainage. The deposits from which they were derived were largely laid

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[1]United States Bureau of the Census, 1959 Census of Agriculture-Preliminary: Missouri, United States Government Printing Office, Washington, D. C., September 1960.

FIGURE 1 - SOUTH EASTERN MISSOURI COUNTIES WHERE IRRIGATORS WERE INTERVIEWED, 1959

down by the Mississippi and other large rivers and are of complex origin. It is difficult to find even a ten acre field which is of the same character throughout. Sandy spots or streaks are common even in the prevailingly heavier soils while the sandy soil areas are interlaced with swales of lower lying silts and clays. This extreme variability makes a general classification of the Southeastern Missouri soils very difficult.[2] The dominant series are Sharkey clay loam, Sarpy fine sandy loam, Lintonia fine sand, Waverly and Knox silt loams (Figure 2).

Sharkey clay loam is the dominant soil type in the four county area. It forms the belt of heavy soil extending from Cape Girardeau County through the Center of the area to the Arkansas state line.[3] Sharkey is a dark gray clay soil with a clay subsoil which hinders its permeability to air and water. The topography is flat and both surface and internal drainage are problems. Sharkey clay loam was classed as medium cropland in the description of soils in Appendix Table A-I.

Sarpy fine sandy loam represents the frontal land

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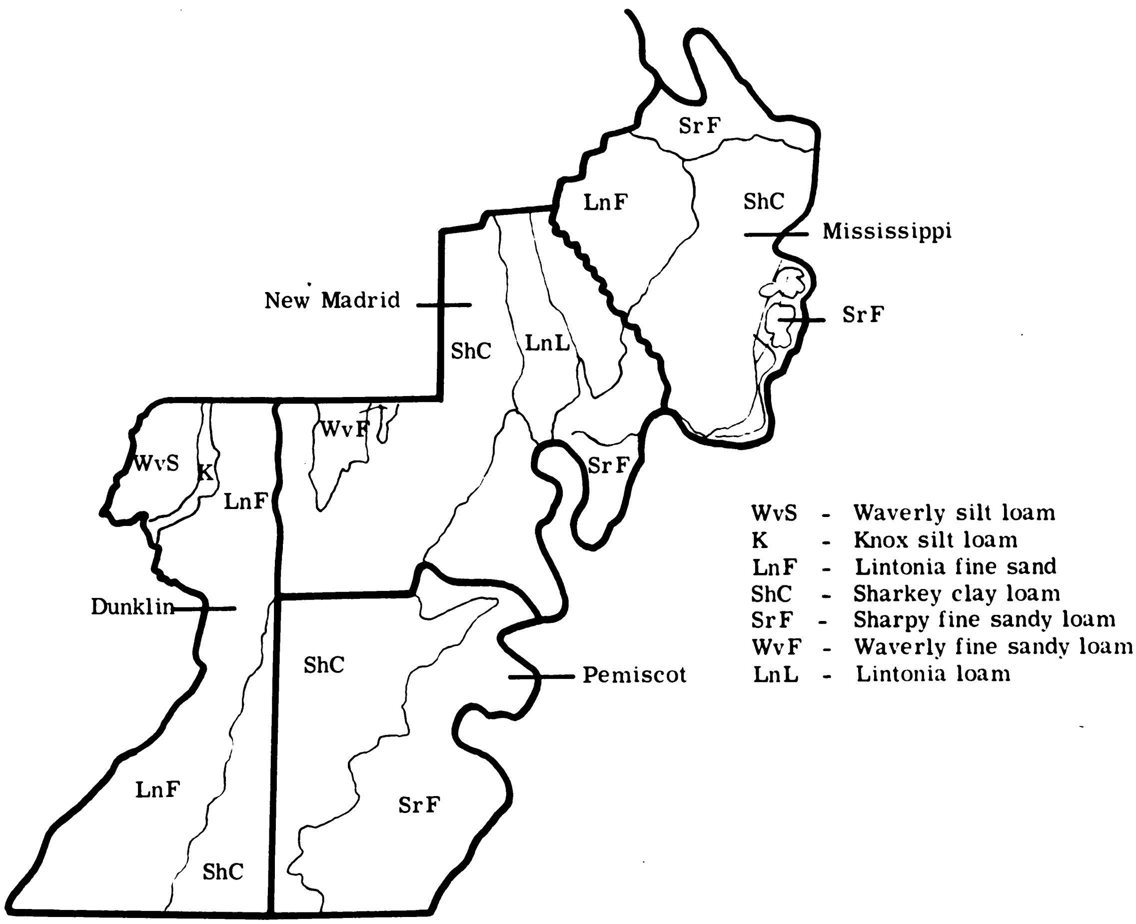
[2] M. F. Miller and H. H. Krusekopf, The Soils of Missouri, University of Missouri College of Agriculture, Agricultural Experiment Station Bulletin 264, January 1929, pp. 95-98.

[3] Ibid. pp. 106-109.

FIGURE 2
GENERALIZED SOIL MAP OF DUNKLIN, PEMISCOT, NEW MADRID, AND MISSISSIPPI COUNTIES



along the Mississippi River in Pemiscot, New Madrid and parts of Mississippi County.[4] The texture ranges from fine sand to very fine sandy loam, with areas of loam, silt loam, and some clay. The light soil and sandy substratum facilitate internal drainage. Sarpy fine sandy loam is the most productive land in the area. It has been placed in class I which is superior crop land (Appendix Table A-I).

Lintonia fine sandy loam occupies two separate area (Figure 2).[5] One is in Dunklin County where it varies from four to six miles wide in the northern part and from twelve to fourteen miles wide in the southern part. The other includes parts of Mississippi and New Madrid Counties. The soil is dominantly a fine sandy loam, but it has areas of fine sand and silt loam included in it. The topography varies from almost level in Dunklin County to undulating in Scott County. Surface drainage and permeability to air and water are good. It has been classed as good crop land.

Lintonia loam forms Sikeston Ridge, which extends from near the center of Scott County to the town of New

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[4]*Ibid*. pp. 98-101.

[5]*Ibid*. pp. 103-106.

Madrid.[6] The surface soil is variable, and ranges from a brown or grayish silt loam or fine sandy loam to a depth of ten to fifteen inches. Lintonia loam represents outwash from the loessial hills, probably in Scott and Cape Girardeau Counties. Due to the relatively higher elevation and sandy substratum, both surface and underdrainage are good. It has been classed as good crop land.

The Lintonia loam area was settled early in the history of the state. A large share of the soil type was divided into grants which were donated to early settlers during the Spanish regime.[7]

Climate

The area has a humid continental climate. The average annual precipitation is approximately 50 inches, which is the highest in the state.[8] Precipitation is greatest in January, March, and April.[9] The average growing season is 210 days. The first parts of June, July,

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[6]Ibid. pp. 101-103.

[7]Ibid.

[8]Climate and Man, Yearbook of Agriculture, 1941, United States Department of Agriculture, U. S. Government Printing Office, pp. 550-554.

[9]Wayne L. Decker, Monthly Precipitation in Missouri, University of Missouri Agricultural Experiment Station Bulletin 650, March 1955, pp. 38-39.

and August are periods of low-dry-weather risk, but early May, late June, July and August have high frequencies of dry periods.[10] From the standpoint of crop production, lack of moisture during the growing season often is critical. Also the area has more dry periods lasting three and four weeks than other areas of the state, except East Central Missouri.[11]

<u>Water Supply for Irrigation</u>

The area appears to have an unlimited supply of water for irrigation. Wells, from 80 to 125 feet in depth, have supplied farmers with sufficient water for all irrigation needs.[12] However, it should be kept in mind that only a small percentage of the farmers have used water for irrigation. Whether the supply would be adequate, if all farmers were irrigating intensively, is unknown.

I. ECONOMIC CHARACTERISTICS

<u>Early Settlement</u>

The first white settlement in the area was made in

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[10] Wayne L. Decker, <u>Chances of Dry Periods in Missouri</u>, University of Missouri Agricultural Experiment Station Bulletin 707, June 1959, pp. 10-11.

[11] <u>Ibid</u>.

[12] Ted L. Jones and Frank Miller, <u>Nature and Extent of Irrigation in Missouri</u>, University of Missouri Agricultural Experiment Station Research Bulletin 735, May 1960, pp. 29-31.

the Winter of 1786-87 by two Frenchmen, Francois and Joseph Lesieur in the New Madrid district. The brothers established a post to trade with the Delaware Indians. In a short time, the small settlement was one of the best trading points in the country west of the Mississippi River.[13] Administrative control was under the Spanish Government at this time.

The first American settlers came into the district in 1789. A group of fifty or sixty American immigrants, under the leadership of a Colonel George Morgan, arrived to establish a city. Colonel Morgan had obtained a grant of 12,000,000 to 15,000,000 acres from the Spanish Government. Colonel Morgan did not establish the city as the Spanish governor, Miro, stripped the concession from him before the city could be built. Colonel Morgan soon left the area, but several of the American families remained to establish homes and farms.[14]

The first town in the area was New Madrid. It was laid out by Pierre Foucher, the first Commandant, in 1789. The Mississippi River has destroyed the original site, thus the New Madrid of today has nothing about it to

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[13] Goodspeed's History of Southeast Missouri, Goodspeed Publishing Company, 1883, pp. 284-291.

[14] Ibid.

suggest its origin.

As the Indians moved from the area, the settlers turned their attention to crop production. Cotton was grown extensively from 1800 to about 1820, in New Madrid County. It was then abandoned until after the close of the Civil War. Corn and wheat were produced extensively.[15] The area possesses no minerals of commercial value. Its wealth lies solely in the agricultural and timber resources.[16]

New Madrid County was organized from the New Madrid district in 1812. Dunklin and Mississippi Counties were organized in 1845. Pemiscot County was organized just prior to the Civil War in February, 1861.[17] The population of the area was slightly over 2,100 when New Madrid County was organized (Table I). It increased slowly until the 1840's, then more than doubled by 1850. The population peak was reached at 154,750 in 1940. There was a net decrease of 1,802 persons during the 1940's.

Drainage was necessary before the area could become highly productive for agricultural purposes. The first

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[15] Ibid. p. 199.

[16] Ibid.

[17] Ibid. pp. 176-181.

TABLE I

POPULATION OF DUNKLIN, PEMISCOT, NEW MADRID AND MISSISSIPPI COUNTIES, 1810–1950[a]

Year	Number of People
1810	2,103
1820	2,445
1830	2,351
1840	4,554
1850	9,884
1860	18,501
1870	19,380
1880	30,867
1890	40,493
1900	56,938
1910	83,932
1920	97,447
1930	119,107
1940	154,750
1950	152,948

[a]Data for 1810 to 1880 from Tenth Census of the United States, Volume I, pp. 68–69. Data for 1890 to 1910 from Thirteenth Census of the United States, Volume II, pp. 1074–1082. Data for 1920 from Fourteenth Census of the United States, Volume III, pp. 554–58. Data for 1930, 1940 and 1950 from United States Census of Population, 1930, Volume III, Part 1, pp. 1,339–1,370; 1940, Volume II, part 4, pp. 368–69; and 1950, Volume II, part 25, pp. 123–36.

dredge work in Southeastern Missouri was started about 1896 in New Madrid County. Approximately 7 years later, drainage work was started in several other counties, and ditches were constructed to drain approximately 400,000 acres. In 1907, the Little River drainage district was organized. This was the largest drainage project in the world outside of Holland up to that time. It was designed to drain an additional 500,000 acres of land.[18]

Economic Characteristics

Agriculture has remained the major industry of the area up to the present time (Table II). In 1930, 71.5 per cent of the people employed were engaged in agriculture. The percentage had decreased to 58.1 per cent in 1950, but agricultural workers were still the most prominent group. The percentage of people employed by wholesale and retail stores has steadily increased from 6.8 to 9.4 to 13.6 per cent in 1930, 1940, and 1950, respectively. This group was second in importance to agricultural workers. Manufacturing was third in 1930, but was replaced by service groups in 1940 and 1950.

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[18] A. T. Sweet, C. J. Mann, H. H. Krusekopf, E. S. Vanalta, and H. G. Lewis, Soil Survey of Pemiscot County, Missouri, United States Department of Agriculture, Bureau of Soils, Government Printing Office, 1912, pp. 29-31.

TABLE II

SOME CHARACTERISTICS OF THE POPULATION BY SEX IN DUNKLIN, PEMISCOT, NEW MADRID AND MISSISSIPPI COUNTIES, 1930, 1940, AND 1950

Item	1930[a]		1940[b]		1950[c]	
	Male	Female	Male	Female	Male	Female
	Number		Number		Number	
Total Population	62,115	56,992	80,154	74,595	77,490	75,458
Percentage:	Per cent of total		Per cent of total		Per cent of total	
14 years of age & over	63.3[d]	61.7[d]	68.8	67.6	64.8	65.7
In labor force	-	-	54.9	10.0	49.9	11.4
Employed in industry	56.3	8.3	44.9	8.0	44.2	10.2
Employed in W.P.A.	-	-	5.1	.8	-	-
Unemployed	-	-	4.9	1.1	3.7	1.2
	Number		Number		Number	
Total number employed in industry	34,979	4,724	35,991	5,983	34,223	7,731
Percentage in:	Per cent of total		Per cent of total		Per cent of total	
Agriculture	71.5	29.3	69.1	12.4	58.1	14.2
Forestry & mining	1.3	-	.2	-	.2	-
Construction	1.8	-	3.1	-	5.4	.3
Manufacturing	6.2	9.0	5.9	23.1	6.3	16.4
Transportation & communication	3.6	1.7	2.8	1.3	3.4	2.1

TABLE II (Continued)

Item	1930[a] Male	1930[a] Female	1940[b] Male	1940[b] Female	1950[c] Male	1950[c] Female
Percentage in:	Per cent of total		Per cent of total		Per cent of total	
Public utilities	.9	.8	.3	.2	.9	.5
Wholesale & retail trade	6.8	8.8	9.4	13.5	13.6	23.7
Service	4.4	49.1	6.6	44.3	8.9	35.6
Public administration	.9	.4	1.3	2.6	1.6	2.8
Other	2.6	.9	1.3	2.6	1.6	4.4

[a]United States Census of Population, 1930, Volume III, part I, pp. 1,339-1,370.

[b]United States Census of Population, 1940, Volume II, part 4, pp. 368-369.

[c]United States Census of Population, 1950, Volume II, part 25, pp. 123-136.

[d]Over 15 years of age.

__Agriculture__

In the early period of agricultural development, farms were small, reflecting the high labor requirement of the principal cash crop which was cotton. Cotton still brings more money into the area than any other crop, but the trend is toward mechanization thus releasing labor from agriculture and making larger operating units necessary. The number of farms decreased 21.8 per cent from 1950 to 1954. By 1959, an additional 24.8 per cent of the farm operators had quit farming. Farm businesses were being reorganized into larger, more efficient units in an attempt to lower the cost of production per unit of output. The average size was 91.4 acres in 1950, 111.6 acres in 1954, and 163.7 acres in 1959, an increase of 79.1 per cent from 1950 to 1959.

Farm assets were increasing in value throughout the 1950's. The value of land and buildings averaged $14,048 per farm in 1950, $18,991 in 1954, and $38,714 in 1959. The average value of land and buildings per farm was 175.6 per cent greater in 1959 than 1950. The average price per acre was $274.09 in 1959 as compared to $154.15 in 1950 an increase of 77.8 per cent in the ten-year period. (Table III).

The census definition of a commercial farm was changed in 1959 from that used in 1950 and 1954. However,

TABLE III

NUMBER, AVERAGE SIZE OF FARM, AND VALUE OF LAND AND BUILDINGS IN FOUR SOUTHEASTERN MISSOURI COUNTIES, 1950, 1954, AND 1959[a]

	Number of Farms			Average Size of Farm (Acres)		
County	1950	1954	1959	1950	1954	1959
Dunklin	3,313	2,605	2,252	90.8	103.4	137.7
Pemiscot	3,347	2,794	1,844	81.3	96.0	151.2
New Madrid	3,857	2,865	2,108	89.1	116.8	173.5
Mississippi	1,879	1,435	1,085	115.1	146.4	209.8
Total	12,396	9,699	7,289			
Average				91.4	111.6	163.7
Percentage Change From:						
1950 to 1954		-21.8			+22.1	
1954 to 1959			-24.8			+46.7
1950 to 1959			-41.2			+79.1

[a]Data for 1950 and 1954 from Census of Agriculture, Volume 1, Part 10, pp. 47-51. Data for 1959 from 1959 Census of Agriculture - Preliminary Report, By Counties.

TABLE III (Continued)

Value of Land and Buildings Dollars					
Average Per Farm			Average Per Acre		
1950	1954	1959	1950	1954	1959
14,511	20,537	35,008	155.41	204.17	249.37
15,500	20,334	44,239	188.16	237.84	323.82
12,165	17,673	35,870	150.24	191.79	280.25
14,510	16,203	42,541	115.83	141.51	234.57
14,048	18,991	38,714	154.15	196.52	274.09
	+35.2			+28.5	
		+104.4			+39.5
		+175.6			+77.8

the reduction in number of farms due to the change in definition was only .88 per cent or 86 farms in the four county area. For 1954, each place operated as a unit of 3 or more acres on which the value of the farm products produced totaled $150 or more, as well as each place of less than 3 acres from which the value of all agricultural products sold totaled $150 or more was counted as a farm. For 1959, each place operated as a unit of 10 or more acres from which the sale of agricultural products totaled $50 or more, as well as each place operated as a unit of less than 10 acres from which the sale of agricultural products totaled $250 or more, was called a farm.[19] Commercial farms are divided into six groups on the basis of total value of products sold. The class intervals for 1954 and 1959 are as follows:

	1954	1959
Class I	$25,000 or more	$40,000 or more
Class II	10,000 to 24,999	20,000 to 39,999
Class III	5,000 to 9,999	10,000 to 19,999
Class IV	2,500 to 4,999	5,000 to 9,999

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[19]United States Bureau of the Census, 1959 Census of Agriculture - Preliminary: 1959, Missouri, Farms, Farm Characteristics, Farm Products, Washington 25, D. C. September 1960.

	1954	1959
Class V	$ 1,200 to 2,499	$ 2,500 to 4,999
Class VI	250 to 1,199	50 to 2,499

The 1954 commercial farm class I and II were equivalent to 1959 classes of I and II and III. The 1954 classes III and IV were comparable to 1959 classes IV and V. The 1954 classes V and VI are comparable to 1959 class VI.

The total number of commercial farms decreased 20 per cent from 1950 to 1954 (Table IV). The number of farms in class I, II, and III increased as the number in classes IV, V, and VI decreased. Class I had the largest increase with 36 per cent, while class VI had the greatest decline, a decrease of 74 per cent from 1950 to 1954. The number of commercial farms in 1959 is shown in Table IVa, which is based on the 1959 definition. When the 1950 and 1954 classes were changed to conform with the 1959 definition, the number of commercial farms decreased 43 per cent as shown in Table IVb. The number of farms selling the greatest amounts of farm products increased as the total number decreased.

The number of farms of 180 or more acres has increased as smaller farms have decreased (Table V and Figure 3). The increase from 1950 to 1959 in the 180-256 acre group was 23 per cent; in the 260-499 group, 66 per cent; 500-999, 100 per cent; and 1,000 or more, 95 per

TABLE IV

NUMBER OF COMMERCIAL FARMS IN FOUR SOUTHEASTERN MISSOURI COUNTIES, 1950-1954[a]

County	Year	Commercial Farms I	II	III	IV	V	VI	Total
Dunklin	1950	112	450	851	915	518	237	3,083
	1954	50	430	750	680	320	110	2,340
Pemiscot	1950	66	261	790	886	788	252	3,143
	1954	182	585	795	780	315	65	2,722
New Madrid	1950	103	380	808	1,106	974	318	3,689
	1954	150	480	1,020	850	355	35	2,890
Mississippi	1950	46	198	358	443	580	166	1,791
	1954	63	290	290	420	260	40	1,363
Total	1950	327	1,389	2,807	3,350	2,860	973	11,706
	1954	445	1,785	2,855	2,730	1,250	250	9,315
Percentage Change From								
1950 to 1954		+36	+29	+2	-19	-56	-74	-20

[a]Data from 1954 Census of Agriculture, Missouri, pp. 83-87.

TABLE IVa

NUMBER OF COMMERCIAL FARMS IN FOUR SOUTHEASTERN MISSOURI COUNTIES, 1959[a]

	Commercial Farms Class[b]						
County	I	II	III	IV	V	VI	Total
Dunklin	76	266	605	610	340	120	2,017
Pemiscot	164	220	470	345	365	120	1,684
New Madrid	122	323	475	505	445	160	2,030
Mississippi	83	147	200	225	180	120	955
Total	445	956	1,750	1,685	1,330	520	6,686

[a]Data from 1959 Census of Agriculture, Preliminary Report, By Counties.

[b]1959 definition.

TABLE IVb

COMPARISON OF COMMERCIAL FARMS IN FOUR SOUTHEASTERN MISSOURI COUNTIES, 1950, 1954, AND 1959[a]

	Commercial Class[b]				
	I and II I, II, and III	III IV	IV V	V and VI VI	Total
1950	1,716	2,807	3,350	3,833	11,706
1954	2,230	2,855	2,730	1,500	9,315
1959	3,131	1,685	1,330	520	6,666
Percentage Change					
1950 to 1954	+30	+ 2	-18	-61	-20
1954 to 1959	+40	-41	-51	-65	-28
1950 to 1959	+82	-40	-60	-86=	-43

[a]Data for 1950 and 1954 from 1954 Census of Agriculture, pp. 83-87. Data for 1959 Census of Agriculture, Preliminary Report, By Counties.

[b]The upper numbers above each column represent the commercial farm classification as defined in the 1950 and 1954 Census of Agriculture. The lower number represents the commercial farm classification as defined by the 1959 Census of Agriculture.

TABLE V

NUMBER OF FARMS IN FOUR SOUTHEASTERN MISSOURI COUNTIES, ACCORDING TO SIZE IN ACRES, 1950, 1954, AND 1959[a]

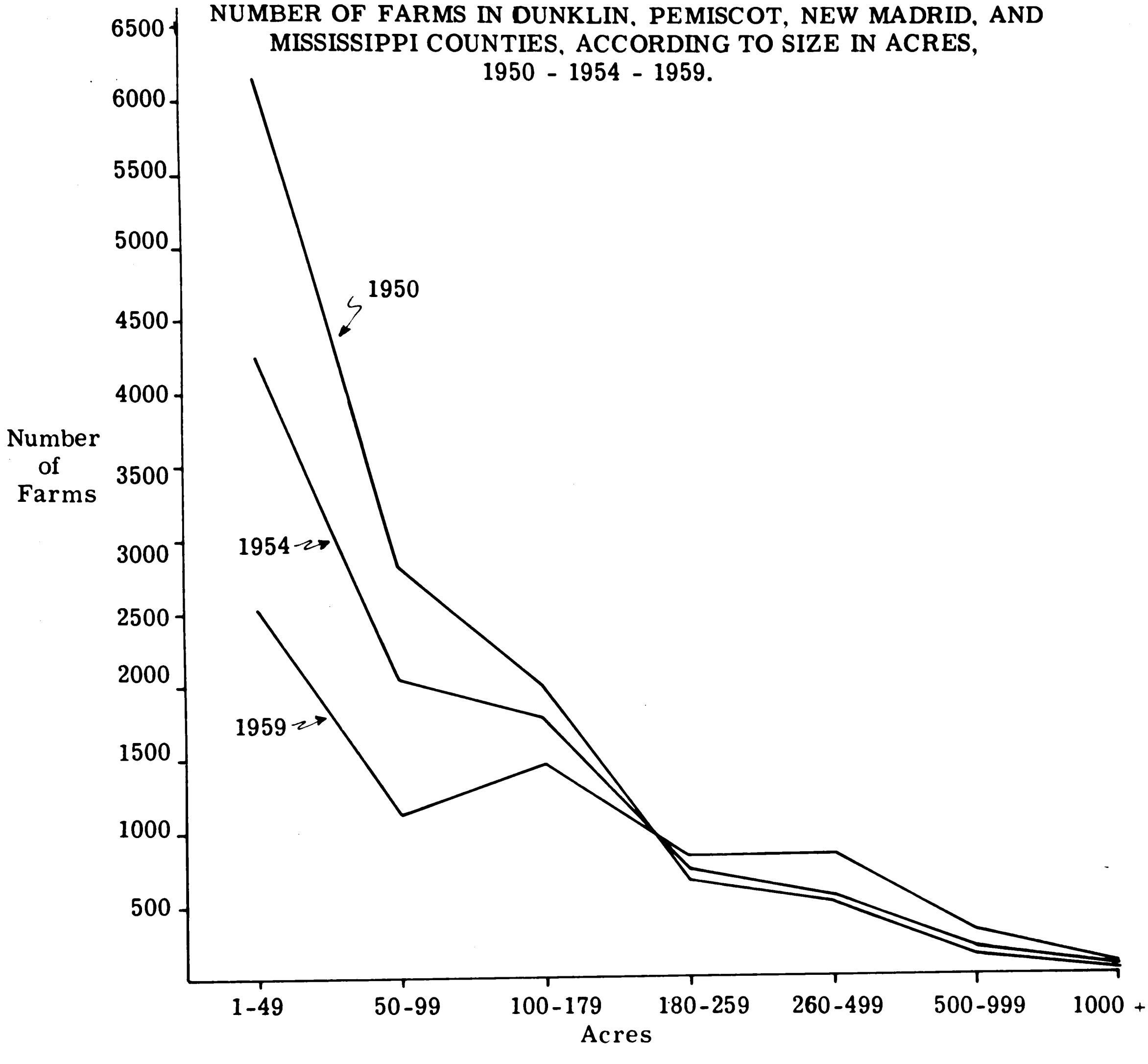
Acres	Dunklin	Pemiscot	New Madrid	Mississippi	Total	Percentage Change 1950 to 1954	Percentage Change 1954 to 1959	Percentage Change 1950 to 1959
1 - 49								
1950	1,136	1,889	2,041	1,054	6,120			
1954	748	1,429	1,333	737	4,247	-31		
1959	534	662	822	485	2,503		-41	-59
50 - 99								
1950	1,106	703	763	271	2,843			
1954	806	550	552	172	2,080	-27		
1959	525	300	251	92	1,168		-44	-59
100 - 179								
1950	770	449	584	216	2,019			
1954	690	433	506	168	1,797	-11		
1959	616	377	358	134	1,485		-17	-26
180 - 259								
1950	192	134	232	126	684			
1954	219	172	210	127	728	+ 6		
1959	306	193	252	98	849		+16	+ 23

TABLE V (Continued)

	County					Percentage Change		
Acres	Dunklin	Pemiscot	New Madrid	Mississippi	Total	1950 to 1954	1954 to 1959	1950 to 1959
250 - 499								
1950	95	114	172	135	516			
1954	121	143	173	150	587	+14		
1959	216	208	286	148	858		+46	+66
500 - 999								
1950	11	48	51	60	170			
1954	21	55	71	63	210	+24		
1959	49	82	111	98	340		+62	+100
1,000 or over								
1950	3	10	14	17	44			
1954	00	12	20	18	50	+14		
1959	6	22	28	30	86		+84	+95

[a]Data for 1950 and 1954 from 1954 Census of Agriculture, Volume 1, Part 10, pp. 68-71. Data for 1959 from 1959 Census of Agriculture, Preliminary Report, by Counties.

FIGURE 3
NUMBER OF FARMS IN DUNKLIN, PEMISCOT, NEW MADRID, AND MISSISSIPPI COUNTIES, ACCORDING TO SIZE IN ACRES, 1950 - 1954 - 1959.



cent.

The number of farms with 199 acres or less of cropland harvested decreased from 1949 to 1959 (Table VI). The number harvesting 200 or more acres increased 82 per cent during the same period. These increases were in harmony with the changes needed as hand labor was replaced with machinery.

According to the 1954 Census of Agriculture, there were no irrigators in the four county area in 1949. In 1954, 108 farmers were reported to be irrigating 8,348 acres. The number had decreased to 88 in 1959 with 6,606 irrigated acres (Table VII).

The number of full owners and tenants decreased during the 1950-1959 period, while the number of part owners remained constant (Table VIII). Tenants decreased 4,137 or 47 per cent. Full owner operators went down 958 or 40 per cent. The per cent of tenancy in the area was 70.5 in 1950; it was 63.2 in 1959. This decline was the result of a reduction in the number of people employed in agriculture and use of hired labor where the work had previously been done by farm operators.

The next task deals with the characteristics of the farms where the data on irrigation were obtained. Particular attention is given to size of operating unit, tenure of operator, fixed investment in irrigation equipment,

TABLE VI

ACRES OF CROPLAND HARVESTED IN FOUR SOUTHEASTERN MISSOURI COUNTIES, ACCORDING TO SIZE, 1949, 1954, AND 1959[a]

County	Year	Cropland Harvested Acres 1-9	10-19	20-29	30-49	50-99	100-199	200+	Total Farms Reporting
Dunklin	1949	138	245	266	736	1,097	577	134	3,193
	1954	99	172	149	420	910	594	177	2,521
	1959	90	141	106	277	609	603	325	2,151
Pemiscot	1949	201	579	464	682	696	423	198	3,243
	1954	162	525	315	442	581	456	276	2,757
	1959	82	254	129	196	330	437	387	1,815
New Madrid	1949	108	587	605	852	778	580	281	3,791
	1954	87	426	413	471	593	540	318	2,848
	1959	66	316	250	208	282	464	504	2,090
Mississippi	1949	166	450	217	245	285	255	215	1,833
	1954	106	303	169	173	194	214	246	1,405
	1959	92	195	90	84	105	179	294	1,039
Total	1949	613	1,861	1,552	2,515	2,856	1,835	828	12,060
	1954	454	1,426	1,046	1,506	2,278	1,804	1,017	9,531
	1959	330	906	575	765	1,326	1,683	1,510	7,095
Percentage Change From									
1949 - 1954		-26	-21	-33	-40	-25	-2	+23	-21
1954 - 1959		-27	-36	-45	-49	-42	-7	+48	-26
1949 - 1959		-46	-51	-63	-70	-54	-8	+82	-41

[a]Data for 1949 and 1954 from 1954 Census of Agriculture, Volume 1, Part 10, pp. 45-51. Data for 1959 from 1959 Census of Agriculture, Preliminary Report, By Counties.

TABLE VII

NUMBER OF FARMS WITH IRRIGATED LAND IN FOUR SOUTHEASTERN MISSOURI COUNTIES, 1949, 1954, AND 1959[a]

County	Farms Number Reporting	Total Irrigated Acres
Dunklin		
1949	-	-
1954	43	2,458
1959	47	2,831
Pemiscot		
1949	-	-
1954	20	2,086
1959	26	2,526
New Madrid		
1949	-	-
1954	34	2,531
1959	12	982
Mississippi		
1949	-	-
1954	11	1,273
1959	3	270
Total		
1949	-	-
1954	108	8,348
1959	80	6,606
Percentage Change		
1954 - 1959	-19	-21

[a]Data for 1949 and 1954 from 1954 Census of Agriculture, pp. 47-51. Data for 1959 from 1959 Census of Agriculture, Preliminary Report, By Counties.

TABLE VIII

TENURE CONDITION IN FOUR SOUTHEASTERN MISSOURI COUNTIES, 1950, 1954, AND 1959[a]

Tenure and Year	County: Dunklin	Pemiscot	New Madrid	Mississippi	Total	Percentage Change: 1950-1954	1954-1959	1950-1959
Full Owner								
1950	963	593	517	329	2,402			
1954	746	449	426	256	1,877	-22		
1959	626	234	313	221	1,444		-23	-40
Part Owner								
1950	498	318	241	163	1,220			
1954	439	304	198	161	1,102	-10		No Change
1959	449	374	227	170	1,220		+10	
Manager								
1950	5	8	8	9	30			
1954	4	6	5	6	21	-30		
1959	4	3	7	5	19		-10	-37
All Tenants								
1950	1,846	2,428	3,091	1,378	8,743			
1954	1,416	2,035	2,236	1,012	6,699	-23		
1959	1,173	1,183	1,561	689	4,606		-31	-47
Per Cent of Tenancy								
1950	55.7	72.5	80.1	73.3	70.5			
1954	54.4	72.8	78.0	70.5	69.1	-1.4		
1959	52.1	64.2	74.1	63.5	63.2		-5.9	-7.3
Cash								
1950	104	86	76	17	283			
1954	37	37	37	10	121	-57		
1959	-[b]	-	-	-	-		-	-

TABLE VIII (Continued)

Tenure and Year	County					Percentage Change		
	Dunklin	Pemiscot	New Madrid	Mississippi	Total	1950-1954	1954-1959	1950-1959
Share Cash								
1950	658	446	348	33	1,485			
1954	278	158	91	12	539	-64		
1959	-	-	-	-	-		-	-
Share and Cropper								
1950	1,017	1,820	2,567	1,272	6,676			
1954	1,064	1,771	2,026	982	5,843	-12		
1959	-	-	-	-	-		-	-
Crop Share and Cropper								
1950	994	1,814	2,549	1,212	6,569			
1954	1,046	1,759	1,990	936	5,731	-13		
1959	-	-	-	-	-		-	-
Livestock Share								
1950	23	6	18	60	107			
1954	18	12	36	46	112	+ 5		
1959	-	-	-	-	-		-	-
Other								
1950	67	76	100	56	299			
1954	37	69	82	8	196	-34		
1959	-	-	-	-	-		-	-

[a]Data for 1950 and 1954 from 1954 Census of Agriculture, Volume 1, part 10, pp. 57-61. Data for 1959 from 1959 Census of Agriculture - Preliminary Report, By Counties.

[b]Data not available.

year irrigation began, and type of irrigation system used.

CHAPTER III

CHARACTERISTICS OF SAMPLE FARMS

I. SIZE OF FARMS

The average size of farm operated by the 65 farmers with irrigation equipment was 405 acres. The median was 342 while the modal size was 216 acres. The 0.95 confidence interval for the average size in the universe was from 325 to 485 acres. This means that the interval has a 0.95 chance of including the universe mean or 95 times out of 100, samples drawn from this universe would lead to confidence intervals that would include the universe value.

The average size farm in 1959 for all farmers in the four county area was 164 acres (Table III, page 31). The average farm in the sample was 147 per cent larger than the average size of all farms. Since the fixed investment required for irrigation is large, it was expected that irrigators, in general, would operate larger than average farms.

The 65 farmers operated 25,498 total acres. When the sample total was projected to include 186 farmers in the population, it was estimated that 75,280 acres were operated by farmers with irrigation equipment. There are approximately 1,192,726 acres in farm land and 6,686 commercial farmers in the four counties. These facts indicate that farmers with irrigation equipment are a very small part of the total agricultural industry in the Delta Area. Only 6.3 per cent of the farm land and 2.8 per cent of the commercial farmers in 1959 were associated with irrigation.

Forty-six of the 65 farmers applied water to various crops in 1959. The hypothesis of independence between the size of farm and whether the farmer irrigated or did not irrigate was tested. A chi square of 4.2 was obtained, which suggested the probability of obtaining a larger chi square was about .50. As a result, the hypothesis was not rejected.

Tenure of Farm Operator

The tenure pattern among the 65 farmers from whom data were obtained varied greatly from that of all farmers in the area. The 1959 Preliminary Census of Agriculture showed the percentage of owners, part owners and tenants to be 20, 17, and 63 respectively. The proportion of owners and part owners among the farmers included in this analysis was 11 and 23 per cent greater than among all farmers, while the proportion of tenants was 34 per cent smaller. These facts indicate that owners and part owners are more likely to have irrigation equipment than tenants. Since the cost of irrigation equipment is relatively large, it is not surprising that tenants do not invest in it as readily as owner operators.

The 0.95 confidence interval for the per cent of owners in the universe of irrigators was .22 to .40. This interval has a 0.95 chance of including the universe proportion of owners. The 0.95 confidence intervals for the per cent of part owners and tenants were .302 to .498 and .201 to .379, respectively.

Sixty-five, 65, and 84 per cent of the owners, part owners, and tenants respectively in the sample applied water to various crops in 1959. The hypothesis of independence between tenure status and whether the farmer irrigated or did not irrigate was tested. A chi square of 2.20 was obtained, which was not significant at the .05 probability level. A chi square of this magnitude suggests that the probability of obtaining a larger chi square was about .35. The hypothesis was not rejected.

Sixteen, 24, and 11 per cent of the owners, part owners, and tenants respectively were operating farms in the 360-479 acre group (Table IX). Sixty-three per cent of the owners and tenants and 36 per cent of the part owners were operating farms smaller than 360 acres. Forty per cent of the part owner farms were larger than 479 acres, but only 21 and 16 per cent of the owner and tenant farms were in this category. The part owners were operating farms larger than owners and tenants.

TABLE IX

SIZE OF FARM WITH IRRIGATION EQUIPMENT IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TYPE OF TENURE, 63 FARMERS, 1959

	Tenure			
Size of Farm (acres)	Owner Operator	Part Owner	Tenant	Total
1 - 119	3	1	1	5
120 - 239	4	3	8	15
240 - 359	5	5	3	13
360 - 479	3	6	2	11
480 - 599	-	4	2	6
600 - 719	1	4	1	6
720 - 839	-	2	1	3
840 - 1,059	2	-	-	2
1,060 - 1,279	-	-	1	1
Over 1,280	1	-	-	1
Total	19	25	19	63

Year Irrigation Was Started

As shown in Table X, none of the farmers had irrigation systems before 1952, and only 18 purchased their equipment before 1954. The largest number of farmers started irrigating in 1954 when 28 per cent applied water to crops for the first time. Twenty-five per cent started irrigating in 1956.

Apparently there is no particular relationship between size of farm and the year irrigation was started. In 1953, the largest proportion of farmers in the 240-359 acre class started to irrigate. The largest proportion of farmers in the 480-599, 1,060-1,279 and over 1,280 acre classes started in 1954. Since there was only 1 farm in the last two of these classes, the data have very little meaning. The largest proportion of farmers in the 1-119, 120-239, 360-479, 600-719, and 840-1,059 acre classes started after 1954. The hypothesis of independence between the year irrigation was started and whether the farmer irrigated or did not irrigate was tested. A chi square of 2.97 was calculated, which was not significant at the .05 level. The hypothesis was not rejected.

Eighteen and three per cent of the 65 farmers obtained irrigation equipment in 1957 and 1958, respectively. These men have made limited use of their irrigation system due primarily to changes in the amount

TABLE X

YEAR IRRIGATED STARTED IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TOTAL ACRES OPERATED, 65 FARMERS, 1959

Total Acres Operated	Year Irrigation was Started: 1951 or Before	1952	1953	1954	1955	1956	1957	1958	Total
1-119	-	-	-	1	2	-	2	-	5
120-239	-	-	1	2	1	8	2	1	15
240-359	-	-	4	3	1	1	3	1	13
360-479	-	1	-	3	4	1	2	-	11
480-599	-	-	1	4	-	-	1	-	6
600-719	-	-	1	1	-	2	2	-	6
720-839	-	-	-	2	-	1	-	-	3
840-1,059	-	-	-	-	1	1	-	-	2
1,060-1,279	-	-	-	1	-	-	-	-	1
Over 1,280	-	-	-	1	-	-	-	-	1
Total	-	1	7	18	9	16[a]	12	2	65[a]

[a]Includes two farmers who started irrigating in 1956, but did not report total acres operated.

and distribution of rainfall. Over 100 inches of rain fell in 1957 in various areas of the Delta. The amount and distribution of precipitation in 1958 and 1959 permitted better than average crop yields without irrigation. As a result, the farmers obtaining irrigation systems in 1957 and 1958 have had a rather large investment tied up in equipment which has had limited use. When the 25 per cent who started in 1956 are added to the 21 per cent who started in 1957 and 1958, 46 per cent of the farmers have had limited opportunities to recover their fixed investment and have borne a relatively large annual fixed cost in depreciation, interest, and taxes. The amount of annual fixed costs will be discussed later in the chapter.

Part owners, in general, started to irrigate and stopped buying irrigation equipment earlier than owners or tenants, as shown in Table XI. Twenty-three per cent of the part owners and 11 per cent of the tenants started to irrigate in 1952 and 1953, but none of the owners started to irrigate in 1952 and 1953. The majority of all tenure groups started between 1954 and 1956, when 75 per cent of the owners, 58 per cent of the part owners, and 68 per cent of the tenants began. Twenty-five per cent of the owners and 21 per cent of the tenants started in 1957 and 1958. Nineteen per cent of the part owners started in 1957, but

TABLE XI

YEAR IRRIGATION BEGAN IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TYPE OF TENURE, 65 FARMERS, 1959

	Tenure			
Year	Owner Operator	Part Owner	Tenant	Total
1952	-	1	-	1
1953	-	5	2	7
1954	6	5	7	18
1955	4	4	1	9
1956	5	6	5	16
1957	4	5	3	12
1958	1	-	1	2
Total	20	26	19	65

none started in 1958. In general, part owners appear to be more responsive to changing weather conditions than owners or tenants.

Major Irrigated Crop

Cotton was the major irrigated crop in terms of total acres on all size farms except 1-119 acre class, as shown in Table XII. Cotton was the major irrigated crop on 29 of the 46 farms where water was applied in 1959. Corn was the major irrigated crop in the 1-119 acre class. Seven farmers applied water to more acres of corn than any other crop.

Soybeans, strawberries, pasture, vegetables, wheat, and sweet corn were the other irrigated crops on 10 of the irrigating farms.

Cotton was the major crop irrigated on 46, 76, and 63 per cent of the owner, part owner, and tenant operated farms respectively (Table XIII). Corn was second in importance for 15 per cent of the owner operators, while soybeans was second in importance for an additional 15 per cent. The number of acres of each crop will be presented in another section of this chapter.

