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Cost and Efficiency in Producing Sugar Beets in Utah County, Utah, 1951

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COST AND EFFICIENCY IN PRODUCING SUGAR BEETS
IN UTAH COUNTY, UTAH, 1951

by

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INTRODUCTION

History of the sugar beet industry

Man has always included some form of sugar in his diet. Only in the past two centuries has sugar been developed as an individual food. During that time vast amounts of money and time have gone into the development and improvement of sugar. In 1747, a German chemist by the name of Andreas Marggraf proved that sugar beets contained sugar. One of his pupils, Franz Karl Achard, in 1799 gave further evidence of this fact by his experiments. (6)

The first beet-sugar factory started operation in 1803 at Cunern, Silesia. In 1811, when the French were cut off by the English from their West Indies source of sugar, Napoleon gave the beet-sugar industry impetus by decreeing that 70,000 acres of land be planted to sugar beets. By 1812 there were 40 factories in France producing 3,000,000 pounds of beet-sugar. One year after the Battle of Waterloo only two sugar factories remained in operation.

Slowly the manufacturing processes were improved until 5, instead of 2, per cent of sugar could be extracted from the beets. Sugar beets with higher sugar content were developed. These improvements, plus protective tariffs, gradually brought about a restoration of the industry.

Prior to 1855 several attempts were made in the United States to process sugar from beets, but all ended in failure. Nevertheless, many valuable lessons were learned from these failures. In 1879 the first successful sugar factory was established at Alvarado, California. (6) After this first successful venture, sugar factories sprang up in various parts of the United States. As the industry became nationwide, Congress gave it tariff protection which it has always needed in order to compete with sugar produced in the tropical regions. Cost of production in the cane-producing areas is low because of low wage rates, low land values and high production per acre. (2)

A severe blow was given to the domestic beet-sugar industry when Congress reduced the tariffs on Philippine sugars shortly after the Spanish-American War. Another jolt was handed the industry when Philippine sugars were placed on the duty-free list in 1916. However, World War I came along and the allied demand for sugar was so great that increased production in the United States was almost imperative. The beet-sugar industry was revived and well on its way again. Had not World War I intervened many feared that the domestic beet-sugar industry would have been destroyed. (6)

The farm value of sugar beets in the United States reached a peak in 1920. The retail price of sugar at that time was 26.5 cents per pound. At that price the influx of foreign sugar flooded the domestic market and the sugar beet industry in the United States was almost wiped out. This led, in 1934, to the establishment by Congress of sugar quotas for each area supplying the United States -- both domestic and foreign. The Sugar Act of 1948 was a means of protecting the domestic sugar industry. By this act the Secretary of Agriculture regulates the supply in order to maintain prices in line with the general price level in the United States.

Importance of the sugar beet industry

Since 1935 there has been about a 20 per cent increase in the world production of sugar beets. (14) Production in the United States during the same period increased only about 8 per cent. Production in most of the European countries was curtailed during the period of World War II, but has shown a steady increase since that time. The rate of increased production in the United States has not been as great as that in Europe.

While Utah is still one of the 10 leading sugar producing states in the United States, its production has been decreasing since 1920. (12) The contribution of sugar beets to total value of all farm crops has also decreased in importance during that time. In spite of increased yields per acre the total production of sugar beets in Utah has been on the decline since 1920. The harvested acreage in 1951 was the lowest since 1910. (3)

Utah County, located in the central part of the State of Utah, has also decreased in importance as a producer of sugar beets. In 1951 Utah County produced about half as much sugar as it did in 1910. About 6 per cent of the state total was produced in Utah County in 1951.

The first successful beet-sugar factory in Utah was built in Lehi, Utah County, in 1891. That year over one million pounds of white sugar were refined in the new plant. E. H. Dyer came from California to supervise the construction of the factory. He had gained much experience of this type in California. The factory at Lehi was dismantled in 1937. Another sugar beet factory was built by Dyer at Payson, Utah County, in 1913 but was dismantled in 1940. The factory at Spanish Fork, Utah County, built by Dyer in 1916 was abandoned in 1942. A sugar beet factory built at Springville, Utah County, in 1918 by Dyer was dismantled in 1940. (6) All sugar beets grown in Utah County since 1942 have been shipped by railroad to West Jordan in Salt Lake County for processing.

Production of sugar beets in Utah County has not been sufficient since 1942 to warrant the economical operation of a sugar beet factory in that area.

PURPOSE OF STUDY

Lack of sufficient farm labor during the thinning and harvesting seasons is one of the limiting factors in the production of sugar beets in Utah County. The advent of mechanical thinners and harvesters will, no doubt, have some effect upon the costs of operation and the labor requirements in sugar beet production.

Each producer by comparing his costs and labor requirements with the average of a group or with his neighbors is in a better position to improve his management practices and to determine where his costs might be reduced. Profits are secured by reducing costs while maintaining or increasing yields. The producer who is able to prune costs here and there in his operations without reducing production is more likely to end up with a profit than one who trims too much in one operation. A proper balance between costs and returns is paramount.

The primary objectives of this study, then, are: (a) to determine the average physical and monetary requirements of producing sugar beets in Utah County in 1951; (b) to ascertain the extent to which mechanical thinning and harvesting of sugar beets may reduce the cost and labor requirements of sugar beet production in Utah County; and (c) to determine the factors associated with success in sugar beet production in that area.

This study aims to help the sugar beet producers of Utah County improve their management and increase their profits.

SCOPE OF STUDY

The data for this study were secured from an area bordering the eastern shore of Utah Lake located in the central part of the State of Utah. This area extends from Lehi, Utah on the north to Payson, Utah on the south and from the shores of Utah Lake on the west to Highway 89 on the east. The survey did not include sugar beet enterprises from institutional farms, corporate farms, or extremely large farms.

Records were taken from 51 sugar beet producers wherever they could be found and when they had time to furnish information pertaining to their sugar beet enterprise. These 51 producers represented about 20 per cent of all growers in Utah County in 1951 and were all that could be secured by the survey team during the week following Christmas 1951. An attempt was made to secure all the monetary costs and physical in-puts required to produce a crop of sugar beets for the 1951 season.

No records were taken on farms where beets were frozen in the ground or where the sugar beet enterprise was less than three acres. No attempt was made to determine the competitive position of the sugar beet enterprise with other enterprises on the farm.

REVIEW OF LITERATURE

Studies have been made by various agricultural experiment stations to show the labor requirements and costs of the various operations connected with the production of sugar beets. Studies made in Colorado over a period of years indicate a great reduction in man hours of labor required to produce an acre of sugar beets. According to Sitler and Burdick (10) a total of 120.0 man hours were required to produce an acre of sugar beets in Colorado in 1915. In 1922 the number of man hours was reduced to 116.0; in 1930, to 100.3; in 1936 to 93 man hours, and for the 1947-48 crop years it took a total of 82.2 man hours when harvested by hand and 60.2 when harvested mechanically. With the aid of machinery, this showed a 50 per cent reduction in labor requirements during the 37-year period.

The most important study pertaining to the cost of sugar beet production in Utah County, Utah was made in 1945 by Morrison. (8) In this study an average of 114.0 man hours of labor were required to produce an acre of sugar beets. It required 20.5 man hours of labor to prepare the seed bed and plant the crop with about half this time being spent manuring the land. The growing process, from planting to harvest time, required 50.7 hours of man labor. The major portion of this time was spent in the thinning and hoeing operations. Blocking and thinning required 22.6 man hours. The harvesting process required 42.8 man hours of labor; 32.2 man hours of this time were spent topping and loading the beets.

A Michigan study (15) made in 1933-36 showed that approximately 85 hours of man labor were spent per acre on non-irrigated land producing an average of 10 tons of sugar beets per acre. An average of 26 hours of horse labor and 2.5 hours of tractor time per acre were also used.

At the Michigan Agricultural Experiment Station a study (4) was made in 1946 to compare the labor requirements on sugar beet production with those of a similar study made in 1933-36. The 1933-36 study showed 15 hours of operator and family labor, two hours of tractor use and 26 hours of horse work per acre. Comparable figures in 1946 were 11, nine and three, respectively. During the period 1936 to 1946, mechanical power rapidly took the place of horse power as well as reduced the amount of man labor necessary to produce an acre of sugar beets.

An experiment conducted at Fort Collins, Colorado, in 1942 (7) showed that just as high yields were secured by complete mechanical thinning as by the customary hand block and thin method. The mechanical method required only 2.45 man hours per acre as compared to 27.2 man hours by the hand method. Less than one-tenth as much labor was required for the thinning process by the mechanical method compared with the old conventional method.

Prior to 1942 nine years of study at the Colorado Agricultural Experiment Station (7) on the average time required for different systems of thinning sugar beets resulted as follows:

	Man hours per acre
Hand block and thin	23.34
Mechanical blocker and hand thinning	15.96
Mechanical blocker followed by long-handled hoe	9.55
Long-handled hoe, only	16.20
Mechanical thinning, only	2.55

This study showed slightly more than one-tenth as much labor required in the thinning process by mechanical method only as compared with complete hand thinning.

A more recent study (10) made at the same station showed that 6.6 man-hours were required for preparing the seed bed, all of which was done with tractors. Planting and caring for the sugar beet crop to harvest time required 42.8 man-hours, 10 per cent of which was used with tractors. Approximately eight man-hours were used in irrigating the crop, and the remaining 71 per cent, or 30.5 man-hours, were used in blocking, thinning, hoeing and weeding the sugar beets. This same study showed that mechanical sugar beet harvesters, using about half the labor force, harvested 25 per cent more acreage per day than an average hand-topping crew.

Reports from various experiment stations indicate the variability in costs of producing sugar beets in different areas and at different periods of time.

The study made in Colorado for the years 1922-33 (1) showed an average cost per acre of $82.57, with an average yield of 15.17 tons per acre, or a cost of $5.44 per ton.

The most recent study (10) made at the same experiment station stated that the cost of harvesting sugar beets by hand-topping and mechanical loading was $1.93 per ton. The cost by mechanical harvester and loader was $1.03 per ton. There was a slight variation in cost among the different types of harvesters.

This same study disclosed the fact that, at 1947-1948 cost rates, a farmer should have 20 acres or more of 13-ton beets in order to justify the ownership of a mechanical harvester. This is assuming the average life of a harvester to be 10 years. If the average life were reduced to five years it would require from 25 to 30 acres. The study further concludes that the mechanical sugar beet harvester has proved successful in most cases. As the change from hand harvesting to mechanical harvesting is made there will necessarily be some changes in crop acreages and production practices.

Morrison and Davis (9) reported in 1950 that 36 acres of 15-ton beets would be required to make mechanical harvesting of sugar beets in Utah as economical as hand harvesting. Their calculated cost of $1.04 per ton for mechanical harvesting compares favorably with the study made in Colorado the same year.

In an earlier study made by Morrison (8) the average cost of producing sugar beets in Utah County in 1945 was $8.62 per ton. Material costs amounted to $1.09; fixed overhead $1.37; labor $4.79 and power costs $1.37 per ton. With total receipts averaging $12.15 per ton, this left a net return of $3.53 per ton. On an acre basis the total receipts were $204.83; total costs $145.28, with a net return of $59.55 per acre. Labor costs constituted about 55 per cent of total costs. Net returns averaged $530.00 per farm.

The average cost in 1946 of producing sugar beets in Michigan (4) on non-irrigated land was $92.92 per acre. With a yield slightly under 10 tons per acre the total cost was $9.44 per ton. Total receipts averaged $167.60 per acre, leaving almost $75.00 an acre as net returns. Harvesting costs were $18.55 per acre or about 20 per cent of the total cost. Hand labor accounted for over half of the harvesting costs. Getting the beets blocked, thinned and hoed, cost an average of $19.49 per acre, or almost two-thirds of the labor, power and machine costs up to harvest time.

The Michigan farmers with an average of 50 acres of sugar beets using hand labor for harvesting had costs of $20.25 an acre. Those with an average of 50 acres using the mechanical harvester had costs of $16.46 per acre. This was a saving of $3.79 per acre over hand harvesting. The group of farmers with an average of 107 acres using the mechanical harvester had costs of $12.85 an acre with a saving of $7.40 an acre over the hand harvesting method. This same study showed that hand harvesting was cheaper up to 33 acres. On acreages above 33 it was cheaper to use the mechanical harvester.

While these studies are not comparable on a cost and returns basis due to the changing price levels, the physical factors involved indicate to some degree the changes taking place due to mechanization -- the transition from horse power to tractor power and from hand thinning and harvesting to mechanical thinning and harvesting.

The literature also indicates the variability in the values placed on sugar beet tops as well as the yield of tops. In the Western United States under irrigation sugar beet tops range in green weight from 30 to 70 per cent of total plant weight.

Dunn and Rost of the Minnesota Agricultural Experiment Station (3) showed that the yield of beet tops varied closely with yields of roots regardless of location, fertilizer treatments, or season. They also showed that, on the average, the root made up 58 per cent and the top 42 per cent of the green weight of a sugar beet plant. This may vary with soil and climatic conditions, but where vegetative growth is heavy the ratio may be 1 to 1. They also showed by data that 1,489 pounds of green tops yielded 225 pounds of dry tops. Yield of dry tops range from 10 to 12.7 per cent of root tonnage, with an average of 11.25 per cent. A conservative estimate would be 10 per cent for most cases of 200 pounds per ton. A 17-ton yield of beets would then produce 1.7 tons of dry tops.

Their analysis showed that beet tops were about equal to alfalfa hay in protein and high in mineral matter. They concluded that beet tops were equal to alfalfa hay in feeding value.

E. J. Maynard (5), General Livestock Consultant for Great Western Sugar Company, stated that the 200 pounds of dried tops produced from an average ton of sugar beets had a replacement value equal to 46 pounds of corn and 150 pounds of alfalfa. These feed replacement values for beet tops expressed in terms of grain and hay provide a ready method for determining the money value of tops based on current prices for these other feeds. For instance, with corn prices at $1.35 per bushel or $2.41 per hundred pounds and alfalfa hay at $18.00 per ton the dried tops produced from a ton of sugar beets would be worth $2.46.

The fertilizing value of beet tops must also be considered. Their value as green manure, however, depends upon the current price of fertilizing elements. The Minnesota Agricultural Experiment Station (3) has also furnished data on the fertilizing value of tops plowed under green. From a 15-ton crop of sugar beets the report showed the following:

81.0 pounds of Nitrogen	@ 14.5 cents per pound	$11.75
16.5 pounds of P_2O_5	@ 8.5 cents per pound	1.40
210.0 pounds of K_2O	@ 6.25 cents per pound	13.13
		$26.28

On a 15-ton crop the fertilizing value of tops amounted to $26.28 per acre, or $1.75 per ton of beets. This compares favorably with the feed value of tops as reported by Maynard, which was $2.46 per ton of beets.

METHOD OF PROCEDURE

The data for this study were secured from 51 farmers in Utah County shortly after the close of the 1951 crop year. Enumerators trained for the purpose interviewed the farm operator and obtained detailed information about the labor requirements and costs on each sugar beet enterprise. Whenever possible, the data were taken from farm records, tax notices and and sugar company statements. Questionnaires were used by the enumerators to guide the interview and to record the information obtained. A sample of the questionnaire used appears in Appendix A.

The farms represented in this survey are located in an area bordering the east shore of Utah Lake. The enumerators made inquiries in the area until a producer of sugar beets was found. The enumerator then secured the information desired and asked where other producers lived. In this manner, 17 records were taken in the North Lake area which extends from Provo northward as far as Salt Lake County. Twenty-eight records were secured from farmers in the South Lake region extending west from Spanish Fork to Utah Lake and from Payson on the south to Springville on the north. The remainder, or six records, were taken in the area west of Provo, or the Lakeview area. Twenty per cent of the total beet acreage in Utah County was represented in this survey.

After the data were collected, the records were checked for accuracy; extensions and summaries were made and checked. All the information was then transferred from the original records to tabulation sheets. This was to aid in summarizing and analyzing the data. The tabulation sheets also provided cross-checks to aid in detecting errors. Some of the data were transferred from the original records to cards which were sorted manually to find any association that existed between the various factors.

In this study all averages were calculated by the simple average method in which each producer's data were put on a per acre, per ton, or per man hour basis. Any group or class average was then determined by adding together the various items in the group and dividing by the number in the group.

PRESENTATION AND ANALYSIS OF DATA

The sugar beet enterprise in Utah County

Most of the sugar beets produced in Utah County were grown under irrigation on fairly good land. The farms producing sugar beets were mostly of the small size diversified family type. On the 51 farms included in this survey, the size of the sugar beet enterprise ranged from three to 32 acres. The average size of the enterprise was 9.6 acres. Thirty-two, or 63 per cent, of the operators had sugar beet enterprises below the average.

Growers produced their beets under contract to the Utah-Idaho Sugar Company. In the Sliding Scale Contract a table of payments was developed which gave consideration to two factors: sugar content of beets and net return for sugar sold. The payment schedule showed a definite price to be paid the grower by the company for each combination of sugar content and net return. (2) In this way the grower knew approximately how much he would receive prior to planting his crop. He was also assured of a market for his crop. The sugar company supplied sugar beet seed of a suitable variety to the producer at a nominal price. Field representatives of the sugar company gave each farmer advice on growing his crop and notified him when his crop was ready for harvest.