Source of Water

Wells were the major source of irrigation water. Fifty of the 65 farms had only wells; three used drainage

TABLE XII

MAJOR CROP IRRIGATED IN TERMS OF TOTAL ACRES IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TOTAL ACRES OPERATED, 46 IRRIGATORS, 1959

Total Acres Operated	Major Crop Irrigated							
	Corn	Cotton	Soybeans	Strawberries	Pasture	Vegetables	Other[a]	Total
1-119	2	1	1	-	-	-	-	4
120-239	1	8	1	2	-	-	1	13
240-359	1	6	-	1	-	1	-	9
360-479	3	4	-	-	1	-	1	9
480-599	-	3	-	-	-	-	-	3
600-719	-	4	1	-	-	-	-	5
720-839	-	1	-	-	-	-	-	1
840-1,059	-	-	-	-	-	-	-	-
1,060-1,279	-	1	-	-	-	-	-	1
Over 1,280	-	1	-	-	-	-	-	1
Total	7	29	3	3	1	1	2	46

[a]One-wheat, one-sweet corn.

TABLE XIII

MAJOR CROP IRRIGATED IN TERMS OF TOTAL ACRES IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TYPE OF TENURE, 46 IRRIGATORS, 1959

	Tenure			
Major Crop Irrigated	Owner Operator	Part Owner	Tenant	Total
Corn	2	1	4	7
Cotton	6	13	10	29
Soybeans	2	1	-	3
Strawberries	1	2	-	3
Pasture	1	-	-	1
Vegetables	-	-	1	1
Other[a]	1	-	1	2
Total	13	17	16	46

[a]One - sweet corn, one - wheat.

ditches only, and 12 used a combination of wells and drainage ditches, as shown in Table XIV.

Wells were the exclusive source of water on 60, 81, and 89 per cent of the owner, part owner, and tenant operated farms. An additional 35, 15, and 5 per cent respectively had drainage ditches in addition to wells available as a water source. The remainder considered drainage ditches as their exclusive source of water, as shown in Table XV.

Methods of Distributing Water

Sprinklers were the major method of distributing water on all size farms, as shown in Table XVI. Three different types were used. The most common was the conventional sprinkler system, which usually has 12 to 22 small sprinklers 60 to 90 feet apart on lateral lines. This type operates under low pump pressure, and applies water at a relatively slow rate. It is called the 60 X 60 or 90 X 90 system, meaning the sprinklers are 60 to 90 feet apart on the lateral lines and the entire line is moved 60 to 90 feet after the completion of irrigation from each set. Twenty-five of the 46 farmers used this method exclusively in 1959.

The second type of sprinkler system has two or three giant sprinklers per quater mile of lateral line. It uses high pump pressure, and applies water at a rapid

TABLE XIV

SOURCES OF WATER USED FOR IRRIGATION IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TOTAL ACRES OPERATED, 65 FARMERS, 1959

Total Acres Operated	Source of Water: Wells Only	Drainage Ditch Only	Combination - Well and Drainage Ditch	Total
1-119	4	-	1	5
120-239	12	1	2	15
240-359	11	-	2	13
360-479	8	-	3	11
480-599	5	1	-	6
600-719	5	-	1	6
720-839	2	-	1	3
840-1,059	1	-	1	2
1,060-1,279	1	-	-	1
Over 1,280	-	-	1	1
Total	50[a]	3[a]	12	65[b]

[a]Includes one farmer who did not report total acres operated.

[b]Includes two farmers who did not report total acres operated.

TABLE XV

SOURCES OF WATER USED FOR IRRIGATION IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TYPE OF TENURE, 65 FARMERS, 1959

	Tenure			
Source of Water	Owner Operator	Part Owner	Tenant	Total
Wells	12	21	17	50
Drainage Ditch	1	1	1	3
Combination Well and Drainage Ditch	7	4	1	12
Total	20	26	19	65

TABLE XVI

METHODS OF APPLYING WATER IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TOTAL ACRES OPERATED, 46 IRRIGATORS, 1959

	Total Acres Operated										
Methods of Applying Water	1-119	120-239	240-359	360-479	480-599	600-719	720-839	840-1,059	1,060-1,279	Over 1,280	Total
Sprinkler Only:											
Portable Pipe and Sprinkler	1	11	5	4	2	1	1	-	-	-	25
Trailer Boom	-	-	-	2	-	-	-	-	1	-	3
Giant Sprinkler	1	1	1	-	-	1	-	-	-	-	4
Surface Only:											
Gated Pipe	2	-	2	1	1	1	-	-	-	-	7
Ditches and Furrows	-	-	-	-	-	1	-	-	-	-	1
Combination of Methods:											
Portable Pipe and Sprinkler and											
a. Gated Pipe	-	-	-	1	-	-	-	-	-	-	1
b. Ditches and Furrows	-	-	1	-	-	1	-	-	-	-	2
c. Giant Sprinkler	-	-	-	1	-	-	-	-	-	-	1
d. Trailer Boom	-	-	-	-	-	-	-	-	-	1	1
Gated Sprinkler and a. Gated Pipe	-	1	-	-	-	-	-	-	-	-	1
Total[a]	4	13	9	9	3	5	1	-	1	1	46

[a]Nineteen farmers did not irrigate in 1959. The types of irrigation system available were: 13 portable pipe and sprinklers, 3 gated pipe, 2 ditches and furrows, 1 trailer boom.

rate. Four farmers used this method exclusively, and one farmer used both of the above types.

The third type of sprinkler system has a large rotating boom mounted on a trailer. The system is operated under high pump pressure and has a high rate of application. Three farmers used this method exclusively, and one used both this method and the conventional portable pipe and sprinklers.

Eight farmers used surface irrigation exclusively. Two procedures of distribution were followed. Seven of the eight farmers used light portable gated pipes with gates or openings 36 to 40 inches apart to carry water to the rows where it was applied. One farmer used ditches and furrows exclusively. Water was transferred from the irrigation ditch to the furrows between the rows by siphon tubes.

Nineteen farmers with irrigation equipment did not irrigate in 1959. Thirteen of this group owned portable pipe and sprinklers; three had gated pipe; two had used ditches and furrows, and one, a trailer boom type of water distribution system.

The portable pipe and sprinkler system was the major type employed by all tenure groups, as shown in Table XVII. Forty-six, 47, and 69 per cent of the owners, part owners, and tenants, applying water in 1959, employed

TABLE XVII

METHODS OF APPLYING IRRIGATION WATER IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TYPE OF TENURE, 46 IRRIGATORS, 1959

Methods of Applying Water	Tenure			
	Owner Operator[a]	Part Owner[b]	Tenant[c]	Total
Sprinkler only:				
Portable pipe and sprinkler	6	8	11	25
Trailer boom	-	1	2	3
Giant sprinkler	3	1	-	4
Surface only:				
Gated pipe	3	3	1	7
Ditches and furrows	-	1	-	1
Combination of methods:				
Portable pipe and sprinkler and				
a. Gated pipe	-	1	-	1
b. Ditches and furrows	-	1	-	1
c. Giant sprinkler	1	-	1	2
d. Trailer boom	-	-	1	1
Giant sprinkler and				
a. Gated pipe	-	1	-	1
Total	13	17	16	46

[a]Seven owner operators did not irrigate in 1959. Six portable pipe and sprinkler systems, one ditch and furrow system.

[b]Nine part owners did not irrigate in 1959. Five portable pipe and sprinkler systems, three gated pipe systems and one trailer boom.

[c]Three tenants did not irrigate in 1959. Two portable pipe and sprinkler systems, one ditch and furrow system.

this type of system exclusively. Twenty-three, 12, and 13 per cent of the owners, part owners, and tenants respectively used trailer booms or giant sprinklers to apply water. Surface irrigation methods were employed by 23, 23, and six per cent of the owners, part owners, and tenants respectively. Six farmers used a combination of methods to apply water.

For purposes of analysis, the different types of irrigation systems were divided into three classifications. The first was the portable pipe and sprinkler system. Classification two was a combination of trailer booms and giant sprinklers. The two surface irrigation methods were combined for the third classification. The above classifications were used to test the hypothesis of independence between the tenure classification of the farm operators and the type of irrigation system used to distribute water in 1959. A chi square of 3.32 was obtained, which was not statistically significant at the .05 level. Therefore, the hypothesis was not rejected. The probability of obtaining a chi square larger than 3.32 was .51.

The chi square technique also was used to test the hypothesis of independence between use of irrigation in 1959 and the tenure of the farm operators. A chi square of 2.34 was calculated, which was not statistically significant at the .05 level. The probability of obtaining a chi square larger than the one above was approximately .33.

<u>Capacity of Irrigation System</u>

The capacity of an irrigation system was defined as the total number of acres the farmer thought could be covered by the system to prevent a decreased crop yield from lack of moisture. Implicit in the definition is the fact that the total number of acres may be irrigated more than one time and/or different crops may be irrigated at different times of the growing season.

The average capacity of all irrigation systems in the sample was 128 acres. The capacity of individual systems ranged from 11 to 510 acres per farm. The modal size was in the 60-99 acre class, as shown in Table XVIII.

The hypothesis of independence between capacity of irrigation system and total acres operated was tested. A chi square of 23.5 was obtained, which was not significant at the .05 level.

The 60-99 acre class was the modal acreage for all tenure classes, as shown in Table XIX. Forty-two, 50, and 37 per cent of the owners, part owners, and tenants were in this group.

TABLE XVIII

CAPACITY OF IRRIGATION SYSTEMS IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TOTAL ACRES OPERATED, 65 FARMERS, 1959

Capacity of Irrigation System (Acres)	Total Acres Operated										
	1-119	120-239	240-359	360-479	480-599	600-719	720-839	840-1,059	1,060-1,279	Over 1,280	Total
19 or less											
Irrigated	-	1	1	-	-	-	-	-	-	-	2
Did not irrigate	-	-	-	-	-	-	-	-	-	-	-
20 - 59											
Irrigated	-	2	-	-	-	-	-	-	-	-	2
Did not irrigate	-	-	1	-	-	-	-	-	-	-	1
60-99											
Irrigated	3	4	2	2	1	3	2	-	-	-	17
Did not irrigate	1	1	3	2	2	-	1	-	-	-	11[a]
100 - 139											
Irrigated	1	4	-	1	-	1	-	-	-	1	8
Did not irrigate	-	1	-	-	-	-	-	-	-	-	1
140 - 179											
Irrigated	-	-	2	2	1	-	-	-	-	-	5
Did not irrigate	-	-	1	-	1	1	-	2	-	-	5
180 - 219											
Irrigated	-	1	2	1	1	1	-	-	-	-	6
Did not irrigate	-	-	-	-	-	-	-	-	-	-	-

TABLE XVIII (Continued)

Capacity of Irrigation System (Acres)	Total Acres Operated										
	1-119	120-239	240-359	360-479	480-599	600-719	720-839	840-1,059	1,060-1,279	Over 1,280	Total
220 - 259											
Irrigated	-	1	1	2	-	-	-	-	-	-	4
Did not irrigate	-	-	-	-	-	-	-	-	-	-	-
300 - 339											
Irrigated	-	-	-	1	-	-	-	-	-	-	1
Did not irrigate	-	-	-	-	-	-	-	-	-	-	-
Over 340											
Irrigated	-	-	-	-	-	-	-	-	1	-	1
Did not irrigate	-	-	-	-	-	-	-	-	-	-	-
Total											
Irrigated	4	13	8	9	3	5	2	-	1	1	46
Did not irrigate	1	2	6	2	3	1	1	2	-	-	19[b]

[a]Includes one farmer who did not report total acres irrigated.

[b]Includes one farmer who did not report total acres operated or capacity of irrigation system.

TABLE XIX

CAPACITY OF IRRIGATION SYSTEMS IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TYPE OF TENURE, 65 FARMERS, 1959

	Capacity of Irrigation System (Acres)										
Tenure	19 or Less	20-59	60-99	100-139	140-179	180-219	220-259	260-299	300-339	340 or Over	Total
Owner-Operator											
Irrigated	1	2	5	4	-	1	-	-	-	-	13
Did not irrigate	-	-	3	1	2	-	-	-	-	-	6
Part-Owner											
Irrigated	1	1	6	1	3	3	2	-	-	-	17
Did not irrigate	-	-	7	-	2	-	-	-	-	-	9
Tenant											
Irrigated	-	-	5	3	2	2	2	-	1	1	16
Did not irrigate	-	-	2	-	1	-	-	-	-	-	3
Total											
Irrigated	2	3	16	8	5	6	4	-	1	1	46
Did not irrigate	-	-	12	1	5	-	-	-	-	-	18[a]

[a]One owner-operator did not irrigate and did not report capacity of system.

The mean capacity of the irrigation system for owner operators was 105 acres; 121 for part owners, and 160 for tenants. The average capacity of the tenant operated farms was 52 and 32 per cent larger than the systems on the farms of owners and part owners respectively.

The difference between the mean capacity of irrigation systems was tested for the three tenure classes. The null hypothesis, that $\bar{X}_1' - \bar{X}_2' = 0$, was used. The standard deviations of the populations were not known, but were assumed to be equal. A "t" value of -.79 was obtained, when the difference between the system capacity of owners and part owners was tested. A "t" value of 2.021 was necessary to reject the null hypothesis. Consequently, the null hypothesis was not rejected. Values for "t" of -1.812 and 1.47 were obtained when the differences between owners and tenants and tenants and part owners were tested. The null hypotheses were not rejected in either test.

The hypothesis of independence between the capacity of the irrigation system and whether the farmer irrigated or did not irrigate in 1959 was tested. A chi square of 5.29 was obtained. The chi square at the .05 level was 7.81. As a result, the hypothesis was not rejected. The probability of obtaining a chi square larger than 5.29 was .17.

Credit Characteristics of Irrigation Equipment Loans

Twenty-nine of the 65 farmers had purchased irrigation equipment on credit, as shown in Table XX. The average amount borrowed was $5,291, but the amount per farm ranged from $1,500 to $15,550. Credit was obtained from irrigation equipment dealers, commercial banks, Farmers Home Administration, Production Credit Associations, Federal Land Bank Associations and insurance companies. Commercial banks and irrigation equipment dealers were the major sources of funds, in terms of number of loans. The average interest rate was 5.6 per cent, with a range from 4.0 to 8.0 per cent. The average length of the loan was 9.5 years, with a range from 1 to 30 years. Most of the loans were executed in 1954 and 1956.

The proportion of irrigators who used credit was used to establish confidence limits for the population. The 0.95 confidence interval was from .325 to .567. The universe proportion has a .95 chance of being within this interval.

The loans obtained by tenants were larger, had a higher rate of interest, and a shorter average length than those obtained by owners and part owners. The average amount borrowed by tenants was $6,348, the interest rate averaged 6.28 per cent, and the term, 4.6 years. The sources were commercial banks and irrigation equipment

TABLE XX

AMOUNT BORROWED, SOURCE, INTEREST RATE, AND LENGTH OF LOAN OF CREDIT USED TO PURCHASE IRRIGATION EQUIPMENT IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TYPE OF TENURE, 29 FARMERS, 1953–1958

Characteristic of Loan	Tenure: Owner Operator	Part Owner	Tenant	Total
Number of farmers	8	14	7	29
Average amount borrowed	$4,500	$ 4,550	$ 6,348[a]	$ 5,291
Range	$2,500– $7,700	$ 1,500– $10,000	$ 3,440– $15,550	$ 1,500– $15,550
Source:				
Irrigation Dealer	1	4	3	8
Commercial Bank	1	5	4	10
Farmers Home Administration	2	2	-	4
Production Credit Association	-	1	-	1
Insurance Company	3	1	-	4
Federal Land Bank	1	1	-	2
Average Interest Rate	5.0	5.58	6.28	5.59
Range	4.0– 7.0	4.0– 8.0	5.0– 8.0	4.0– 8.0
Average Length of Loan	15.1	8.8	4.6	9.5
Range (Years)	3–30	1–30	3–10	1–30

TABLE XX (Continued)

Characteristics of Loan	Tenure Owner Operator	Part Owner	Tenant	Total
Year Borrowed:				
1953	-	2	-	2
1954	1	3	3	7
1955	2	2	1	5
1956	2	4	2	8
1957	2	3	1	6
1958[a]	1	-	-	1

[a]Does not include two loans obtained by the land owners to purchase irrigation equipment.

dealers.

Owner operators obtained the smallest loans and had lower annual costs of financing the credit. The average amount borrowed was $4,500, and the interest rate 5.0 per cent. The average length of loan was 15.1 years. Fifty per cent of the loans were obtained from insurance companies and the Federal Land Bank with farm land given as security. Availability of land for security was the primary reason for the superior credit terms obtained by owners as compared to tenants.

The average amount borrowed by part owners was $4,550, and the term, 3.8 years. The average rate of interest was 5.58 per cent, which is between the rates for the other tenure groups. The majority of part owners obtained loans from commercial banks and irrigation equipment dealers; however, the longer term, lower rate loans from insurance companies and the Federal Land Bank lowered the average rate of interest and increased the average time for repayment.

Soils

Supplemental water was applied to a wide range of soils in 1959. As noted in Chapter II, alluvial soils vary greatly in physical properties. Consequently, it is difficult to make a general classification of soil types where water was applied. The following procedure was used to determine the type of soil on the 65 farms. The fields, which were irrigated or could have been irrigated, were plotted on a county highway map. Soil Conservation personnel inspected the maps and compared them to detailed county soil maps to determine the soil characteristics. The soils were divided into four groups for analysis: Those which were predominately sandy, silt loam, clay loam, and combinations of the first three, as shown in Table XXI.

Thirty-five, 23, 14, and 28 per cent of the farm operators reported their type of soil as clay loam, sandy, silt loam, and combinations respectively.

The hypothesis of independence between type of tenure and type of soils was tested. A chi square of 8.31 was obtained, which was not statistically significant at the .05 level. The hypothesis was not rejected. The probability of obtaining a chi square larger than 8.31 was .22.

A chi square statistical test was used to determine if there was a significant difference between type of soil and whether or not the farmer irrigated his crops in 1959. A value of 5.18 was obtained, which was not statistically significant at the .05 level. The result indicates that the type of soil was not an important reason either for irrigating or not irrigating in 1959.

TABLE XXI

SOIL TYPES IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TYPE OF TENURE, 65 FARMERS, 1959

Type of Soil	Type of Soil: Predominately: Sandy	Silt Loam	Clay Loam	Combination: Sandy and Silt Loam	Sandy and Clay Loam	Silt and Clay Loam	Silt Sandy and Clay Loam	Total
Owner-Operator								
Irrigated	5	2	5	1	-	-	-	13
Did not irrigate	1	1	5	-	-	-	-	7
Part-Owner								
Irrigated	5	2	5	1	3	1	-	17
Did not irrigate	-	2	2	1	2	1	1	9
Tenant								
Irrigated	4	1	5	4	1	1	-	16
Did not irrigate	-	1	1	-	-	1	-	3
Total								
Irrigated	14	5	15	6	4	2	-	46
Did not irrigate	1	4	8	1	2	2	1	19

<u>Changes in Methods of Distributing Water</u>

Seventeen or 26 per cent of the 65 farmers have changed their method of distributing water since their original investment in equipment was made (Table XXII). The sample statistic, .2615, was considered to be the best estimate of the proportion in the population which had changed methods of applying water. The 0.95 confidence interval was .158 to .372. Ninety-five per cent originally had purchased portable pipe and sprinkler systems. One had changed from using gated pipe to sprinklers, because the land had not been graded and distribution of the water over the field was unsatisfactory. Nine changed from the conventional portable pipe and sprinkler method either to the trailer boom or giant sprinkler method. The other eight changed to surface irrigation. Seven of these had changed to gated pipe and one to ditches and furrows.

The primary reason for the change was the labor requirements for the portable pipe and sprinkler system. Eighty-eight per cent of the farmers had made the change to reduce labor requirements or to be able to hire personnel to work with the irrigation equipment.

The hypothesis of independence between type of tenure and whether the farmer had changed or did not change methods of applying water was tested. A chi square of .68 was obtained which was not significant at the .05

TABLE XXII

CHANGE IN TYPE OF IRRIGATION SYSTEMS IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TYPE OF TENURE, 17 FARMERS, 1959

Type of Irrigation System	Tenure: Owner Operator	Part Owner	Tenant	Total
Changed from:				
Portable pipe and sprinkler	4	7	5	16
Gated pipe	-	1	-	1
Total	4	8	5	17[a]
Changed to:				
Trailer boom	-	1	3	4
Giant sprinkler	3	1	1	5
Gated pipe	1	6	-	7
Ditch and furrow	-	-	1	1
Total	4	8	5	17
Reasons for Changing Type of Irrigation System:				
Less labor required	4	2	4	10
Could not hire labor for portable pipe and sprinkler	-	4	1	5
Better drainage	-	1	-	11
Land not levelenough for gated pipe	-	1	-	1
Total	4	8	5	17

[a]Forty-eight of 65 farmers have not changed type of system.

level. The hypothesis was not rejected. In addition, the relationship between type of tenure and type of original irrigation system was tested. A chi square of .98 was obtained which was not statistically significant.

The relationship between type of tenure and the new method of distributing water was tested. A chi squre of 4.78 was obtained, which was not statistically significant at the .05 level. The probability of obtaining a chi square larger than 4.78 was .093, which is relatively close to the zone of rejection.

II. FIXED INVESTMENT IN IRRIGATION EQUIPMENT

The average fixed investment in irrigation equipment was $7,122 per farm for the 65 farmers. This amount was considered the best estimate of the population value. The 0.95 confidence interval was from $6,232 to $8,012. This interval has a 0.95 chance of including the value of the universe mean.

As shown previously, the average capacity of the irrigation systems was 128 acres. Therefore, the average fixed investment per capacity acre was $56. The modal class of total fixed investment was $3,000 to $5,999. Twenty-six of the 65 farmers were in this group, as shown in Table XXIII.

TABLE XXIII

FIXED INVESTMENT IN IRRIGATION EQUIPMENT IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TOTAL ACRES OPERATED, 65 FARMERS, 1959

Fixed Investment (Dollars)	Total Acres Operated 1-119	120-239	240-359	360-479	480-599	600-719	720-839	840-1,059	1,060-1,279	Over 1,280	Total
1,000 - 2,999											
Irrigated	1	-	1	-	-	-	-	-	-	-	2
Did not irrigate	-	-	-	-	1	-	1	-	-	-	2
3,000 - 5,999											
Irrigated	-	6	3	2	-	3	-	-	-	-	14
Did not irrigate	1	2	3	2	-	-	1	1	-	-	12[a]
6,000 - 8,999											
Irrigated	3	6	1	1	2	2	1	-	-	-	16
Did not irrigate	-	-	-	-	1	1	-	1	-	-	3
9,000 - 11,999											
Irrigated	-	-	2	3	-	-	-	-	-	-	5
Did not irrigate	-	-	1	-	1	-	-	-	-	-	2
12,000 - 14,999											
Irrigated	-	-	2	2	-	-	-	-	-	1	5
Did not irrigate	-	-	-	-	-	-	-	-	-	-	-
15,000 - 17,999											
Irrigated	-	1	-	1	-	-	-	-	1	-	3
Did not irrigate	-	-	-	-	-	-	-	-	-	-	-

TABLE XXIII (Continued)

Fixed Investment (Dollars)	Total Acres Operated 1-119	120-239	240-359	360-479	480-599	600-719	720-839	840-1,059	1,060-1,279	Over 1,280	Total
18,000 - 20,999											
Irrigated	-	-	-	-	1	-	-	-	-	-	1
Did not irrigate	-	-	-	-	-	-	-	-	-	-	-
Total											
Irrigated	4	13	9	9	3	5	1	-	1	1	46
Did not irrigate	1	2	4	2	3	1	2	2	-	-	19[a]

[a]Includes two farmers who did not report total acres operated.

The relationship between fixed investment in irrigation equipment and total acres operated was analyzed. When the hypothesis of independence was tested, a chi square of 24.98 was obtained, which was not significant at the .05 probability level. A chi square of this magnitude suggests a probability of .21 of obtaining a larger chi square. The hypothesis was not rejected.

The relationship between fixed investment in irrigation per farm and whether the farmer irrigated or did not irrigate in 1959 was not statistically significant. When the hypothesis of independence was tested, a chi square of 7.32 was obtained. The probability of obtaining a larger chi square was about .12, which is relatively close to the zone of rejection.

Other things being equal, the assumption can be made that farmers with large investment in irrigation equipment will attempt to recover their fixed investment at a faster rate than farmers with smaller investments. In other words, farmers with larger investments are more responsive to irrigation opportunities than farmers with small investments. As shown above, the data do not support this assumption statistically.

The 65 farmers had made investments in irrigation equipment which ranged from $1,900 to $19,000 per farm (Table XXIV). Forty per cent of the 65 had investments

TABLE XXIV

FIXED INVESTMENT IN IRRIGATION EQUIPMENT IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TYPE OF TENURE, 65 FARMERS, 1959

Tenure	Fixed Investment (Dollars) 1,000-2,999	3,000-5,999	6,000-8,999	9,000-11,999	12,000-14,999	15,000-17,999	18,000-20,999	Total
Owner-Operator								
Irrigated	1	6	4	1	1	-	-	13
Did not irrigate	-	6	1	-	-	-	-	7
Part Owner								
Irrigated	1	5	5	3	3	-	-	17
Did not irrigate	1	5	1	2	-	-	-	9
Tenant								
Irrigated	-	4	6	1	1	3	1	16
Did not irrigate	1	1	1	-	-	-	-	3
Total								
Irrigated	2	15	15	5	5	3	1	46
Did not irrigate	2	12	3	2	-	-	-	19

within the $3,000 to $5,999 class. Sixty, 38, and 26 per cent of the owners, part owners, and tenants respectively were in this class. However, 35, 54, and 68 per cent of the owners, part owners, and tenants respectively had investments of $6,000 or more.

The relationship between the fixed investment in irrigation equipment and the tenure of operators was analyzed. When the hypothesis of independence was tested, a chi square of 10.0 was obtained, which was not statistically significant at the .05 probability level. The hypothesis was not rejected. The probability of obtaining a chi square larger than 10.0 was approximately .27.

As shown in Table XXV, the average investment in irrigation equipment per farm was $7,122. The cost of wells, pumps, power units, and distribution systems were classed as fixed investment. The average investment per farm in the distribution system was $3,671 or 52 per cent of the total amount. The average investment per farm in wells was $1,379 or 19 per cent. Cost of power units averaged 15 per cent or $1,094 per farm. Investments in pumps averaged $978 or 14 per cent of the total.

The investment on farms operated by tenants averaged $8,817, which was the largest of the tenure groups (Table XXV). Distribution systems, wells, power units, and pumps

TABLE XXV

FIXED INVESTMENT IN IRRIGATION WELLS, PUMPS, POWER UNITS, AND DISTRIBUTION SYSTEMS, IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TYPE OF TENURE, 65 FARMERS, 1959

Type of Equipment	Tenure: Owner Operator	Part Owner	Tenant	Total
Wells:				
Number of wells	34	50	38	122
Average cost per well	$ 667	$ 683	$ 864	$ 735
Average investment per farm	$1,134	$1,313	$1,727	$1,379
Per cent of total investment	19	19	20	19
Pumps:				
Number of pumps	25	40	28	93
Average cost per pump	$ 740	$ 643	$ 693	$ 684
Average investment per farm	$ 925	$ 988	$1,201	$ 978
Per cent of total investment	16	15	12	14
Power Units:[a]				
Number of power units	24	33	27	84
Average cost per power unit	$ 729	$ 885	$ 904	$ 846
Average investment per farm	$ 875	$1,123	$1,285	$1,094
Per cent of total investment	15	16	15	15
Distribution Systems:				
Number of systems	20	26	19	65
Average investment per farm	$2,920	$3,435	$4,784	$3,671
Per cent of total investment	50	50	54	52
Total Investment	$5,854	$6,859	$8,817	$7,122

[a]Excludes power unit investment on 2 farms using the farm tractor as a source of power.

accounted for 54, 20, 15, and 12 per cent, respectively of the average investment per farm.

The fixed investment in irrigation equipment on the farms of part owners averaged $6,859. The cost of the distribution system accounted for 50 per cent of the total. The investment in wells was second with 19 per cent. Power units and pumps accounted for 16 and 15 per cent respectively.

The fixed investment of owner operators averaged $5,854 per farm, which was the smallest of the three tenure groups. The proportion of the total in the four items was similar to the part owners (Table XXV).

<u>Types of Irrigation Systems</u>

The characteristics of the five different types of irrigation systems have been explained in an earlier section of this chapter. As shown in Table XXVI, there was a wide variation in the average fixed investment. Sprinkler systems cost more than surface systems, but require less expenditure for land leveling.

<u>Trailer boom</u> -- The average fixed investment for the five farmers with trailer boom systems was $13,200, which was the largest among the five types of systems. Wells, pumps, power units, and distribution systems made up 19, 13, 15, and 53 per cent, respectively of the total

TABLE XXVI

FIXED INVESTMENT IN IRRIGATION EQUIPMENT IN FOUR SOUTHEASTERN MISSOURI COUNTIES, BY TYPE OF IRRIGATIN SYSTEM, 65 FARMERS, 1959

Type of Equipment	Sprinkler: Trailer Boom	Sprinkler: Giant Sprinkler	Sprinkler: Portable Pipe and Small Sprinkler	Surface: Gated Pipe	Surface: Ditches and Furrows	Total
Wells:						
Number of wells	11	71	71	24	4	122
Average cost per well	$1,127	$ 827	$ 711	$ 550	$ 775	$ 735
Average investment per farm	$2,480	$1,984	$1,232	$1,200	$1,033	$1,379
Per cent of total investment	19	22	18	22	25	19
Pumps:						
Number of pumps	10	8	54	17	4	93
Average cost per pump	$ 860	$ 775	$ 647	$ 618	$ 850	$ 684
Average investment per farm	$1,720	$1,240	$ 851	$ 9955	$1,133	$ 978
Per cent of total investment	13	14	12	17	28	14
Power Unit:[a]						
Number of power units	10	8	48	14	4	24
Average cost per power unit	$1,020	$ 912	$ 756	$ 843	$1,125	$ 846
Average investment per farm	$2,040	$1,460	$ 886	$1,073	$1,500	$1,094
Per cent of total	15	17	13	19	36	15

TABLE XXVI (Continued)

Type of Equipment	Sprinkler: Trailer Boom	Sprinkler: Giant Sprinkler	Sprinkler: Portable Pipe and Small Sprinkler	Surface: Gated Pipe	Surface: Ditches and Furrows	Total
Distribution Systems:						
Number of systems	5	5	41	11	3	65
Average investment per farm	$6,970	$4,160	$3,841	$2,291	$ 434	$3,671
Per cent of total investment	53	47	57	42	11	52
Total Investment	$13,200	$8,844	$6,810	$5,518	$4,100	$7,122

[a]Excludes power unit on two farms using farm tractor as a source of power.

investment per farm. The average amount invested in the distribution system, $6,970, was larger than the total investment for portable pipe and sprinkler, gated pipe, and ditches and furrows.

<u>Giant sprinkler</u> -- The five farmers with giant sprinkler systems had average investments of $8,844 per farm. The average cost per well, pump, power unit, and distribution system was smaller than for the same items for the trailer boom system. Twenty-two, 14, 17, and 47 per cent of the total investment was in wells, pumps, power units, and distribution systems, respectively.

<u>Portable pipe and sprinkler</u> -- Forty-one farmers had an average of $6,810 per farm invested in portable pipe and sprinkler systems. The total invested per well, pump, power unit, and distribution system was smaller for portable pipe and sprinkler systems than for trailer boom and giant sprinkler systems. The per cent of the total investment per farm for wells, pumps, and power units was smaller for portable pipe and sprinkler systems than for the other types. The distribution system investment for portable pipe and sprinkler systems was 57 per cent of the total, which was higher than for any other type.

<u>Surface irrigation-gated pipe</u> -- The average investment per farm for the 11 farmers with gated pipe was

$5,518. The average cost per well and pump was the lowest of all systems. The average cost per power unit was lower than in other systems, except those that used portable pipe and sprinklers. The need for high capacity pumps was reduced, since the water was not distributed under pressure. The investment in the distribution system averaged 42 per cent of the total investment per farm.

Surface irrigation-ditches and furrows -- The per cent of the total investment that was in wells, pumps, and power units was higher for this type of system than for any other type. Only 11 per cent of the total was invested in the distribution system. The cost of siphon tubes was small when compared to the cost of pipes and sprinklers. Water was pumped under open discharge directly into the irrigation ditch, in most cases. The water was transferred from the irrigation ditch to the furrows or rows by means of siphon tubes. The three farmers who used this system had an average investment per farm of $4,100.

Statistical tests -- The null hypothesis of no difference between the types of irrigation systems and the average investment per farm was tested. As stated previously, the five different types were divided into three categories, due to the small number in certain systems. Category I was the portable pipe and sprinkler systems exclusively. Trailer boom and giant sprinklers were combined to form Category II. The two methods of surface irrigation were combined as Category III. With this arrangement, the average investment per farm was $6,810 for Category I, $11,022, Category II, and $5,252 for Category III.

The difference between the means of the categories was tested statistically. The "t" statistic was used. The standard deviations were unknown, but assumed to be equal. A "t" value of 1.59 was obtained when the difference between the means of Category I and III was tested. The "t" value was not statistically significant at the .05 level. As a result, the null hypothesis was not rejected. The "t" values, when the differences between the means of Category I and II and Category II and III were tested, were -3.38 and -4.34 respectively. The former was statistically significant at the .01 level, and the latter at the .001 level. The null hypotheses were rejected in both tests. There was a significant difference between the average investment in irrigation equipment on Category II farms and Category I and III farms.

In order to obtain additional insight into the reasons for a significant difference between the means, the average cost per well, pump, power unit, and distribution system was determined. By reducing the analysis of costs to a per well, pump, and power unit basis, the effects of the larger capacity systems were partially eliminated. The larger capacity effect was not removed, however, by using the cost per distribution system, because the larger systems of all categories directly reflected the increased quantity of main and lateral lines or gated pipe.

The average cost per well was $850 for Category I: $893, Category II, and $881 for Category III systems. The differences between the means were tested, but were not statistically significant. The null hypotheses were not rejected.

The average cost per pump was $639, $790, and $771 for Category I, II, and III systems respectively. The differences between the means were not statistically significant.

Category I, II, and III systems had an average cost per power unit of $848, $1,027, and $1,042 respectively. The differences between the means were not statistically significant.

The average cost per distribution system was $3,842, $5,560, and $1,893 for Category I, II, and III systems respectively. A "t" value of -2.44 was calculated when the difference between the means of Category I and II were tested. The "t" value was statistically significant at the .02 probability level. The null hypothesis was rejected. There was a significant difference in the average cost of distribution equipment for Category I and II systems.

A "t" value of 3.46 was calculated when the difference between the means of Category I and III were tested, which was statistically significant at the .01 probability level. The null hypothesis was rejected.

The null hypothesis also was rejected, when the difference between the means of Category II and III systems was tested. A "t" value of 4.19 was computed, which was statistically significant at the .001 probability level.

Capacity of irrigation system -- The average capacity of the portable pipe and sprinkler systems was 118 acres. The range was from 11 to 219 acres. The average investment in irrigation equipment ranged from $3,600 for the 19 or less group to $10,660 for the 180-219 acres group, as shown in Table XXVII. The average investment per acre of irrigation capacity varied from $360 for the 19 or less group to $52 for the 140-179 acre group.

The five farms with giant sprinkler systems had an average capacity of 144 acres. The range was from 60 to 259 acres, as shown in Table XXVIII. The average

TABLE XXVII

FIXED INVESTMENT IN PORTABLE PIPE AND SPRINKLER IRRIGATION SYSTEMS IN FOUR SOUTHEASTERN MISSOURI COUNTIES, ACCORDING TO CAPACITY OF IRRIGATION SYSTEM IN ACRES PER YEAR, 39 FARMERS, 1959

Type of Equipment	Capacity of Irrigation System (Acres Per Year) 19 or Less	20-59	60-99	100-139	140-179	180-219
Wells:						
Number of wells	2	3	27	11	11	13
Average cost per well	$ 600	$ 633	$ 550	$ 764	$ 936	$ 892
Average investment per farm	$ 600	$ 633	$ 993	$1,200	$1,471	$ 2,320
Per cent of total investment	17	18	17	18	18	22
Pumps:						
Number of pumps	2	3	17	9	7	11
Average cost per pump	$ 500	$ 400	$ 632	$ 733	$ 725	$ 627
Average investment per farm	$ 500	$ 400	$ 714	$ 943	$ 828	$ 1,380
Per cent of total investment	14	11	13	14	10	13
Power Units:[a]						
Number of power units	1	2	16	8	7	9

TABLE XXVII (Continued)

Type of Equipment	Capacity of Irrigation System (Acres Per Year)					
	19 or Less	20-59	60-99	100-139	140-179	180-219
Average cost per power unit	$ 500	$ 600	$ 806	$ 787	$1,086	$ 655
Average investment per farm	$ 250	$ 400	$ 860	$ 940	$1,086	$ 1,180
Per cent of total investment	7	11	15	14	13	11
Distribution System:						
Number of systems	2	3	15	7	7	5
Average investment per farm	$2,250	$2,167	$3,113	$3,514	$4,942	$ 5,780
Per cent of total investment	62	60	55	54	59	54
Total investments	$3,600	$3,600	$5,680	$6,557	$8,327	$10,660
Average per acre investment	$ 360	$ 90	$ 71	$ 55	$ 52	$ 53

[a]Excludes power unit investment on 2 farms using farm tractors as a source of power.

TABLE XXVIII

FIXED INVESTMENT IN TRAILER BOOM AND GIANT SPRINKLER IRRIGATION SYSTEMS IN FOUR SOUTHEASTERN MISSOURI COUNTIES, ACCORDING TO CAPACITY OF IRRIGATION SYSTEM IN ACRES PER YEAR, 10 FARMERS, 1959

	Capacity of Irrigation Systems (Acres Per Year)							
	Giant Sprinkler				Trailer Boom			
Type of Equipment	60-99	100-139	180-219	220-259	140-147	220-259	300-339	340 or Over
Wells:								
Number of wells	2	4	4	2	2	5	2	2
Average cost per well	$ 750	$ 725	$ 1,025	$ 711	$ 650	$ 880	$ 800	$ 2,550
Average investment per farm	$ 750	$2,900	$ 4,100	$ 1,422[a]	$ 1,300	$ 2,200	$ 1,600	$ 5,100
Per cent of total investment	13	35	34	12	18	16	10	31
Pumps:								
Number of pumps	2	1	3	2	1	5	2	2
Average cost per pump	$ 750	$ 400	$ 1,033	$ 600	$ 800	$ 640	$ 1,300	$ 1,000
Average investment per farm	750	400	3,100	1,200	800	1,600	2,600	2,000
Per cent of total investment	13	5	26	10	11	12	17	12
Power Units:								
Number of power units	2	1	3	2	1	5	1	3
Average cost per power unit	$ 700	$1,700	$ 800	$ 900	$ 900	$ 840	$ 1,800	$ 1,100
Average investment per farm	700	1,700	2,400	1,800	900	2,100	1,800	3,300

TABLE XXVIII (Continued)

Type of Equipment	Capacity of Irrigation Systems (Acres Per Year)							
	Giant Sprinkler				Trailer Boom			
	60-99	100-139	180-219	220-259	140-147	220-259	300-339	340 or Over
Per cent of total investment	12	20	20	15	12	16	12	21
Distribution System:								
Number of systems	22	11	1	1	1	2	1	1
Average investment per farm	$ 3,700	$3,300	$ 2,400	$ 7,700	$ 4,400	$ 7,600	$ 9,500	$ 5,700
Per cent of total investment	62	45	20	63	59	56	61	36
Total Investment	$ 5,900	$8,300	$12,000	$12,122	$ 7,400	$13,500	$15,500	$16,100
Average per acre investment	74	69	60	50	46	56	48	45

[a]Drainage ditch was used as source of irrigation water also.

investment in irrigation equipment ranged from $5,900 for the 60-99 acre group to $12,122 for the 220-259 acre group. The small number of cases within each class limited the importance of the data for purposes of projection.

The trailer boom systems had an average capacity of 290 acres, which was the largest of the five systems. The range was from 140 to 510 acres. The limited number of cases, particularly in the large capacity systems, had a large effect on the data. The average investment in irrigation equipment ranged from $7,400 to $16,100. The average investment per capacity acre was practically constant, ranging from $45 to $56, with a mean of $46.

The capacity of the irrigation systems on the three farms with ditches and furrows where siphon tubes were used to distribute the water was different for each farm. Essentially, the analysis required a case study of the three different capacities. The cost of grading land was not included in the total investment for the two surface type systems. The total investment for the 60-99, 100-139, and 140-179 acres was $2,500, $4,600, and $5,200 respectively, as shown in Table XXIX. The average investment per acre was $31, $38, and $32 for the 60-99, 100-139, and 140-179 acre groups respectively.