General cultural practices

Land preparation and planting. The cultural practices generally used in the production of sugar beets in Utah County were to plow the land in the fall of the year. If fall plowing was done, a renovator, field cultivator, or disc harrow was used in the spring to loosen the soil which became compacted during the winter. When barnyard manure was used as a fertilizer it was usually applied in the early spring before tillage began.

Tillage consisted of going over the land several times with a land leveler or float and a spike tooth harrow. Commercial fertilizer was, in some cases, applied at this time and worked into the seed bed. Commercial fertilizer was side dressed at the time of planting in other cases. The aim of tillage was to secure a fine, firm seed bed.

Planting was done the latter part of March or early April depending upon weather conditions and the stage of seed bed preparation. Usually three to five pounds of sheared seed, or 10 to 15 pounds of whole seed were planted per acre. Sheared seed usually produced single plants within the row, thus reducing thinning time. Whole seed is actually a seed ball and may produce two or more plants. In the thinning process these are reduced to a single plant every eight to 16 inches.

Growing of sugar beets. On land where there was not sufficient moisture for germination of the seeds, irrigation water was applied. As soon as the plants were up and the rows could be seen cultivation was done to check weed growth between the rows. When four to six main leaves appeared the thinning process began. Some thinners used a short handled hoe, blocking and thinning as they proceeded along the row. Others preferred to use a long handled hoe, first blocking the row and then thinning it. When mechanical thinners were used the stands of beets were reduced to some extent but hand work was necessary to complete the thinning process. Soon after the beets were thinned they were gone over a second time and in some cases a third time to remove any double beets or weeds which had been missed. The second and third operation was done entirely by hand.

Irrigation water was applied soon after the beets were thinned, depending upon the moisture content of the soil. The number of irrigations applied during the growing season depended upon the type of soil, the rainfall, temperature, and the amount of water available for irrigation.

Harvesting of sugar beets. The sugar beets were harvested during the month of October and early part of November. The farmers using the windrow type of harvester loaded the beets either by hand or with a mechanical loader. Those using the Marbeet type harvester pulled, topped, and loaded the beets all in one operation. The farmers using no mechanical harvesters pulled their beets with a beet plow and a team of horses or tractor. The beets were then topped by hand and thrown into piles or windrows. They were then loaded onto trucks by hand or a mechanical loader. Most of the beets were hauled to the receiving station by trucks. In a few cases, on short hauls, tractors and rubber tired wagons were used. From the receiving station the beets were delivered by railway cars to the processing factory at West Jordan, Utah.

Analysis of man labor requirements

Man labor requirements were studied under three main headings: (1) requirements for land preparation and planting; (2) requirements for growing; and (3) requirements for harvesting. In the land preparation the operations performed were manuring, plowing, discing and harrowing, leveling and floating, fertilizing, rolling and cultipacking, drilling and ditching. The miscellaneous operations consisted mainly of weeding with a renovator or field cultivator. Not all operators performed every one of these operations, as shown in Table 1 under "operators reporting the practice." The growing operations included blocking and thinning, cultivating, hoeing and irrigating. The harvesting operations consisted of pulling, topping, loading and hauling the beets to a company receiving station. Harvesting operations were performed by all producers. The man labor requirements for individual enterprises were arrived at from the growers' estimates of the actual time required to perform the various operations.

Labor for land preparation and planting. The operations performed in preparing the land and planting required an average of 13.5 man hours per acre. This was 16.5 per cent of the total labor required to produce an acre of sugar beets. Manuring the land was the operation requiring the most labor. An average of 5.7 man hours per acre or 7.0 per cent of the total time was spent in manuring the land. Forty of the 51 operators performed this operation. Other operations required the following amounts of time: plowing, 1.8 man hours per acre; discing and harrowing, 2.0 hours per acre; leveling and floating, 0.7 hours; fertilizing, 0.9 hours; rolling and cultipacking, 0.1 hours; drilling, 1.0 hour; ditching, 1.2 hours; and miscellaneous operations, 0.1 man hours per acre (Table 1).

When compared with the earlier study (8) made in Utah County in 1945 the man labor requirements for preparing the seed bed and planting have been reduced 7.0 hours.

On the 51 farms in this study 7.3 per cent of the labor used in preparing the land and planting was hired labor. This averaged 0.9 man hours per acre. Twenty-eight of the farms hired the drilling operation. Most of the land preparation was done by the operator with family help.

Labor for growing. An average of 43.7 man hours per acre was required to grow the crop from planting time to harvest time. This was 53.4 per cent of the total man labor required for all operations. Of the 43.7 hours of labor used, 19.8 man hours per acre, or 46.3 per cent was hired labor. Operator and family labor averaged 23.9 man hours per acre. Thirty-six farms used some hired labor during the growing season, mostly for thinning and hoeing. Blocking and thinning by the hand method, required 13.6 man hours per acre. The mechanical blocker required 0.4 man hours per acre. In addition, 4.0 man hours were needed to finish the thinning operation. Cultivating required 4.7 man hours; hoeing, 18.1 man hours; irrigating, 7.4 man hours, and miscellaneous operations, 0.1 man hours per acre. Blocking, thinning and hoeing required 75.1 per cent of the man hours during the growing season, or 40.2 per cent of the total man hours required to produce an acre of sugar beets.

The man labor for growing the crop was reduced from 50.7 in 1945 to 43.7 man hours per acre in 1951, or a 13.8 per cent decrease. With greater efficiency in the use of mechanical thinners, as demonstrated in the Colorado study (7), hours of the man labor required for thinning and weeding might be reduced even more.

Labor for harvesting. The harvesting operations required an average of 24.6 man hours of labor per acre. This was 30.1 per cent of the total labor required to produce an acre of sugar beets. Hired labor accounted for 48.1 per cent of the 24.6 man hours, or 11.8 man hours per acre. Operator and family labor amounted to 12.8 man hours per acre. Pulling the beets required 0.9 man hours per acre. Hand topping required 7.0 man hours; hand loading, 3.1 man hours, making a total of 10.1 man hours to top and load by hand.

With the trail-type harvester, such as the International or Marbeet, the topping and loading was done in one operation; this operation required 6.6 man hours per acre. Hauling the beets to a receiving station required 5.7 man hours with the miscellaneous operations, such as dragging and harrowing, being less than 0.1 man hours per acre. Hired labor accounted for 41.1 per cent of the total man hours required; operator and family labor made up the remaining 58.9 per cent.

Table 1. Hours of man labor required for various operations, and number of operators reporting various practices in the production of sugar beets on 51 farms in Utah County, 1951

Item	Hours per acre	Per cent of total	Operators reporting practice	Cost per acre
	(hours)	(per cent)	(number)	(dollars)
Land preparation and planting				
Manuring	5.7	7.0	40	
Fertilizing	0.9	1.1	45	
Plowing	1.8	2.2	50	
Discing and harrowing	2.0	2.4	51	
Leveling and floating	0.7	0.9	40	
Rolling and cultipacking	0.1	0.1	9	
Drilling	1.0	1.2	51	
Ditching	1.2	1.5	42	
Miscellaneous	0.1	0.1	12	
Subtotal	13.5	16.5		13.00
Growing				
Hand block and thinning	13.6	16.6	38	
Mechanical blocking	0.4	0.5	13	
Hand thinning after mechanical blocking	4.0	5.0	13	
Cultivating	4.7	5.7	51	
Hoeing	14.8	18.1	50	
Irrigating	6.1	7.4	51	
Miscellaneous	0.1	0.1	5	
Subtotal	43.7	53.4		42.08
Harvesting				
Pulling	0.9	1.1	17	
Hand topping	7.0	8.5	17	
Hand loading	3.1	3.8	17	
Mechanical topping	0.9	1.1	5	
Mechanical loading	0.4	0.5	5	
Mechanical harvesting	6.6	8.1	29	
Hauling	5.7	7.0	51	
Miscellaneous	*	**	2	
Subtotal	24.6	30.1		23.68
Total	81.8	100.0		78.76

* Less than 0.1 hours
** Less than 0.1 per cent

The 1945 study made in Utah County (8) reported one mechanical harvester, while 34 were reported in this survey. The reduction of 18.2 man hours per acre in the harvesting operations was due mainly to the increased use of mechanical harvesters and trucks. Similar reductions were noted in preparing the seed bed and growing the crop. These savings in man hours since 1945 came largely through the increased use of trucks and tractors.

Analysis of cost items

Cost items were grouped into four main classifications: (1) labor cost; (2) power and machinery cost; (3) material cost; and (4) overhead cost. Labor cost accounted for 40.7 per cent of the total cost; power and machinery cost, 30.9 per cent; material cost, 11.8 per cent; and overhead cost, 16.6 per cent of the total cost.

Cost of man labor. Cost of man labor, which was the largest single cost item, was studied under the same three headings as was labor requirements. The man labor cost per acre was $13.00 for preparing the land and planting, $42.08 for growing the crop, and $23.68 for the harvesting operations, making a total labor cost of $78.76 per acre (Table 1).

The operator and family labor cost was $47.73 per acre, or $2.97 per ton. This was 24.7 per cent of total costs (Table 2). Hired labor amounted to $31.03 per acre, or $1.92 per ton which was 16.0 per cent of the total cost. Together these made a total labor cost of $78.76 per acre, or $4.89 per ton. This was 40.7 per cent of the total cost. The average wage rate for the operator and his family amounted to $0.99 per hour. This rate was determined by the operator's estimate of his earning ability in alternative employment, or the cost of hiring someone to do the work. The average wage rate for hired labor was $0.92 per hour, making an average of $0.96 per hour for all labor. Many operators considered themselves more efficient than hired labor would have been, and accordingly valued their time higher. Whenever the operator gave the interviewer information on a piece rate basis this was converted to the hourly rate so that a total could be made on an hourly basis. No attempt was made to distinguish differences in earnings under these two methods.

Cost of power and machinery. The cost of operating the tractor was \$44.30 per acre, or \$2.75 per ton. This was 22.9 per cent of the total cost. The tractor was used an average of 16.4 hours per acre at an average rate of \$2.70 per hour. This cost included the use of the tractor-drawn implement or attachment as well as for the gasoline, oil, depreciation and repairs associated with the tractor or implement being used. However, this did not include the cost of the tractor operator. The rate charged per hour was determined by the custom rate prevailing in the particular vicinity of the operator. The depreciation on equipment, as noted under overhead costs, applies only to horse-drawn equipment. Tractor costs amounted to 74.0 per cent of the total power and equipment cost.

Truck charges amounted to \$12.00 per acre, or \$0.74 per ton. This was 6.2 per cent of the total cost. Truck rates and expenses were handled in the same manner as were the tractor rates and expenses. Trucks were used mainly for hauling the beets from the field to a company receiving station, but some were used for hauling manure and commercial fertilizer. The charge for trucks was 20.0 per cent of the total power and equipment cost. They were used an average of 6.9 hours per acre at an average cost of \$1.75 per hour.

The charge for horse labor was set by the operator on the basis of the cost per hour of hiring a team. Horse power was used an average of 7.9 hours per acre at an average rate of \$0.45 per hour. This amounted

Table 2. Cost of producing sugar beets on 51 farms in Utah County, 1951

Cost item	Average per acre				Cost per ton	Per cent of total cost
	Unit	Amount	Rate	Cost		
			(Dollars)	(Dollars)	(Dollars)	
Labor cost						
Operator and family	(hours)	48.2	0.99	47.73	2.97	24.7
Hired	(hours)	33.6	0.92	31.03	1.92	16.0
Total labor cost	(hours)	81.8	0.96	78.76	4.89	40.7
Power and machinery cost						
Tractor and attachment	(hours)	16.4	2.70	44.30	2.75	22.9
Truck	(hours)	6.9	1.75	12.00	0.74	6.2
Horse	(hours)	7.9	0.45	3.57	0.22	1.8
Total power and machinery cost				59.87	3.71	30.9
Material cost						
Manure	(ton)	5.8	1.30	7.50	0.47	3.9
Commercial fertilizer	(cwt)	3.4	3.64	12.36	0.77	6.4
Seed	(lbs.)	4.7	0.49	2.30	0.14	1.2
Machine rental				0.39	0.03	0.2
Miscellaneous				0.18	0.01	0.1
Total material cost				22.73	1.42	11.8
Overhead cost						
Interest on money				2.71	0.17	1.4
Interest on capital				17.99	1.12	9.3
Building depreciation				0.01	*	**
Equipment depreciation				0.77	0.05	0.4
Land taxes				3.09	0.19	1.6
Water assessments				4.06	0.25	2.1
Fees				0.39	0.02	0.2
Miscellaneous				3.09	0.19	1.6
Total overhead cost				32.11	1.99	16.6
Total cost				193.47	12.01	100.0

* Less than $0.01

** Less than 0.1%

to $3.57 per acre, or $0.22 per ton. This was 6.0 per cent of the total power and equipment cost. Taken together, the tractor, truck, and horse power costs amounted to $59.87 per acre, or $3.71 per ton, which was 30.9 per cent of the total cost of production. The depreciation on horse-drawn equipment is shown under overhead costs (Table 2).

Cost of material. Material cost includes such items as manure, commercial fertilizer, seed, machine rental, and miscellaneous items. Commercial fertilizer was the largest expense item in this group. The cost was $12.36 per acre, or $0.77 per ton and 6.4 per cent of total cost. It was applied at the rate of 340 pounds per acre on 450 acres at an average cost of $3.64 per hundred pounds. Most of the fertilizer used was of the 10-20-0, or 16-20-0 formula. Manure cost amounted to $7.50 per acre. An average of 5.8 tons per acre was applied at an average cost of $1.30 per ton. This was in addition to the commercial fertilizer applied. Manure cost was 3.9 per cent of the total cost. In arriving at a charge for manure applied, 50 per cent of that applied in 1951; 30 per cent of that applied in 1950; and 20 per cent of that applied in 1949 was charged to the sugar beet enterprise. The cost of applying manure and commercial fertilizer was charged to labor, power and machinery.

Seed cost averaged $2.30 per acre. This was 1.2 per cent of the total cost. The seed was planted at an average rate of 4.7 pounds per acre at an average cost of $0.49 per pound. Most of the sugar beet seed was of the segmented type.

The machine rental consisted mainly of the charge for the use of the sugar company's beet drill and for some horse-drawn machinery. The rental rate for the use of the sugar company's drill in planting the crop was $1.00 per acre. Twenty-four operators hired the company drill.

Miscellaneous items consisted mainly of spray material which cost \$0.18 per acre, or \$0.01 per ton of beets.

Total material cost was \$22.73 per acre, or \$1.42 per ton, which was 11.8 per cent of the total cost of production.

Cost of overhead. Overhead costs were those cash and non-cash costs which are more or less fixed and would occur regardless of the intensity of cultivation or volume of output. These charges include interest on fixed capital, depreciation and repairs on buildings used for horse-drawn machinery, depreciation and repairs on all horse-drawn machinery, taxes on the land, water assessments, and miscellaneous which was a 10 per cent additional charge to take care of any expenses which might have been overlooked.

Interest on capital invested in land and machinery was the largest overhead cost. This amounted to \$17.00 per acre, or \$1.12 per ton, which was 9.3 per cent of total costs. Capital investment averaged \$359.80 per acre. Interest was charged on this amount for a full year at 5 per cent.

Water assessments were the next highest cost item. Cost of water was \$4.06 per acre, or \$0.25 per ton, which was 2.1 per cent of all costs. Interest on working capital was \$2.71 per acre, or \$0.17 per ton. This was 1.4 per cent of the total cost. The cost of building depreciation and repairs was almost negligible. Machinery depreciation and repairs came to \$0.77 per acre, or \$0.05 per ton. As stated previously, this cost item pertained only to the horse-drawn equipment. The tractor rates were made sufficiently high to cover this cost on tractor drawn equipment.

Land taxes were \$3.09 per acre, or \$0.19 per ton, which amounted to 1.8 per cent of total costs. All overhead costs amounted to \$32.11 per acre, or \$1.99 per ton, and comprised 16.6 per cent of the total cost of production (Table 2).

Since the charge of interest on investment in trucks, tractors and equipment used with them was included in power and equipment costs it was not necessary to include them in overhead costs. Fixed capital investment included only land, horse-drawn equipment, and buildings used in housing this equipment. Each producer was asked the value of his beet land. This was considered his investment in land. Interest was charged on this amount at the rate of 5 per cent per annum, which was considered to be the average market rate of interest. The average values of horse-drawn equipment and buildings used to house that equipment were also obtained. Interest was charged on this equipment and buildings at the same rate as that charged on land and pro-rated to the sugar beet enterprise on the basis of use. Interest on horse-drawn equipment and buildings used for this equipment combined with interest on the land made up the total charge for interest on capital. Land investment accounted for 98.0 per cent of the fixed capital investment; horse-drawn equipment, 1.65 per-cent; and buildings, 0.35 per cent. No data were secured on the investments in trucks, tractors and equipment used with them.

Interest at a rate of 5 per cent per annum was charged against working capital invested in the crop. This cost was calculated on all expenditures from the time the expense was made until payment was received. The cost items on which interest was charged and the amount of time for which charges were made were: labor for preparing the land and planting, seven months; labor for growing the crop, four months; labor for harvesting the crop, one month; manure for 1951, eight months; manure for 1950 and 1949, one year; commercial fertilizer, seven months; and seed, six months. Interest was charged regardless of whether the capital was owned or borrowed, since the use of capital is a cost to the enterprise regardless of its source. Charges for the use of horse-drawn equipment and buildings used to house that equipment were calculated from the cost of depreciation and repairs and interest on the money so invested. A flat rate of 10 per cent of the average inventory value was applied in calculating depreciation on the equipment, and 5 per cent was used to depreciate buildings. Depreciation and cost of repairs were charged against the sugar beet enterprise in proportion to the use made of the equipment and buildings for the sugar beet enterprise.

Taxes on the land were determined from the tax notice on the land producing sugar beets. The sugar beet acreage was assigned a proportionate part of the total land tax.

Water assessments were charged in proportion to the amount of water used on the sugar beets compared to the total water used on the farm.

The item of fees included the deduction of \$0.02 per ton for membership in the Utah Sugar Beet Growers' Association. This amounted to \$0.39 per acre.

Total cost per acre was \$193.47, which consisted of labor cost, \$78.76; power and machinery cost, \$59.87; material cost, \$22.73; and overhead cost \$32.11. On a per acre basis the total cost was \$12.01, which was made up of labor cost, \$4.89; power and machinery cost, \$3.71; material cost, \$1.42; and \$1.99 for overhead cost. As a per cent of total cost, labor cost was 40.7 per cent; power and equipment, 30.9 per cent; material cost, 11.8 per cent; and overhead cost, 16.6 per cent.

Receipts and net returns

Receipts from the sugar beet enterprise were obtained from three sources: the value of the beet roots delivered to the sugar company;

the appraised value of the tops as livestock feed or as green manure; and the government benefit payment. The sugar company payments are usually made in two or more payments and was established by the sugar company at $11.42 per ton for the 1951 crop year. The exact amount to be paid the producer was not known until the sugar for that crop was sold. The value of the beet tops as estimated by the various producers averaged $0.92 per ton of all beets sold. The government benefit payment was $2.33 per ton for the 1951 crop year (Table 3).

Total receipts per ton varied from $14.33 to $16.29, with an average of $14.67 per ton. Since the sugar company payment, and the government benefit payments were the same for all producers the variation in total receipts was due entirely to the producers' valuation of the tops. This valuation ranged from no value in five cases to $1.96 per ton of beets in one case. The average was $0.92 per ton of beets. Since total receipts are variable the net returns per ton and net returns per acre will also vary. This should be kept in mind throughout the remainder of this study. All calculations were made by using the average of $14.67 as receipts per ton from which is deducted $12.01 as total cost per ton. This leaves $2.66 as average net returns per ton. Net returns ranged from minus $13.83 to plus $7.45 per ton.

After allowing a return to the operator and family for their labor and a return to the capital invested in land and machinery and to the money going for expenses there was a return which should go to the operator for efficient management. Net returns, then, was the reward for efficient management (Table 3).

Table 3. Gross receipts and net returns from the sugar beet enterprise on 51 farms in Utah County, 1951

Item	Receipts per enterprise	Receipts per acre	Receipts per ton
Gross receipts			
Beets	$2,002.00	$204.32	$11.42
Beet tops	61.00	6.19	0.92
Government payment	389.00	39.67	2.33
Total receipts	2,452.00	250.18	14.67
Total costs	1,814.00	193.47	12.01
Net returns	638.00	56.71	2.66

On a per acre basis the total receipts amounted to $250.18, which consisted of $204.32 for the beets; $6.19 for the beet tops; and $39.67 as a government benefit payment. When the total cost of $193.47 was deducted there was a net return of $56.71 per acre. Net returns per acre ranged from minus $119.83 to plus $186.25 per acre.

When calculated on a per enterprise basis the total receipts were $2,452.00; total costs, $1,814.00; and net returns, $638.00. The net returns per enterprise ranged from minus $719.00 to plus $3,799.00.

Analysis of factors associated with success of the sugar beet enterprise

In analyzing the relationships which exist between the various factors studied, the tabular method was used. This method compares the variation in one factor with the variation in another factor. It involves the classification or sorting of data into groups according to one factor and the calculation of averages of a second factor for these same groups. In this way it can be shown whether the average of one factor increases as the average of another factor increases or decreases. A relationship exists when the averages show either a consistent increase or a consistent decrease. It is frequently just as important to know that no relationship exists among certain factors as it is to know that relationships do exist among others.

The relationships observed in the tabular method were checked and substantiated by means of the "regression" technique (Appendix B), which is one of the more common methods of statistical analysis used to measure relationship between two variables.

Regression coefficients also were computed to determine the rate of change in the dependent variable with a unit change in the independent variable. The regression coefficient, or rate of change, is herein signified by the letter "b." The standard error of the regression coefficient is signified by "S_b." From these, along with the "t" table, the fiducial limits may be set. (11)

The regression line (Figure 1) was determined by the regression equation $Y = a + bX$. Computations are shown in Appendix B. The standard error of estimate, or the standard deviation from this regression line was also determined and signified by "Syx."

The coefficient of determination, symbolized by r^2, which is a percentage of the portion of one variable that is associated with another, was also determined.

In order to determine the factors which may affect the success of the sugar beet enterprise certain information from each enterprise was tabulated on a separate card. These cards were then sorted and grouped on the basis of some factor. Among the various factors studied were: size of enterprise, yield per acre, use of man-labor, use of mechanical blockers and harvesters, cost of power and machinery and net returns.

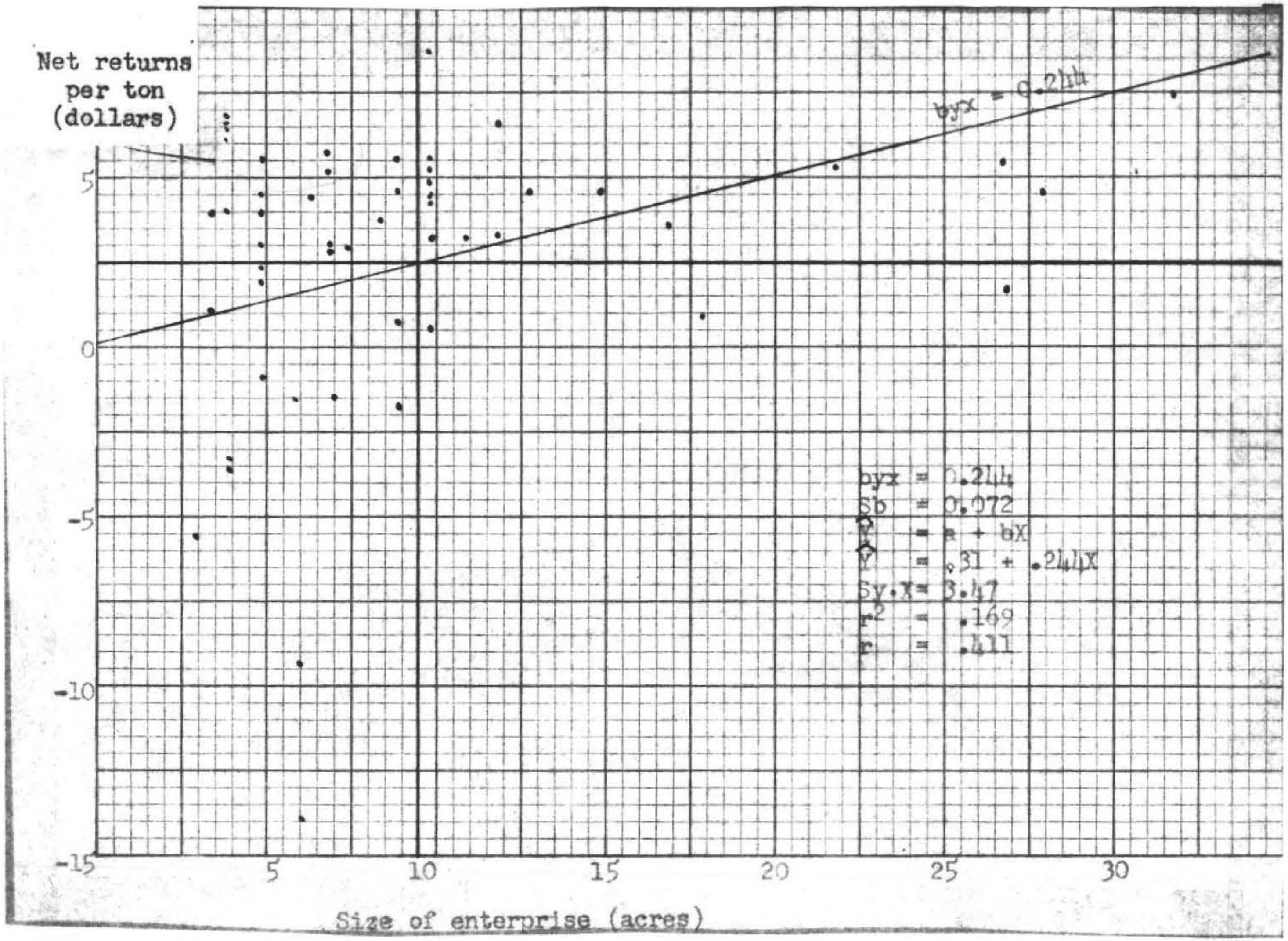

Figure 1. Relationship of size of enterprise to net returns per ton in the production of sugar beets in Utah County, 1951

<u>Size of enterprise.</u> Size of enterprise often results in more efficient use of labor, power and machinery, and in reduction of overhead costs per unit. In order to note the relationship between size of enterprise and various factors, the records were sorted on the basis of the number of acres of sugar beets grown. Net returns per ton were used as the primary measure of success. The relationship between size of enterprise and yields, man hours per acre, power and machinery costs, and total costs per ton were also noted (Table 4).

The records were divided into four groups on the basis of size of enterprise, those with acreages between 3.0 and 6.9 acres, those with 7.0 to 10.9 acres, those between 11.0 and 20.9 acres, and a group with 21.0 acres or more. There were 21 farms in the first group with an average of 4.6 acres in sugar beets. The second group consisted of 18 farms with an average of 8.7 acres. In the third group were seven farms with an average of 14.0 acres. There were five farms in the fourth group with an average of 27.2 acres. The average for all 51 farms was 9.6 acres.

A total of 488.6 acres were included in this study with the size of enterprises ranging from three to 32 acres. Of the 51 farms in the survey 32, or 63 per cent, were below the average in size.

An examination of Table 4 revealed a relationship between size of enterprise and net returns per ton. Other relationships were also noted, but when checked by the regression technique, it was found that the relationship between size of enterprise and net returns per ton was the only one that showed statistical significance. It can be safely stated that there was a significant correlation between size of enterprise and net returns per ton since the correlation coefficient, $r = 0.411$, was high enough to take it out of a chance category. Any correlation between size

Table 4. Relationship of size of enterprise to net returns and other factors on 51 sugar beet enterprises in Utah County, 1951

Range in acres per enterprise	Acres of sugar beets (acres)	Number of farms (no.)	Yield per acre (tons)	Man-hours per acre (hours)	Power and machinery cost per ton (dollars)	Total cost per ton (dollars)	Net returns per acre (dollars)	Net returns per ton (dollars)
3.0 - 6.9	4.6	21	15.7	82.1	4.03	13.42	37.50	1.09
7.0 - 10.9	8.7	18	18.1	83.0	3.63	11.20	63.69	3.38
11.0 - 20.9	14.0	7	17.4	79.2	3.42	10.75	70.60	3.88
21.0 and over	27.2	5	18.1	75.4	3.01	10.01	91.00	4.88
All farms	9.6	51	17.1	81.8	3.72	12.01	56.71	2.66

of enterprise and any of the other variables may have been due to chance.

The test of this significance was determined by the coefficient of correlation, r, and the table of correlation coefficients at the 5 per cent and 1 per cent levels of significance as determined by Professor R. A. Fisher. (11) The degrees of freedom in this case were 49, or N - 2. One degree of freedom was lost in calculating the averages; another in determining the line of regression.

The coefficient of determination, r^2, explains that about 17 per cent of the variation in net returns per ton was accounted for by the size of enterprise. Assuming constant yield, size of enterprise plays an important part in reducing costs and increasing net returns. Table 4 does show, however, that man hours per acre and power and machinery costs per ton decreased as the beet acreage became larger, indicating that efficient use of labor and machinery is associated with larger enterprises.

Yields per acre. When the records were sorted into three groups on the basis of yield per acre, those having yields below 15 tons per acre or an average of 12.5 tons per acre, showed no net returns. The return per ton for this group was minus $0.45 per ton. The intermediate group from 15 to 18.9 tons per acre, with an average of 16.9, showed a return of $2.87 per ton. The group with the highest yields of 19 tons and over, which averaged 21.1 tons per acre showed net returns of $5.11 per ton (Table 5).

A sort was made to determine the association between yields and cost per ton and net returns. The association between yields and size of enterprise, man hours preparing the seed bed and planting, total man hours, and per cent stand were also noted.

The relationship between yield and net returns, per ton (Figure 2), and per acre (Figure 3), proved to be highly significant when the correlation coefficients were checked by R. A. Fisher's table of correlation coefficients. (11)

The coefficient of determination, r^2, (Figure 2) infers that 48 per cent of the variation in net returns per ton was due to yields. Similarly, about 71 per cent of the variation in net returns per acre (Figure 3) were accounted for by yield.

The regression coefficient, b, (Figure 3) indicates an increase of $13.23 in net returns per acre for each additional ton per acre. High yields are very important for a successful sugar beet enterprise.

Another factor of high significance was the relationship between yield and cost per ton. By the coefficient of determination, r^2, (Figure 4) 53 per cent of the variation in cost per ton was associated with yield. Since this is an inverse relationship cost per ton decreased $0.75 for each ton increase in yield. This is shown by the regression coefficient, b. By increasing yields the fixed costs were spread over more units, thereby reducing the unit cost.

According to Table 5 there was a positive relationship between per cent stand of sugar beets and yield. That is, when per cent stand was increased there was likewise an increase in yield. This relationship proved to be statistically significant at the 5 per cent level. Per cent stand in this study was determined by the farmer's estimate of his per cent stand based on the number of single beets after thinning to be found in each hundred feet of beet row. Per cent stand was quite important in producing high yields.