The average capacity of the irrigation systems of the 11 farmers with gated pipe was 87 acres. Ten of the 11

TABLE XXIX

FIXED INVESTMENT IN SURFACE IRRIGATION SYSTEMS IN FOUR SOUTHEASTERN MISSOURI COUNTIES, ACCORDING TO CAPACITY OF IRRIGATION SYSTEM IN ACRES PER YEAR, 14 FARMERS, 1959

	Capacity of Irrigation System (Acres Per Year)				
	Ditches and Furrows			Gated Pipe	
Type of Equipment	60 99	100 139	140 179	60 99	140 179
Wells:					
Number of wells	1	1	1	21	3
Average cost per well	$ 700	$ 700	$1,700	$ 581	$ 333
Average investment per farm	$ 700	$ 700	$1,700	$1,220	$ 1,000
Per cent of total investment	28	15	33	24	10
Pumps:					
Number of pumps	2	1	1	15	2
Average cost per pump	$ 300	$1,600	$1,200	$ 524	$ 800
Average investment per farm	$ 600	$1,600	$1,200	$ 890	$ 1,600
Per cent of total investment	24	35	23	17	16
Power Units:					
Number of power units	2	1	1	12	2
Average cost per power unit	$ 450	$1,500	$2,100	$ 825	$ 1,950

TABLE XXIX (Continued)

Type of Equipment	Capacity of Irrigation System (Acres Per Year)				
	Ditches and Furrows			Gated Pipe	
	60 99	100 139	140 179	60 99	140 179
Average investment per farm	$ 900	$1,500	$2,100	$ 910	$ 1,900
Per cent of total investment	36	33	40	20	19
Distribution Systems:					
Number of systems	1	1	1	10	1
Average investment per farm	$ 300	$ 800	$ 200	$1,970	$ 5,500
Per cent of total investment	12	17	4	39	55
Total investment	$2,500[a]	$4,600[b]	$5,200	$5,070[c]	$10,000
Average per acre investment	$ 31	$ 38	$ 32	$ 63	$ 62

[a] Sixty-two acres were graded with an average cost of $15 per acre.

[b] One hundred and twenty-five acres were graded with an average cost of $104 per acre.

[c] Twenty acres graded with an average cost of $20 per acre.

had systems with capacities in the 60-99 acre range. The total investment in equipment averaged $5,070 for the 60-99 acre group, and $10,000 for the 140-179 acre group. The average investment per acre was $63 and $62, as shown in Table XXIX.

Based on the above analysis, it appeared that the total investment and the average investment per acre were approximately twice as much for the gated pipe systems as for the ditch and furrow systems, when the same number of acres could be irrigated.

The same three categories were used to test the difference between the average capacity for different types of irrigation systems, as was used in the previous section. Category I, II, and III systems had average capacities of 118, 217, and 93 acres respectively.

The null hypothesis of no difference between the type of irrigation system and average capacity per farm was tested. A "t" value of 1.33 was obtained when differences between the means of Category I and III were tested. The "t" value was not statistically significant at the .05 probability level. Therefore, the null hypothesis was not rejected.

The "t" values, when the differences between the means of Category I and II and Category II and III was tested, were -3.30 and -3.35 respectively. Both "t" values were statistically significant at the .01 probability level. The null hypotheses were rejected in both tests. There was a significant difference between the average capacity per farm with a Category II system and Category I and III systems.

Type of irrigation system and whether the operator irrigated or did not irrigate in 1959 -- The relationship between the type of irrigation system and whether the operator used the equipment or did not irrigate in 1959 was tested. A chi square of 1.73 was obtained, which was not statistically significant at the .05 probability level. The hypothesis was not rejected. The probability of obtaining a chi square larger than 1.73 was .44.

III. IRRIGATION IN 1959

Number of Farmers Applying Water

Forty-six of the 65 farmers from whom data were obtained applied water to crops in 1959. This number was .7077 of the number interviewed. The proportion of farmers who did not irrigate was designated as "q," which was 1 - p or .2923. The sample statistic, "p," was considered the best estimate of the proportion of irrigating farmers in the population. The 0.95 confidence interval for the population proportion of irrigators was between .597 and .818.

Irrigated Acres

The acres irrigated was defined as the area to which water was applied, regardless of the number of water applications. An acre application was defined as the application of water to one acre one time. For example, ten acres watered four times would equal ten irrigated acres and 40 acre applications. However, if the ten acres were only watered one time, then both the irrigated acres and acre applications would equal ten.

The 46 irrigating farmers applied water to 2,637 acres of land. The average number of irrigated acres per farm was 57. The range was from 11 to 232 acres. The average number of irrigated acres per farm was considered the best estimate of the average number of irrigated acres per farm in the population. The 0.95 confidence interval for the average number of irrigated acres in the population was from 44 to 71 acres per farm. This interval has a 0.95 chance of including the universe mean.

It was estimated that 7,546 total acres were irrigated by the 186 farmers in the population. The formula, $\frac{1}{f}(X)$ = estimate of total acres irrigated, was used. X equaled the total number of acres irrigated by the 65 sample members, and "f" was the sampling fraction. The 0.95 confidence interval for the total irrigated acres by the 186 population members was from 4,883 to 10,210 acres.

The total capacity of the irrigation systems within the population was estimated to be 23,445 acres, using the irrigated acres concept. No attempt was made to estimate the number of acre applications which could have been made by the 186 farmers.

The percentage of the total irrigation capacity employed in 1959 was estimated to be 20 to 44 per cent. These percentages were estimated from the sample proportion of irrigated acres. Based upon this analysis, it was evident that the irrigation systems were not fully employed in 1959.

Acre Application

The 46 farmers irrigating in 1959 made 4,486 acre applications of water. The average number per farm was 97.5, with a range from 11 to 522. The probability was 0.95 that the universe mean of acre applications per farm was between 69 and 126. Since, 2,637 acres were irrigated, and 4,486 acre applications of water were applied, each acre was watered an average of 1.7 times.

Crops Irrigated

Cotton, corn, and soybeans were the major irrigated crops, in terms of number of irrigated acres. Other irrigated crops were strawberries, sweet corn, pasture, cabbage, and wheat. The detailed analysis will cover only cotton, corn, and soybeans, due to the limited number of irrigators and irrigated acreage of other crops. The irrigated acres of cotton, corn, and soybeans were 94.7 per cent of the total to which water was applied.

Cotton -- Cotton was the major irrigated crop. Thirty-five farmers applied water to 1,523 acres. Four hundred and eleven acres were irrigated twice and 273 acres, three times. An average of 2.89 inches of water was applied per acre. The farmers believed that they were actually getting 2.89 inches of water on the ground. The loss from evaporation, wind, and seepage had been taken into consideration. The 0.95 confidence interval for the universe mean was between 2.38 and 3.41 inches of water per acre.

An average of 43.5 acres of cotton was irrigated per farm by the 35 farmers. It was estimated that the average number of acres of cotton irrigated by all farmers with equipment was from 34 to 53 acres.

The irrigated acres of cotton were 58 per cent of the total acreage to which water was applied. Based on the sample statistics from the records obtained, it was estimated that cotton was between .45 and .70 of the total acres irrigated by all of the farmers who had equipment.

<u>Cotton yield response from irrigation</u> -- Fifteen or 43 per cent of the 35 farmers obtained a yield response from irrigation, but 57 per cent did not. One reason for the limited results was time of application. Ten of the 35 farmers applied a limited quantity of water to germinate the seed immediately following planting. Most of these growers made no further applications. In view of this fact, it was not surprising that no yield response could be attributed to irrigation.

The average yield response attributed to irrigation was 66 pounds of lint cotton per acre, even though 57 per cent of the cotton irrigators did not receive a yield increase. The range was from 0 to 300 pounds of lint per acre.

Yield responses for all crops were estimated by the farmers. No field checks were made. In many cases, the farmer actually had two fields of the crop on comparable soils with comparable production techniques, with the exception of irrigation. Other farmers, however, did not have comparable crops on the same farm. In the latter case, the farmer's estimate was simply his opinion of the yield increase or a check of the difference in the yields of a neighbor's crop and his own.

<u>Corn</u> -- Sixteen farmers applied water to 659 acres of corn. Of the total, 397 acres were irrigated twice,

and 235 acres, three times. An average of 5.25 inches of water was applied per acre. It was estimated that the average amount of water applied per acre by all the farmers who irrigated corn was between 4.2 and 6.3 inches.

The 16 farmers irrigated an average of 41 acres per farm. The universe mean was estimated to be between 21 and 62 acres per farm.

Corn-yield response -- Ten or 62.5 per cent of the 16 farmers reported a yield response from irrigation. Six or 37.5 per cent did not obtain a yield response. The average yield increase was 30 bushels per acre. The range was from 0 to 50 bushels per acre. It was estimated that the average yield increase for all corn irrigators in the area was between 21 and 40 bushels per acre.

Soybeans -- Thirteen farmers who contributed data for the analysis irrigated 316 acres of soybeans. The average number of acres per farm was 24 with a range from 5 to 70. It was estimated that the average number of acres irrigated per farm in the population of soybean irrigators was between 14 and 34. One hundred and sixty-four acres were irrigated twice. The remaining acreage received water only once. An average of 4.4 inches of water was applied per acre. It ranged from one to ten inches.

Soybeans-yield response -- Nine or 69.2 per cent of the 13 farmers reported a yield response from irrigation. The average was 8.5 bushels per acre with a range from 0 to 19 bushels. It was estimated that the average yield increase for soybean irrigators in the Delta Area was from five to 12 bushels per acre.

Other irrigated crops -- Four farmers irrigated 51 acres of strawberries. Four applied water to 34 acres of pasture. Thirty-five, 15, and four acres of sweet corn, wheat, and cabbage were irrigated. No detailed analysis was made of these crops due to the small number of irrigators.

Statistical test-difference between the average amount of water applied to different crops -- As stated in a previous section of this chapter, an average of 5.23, 2.89, and 4.37 inches of water per acre was applied to corn, cotton, and soybeans respectively in 1959. The null hypothesis of no difference between the average for the three crops was tested.

A "t" value of 4.5 was obtained when the difference between the means of corn and cotton was tested. A "t" value of this magnitude was statistically significant at the .001 probability level. The null hypothesis was rejected. Corn received more water per acre in 1959 than cotton.

When the difference between the means of corn and soybeans was tested, a "t" value of .95 was obtained. The "t" value was not statistically significant at the .05 probability level. The null hypothesis was not rejected.

A "t" value of 2.26 was obtained when the difference between the means of cotton and soybeans was tested. The "t" value was statistically significant at the .05 probability level. The null hypothesis was rejected. Soybeans received more water per acre than cotton.

There was a significant difference between the average amount of water applied per acre in 1959 to corn and cotton and to soybeans and cotton. Cotton received the smallest amount of water per acre.

<u>Statistical test-difference between the average gross return per acre attributable to irrigation</u> -- The average physical product attributable to irrigation was 30 bushels of corn, 8.5 bushels of soybeans, and 66 pounds of lint cotton per acre. The average prices received by Missouri farmers in September, October, and November, and December, 1959, were $1.00 per bushel for corn; .322¢ per pound for lint cotton, and $1.95 per bushel for soybeans. The price per unit of output multiplied by the average

physical product per acre equaled the average gross return per acre attributable to irrigation in 1959. The average gross return per acre was $30.36 for corn; $21.24 for cotton, and $16.66 for soybeans.

The difference between the average gross return per acre of the three crops was tested. A "t" value of 1.06 was obtained when the difference between the means of corn and cotton was tested. This value was not statistically significant at the .05 probability level. The null hypothesis was not rejected.

A "t" value of 2.23 was obtained when the difference between the means of corn and soybeans was tested. A value of this magnitude was statistically significant at the .05 probability level. The null hypothesis was rejected. There was a significant difference between the average gross return per acre of corn and soybeans. Corn received the higher return.

When the difference between the means of cotton and soybeans was tested, a "t" value of .50 was found. It was not statistically significant at the .05 probability level, and the null hypothesis was not rejected.

The analysis revealed a significant difference between the average gross return per acre of corn and soybeans in 1959. The average irrigated acre of corn returned $13.70 more than the average irrigated acre of soybeans.

<u>Statistical test-difference between adjusted gross return per acre attributable to irrigation</u> -- The average gross return per acre minus the harvest cost of the additional yield was assumed to equal the adjusted gross return per acre attributable to irrigation. The harvest cost per bushel of corn was .15¢;per pound of seed cotton, .02¢, and per bushel of soybeans, .30¢.[1] The average physical output per acre multiplied by the unit harvest cost equaled the average harvest cost per irrigated acre. The adjusted gross return per acre was $25.81 for corn; $17.28 for cotton, and $14.10 for soybeans.

The difference between the adjusted gross return per acre of the three crops was tested. The computed "t" values, when the difference between corn and cotton, corn and soybeans, and cotton and soybeans was tested, were .99, 2.25, and .35 respectively. The "t" value of 2.25 was statistically significant at the .05 probability level. Irrigated corn had a higher adjusted gross return per acre than soybeans. The difference between the

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[1]Albert Hagan, "Missouri Custom Rates" (University of Missouri Department of Agricultural Economics, 1960), pp. 1, 4, and 19. (mimeographed).

adjusted gross return per irrigated acre in 1959 was not significant for corn and cotton, and cotton and soybeans.

Summary of Statistical Tests

Test of independence --

Factors tested	Computed Chi Square	Critical Chi Square .05 Level	Signif- icant	Not Signif- icant
Size of farm and				
(1) Whether irriga- tion was used	4.20	9.49		X
(2) Capacity of irrigation system	23.52	25.00		X
Tenure of farm operator and				
(1) Whether irriga- tion system was used	2.34	5.99		X
(2) Type of soil	8.31	12.59		X
(3) Type of irriga- tion system	3.32	9.49		X
(4) Whether type of system has been changed	.68	5.99		X
Old type system	.98	5.99		X
New type system	4.78	5.99		X
Fixed investment in irrigation equipment and				
(1) Size of farm	24.98	31.41		X

Factors tested	Computed Chi Square	Critical Chi Square .05 Level	Signif-icant	Not Signif-icant
(2) Whether irrigation system was used	7.32	9.49		X
(3) Tenure	10.00	15.51		X
Whether irrigation system was used and				
(1) Type of irrigation system	1.72	5.59		X
(2) Capacity of irrigation system	5.29	7.81		X
(3) Year irrigation was started	2.97	5.99		X
(4) Type of soil	5.13	7.81		X

Test of difference between means when standard deviations are unknown, but assumed equal.

Factors tested	Computed "t" Value	Critical "t" Value .05 Level	Signif-icant	Not Signif-icant
Type of irrigation system and				
(1) Fixed investment in irrigation equipment				
Category I and II	3.38	2.021	.01	
Category I and III	1.59	2.021		X
Category II and III	4.34	2.074	.001	

Factors tested	Computed "t" Value	Critical "t" Value .05 Level	Signif-icant	Not Signif-icant
(2) Capacity of irrigation system				
Category I and II	3.30	2.021	.01	
Category I and III	1.33	2.021		X
Category II and III	3.35	2.074	.01	
(3) Average cost per well				
Category I and II	.24	2.021		X
Category I and III	.18	2.021		X
Category II and III	.04	2.074		X
(4) Average cost per pump				
Category I and II	1.26	2.021		X
Category I and III	1.14	2.021		X
Category II and III	.12	2.074		X
(5) Average cost per power unit				
Category I and II	1.03	2.021		X
Category I and III	1.12	2.021		X

Factors tested	Computed "t" Value	Critical "t" Value .05 Level	Signif- icant	Not Signif- icant
Category II and III	.06	2.074		X
(6) Average cost per distribution system				
Category I and II	2.44	2.021	.02	
Category I and III	3.46	2.021	.01	
Category II and III	4.19	2.074	.001	
Kinds of irrigated crop and				
(1) Amount of water applied per acre				
Corn and cotton	4.50	2.021	.001	
Corn and soybeans	.95	2.052		X
Soybeans and cotton	2.26	2.021	.05	
(2) Gross return per acre				
Corn and cotton	1.06	2.021		X
Corn and soybeans	2.23	2.052	.05	
Soybeans and cotton	.50	2.021		X
(3) Adjusted gross return per acre				
Corn and cotton	.99	2.021		X
Corn and soybeans	2.25	2.052	.05	

Factors tested	Computed "t" Value	Critical "t" .05 Level	Signif- icant	Not Signif- icant
Soybeans and cotton	.35	2.021		X
Capacity of irrigation system and				
(1) Tenure Owner-operator and part-owner	.79	2.021		X
Owner-operator and tenant	1.81	2.042		X
Part-owner and tenant	1.47	2.021		X

CHAPTER IV

IRRIGATION COSTS AND RETURNS

Production costs are important to decision makers in all firms. Irrigation costs are no exception. The farm operator needs to have the best available data showing the cost of applying water. The decision as to whether or not to irrigate his crops in a given year depends upon the information that is available concerning costs in relation to expected returns. The amount of investment in equipment has already been pointed out. In a humid region such as the Delta of Missouri, profitable crops can be grown in most years without irrigation. The question to which this analysis will be addressed is whether or not more profit can be made by applying water. Many variables of indeterminate magnitude must be considered. They include the amount and distribution of rainfall, the yield response from irrigation, and the price of the product.

The costs involved in the purchase and use of irrigation systems are of two general types--fixed and variable. Annual fixed costs reflect the amount of capital invested in irrigation equipment and the length of time in the investment period. Variable or operating costs reflect prices of variable inputs such as labor, fuel, oil, and other supplies required to pump and distribute the water and to harvest the increased yield.

Annual Fixed Cost

The annual fixed cost per irrigation system included depreciation, interest, taxes, and insurance. The following procedures were used to compute the individual items:

$$\text{Depreciation} = \frac{\text{Original Value}}{\text{Years of Useful Life}}$$

The useful life of wells and siphon tubes was estimated to be 20 years. The depreciation schedule for pumps, power units, and distribution systems, other than siphon tubes, was 15 years. The annual interest charge was equal to one-half of the original value of the equipment multiplied by 5.0 per cent

$$(\text{Annual Interest} = \frac{\text{Original Value}}{2} \times .05).$$

The tax charge was the assessed value multiplied by 30 cents per $100 valuation (Taxes = assessed value X $0.30). The annual charge for insurance was obtained by taking 80 per cent of the original value of the pump, power unit, and distribution system and multiplying the result in thousands of dollars by $5.80 (Insurance Charge =

$$\frac{\text{Original Value} \times .80 \times \$5.80}{\$1000}).$$

Depreciation charges made up 69 per cent of the annual fixed cost for the three different types of systems, as shown in Table XXX. Interest charges averaged 27 per cent, which was second in importance, and taxes and

TABLE XXX

ANALYSIS OF FIXED COSTS AS PERCENTAGES OF FIXED AND TOTAL IRRIGATION COSTS BY TYPE OF IRRIGATION SYSTEMS, FOUR SOUTHEASTERN MISSOURI COUNTIES, 46 FARMS, 1959

	Per Cent of Fixed Costs		Per Cent of Total Costs	
Type of System	Average	Range	Average	Range
Gated Pipe and Ditches and Furrows:[a]				
Depreciation	69	67-76	55	40-66
Interest	27	21-29	21	16-25
Taxes and Insurance	4	3- 5	4	3- 6
Total Fixed Costs			80	59-91
Giant Sprinkler and Trailer Boom:[b]				
Depreciation	69	64-71	45	31-62
Interest	27	25-31	18	13-24
Taxes and Insurance	4	4- 5	3	2- 5
Total Fixed Costs			65	48-91
Portable Pipe and Sprinkler:[c]				
Depreciation	69	66-70	55	27-68
Interest	27	26-29	21	10-27
Taxes and Insurance	4	4- 5	3	2- 6
Total Fixed Costs			80	38-98

[a]Nine irrigators.

[b]Nine irrigators.

[c]Twenty-eight irrigators.

insurance, four per cent.

Fixed charges in 1959 averaged 80 per cent of the total irrigation costs for the surface and portable pipe and sprinkler systems, and 65 per cent for the trailer boom-giant sprinkler systems (Table XXX). The relative proportion of fixed costs to total costs depended upon the amount the system was used. The more use, or the higher the variable costs, the lower the per cent of fixed charges in relation to the total. The trailer boom-giant sprinkler systems were used more extensively than the other two types, and the per cent of fixed costs, in relation to total costs, were smaller. The range in fixed costs as a per cent of the total costs was 59-91, 48-91, and 38-98 for the surface, trailer boom-giant sprinkler, and portable pipe and sprinkler systems respectively. These ranges show that one of the portable pipe and sprinkler systems was used more, and one less than any other type of system. In general, portable pipe and sprinkler systems where strawberries were irrigated received more use in 1959 than systems which were used exclusively for field crops.

Variable Costs

After a farm operator has invested in irrigation equipment, and can apply supplemental water to crops, variable costs must be considered. The annual fixed costs must be borne as long as the equipment is owned or until the cost has been charged off regardless of the annual use. If the production functions were known and accurate cost data were available, the decision maker should apply water to the point where the marginal cost was equal to the marginal revenue from the last unit applied in order to maximize profit. However, knowledge is not perfect in the real world and many uncertainties must be faced. Therefore, on a given farm in a given year, the decision maker should consider the variable costs of applying water in relation to the expected returns from its use. If he expects the return from irrigation to equal or exceed the variable cost, water should be applied. Irrigation can be justified, as long as the average variable costs are covered. Any additional return above the average variable cost will reduce the average fixed cost. The decision maker will have to receive a return greater than the average irrigation cost in many years to make up for the years when the system was not used, and those in which the returns did not pay average variable costs, if the practice is to be profitable. It was assumed that farmers who had purchased irrigation equipment expected returns over the time period of the investment which would equal or be greater than could be expected from investment in other endeavors. Otherwise, the original investment in irrigation equipment would not have been logical.

Variable costs as a percentage of the items in this class, and total irrigation costs were analyzed (Table XXXI). Expenditures for fuel and oil averaged 55, 57, and 51 per cent of the variable costs for the surface, trailer boom-giant sprinkler, and portable pipe and sprinkler systems respectively. Labor costs were second in importance. Thirty-six, 32, and 41 per cent of the variable costs was attributed to labor charges for the surface, trailer boom-giant sprinkler, and portable pipe and sprinkler systems respectively.

Variable costs as a per cent of the total irrigation costs were 20 per cent for the surface and portable pipe and sprinkler systems respectively. The fuel and oil costs were about twice as large for the trailer boom-giant sprinkler as for the other two systems. Labor costs were seven, 11, and eight per cent of the total costs for the three systems.

The labor, tractor, fuel and oil, and minor repair costs per acre application of water were determined for the three different systems (Table XXXII). The average variable cost per acre application for the surface systems was $1.59, which was the lowest among the three types of

TABLE XXXI

ANALYSIS OF VARIABLE COSTS AS PERCENTAGE OF VARIABLE AND TOTAL IRRIGATION COSTS BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 46 FARMS, 1959

Type of System	Per Cent of Variable Costs		Per Cent of Total Costs	
	Average	Range	Average	Range
Gated Pipe and Ditches and Furrows:[a]				
Labor	36	14-57	7	1-19
Tractor	4	2- 7	1	0- 1
Fuel and oil	55	33-87	11	4-26
Minor repairs and miscellaneous	5	0-15	1	0- 4
Total Variable Costs			20	12-52
Giant Sprinkler and Trailer Boom:[b]				
Labor	32	22-41	11	5-20
Tractor	5	1- 7	1	0- 4
Fuel and oil	57	43-76	20	6-32
Minor repairs and miscellaneous	6	0-24	2	0-12
Total Variable Costs			35	11-52
Portable Pipe and Sprinkler:[c]				
Labor	41	13-69	8	1-34
Tractor	5	1-18	1	0- 4
Fuel and oil	51	21-70	10	1-40
Minor repairs and miscellaneous	3	0-30	1	0- 3
Total Variable Costs			20	2-62

[a]Nine irrigators.

[b]Nine irrigators.

[c]Twenty-eight irrigators.

TABLE XXXII

ANALYSIS OF VARIABLE COSTS PER ACRE APPLICATION OF WATER, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 46 FARMS, 1959

Type of System	Variable Costs (Dollars)	
	Average	Range
Gated Pipe and Ditches and Furrows:[a]		
Labor	.58	.12-1.24
Tractor Cost	.06	.02- .11
Fuel and Oil	.87	.39-1.20
Minor Repairs	.08	.00- .38
Total	1.59	1.00-2.60
Giant Sprinkler and Trailer Boom:[b]		
Labor	.83	.45-1.75
Tractor Cost	.11	.04- .18
Fuel and Oil	1.48	.86-2.80
Minor Repairs	.16	.00- .56
Total	2.58	1.70-4.60
Portable Pipe and Sprinkler:[c]		
Labor	1.15	.50-2.81
Tractor Cost	.14	.10- .24
Fuel and Oil	1.44	.42-3.22
Minor Repairs	.09	.00- .83
Total	2.82	1.37-4.95

[a]Nine irrigators.

[b]Nine irrigators.

[c]Twenty-eight irrigators.

systems.[1] The range was from $1.00 to $2.60. The following items were included: labor, $0.58; tractor, $0.06; fuel and oil, $0.87, and minor repairs, $0.08. The variation in the average variable cost per acre application was very noticeable within a given type of system as well as among the different types. The average labor cost per acre application ranged from $0.12 to $1.24 for the surface systems. A range of $0.39 to $1.20 per acre application of water was found for the fuel and oil costs.

The average variable cost per acre application of water for the trailer boom-giant sprinkler systems was $2.58 with a range from $1.70 to $4.60. All variable costs were higher for the trailer boom-giant sprinkler systems than for the surface systems. The labor, tractor, fuel and oil, and minor repair costs averaged $0.83, $0.11, $1.48, and $0.16 respectively.

The portable pipe and sprinkler systems had an average variable cost of $2.82 per acre application with a range from $1.37 to $4.95. This was the highest average variable cost among the three different types of systems. The labor and tractor costs were greater for the portable pipe and sprinkler systems than for the other two types.

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[1]An acre application is an acre irrigated one time.

However, the trailer boom-giant sprinkler system had the greatest fuel and oil, and minor repair costs per acre application.

The difference between the average labor, tractor, fuel and oil, and minor repair costs for the three systems was analyzed. The null hypothesis was tested in all cases. The same classification was given to the different irrigation systems as was followed in Chapter III. Category I or portable pipe and sprinklers, Category II or giant sprinkler and trailer boom combinations and Category III or gated pipe and ditches and furrows were used.

Average labor cost per acre application -- The difference between the means of average labor cost per acre application was tested. The "t" statistic was used. The standard deviations were unknown, but assumed to be equal. A "t" value of +1.23 was obtained when the difference between the means of Category II and III were tested. The "t" value was not statistically significant at the .05 probability level. The null hypothesis was not rejected. When the difference between the means of Category II and I was tested, a "t" value of -1.42 was obtained. This value was not statistically significant.

The average labor cost per acre application of water was $0.58 and $1.15 for Categories III and I respectively.

A "t" value of -2.6 was calculated, which was statistically significant at the .05 probability level. The null hypothesis was rejected. There was a significant difference between the average labor cost per acre application between Category III and I. The average labor cost was greater for Category I. The average labor cost was greater for Category I and the users of this type of equipment had difficulty in hiring workers to move the pipe and sprinklers.

Average tractor cost per acre application -- The average tractor cost per acre application was $0.14, $0.11, and $0.06 for Categories I, II, and III respectively, as shown in Table XXXII. The "t" values, when the difference between means of Category II and III and Category III and I was tested, were 2.13 and -4.40 respectively. The former was statistically significant at the .05 probability level, and the latter at the .001 level. The null hypotheses were rejected in both tests. There was a significant difference between the average tractor cost per acre application on farms with Category III and Category I and II irrigation systems. The average tractor cost was smallest on farms with surface type systems. A "t" value of 1.28 was obtained when the difference between the means of Category II and I was tested. The difference was not statistically significant. The null hypothesis was not rejected.

Average fuel and oil cost per acre application -- The average fuel and oil cost per acre application was \$1.44, \$1.48, and \$0.87 for Categories I, II, and III respectively. The "t" values, when the difference between the means of Category II and III and Category III and I was tested, were 2.78 and -2.29 respectively. The former was statistically significant at the .02 probability level, and the latter at the .05 probability level. The null hypotheses were rejected in both cases. There was a significant difference between the average fuel and oil costs per acre application on Category III farms and Category I and II farms. The average fuel and oil cost was the lowest on farms with surface type systems. The water was not pumped under pressure on farms with surface irrigation systems, while it was on farms with portable pipe and sprinklers and trailer boom-giant sprinkler systems. A "t" value of .16 was obtained when the difference between the means of fuel and oil costs of Category II and I was tested. The difference was very small, and consequently not statistically significant. The null hypothesis was not rejected.

Average minor repair cost per acre application -- The average minor repair cost per acre application was $0.09, $0.16, and $0.08 for Categories I, II, and III respectively. The differences between the means were tested. The "t" values were .78, .64, and .06, which were not statistically significant. The null hypotheses were not rejected.

Total Cost of Irrigation

Fixed costs plus variable costs equal total irrigation costs. The average fixed, variable, and total costs per acre inch of water applied, per acre irrigated, and per acre application for the three different types of systems were analyzed, as shown in Table XXXIII. The computations included the cost of all of the irrigation that was done on the farms where data were obtained in 1959. However, costs of harvesting the increased yield were not included in order to keep the analysis on a comparable basis between the farmers who received a yield response and those who did not. The costs of irrigating individual crops will be analyzed in a later section of the chapter. Data in Table XXXIII show average fixed, variable, and total cost of applying water in 1959 by use of three different systems based upon the estimated amount of water applied. The farmers who used portable pipe and sprinkler

TABLE XXXIII

FIXED, VARIABLE AND TOTAL COST OF IRRIGATION PER ACRE INCH OF WATER APPLIED, PER ACRE IRRIGATED, AND PER ACRE APPLICATION, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 46 IRRIGATORS, 1959

Type of System	Amount Per Farm	Fixed Cost (Dollars)	Variable Cost (Dollars)	Total Cost (Dollars)
Gated Pipe and Ditch and Furrow[a]				
Per Acre Inch				
Average	272	2.12	.55	2.67
Range	118-570	.73-4.41	.21-1.11	1.23-5.25
Per Acre Irrigated				
Average	63	9.11	2.34	11.45
Range	34-115	3.61-20.25	1.00-3.52	6.11-21.62
Per Acre Application				
Average	93	6.21	1.59	7.80
Range	34-190	2.19-20.25	1.00-2.60	3.69-21.62
Giant Sprinkler and Trailer Boom[b]				
Per Acre Inch				
Average	486	2.18	1.17	3.35
Range	86-1,220	.98-13.21	.69-1.90	1.93-14.68
Per Acre Irrigated				
Average	111	9.52	5.13	14.65
Range	40-232	4.81-28.41	1.84-9.01	10.10-31.56
Per Acre Application				
Average	221	4.80	2.58	7.38
Range	60-522	2.13-18.94	1.70-4.60	4.48-21.04

TABLE XXXIII (Continued)

Type of System	Amount Per Farm	Fixed Cost (Dollars)	Variable Cost (Dollars)	Total Cost (Dollars)
Portable Pipe and Sprinkler[c]				
Per Acre Inch				
Average	168	4.00	1.00	5.00
Range	10-1,667	.23-97.28	.37-2.43	.60-99.22
Per Acre Irrigated				
Average	38	17.62	4.39	22.01
Range	4-120	4.41-252.95	1.37-56.00	7.23-260.95
Per Acre Application				
Average	59	11.29	2.82	14.11
Range	8-176	2.01-97.28	1.37-4.95	4.18-99.22

[a]Nine irrigators.

[b]Nine irrigators.

[c]Twenty-eight irrigators.

systems applied the smallest amount of water to the smallest number of acres, while those with giant sprinkler-trailer boom systems applied the greatest amount. Differences in system use affected costs, but the small number of cases did not permit further breakdown of the data.

<u>Cost per acre inch of water</u> -- Twenty-eight Category I irrigators applied an average of 168 acre inches of water per farm. The range was extremely wide, from ten to 1,667 inches. The 1,667 acres inches were applied to strawberries. The average cost was $5.00 with a range from $0.60 to $99.22 per acre inch. The extremely low average cost was the result of intensive use of a small system while the extremely high average cost resulted from limited use of a large system. The average fixed cost was $4.00 with a range from $0.23 to $97.28. The wide range resulted from the same factors that affected the average cost figure. The average variable cost was $1.00 with a range of $0.37 to $2.43. The difference between the high and low average variable cost was $2.06, which was the greatest difference in cost items among the three systems. Category I farmers had the largest average fixed and total cost per acre inch of water, but Category II farmers had the largest average

variable cost.

Nine Category II farmers applied an average of 486 acre inches of water per farm with a range from 26 to 1,220. The average farm in this group received 2.9 times as much water as was applied to the Category I farms. The average cost was $3.35 with a range from $1.93 to $14.68. The narrower range indicated less variation in system use than among the Category I farms. The average fixed and variable costs were $2.18 and $1.17 respectively. The average fixed cost ranged from $0.92 to $13.21, while the average variable cost ranged from $0.69 to $1.90.

An average of 272 acre inches of water per farm was applied by nine Category III farmers. The amount per farm ranged from 118 to 570. The average fixed, variable, and total costs were $2.12, $0.55, and $2.67 respectively. The average farm received 62 per cent more water than Category I farms, but only 56 per cent as much as Cateogry II farms. The range was smaller for all three cost groups on Category III farms than on the other two system types. One reason for the smaller variation was the design of the system. Water can be applied effectively by surface methods only after the land had been graded. The land area that can be irrigated by this method is limited. Also, surface irrigation is not practiced for strawberries or seed germination irrigation in most cases. As a result, when applied to graded land, the entire area will receive water, unless rainfall makes the irrigation unnecessary. Field crops normally will require no more than three applications of water during the growing season, so the range in acre inches applied per farm usually will be narrower than with the other two systems.

Cost per acre irrigated -- Category I, II, and III farms averaged 38, 11, and 63 irrigated acres respectively. The range per farm was smallest in Category III. The average cost per irrigated acre varied from $22.01 on Category I farms to $11.45 on Category III farms. The average fixed and total costs were the largest on Category I farms, but the average variable costs were largest on Category II farms. Category III farms averaged $9.11, $2.34, and $11.45 for the average fixed, variable, and total costs, which were the lowest among the three types of systems (Table XXXIII).

Cost per acre application -- Nine Category II farmers averaged 221 acre applications of water per farm, which was the largest among the three systems. Each irrigated acre received two water applications on the average on Category II farms in comparison with 1.6 and 1.5 on Category I and III farms respectively. As a result, the average fixed and total costs were $4.80 and $7.38 for Category II farms, which were the smallest averages among the three systems. The average variable cost was $1.59 on Category III farms, which was the smallest average.

Irrigation costs per farm -- The absolute dollar cost of irrigation per farm was studied to gain an insight into the difference in magnitude of total costs among the three systems (Table XXXIV). The average fixed cost per farm was $671, $1,059 and $578 on Category I, II, and III farms. These data reflected differences in the investment in irrigation equipment among the three systems.

The average variable cost per farm was $167, $570 and $148 for Category I, II, and III farms respectively. The absolute variable cost in 1959 on Category II farms was 285 per cent greater than on Category III farms, and 241 per cent greater than on Category I farms.

When a farm operator decides to apply water, the risk involved per farm approximates the expected variable cost of irrigation. The magnitude of cash loss per farm does not appear to be large in light of the average variable cost per farm in 1959. The breakeven point required to cover average variable cost per acre inch of water, per irrigated acre, and per acre application will be analyzed later in the chapter.

TABLE XXXIV

ANALYSIS OF IRRIGATION COSTS PER FARM, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 46 FARMS, 1959

Irrigation Costs Per Farm	Type of Systems: Gated Pipe and Ditches and Furrows	Type of Systems: Giant Sprinkler and Trailer Boom	Type of Systems: Portable Pipe and Sprinkler
Number of Farms	9	9	28
Average Fixed Costs	$578	$1,059	$671
Per Cent of Total Cost	80	65	80
Average Variable Costs	$148	$ 570	$167
Per Cent of Total Cost	20	35	20
Average Cost	$726	$1,629	$838
Per Cent of Total Cost	100	100	100

I. COST OF IRRIGATING SPECIFIC CROPS

The average fixed, variable, and total cost of irrigating corn, cotton, and soybeans was determined. Due to the limited number of irrigators, the cost of applying water to other crops was not computed. The proportion of the annual fixed cost assigned to each crop was determined by the following procedure:

$$\frac{\text{Irrigated acres of one crop}}{\text{Total irrigated acres}} \times \text{annual fixed cost} =$$

Fixed cost assigned to that crop.

If the irrigation system was used exclusively to water one crop, all of the fixed were assigned to that crop. Consequently, the average cost per unit analyzed was exceedingly large, where a relatively small acreage of one crop received water.

Corn

Cost per acre inch of water -- Eight Category I farmers applied an average of 66 acre inches of water per farm (Table XXXV). The range was from 24 to 212. The average fixed, variable, and total cost was $4.97, $1.16, and $6.13 respectively.

The estimated yield response was 12 bushels of corn per acre inch of water applied. The range was from no increase to 23 bushels. The net return attributed to

TABLE XXXV

ESTIMATED YIELD RESPONSE, FIXED, VARIABLE, AND TOTAL COST OF IRRIGATION PER ACRE INCH OF WATER, PER ACRE IRRIGATED AND PER ACRE APPLICATION, CORN, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 16 IRRIGATORS, 1959

Type of System	Amount Per Farm	Fixed Cost Dollars	Variable Cost Dollars	Total Cost Dollars	Yield Response
Portable Pipe and Sprinkler[a]					
Per Acre Inch					
Average	66	4.97	1.16	6.13	12
Range	24-212	2.15-17.93	.46-2.20	2.66-17.75	0-23
Per Acre Irrigated					
Average	25	12.97	3.04	16.01	31
Range	2-85	4.41-53.78	.92-10.20	5.32-55.40	0-50
Per Acre Application					
Average	27	11.96	2.81	14.77	28
Range	8-85	4.41-53.78	.92-5.10	5.32-55.40	0-50
Giant Sprinkler and Trailer Boom[b]					
Per Acre Inch					
Average	398	1.21	.98	2.19	5
Range	72-1,020	.75-4.01	.68-1.76	1.77-4.69	0-7

TABLE XXXV (Continued)

Type of System	Amount Per Farm	Fixed Cost Dollars	Variable Cost Dollars	Total Cost Dollars	Yield Response
Per Acre Irrigated					
Average	66	7.33	5.87	13.20	32
Range	15-160	4.81-12.03	2.04-8.47	11.26-20.47	0-40
Per Acre Application					
Average	167	2.89	2.32	5.21	13
Range	24-440	1.75-12.03	2.04-3.02	4.10-14.07	0-16
Surface System[c]					
Per Acre Inch					
Average	233	1.05	.47	1.52	5
Range	28-551	.94-2.50	.44-1.11	1.38-3.61	0-6
Per Acre Irrigated					
Average	42	5.79	2.59	8.38	26
Range	7-80	3.61-10.01	1.43-4.43	5.04-14.44	0-40

TABLE XXXV (Continued)

Type of System	Amount Per Farm	Fixed Cost Dollar	Variable Cost Dollar	Total Cost Dollar	Yield Response
Per Acre Application					
Average	77	3.17	1.42	4.59	14
Range	7-185	2.82-10.01	1.30-4.43	4.12-14.44	0-20

[a]Eight farmers applied an average of 2.6 inches of water per acre. Each acre was irrigated the equivalent of 1.1 times.

[b]Five farmers applied an average of 6.0 inches of water per acre. Each acre was irrigated the equivalent of 2.5 times.

[c]Three farmers applied an average of 5.5 inches of water per acre. Each acre was irrigated the equivalent of 1.8 times.

irrigation and the effect of irrigation on farm income will be discussed in later sections of the chapter.

Five Category II farmers applied an average of 398 acre inches of water per farm (Table XXXV). The average fixed, variable, and total cost per acre inch was $1.21, $0.98, and $2.19 respectively.

The estimated yield response was five bushels of corn per acre inch of water. The range was from no increase to seven bushels.

Three Category III farmers applied an average of 233 acre inches of water per farm. The range was from 28 to 551 acre inches. The average fixed, variable, and total cost per acre inch of water was lower on farms with Category III systems than on farms with other types of systems.

<u>Cost per acre irrigated</u> -- Farmers with Category II systems applied water to an average of 66 acres of corn, while farmers with Category III and I systems irrigated 42 and 25 acres respectively. The average fixed, variable, and total cost per acre was $5.79, $2.59, and $8.38 respectively for Category III systems, which was the smallest among the three different systems (Table XXXV). The average application of water per acre was 2.6, 6.0, and 5.5 inches with Category I, II, and III systems respectively. The average yield

increase per acre ranged from no increase to 50 bushels, but the average yield increase for Category I, II, and III systems was 31, 32, and 26 bushels respectively.

Cost per acre application -- Water was applied an average of 1.1, 2.5, and 1.8 times per acre on farms with Category I, II, and III systems respectively. The estimated yield response per acre application ranged from no increase to 50 bushels, but the average for Category I, II, and III systems was 28, 13, and 14 bushels respectively. Category I systems had an average fixed, variable, and total cost per application of $11.96, $2.81, and $14.77 respectively, which was the largest average cost among the three systems. The close relationship between the per irrigated acre cost and per acre application cost with Category I systems reflected limited use in comparison with the other two systems.

Cotton

Cost per acre inch of water -- Nineteen farmers with Category I systems applied an average of 77 acre inches per farm. The amount ranged from ten to 255 acre inches. The average cost per acre inch was $8.92. The average fixed cost represented $7.60 of the average cost (Table XXXVI). The average fixed cost and average cost range was extremely

TABLE XXXVI

ESTIMATED YIELD RESPONSE, FIXED, VARIABLE AND TOTAL COST OF IRRIGATION PER ACRE INCH OF WATER, PER ACRE IRRIGATED AND PER ACRE APPLICATION, COTTON, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 35 IRRIGATORS, 1959

Type of System	Amount Per Farm	Fixed Cost Dollars	Variable Cost Dollars	Total Cost Dollars	Yield Response Pounds of Lint
Portable Pipe and Sprinkler[a]					
Per Acre Inch					
Average	77	7.60	1.32	8.92	23
Range	10-255	1.42-97.28	.75-2.38	2.18-99.22	0-100
Per Acre Irrigated					
Average	34	17.30	3.01	20.31	53
Range	8-82	4.21-97.28	1.37-4.98	7.81-99.22	0-300
Per Acre Application					
Average	44	13.50	2.34	15.84	42
Range	8-93	2.63-97.28	1.38-4.35	4.95-99.22	0-300
Giant Sprinkler and Trailer Boom[b]					
Per Acre Inch					
Average	214	3.42	1.45	4.87	21
Range	20-458	1.56-13.22	.80-1.90	2.70-14.68	0-46

TABLE XXXVI (Continued)

Type of System	Amount Per Farm	Fixed Cost Dollars	Variable Cost Dollars	Total Cost Dollars	Yield Response Pounds of Lint
Per Acre Irrigated					
Average	65	11.21	4.75	15.96	68
Range	8-102	4.81-28.41	1.61-9.50	7.50-31.56	0-240
Per Acre Application					
Average	111	6.56	2.79	9.35	40
Range	8-254	2.65-18.94	1.61-4.75	5.57-21.04	0-240
Surface System[c]					
Per Acre Inch					
Average	154	2.67	.69	3.36	13
Range	26-450	.60-8.92	.26-1.11	1.11-9.95	0-112
Per Acre Irrigated					
Average	45	9.23	2.38	11.61	45
Range	14-104	3.61-20.25	.80-3.53	6.41-21.05	0-225

TABLE XXXVI (Continued)

Type of System	Amount Per Farm	Fixed Cost Dollars	Variable Cost Dollars	Total Cost Dollars	Yield Response Pounds of Lint
Per Acre Application					
Average	61	6.72	1.73	8.45	33
Range	14-150	1.81-20.25	.80-2.60	3.34-21.05	0-225

[a]Nineteen farmers applied an average of 2.3 inches of water per acre. Each acre was irrigated the equivalent of 1.3 times.

[b]Eight farmers applied an average of 3.3 inches of water per acre. Each acre was irrigated the equivalent of 1.7 times.

[c]Eight farmers applied an average of 3.5 inches of water per acre. Each acre was irrigated the equivalent of 1.4 times.

wide due to limited use of large capacity systems. Eight of the 19 farmers applied one to 1.5 inches of water per acre on a limited number of acres to germinate the cotton seed. Since this was the extent of irrigation on most of the farms, the entire annual fixed cost was charged to cotton irrigation.

The estimated yield response averaged 23 pounds of lint cotton per acre inch of water. It ranged from no increase to 100 pounds of lint. A yield increase was not expected on the eight farms where only seed germination irrigation was applied. In all cases, the total acres of cotton, which could have been irrigated, did not receive an application, and the seed germination irrigation was halted due to rain.

An average of 214 acre inches of water per farm was applied by eight farmers with Category II systems. The average fixed, variable, and total cost was $3.42, $1.45, and $4.87 respectively. The average yield response per acre inch of water was 21 pounds of lint cotton. The range was from no increase to 46 pounds.

The average number of acre inches of water applied per farm was 154 on farms with Category III systems. The amount per farm ranged from 26 to 450 acre inches. The average fixed, variable, and total cost was $2.67, $0.69, and $3.36 respectively. The estimated yield response averaged 13 pounds of lint cotton per acre inch of water. The range was from no increase to 112 pounds.

Cost per acre irrigated -- Farmers with Category I systems irrigated 34 acres per farm. The farmers operating Category II and III systems averaged 65 and 45 acres respectively. The average fixed, variable, and total cost was $17.30, $3.01, and $20.31 for Category I systems, and $9.23, $2.38, and $11.61 respectively for Category III systems.

The average water application per acre was 2.3, 3.3, and 3.5 inches of water for Category I, II, and III systems respectively. The farmers applied less water to cotton than to corn. The greatest differences were on farms with Category II and III systems. Farmers with Category II systems averaged an increase of 68 pounds of lint cotton per acre, which was a larger increase than was obtained by users of Category I and III systems.

Cost per acre application -- Water was applied an average of 1.3, 1.7, and 1.4 times per acre with Category I, II, and III systems respectively. The farmers using Category III systems had the lowest cost per acre application, which was $6.72, $1.73, and $8.45 for the average fixed, variable, and total cost respectively.

Farmers operating Category I systems averaged an increase of 42 pounds of lint cotton per acre application, which was the largest increase among the three systems. However, the difference in yield response was smaller for cotton than for corn.

Soybeans

Cost per acre inch of water -- The average cost per acre inch of water was $2.58 for Category III, which was the lowest cost among the three systems. However, the average fixed cost was $1.87 on Category II farms, which was smaller than on Category III farms (Table XXXVII).

The average yield response per acre inch of water was two bushels for all three systems. The range was from no increase to seven bushels on farms using Category II systems.

Cost per acre irrigated - Farmers using Category I, II, and III systems averaged 17, 36, and 22 irrigated acres. The average fixed, variable, and total cost per acre was $9.02, $4.10, and $13.12 respectively on farms with Category I systems. The highest fixed and total cost system was in Category III, which averaged $13.38 and $15.21 for the average fixed and total cost respectively. The average variable cost per acre was $1.83 on farms using Category III systems, which was the lowest cost

TABLE XXXVII

ESTIMATED YIELD RESPONSE, FIXED, VARIABLE AND TOTAL COST OF IRRIGATION PER ACRE INCH OF WATER, PER ACRE IRRIGATED AND PER ACRE APPLICATION, SOYBEANS, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 13 IRRIGATORS, 1959

Type of System	Amount Per Farm	Fixed Cost Dollars	Variable Cost Dollars	Total Cost Dollars	Yield Response
Portable Pipe and Sprinkler[a]					
Per Acre Inch					
Average	42	3.75	1.63	5.20	2
Range	10-105	1.28-10.21	.68-3.33	1.95-13.28	0-6
Per Acre Irrigated					
Average	17	9.02	4.10	13.12	4
Range	5-40	4.41-12.06	2.40-10.00	7.61-22.06	0-12
Per Acre Application					
Average	19	8.06	3.66	11.72	3
Range	5-40	4.41-12.06	2.40-10.00	7.61-22.06	0-12
Giant Sprinkler and Trailer Boom[b]					
Per Acre Inch					
Average	163	1.87	1.06	2.93	2
Range	22-420	1.44-7.03	.69-1.91	2.13-8.94	0-7

TABLE XXXVII (Continued)

Type of System	Amount Per Farm	Fixed Cost Dollars	Variable Cost Dollars	Total Cost Dollars	Yield Response
Per Acre Irrigated					
Average	36	8.44	4.77	13.21	9
Range	16-70	7.84-8.65	2.06-8.03	9.89-16.27	0-12
Per Acre Application					
Average	62	4.88	2.76	7.64	5
	16-140	4.33-8.60	2.06-4.28	6.40-10.93	0-8
Surface System[c]					
Per Acre Inch					
Average	130	2.27	.31	2.58	2
Range	43-200	1.34-6.06	.19-.58	1.91-6.64	0-5
Per Acre Irrigated					
Average	22	13.38	1.83	15.21	12
Range	19-29	5.35-20-25	1.32-1.95	7.63-22.20	0-19

TABLE XXXVII (Continued)

Type of System	Amount Per Farm	Fixed Cost Dollars	Variable Cost Dollars	Total Cost Dollars	Yield Response
Per Acre Application					
Average	29	10.06	1.38	11.44	9
Range	19-58	2.68-20.25	1.14-1.95	3.81-22.20	0-15

[a]Five farmers applied an average of 2.5 inches of water per acre. Each acre was irrigated the equivalent of 1.1 times.

[b]Four farmers applied an average of 4.5 inches of water per acre. Each acre was irrigated the equivalent of 1.7 times.

[c]Four farmers applied an average of 5.9 inches of water per acre. Each acre was irrigated the equivalent of 1.3 times.

among the three types.

The estimated yield response per acre ranged from an average of four to twelve bushels on farms with Category I and III systems respectively. The widest variation occurred on farms with Category I systems, where the range was from no increase to 19 bushels.

Cost per acre application -- Water was applied an average of 1.1, 1.7, and 1.3 times per acre on farms with Category I, II, and III systems respectively. The average number of acre applications per farm was 19, 62, and 29 on farms with Category I, II, and III systems respectively. The lowest average cost was $7.64, which occurred on farms with Category II systems. The average variable cost on farms with Category III systems was $1.38, which was lower than the other two systems.

The estimated yield response per acre application ranged from three bushels on farms with Category I systems to nine bushels on farms with Category III systems.

II. RETURNS FROM IRRIGATION

In general, returns attributable to irrigation result from increased yields or increased quality of product. Since this study was concerned primarily with field crops, additional returns reflected increased yields.

The variation in yield response from irrigation was extremely wide in 1959. Yields on irrigated land were substantially higher than on non-irrigated fields in several cases. In other instances, no yield increase was obtained from irrigation. The variation was a result of many factors. Among them were differences in soil types, planting rates, planting dates, time of irrigation, fertilizer applications, and cultural practices. If all of the farming practices except irrigation had been controlled, the effect of irrigation could have been determined precisely. Since this procedure was not practical for this study, the effect of irrigation was estimated under general farming conditions. An estimate for one year limits the reliability of the data.

In addition to the above factors, normal variations in temperature and amount and distribution of rainfall affect the yield response from irrigation. In general, 1959 was a near normal year in regard to amount and distribution of rainfall (Table XXXVIII). The amount was slightly above the long time average in May and September, and below normal in June and August. In June, the rainfall was 1.07 inches less than the long time average. This was the greatest deficit in the five month period. Rainfall distribution also has an important effect on yield responses from irrigation. The amount and distribution of rainfall

TABLE XXXVIII

AVERAGE TEMPERATURE AND PRECIPITATION, MAY-SEPTEMBER, FOUR SOUTHEASTERN MISSOURI COUNTIES, 1959

	Months				
	May	June	July	August	September
			Precipitation (inches)		
Bootheel Area					
Average	4.39	2.85	3.10	2.95	4.44
Departure from Normal	.18	- 1.07	.00	- .15	1.18
Normal	4.21	3.92	3.10	3.10	3.26
Six Stations[a]					
Average	4.09	2.99	3.03	3.10	4.57
Departure from Normal	- .13	- .93	- .07	.00	1.31
			Temperature (Degrees Fahrenheit)		
Bootheel Area					
Average	72.2	75.1	77.9	79.6	72.9
Departure from Normal	4.3	- 2.3	- 2.7	.4	1.0
Normal	67.9	77.4	80.6	79.6	71.9
Six Stations[a]					
Average	72.5	75.3	78.2	79.7	73.3
Departure from Normal	4.6	- 2.1	- 2.4	.5	5.4

[a]Kennett, Malden, Caruthersville, Portageville, Sikeston Experimental Farm, and Charleston.

Source: Climatological Data, Missouri, Volume LXIII, Number 4-9, United States Department of Commerce, Weather Bureau, 1959.

at six selected stations in the sample area were analyzed (Table XXXIX). In May, the Malden Station reported only a trace of precipitation up to May 11, while the Portageville Station recorded .67 of an inch during this same period. Precipitation was limited throughout the area the first ten days in May.

The relationship between time of application of irrigation water and the estimated yield increase per acre was studied in an effort to explain some of the yield variation. The estimated yield increase of corn and the time of application were plotted (Figure 4). In general, the highest yield increase resulted from water application near June 15 and July 1. The data in Table XXXIX show that precipitation from June 16-20 and from June 26-30 was low. Therefore, it would appear that the crop was in need of moisture during this period.

Figure 5 indicates that irrigators who applied water to cotton early in May got no yield increase from the one application. The majority of those who applied water near July 15 received a substantial increase.

Figure 6 indicates that water applied to soybeans near July 1 and 15 resulted in substantial yield increases. The farmers who applied water near August 15 also received yield increases, but not as large as those irrigating earlier in the growing season.

TABLE XXXIX

PRECIPITATION AT SIX LOCALITIES, MAY-AUGUST, FOUR SOUTHEASTERN MISSOURI COUNTIES, 1959

Localities	Precipitation Inches 1-5	6-10	11-15	16-20	21-25	26-30(31)	Total
				May			
Caruthersville	.02	.10	1.85	.75	.35	.89	3.96
Charleston	-	.46	1.37	.95	.56	1.00	4.34
Kennett	-	.04	.66	.54	.65	1.74	3.63
Malden	-	T[a]	1.20	.52	.87	.34	2.93
Portageville	.10	.57	1.33	.64	.34	1.93	4.91
Sikeston[b]	.18	-	1.71	.71	.49	1.00	4.77
Total	.30	1.17	8.12	4.11	3.94	6.90	24.54
Average	.05	.19	1.35	.69	.66	1.15	4.09
				June			
Caruthersville	.85	.85	1.37	-	.64	.45	4.16
Charleston	.03	.75	1.25	-	.73	.08	2.84
Kennett	.07	1.01	.12	-	1.19	-	2.39
Malden	.67	1.26	T	-	1.24	.06	3.23
Portageville	.02	2.03	.04	-	.49	.01	2.59
Sikeston[b]	.05	1.36	.11	-	1.20	.03	2.75
Total	1.69	7.26	2.89	-	5.49	.63	17.96
Average	.28	1.21	.48	-	.91	.11	2.99
				July			
Caruthersville	.06	1.01	.20	-	.66	.03	1.96
Charleston	.91	-	-	.63	1.00	.49	3.03
Kennett	.88	-	.05	-	1.50	.09	2.52
Malden	.69	-	-	.24	3.87	.24	5.04

TABLE XXXIX (Continued)

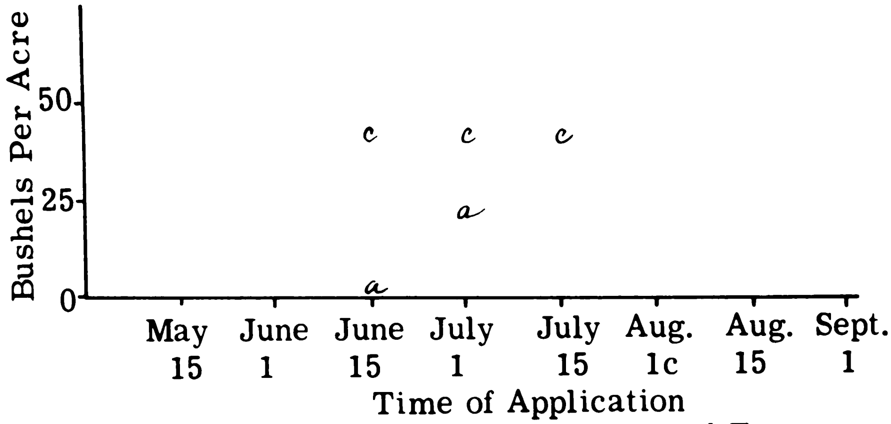
Localities	1-5	6-10	11-15	16-20	21-25	26-30(31)	Total
				Precipitation Inches			
Portageville	1.58	-	.05	.23	.57	.03	2.46
Sikeston[b]	.52	-	-	.86	1.80	.02	3.20
Total	4.64	1.01	.30	1.96	9.40	.90	18.21
Average	.77	.17	.05	.33	1.56	.15	3.03
				August			
Caruthersville	-	.43	-	.53	-	1.30	2.26
Charleston	.13	.15	-	.08	-	1.23	1.59
Kennett	.73	.04	.12	.42	-	2.50	3.81
Malden	.08	.47	-	1.89	-	1.00	3.44
Portageville	.50	1.08	-	1.35	-	1.16	4.09
Sikeston[b]	.37	.37	-	.49	-	2.21	3.44
Total	1.81	2.54	.12	4.76	-	9.40	18.63
Average	.30	.42	.02	.79	-	1.57	3.10

[a]T represents trace of precipitation.

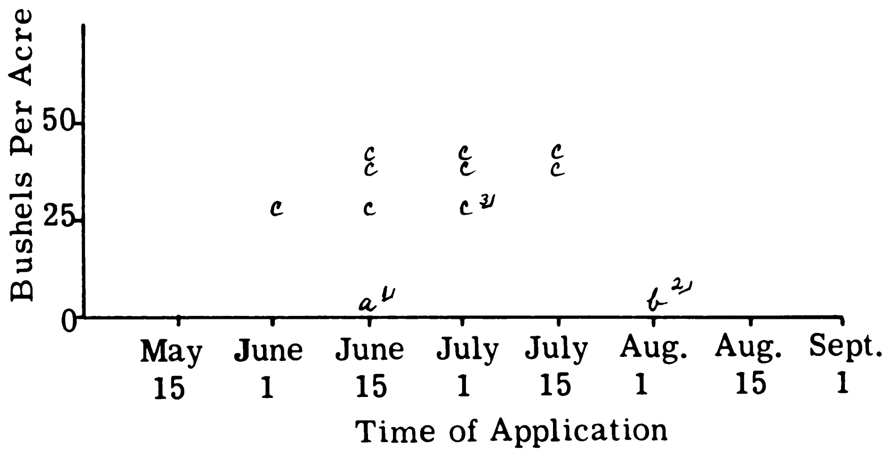
[b]Sikeston Experimental Farm.

Source: Climatological Data, Missouri, Volume LXIII, Number 4-9, United States Department of Commerce, Weather Bureau, 1959.

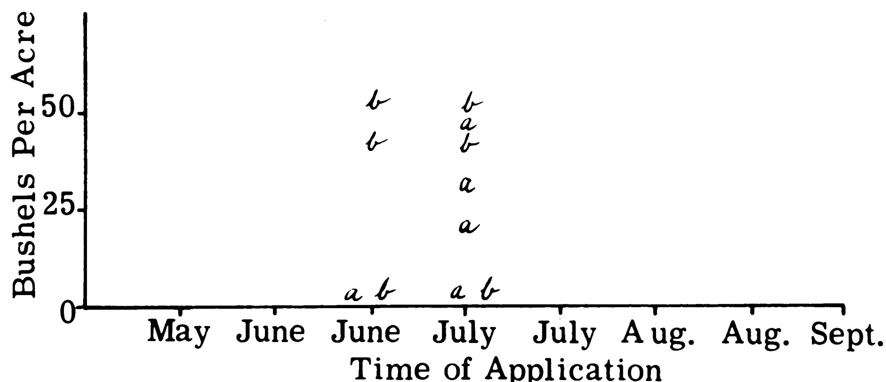
FIGURE 4
YIELD INCREASE PER ACRE OF CORN IRRIGATED AND TIME OF APPLICATION, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEAST MISSOURI COUNTIES, 16 FARMS, 1959



A. Surface - Gated Pipe and Ditches and Furrows



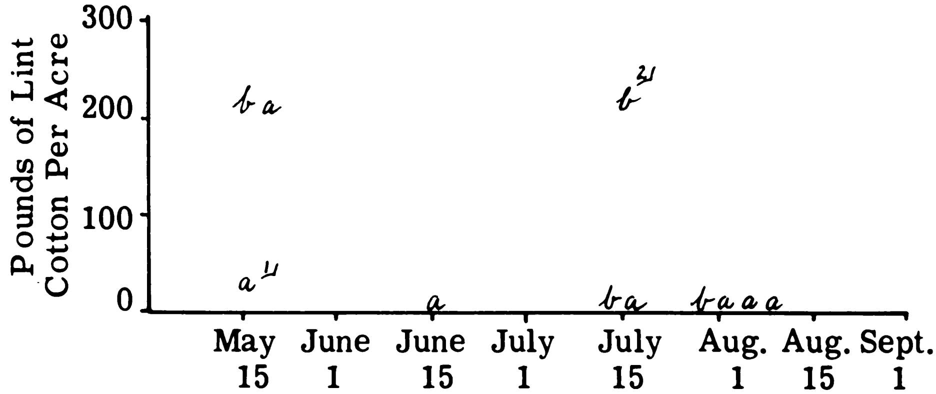
B. Sprinkler - Trailer Boom and Giant Sprinkler



C. Portable Pipe and Sprinklers

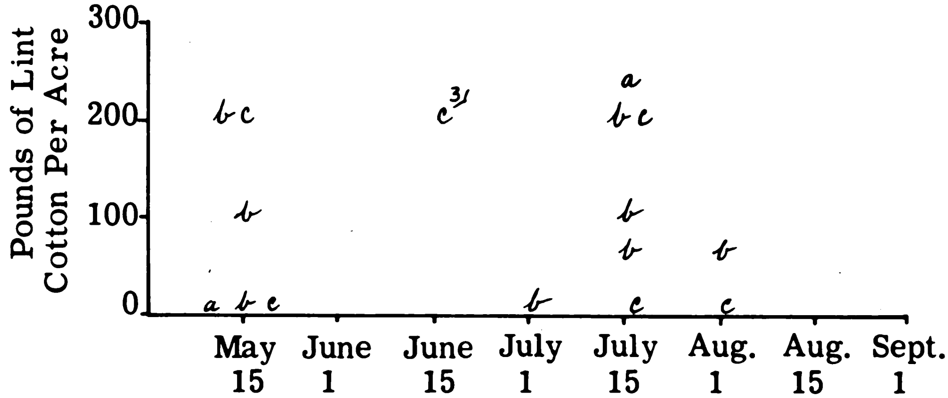
1/ Notation for 1 application of water - a.
2/ Notation for 2 applications of water - b.
3/ Notation for 3 applications of water - c.

FIGURE 5
YIELD INCREASE PER ACRE OF COTTON IRRIGATED AND TIME OF APPLICATION, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 35 FARMS, 1959



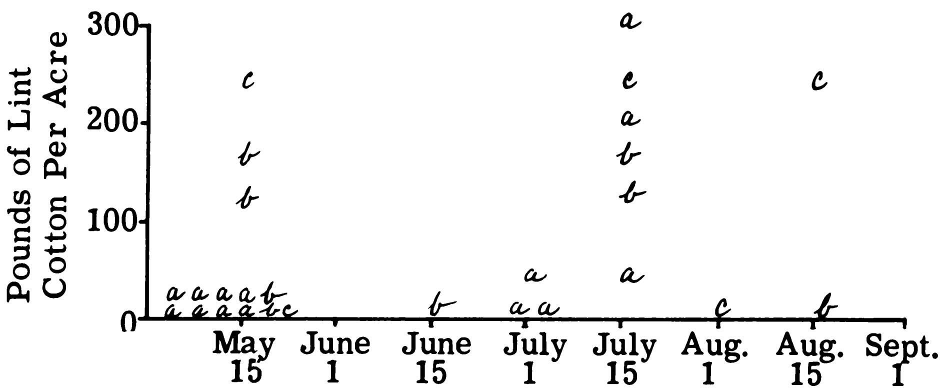
A. Surface - Time of Application

A. Surface - Gated Pipe and Ditches and Furrows



Time of Application

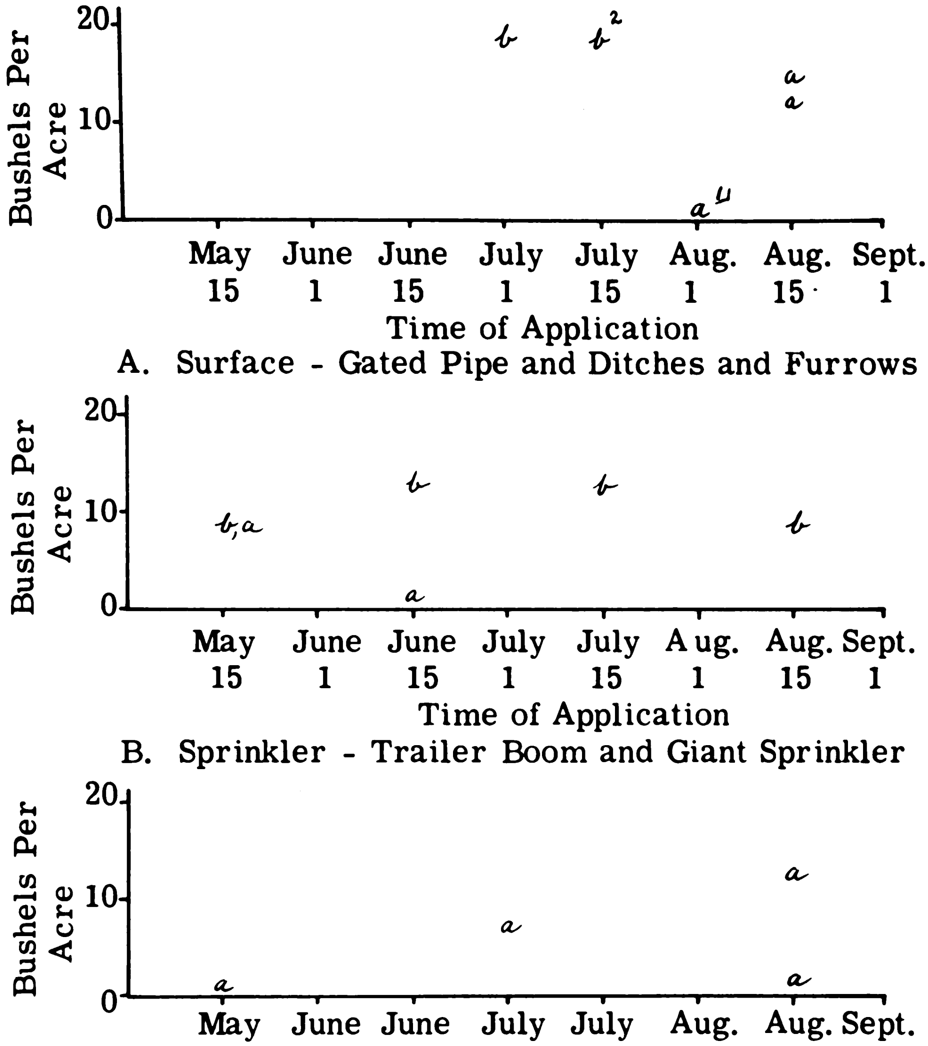
B. Sprinkler - Trailer Boom and Giant Sprinkler



Time of Application

[1] Notation for 1 application of water - a.
[2] Notation for 2 applications of water - b.
[3] Notation for 3 applications of water - c.

FIGURE 6
YIELD INCREASE PER ACRE OF SOYBEANS IRRIGATED AND TIME OF APPLICATION, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 13 FARMS, 1959



A. Surface - Gated Pipe and Ditches and Furrows

B. Sprinkler - Trailer Boom and Giant Sprinkler

C. Portable Pipe and Sprinkler

1/ Notation for 1 application of water - a

2/ Notation for 2 applications of water - b

Procedures Used to Determine Net Return and Return Above Variable Cost

The average fixed, variable, and total cost computations, as shown in Table XXXIII, XXXV, XXXVI, and XXXVII, did not include expenses of harvesting the increased yield attributable to irrigation. The purpose in that section of the chapter was to estimate the cost of applying water by different types of systems. Here the purpose is to indicate the relationship between total costs and total returns attributable to irrigation. Harvesting costs are included.

The average estimated yield response, shown in the above tables, was multiplied by the average prices received for the products from September-December, 1959 to compute the gross returns attributable to irrigation. The prices used were $1.00 per bushel for corn; $1.95 per bushel for soybeans, and $0.322 per pound for lint cotton.

The adjusted gross returns were equal to gross returns minus harvesting costs, which were $0.15 per bushel for picking and shelling corn; $0.30 per bushel for combining soybeans, and $2.00 per hundredweight for picking seed cotton.

The net returns and returns above average variable costs per acre inch, per acre irrigated, and per acre application of irrigation water were computed for the three different systems. Net returns to irrigation were equal to total revenue minus total costs or adjusted gross returns minus average costs. The returns above average variable costs were equal to the adjusted gross returns minus the average variable costs. Greater insight into the relationship between costs of and returns from irrigation in 1959 was obtained by analyzing both the net returns and the returns above average variable costs, than if either had been analyzed alone.

III. IRRIGATION RETURNS FOR SPECIFIC CROPS

Corn

Per acre inch of water -- The net returns were positive for the three different systems of water distribution used in the area. The average net returns per acre inch of water applied ranged from $4.07 for Category I to $2.06 for Category II (Table XL).

The net returns on individual farms ranged from -$18.47 to +$13.91 (Figure 7 and Table A-II, in the Appendix). Fifty, 60, and 67 per cent of the farmers who used Category I, II, and III systems received positive net returns from corn irrigation. Forty-four per cent of the corn irrigators did not receive returns from irrigation large enough to pay the total irrigation costs (Table XLI).

TABLE XL

NET RETURN AND RETURN ABOVE AVERAGE VARIABLE COST PER ACRE INCH OF WATER, PER ACRE IRRIGATED AND PER ACRE APPLICATION OF CORN, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 16 FARMERS, 1959

	Type of Irrigation System		
Irrigation, Cost and Return	Surface System[a] (Dollars)	Giant Sprinkler and Trailer Boom[b] (Dollars)	Portable Pipe and Sprinkler[c] (Dollars)
Per Acre Inch of Water:			
Adjusted Gross Return	4.25	4.25	10.20
Average Cost	1.52	2.19	6.13
Net Return	+ 2.73	+ 2.06	+ 2.07
Average Variable Cost	.47	.98	1.16
Return Above Average Variable Cost	+ 3.78	+ 3.27	+ 9.04
Per Acre Irrigated:			
Adjusted Gross Return	22.10	27.20	26.35
Average Cost	8.38	13.20	16.01
Net Return	+13.72	+14.00	+10.34
Average Variable Cost	2.59	5.87	3.04
Return Above Average Variable Cost	+19.51	+21.33	+23.31
Per Acre Application:			
Adjusted Gross Return	11.90	11.05	23.80
Average Cost	4.59	5.21	14.77
Net Return	+ 7.31	+ 5.84	+ 9.03
Average Variable Cost	1.42	2.32	2.81
Return Above Average Variable Cost	+10.48	+ 8.73	+20.99

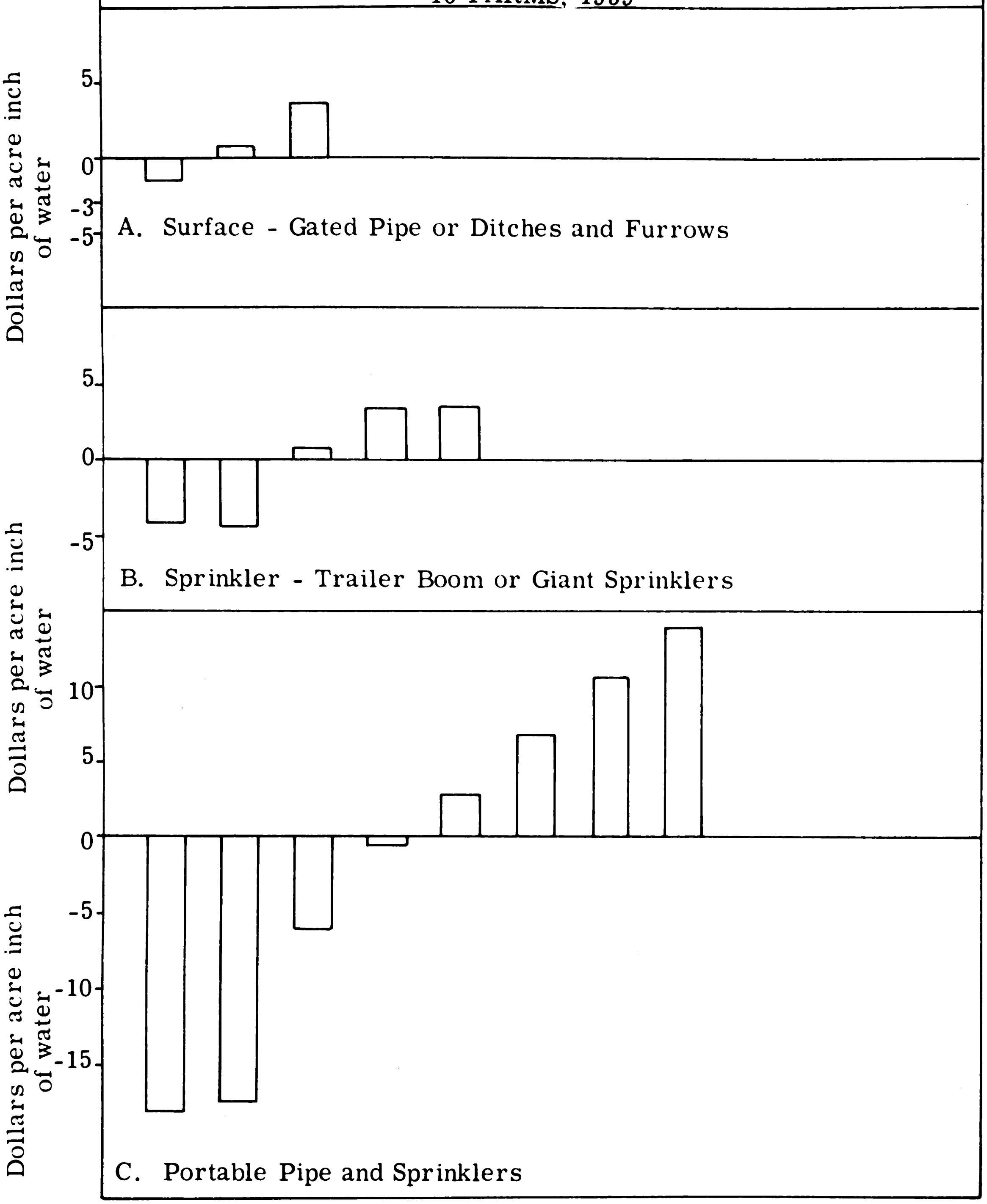
[a]Three farmers.

[b]Five farmers.

[c]Eight farmers.

FIGURE 7

NET RETURN OR LOSS PER ACRE INCH OF WATER APPLIED TO CORN ABOVE TOTAL COST OF IRRIGATION BY TYPE OF IRRIGATION SYSTEM SOUTHEASTERN MISSOURI, 16 FARMS, 1959*



*Each bar represents one farm.

TABLE XLI

NET RETURN OR LOSS ABOVE TOTAL IRRIGATION COSTS PER ACRE INCH OF WATER, CORN, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 16 FARMERS, 1959

	Type of Irrigation System			
Return Above Total Costs	Portable Pipe and Sprinklers	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	Per Cent of Farms
Dollars Per Acre Inch				
-15.00 to -19.99	2	-	-	13
-10.00 to -14.99	-	-	-	--
- 5.00 to - 9.99	1	-	-	6
- 0.01 to - 4.99	1	2	1	25
+ 0.01 to + 4.99	1	3	2	37
+ 5.00 to + 9.99	1	-	-	6
+10.00 to +14.99	2	-	-	13
Total	8	5	3	100

Thirty-seven per cent received net returns from $0.01 to $4.99 per acre inch of water above the average costs. The positive net returns were from $5.00 to $14.99 for 19 per cent of the corn irrigators.

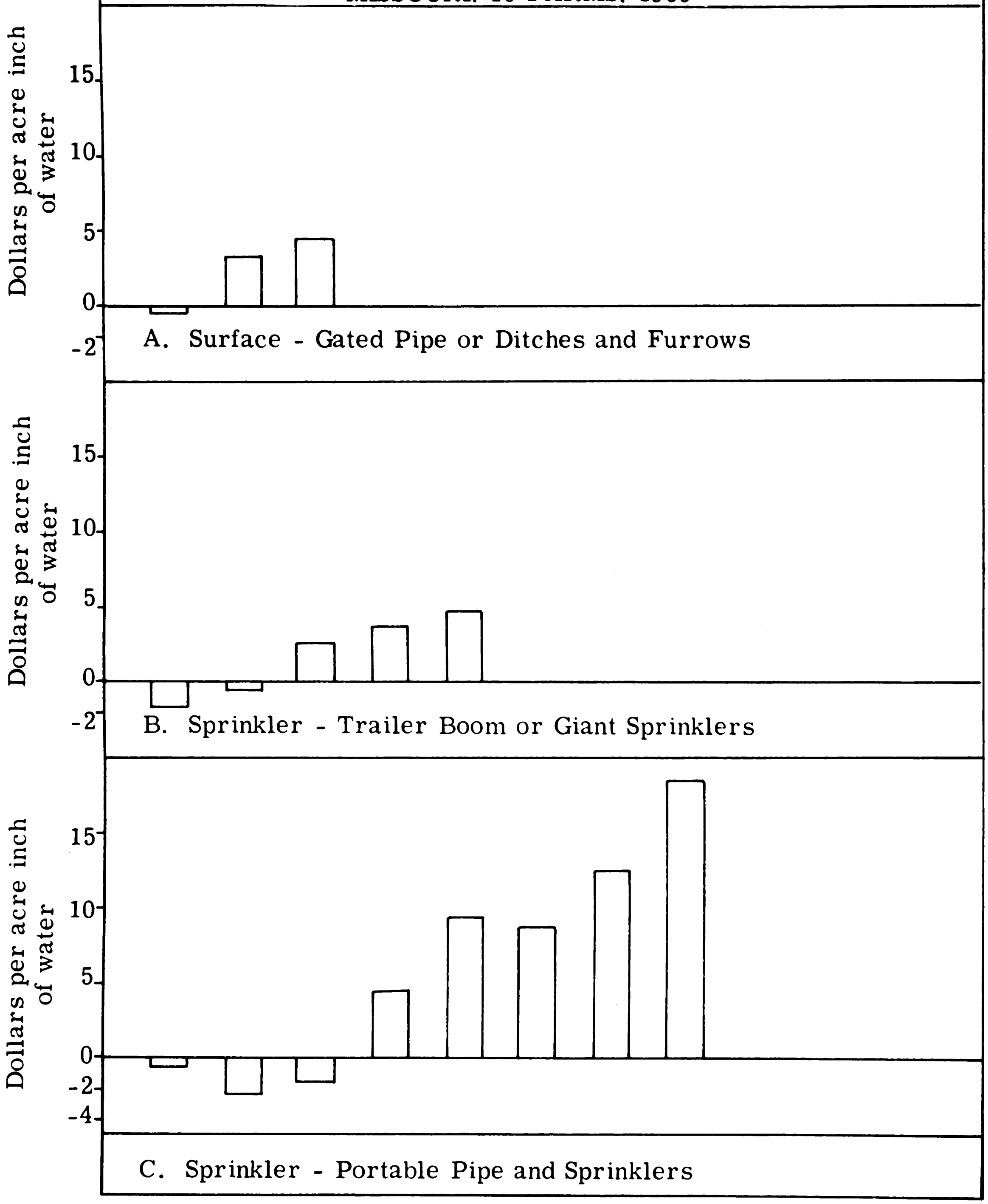
The returns above average variable costs per acre inch of water were $9.04, $3.27, and $3.78 for farmers using Category I, II, and III systems respectively (Table XL). On individual farms, the returns above average variable costs ranged from $2.20 to $18.13 (Figure 8 and Table A-II). Sixty-three, 60, and 67 per cent of the farmers employing Category I, II, and III systems received positive returns.

Thirty-eight per cent of the corn irrigators did not cover their average variable costs (Table XLII). An additional 37 per cent received returns above average variable costs between $0.01 and $4.99. The returns above variable costs ranged from $15.00 to $19.99 for six per cent of the farmers.

Yield increase required to pay irrigation costs -- The yield increase necessary to pay total irrigation costs ranged from 1.7 to 18.5 bushels of corn per acre inch of water (Figure 9 and Table A-II). The wide variation resulted from limited employment of some of the systems. Average fixed costs per acre inch of water applied were extremely

FIGURE 8

ADDITIONAL RETURN OR LOSS PER ACRE INCH OF WATER APPLIED TO CORN ABOVE VARIABLE COSTS OF IRRIGATION BY TYPE OF IRRIGATION SYSTEM, SOUTHEASTERN MISSOURI. 16 FARMS. 1959*



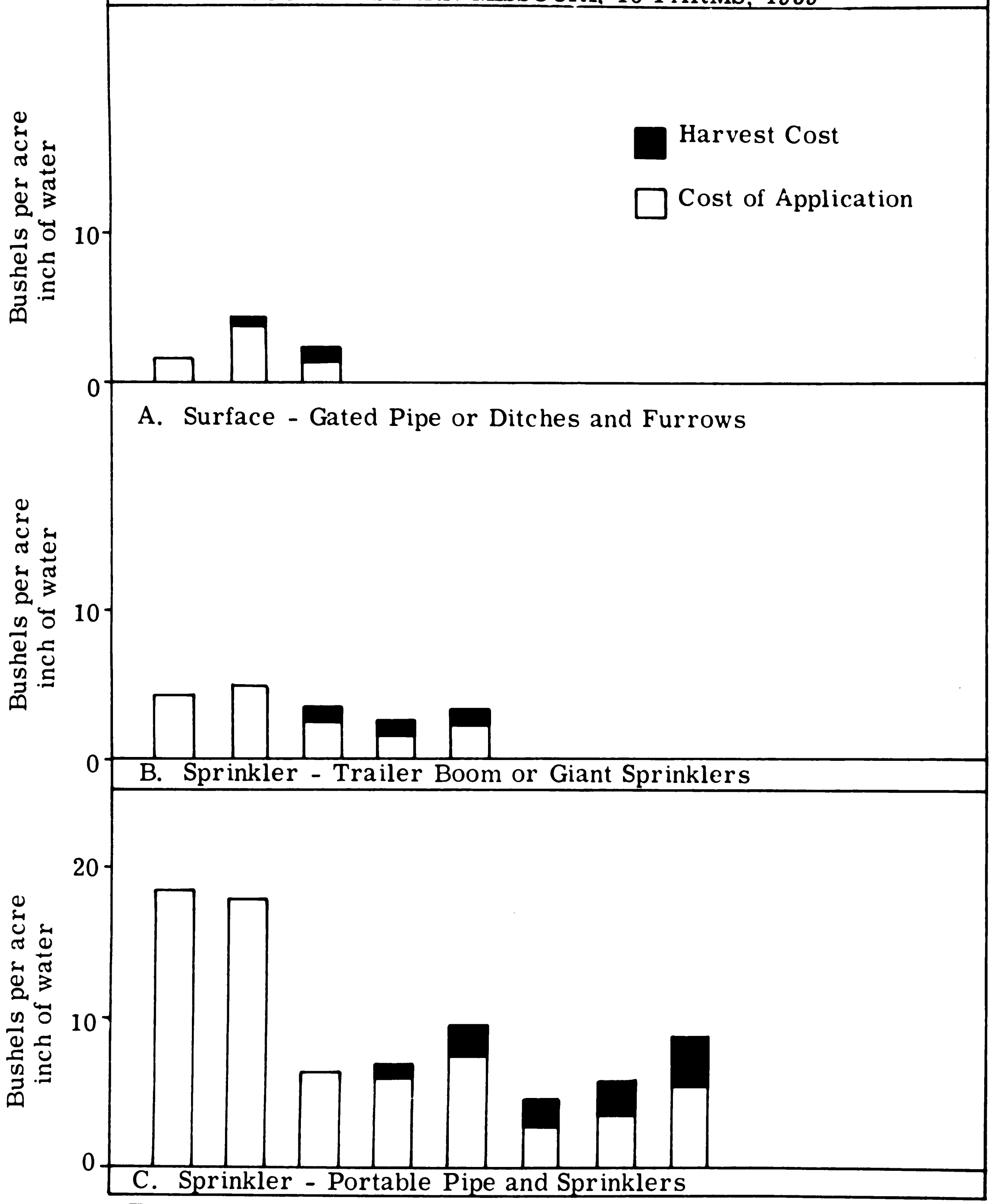
*Each bar represents one farm.