There seemed to be very little relationship between yield and the amount of labor applied per acre, at least the relationship was not close

Table 5. Relationship of yields per acre to net returns and other factors on 51 sugar beet enterprises in Utah County, 1951

Yield per acre: Range	Yield per acre: Average	Number of farms	Acres of beets	Total man hours per acre	Man hours P & P* per acre	Power and machinery cost per acre	Per cent stand	Cost per ton	Net returns per acre	Net returns per ton
	(tons)	(no.)	(acres)	(hours)	(hours)	(dollars)	(per cent)	(dol.)	(dol.)	(dollars)
14.9 & less	12.5	16	7.9	78.0	12.4	56.17	73	15.16	-1.95	-0.45
15.0 - 18.9	16.9	16	10.3	82.4	13.8	61.64	86	11.80	50.13	2.87
19.0 & over	21.1	19	10.4	84.5	14.0	61.48	90	9.52	108.59	5.11
All farms	17.1	51	9.6	81.8	13.4	59.84	84	12.01	56.71	2.66

* Preparing the seed bed and planting

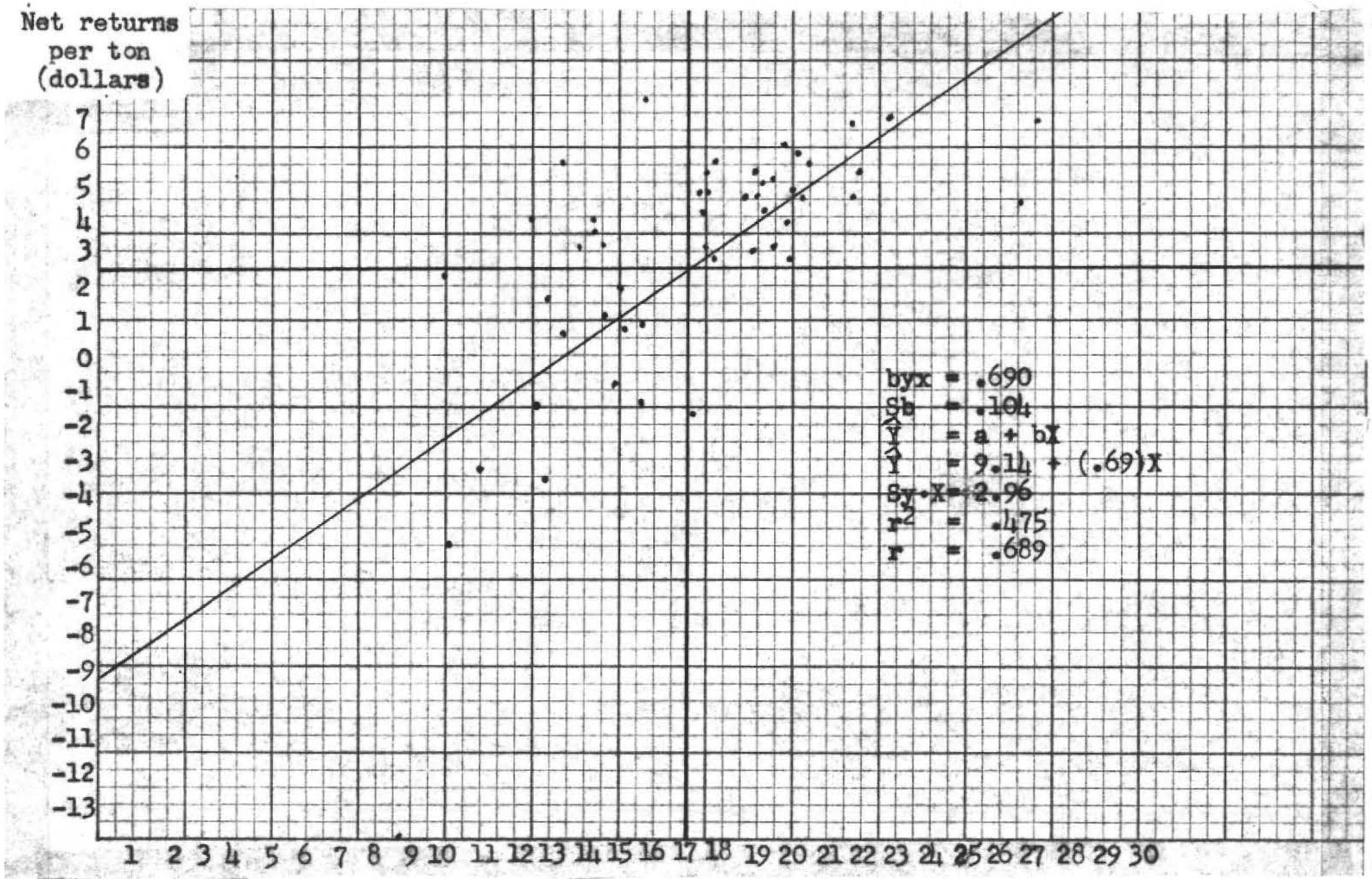

Figure 2. Relationship of yield per acre to net returns per ton in the production of sugar beets in Utah County, 1951

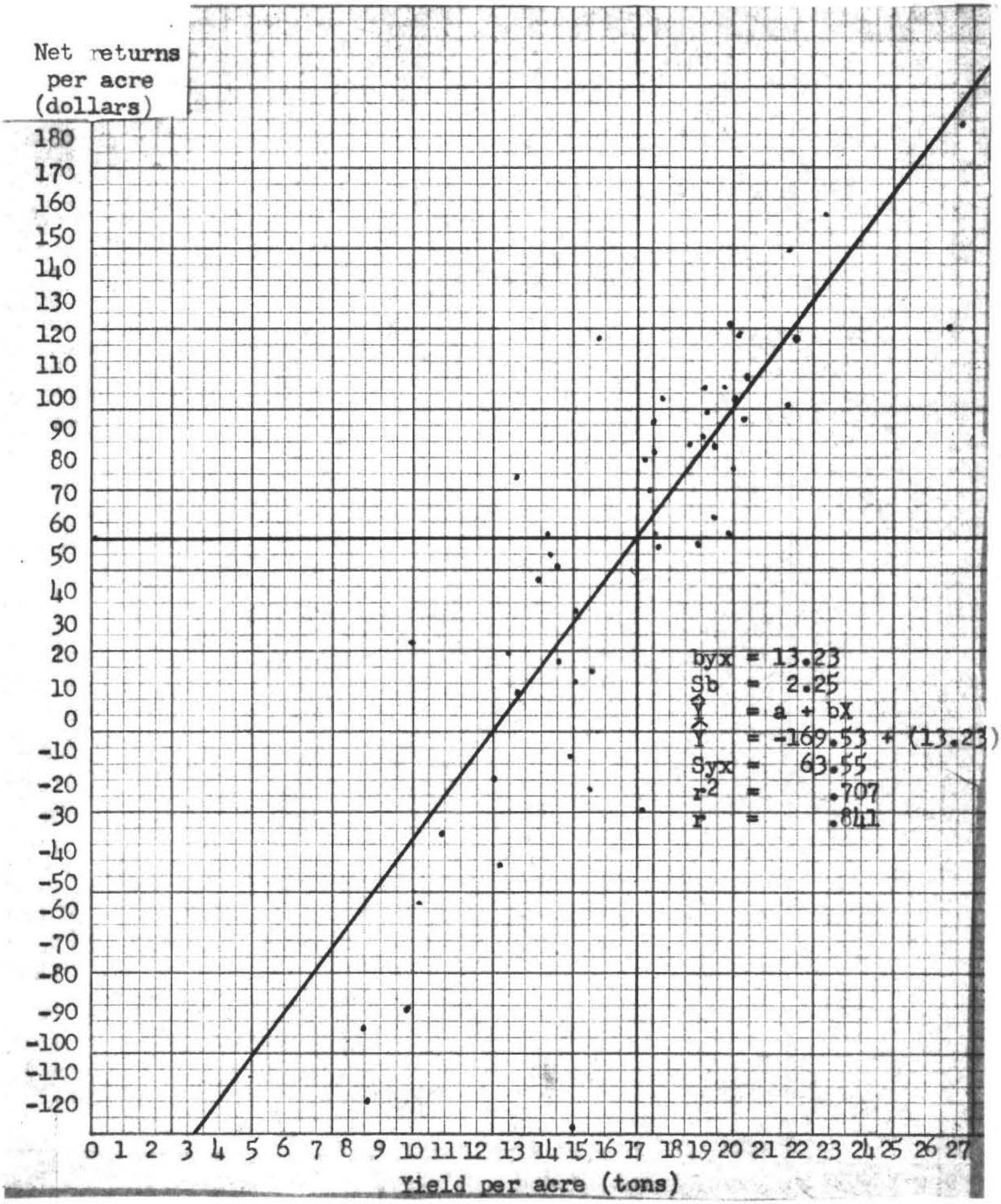

Figure 3. Relationship of yield to net returns per acre of sugar beets in Utah County, 1951

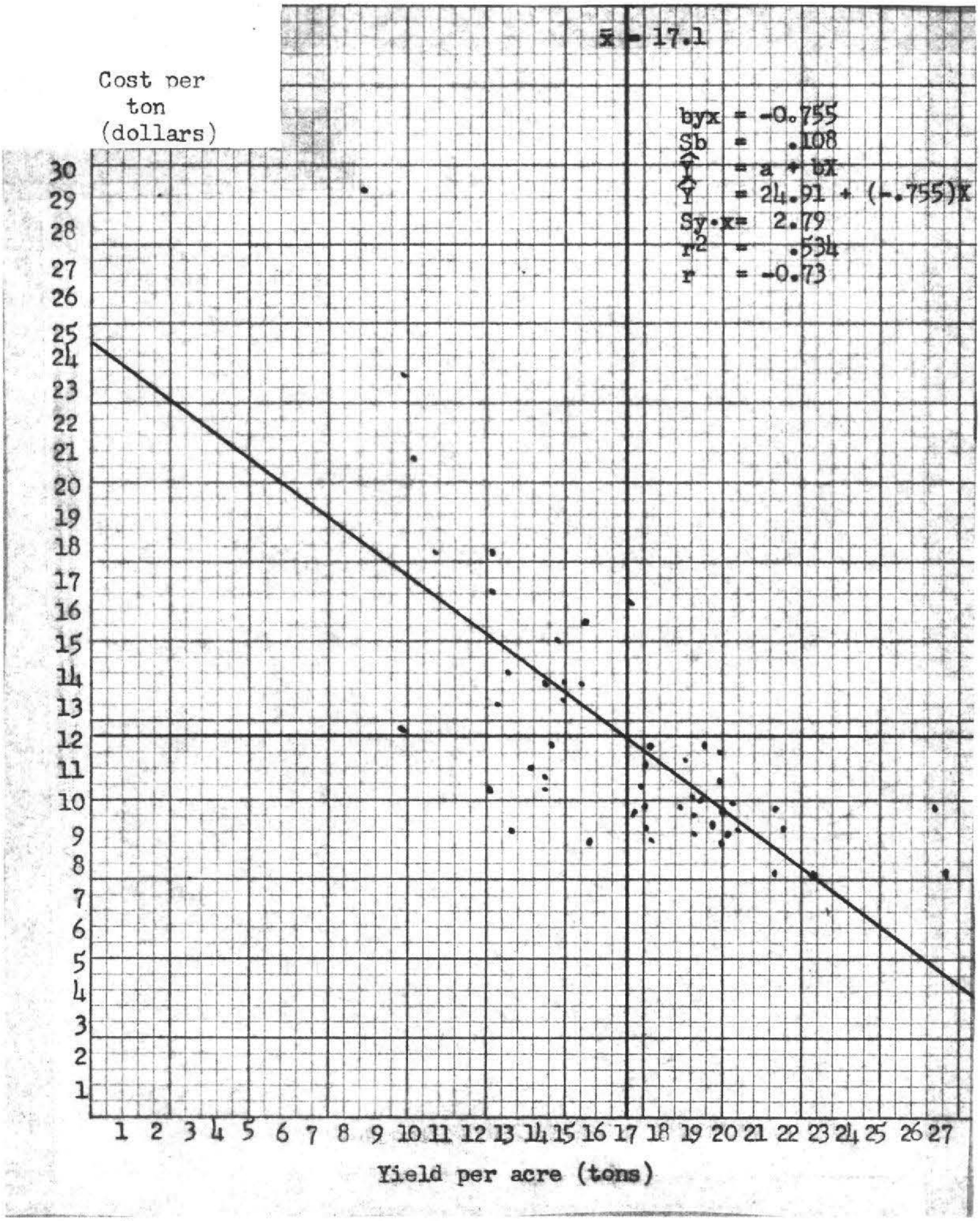

Figure 4. Relationship of yield to cost per ton in the production of sugar beets in Utah County, 1951

enough to be statistically significant at the 5 per cent level. Possibly more labor was expended on some of the enterprises than was necessary to secure the yields attained. Previous cropping practices may affect yields. Improper preparation of the seed bed may also affect yields.

There was very little relationship between yield and the size of enterprise.

Labor efficiency. In order to determine the association between the amount of labor used on the sugar beet enterprise and net returns and other factors the records were sorted into three groups on the basis of total hours of man-labor per acre (Table 6).

Labor efficiency is generally referred to as the amount of productive work accomplished per man. In this study the labor of children was converted to man equivalents[1] and then considered as regular man labor.

Since labor costs constitute the major cost item in the production of sugar beets, efficient and economical use of labor had an important effect upon net returns. Sugar beet enterprises with high labor efficiency, as measured in man hours per acre, were the most successful enterprises. Man hours per acre was used as the measure of labor efficiency. Cost of labor per acre averaged about $1.00 per hour.

Table 6 shows that those farmers who used 57.1 man hours per acre had yields as high as those using 111.0 man hours. By this standard they accomplished the same results with less labor.

Since material costs and overhead costs were about the same for each acre of land, the variation in total cost is a result of power and machinery

1. Children's labor was converted to man hours on the following scale: 16 years and over equal to 1 man, 15 - 16 equal to 7/8, 14 - 15 equal to 3/4, 13 - 14 equal to 5/8, 12 - 13 equal to 1/2, 11 - 12 equal to 1/4.

Table 6. Relationship of man-hours of labor per acre to costs, net returns, and other factors on 51 farms in Utah County, 1951

Man-hours of labor per acre: Range	Man-hours of labor per acre: Average	Number of farms	Acres in beets	Yield per acre	Power and machinery cost per acre	Total cost per ton	Total cost per acre	Net returns per ton	Net returns per acre
	(hours)	(no.)	(acres)	(tons)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
69.9 & less	55.8	17	10.5	17.3	58.62	9.90	168.84	4.77	85.14
70.0 - 89.9	79.8	17	10.9	17.0	59.65	11.89	192.92	2.79	55.27
90.0 & over	109.7	17	7.4	17.0	61.32	14.23	218.64	0.43	29.72
All farms	81.8	51	9.6	17.1	59.84	12.01	193.47	2.66	56.71

and labor costs. And since there was no significant difference in the power and machinery cost per acre on farms with low labor efficiency and those with high labor efficiency the real cause of variation in total cost was due to labor costs.

Farmers with high labor efficiency are usually more successful than others because they accomplish more work per man, or they accomplish the same results with less labor. The labor cost per unit is reduced with high labor efficiency. Any reduction in labor cost should result in a substantial decrease in the total cost of production per unit.

From Table 6 it can be noted that there is a consistent positive relationship between man hours of labor per acre and cost per acre and per ton. As man hours per acre increase costs also increase. A consistent negative relationship exists between man hours per acre and net returns.

These observations can be checked readily by correlation and regression techniques. The correlation coefficient, ($r = .608$) indicates a relationship that is highly significant (Figure 5). The coefficient of determination, r^2, indicates that approximately 37 per cent of the variation in cost per acre can be attributed to man hours per acre.

The regression coefficient, $b = .826$, indicates that for each additional hour of labor per acre the cost per acre would increase $0.83 with a standard error, S_b, of $0.15. The regression line, determined by the regression equation $Y = a + bX$, has a standard error, $S_y.x$, of $27.30.

The relationship between man hours per acre and cost per ton (Figure 6) was similar to that of cost per acre, except that the correlation coefficient was significant at the 5 per cent level. The coefficient of determination, r^2, in this case accounted for 11 per cent of the variation in cost per ton.

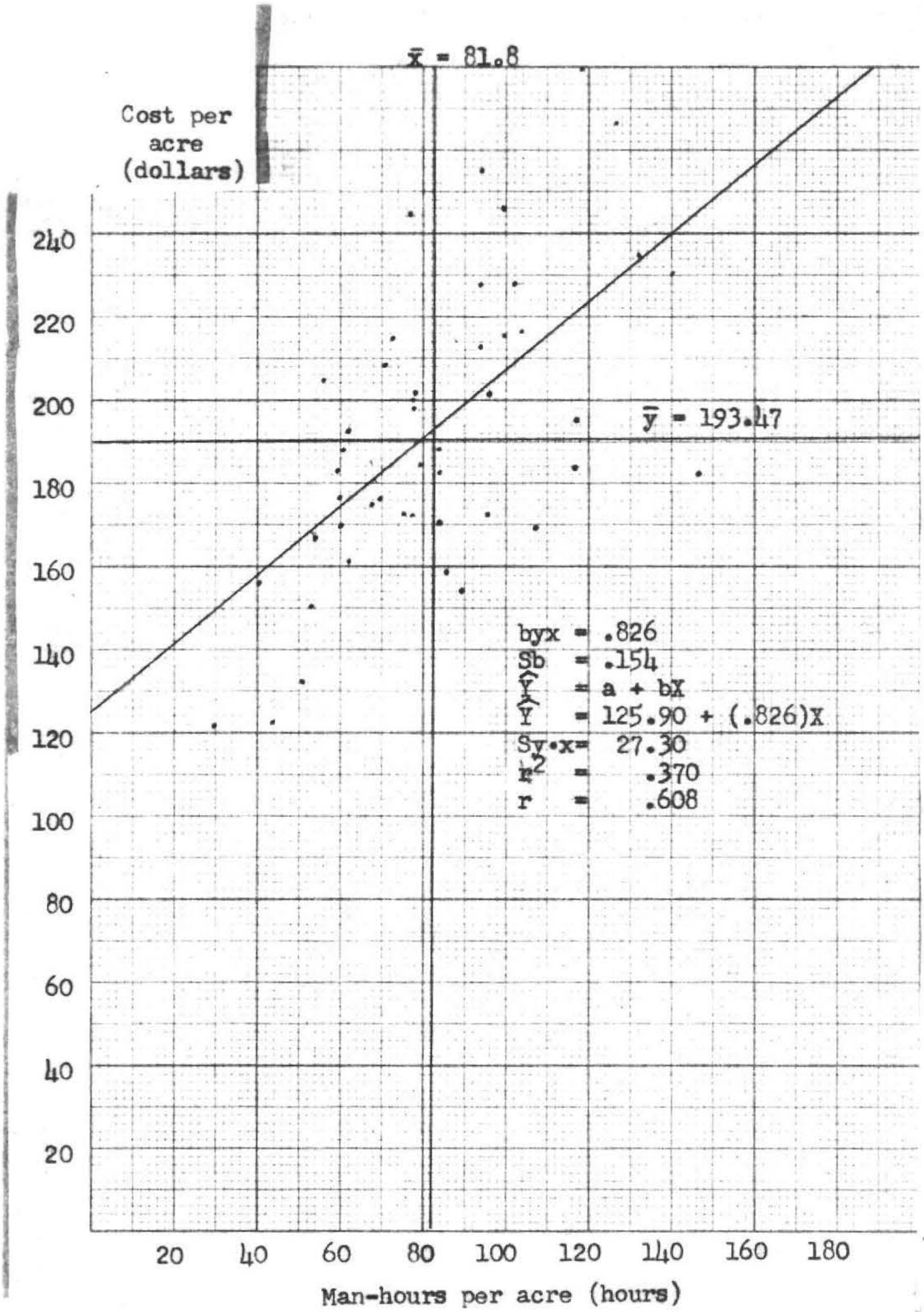

Figure 5. Relationship of man-hours to cost per acre in the production of sugar beets in Utah County, 1951