TABLE XLII

ADDITIONAL RETURN OR LOSS ABOVE AVERAGE VARIABLE COSTS PER ACRE INCH OF WATER, CORN, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 16 FARMERS, 1959

Return Above Variable Costs Dollars Per Acre Inch	Type of Irrigation System			
	Portable Pipe and Sprinklers	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	Per Cent of Farms
- 0.01 to - 4.99	3	2	1	38
+ 0.01 to + 4.99	1	3	2	38
+ 5.00 to + 9.99	2	-	-	12
+10.00 to +14.99	1	-	-	6
+15.00 to +19.99	1	-	-	6
Total	8	5	3	100

FIGURE 9
YIELD INCREASE PER ACRE INCH OF WATER APPLIED TO PAY TOTAL COST OF IRRIGATION, INCLUDING HARVESTING COST, CORN BY TYPE OF IRRIGATION SYSTEMS, SOUTHEASTERN MISSOURI, 16 FARMS, 1959*



*Each bar represents one farm.

high for systems which received limited usage in 1959. The increased yield requirement ranged from three to 19, two to five, and one to four bushels for Category I, II, and III systems respectively.

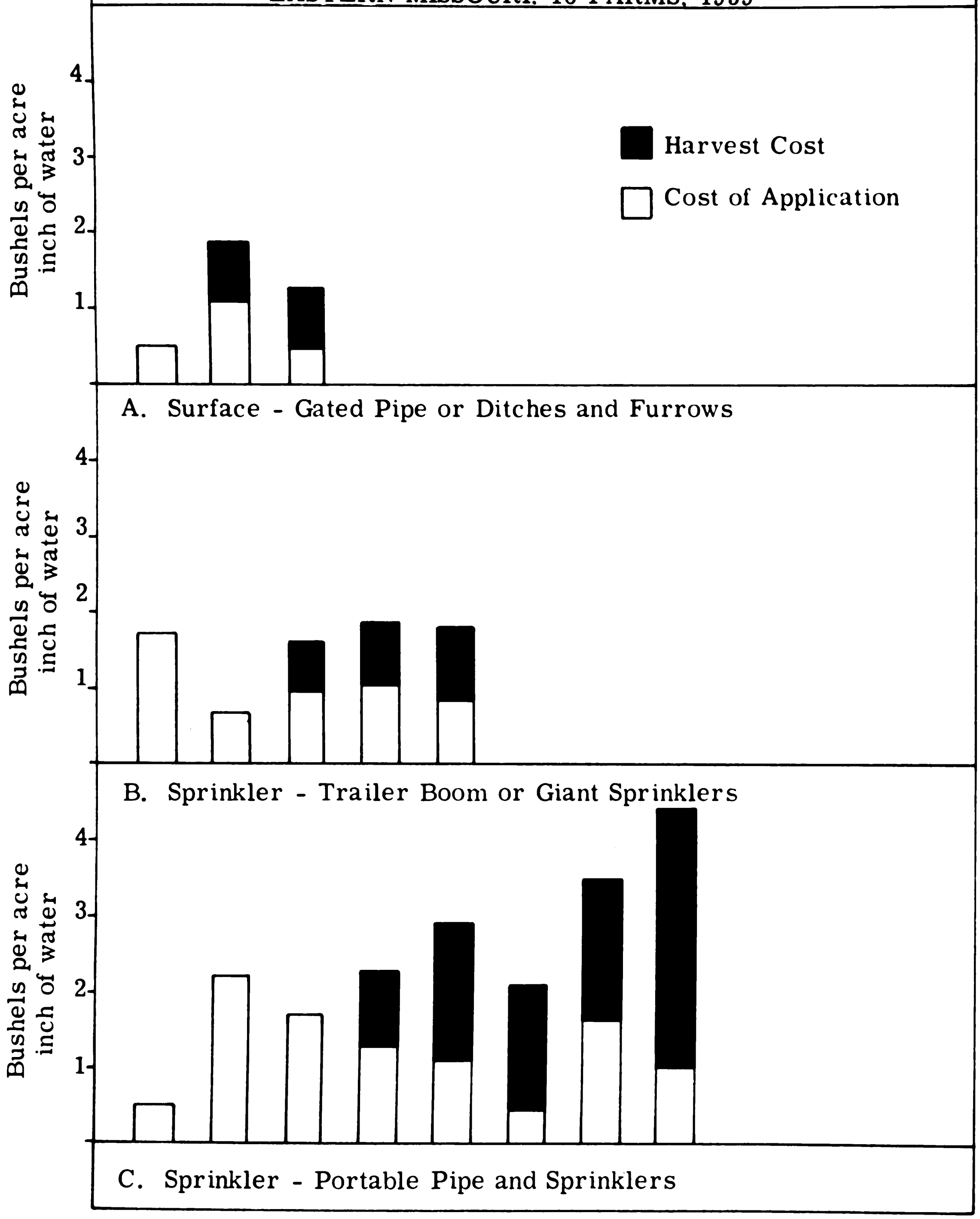
The yield increase required to pay average variable costs was much less than the increase necessary to pay total costs.

Since average variable costs were defined as operating or use cost, this was expected. Category I, II, and III systems required from one to four, one to two, and one to two bushels of corn respectively to pay average variable costs (Figure 10 and Table A-II).

Per irrigated acre — The net return per irrigated acre of corn averaged $10.34, $14.00, and $13.72 for farmers using Category I, II, and III systems respectively (Table XL). The net return on individual farms ranged from -$55.41 to $27.82 per irrigated acre (Figure 11 and Table A-III). Farmers using Category I systems had both the highest and lowest net return per acre.

Forty-four per cent of the corn irrigators failed to recover their water application costs. Twenty-six per cent lost from $20.00 to $55.00 per acre (Table XLIII). On the other end of the distribution, 31 per cent obtained positive net returns per acre ranging from $20.00 to $29.99.

FIGURE 10
YIELD INCREASE PER ACRE INCH OF WATER APPLIED TO PAY VARIABLE COST OF IRRIGATION, INCLUDING HARVESTING COST, CORN BY TYPE OF IRRIGATION SYSTEMS, SOUTH-EASTERN MISSOURI, 16 FARMS, 1959*



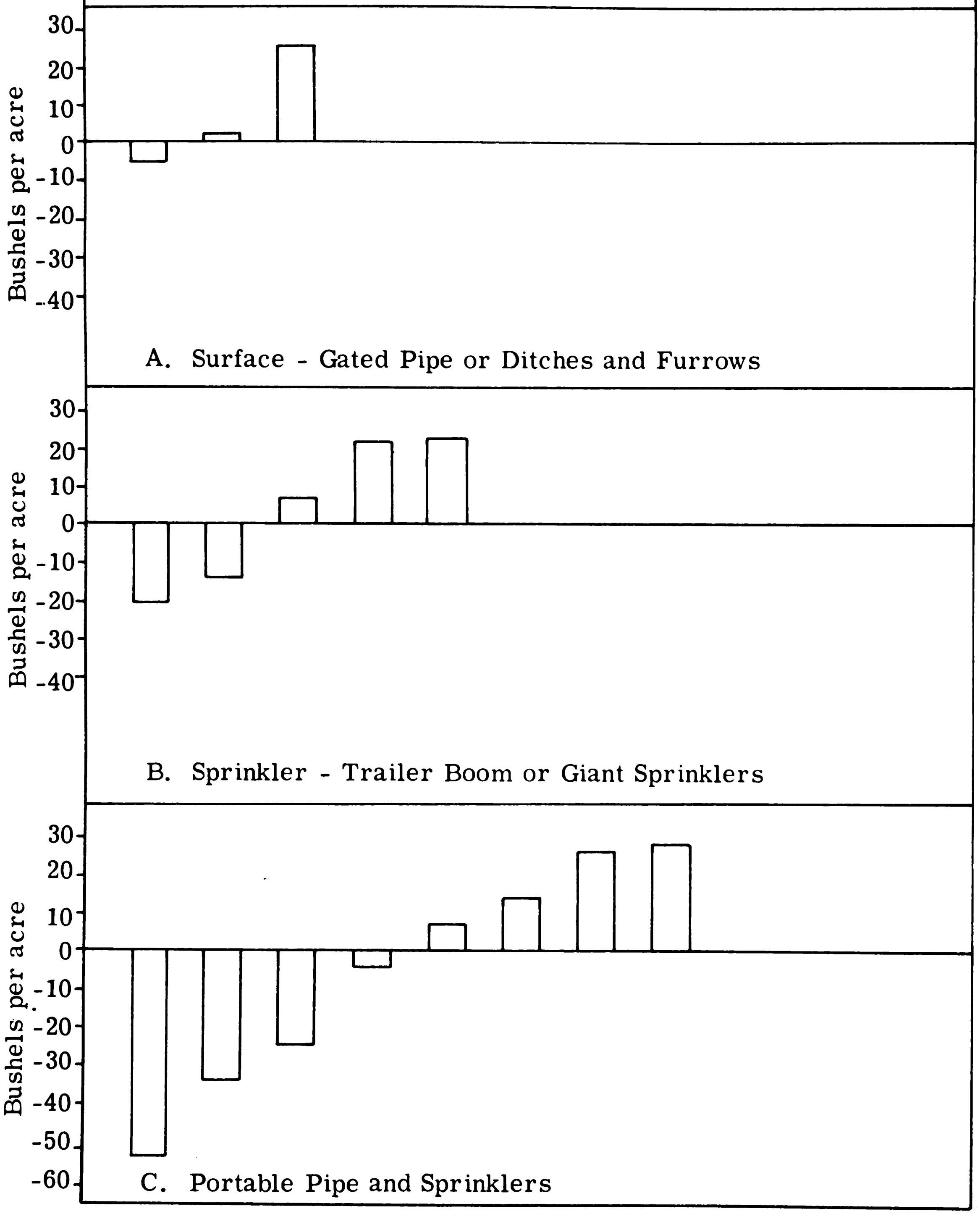
A. Surface - Gated Pipe or Ditches and Furrows

B. Sprinkler - Trailer Boom or Giant Sprinklers

C. Sprinkler - Portable Pipe and Sprinklers

*Each bar represents one farm.

FIGURE 11
NET RETURN OR LOSS PER ACRE OF CORN ABOVE TOTAL COST OF IRRIGATION BY TYPE OF IRRIGATION SYSTEM, SOUTHEASTERN MISSOURI, 16 FARMS 1959*



*Each bar represents one farm.

TABLE XLIII

NET RETURN OR LOSS ABOVE TOTAL IRRIGATION COSTS PER IRRIGATED ACRE OF CORN, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 16 FARMERS, 1959

Return Above Total Costs Dollars Per Acre	Type of Irrigation System: Portable Pipe and Sprinkler	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	Per Cent of Farms
-25.00 or More	2[a]	-	-	13
-20.00 to -24.99	1	1	-	13
-15.00 to -19.99	-	-	-	--
-10.00 to -14.99	-	1	-	6
- 5.00 to - 9.99	-	-	1	7
- 0.01 to - 4.99	1	-	-	6
+ 0.01 to + 4.99	-	-	1	6
+ 5.00 to + 9.99	1	1	-	13
+10.00 to +14.99	1	-	-	6
+15.00 to +19.99	-	-	--	--
+20.00 to +24.99	-	2	1	18
+25.00 to +29.99	2	-	-	13
Total	8	5	3	100

[a] -$35.50 and -$55.41.

The return above average variable costs for Category I, II, and III systems averaged $23.31, $21.33, and $19.51 per acre respectively (Table XL). On indidivual farms, the range was from -$8.47 to $36.25 (Figure 12 and Table A-III).

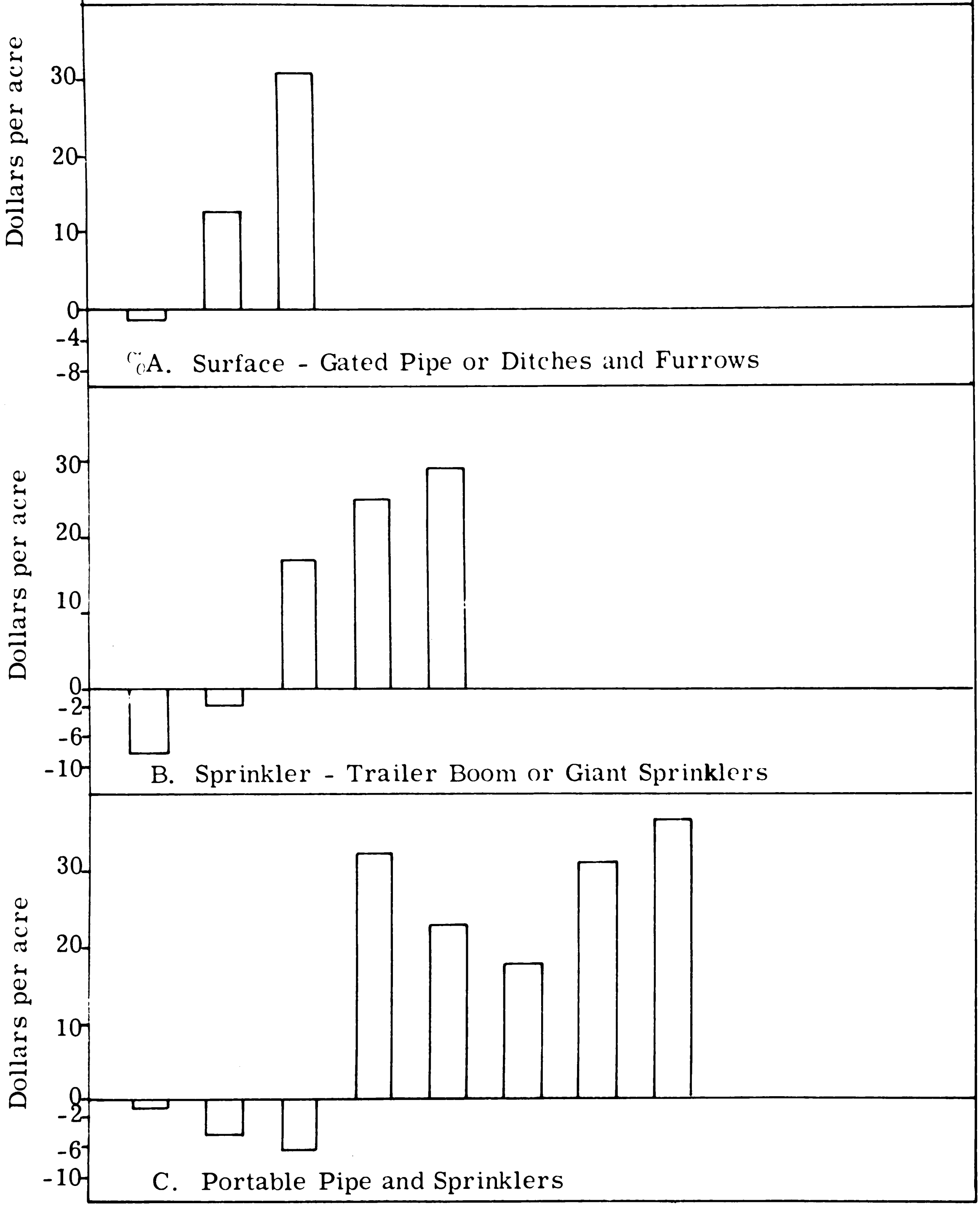
Thirty-seven per cent of the farmers applying water to corn failed to recover variable irrigation costs. The losses ranged from $0.01 to $9.99 per acre (Table XLIV). Sixty-three per cent obtained yield increases large enough to pay average variable costs and all or a share of the fixed costs. Twenty-five per cent had a return of $30.00 or more above the average variable costs.

Yield increase required to pay irrigation costs -- The yield increase needed to pay total costs of irrigation ranged from five to 55 bushels (Figure 13 and Table A-III). Limited system use was the major cause of the wide variation.

The yield increase needed to pay average variable costs ranged from two to eighteen, two to twelve, and one to nine bushels of corn for Category I, II, and III systems respectively (Figure 14 and Table A-III).

Summary of corn irrigation -- Average net returns per acre inch and per irrigated acre were positive for farmers using all three systems in 1959. The average net

FIGURE 12
ADDITIONAL RETURN OR LOSS PER ACRE OF CORN ABOVE VARIABLE COSTS OF IRRIGATION BY TYPE OF IRRIGATION SYSTEM, SOUTHEASTERN MISSOURI, 16 FARMS, 1959*



*Each bar represents one farm.

TABLE XLIV

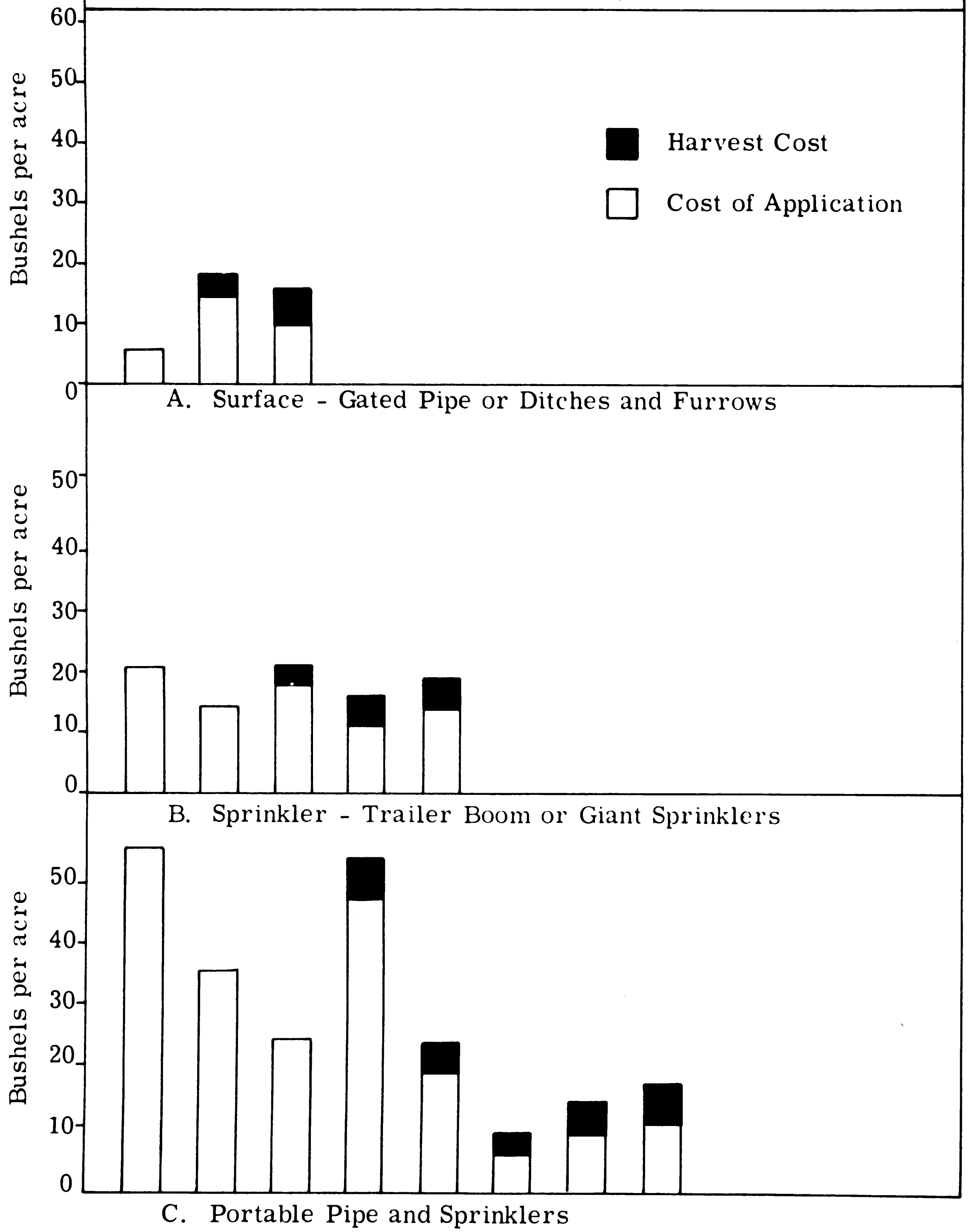
ADDITIONAL RETURN OR LOSS ABOVE AVERAGE VARIABLE COSTS FOR IRRIGATED ACRE OF CORN, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 16 FARMERS, 1959

Return Above Variable Costs	Type of Irrigation System			Per Cent of Farms
	Portable Pipe and Sprinklers	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	
Dollars Per Acre				
- 5.00 to - 9.99	1	1	-	12
- 0.01 to - 4.99	2	1	1	25
+ 0.01 to + 4.99	-	-	-	--
+ 5.00 to + 9.99	-	-	-	--
+10.00 to +14.99	-	-	1	7
+15.00 to +19.99	1	1	-	12
+20.00 to +24.99	1	1	-	12
+25.00 to +29.99	-	1	-	7
+30.00 and Over	3[a]	-	1[b]	25
Total	8	5	3	100

[a]+$31.32, $32.30, and $36.25.

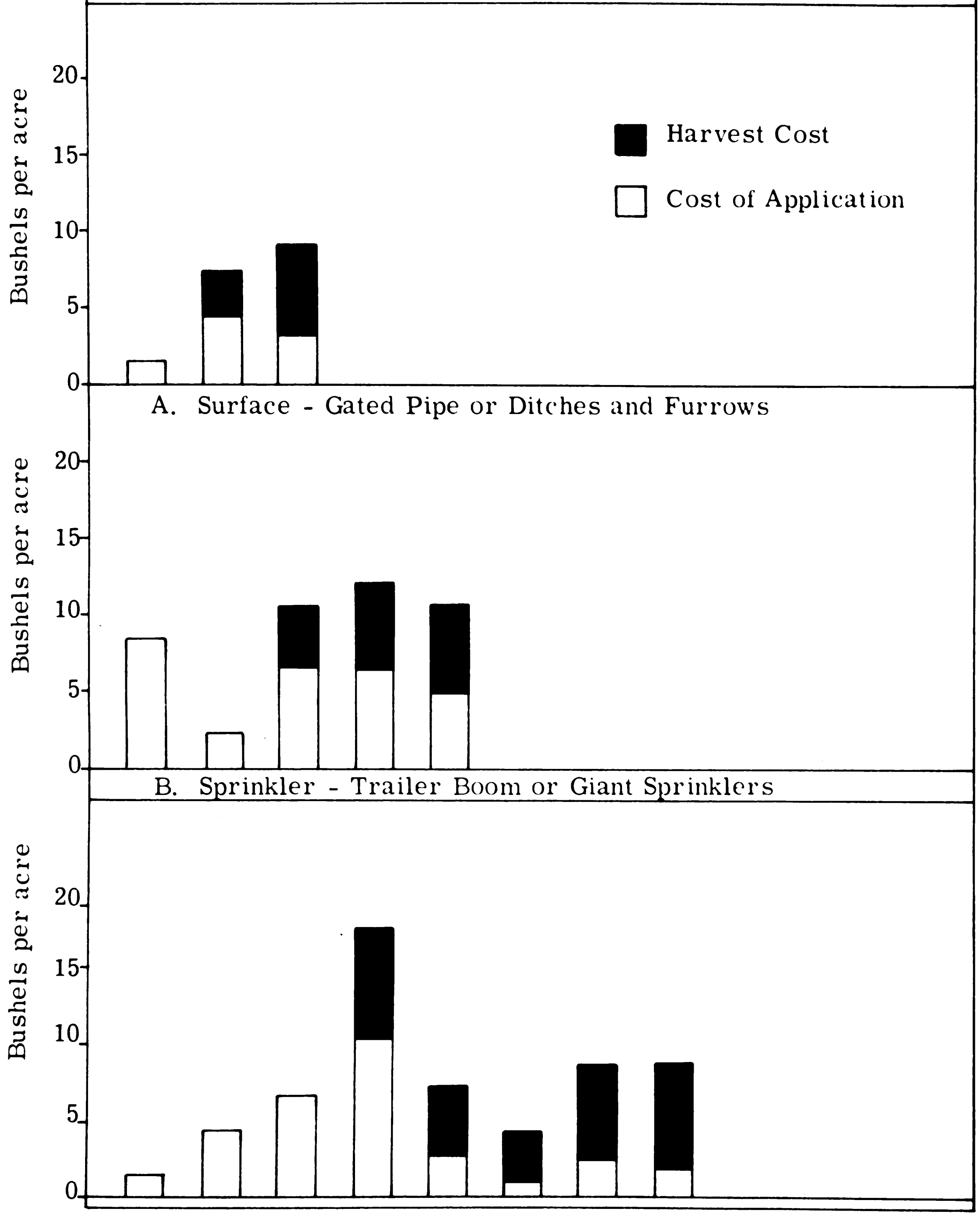
[b]+$30.99.

FIGURE 13
PER ACRE YIELD INCREASE REQUIRED TO PAY TOTAL COST OF IRRIGATION, INCLUDING HARVESTING COST, CORN BY TYPE OF IRRIGATION SYSTEMS, SOUTHEASTERN MISSOURI, 16 FARMS, 1959*



*Each bar represents one farm.

FIGURE 14
PER ACRE YIELD INCREASE REQUIRED TO PAY VARIABLE COSTS OF IRRIGATION, CORN BY TYPE OF IRRIGATION SYSTEM, SOUTHEASTERN MISSOURI, 16 FARMS, 1959*



C. Portable Pipe and Sprinklers

*Each bar represents one farm.

returns per irrigated acre averaged $10.34, $14.00, and $13.72 for farmers using Category I, II, and III systems respectively.

When returns on individual farms were analyzed, it was found that 44 per cent of the operators did not receive enough increase from irrigation to pay the total cost of applying water. However, 62 per cent of the corn irrigators obtained enough return to equal or exceed the average variable costs. Since only 62 per cent obtained a yield increase large enough to pay variable costs, the conclusion was reached that the actual yield increase was less than expected on 38 per cent of the farms. Otherwise, the 38 per cent would not have applied water to corn in 1959.

Cotton

Per acre inch of water -- Net returns averaged -$1.93, $1.23, and $0.74 for farmers using Category I, II, and III systems respectively (Table XLV). Average net returns per acre inch were smaller for cotton than for corn. Farmers using Category I systems got average returns that were negative in 1959. This means that the average farmer employing a Category I system in 1959 had a loss of $1.93 per acre inch of water applied to cotton. The primary reason was limited system use during the year. In many cases, a small acreage of cotton was charged with a large

TABLE XLV

NET RETURN AND RETURN ABOVE AVERAGE VARIABLE COST PER ACRE INCH OF WATER, PER ACRE IRRIGATED, AND PER ACRE APPLICATION, COTTON, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 35 FARMERS, 1959

Irrigation, Cost and Return	Type of Irrigation System: Surface System[a] (Dollars)	Giant Sprinkler and Trailer Boom[b] (Dollars)	Portable Pipe and Sprinkler[c] (Dollars)
Per Acre Inch of Water:			
Adjusted Gross Return	4.10	6.20	6.99
Average Cost	3.36	4.87	8.92
Net Return	+ .74	+ 1.33	- 1.93
Average Variable Cost	.69	1.45	1.32
Return Above Average Variable Cost	+ 3.41	+ 4.75	+ 5.67
Per Acre Irrigated:			
Adjusted Gross Return	14.18	20.08	15.65
Average Cost	11.61	15.96	20.31
Net Return	+ 2.57	+ 4.12	- 4.66
Average Variable Cost	2.38	4.75	3.01
Return Above Average Variable Cost	+11.80	+15.33	+12.64

TABLE XLV (Continued)

Irrigation, Cost and Return	Type of Irrigation System: Surface System (Dollars)	Giant Sprinkler and Trailer Boom (Dollars)	Portable Pipe and Sprinkler (Dollars)
Per Acre Application:			
Adjusted Gross Return	10.40	11.81	12.39
Average Cost	8.45	9.35	15.84
Net Return	+ 1.95	+ 2.46	- 3.45
Average Variable Cost	1.73	2.79	2.34
Return Above Average Variable Cost	+ 8.67	+ 9.02	+10.05

[a]Eight farmers.

[b]Eight farmers.

[c]Nineteen farmers.

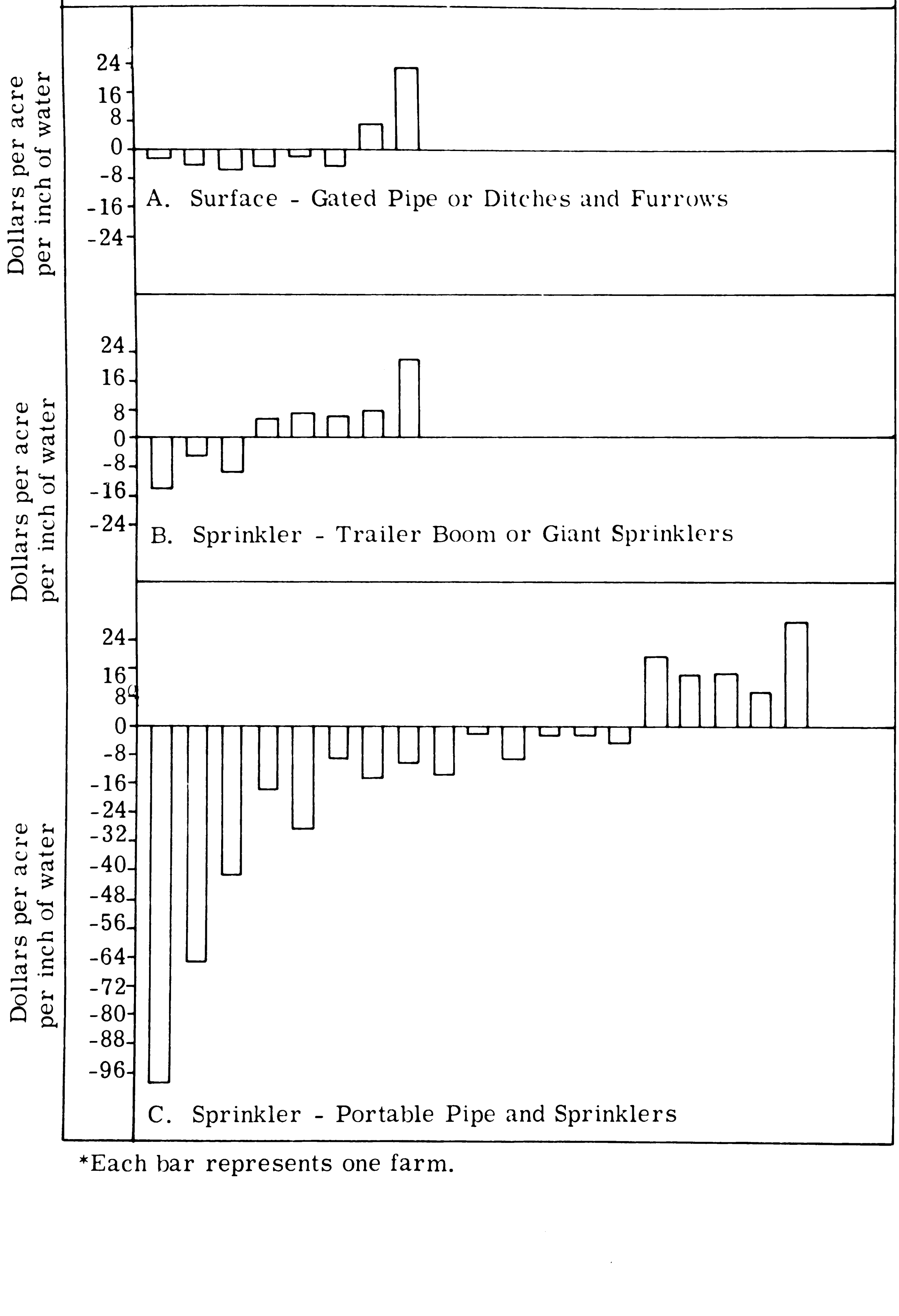
share of the annual fixed costs. In fact, eight of the 22 cotton irrigators made only one application of water to a limited cotton acreage during the first part of May. None of these men obtained a yield response.

The net returns per acre inch of water on individual farms ranged from -$99.22 to $25.61 (Figure 15 and Table A-IV). Sixty-five per cent of the cotton irrigators did not obtain a yield increase sufficient to pay total irrigating costs (Table XLVI). Thirty-five per cent obtained a positive net return. Nine per cent of the 35 per cent received net returns ranging from $20.00 to $29.99 per acre inch of water applied.

Returns above variable costs averaged $5.67, $4.75, and $3.41 for farmers employing Category I, II, and III systems respectively (Table XLV). When average fixed costs were not considered, average returns from irrigation more than paid the average variable costs for all three systems. On individual farms, the returns above average variable costs ranged from -$2.20 to $32.17 (Figure 16 and Table A-IV). Thirty-seven, 62, and 29 per cent of the farmers employing Category I, II, and III system respectively obtained positive returns above average variable costs.

Fifty-seven per cent of the cotton irrigators did not obtain a yield increase large enough to pay average variable costs (Table XLVII). Fourteen per cent obtained

FIGURE 15
NET RETURN OR LOSS PER ACRE INCH OF WATER APPLIED TO COTTON ABOVE TOTAL COST OF IRRIGATION, SOUTH-EASTERN MISSOURI, 35 FARMS, 1959*



*Each bar represents one farm.

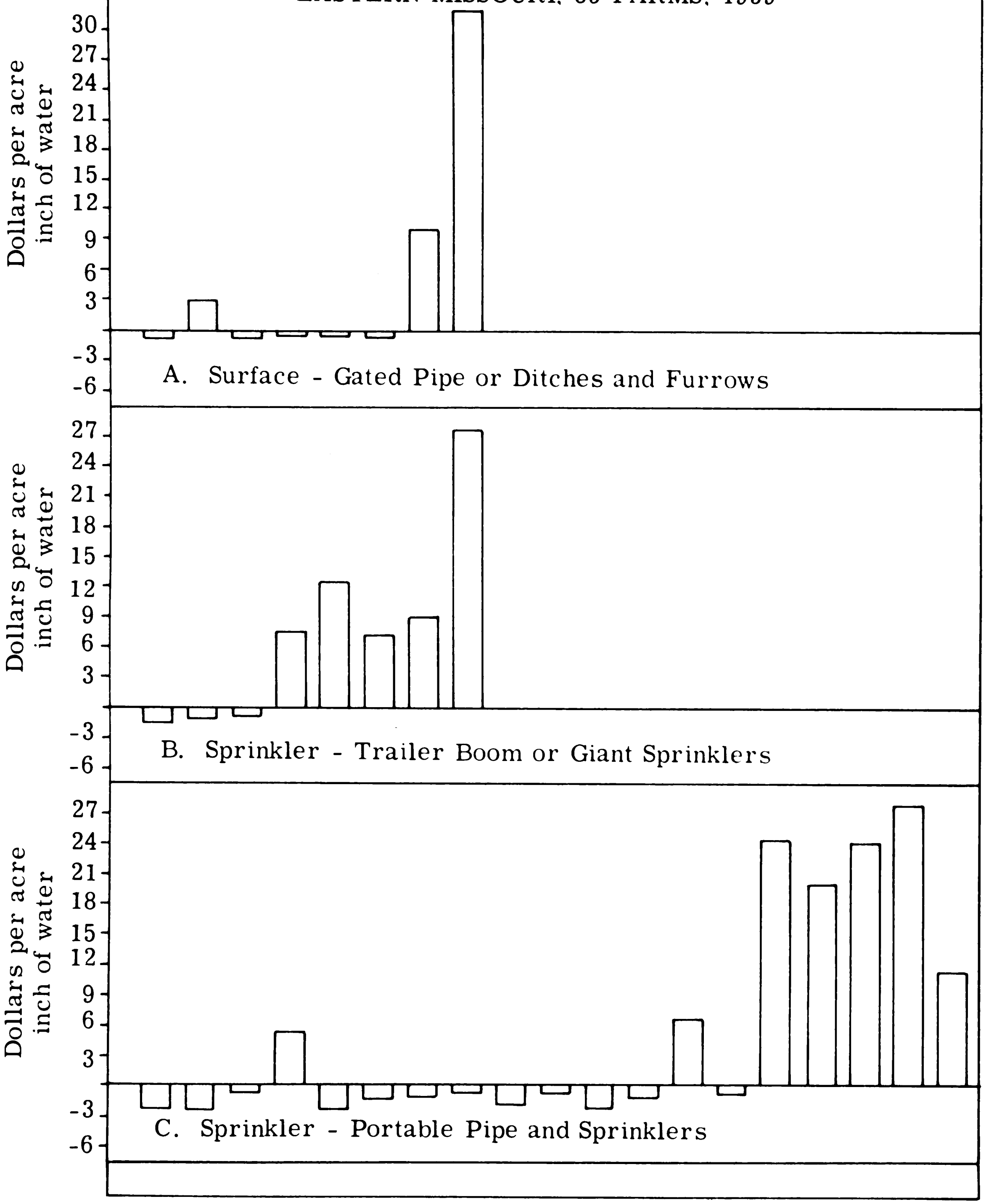
TABLE LXVI

NET RETURN OR LOSS ABOVE TOTAL IRRIGATION COSTS PER ACRE INCH OF WATER, COTTON, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 35 FARMERS, 1959

Return Above Total Costs	Type of Irrigation System: Portable Pipe and Sprinklers	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	Per Cent of Farms
Dollars Per Acre Inch				
-30.00 or More	3[a]	-	-	8
-25.00 to -29.99	1	-	-	3
-20.00 to -24.99	-	-	-	-
-15.00 to -19.99	2	-	-	6
-10.00 to -14.99	2	1	-	8
- 5.00 to - 9.99	3	1	1	14
- 0.01 to - 4.99	3	1	5	26
+ 0.01 to + 4.99	-	-	-	-
+ 5.00 to + 9.99	1	4	1	17
+10.00 to +14.99	2	-	-	6
+15.00 to +19.99	1	-	-	3
+20.00 to +24.99	-	1	1	6
+25.00 to +29.99	1	-	-	3
Total	19	8	8	100

[a]-$41.57, -65.90, and -99.22.

FIGURE 16
ADDITIONAL RETURN OR LOSS PER ACRE INCH OF WATER APPLIED TO COTTON ABOVE VARIABLE COSTS OF IRRIGATION BY TYPE OF IRRIGATION SYSTEM, SOUTHEASTERN MISSOURI, 35 FARMS, 1959*



*Each bar represents one farm.

TABLE XLVI

ADDITIONAL RETURN OR LOSS ABOVE AVERAGE VARIABLE COSTS PER ACRE INCH OF WATER, COTTON, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 35 FARMERS, 1959

Return Above Variable Costs	Type of Irrigation System: Portable Pipe and Sprinklers	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	Per Cent of Farms
Dollars Per Acre Inch				
- 0.01 to - 4.99	12	3	5	57
- 0.01 to + 4.99	1	-	1	6
+ 5.00 to + 9.99	1	3	1	14
+10.00 to +14.99	1	1	-	6
+15.00 to +19.99	11	-	-	3
+20.00 to +24.99	1	-	-	3
+25.00 to +29.99	2	1	-	8
+30.00 and Over	-	-	1[a]	3
Total	19	8	8	100

[a]+$32.17.

returns from $20.00 to $32.17 above average variable costs.

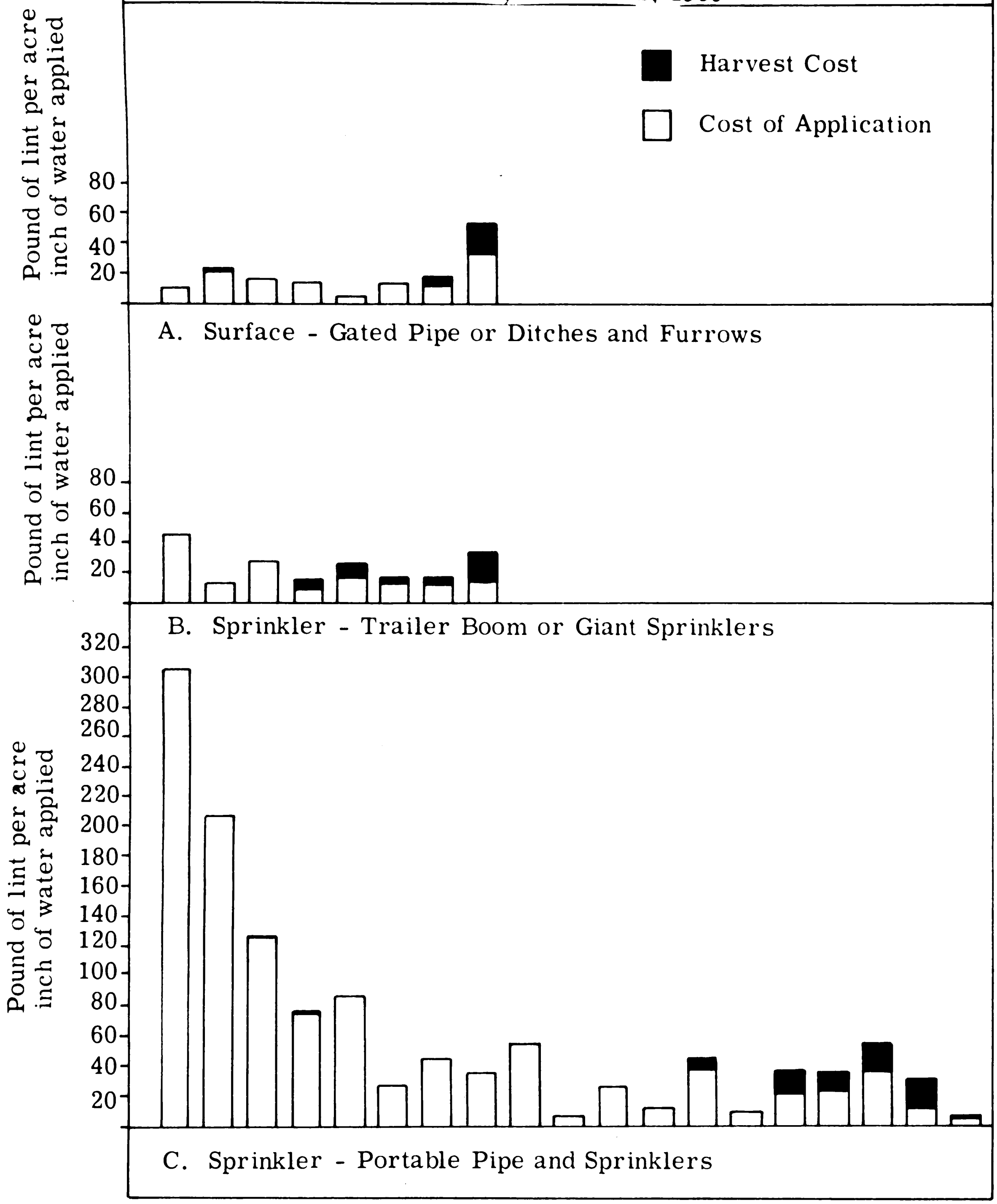
Yield increase required to pay irrigation costs -- The yield increase needed to pay total irrigation costs per acre inch of water ranged from 3 to 308 pounds of lint cotton on individual farms (Figure 17 and Table A-IV). The required increase for farmers with different types of equipment was from 5 to 308, 8 to 45, and 3 to 52 pounds of lint for Category I, II, and III systems respectively.

The yield increase needed to pay operating or variable costs ranged from 3 to 24 pounds of lint cotton, when harvesting costs were included. An increase of 1 to 8 pounds would pay average variable costs per acre inch of water applied by all systems, if harvesting costs were excluded (Figure 18 and Table A-IV).

Per irrigated acre -- Net returns per irrigated acre of cotton averaged -$4.66, $4.12, and $2.57 for farmers employing Category I, II, and III systems respectively (Table XLV). On individual farms, the net returns ranged from -$99.22 to $55.63 (Figure 19 and Table A-V). Individual farmers using Category I systems had both the highest and lowest net return per acre.

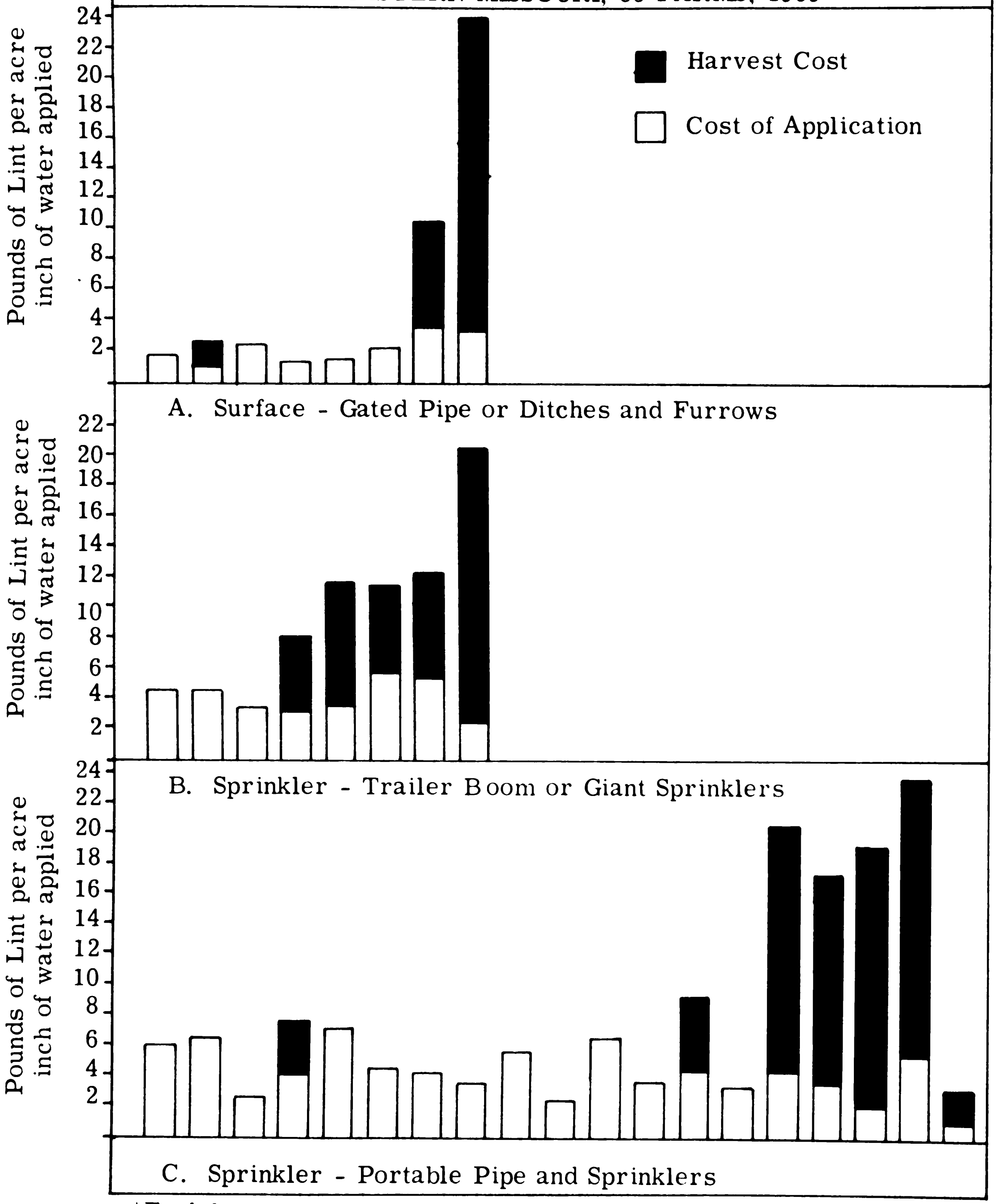
Fourteen per cent of the cotton irrigators had net losses of $30.00 or more per acre (Table XLVIII). An

FIGURE 17
YIELD INCREASE PER ACRE INCH OF WATER APPLIED TO PAY TOTAL COST OF IRRIGATION, INCLUDING HARVESTING COST, COTTON BY TYPE OF IRRIGATION SYSTEM, SOUTHEASTERN MISSOURI, 35 FARMS, 1959*



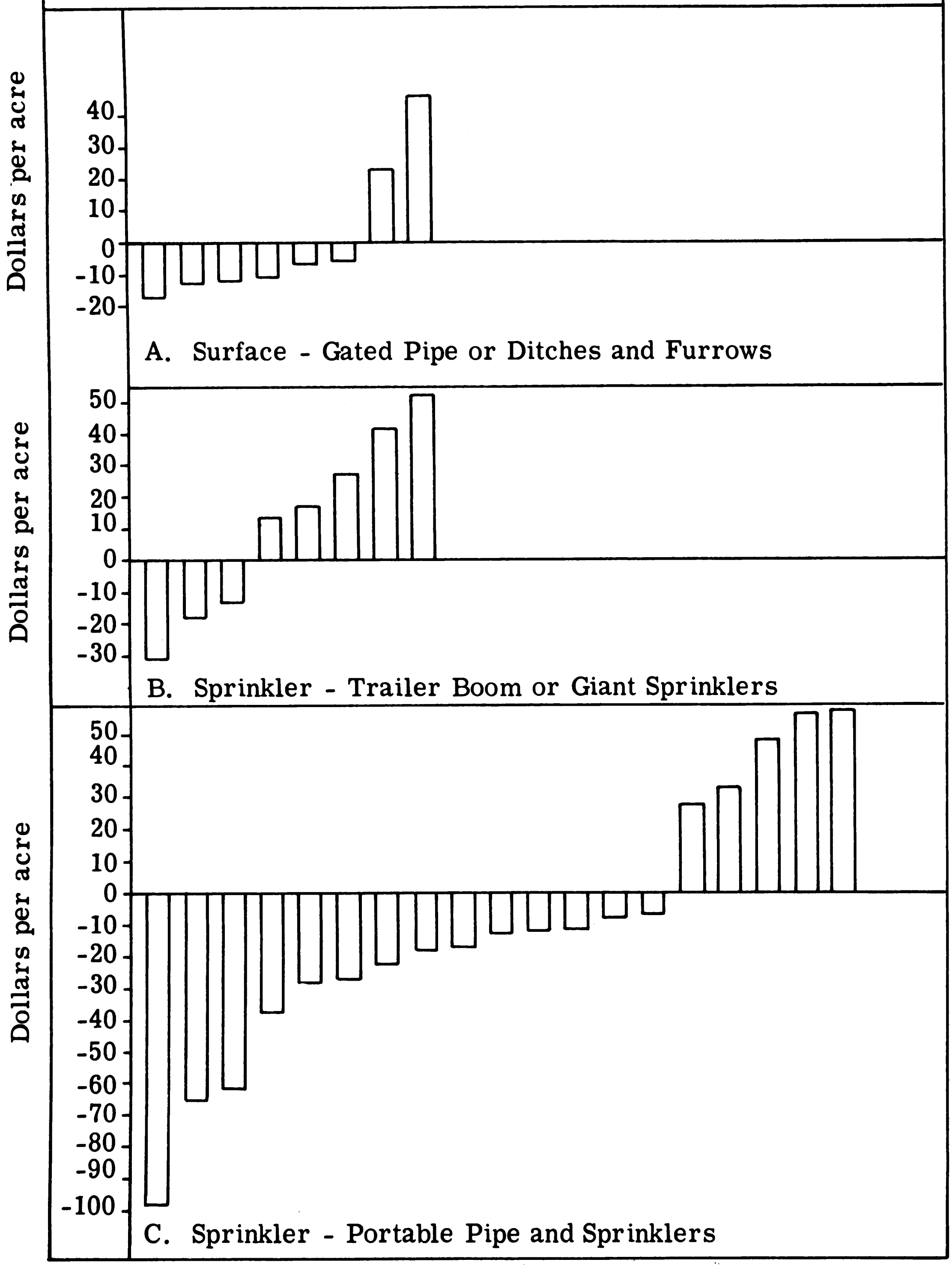
*Each bar represents one farm.

FIGURE 18
YIELD INCREASE PER ACRE INCH OF WATER APPLIED TO PAY VARIABLE COST OF IRRIGATION, INCLUDING HARVESTING COSTS, COTTON, BY TYPE OF IRRIGATION SYSTEM, SOUTHEASTERN MISSOURI, 35 FARMS, 1959*



*Each bar represents one farm.

FIGURE 19
NET RETURN OR LOSS PER ACRE OF COTTON ABOVE TOTAL COST OF IRRIGATION, BY TYPE OF IRRIGATION SYSTEM, SOUTHEASTERN MISSOURI, 35 FARMS 1959*



*Each bar represents one farm.

TABLE XLVIII

NET RETURN OR LOSS ABOVE TOTAL IRRIGATION COST PER IRRIGATED ACRE, COTTON, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 35 FARMERS, 1959

Return Above Total Costs	Type of Irrigation System			
	Portable Pipe and Sprinklers	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	Per Cent of Farms
Dollars Per Acre				
-30.00 or More	4[a]	1[b]	-	14
-25.00 to -29.99	2	-	-	8
-20.00 to -24.99	1	-	-	3
-15.00 to -19.99	2	1	1	11
-10.00 to -14.99	3	1	3	20
- 5.00 to - 9.99	1	-	2	9
- 0.01 to - 4.99	-	-	-	-
+ 0.01 to + 4.99	-	-	-	-
+ 5.00 to + 9.99	1	-	-	3
+10.00 to +14.99	-	1	-	3
+15.00 to +19.99	-	1	-	3
+20.00 to +24.99	-	-	1	3
+25.00 to +29.99	1	1	-	6
+30.00 or More	4[c]	1[d]	1[e]	17
Total	19	8	8	100

[a]-$37.15, -62.90, and -99.22.

[b]$31.56.

[c]+$33.38, +49.38, +55.63, and +57.22.

[d]+$51.04.

[e]+$46.50.

additional 51 per cent had net losses which ranged from $0.01 to $29.99 per acre. Eighteen per cent obtained positive net returns which ranged from $0.01 to $29.99, and 17 per cent had net returns of $30.00 or more.

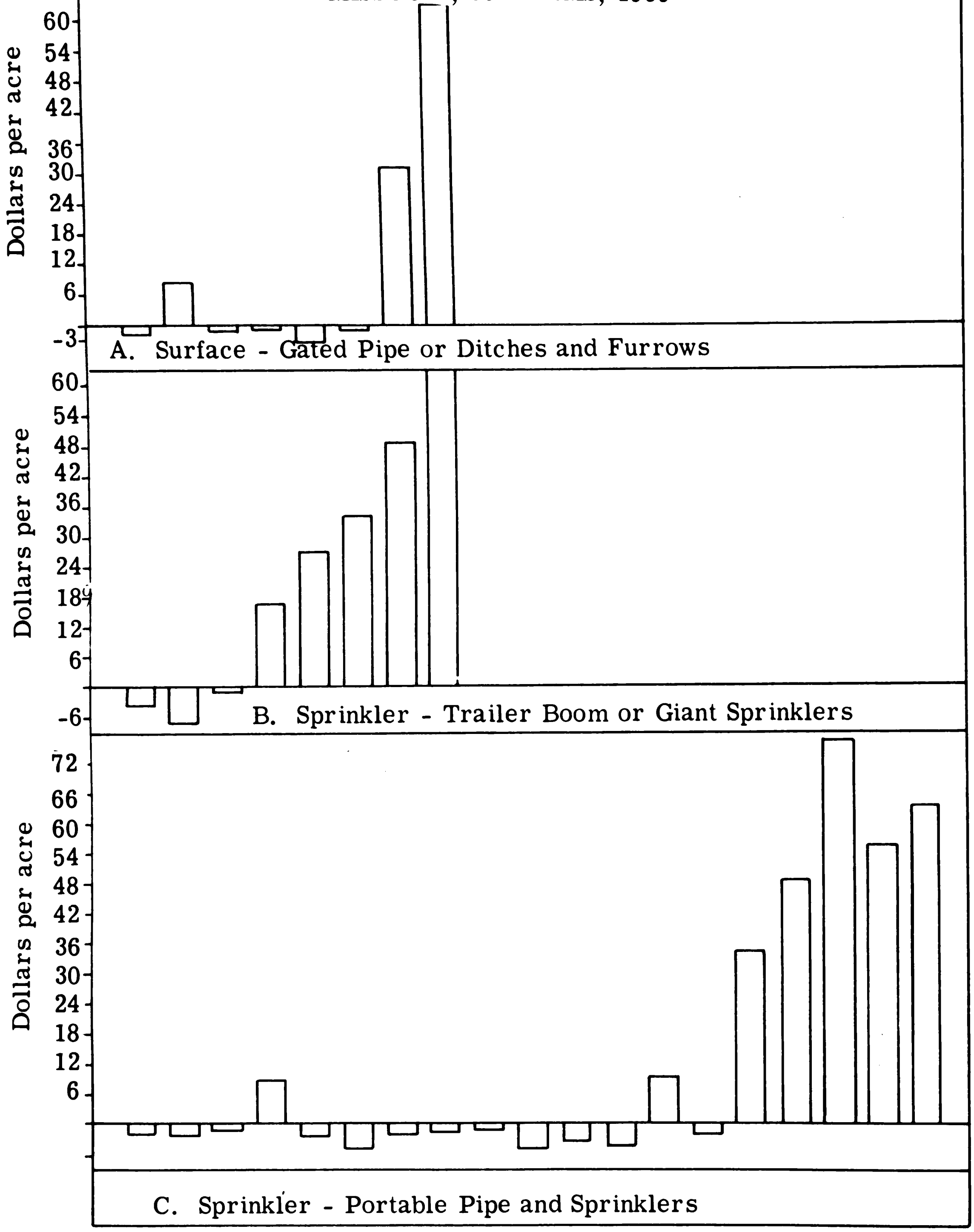
Returns above variable costs averaged $12.64, $15.33, and $11.80 for farmers employing Category I, II, and III systems respectively (Table XLV). On individual farms, the range was from -$6.40 to $86.05 per irrigated acre (Figure 20 and Table A-V).

Sixty per cent of the cotton irrigators did not obtain yield increases large enough to pay average variable costs (Table XLIX). Six per cent had losses ranging from $5.00 to $9.99 per irrigated acre. An additional 56 per cent had variable costs ranging from $0.01 to $4.99, which additional yield increases did not pay.

Forty per cent of the cotton irrigators obtained yield increases that raised incomes more than average variable costs (Table XLIX). Six per cent received returns which were $5.00 to $9.99 above the average variable costs per acre. Twenty-eight per cent paid the average variable cost per acre, and had more than $30.00 per acre remaining.

<u>Yield increase required to pay irrigation costs</u> -- The yield increases needed to pay total irrigation costs

FIGURE 20
ADDITIONAL RETURN OR LOSS PER ACRE OF COTTON ABOVE VARIABLE COSTS OF IRRIGATION, SOUTHEASTERN MISSOURI, 35 FARMS, 1959*



*Each bar represents one farm.

TABLE XLIX

ADDITIONAL RETURN OR LOSS ABOVE AVERAGE VARIABLE COST PER IRRIGATED ACRE, COTTON, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 35 FARMERS, 1959

Return Above Variable Costs	Type of Irrigation System: Portable Pipe and Sprinkler	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	Per Cent of Farms
Dollars Per Acre				
- 5.00 to - 9.99	1	1	-	6
- 0.01 to - 4.99	12	2	5	54
+ 0.01 to + 4.99	--	-	-	--
+ 5.00 to + 9.99	1	-	1	6
+10.00 to +14.99	--	-	-	--
+15.00 to +19.99	--	1	-	3
+20.00 to +24.99	--	-	-	--
+25.00 to +29.99	--	1	-	3
+30.00 or More	5[a]	3[b]	2[c]	28
Total	19	8	8	100

[a]+$34.81, +$48.73, +$55.63, +$63.73, and +$86.05.

[b]+$34.78, +$49.53, and +$68.84.

[c]+$31.41 and $64.34.

ranged from 20 to 308 pounds of lint cotton per acre (Figure 21 and Table A-V). They ranged from 24 to 308, 23 to 98, and 20 to 104 pounds of lint cotton for farmers using Category I, II, and III systems respectively.

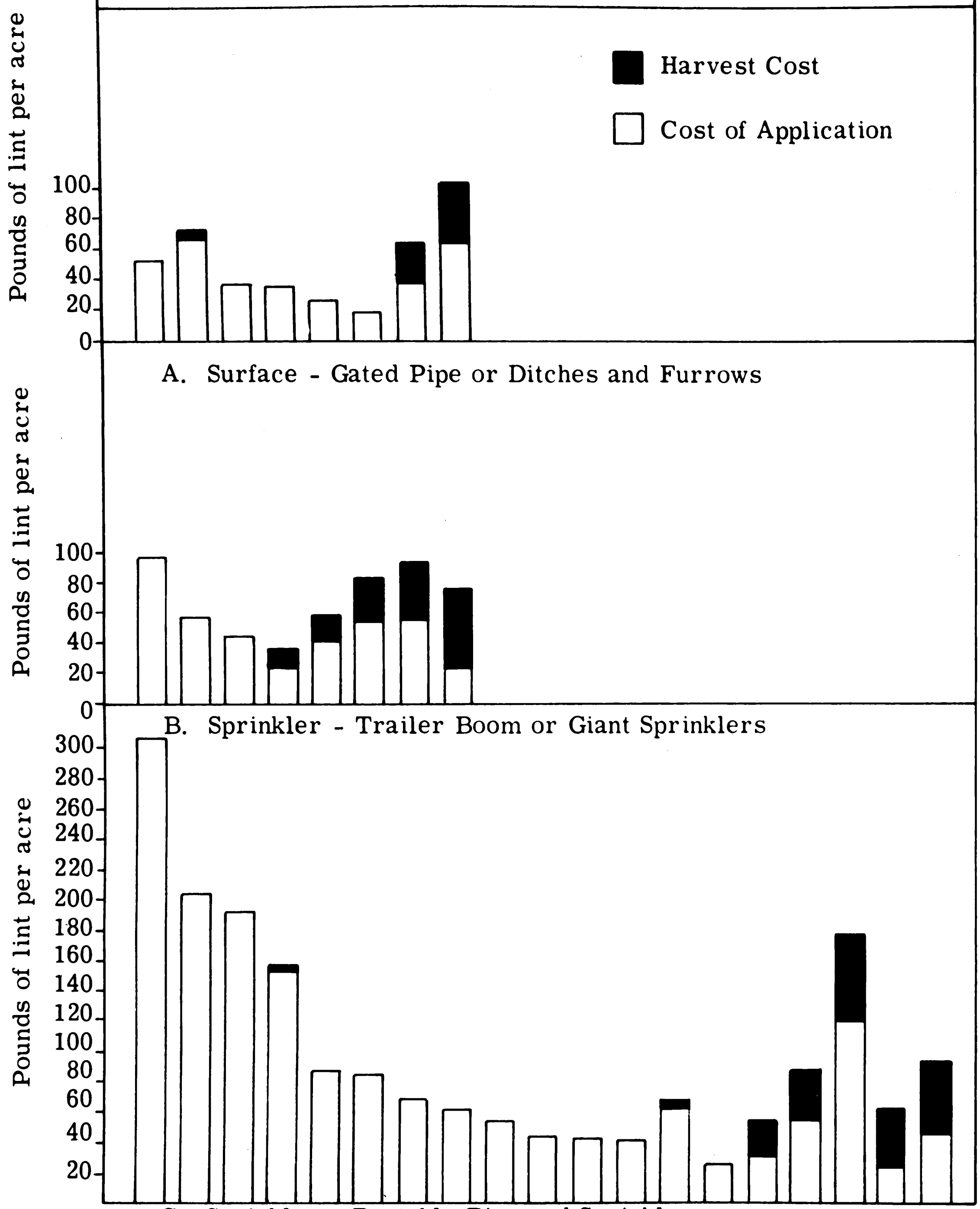
Average variable costs could have been paid by a yield increase of 3 to 67 pounds of lint cotton (Figure 22 and Table A-V). Farmers using Category I, II, and III systems needed from 6 to 67, 5 to 67 and 3 to 48 pounds of lint cotton respectively to pay average variable costs.

Summary of cotton irrigation -- Applying water to this crop was not as profitable as irrigating corn in 1959. The average net return per acre was $4.12 on farms where Category II systems were used and $2.57 for Category III farms, but those where Category I systems were used had average net losses per acre of $4.66.

Sixty-five per cent of the cotton irrigators did not obtain yield increases sufficient to pay total irrigation costs. Fifty-seven of the 65 per cent could not pay average variable costs from the increased yields.

A modest yield increase would have paid the average variable costs for all systems. However, 1959 was an excellent cotton year in the Delta area without irrigation. The average yield per acre was 613 pounds of lint, which

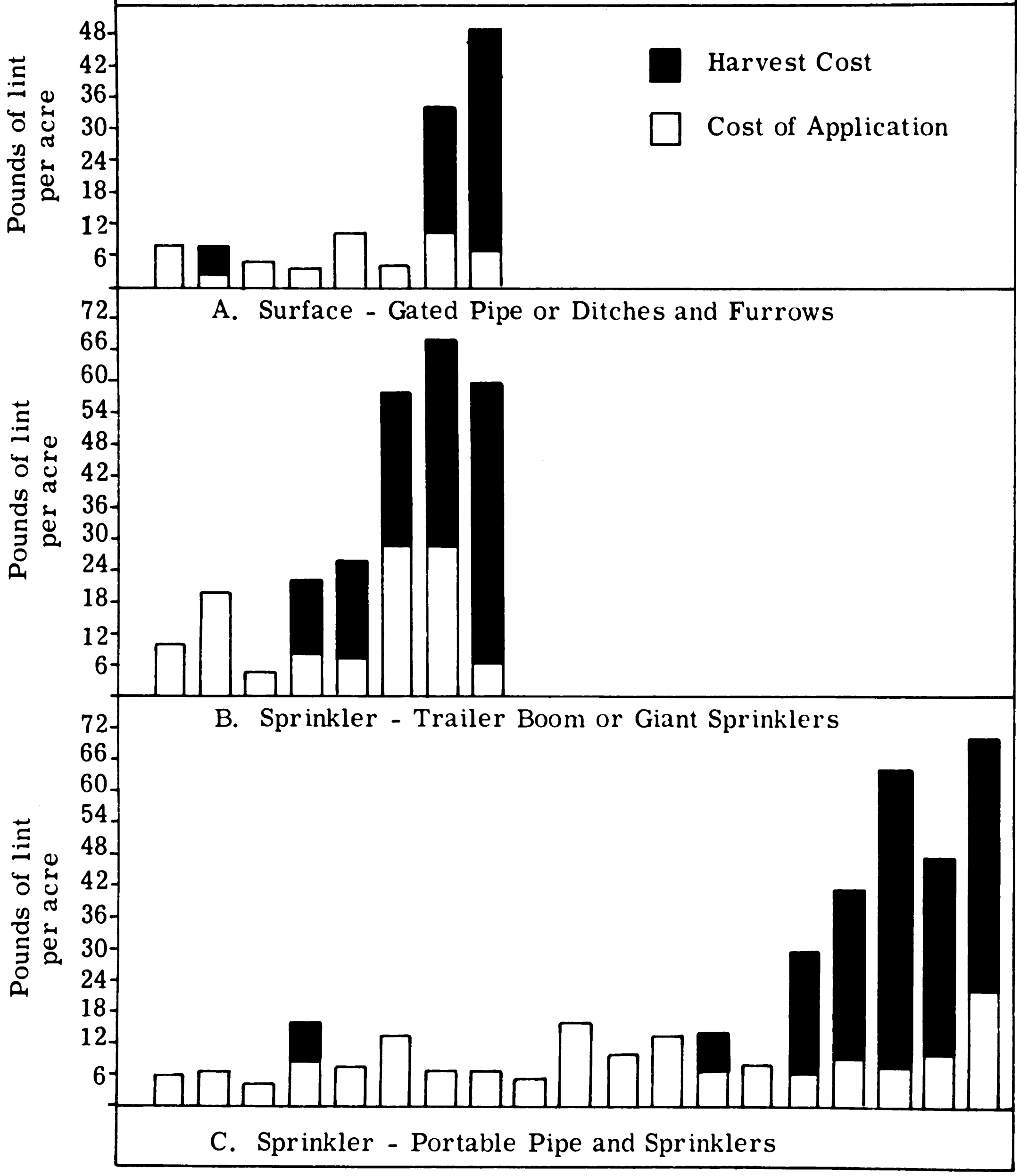
FIGURE 21
PER ACRE YIELD INCREASE REQUIRED TO PAY TOTAL COST OF IRRIGATION, INCLUDING HARVESTING COSTSCOTTON BY TYPE OF IRRIGATION SYSTEM: SOUTHEASTERN MISSOURI, 35 FARMS, 1959*



C. Sprinkler - Portable Pipe and Sprinklers

*Each bar represents one farm.

FIGURE 22
PER ACRE YIELD INCREASE REQUIRED TO PAY VARIABLE COST OF IRRIGATION COTTON BY TYPE OF IRRIGATION SYSTEM, SOUTHEASTERN MISSOURI, 35 FARMS, 1959*



*Each bar represents one farm.

was 165 pounds greater than the average in 1958.[2]

Soybeans

Per acre inch of water -- Net returns were -$1.90, $0.37, and $0.72 for farmers using Category I, II, and III systems respectively (Table L). The net per acre inch of water was less for soybeans than for corn and cotton. On individual farms it ranged from -$12.28 to $5.92 (Figure 23 and Table A-VI).

The revenue attributable to irrigation did not pay the total costs on 46 per cent of the farms where water was applied to this crop (Table LI). Eight per cent of the 46 had net losses ranging from $10.00 to $14.99 for each acre inch of water applied. Fifty-four per cent obtained net returns in excess of costs from irrigating soybeans. The gain ranged from $0.01 to $4.99 and $5.00 to $9.99 for 46 and 8 per cent of the operators respectively.

The returns above variable costs averaged $1.67, $2.24 and $2.29 for farmers employing Category I, II, and III systems respectively (Table L).

On individual farms, the return above variable cost ranged from -$3.33 to $8.91 per acre inch of water (Figure

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[2]United States Department of Agriculture, *Agricultural Statistics*: 1960 (Washington: Government Printing Office, 1961, page 61.

TABLE L

NET RETURN AND RETURN ABOVE AVERAGE VARIABLE COST PER ACRE INCH OF WATER, PER ACRE IRRIGATED AND PER ACRE APPLICATION, SOYBEANS, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 13 FARMERS, 1959

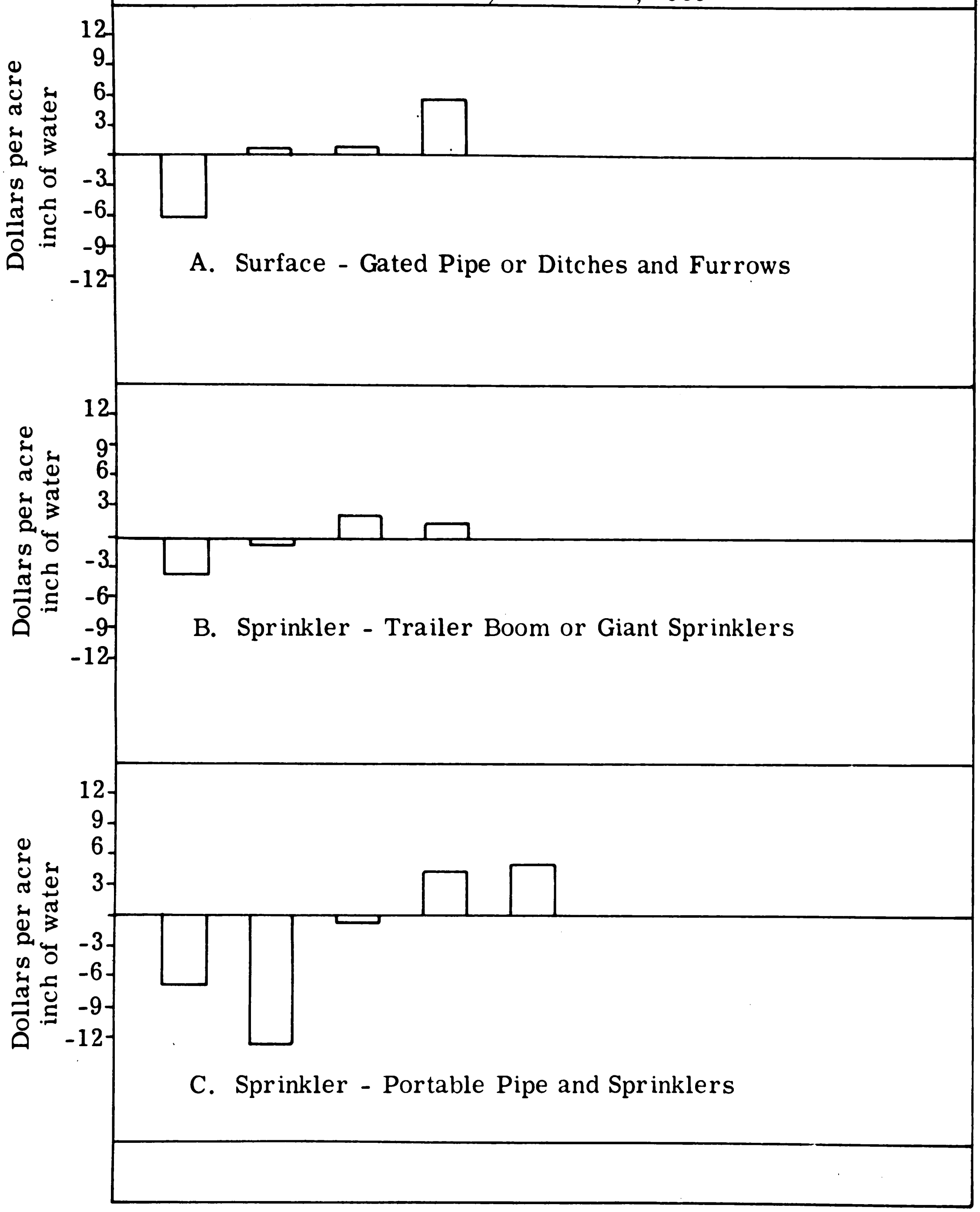
	Type of Irrigation System		
Irrigation, Cost and Return	Surface System[a] (Dollars)	Giant Sprinkler and Trailer Boom[b] (Dollars)	Portable Pipe and Sprinkler[c] (Dollars)
Per Acre Inch of Water:			
Adjusted Gross Return	3.30	3.30	3.30
Average Cost	2.58	2.93	5.20
Net Return	+ .72	+ .37	- 1.90
Average Variable Cost	.31	1.06	1.63
Return Above Average Variable Cost	+ 2.99	+ 2.24	+ 1.67
Per Acre Irrigated:			
Adjusted Gross Return	19.80	14.85	6.60
Average Cost	15.21	13.21	13.12
Net Return	+ 4.59	+ 1.64	- 6.52
Average Variable Cost	1.83	4.77	4.10
Return Above Average Variable Cost	+17.99	+10.08	+ 2.50
Per Acre Application:			
Adjusted Gross Return	14.85	8.25	4.95
Average Cost	11.44	7.64	11.72
Net Return	+ 3.41	+ .61	- 6.77
Average Variable Cost	1.38	2.76	3.66
Return Above Average Variable Cost	+13.47	+ 5.49	+ 1.29

[a]Four farmers.

[b]Four farmers.

[c]Five farmers.

FIGURE 23
NET RETURN OR LOSS PER ACRE INCH OF WATER APPLIED TO SOYBEANS ABOVE TOTAL COST OF IRRIGATION BY TYPE OF IRRIGATION SYSTEM, SOUTHEASTERN MISSOURI, 13 FARMS, 1959*



*Each bar represents one farm.

TABLE LI

NET RETURN OR LOSS ABOVE TOTAL IRRIGATION COSTS PER ACRE INCH OF WATER, SOYBEANS, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 13 FARMERS, 1959

Return Above Total Costs	Type of Irrigation System			
	Portable Pipe and Sprinklers	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	Per Cent of Farms
Dollars Per Acre Inch				
-10.00 to -14.99	1	-	-	8
- 5.00 to - 9.99	1	-	1	15
- 0.01 to - 4.99	1	2	-	23
+ 0.01 to + 4.99	2	2	2	46
+ 5.00 to + 9.99	-	-	1	8
Total	5	4	4	100

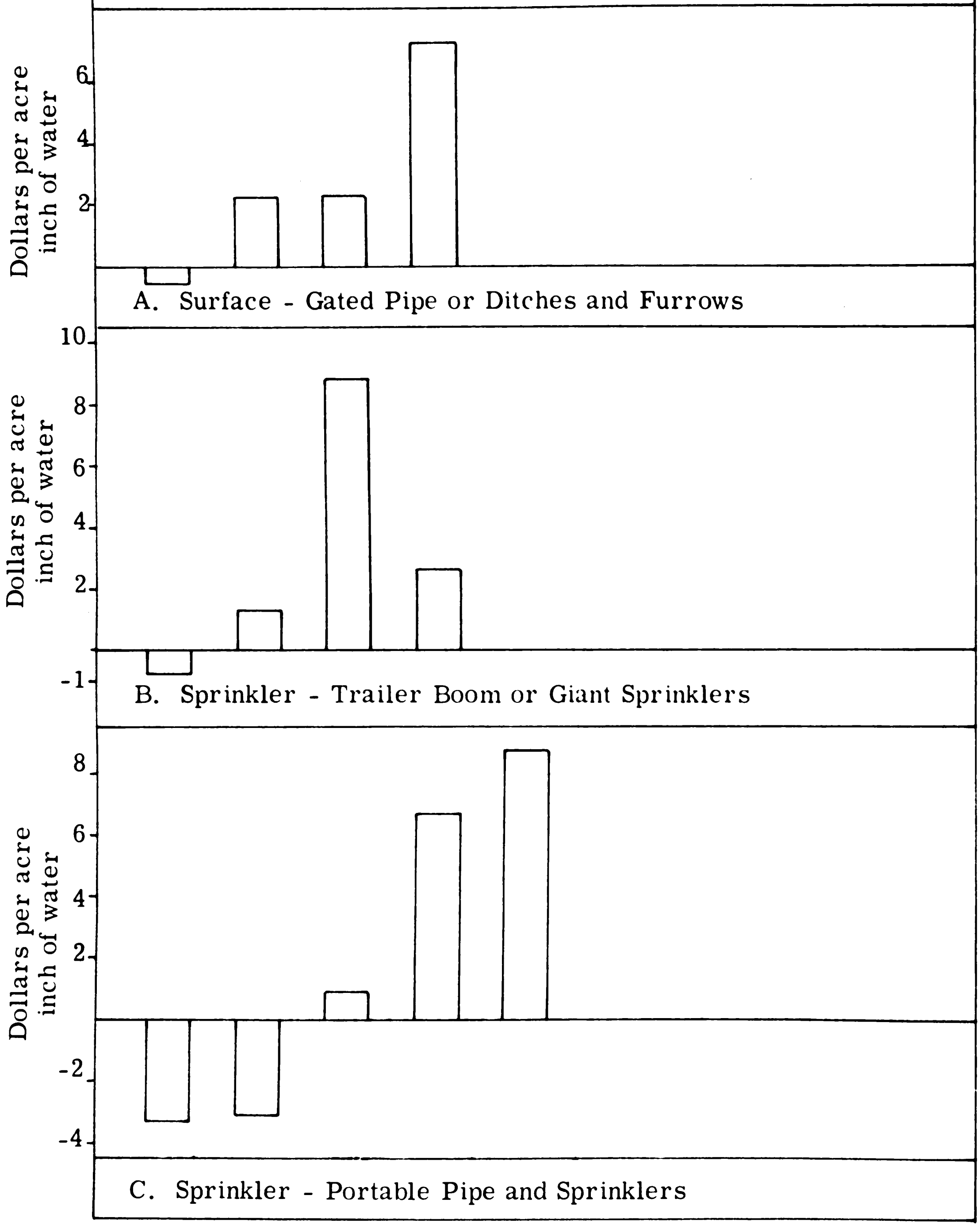
24 and Table A-VI). Thirty-one per cent of the soybean irrigators did not obtain a yield increase sufficient to pay the variable costs of applying the water (Table LII). Thirty-eight per cent obtained returns which were from $0.01 to $4.99 above variable costs. An additional 31 per cent obtained returns above variable costs ranging from $5.00 to $9.99.

Yield increase required to pay irrigation costs -- The yield increases needed to pay all irrigation costs ranged from 1 to 7 bushels of soybeans on individual farms (Figure 25 and Table A-VI). The increase required to pay average variable costs was less than that needed to pay total costs. It ranged from .1 to 2 bushels per acre inch of water applied (Figure 26 and Table A-VI).

Per irrigated acre -- Net returns per irrigated acre averaged $1.64 and $4.59 for farmers using Category II and III systems respectively. Farmers employing Category I systems had net losses per acre, which averaged $6.52.