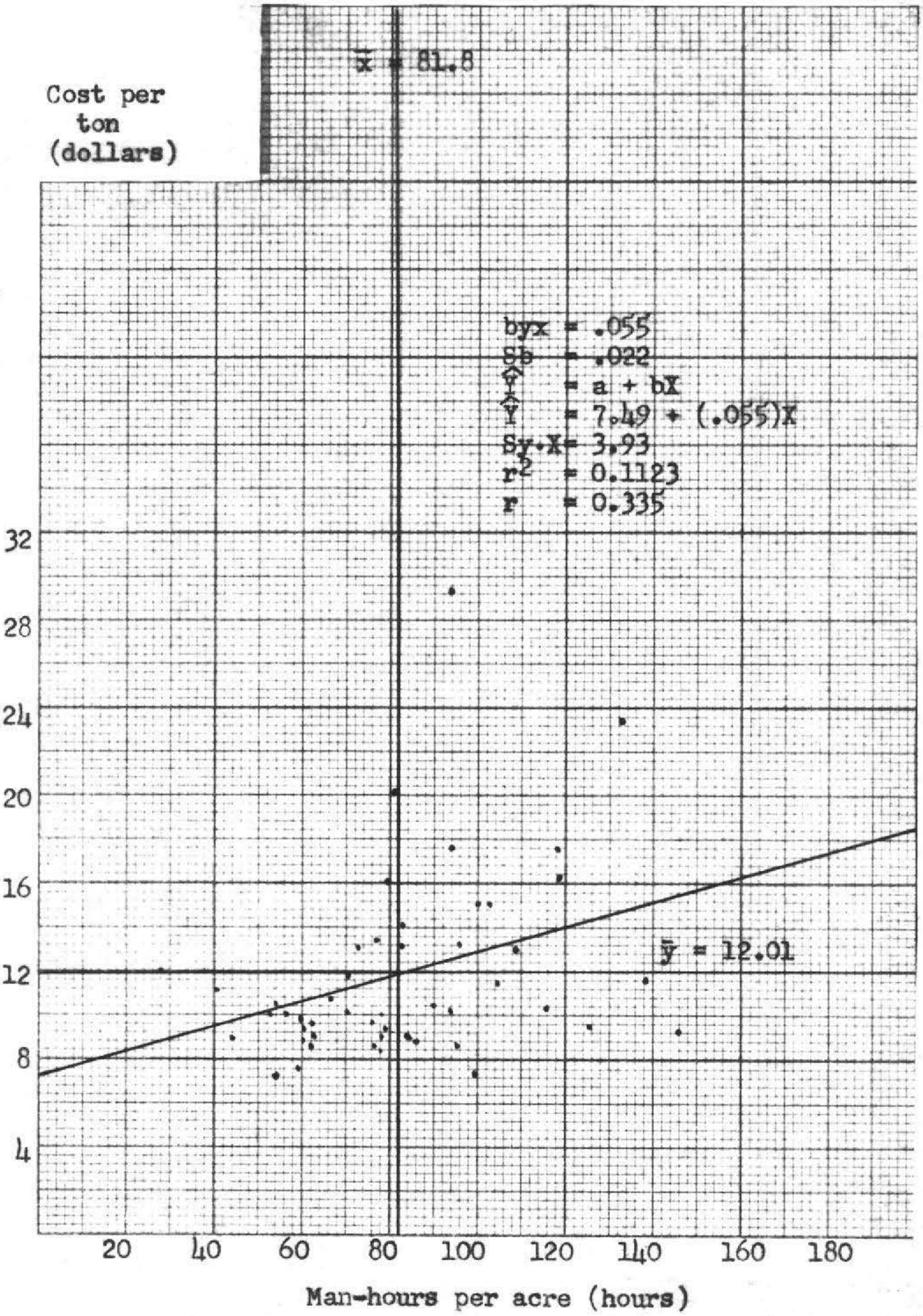

Figure 6. Relationship of man-hours to cost per ton in the production of sugar beets in Utah County, 1951.

When man hours per acre was correlated with net returns per ton (Figure 7) the correlation coefficient, r, was significant at the 5 per cent level. The amount of variation in net returns per ton accounted for by man hours per acre was about 12 per cent. The regression coefficient, b, in this case shows a decrease in net returns per ton as more labor was applied per acre.

The regression of net returns per acre on man hours per acre also shows a downward trend. Net returns decreased as more labor was applied.

As noted previously under size of enterprise there was very little correlation between man hours per acre and size of enterprise. About as much labor per acre was applied to small enterprises as was applied to large enterprises.

Likewise, the correlation between man hours per acre and yield was not high enough to be significant at the 5 per cent level. From this it can be assumed that application of more labor per acre had no effect upon yield.

Efficiency of power and machinery. In order to get some idea of the efficiency of power and machinery used on the farms of this study the records were sorted into three groups on the basis of power and machinery cost per acre. Power and machinery cost was composed of the cost of horse power, trucks, and tractors with their attached machinery. The association of power and machinery cost per acre and net returns, and other factors were noted (Table 7). Net returns per acre increased to a point with additional increments of power and machinery, but beyond that point net returns seemed to decrease. The indications are that the point of marginal net returns had been reached shortly after power and machinery costs had reached $67.00 per acre. This can also be explained by the fact that

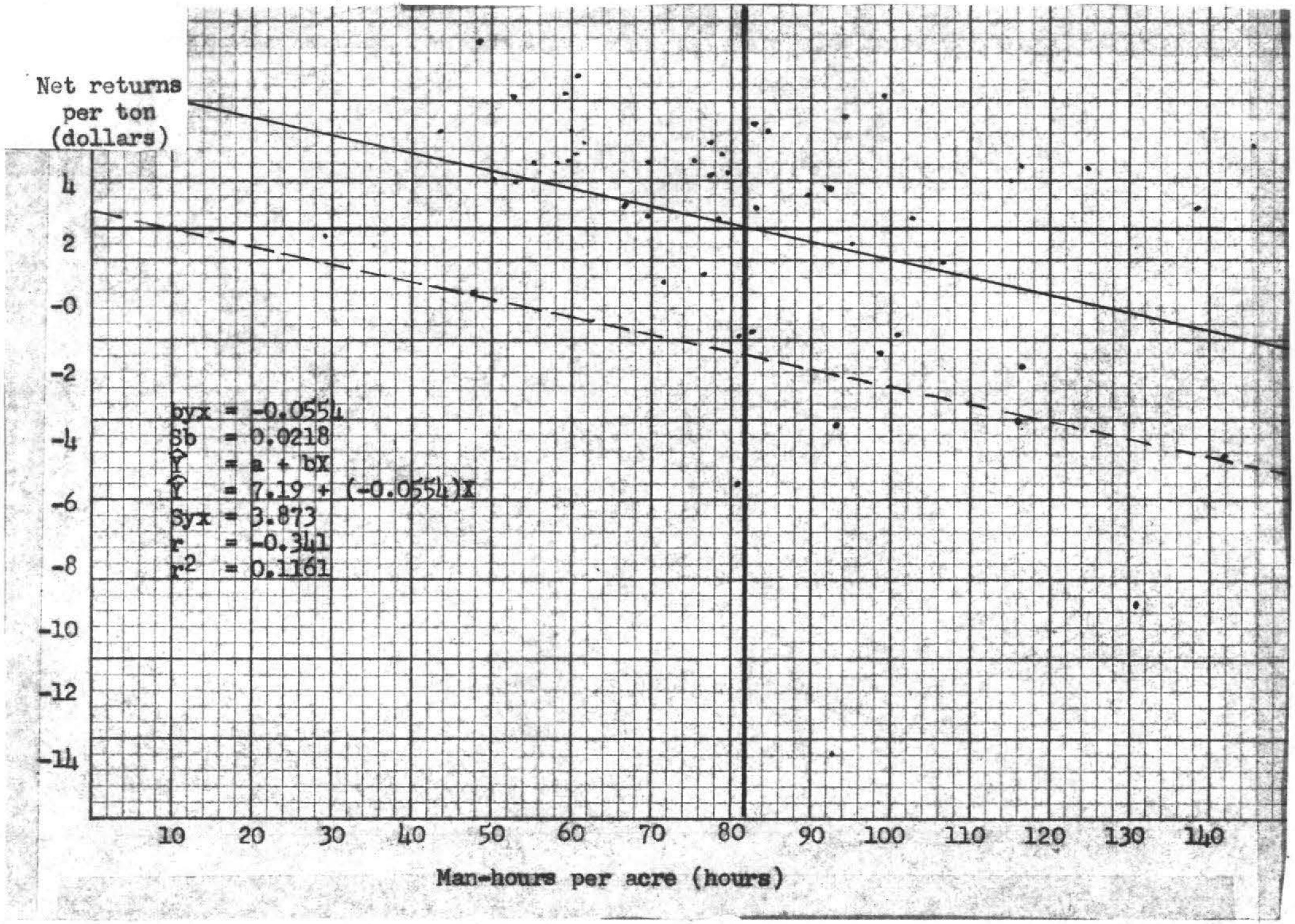

Figure 7. Relationship of man-hours per acre to net returns per ton in the production of sugar beets in Utah County, 1951

Table 7. Relationship of power and machinery cost per acre to net returns and other factors on 51 farms in Utah County, 1951

Power and machinery cost per acre: Range	Power and machinery cost per acre: Average	Number of farms	Acres of beets	P & P* cost per acre	Harvesting cost per acre	Total cost per acre	Yield per acre	Man-hours per acre	Degree of mechanization	Net returns per ton	Net returns per acre
	(dollars)	(no.)	(acres)	(dol.)	(dollars)	(dol.)	(tons)	(hours)	(per cent)	(dollars)	(dollars)
25.00 - 49.99	40.15	17	10.4	27.35	47.67	165.36	15.6	83.4	88	3.47	63.14
50.00 - 66.99	60.90	18	9.2	35.67	55.78	199.46	19.1	78.6	88	3.77	78.07
67.00 - 105.00	79.65	16	9.2	41.17	59.16	216.63	16.5	83.6	93	0.55	25.86
All farms	59.87	51	9.6	34.62	54.11	193.47	17.1	81.8	90	2.66	56.71

* Preparing the seed bed and planting

added units of power, as well as labor, increased the yield up to a certain point. As costs of power and labor increased with no additional increase in yield, net returns decreased sharply as noted in the third group of Table 7.

The regression between power and machinery cost per acre and net returns per acre (Figure 8) shows that there was a significant relationship. The correlation coefficient, r, was not quite high enough to be significant at the 1 per cent level. About 12 per cent of the variation in net returns per acre was associated with power and machinery cost per acre.

The regression coefficient, b, indicates a decrease in net returns per acre of $1.19 for each dollar of increase in power and machinery cost per acre.

The relationship between power and machinery cost per acre and net returns per ton (Figure 9) proved to be highly significant. The coefficient of determination, r^2, indicates that 15 per cent of the variation in net returns per ton was due to power and machinery cost.

The relationship between power and machinery cost per acre and total cost per acre (Figure 10) was also highly significant when tested by the correlation coefficient standards. (11) As power and machinery cost increased $1.00 per acre, total cost increased $1.31 per acre. The cost of labor to operate the tractor would add to total cost. Forty-eight per cent of the variation in total cost per acre was due to power and machinery cost.

The relationship between power and machinery cost and the cost per acre to prepare the seed bed and to plant the beets was significant, as was the cost per acre to harvest.

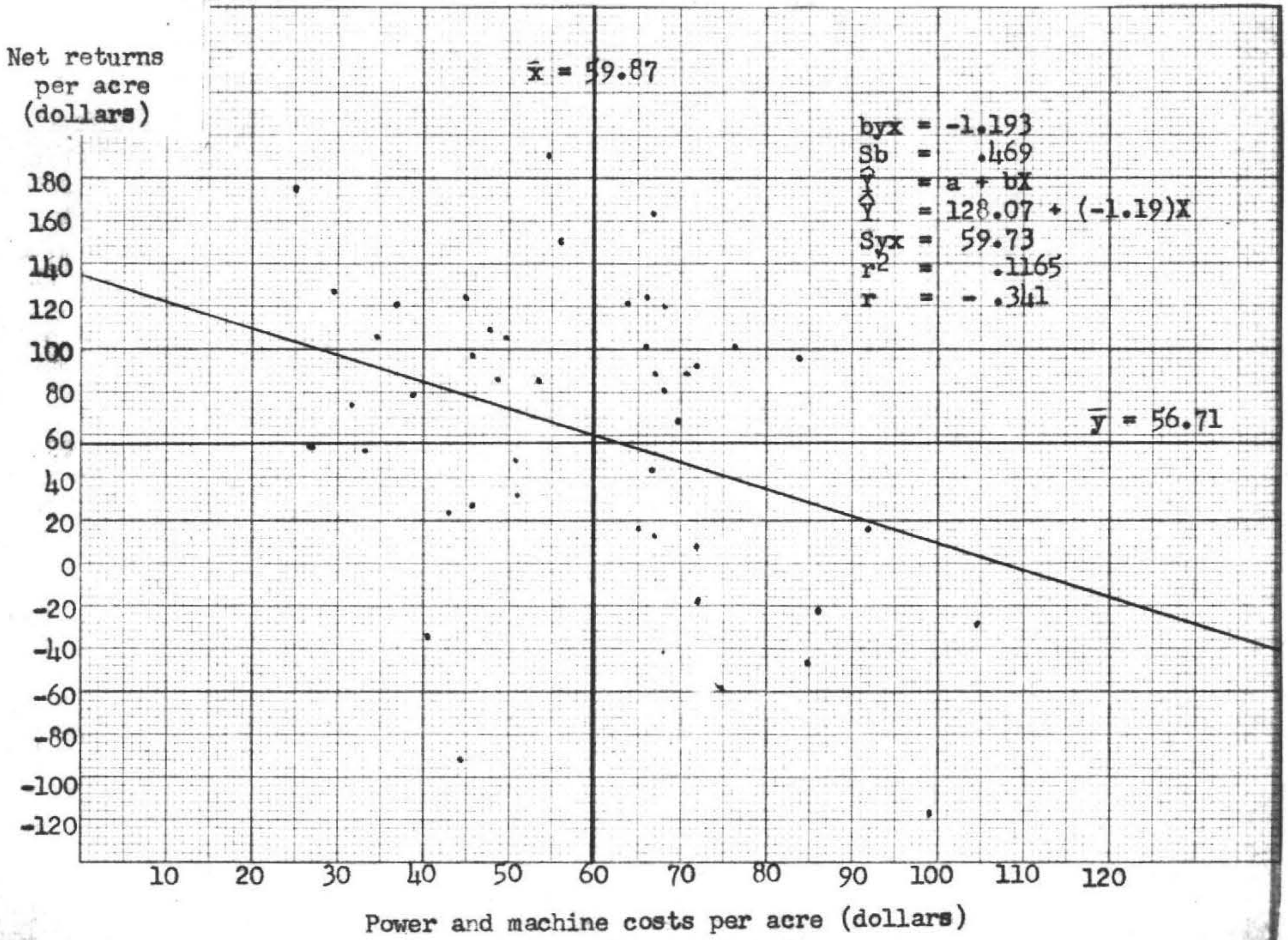

Figure 8. Relationship of power and machine costs to net returns per acre in the production of sugar beets in Utah County, 1951

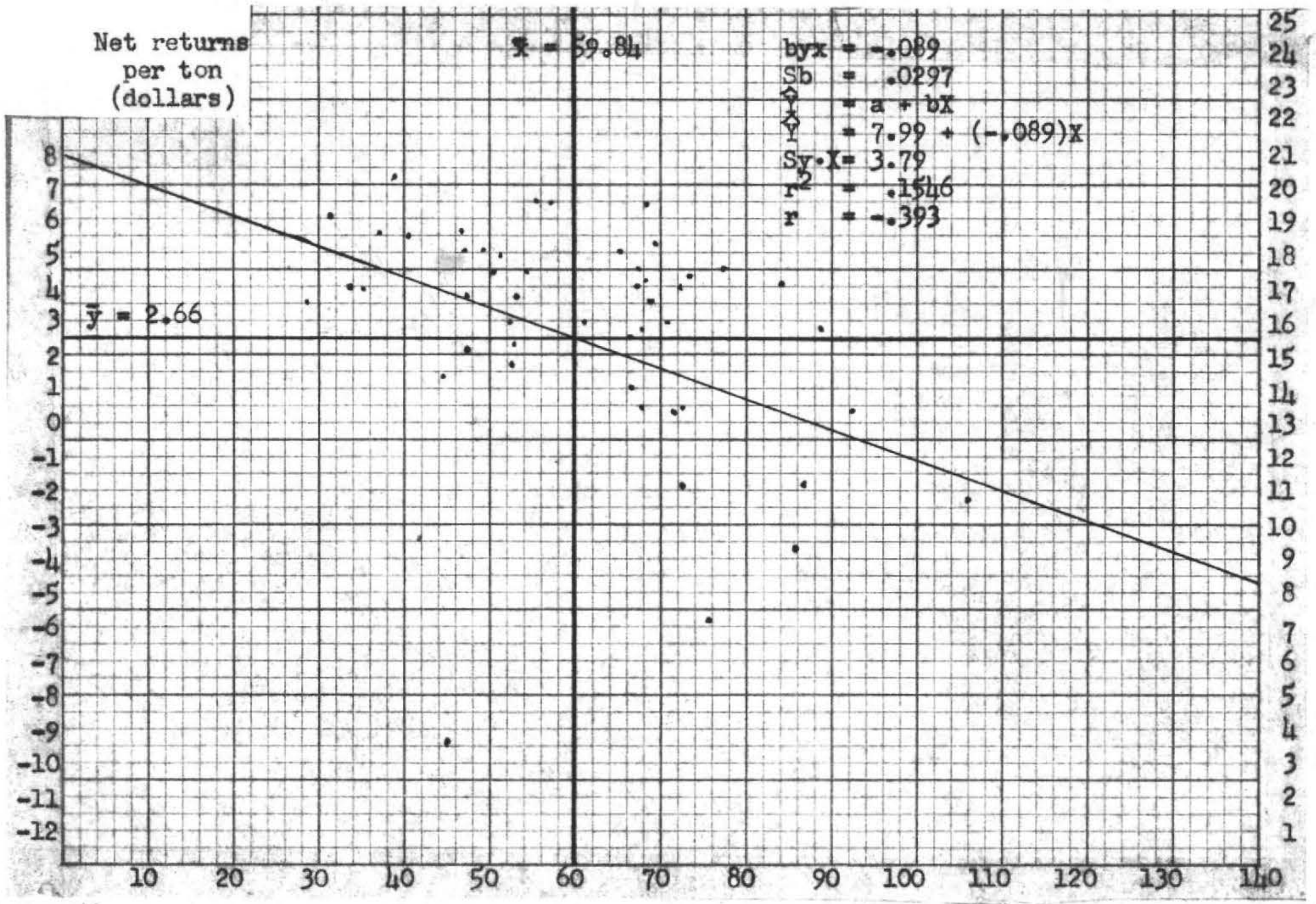

Figure 9. Relationship of power and machine costs per acre to net returns per ton in the production of sugar beets in Utah County, 1951

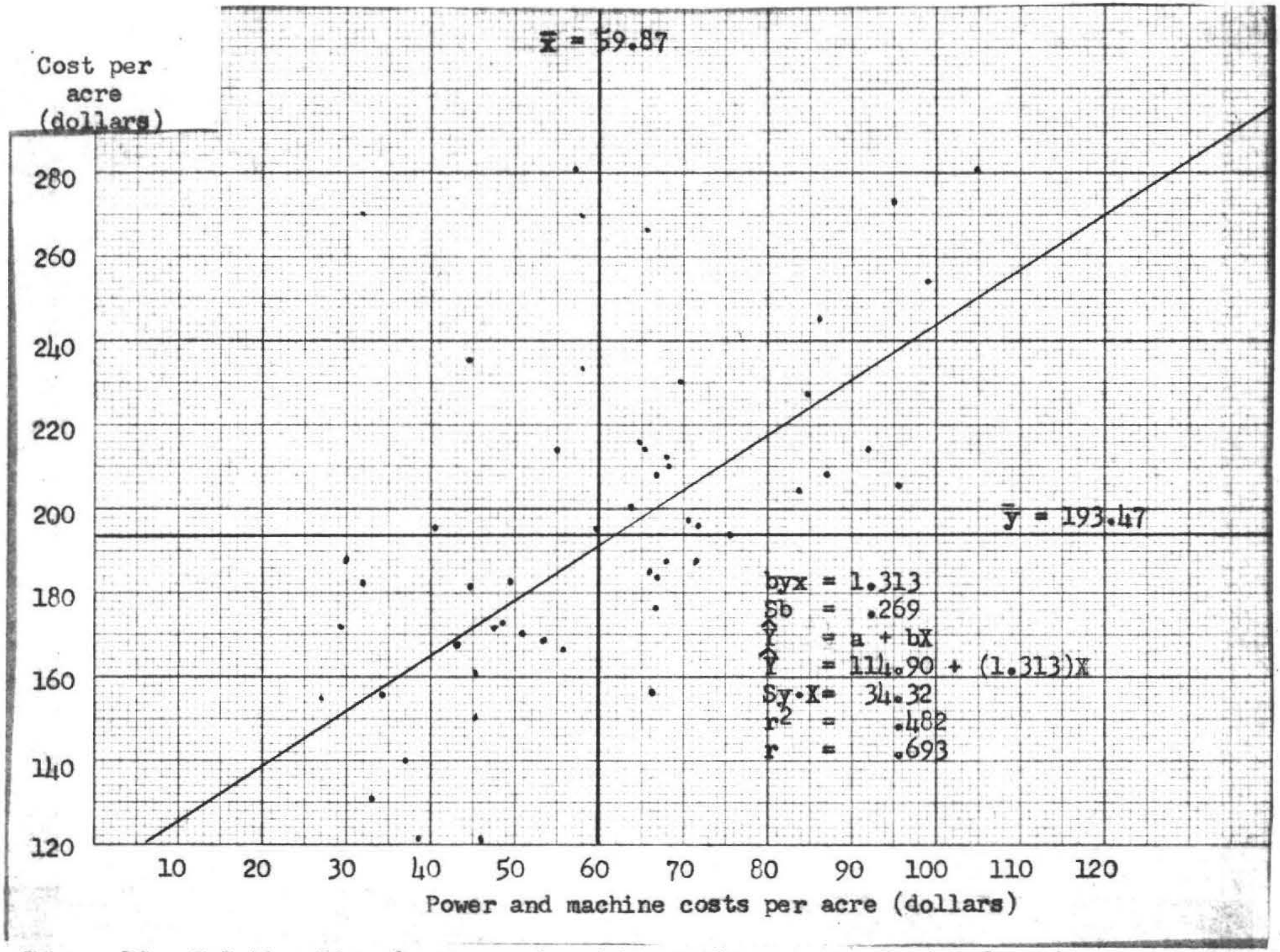

Figure 10. Relationship of power and machine costs per acre to total cost per acre in the production of sugar beets in Utah County, 1951

Power and machinery may be substituted for labor as long as the cost per unit is no greater. The lowest cost for accomplishing the task is the criteria for substitution. If labor is high in price relative to machines, costs may be lessened by substituting machinery for labor. If machinery prices are high relative to labor, costs may be lessened by using more labor and less machinery.

Efficiency and low cost of operation depends upon full use of power and machinery. Overhead costs, such as depreciation, insurance and interest are about the same for the year regardless of the amount of use. As a result, the cost per hour of operation or per unit of work accomplished for power and machinery declines with increased utilization.

Since 1910 the tractor has gradually taken the place of horses as a source of farm power. This study showed that 31 of the 51 farms still used some horse power, while 20 used tractors exclusively as a source of power on their sugar beet enterprise.

The degree of mechanization, which was determined by a ratio of truck and tractor cost to total power and machinery cost, showed no significant difference in the three groups (Table 7). There was no significant relationship between power and machinery cost per acre and the degree of mechanization.

Likewise, there was no relationship between power and machinery cost and man hours of labor or the size of enterprise.

An examination of Table 7 showed that yields increased with additional increments of power and machinery, as measured by cost, until the point of marginal net returns was reached at about 19 tons per acre. Shortly thereafter yields began to decline. Increased use of power and machinery would would not cause yields to decrease, but it would have an effect upon increasing costs and decreasing net returns. However, such factors as soil and climate may affect yields.

Use of mechanical blockers. There were 39 operators who thinned their beets by the hand-hoe method. Eleven operators used a mechanical blocker which reduced the stand of beets to blocks at regular intervals. This method required some hand work to reduce the blocks to single beets. One operator used both methods. It was not known how many acres were thinned by each method, hence his record was not included in this sort. The mechanical blocker required an operator and a tractor with an attachment to chop out beets between the blocks.

It was desired to know whether there was any saving in man hours of labor or cost of thinning by using a mechanical blocker. The records were divided into two groups for this determination, those using all hand labor for thinning and those using a mechanical blocker.

It was found (Table 8) that the mechanical method used 1.8 man-hours per acre in reducing the stand to blocks of beets with the aid of the tractor and its attachment. An additional 16.6 man-hours of labor per acre was required to reduce the blocks to single beets. A total of 18.4 man-hours per acre were required to thin the beets by the mechanical blocking method. By the hand-hoe method the same results were obtained with 17.4 man-hours of labor. When these averages were tested by the "t" test (11) there was found to be no significant difference, at the 5 per cent level. For all practical purposes, it could be said that one method required as much labor as the other.

The cost of labor to operate the mechanical blocker (Table 9) was $1.77 per acre, or approximately $1.00 per hour. The cost of the hand labor to finish the thinning operation amounted to $14.48 per acre, or

Table 8. Comparison of labor requirements by different methods of thinning sugar beets on 51 farms in Utah County, 1951

Method of thinning	No. of farms	Acres per farm	Yield per acre	Thinning Operation Man-hours per acre			Total man-hours per acre	Net Returns	
				Mechan. blocking	Thin after block	Hand-hoe		Per ton	Per acre
	(no.)	(acres)	(tons)	(hours)	(hours)	(hrs.)	(hours)	(dollars)	(dollars)
Hand-hoe	39	9.5	17.4	--	--	17.4	83.4	2.98	62.72
Mechanical blocker	11	10.2	15.8	1.8	16.6	--	74.2	1.48	35.49
All farms	51	9.6	17.1				81.8	2.66	56.71

about $0.91 per hour. The total cost of man labor for mechanical blocking and thinning was $16.25 per acre.

In addition to the hand labor cost there was a power cost of $2.83 per acre for the use of the tractor and blocking attachment charged to the mechanical method. This amounted to $1.76 per hour. The total thinning cost was $19.08 when the mechanical blocker was used as against $15.79 by the hand method.

When the cost of man labor was compared between the two methods of thinning it was found that there was no significant difference at the 5 per cent level. But when the total cost of thinning by the two methods was compared there was a significant difference at the 5 per cent level. The additional cost of the mechanical machinery was enough to make a substantial difference in the total cost of thinning.

Use of mechanical harvesters. It is generally thought that the use of mechanical equipment saves time and reduces costs. In order to determine the effect of mechanical harvesters on man-labor requirements and costs the records were sorted into four groups on the basis of how the sugar beets were harvested (Table 10). In one group of 13 records all the beets were harvested by the hand-topping method, and loaded by hand. In another group of 29 records the harvesting was done by mechanical harvesters that pull, top and load the beets into a hopper or directly into a truck. This method, which completes the harvesting process in one operation, was designated as the combine harvester. In a third group were five records using mechanical harvesters but in two operations the beets were first pulled, topped mechanically and windrowed by a mechanical harvester. Later, when trucks were available the beets were loaded by a mechanical loader. The fourth group of four records started the harvesting operation with mechanical

Table 9. Comparison of cost per acre by different methods of thinning sugar beets on 51 farms in Utah County, 1951

Method of thinning	No. of farms	Acres per farm	Yield per acre	Cost of labor per acre			Thinning costs per acre			Net returns	
				Mechanical blocker	Thin after block	Hand-hoe	Labor cost	P & M cost	Total	Per ton	Per Acre
	(no.)	(acres)	(tons)	(dol.)	(dol.)	(dol.)	(dol.)	(dol.)	(dol.)	(dol.)	(dol.)
Hand-hoe	39	9.5	17.4	--	--	15.79	15.79	--	15.79	2.98	62.72
Mechanical blocker	11	10.2	15.8	1.77	14.48	--	16.25	2.83	19.08	1.48	35.49
All farms	51	9.6	17.1				15.89		16.51	2.66	56.71

Table 10. Relationship of labor requirements for harvesting sugar beets by various methods and net returns on 51 farms in Utah County, 1951

Method of harvesting	No. of farms	Tons harvested per farm	Acres harvested per farm	Yield per acre	Man-hours per acre: Harvesting	Man-hours per acre: Total	Net returns: Per ton	Net returns: Per acre
	(No.)	(tons)	(acres)	(tons)	(hours)	(hours)	(dollars)	(dollars)
Hand harvesting	13	123.5	6.8	18.7	44.2	101.1	3.71	78.23
Combine harvesting	29	175.0	9.8	16.6	15.2	71.7	2.46	52.63
Mechanical harvester and loader	5	242.0	14.3	17.5	14.3	71.8	4.30	75.06
Hand and mechanical harvester	4	156.0	11.2	14.5	42.8	104.6	-1.38	-6.58
All farms	51	167.0	9.6	17.1	24.6	81.8	2.66	56.71

harvesters but due to bad weather, breakdown of machines, and other reasons, resorted to the hand method to finish harvesting. This group has been designated as the hand and mechanical method of harvesting (Table 10).

In analyzing the results of this sort it was found that hand harvesting required 44.2 man-hours per acre while the combine harvesters required 15.2 man-hours per acre. The group using the mechanical harvester and mechanical loader used 14.3 man-hours of labor per acre. Due to adverse conditions the group using both mechanical harvesters and hand labor had high labor requirements, 42.8 man-hours per acre. The average for all farms was 24.6 man hours per acre. On the basis of total man-hours per acre the operators using a mechanical harvester saved about 30 man-hours per acre over those using the hand harvesting method.

The test of significance for the four different methods of harvesting was accomplished by the Analysis of Variance technique. (11) The difference between groups was highly significant. By inspection of Table 10 it is apparent that there was a significant difference between the mechanical methods and those using any hand labor. There was no significant difference between the two mechanical methods or between the two methods using hand labor. These observations were checked by the "t" test.

When considering total cost per acre for harvesting there was no significant difference between the four groups (Table 11). The group using the hand harvesting method had a cost of \$58.32 per acre. The group using the combine harvester had a cost of \$51.98 per acre. The group using both mechanical harvester and loader had a cost of \$53.64 per acre and the group using both the hand and mechanical method had a cost of \$56.70 per acre. The average for all farms was \$54.11 per acre. Even though the labor costs were higher for those using hand harvesting the higher cost of power and

Table 11. Relationship of costs for harvesting sugar beets by various methods and net returns on 51 farms in Utah County, 1951

Method of harvesting	No. of farms	Tons harvested per farm	Acres harvested per farm	Yield per acre	Harvesting cost per acre	Power and machinery cost per acre	Total cost		Net returns	
							Per ton	Per acre	Per ton	Per acre
	(No.)	(tons)	(acres)	(tons)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
Hand harvesting	13	123.5	6.8	18.7	58.32	48.28	10.94	195.87	3.71	78.23
Combine harvesting	29	175.0	9.8	16.6	51.98	66.27	12.19	190.49	2.46	52.63
Mechanical harvester and loader	5	242.0	14.3	17.5	53.64	59.78	10.66	186.15	4.30	75.06
Hand and mechanical harvester	4	156.0	11.2	14.5	56.70	51.17	15.85	216.42	-1.38	-6.58
All farms	51	167.0	9.6	17.1	54.11	59.84	12.01	193.47	2.66	56.71

machinery used in mechanical harvesting tended to equalize the cost of harvesting.

While there is no significant difference in the cost of harvesting by the various methods, the advantage of the mechanical harvester lies in being able to harvest the crop in a shorter period of time, allowing for a longer growing period, and the elimination of difficulties in securing hand labor. As less expensive and more adaptable harvesters come on the market these advantages will increase.

Combined effect of efficiency factors on net returns. Net returns from the sugar beet enterprise depends on reasonable efficiency in all factors which can be controlled by the operator, rather than unusual superiority in one factor. Total returns are limited by low performance in any one of the production factors. A large size enterprise is useless in providing high net returns if it is not accompanied by high yields and relatively high efficiency in the use of labor and machinery.

High efficiency in one factor of production is no assurance of high net returns, but as the number of factors above average increases, higher net returns may be expected.

In order to note the relationship of balance in the various in-put factors to net returns the records were sorted on the basis of the number of factors better than average (Table 12). The factors considered were size of enterprise, yield per acre, man-hours of labor per acre, power and machinery cost per acre. After grouping the records in this way it was possible to note the association between the number of factors better than average and net returns.