On individual farms, net returns ranged from -$22.06 to $23.69 (Figure 27 and Table A-VII). Forty-six per cent of the irrigators had net losses from irrigating soybeans. Twenty-two per cent of the 46 lost from $0.01 to $9.99 per acre (Table LIII). An additional 24 per cent lost from $10.00 to $24.99 per acre. Forty-six of the 54 per cent

FIGURE 24
ADDITIONAL RETURN OR LOSS PER ACRE INCH OF WATER APPLIED TO SOYBEANS ABOVE VARIABLE COSTS OF IRRIGATION, SOUTHEASTERN MISSOURI, 13 FARMS, 1959*



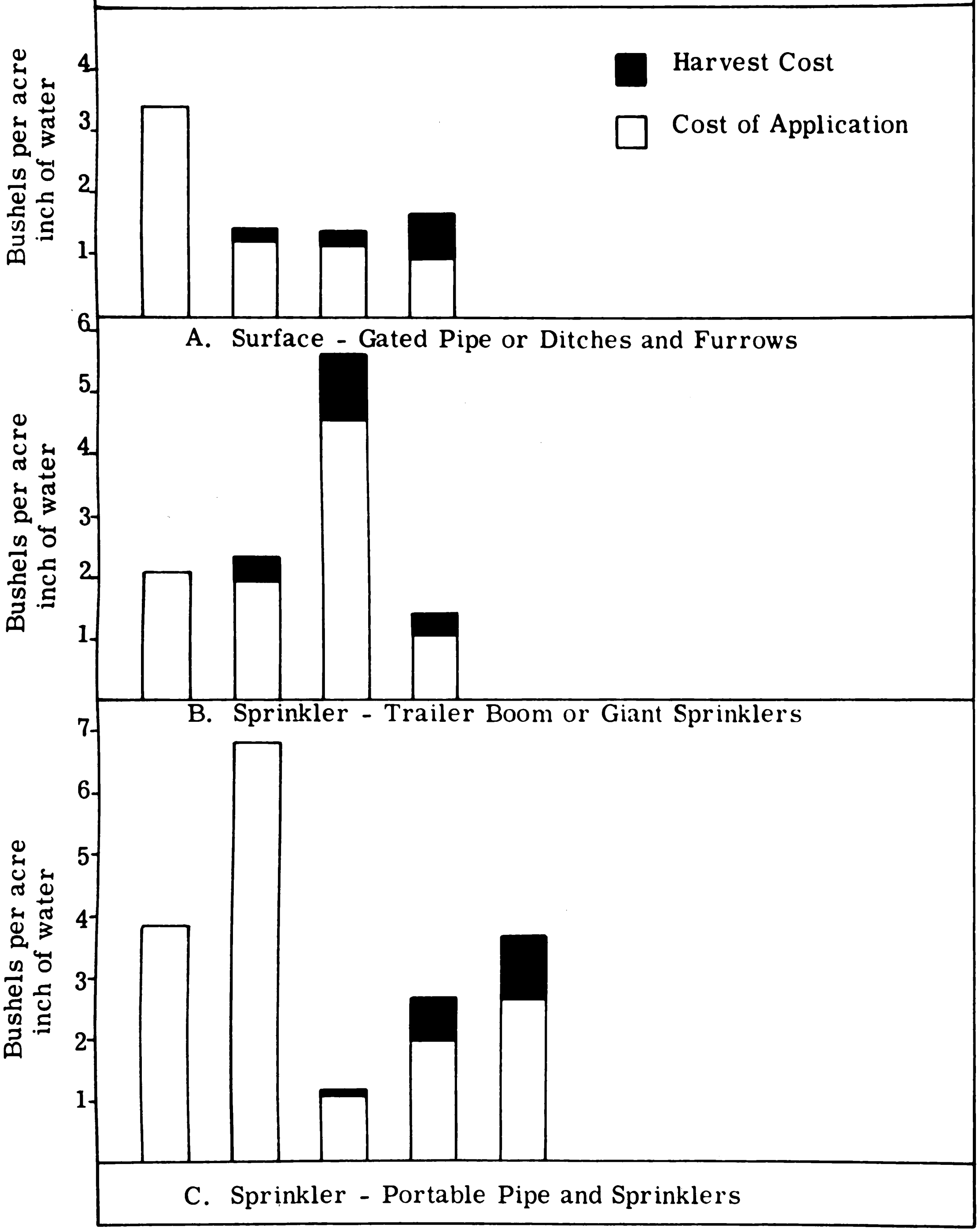
*Each bar represents one farm.

TABLE LII

ADDITIONAL RETURN OR LOSS ABOVE AVERAGE VARIABLE COSTS PER ACRE INCH OF WATER, SOYBEANS, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 13 FARMERS, 1959

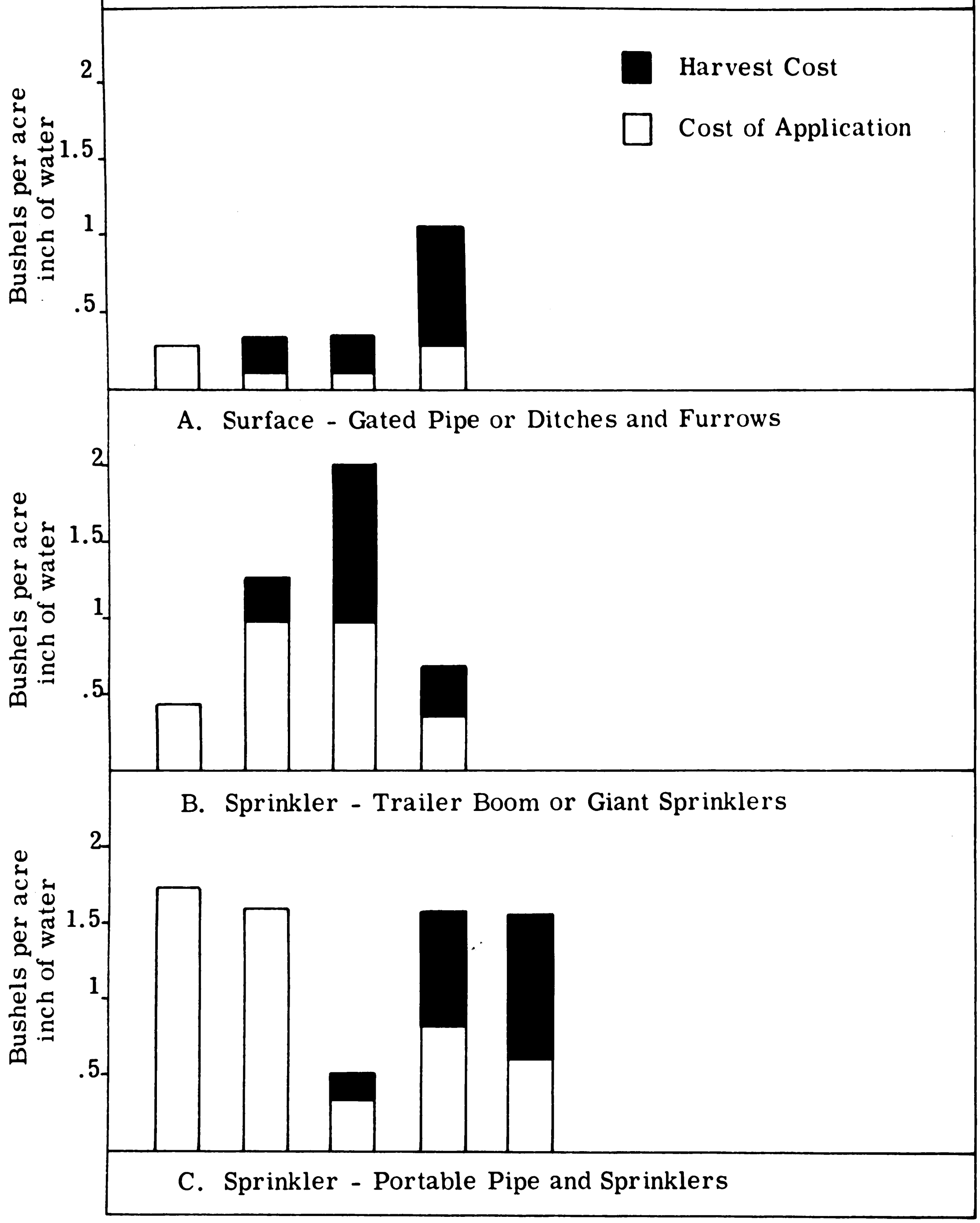
Return Above Variable Costs Dollars Per Acre Inch	Type of Irrigation System: Portable Pipe and Sprinklers	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	Per Cent of Farms
- 0.01 to - 4.99	2	1	1	31
+ 0.01 to + 4.99	1	2	2	38
+ 5.00 to + 9.99	2	1	1	31
Total	5	4	4	100

FIGURE 25
YIELD INCREASE PER ACRE INCH OF WATER TO COVER TOTAL COST OF IRRIGATION, INCLUDING HARVESTING COSTS, SOYBEANS BY TYPE OF IRRIGATION SYSTEM SOUTHEASTERN MISSOURI, 13 FARMS, 1959*



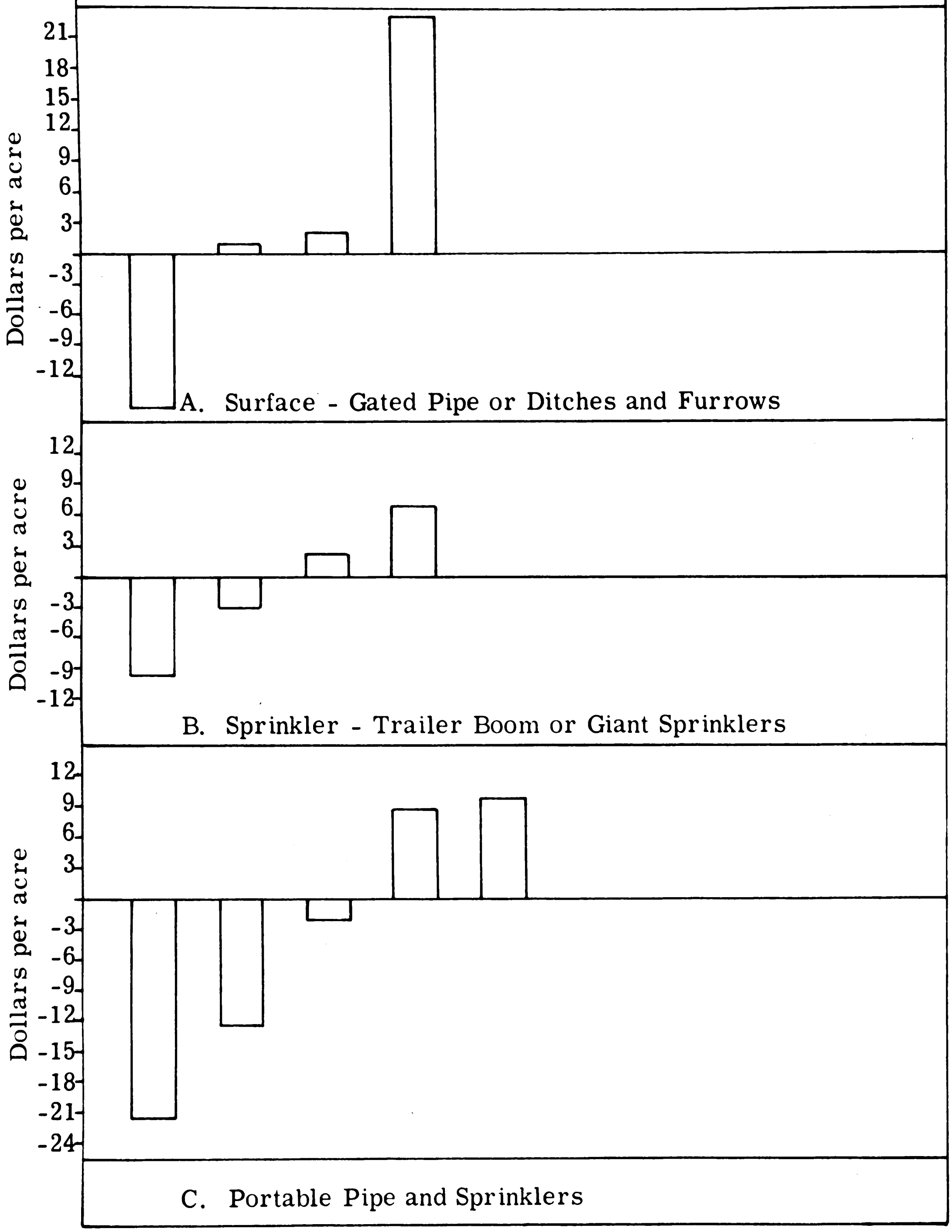
*Each bar represents one farm.

FIGURE 26
YIELD INCREASE PER ACRE INCH OF WATER TO PAY VARIABLE COST OF IRRIGATION, INCLUDING HARVESTING COST, SOYBEANS, BY TYPE OF



*Each bar represents one farm.

FIGURE 27
NET RETURN OR LOSS PER ACRE OF SOYBEANS ABOVE TOTAL COST OF IRRIGATION, BY TYPE OF IRRIGATION SYSTEM, SOUTHEASTERN MISSOURI, 13 FARMS, 1959*



*Each bar represents one farm.

TABLE LIII

NET RETURN OR LOSS ABOVE TOTAL IRRIGATION COSTS PER IRRIGATED ACRE, SOYBEANS, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 13 FARMERS, 1959

Return Above Total Cost	Type of Irrigation System: Portable Pipe and Sprinklers	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	Per Cent of Farms
Dollars Per Acre				
-20.00 to -24.99	1	-	-	8
-15.00 to -19.99	-	-	1	8
-10.00 to -14.99	1	-	-	8
- 5.00 to - 9.99	-	1	-	8
- 0.01 to - 4.99	1	1	-	14
+ 0.01 to + 4.99	-	1	2	23
+ 5.00 to + 9.99	2	1	-	23
+10.00 to +14.99	-	-	-	-
+15.00 to +19.99	-	-	-	-
+20.00 to +24.99	-	-	1	8
Total	5	4	4	100

obtained net returns per acre which ranged from $0.01 to $9.99. The other 8 per cent had net returns, ranging from $20.00 to $24.99 per acre.

Returns above average variable costs per acre for farmers employing Category I, II, and III systems averaged $2.50, $10.08, and $17.99 respectively (Table L). On individual farms, net returns ranged from -$10.00 to $29.04 per acre (Figure 28 and Table A-VII).

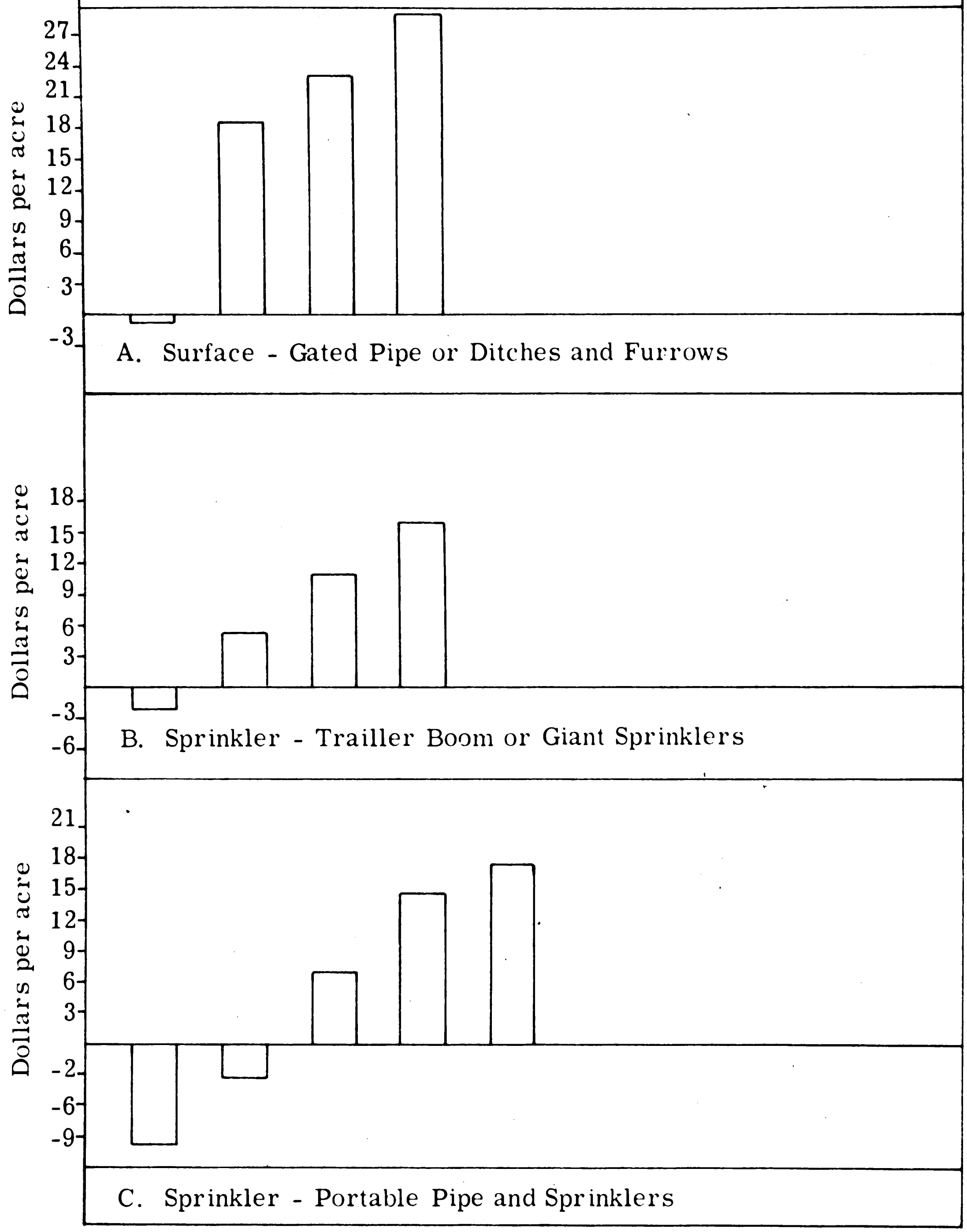
Thirty-two per cent of the soybean irrigators failed to obtain yield increases large enough to pay their variable costs (Table LIV). Thirty per cent met their variable costs and received additional returns per acre ranging from $5.00 to $14.99. An additional 38 per cent obtained returns ranging from $15.00 to $29.00 per acre over variable costs.

Yield increase required to pay all irrigation costs -- The yield increase needed to pay the total costs of irrigation ranged from 4 to 14 bushels (Figure 29 and Table A-VII).

Average variable costs could have been paid, if increases of 1 to 5 bushels had been obtained (Figure 30 and Table A-VII).

Summary of soybean irrigation -- Farmers using Category II and III systems obtained average net returns

FIGURE 28
ADDITIONAL RETURN OR LOSS PER ACRE OF SOYBEANS ABOVE VARIABLE COST OF IRRIGATION, BY TYPE OF IRRIGATION SYSTEM SOUTHEASTERN MISSOURI, 13 FARMS, 1959*



*Each bar represents one farm.

TABLE LIV

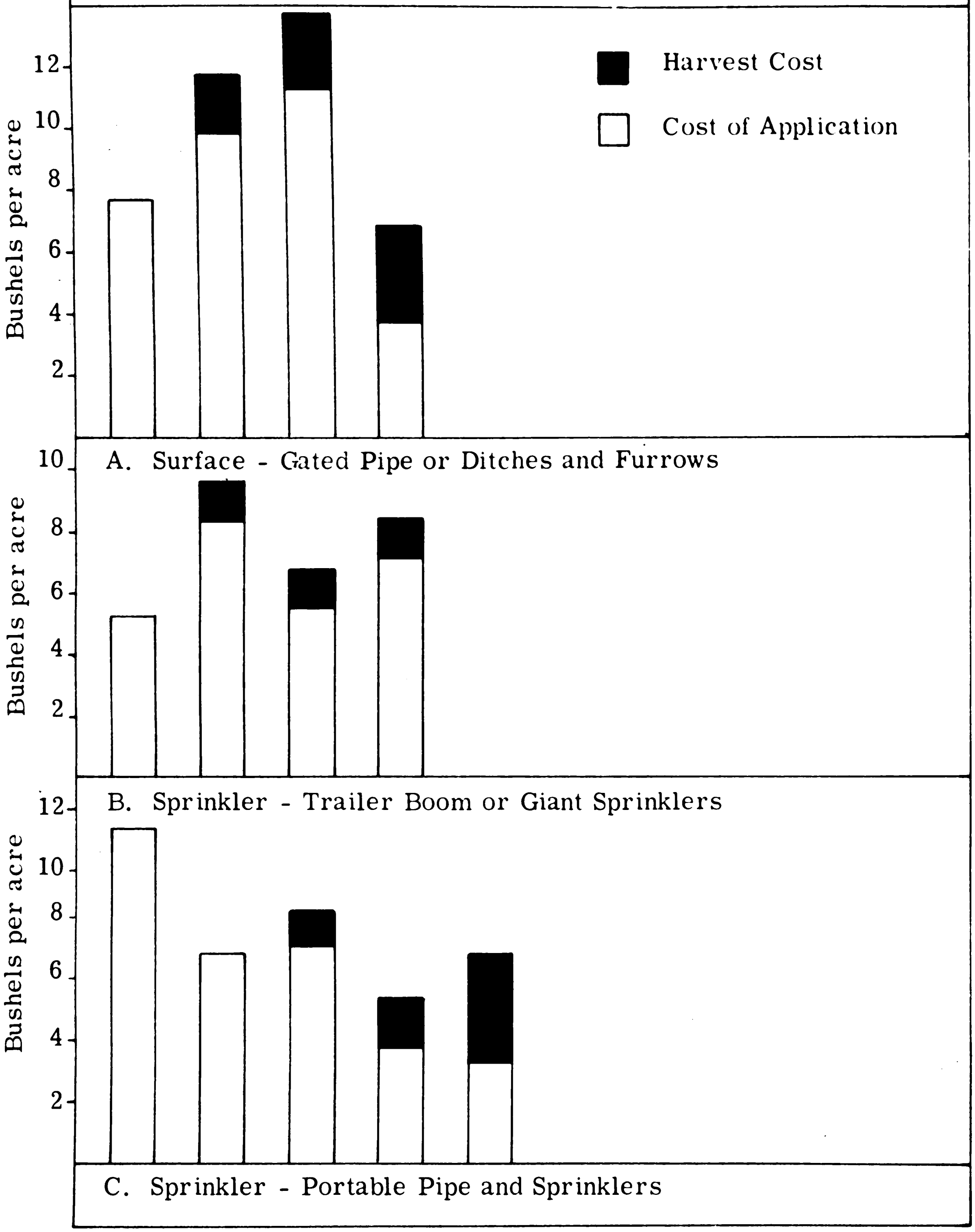
ADDITIONAL RETURN OR LOSS ABOVE AVERAGE VARIABLE COSTS PER IRRIGATED ACRE, SOYBEANS, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 13 FARMERS, 1959

Return Above Variable Costs	Type of Irrigation System: Portable Pipe and Sprinkler	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	Per Cent of Farms
Dollars Per Acre				
-10.00 to -14.99	1	-	-	9
- 5.00 to - 9.99	-	-	-	-
- 0.01 to - 4.99	1	1	1	23
+ 0.01 to + 4.99	-	-	-	-
+ 5.00 to + 9.99	1	1	-	15
+10.00 to +14.99	1	1	-	15
+15.00 to +19.99	1	1	1	23
+20.00 or Over	-	-	2[a]	15
Total	5	4	4	100

[a] +$22.80 and $29.04.

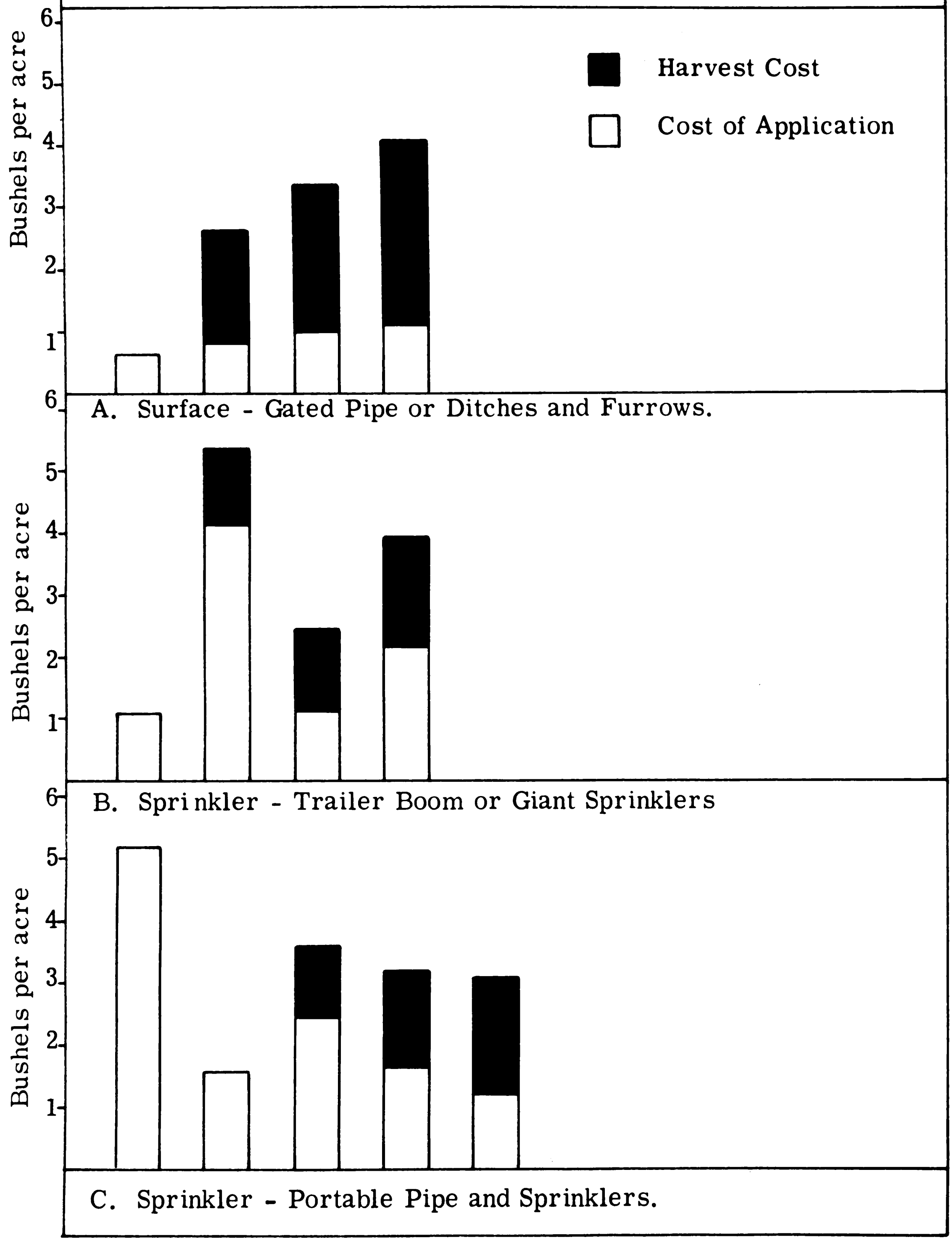
FIGURE 29

PER ACRE YIELD INCREASE REQUIRED TO PAY TOTAL COST OF IRRIGATION, INCLUDING HARVESTING COSTS, SOYBEAN SOUTHEASTERN MISSOURI, 13 FARMS, 1959*



*Each has represents one farm.

FIGURE 30
PER ACRE YIELD INCREASE REQUIRED TO PAY VARIABLE COSTS OF IRRIGATION, SOYBEANS SOUTHEASTERN MISSOURI, 13 FARMS 1959*



*Each bar represents one farm.

per acre of $1.64 and $4.59, but farmers using Category I systems had losses that averaged $6.52 an acre.

Forty-six per cent of the soybean irrigators did not obtain yield increases that were sufficient to pay total irrigation costs. However, the additional returns were equal to or larger than variable costs on 69 per cent of the farms.

Farmers employing Category III systems had higher net returns per acre than those using the other types of systems.

IV. CROP YIELDS IN THE DELTA AREA

The average yield of cotton has been increasing rapidly during the past ten years (Table A-VIII). In 1950, it was 280 pounds of lint per acre. In 1959, the average was 613 pounds. The 10 year average, 1950-1959, was 420. This increase has resulted primarily from use of more fertilizer and superior varieties. Irrigation has had very limited influence for several reasons. One is the small percentage of farmers who have used irrigation. A large proportion of the farmers with irrigation equipment obtained it between 1953 and 1956. Another reason is variability in rainfall. Supplemental water is not needed every year. The rainfall in 1957 was extremely heavy. It appears that irrigation could have been used in

1958, but crop yields in 1959 on farms where irrigation was not used were only slightly lower than on irrigated farms (Table LV).

The estimated yield per acre for corn, cotton, and soybeans on the forty farms where irrigation was practiced in 1959 was 86 bushels, 668 pounds of lint, and 29 bushels respectively (Table LV). The 19 farmers, who had irrigation equipment but did not irrigate, reported estimated yields of 80 bushels of corn, 655 pounds of lint cotton, and 25 bushels soybeans. These men could have irrigated if they had deemed it necessary.

Corn and soybean yields throughout the state have not increased as rapidly as cotton (Table A-VIII). The average yield from 1950-1959 was 44 bushels per acre for corn and 20 bushels for soybeans. Yields of these crops were particularly low from 1953 through 1955, when the weather was abnormally dry during a large part of the growing season.

V. EFFECT OF IRRIGATION ON FARM INCOME-1959

Net Return to Corn, Cotton and Soybean Irrigators

The net return from corn, cotton, and soybean irrigation on 40 farms was computed. The individual farmer was concerned with the influence of irrigation upon net farm income, which encompassed all of his farm enterprises.

TABLE LV

ESTIMATED YIELD PER IRRIGATED ACRE OF CORN, COTTON, AND SOYBEANS, 40 IRRIGATORS AND 19 NON-IRRIGATORS, FOUR SOUTHEASTERN MISSOURI COUNTIES, 1959

	Type of Crop		
	Corn	Cotton	Soybeans
	Bushels	Pounds of Lint	Bushels
Irrigators:			
Average Yield	86	668	29
Range	55-120	500-900	15-34
Number	16	35	13
Non-Irrigators:			
Average Yield	80	655	25
Range	70-90	500-900	17-30
Number	9	15	14

For this reason, net returns from corn, cotton, and soybean irrigation were added together to determine the effect on net farm income.

Forty-three per cent or 17 of the 40 farmers obtained net gains from irrigation, and 57 per cent had net losses (Table LVI). The average net gain per farm was $761 and $316 for farmers using Category II and III systems respectively. Farmers employing Category I systems had an average net loss of $65.00.

Fifteen per cent or 6 of the 40 farmers had net losses ranging from $1,000 to $2,499 per farm (Table LVII and Figure 31). The net loss per farm ranged from $1.00 to $999 on 42 per cent of the farms. Fifteen per cent had net returns ranging from $1.00 to $1,499 per farm. Twenty per cent obtained net gains varying from $1,500 to $1,999, and 8 per cent had net returns greater than $2,000.

Records from forty of the 46 farmers who applied water in 1959 were used in the calculations. The other 6 farmers did not apply water to corn, cotton, or soybeans. Since 40 of the 46 irrigating farmers applied water to corn, cotton, and soybeans, it was estimated that 58 of the 65 from whom records were obtained were potential irrigators of the same crops. The sample proportion, p, of farmers obtaining a net return from irrigation was 17/58 or .29. The sample p was considered the best

TABLE LVI

TOTAL RETURN FROM IRRIGATION PER FARM MINUS TOTAL COST OF IRRIGATION AND TOTAL RETURN FROM IRRIGATION MINUS TOTAL VARIABLE COST OF IRRIGATION PER FARM FOR COTTON, CORN, AND SOYBEAN IRRIGATION, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 40 FARMERS, 1959

Total Return from Irrigation					
Less		Less		Less	
Total Cost	Total Variable Cost	Total Cost	Total Variable Cost	Total Cost	Total Variable Cost
Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Portable Pipe and Sprinklers[a]		Giant Sprinkler & Trailer Booms[b]		Gated Pipe and Ditches & Furrows[c]	
Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
+2,231	+2,855	+4,284	+5,399	+2,350	+3,270
+1,926	+2,569	+1,999	+2,989	+1,958	+2,479
+1,830	+2,032	+1,948	+2,763	+ 659	+1,266
+1,629	+3,857	+1,678	+2,177	+ 579	+ 825
+1,493	+1,826	+1,613	+3,071	- 194	+ 617
+ 571	+1,194	+ 489	+1,095	- 503	- 104
- 147	- 677	-1,263	- 126	- 629	- 81
- 199	- 90	-1,716	- 212	- 671	- 60
- 409	+ 102	-2,185	- 780	- 702	- 287
- 443	- 29				
- 483	- 198				
- 499	- 11				
- 532	- 66				
- 547	- 87				
- 588	- 97				
- 620	- 66				
- 660	- 21				
- 824	- 78				
- 979	- 81				
-1,041	- 109				
-1,538	- 364				
-1,786	- 35				
Mean	Mean	Mean	Mean	Mean	Mean
- 65	629	761	1,820	316	880

[a]Twenty-two farmers.

[b]Nine farmers.

[c]Nine farmers.

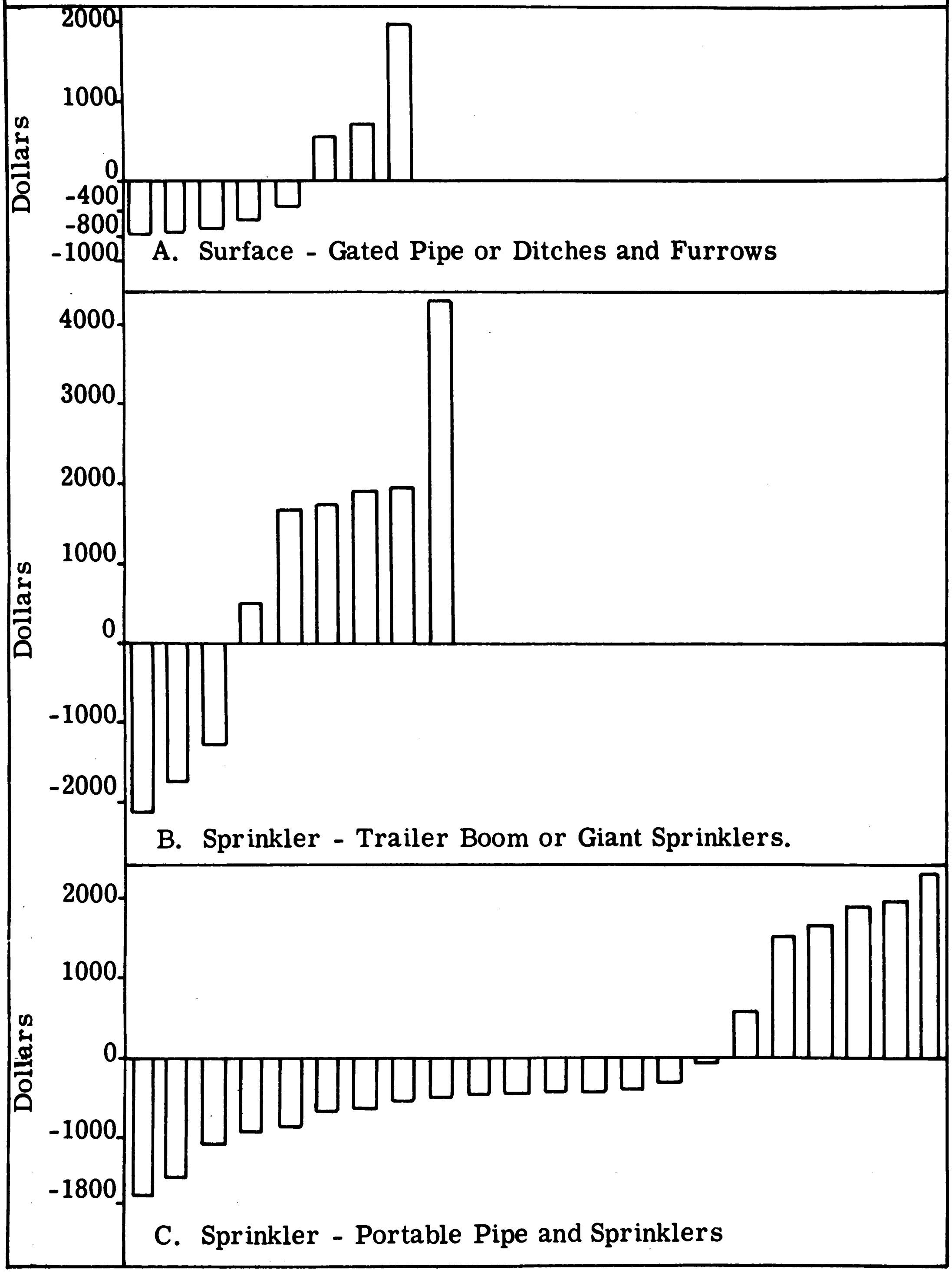
TABLE LVII

NET RETURN PER FARM FROM IRRIGATION FOR COTTON, CORN, AND SOYBEAN IRRIGATORS, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 40 FARMERS, 1959

Net Return Per Farm	Type of Irrigation System: Portable Pipe and Sprinklers	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	Per Cent of Farms
Dollars				
-2,000 to -2,499	-	1	-	3
-1,500 to -1,999	2	1	-	7
-1,000 to -1,499	1	1	-	5
- 500 to - 999	7	-	4	27
- 1.00 to - 499	5	-	1	15
+ 1.00 to + 499	1	1	-	5
+ 500 to + 999	1	-	2	7
+1,000 to +1,499	1	-	-	3
+1,500 to +1,999	3	4	1	20
+2,000 to +2,499	1	-	1	5
+2,500 or Above	-	1[a]	-	3
Total	22	9	9	100

[a]+$4,284.

FIGURE 31
NET RETURN FROM IRRIGATION, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 39 FARMS, 1959*



*Each bar represents one farm.

estimate of the population parameter, or proportion of farmers in the population of farmers with irrigation equipment who received a net return from irrigation in 1959. The 0.95 confidence interval was from .17 to .41, which meant the probability that the universe proportion of irrigators was within the interval was .95.

The relationship between the type of irrigation system employed and whether a net gain or a net loss was obtained in 1959 was studied. The hypothesis of independence was tested. A chi square of 3.3 was calculated, which was not statistically significant. The hypothesis was not rejected. There was no significant difference between the type of irrigation system and the number of irrigators obtaining a gain or a loss.

The difference between the average net gain or loss per farm, according to type of irrigation system used, was studied. Null hypotheses were tested in all cases. The "t" statistic was used. As stated earlier, average net gains or losses were $761, $316, and -$65 for farmers using Category II, III, and I systems respectively. When the difference between the means of Category I and II was tested, a "t" value of 1.34 was obtained. When Category I and III, and Category II and III differences were tested, "t" values of .81 and .52 were computed. None of the "t" values were large enough to be statistically significant. The null hypotheses were not rejected. There was no significant difference between the average net return or loss per farm, according to the type of irrigation system.

<u>Returns Above Variable Cost to Corn, Cotton, and Soybean Irrigators</u>

The average gains per farm above variable irrigation costs were $629, $1,320, and $380 for farmers using Category I, II, and III systems respectively (Table LV).

Forty-eight per cent or 19 of the 40 irrigators obtained returns which were larger than the variable irrigation costs (Table LVIII and Figure 32). Fifty-two per cent did not obtain a return from irrigation which was as large as the variable irrigation costs. These costs for 50 per cent of the irrigators were from $1 to $400. Nineteen per cent obtained returns above variable costs per farm, which ranged from $1.00 to $1,499. An additional 20 per cent received returns ranging from $1,500 to $2,999 above variable costs, and seven per cent obtained returns greater than $3,000 per farm.

The sample proportion of irrigators obtaining returns larger than variable costs was 19/58 or .33. The sample p was the best available estimate of the number of

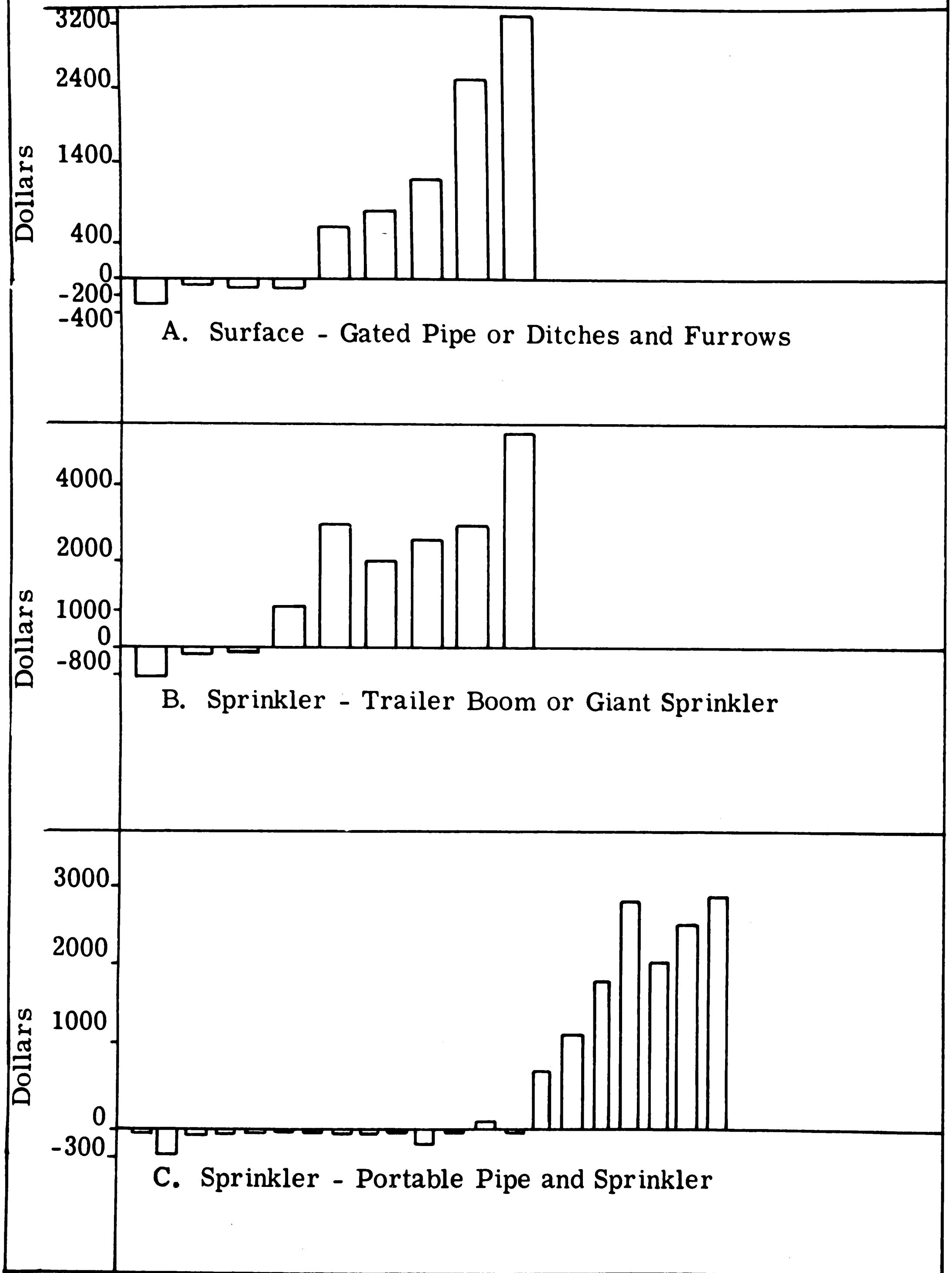
TABLE LVIII

RETURN ABOVE VARIABLE COSTS PER FARM FOR COTTON, CORN, AND SOYBEAN IRRIGATORS, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 40 FARMERS, 1959

Return Above Variable Costs Dollars	Type of Irrigation System: Portable Pipe and Sprinklers	Giant Sprinklers and Trailer Booms	Gated Pipe and Ditches and Furrows	Per Cent of Farms
- 500 to - 999	-	1	-	2
- 1.00 to - 499	14	2	4	50
+ 1.00 to + 499	1	-	-	3
+ 500 to + 999	1	-	2	8
+1,000 to +1,499	1	1	1	8
+1,500 to +1,999	1	-	-	2
+2,000 to +2,499	1	1	1	8
+2,500 to +2,999	3	2	-	12
+3,000 to +3,499	-	1	1	5
+3,500 and Above	-	1[a]	-	2
Total	22	9	9	100

[a]+$5,399.