There was a positive relationship between the number of factors better than average and net returns. Net returns increased as the number of

Table 12. Relationship of number of factors better than average and net returns and other factors on 51 farms in Utah County, 1951

Number of factors better than average	No. of farms	Acres of beets	Yield per acre	Man-hours per acre	Power and machinery cost per acre	Total cost: Per ton	Total cost: Per acre	Net returns: Per ton	Net returns: Per acre
	(No.)	(acres)	(tons)	(hours)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
0	3	5.7	12.4	94.8	89.54	20.93	242.40	-6.22	-61.72
1	10	6.0	13.5	96.0	64.87	16.47	216.01	-1.70	-17.24
2	6	8.3	17.6	76.8	69.90	11.51	198.11	2.99	56.55
3	17	8.0	17.9	85.2	49.94	10.06	176.51	4.64	86.72
4	10	15.8	19.6	70.1	62.52	9.82	192.27	4.91	95.15
5	5	13.4	18.7	63.4	52.04	9.35	173.52	5.10	96.97
All farms	51	9.6	17.1	81.8	59.87	12.01	193.47	2.66	56.71

factors better than average increased. Size of enterprise and yield showed a positive relationship. Power and machinery cost and man-hours of labor showed a negative or inverse relationship to the number of factors better than average. Proper balance of efficiency factors was important in securing high net returns.

<u>Comparison of most profitable with least profitable enterprises.</u> In order to compare the most profitable enterprises with the least profitable enterprises the records were sorted into two equal groups on the basis of net returns per ton, which was used as the measure of profitableness (Table 13). The average of the most profitable group was compared with the average for the least profitable group as well as with the averages of all enterprises included in this study.

A significant difference was noted in net returns between the most profitable and the least profitable group. Except for the harvesting operation the most profitable group showed greater efficiency in the use of man labor. The most profitable group showed greater efficiency in the use of power and machinery as measured by cost per acre. The size of enterprise was larger and the yields were higher on the most profitable enterprises. These observations substantiate the findings of the previous section relative to the number of factors better than average.

Table 13. Comparison of the most profitable third, least profitable third, and averages of all sugar beet enterprises on 51 farms in Utah County, 1951

Item	Unit	Average of most profitable one-third of enterprises	Average of least profitable one-third of enterprises	Average of all enterprises
Receipts per ton	dol.	14.71	14.71	14.67
Cost per ton	dol.	8.96	16.36	12.01
Net returns per ton	dol.	5.75	-1.65	2.66
Receipts per acre	dol.	287.80	199.08	250.18
Cost per acre	dol.	174.40	213.34	193.47
Net returns per acre	dol.	113.40	-14.26	56.71
Receipts per enterprise	dol.	3136.00	1615.00	2452.00
Cost per enterprise	dol.	1903.00	1650.00	1814.00
Net returns per enterprise	dol.	1233.00	-35.00	638.00
Hours of man labor per acre				
Preparation and planting	hours	11.7	14.9	13.5
Growing of crop	hours	37.9	49.2	43.7
Harvesting of crop	hours	25.3	25.9	24.6
Total	hours	74.9	90.0	81.8
Hours of man labor per ton	hours	3.8	7.0	5.1
Acres in beets	acres	11.1	7.9	9.6
Yield per acre	tons	19.0	13.9	17.1
Power and machinery cost per acre*				
Tractor cost per acre	dol.	35.00	51.00	43.00
Truck cost per acre	dol.	12.00	12.00	12.00
Horse cost per acre	dol.	4.00	4.00	4.00
Total	dol.	51.00	67.00	59.00
Labor cost per acre	dol.	71.00	87.00	79.00
P and M cost per acre*	dol.	51.00	67.00	59.00
Material cost per acre	dol.	21.00	27.00	23.00
Overhead cost per acre	dol.	32.00	32.00	32.00
Total	dol.	175.00	213.00	193.00

* Power and machinery

SUMMARY

1. This study included 51 farms producing sugar beets in Utah County for the crop year 1951. The acreage of sugar beets on these farms ranged from three to 32 acres with an average of 9.6 acres. Of the total sugar beet acreage in Utah County in 1951, 488.6 acres or about 20 per cent was represented in this study.

2. The labor required to produce an acre of sugar beets averaged 81.8 man-hours. The labor required to prepare the seed bed and plant the beets was 13.5 man-hours per acre, or 16.5 per cent of the total labor requirements at a cost of $13.00 per acre. Growing the crop from planting time to harvest time required 43.7 man-hours per acre, or 53.4 per cent of the total labor at a cost of $42.08 per acre. Harvesting operations required 24.6 man-hours per acre, or 30.1 per cent of the total man-hours at a cost of $23.68 per acre.

3. The average cost of producing sugar beets was $193.47 per acre, or $12.01 per ton. Labor cost averaged $78.76 per acre, or $4.89 per ton which was 40.7 per cent of total costs. Power and machinery costs were $59.87 per acre, $3.71 per ton, or 30.9 per cent of total costs. Material costs amounted to $22.73 per acre, or $1.42 per ton, which was 11.8 per cent of total costs. Overhead costs were $32.11 per acre, $1.99 per ton and 16.6 per cent of total costs.

4. Receipts from sugar beets sold by contract were $11.42 per ton. The tops were valued at $0.92 per ton of beets and the government benefit payment amounted to $2.33 per ton, making the gross receipts $14.67 per ton of beets produced.

5. Net returns averaged \$56.71 per acre, or \$2.66 per ton. Net returns varied from minus \$13.83 to plus \$7.45 per ton. Forty-two enterprises had positive net returns, and nine had negative net returns. Thi Thirty-five had net returns per ton above the average.

6. Size of enterprise measured in acres of beets was closely associated with net returns. On a per ton basis net returns increased and costs decreased as size of enterprise increased. There was a tendency for man-hours and power and machinery costs to decrease as the size of enterprise increased but the difference was not statistically significant.

7. The average yield of the 51 farms was 17.1 tons per acre. Yield per acre was closely associated with cost of production and net returns. Net returns per ton and per acre increased as yield increased but at a faster rate, indicating that high yields are associated with high net returns. Total cost per ton decreased as yield increased. There was no relationship between yield and man labor. Small enterprises had yields as high as large enterprises. The relationship between yield and the size of enterprise was not statistically significant at the 5 per cent level.

8. Efficient use of labor was important in achieving low cost production and high net returns. Those farms using less than the average amount of man labor showed the highest returns. The average amount of labor required to produce an acre of sugar beets was 81.8 man-hours. The small enterprises were as efficient in the use of man labor as were the large enterprises. The relationship between labor efficiency and yield was not statistically significant at the 5 per cent level.

9. Power and machinery cost averaged \$59187 per acre. The relationship between power and machinery cost and net returns was statistically significant at the 1 per cent level. There was also a close relationship

between power and machinery cost and total costs. There was no significant relationship between power and machinery cost and yield, man-hours of labor and size of enterprise.

10. It required 17.4 man-hours per acre to thin the beets by the hand-hoe method. When a mechanical blocker was used followed by hand thinning 18.4 man-hours were required. The total cost of thinning when mechanical blockers were used was \$19.08 per acre as compared with \$15.79 by the hand method. The average hourly rate by the hand method was \$0.96 while \$1.08 was the hourly rate for the mechanical method.

11. Those farms using mechanical harvesters used less than the average amount of man labor but their power and machinery costs per acre were higher. The farms using mechanical harvesters averaged about 30 man-hours less per acre than did those using hand labor for harvesting. Costs, however, were about the same. Labor costs for more labor in harvesting by hand were about equal to power and machinery costs where mechanical harvesters were used.

12. The farms having less than two factors better than average showed expenses in excess of receipts. The operators who were able to attain efficiency better than average in a number of factors received high net returns. Net returns increased from minus \$6.22 to plus \$5.10 per ton as the number of factors better than average increased.

13. The most profitable third of the enterprises had the higher yields and the larger enterprises. They also had lower costs and higher net returns. The least profitable third compared favorably with the most profitable third in horse costs per acre, truck costs, labor requirements for harvesting, and general overhead costs. The most profitable third had lower power and machinery costs and used less man labor per acre than the least profitable third.

CONCLUSIONS

From the data assembled in this study it is concluded that sugar beets can be profitably produced in Utah County. When attention was given to the various efficiency factors high net returns were the result.

The average amount of time spent in producing an acre of sugar beets compared favorably with other reports. Hours of man labor to produce an acre of sugar beets have been reduced in the past few years. With the development and improvement of mechanical machinery further reductions may be expected.

The total cost of producing sugar beets in Utah County has increased since the 1945 study was made. Costs in general increased during the same period. The greatest increase in cost was that of power and machinery. More extensive use of mechanical machinery resulted in higher power and machinery cost. This, no doubt, accounted for some of the reduction in labor requirements.

By trimming costs, a little here and a little there, net returns can be increased. This probably would be the most effective way for most producers to increase their net returns. It would not be feasible to cut out any one operation to reduce costs but it would be judicious to trim costs as a tree is trimmed. More attention on the part of most operators to costs and their effect on net returns would aid them in achieving a successful enterprise.

The data reveal no saving in man-hours by the use of mechanical blockers. In fact, it required more labor per acre with the mechanical blocker than without. Since mechanical blockers were in the experimental stage in Utah County, soil conditions and other factors may have hampered their most efficient use. As more efficient thinning equipment comes on the market, labor requirements should decrease. Because of the added labor cost, along with the cost of the mechanical machinery, thinning costs were higher with mechanical machinery than by the hand-hoe method. The evidence was not conclusive on this point; therefore, further study needs to be done in the area of mechanical thinners.

More reliable conclusions can be made relative to mechanical harvesters, mainly because they have been in use longer than mechanical thinners. Mechanical harvesters were responsible for large decreases in man power during the harvest. This is significant in an area where the labor supply for sugar beet harvesting is limited. Since the saving in labor cost was cancelled by the increased power and machinery costs, harvesting costs by mechanical harvesters were about the same as when harvested by hand. The fact that the harvesting operation can be completed in less time at no additional cost above hand harvesting should encourage farmers to expand their acreage and reap the benefits of enlarged enterprises.

The permanency of the sugar beet industry in Utah County will depend upon the ability of the farmers to make adjustments to various conditions, which are within their control. Among these conditions are the feasibility of enlarging the sugar beet enterprise per farm, combining capital resources with neighbors in the ownership of mechanical harvesters and thinners and improving the fertility of their soil.

The data of this study showed that the nine farms with negative net returns were all below the average in size or acres in sugar beets. On the other hand, 16 farms showed net returns above the average as the size of enterprise increased above average. Indications are that large net returns were closely associated with the large enterprises.

Another important condition or factor to consider is yield. It was found that yields were more closely associated with net returns than any other factor. Those farmers who showed high yields also showed high net returns. Attention to those factors responsible for high yields should be given first consideration.

Efficient use of labor is another factor of great importance. Man-hours per acre was highly significant when correlated with total cost per acre. Getting the most out of labor for each unit of in-put helps to reduce the cost per unit. This is especially true under conditions where labor costs are high or where labor is scarce at thinning or harvest time. Efficient use of labor is the most effective way to reduce costs.

Low power and machinery costs per acre was highly correlated with low costs per acre. Similarly, low power and machinery costs per acre were closely associated with high net returns. The operator thus has another means of lowering cost and increasing net returns.

At least four methods are available for increasing net returns on sugar beet enterprises, providing other factors remain the same. These factors are all within the control of the operator. It is up to him to apply the in-put factors in such a manner as to maximize his net returns. This is the essence of efficient management and a successful sugar beet enterprise.

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APPENDIX A

Sugar Beet Survey

SUGAR BEET SURVEY
UTAH STATE AGRICULTURAL COLLEGE EXP. STATION
DEPARTMENT OF AGRICULTURAL ECONOMICS

Record No.

(Crop Year)

Operator ______________________ Town ______________________

County ________________ Post Office ________________

Acres in sugar beets ___ Value per acre _____ Total value __________

What is the assessed value of this land _____ Mill levy __________

Machinery and Buildings

Kind	Age	Beg. value	Re- pairs	De- prec.	End value	Avg. value	Charged to beets: Per cent	Value	Re- pairs	Deprec.
Beet drill										
Cultivator										
Puller										
Harvester										
Topper										
Spreader										
Plow										
Harrow										
Disc										
Level										
Ditcher										
All others										
Total										
Machine shed										
Other bldgs.										
Total										

OPERATIONS PERFORMED BY OPERATOR AND OPERATOR'S FAMILY
Labor and Power Record

	Operations	No. x over	Kind and size of equipment used	Man		Tractor		Truck		Horse		
				Hrs	Am't	Hrs	Am't	Hrs	Am't	Hrs	Am't	Am't
Planting & Preparation	Manuring											
	Fertilizing											
	Plowing											
	Harrowing											
	Drilling											
	Ditching											
	Sub-total:											
Growing	Thinning											
	Cultivating											
	Hoeing											
	Irrigating											
	Sub-total:											
Harvesting												
	Loading											
	Hauling											
	Sub-total											
	Total											

Convert children's labor to man-hours on the following scale: 16 and over equals 1 man, 15-16 equals 7/8, 14-15 equals 3/4, 13-14 equals 5/8, 12-13 equals 1/2, 11-12 equals 1/4. If because of the type of operation a boy under 16 years is just as productive in performing all of the requirements of that operation, the rate may be adjusted accordingly.

OPERATIONS PERFORMED BY HIRED LABOR
Labor and Power Record

	Operations	No. x over	Kind and size of equipment used	Man		Tractor		Truck		Horse		Total Am't
				Hrs	Am't	Hrs	Am't	Hrs	Am't	Hrs	Am't	
Planting & Preparation	Manuring											
	Fertilizing											
	Plowing											
	Harrowing											
	Drilling											
	Ditching											
	Sub-total:											
	Thinning											
Growing	Cultivating											
	Hoeing											
	Irrigating											
	Sub-total:											
Harvesting	Loading											
	Hauling											
	Sub-total:											
	Total hired											
	Total operator & op. family											
	Grand total											

EXPENSE

Item	Time	Quant.	Price	Cost
Fertilizers				
Seed				
Other				
Fees				
Total Material Cost				

Fixed overhead charges assigned to sugar beet enterprise:	
Interest on money in crop	
Interest on capital investment	
Building upkeep	
Building depreciation	
Equipment repairs	
Taxes: Land	
Drainage	
Water	
Overhead charges - misc.	
TOTAL FIXED COSTS	

Income from sugar beet enterprise

Product	Amount	Price	Receipts
Beets			
Tops			
Gov't payment			
TOTAL RECEIPTS			

INTEREST ON MONEY IN CROP

Item	Am't	Time	Int.
Labor: Prep. & Planting			
Growing			
Harvesting			
Fertilizers:			
Seed			
Other			
Total			

Summary	
Material costs	
Overhead costs	
Operator's family labor costs	
Hired labor costs	
Total Costs	
Net receipts	
NET RETURNS FROM ENTERPRISE	
Return to operator and family	
Number of acres	
Number of tons	
Total man-hours	
Net returns per acre	
Net returns per ton	
Total cost per acre	
Total man-hours per acre	
Total man-hours per ton	

1. Plant diseases or insects infested sugar beets this year (badly___), (slightly_____), (not at all____). Did you spray or dust?_______. What insect or disease was troublesome?_______________________.

2. Crops grown and fertilizer applied to land in sugar beets this year and during the past four years.

Item	1951	1950	1949	1948	1947
Crop grown					
Manure Total amount Quality					
Lbs. of commercial fertilizer					

Notes:

How far apart do you plant rows of sugar beets?_________

How far apart do you like to leave beets in the row when thinning?______

What percentage stand of beets did you attain this year?________

Enumerator	Date	Checked by

APPENDIX B

Computation of Various Statistical Values

$SX = 488.6$	$SY = 135.62$	
$\bar{x} = 9.6$	$\bar{y} = 2.66$	$N = 51$
$SX^2 = 7036.46$	$SY^2 = 1192.34$	$SXY = 1874.78$
$(SX)^2/N = 4680.98$	$(SY)^2/N = 360.64$	$(SX)(SY)/N = 1299.29$
$Sx^2 = 2355.48$	$Sy^2 = 831.70$	$Sxy = 575.49$

$$byx = \frac{Sxy}{Sx^2} = \frac{575.49}{2355.48} = 0.2443$$

$$bxy = \frac{Sxy}{Sy^2} = \frac{575.49}{831.70} = 0.6919$$

$$r^2 = (byx)(bxy) = (0.2443)(0.6919) = 0.1690$$

$$r = \sqrt{r^2} = \sqrt{0.1690} = 0.4111$$

Where:

$Sdy{\cdot}x^2$ = Sum of squares of deviations from regression

$Sy{\cdot}x^2$ = Variance from regression, or average deviation from regression.

$Sy{\cdot}X$ = Standard error of estimate or Standard deviation from regression

sb = Standard error of byx.