FIGURE 32
ADDITIONAL RETURN OR LOSS ABOVE TOTAL VARIABLE COST PER FARM BY COTTON, CORN, AND SOYBEAN IRRIGATORS, FOUR SOUTHEASTERN MISSOURI COUNTIES, 40 FARMERS, 1959*



*Each bar represents one farm.

farmers in the irrigation population who received a return above variable costs. The 0.95 confidence interval was from .20 to .45. The probability that the universe proportion of irrigators receiving a return above variable costs would be within this interval was .95.

The relationship between the type of irrigation system employed and whether or not a return above variable costs was obtained, was studied. The hypothesis of independence was tested. A chi square of 2.66 was computed, which was not statistically significant. There was no significant difference between the type of irrigation system and the number of irrigators who obtained a return above or below variable costs.

The difference between the average return or loss per farm above or below variable costs, according to the type of irrigation system employed, was studied. Null hypotheses were tested in all cases. When the difference between the means of Category I and II, Category I and III, and Category II and III were tested, "t" values of 1.96, .50 and 1.12 obtained. None of the "t" values were statistically significant. The null hypotheses were not rejected.

Annual Fixed Cost of 19 Non-Irrigators

Nineteen of the 65 farmers from whom data were obtained did not irrigate in 1959. The average annual fixed cost attributable to the investment in irrigation equipment was $490. The amount ranged from $178 to $1,103 per farm (Table LIX and Figure 33). The annual fixed cost should be considered a net loss from irrigation. This loss reduced net farm income an average of $490 on the 19 farms.

Summary of the Effect of Irrigation on Net Farm Income

Net income per farm was increased $761 and $316 for farmers using Category II and III systems respectively, but farmers employing Category I systems reduced their net farm income by $65.

Twenty-nine per cent of the farmers who provided information for the study obtained a net return from irrigation. It was estimated that the universe proportion of irrigators obtaining a net return was between .17 and .41. The conclusion was reached that irrigation was not profitable for the majority of the farmers who had equipment in 1959.

The probability was .95 that the universe proportion of irrigators who obtained a return above variable costs was between .20 and .45. Consequently, it was concluded that less than 50 per cent of them obtained a return equal to the variable irrigation costs.

The monetary returns from irrigation in 1959 were below expectations of the majority of irrigating farmers

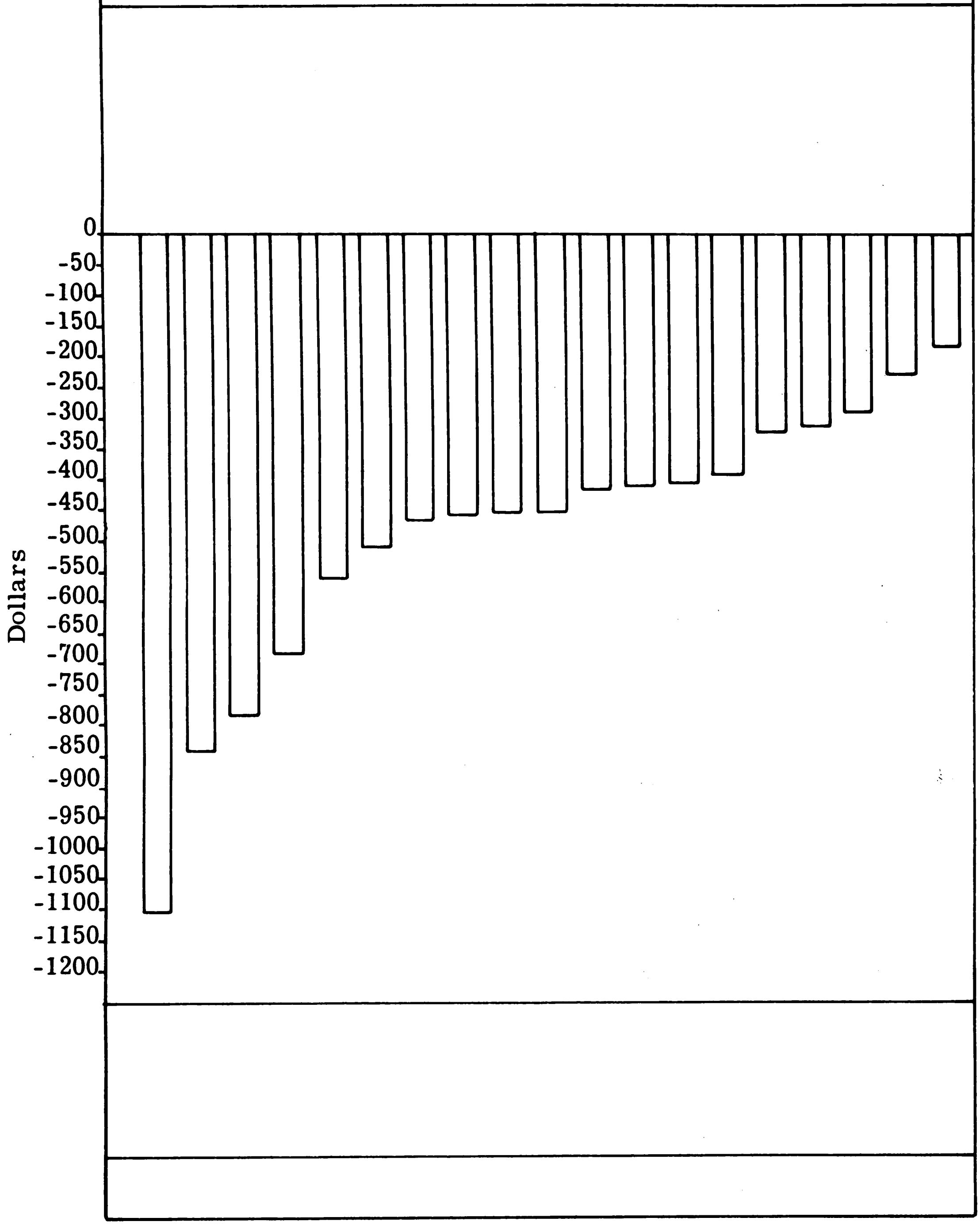
TABLE LIX

ANNUAL FIXED COST ATTRIBUTABLE TO INVESTMENT IN IRRIGATION EQUIPMENT BY 19 FARMERS WHO DID NOT IRRIGATE, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 1959

	Type of Irrigation System		
	Portable Pipe and Sprinkler	Giant Sprinkler and Trailer Boom	Gated Pipe and Ditches and Furrows
	Dollars	Dollars	Dollars
	1,103	687	411
	847		314
	779		227
	561		178
	517		
	472		
	460		
	456		
	453		
	415		
	413		
	394		
	324		
	295		
Total	$7,489	$687	$1,130
Average	535	687	283
Range	$295-$1,103		$178-$411

Overall Mean - $490
Overall Range - $178-$1,103

FIGURE 33
ANNUAL FIXED COST ATTRIBUTABLE TO INVESTMENT IN IRRIGATION EQUIPMENT BY 19 FARMERS WHO DID NOT IRRIGATE, FOUR SOUTHEASTERN MISSOURI COUNTIES, 1959*



*Each bar represents one farm.

who had equipment for this practice. Otherwise, the irrigation system would not have been employed and variable irrigating costs incurred.

Summary of Statistical Tests

Test of independence --

Factors tested	Computed Chi Square	Critical Chi Square .05 Level	Significant	Not Significant
Type of irrigation system and				
(1) Net return or loss per farm	3.32	5.99		X
(2) Return above variable cost per farm	2.66	5.99		X

Test of difference between mean when the standard deviations are unknown, but assumed equal.

Factors tested	Computed "t" Value	Critical "t" Value .05 Level	Significant	Not Significant
Type of irrigation system and				
(1) Average labor cost per acre application				
Category I and II	1.42	2.042		X
Category I and III	2.60	2.042	.02	
Category II and III	1.23	2.120		X

Factors tested	Computed "t" Value	Critical "t" Value .05 Level	Significant	Not Significant
(2) Average tractor cost per acre application				
Category I and II	1.28	2.042		X
Category I and III	4.40	2.042	.001	
Category II and III	2.13	2.120	.05	
(3) Average fuel and oil cost per acre application				
Category I and II	.16	2.045		X
Category I and III	2.29	2.045		X
Category II and III	2.78	2.120	.02	
(4) Minor repair cost per acre application				
Category I and II	.64	2.045		X
Category I and III	.06	2.045		X
Category II and III	.78	2.120		X
(5) Net return or loss per farm				
Category I and II	1.34	2.045		X

Factors tested	Computed "t" Value	Critical "t" Value .05 Level	Signif- icant	Not Signif- icant
Category I and III	.81	2.045		X
Category II and III	.52	2.120		X
(6) Return above variable cost per farm				
Category I and II	1.96	2.045		X
Category I and III	.50	2.045		X
Category II and III	1.12	2.120		X

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The data for the analysis were obtained from farmers who owned or controlled irrigation equipment in Dunklin, Pemiscot, New Madrid, and Mississippi Counties. A random sample of 65 operators was selected from a population of 186 farmers, who were known to have irrigating equipment.

Wells were the major source of irrigation water. Seventy-seven per cent of the farmers from whom data were obtained used wells exclusively, 18 per cent used a combination of wells and drainage ditches, and five per cent used drainage ditches exclusively.

Sprinkler systems were the major method of distributing water. Three different types were used. Fifty-four per cent used the portable pipe and sprinkler system exclusively. Eleven per cent used the giant sprinkler system and nine per cent used the trailer boom method.

Two methods of surface irrigation were used in the area. Fifteen of the 17 per cent used gated pipe and two per cent used ditches and furrows.

Twenty-six per cent of the farmers from whom data were obtained had changed their method of distributing water since the original investment in irrigation equipment was made. Only one had changed from using gated pipe, the others changed from portable pipe and sprinkler systems to other sprinkler or surface methods. The primary reason for the change was the labor requirement for portable pipe and sprinkler systems. Eighty-eight per cent of the farmers made the change to reduce the labor requirement or to be able to hire personnel to work with irrigation equipment.

The fixed investment in irrigation equipment averaged $7,122 per farm or $56 per capacity acre for the 65 farmers.

Farmers with trailer boom systems had an average investment of $13,200 with an average capacity of 290 acres per farm. The investment per capacity acre was practically constant, ranging from $45 to $56, with a mean of $46.

Farmers with giant sprinkler systems had average investments of $8,344 per farm. The average capacity was 144 acres. The average investment per capacity acre decreased from $74 in the 60-99 acre group to $50 in the 200-259 acre group.

Farmers with portable pipe and sprinkler systems had an average of $6,810 invested, and average capacity of 118 acres. The average investment per capacity acre decreased from $360 for the 19 acres or less group to $52 for the 140-179 acre group.

Farmers with gated pipe and ditch and furrow systems had average investments of $5,518 and $4,100 respectively. The average capacity was 87 acres on the 11 farms with gated pipe systems. The average investment per capacity acre was $63 and $62 for the 60-99 and 140-179 acre groups, which was approximately twice as large as the ditch and furrow systems, when the same number of acres could be irrigated.

The average investment per capacity acre declined as the capacity increased for the portable pipe and sprinkler and the giant sprinkler systems, but remained approximately constant within the surface and trailer boom systems.

Forty-six or 71 per cent of the 65 farmers applied water to 2,637 acres. The average number of acres per farm was 57. Cotton was the major irrigated crop. An average of 2.9 inches of water was applied to 1,523 acres. Cotton accounted for 58 per cent of the total irrigated acres. The average yield response was 66 pounds of lint per acre, even though 57 per cent of the cotton irrigators did not obtain a yield increase.

Six hundred and fifty-nine acres of corn received an average of 5.25 inches of water per acre in 1959. An average of 41 acres per farm was irrigated with an average yield increase of 30 bushels. Sixty-three per cent of the corn irrigators obtained a yield increase.

Thirteen farmers applied an average of 4.4 inches of water per acre to 316 acres of soybeans. The average acreage per farm was 24. Sixty-nine per cent of these irrigators reported average yield increases of 8.5 bushels per acre.

Fixed costs averaged 80 per cent of total irrigation costs for the surface and the portable pipe and sprinkler systems, and 65 per cent for the trailer boom-giant sprinkler systems. The averages varied from 59-91, from 48-91, and from 38-98 per cent for the surface, trailer boom-giant sprinkler, and portable pipe and sprinkler systems, respectively, depending upon the amount of use.

Variable costs averaged 20 per cent of total irrigation costs for surface and portable pipe and sprinkler systems, and 35 per cent for the trailer boom-giant sprinkler types.

There was a significant difference in the average labor, tractor, fuel and oil costs per acre of application among the different types of systems. The average labor cost was significantly higher for the portable pipe and sprinkler systems than for the surface systems. The average tractor, fuel and oil costs were significantly higher for the trailer boom-giant sprinkler and portable pipe and sprinkler systems than for the surface systems.

The average cost per irrigated acre of cotton was $20.31, $15,96, and $11.61 for portable pipe and sprinkler, trailer boom-giant sprinkler, and surface systems respectively. Net returns per irrigated acre were -$4.66, $4.12, and $2.57, and returns above variable costs $12.64, $15.33 and $11.80 for portable pipe and sprinkler, trailer boom-giant sprinkler, and surface systems respectively.

The average costs per irrigated acre of corn were $16.01, $13.20, and $8.38 for portable pipe and sprinkler, trailer boom-giant sprinkler, and surface systems respectively. Net returns were $10.34, $14.00, and $13.72, and returns above variable costs $23.31, $21.33, and $19.51 for the portable pipe and sprinkler, trailer boom-giant sprinkler and surface systems respectively.

Average costs per irrigated acre of soybeans was $13.12, $13.21, and $15.21 for portable pipe and sprinkler, trailer boom-giant sprinkler, and surface systems respectively. Net returns were -$6.52, $1.64, and $4.59, and returns above variable costs $2.50, $10.08, and $17.99 for portable pipe and sprinkler, trailer boom-giant sprinkler, and surface systems respectively.

Twenty-nine per cent of the farmers increased their net farm incomes by irrigating cotton, corn, and soybeans. Irrigation was not profitable for the majority of farmers

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controlling irrigation equipment in 1959. Thirty-three per cent of the farmers obtained a return which was greater than variable irrigation costs. Consequently, less than 50 per cent of those who had irrigation equipment obtained increased returns which were large enough to pay variable irrigation costs.

Nineteen or 29 per cent of the 65 farmers did not apply water in 1959. The average fixed cost attributable to investment in irrigation equipment was $490. As a result, net farm income was reduced this amount on these farms.

Conclusions

Net farm income was not increased on the majority of farms where corn, cotton, and soybeans were irrigated in 1959. There was no significant relationship between the number of farmers obtaining a net return from irrigation and the method of distributing water. There was a significant difference between the adjusted gross return per acre of corn and soybeans. Irrigated corn had a higher return than soybeans.

The average cost of irrigation and the yield response required to pay irrigation costs are influenced by many factors. Probably the most important in humid areas like the Delta of Missouri is the amount and distribution of rainfall. Other factors include the number of acres irrigated, number of irrigations during the year, amount of water applied, price of the product, the price of the variable inputs and the managerial skill of the farm operator.

There was a significant difference in the average labor, tractor, fuel and oil costs per acre application among the different methods of distributing water.

A large yield response from irrigation was not needed to pay variable costs of applying water to corn, cotton, and soybeans.

Farmers in the Delta Area of Missouri have been shifting from the portable pipe and sprinkler method of applying water to other sprinkler and surface methods. The high labor requirement associated with portable pipe and sprinkler systems have been the major reason for changing to other types.

The data contained in this study cover only the crop year of 1959. The yield responses reflect returns to a random sample of irrigators under general farm conditions for a single year. Weather conditions were favorable for crop production. The year was near normal in rainfall, and distribution throughout the growing season was better than usual. In fact, the average cotton yield without irrigation was the highest ever obtained in the area.

These facts should be considered when evaluating the results.

Careful attention must be given to varieties and stands of crops, levels of fertility, weed control, and other managerial practices, if profits are to be made. If careful attention is given to these details, irrigation can be profitable in many years.

The results of this study point to the need for additional research. Studies of the type reported here should be repeated over a period of years to increase the reliability of the findings. The intensity and frequency of drought should be determined to establish the frequency of need for supplemental water. This work would require an analysis of long-time weather records in the area. A detailed analysis of the managerial practices on farms where irrigation has been profitable over a period of years should be made to identify the procedures that need to be followed to make irrigation profitable.

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APPENDIX

TABLE A-I

MISSOURI LAND CLASSES

Land class is the grouping of soils according to their inherent fertility, physical properties, slope, erosion, and desirability for agricultural uses. Seven classes have been determined. They are:

Class 1 - Superior Crop Land. This is permanent high-quality land. All conditions of soil and topography are highly favorable for crop production. All of the following qualities are present: high productivity and optimum conditions for crops from the standpoint of drainage, safety from erosion and flooding, ease of tillage, and slopes of less than five per cent. It produced dependable crop yields and is adapted to a wide variety of crops.

Class 2 - Good Crop Land. This is good farm land, but less desirable in one or more respects than Class 1. It may have a wider range of soil and topographic conditions or other factors. Crop adaptation is not as wide as with Class 1. Under good management, a high state of productivity can be maintained. Rolling areas have slopes of less than ten per cent.

Class 3 - Medium Crop Land. Land in this class requires good management for best results. It is either of medium productivity or subject to erosion, poor drainage or overflow. The limits from soil properties, topography, and other factors affecting its use are wider than with Class 2. Erosion control and soil improvement practices are necessary for maximum yields and soil maintenance. Rolling areas do not have slopes of more than 15 per cent.

Class 4 - Inferior Crop Land. This is the lowest class of land suitable for cultivation. It includes land of many limitations due either to soil properties, erosion, overflow or other factors. Low fertility or poor physical properties of the soil results in low productivity and hazardous farming. As a result, low yields are the rule and only the exceptional farmer can get fair yields under favorable weather conditions. Slopes of the folling areas may go as high as 16-17 per cent. In the bottom land the hazards of heavy texture, poor drainage, or frequent and prolonged overflow often exist.

Class 5 - Pasture Land. This is or should be permanent grass land. It is unsuited to cultivation because of one or more of the following conditions: steepness of slope, severe erosion, poor drainage, stone content, low productivity or very high percentage of non-arable land. The classification as grass land is based largely on topography. Since Class 5 contains that land which is too steep for cultivation, its fertility is often equal to Class 4 and even Class 3.

Class 6 - Marginal Pasture-Forest Land. This land is similar to Class 5, but with more unfavorable soil properties and hence lower productivity. The soils are usually shallow, light in color, of poor structure, often with a high gravel and stone content, and the vegetation on it is highly susceptible to changes in moisture conditions. Vegetation cover is hard to maintain on this class of land.

Class 7 - Forest Land. Land with characteristics which make it unsuitable for crops and pasture production and hence its highest usage is classed as forest land. It includes both cleared and uncleared areas which are better suited to tree growth than to pasture. Low fertility and high stone content are the main factors which separate it from Class 5 and Class 6.

Source: Key to Identifying Soils of Missouri, University of Missouri Agricultural Experiment Station Progress Report 12, October 1950, pp. 4-5.

TABLE A-II

ADDITIONAL RETURN OR LOSS, BREAKEVEN POINT IN PHYSICAL UNITS REQUIRED TO PAY AVERAGE TOTAL COST AND AVERAGE VARIABLE COST PER ACRE INCH OF WATER APPLIED TO CORN, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 1959

Number of Farmers	Extra Return or Loss Per Acre Inch Above: Total Costs	Extra Return or Loss Per Acre Inch Above: Variable Costs	Breakeven Point: Average Cost: Including Harvest Cost	Breakeven Point: Average Cost: Excluding Harvest Cost	Breakeven Point: Average Variable Cost: Including Harvest Cost	Breakeven Point: Average Variable Cost: Excluding Harvest Cost
			Portable Pipe and Sprinkler			
	(Dollars)		(Bushels)	(Bushels	(Bushels)	(Bushels)
8	+13.91	+18.13	8.6	5.2	4.4	1.0
	+10.38	+12.53	5.6	3.2	3.5	1.1
	+ 6.69	+ 8.89	4.3	2.7	2.1	.5
	+ 2.94	+ 9.08	9.1	7.3	2.9	1.1
	− .55	+ 4.37	6.8	5.9	2.2	1.3
	− 6.06	− 1.73	−[a]	6.1	−[a]	1.7
	−17.75	− 2.20	−[a]	17.8	−[a]	2.2
	−18.47	− .54	−[a]	18.5	−[a]	.5
			Giant Sprinkler and Trailer Booms			
5	+ 3.49	+ 4.77	3.5	2.1	1.8	.8
	+ 3.17	+ 3.92	2.6	1.8	1.9	1.0
	+ .93	+ 2.54	3.2	2.6	1.6	1.0
	− 4.69	− .68	−[a]	4.7	−[a]	.7
	− 4.26	− 1.76	−[a]	4.3	−[a]	1.8
			Gated Pipe and Ditches and Furrows			
3	+ 3.55	+ 4.50	2.3	1.4	1.3	.4
	+ .64	+ 3.14	4.4	3.6	1.9	1.1
	− 1.68	− .48	−[a]	1.7	−[a]	.5

[a]Farmers did not receive a yield response, therefore, there was no harvest cost attributed to irrigation.

TABLE A-III

ADDITIONAL RETURN OR LOSS, BREAKEVEN POINT IN PHYSICAL UNITS REQUIRED TO PAY AVERAGE TOTAL COST AND AVERAGE VARIABLE COST PER IRRIGATED ACRE OF CORN, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 1959

Number of Farmers	Extra Return or Loss Per Acre Above: Total Costs	Extra Return or Loss Per Acre Above: Variable Costs	Breakeven Point: Average Cost: Including Harvest Cost	Breakeven Point: Average Cost: Excluding Harvest Cost	Breakeven Point: Average Variable Cost: Including Harvest Cost	Breakeven Point: Average Variable Cost: Excluding Harvest Cost
	Portable Pipe and Sprinkler					
	(Dollars)		(Bushels)	(Bushels)	(Bushels)	(Bushels)
8	+27.82	+36.25	17.2	10.4	8.8	2.0
	+25.94	+31.32	14.0	8.0	8.7	2.7
	+13.37	+17.78	8.6	5.3	4.2	.9
	+ 7.35	+22.70	22.7	18.1	7.3	2.8
	- 4.37	+32.30	54.4	46.9	17.7	10.2
	-24.22	- 6.92	-[a]	24.2	-[a]	6.9
	-35.50	- 4.40	-[a]	35.5	-[a]	4.4
	-55.41	- 1.63	-[a]	55.4	-[a]	1.6
	Giant Sprinkler and Trailer Booms					
5	+21.24	+29.06	18.8	12.7	10.9	4.9
	+20.18	+24.99	16.8	11.3	12.0	6.5
	+ 6.28	+17.16	21.7	17.5	10.8	6.6
	-14.07	- 2.04	-[a]	14.1	-[a]	2.0
	-20.48	- 8.47	-[a]	20.5	-[a]	8.5
	Gated Pipe and Ditches and Furrows					
	+24.47	30.99	15.5	9.5	9.0	3.0
	+ 2.56	12.57	17.4	14.4	7.4	4.4
	- 5.04	- 1.43	-[a]	5.0	-[a]	1.4

[a]Farmer did not receive a yield response, therefore, there was no harvest cost attributed to irrigation.

TABLE A-IV

ADDITIONAL RETURN OR LOSS, BREAKEVEN POINT IN PHYSICAL UNITS REQUIRED TO PAY AVERAGE TOTAL COST AND AVERAGE VARIABLE COST PER ACRE INCH OF WATER APPLIED TO COTTON, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 1959

Number of Farmers	Extra Return or Loss Per Acre Inch		Breakeven Point			
			Average Cost		Average Variable Cost	
	Total Costs	Variable Costs	Including Harvest Cost	Excluding Harvest Cost	Including Harvest Cost	Excluding Harvest Cost
	(Dollars)					
			Portable Pipe and Sprinkler			
				Pounds of Lint Cotton		
19	+25.61	+27.82	30.7	12.1	23.9	5.3
	+ 9.76	+11.20	7.2	5.4	3.1	1.2
	+14.83	+25.82	53.3	36.5	19.1	2.3
	+13.63	+19.39	36.5	23.1	17.0	3.7
	+19.03	+24.40	37.4	21.1	20.9	4.5
	- 5.13	+ 6.32	44.7	39.8	9.4	4.5
	- 3.21	- 1.02	- a	10.0	- a	3.3
	- 3.48	- 1.22	- a	10.8	- a	3.8
	- 8.95	- 2.13	- a	27.7	- a	6.6
	- 2.18	- .78	- a	6.8	- a	2.4
	-17.35	- 1.82	- a	53.9	- a	5.7
	-11.26	- 1.20	- a	35.0	- a	3.7
	-14.85	- 1.42	- a	46.5	- a	4.4
	- 9.12	- 1.45	- a	28.3	- a	4.5
	-28.79	- 2.38	- a	89.4	- a	7.4
	-18.57	+ 4.58	79.8	76.0	7.8	4.1
	-41.57	- .92	- a	129.1	- a	2.9
	-65.90	- 2.10	- a	204.7	- a	6.5
	-99.22	- 1.94	- a	308.1	- a	6.0

TABLE A-IV (Continued)

Number of Farmers	Extra Return or Loss Per Acre Inch Above: Total Costs	Extra Return or Loss Per Acre Inch Above: Variable Costs	Breakeven Point — Average Cost: Including Harvest Cost	Breakeven Point — Average Cost: Excluding Harvest Cost	Breakeven Point — Average Variable Cost: Including Harvest Cost	Breakeven Point — Average Variable Cost: Excluding Harvest Cost
	(Dollars)					
	Giant Sprinkler and Trailer Booms					
8	+24.31	+27.54	30.4	12.1	20.7	2.5
	+ 7.44	+ 9.00	17.0	10.2	12.1	5.4
	+ 5.31	+ 6.96	16.6	11.0	11.5	5.9
	+ 7.42	+12.39	27.4	18.9	11.9	3.4
	+ 5.27	+ 7.00	13.4	8.4	8.0	3.0
	- 9.09	- 1.07	- a	23.2	- a	3.3
	- 4.09	- 1.43	- a	12.7	- a	4.4
	-14.68	- 1.47	- a	45.6	- a	4.6
	Gated Pipe and Ditches and Furrows					
8	+23.25	+32.17	51.9	30.9	24.2	3.2
	+ 7.12	+ 9.92	19.1	12.1	10.4	3.5
	- 4.27	- .70	- a	13.1	- a	2.1
	- 1.11	- .51	- a	3.4	- a	1.6
	- 4.48	- .40	- a	13.9	- a	1.2
	- 5.78	- .77	- a	18.0	- a	2.4
	- 4.04	+ 2.64	23.3	21.4	2.6	.8
	- 3.66	- .60	- a	11.3	- a	1.9

[a]Farmer did not receive a yield response, therefore, no harvest cost was attributed to irrigation.

TABLE A-V

ADDITIONAL RETURN OR LOSS, BREAKEVEN POINT IN PHYSICAL UNITS REQUIRED TO PAY AVERAGE TOTAL COST AND AVERAGE VARIABLE COST PER IRRIGATED ACRE OF COTTON, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 1959

Number of Farmers	Extra Return or Loss Per Acre Above Total Cost	Extra Return or Loss Per Acre Above Variable Cost	Breakeven Point: Average Cost Including Harvest Cost	Breakeven Point: Average Cost Excluding Harvest Cost	Breakeven Point: Average Variable Cost Including Harvest Cost	Breakeven Point: Average Variable Cost Excluding Harvest Cost
	(Dollars)					
			Portable Pipe and Sprinkler			
			Pounds of Lint Cotton			
	+57.22	+55.63	61.5	24.3	47.8	10.6
	55.63	+63.73	92.0	47.3	66.8	22.1
	+49.38	+86.05	177.7	121.6	63.7	7.8
	+33.38	+48.73	89.4	56.8	41.7	9.1
	+27.21	+34.81	53.4	30.1	29.8	6.5
	- 7.69	+ 9.61	68.0	60.6	14.3	6.8
	- 8.02	- 2.66	- a	24.9	- a	8.3
	-12.96	- 4.56	- a	40.3	- a	14.2
	-13.42	- 3.21	- a	41.7	- a	10.0
	-13.91	- 4.97	- a	43.2	- a	15.4
	-17.35	- 1.82	- a	53.9	- a	5.7
	-19.37	- 2.06	- a	60.2	- a	6.4
	-22.27	- 2.11	- a	69.2	- a	6.5
	-27.35	- 4.35	- a	84.9	- a	13.5
	-28.79	- 2.38	- a	89.4	- a	7.4
	-37.15	- 9.17	159.5	152.0	15.7	8.2
	-62.40	- 1.37	- a	193.7	- a	4.3
	-65.90	- 2.10	- a	204.7	- a	6.5
	-99.22	- 1.94	- a	308.1	- a	6.0

TABLE A-V (Continued)

Number of Farmers	Extra Return or Loss Per Acre Above Total Cost (Dollars)	Extra Return or Loss Per Acre Above Variable Cost (Dollars)	Breakeven Point: Average Cost, Including Harvest Cost	Breakeven Point: Average Cost, Excluding Harvest Cost	Breakeven Point: Average Variable Cost, Including Harvest Cost	Breakeven Point: Average Variable Cost, Excluding Harvest Cost
			Giant Sprinkler and Trailer Booms			
			Pounds of Lint Cotton			
8	+51.04	+68.84	75.2	24.5	50.9	6.2
	+40.94	+49.53	95.5	56.2	66.8	29.5
	+26.53	+34.78	83.1	55.1	57.5	29.5
	+16.24	+27.13	59.9	41.2	26.1	7.5
	+14.64	+19.45	37.3	23.3	22.3	8.4
	-13.64	- 1.01	- [a]	42.4	- [a]	5.0
	-18.40	- 6.40	- [a]	57.2	- [a]	19.9
	-31.56	- 3.15	- [a]	98.0	- [a]	9.8
			Gated Pipe and Ditches and Furrows			
8	+46.50	+64.34	105.7	61.8	48.3	6.4
	+22.59	+31.41	60.5	38.4	33.0	10.9
	- 6.41	- 1.06	- [a]	19.9	- [a]	3.3
	- 6.68	- 3.07	- [a]	20.7	- [a]	9.5
	-11.19	- 1.00	- [a]	34.7	- [a]	3.1
	-11.56	- 1.55	- [a]	35.9	- [a]	4.8
	-12.12	+ 8.05	71.0	65.4	8.1	2.5
	-16.38	- 2.67	- [a]	50.9	- [a]	8.3

[a]Farmer did not receive a yield response, therefore, no harvest cost was attributed to irrigation.

TABLE A-VI

ADDITIONAL RETURN OR LOSS, BREAKEVEN POINT IN PHYSICAL UNITS REQUIRED TO PAY AVERAGE TOTAL COST AND AVERAGE VARIABLE COST PER ACRE INCH OF WATER APPLIED TO SOYBEANS, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 1959

Number of Farmers	Extra Return or Loss Per Acre Inch Above Total Cost	Extra Return or Loss Per Acre Inch Above Variable Cost	Breakeven Point: Average Cost Including Harvest Cost	Breakeven Point: Average Cost Excluding Harvest Cost	Breakeven Point: Average Variable Cost Including Harvest Cost	Breakeven Point: Average Variable Cost Excluding Harvest Cost
	Portable Pipe and Sprinkler					
	(Dollars)		(Bushels)	(Bushels)	(Bushels)	(Bushels)
5	+ 4.64	+ 8.70	3.6	2.7	1.5	.6
	+ 4.45	+ 6.65	2.7	1.9	1.6	.8
	- .30	+ .97	1.2	1.0	.5	.4
	-13.28	- 3.07	- [a]	6.8	- [a]	1.6
	-- 7.35	- 3.33	- [a]	3.8	- [a]	1.7
	Giant Sprinkler and Trailer Booms					
4	+ 1.17	+ 2.61	1.4	1.1	.7	.4
	+ 1.86	+ 8.91	5.6	4.6	2.0	1.0
	- .73	+ 1.23	2.3	2.0	1.3	1.0
	- 3.96	- .82	- [a]	2.0	- [a]	.4
	Gated Pipe and Ditches and Furrows					
4	+ 5.92	+ 7.26	1.7	1.0	1.0	.3
	+ .26	+ 2.28	1.4	1.1	.3	.1
	+ .05	+ 2.28	1.5	1.2	.3	.1
	- 6.64	- .58	- [a]	3.4	- [a]	.3

[a]Farmer did not receive a yield response, therefore, no harvest cost was attributed to irrigation.

TABLE A-VII

ADDITIONAL RETURN OR LOSS, BREAKEVEN POINT IN PHYSICAL UNITS REQUIRED TO PAY AVERAGE TOTAL COST AND AVERAGE VARIABLE COST PER IRRIGATED ACRE OF SOYBEANS, BY TYPE OF IRRIGATION SYSTEM, FOUR SOUTHEASTERN MISSOURI COUNTIES, 1959

Number of Farmers	Extra Return or Loss Per Acre Above: Total Cost	Variable Cost	Breakeven Point: Average Cost: Including Harvest Cost	Excluding Harvest Cost	Average Variable Cost: Including Harvest Cost	Excluding Harvest Cost
			Portable Pipe and Sprinkler			
	(Dollars)		(Bushels)	(Bushels)	(Bushels)	(Bushels)
5	+ 9.29	+17.40	7.2	5.4	3.1	1.2
	+ 8.89	+13.30	5.4	3.9	3.2	1.6
	- 2.12	+ 6.82	8.1	7.0	3.5	2.4
	-13.28	- 3.07	-[a]	6.8	-[a]	1.6
	-22.06	-10.00	-[a]	11.3	-[a]	5.1
			Giant Sprinkler and Trailer Booms			
4	+ 6.99	+15.64	8.4	6.6	4.0	2.1
	+ 2.27	+10.87	6.8	5.6	2.4	1.2
	- 3.07	+ 5.18	9.6	8.3	5.3	4.1
	- 9.90	- 2.06	-[a]	5.1	-[a]	1.1
			Gated Pipe and Ditches and Furrows			
4	+23.69	+29.04	6.8	3.9	4.1	1.2
	+ 2.55	+22.80	13.7	11.4	3.3	1.0
	+ .41	+18.25	11.8	9.9	2.6	.8
	-15.03	- 1.32	-[a]	7.7	-[a]	.7

[a]Farmer did not receive a yield response, therefore, no harvest cost was attributed to irrigation.

TABLE A-VIII

AVERAGE YIELD PER ACRE FOR SPECIFIED CROPS, MISSOURI, 1950-1959

	Crop		
Year	Corn Bushels	Cotton Pounds of Lint	Soybeans Bushels
1950	44	280	23
1951	34	303	20
1952	41	367	19
1953	33	338	14
1954	20	480	15
1955	39	481	17
1956	48	587	20
1957	44	282	21
1958	60	452	26
1959	55	613	23
Average 1950-1959	44	420	20

Source: Agricultural Statistics 1950-1960, United States Department of Agriculture, United States Government Printing Office, Washington.

VITA

Ted Lee Jones, oldest son of Mr. and Mrs. Julian W. Jones was born [redacted] on a farm northwest of Warrensburg, Missouri. Thirteen years in the early part of his life were spent on tenant farms in Johnson and Saline Counties, Missouri.

In March 1943, the family returned to the home community north of Warrensburg and purchased a 40 acre farm. The father worked for a neighboring farmer, so the farming operations were the responsibility of the son. Ted carried this responsibility and completed his elementary school training in 1943 as the only graduate of the Foster Grade School. In the autumn, he entered Farmers High School, a consolidated rural district in Johnson County.

In March 1944, the family purchased a 120 acre farm in the same community which is still the home of the parents. The father worked in a coal mine during the winter months and farmed the rest of the year. Ted worked on the home farm during the summer months between his first and second years in high school. During the remaining years in high school, he worked for a neighboring farmer when school was not in session.

After graduation from Farmers High School as valedictorian in 1947, Ted entered the College of Agriculture, University of Missouri on a Sears Roebuck

Scholarship. To earn a major share of his college expenses, he worked in a drug store, in a cafe, and as a student laboratory assistant in the Soils Department. In June 1951, he received a Bachelor of Science degree in Agriculture and a reserve commission in the U. S. Army.

On May 1, 1951, Ted was employed by the Missouri Agricultural Extension Service as Assistant County Agent in Livingston County. He entered the U. S. Army in August 1951 as a second lieutenant for a two-year tour of active duty. Sixteen of the 24 months were spent in Germany. He was released July 29, 1953.

In December 1953, Ted and Betty Rose Eckhoff were married. A son, Ted Lee II, was born in February 1961.

Ted was employed as an insurance salesman from August 1953 to May 1954. In June 1954, he returned to the Missouri Agricultural Extension Service as Assistant County Agent in Cass County. He left extension work in June 1956 to return to the University of Missouri for graduate study in Agricultural Economics. From June 1956 until May 1958, he was a Graduate Assistant in Agricultural Economics, and attended the Land Economics Institute at the University of Illinois during the summer of 1958. The Master of Science Degree was received in 1958.

In June 1958, Ted was employed by the Farm Economics Research Division, Agricultural Research Service, United

States Department of Agriculture and was made a research associate at the University of Missouri. He has continued to conduct research for the Farm Economics Research Division until the present time. Publications and manuscripts include Progress in Becoming Established in Farming, Nature and Extent of Irrigation in Missouri, University of Missouri Agricultural Experiment Station Research Bulletin 735, April 1960 and Irrigation Practices and Costs in Southeastern Missouri, 1959.

Ted has maintained his affiliation with the Military Service and at present holds the grade of Captain in the Army Reserve. His present assignment is Assistant Battalion S-3, with the 4th Howitzer Battalion, 84th Artillery at Columbia, Missouri.

IRRIGATION PRACTICES AND COSTS IN SOUTHEASTERN MISSOURI - 1959

Ted Lee Jones

Frank Miller, Dissertation Supervisor

ABSTRACT

Field crop irrigation is a relatively new production technique in Missouri. Prior to this investigation, only limited information was available concerning costs and returns. The research reported here was designed to determine (1) the costs of installing and operating various types of irrigation systems, (2) changes in yields resulting from applying water to specific crops, and (3) the effects of irrigation on farm income.

A random sample of 65 farmers was chosen from a population of 186 farmers who owned or controlled irrigation equipment in Dunklin, Pemiscot, New Madrid, and Mississippi Counties in the Delta Cotton and Corn Area. Each farm operator was interviewed three times in 1959 to obtain the fixed investment in irrigation equipment, the operating costs, the acreage and crop receiving water, and the estimated yield response.

The data obtained showed that the farmers were using five types of irrigating equipment. The fixed investment in all types averaged $7,122 per farm or $56 per capacity

acre. It was highest for trailer boom types with outlays of $13,200 per farm and lowest for ditch and furrow types at $4,100.

The cost per acre of land irrigated varied widely with the type of equipment used and the number of acres to which water was applied. Fixed items made up more than one-half of the average cost per acre for all types. Variable costs averaged 20 per cent of the total for surface, and portable pipe and sprinkler systems, and 35 per cent for the trailer boom-giant sprinkler systems.

There was a significant difference in the average labor, tractor, fuel and oil cost per acre application of water with the different types of systems. The average labor cost was significantly higher for the portable pipe and sprinkler systems than for the surface systems. Average tractor, fuel and oil costs were significantly higher for the trailer boom-giant sprinkler type and for the portable pipe and sprinkler systems than for the surface systems, but considerable leveling was required for use of gravity distribution.

Cotton, corn, and soybeans were the principal crops irrigated in 1959. The average yield response of cotton was 66 pounds of lint per acre, but 57 per cent of the irrigators got no increase. The average yield response of corn was 30 bushels per acre, and 63 per cent of the irrigators had yield increases. Soybean yields were increased an average of 8.5 bushels per acre, and 69 per cent of the farmers reported gains.

Only 29 per cent of the farmers increased their net income by irrigating cotton, corn, and soybeans. Use of supplemental water was not profitable for the majority of the men who had equipment in 1959. However, the data were obtained in a year when weather conditions were favorable for crop production. The average cotton yield without irrigation was the highest ever obtained in the Delta. The fact that more than one-fourth of the farmers increased their net income in one of the most favorable crop years on record, suggests that the practice has merit, but must be applied under conditions of superior management to bring satisfactory returns in relation to costs.

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