Then:

$$Sdy{\cdot}x^2 = Sy^2 - (Sxy)^2/Sx^2 = 831.7 - 240.6 = 591.1$$

$$Sy{\cdot}x^2 = Sdy{\cdot}x^2/N-2 = 591.1/49 = 12.0633$$

$$Sy{\cdot}x = \sqrt{Sg{\cdot}x^2} = \sqrt{12.0633} = 3.47$$

$$sb^2 = Sy{\cdot}x^2/Sx^2 = 12.06/2355.48 = 0.00512137$$

$$Sb = \sqrt{sb^2} = \sqrt{0.00512137} = 0.07156$$

$t = \frac{b}{sb} = \frac{0.2443}{0.07156} = 3.39$ Significant at 1% level with 49 degrees of freedom

$t_{.05}$ (49 d.f.) = 2.009

$t_{.01}$ (49 d.f.) = 2.7895

Figure 1. Computation of regression between size of enterprise (X) and net returns per ton (Y)

$SX = 871.0$	$SY = 132.26$	
$\bar{x} = 17.1$	$\bar{y} = 2.66$	$N = 51$
$SX^2 = 15694.$	$SY^2 = 1162.$	$SXY = 2824.$
$(SX)^2/N = 14875.$	$(SY)^2/N = 343.$	$(SX)(SY)/N = 2259.$
$Sx^2 = 819.$	$Sy^2 = 819.$	$Sxy = 565.$

$$byx = \frac{Sxy}{Sx^2} = \frac{565}{819} = .690$$

$$bxy = \frac{Sxy}{Sy^2} = \frac{565}{819} = .690$$

$$r^2 = (byx)(bxy) = (.690)(.690) = .4761$$

$r = .689$ Significant at 1 percent level

$$a = \bar{y} - b\bar{x} = 2.66 - (.690)(17.1) = 2.66 - 11.80 = -9.14$$

$$\hat{Y} = a + b(x) = -9.14 + (.69)(17.1) = 2.66$$

$$Sdy \cdot x^2 = Sy^2 - (Sxy)^2/Sx^2 = 819.0 - \frac{319225}{819} = 429$$

$Sy \cdot x^2 = Sdy \cdot x^2/n-2 = \frac{429}{49} = 8.7714$ = Variance

$Sy \cdot x = \sqrt{Sy \cdot x^2} = \sqrt{8.7714} = 2.96$ Standard error of estimate

$$Sb^2 = Sy \cdot x^2/Sx^2 = \frac{8.7714}{819} = .01071$$

$Sb = \sqrt{Sb^2} = \sqrt{0.01071} = .104$ Standard error of byx

$t = \frac{b}{Sb} = \frac{.690}{.104} = 6.6346$ Significant at 1% level

$t_{.05} = 2.009$ with 49 d.f.
$t_{.01} = 2.7895$ with 49 d.f.

Figure 2. Computations of regression between yield (X) and net returns per ton (Y)

$SX = 871.0$	$SY = 2892.$	
$\bar{x} = 17.1$	$\bar{y} = 56.71$	$N = 51$
$SX^2 = 15694.$	$SY^2 = 361918.$	$SXY = 60042.$
$(SX)^2/N = 14894.$	$(SY)^2/N = 164000.$	$(SX)(SY)/N = 49460.$
$Sx^2 = 800.$	$Sy^2 = 197918.$	$Sxy = 10582.$

$$byx = \frac{Sxy}{Sx^2} = \frac{10582}{800} = 13.23$$

$$bxy = \frac{Sxy}{Sy^2} = \frac{10582}{197918} = .0535$$

$$r^2 = (byx)(bxy) = (13.23)(.0535) = .7073$$

$r = \sqrt{r^2} = \sqrt{.7073} = .841$ Highly Significant

$$a = \bar{y} - b\bar{x} = 56.71 - (13.23)(17.1) = 56.71 - 226.23 =$$

$$a = -169.53$$

$$\hat{Y} = a + bX = -169.53 + (13.23)(17.1) = 56.71$$

$$Sdy \cdot X^2 = Sy^2 - (Sxy)^2/Sx^2 = 197918 - \frac{10582.}{800} = 197905.$$

$Sy \cdot x^2 = Sdy \cdot x^2/n-2 = \frac{197905}{49} = 4038.868$ = Variance

$Sy \cdot x = \sqrt{Sy \cdot x^2} = \sqrt{4038.868} = 63.55$ Standard error estimate

$$Sb^2 = Syx^2/Sx^2 = \frac{4038.868}{800} = 5.05$$

$Sb = \sqrt{Sb^2} = \sqrt{5.05} = 2.25$ Standard error of byx

$t = \frac{b}{Sb} = \frac{13.23}{2.25} = 5.88$ Significant at 1% level

Figure 3. Computations of regression between yield (X) and net returns per acre (Y)

$SX = 871.$	$SY = 612.4$	
$\bar{x} = 17.1$	$\bar{y} = 12.0$	$N = 51$
$SX^2 = 15694.$	$SY^2 = 8208.$	$SXY = 9869.$
$(SX)^2/N = 14894.$	$(SY)^2/N = 7355.$	$(SX)(Y)/N = 10472.$
$Sx^2 = 800.$	$Sy^2 = 853.$	$Sxy = -603.$

$$byx = \frac{Sxy}{Sx^2} = \frac{-603}{800} = -0.7545$$

$$bxy = \frac{Sxy}{Sy^2} = \frac{-603.}{853} = -0.7076$$

$$r^2 = (byx)(bxy) = (-0.7545)(-0.7076) = 0.5339$$

$$r = \sqrt{r^2} = \sqrt{0.5339} = -0.73$$

$$a = \bar{y} - b\bar{x} = 12.01 - (-0.7545)(17.1) = 12.01 - (-12.90) =$$
$$a = 24.91$$

$$\hat{Y} = a + bX = 24.91 + (-0.7545)(17.1) = 12.01$$

$$Sdy.x^2 = Sy^2 - (Sxy)^2/Sx^2 = 853 - (-603)^2/800 = x\ 455.26$$

$Syx^2 = Sdy.x^2/n-2 = 455.26/49 = 9.29$ Variance

$Syx = \sqrt{Syx^2} = \sqrt{9.29} = 3.05$ Standard error of estimate

$$Sb^2 = Syx^2/Sx^2 = 9.29/800. = .011615$$

$Sb = \sqrt{Sb^2} = \sqrt{.011615} = .108$ Standard error of byx

$t = \frac{b}{Sb} = \frac{-.7545}{.108} = -6.986$ Significant at 1% level

$t_{.05} = 2.009$ with 49 df.

$t_{.01} = 2.7895$ with 49 df.

Figure 4. Computations of regression between yield (X) and cost per ton (Y)

$SX = 4,170.8$	$SY = 9,867.$	
$\bar{x} = 81.8$	$\bar{y} = 193.47$	$N = 51$
$SX^2 = 372,564.$	$SY^2 = 1,966,967.$	$SXY = 832,926.$
$(SX)^2/N = 341,090.$	$(SY)^2/N = 1,908,974.$	$(SX)(SY)/N = 806,927.$
$Sx^2 = 31,474.$	$Sy^2 = 57,993.$	$Sxy = 25,999.$

$$byx = \frac{Sxy}{Sx^2} = \frac{25,999.}{31,474.} = .826$$

$$bxy = \frac{Sxy}{Sy^2} = \frac{25,999}{57,993} = .4483$$

$$r^2 = (byx)(bxy) = (\ .826)(.4483) = .370$$

$$r = \sqrt{r^2} = \sqrt{.370296} = .608$$

$$a = y - bx = 193.47 - (.826)(81.8) = 193.47 - 67.57 = 125.90$$

$$Y = a + bx = 125.90 + (.826)(81.8) = 193.47$$

$$Sdy\cdot x^2 = Sy^2 - (Sxy)^2/Sx^2 = 57,993 - (25,999)^2/31474 =$$
$$= 57,993 - 21,476 = 36,517$$

$Syx^2 = Sdy\cdot x^2/n-2 = 36,517/49 = 745.25$ Variance

$Syx = \sqrt{Syx^2} = \sqrt{745.25} = 27.30$ Standard error of estimate

$$Sb^2 = Syx^2/Sx^2 = 745.25/31,474. = .023678$$

$Sb = \sqrt{Sb^2} = \sqrt{.023678} = .1538$ Standard error of byx

$t = \frac{b}{Sb} = \frac{.826}{.1538} = 5.37$ Significant at 1% level

$t_{.05} = 2.009$ with 49 df.

$t_{.01} = 2.7895$ with 49 df.

Figure 5. Computation of regression between man-hours per acre (X) and total cost per acre (Y)

$SX = 4{,}170.8$	$SY = 612.40$	
$\bar{x} = 81.8$	$\bar{y} = 12.01$	$N = 51$
$SX^2 = 372{,}564.1$	$SY^2 = 8207.70$	$SXY = 51{,}819.27$
$(SX)^2/N = 341{,}089.6$	$(SY)^2/N = 7353.60$	$(SX)(SY)/N = 50{,}082.31$
$Sx^2 = 31{,}474.5$	$Sy^2 = 854.10$	$Sxy = 1{,}736.96$

$$byx = \frac{Sxy}{Sx^2} = \frac{1{,}736.96}{31{,}474.5} = 0.0552$$

$$bxy = \frac{Sxy}{Sy^2} = \frac{1736.96}{854.10} = 2.0337$$

$$r^2 = (byx)(bxy) = (0.0552)(2.0337) = 0.11226$$

$$r = \sqrt{r^2} = \sqrt{0.1126} = 0.335$$

$$a = \bar{y} - b\bar{x} = 12.01 - (0.0552)(81.8) = 12.01 - 4.52 = 7.49$$

$$\hat{Y} = a + b(x) = 7.49 + (0.0552)(81.8) = 7.49 + 4.52 = 12.01$$

Where:
$Sy{\cdot}x$ = Standard deviation from regression, or Standard error of estimate.

$$Sy.x = \sqrt{Sy{\cdot}x^2}$$

$Sy{\cdot}x^2 = Sdy{\cdot}x^2/(n-2)$ = the variance from regression or average deviation from regression

$Sdy{\cdot}x^2 = Sy^2 - (Sxy)^2/Sx^2$ = Sum of squares of deviations from regression

$$Sdy{\cdot}x^2 = 854.1 - (3{,}017{,}169)/31{,}474.5 = 854.1 - 95.86 = 758.14$$

$$Sy{\cdot}x^2 = 758.14/49 = 15.47$$

$$Sy{\cdot}x = \sqrt{Sy{\cdot}x^2} = \sqrt{15.47} = 3.933$$

3.933 = Standard error of estimate.

$$Sb^2 = Sy{\cdot}x^2/Sx^2 = 15.47/31{,}474.5 = 0.0004915$$

$$Sb^2 = 0.0004915$$

$$Sb = \sqrt{Sb^2} = \sqrt{0.0004915} = 0.02217$$

0.02217 = Standard error of **byx**

$t = \frac{b}{Sb} = \frac{0.0552}{0.02217} = 2.489$ Significant at 5% level with 49 degrees of freedom

$t.05$ = d.f. 49 = 2.009 Significant
$t.01$ = d.f. 49 = 2.7895

Figure 6. Computations of regression between man-hours per acre (X) and cost per ton (Y)

$SX = 4{,}170.8$	$SY = 135.62$	
$\bar{x} = 81.8$	$\bar{y} = 2.66$	$N = 51$
$SX^2 = 372{,}564.10$	$SY^2 = 1192.34$	$SXY = 9348.15$
$(SX)^2/N = 341{,}089.60$	$(SY)^2/N = 360.64$	$(SX)(SY)/N = 11091.06$
$Sx^2 = 31{,}474.50$	$Sy^2 = 831.70$	$Sxy = -1742.91$

$$byx = \frac{Sxy}{Sx^2} = \frac{-1{,}742.91}{31{,}474.50} = -0.055375$$

$$bxy = \frac{Sxy}{Sy^2} = \frac{-1742.91}{831.70} = -2.0956$$

$$r^2 = (byx)(bxy) = (0.055375)(-2.0956) = 0.116096$$

$$r = \sqrt{r^2} = \sqrt{0.116096} = 0.3407$$

$$a = \bar{y} - b\bar{x} = 2.66 - (-0.0554)(81.8) = 2.66 - (-4.53)$$

$$a = 7.19 \qquad \hat{Y} = a + b(X) = 7.19 + (-0.0554)(81.8) = 2.66$$

$$Sdy \cdot x^2 = Sy^2 = (Sxy)^2/Sx^2 = 831.7 - 96.51 = 735.2$$

$$Sy \cdot x^2 = Sdy \cdot x^2/n-2 = 735.2/49 = 15.00$$

$$Sy \cdot x = \sqrt{Sy \cdot x^2} = \sqrt{15.00} = 3.873 = \text{Standard error of estimate}$$

$$Sb^2 = Sy \cdot x^2/Sx^2 = 15.00/31{,}474.5 = 0.00047658$$

$$Sb = \sqrt{Sb^2} = \sqrt{0.00047658} = 0.0218 = \text{Standard error of } byx$$

$$t = \frac{b}{Sb} = \frac{0.0554}{0.0218} = 2.541 \quad \text{Significant at 5\% level with 49 d.f.}$$

Figure 7. Computation of regression between man-hours per acre (X) and net returns per ton (Y)

$SX = 3{,}053.19$	$SY = 2{,}892.41$	
$\bar{x} = 59.84$	$\bar{y} = 56.71$	$N = 51$
$SX^2 = 198{,}999.$	$SY^2 = 361{,}918.$	$SXY = 153{,}824.$
$(SX)^2/N = 182{,}785.$	$(SY)^2/N = 164{,}040.$	$(SX)(SY)/N = 173{,}158.$
$Sx^2 = 16{,}214.$	$Sy^2 = 197{,}878.$	$Sxy = -19{,}334.$

$$byx = \frac{Sxy}{Sx^2} = \frac{-19{,}334.}{16{,}214} = -1.1925$$

$$bxy = \frac{Sxy}{Sy^2} = \frac{-19{,}334}{197{,}878} = -0.0977$$

$$r^2 = (byx)(bxy) = (-1.1925)(-0.0977) = .1165$$

$$r = \sqrt{r^2} = \sqrt{.1165} = .3413$$

$$a = \bar{y} - b\bar{x} = 56.71 - (-1.1925)(59.84) = 56.71 - (-71.36) = a = 128.07$$

$$\hat{y} = a + bx = 128.07 + (-1.1925)(100) = 128.07 - 119.25 = \hat{y} = 8.82$$

$$Sdy{\cdot}x^2 = Sy^2 - (Sxy)^2/Sx^2 = 197{,}878. - (-19334)^2/16{,}214.$$
$$= 197{,}878. - 23{,}055. = 174{,}823.$$

$$Syx^2 = Sdy{\cdot}x^2/n-2 = 174{,}823/49 = 3567.814$$

$Syx = \sqrt{Syx^2} = \sqrt{3567.814} = 59.73$ Standard error of estimate

$$Sb^2 = Syx^2/Sx^2 = 3567.814/16214. = .220$$

$Sb = \sqrt{Sb^2} = \sqrt{.220} = .469$ Standard error of byx

$t = \frac{b}{Sb} = \frac{-1.1925}{.469} = -2.5426$ Significant at 5% level

$t_{.05} = 2.009$ with 49 d.f.

Figure 8. Computation of regression between power and machinery cost per acre (X) and net returns per acre (Y)

$SX = 3,053.19$	$SY = 135.62$	
$\bar{x} = 59.84$	$\bar{y} = 2.66$	$N = 51$
$SX^2 = 198,999.$	$SY^2 = 1192.34$	$SXY = 6627.$
$(SX)^2/N = 182,785.$	$(SY)^2/N = 360.64$	$(SX)(SY)/N = 8071.$
$Sx^2 = 16,214.$	$Sy^2 = 831.70$	$Sxy = -1444.$

$$byx = \frac{Sxy}{Sx^2} = \frac{-1444.}{16,214.} = -0.08906$$

$$bxy = \frac{Sxy}{Sy^2} = \frac{-1444}{831.7} = -1.7362$$

$r^2 = (byx)(bxy) = (-0.08906)(-1.7362) = .1546$

$r = \sqrt{r^2} = \sqrt{.1546} = .393$ Significant at 1% level

$a = \bar{y} - b\bar{x} = 2.66 - (-0.08906)(59.84) = 2.66 - (-5.33) = a = 7.99$

$\hat{Y} = a + bx = 7.99 + (-0.08906)(100) = 7.99 + (-8.91) = -0.92$

$Sdy{\cdot}x^2 = Sy^2 - (Sxy)^2/Sx^2 = 831.7 - (-1444)^2/16214 = 703.1$

$Syx^2 = Sdy{\cdot}x^2/n-2 = 703.1/49 = 14.35$ Variance

$Syx = \sqrt{Syx^2} = \sqrt{14.35} = 3.787$ Standard error of estimate

$Sb^2 = Syx^2/Sx^2 = 14.35/16214. = 0.000885$

$Sb = \sqrt{Sb^2} = \sqrt{0.000885} = 0.0297$ Standard error of byx

$t = \frac{b}{Sb} = \frac{-0.08906}{0.0297} = 2.998$ Significant at 1% level

$t.05 = 2.009$ with 49 d.f.

$t.01 = 2.7895$ with 49 d.f.

Figure 9. Computations of regression between power and machine cost per acre (X) and net returns per ton (Y)

$SX = 3,053.19$	$SY = 9,867.$	
$\bar{x} = 59.84$	$\bar{y} = 193.47$	$N = 51$
$SX^2 = 198,999.$	$SY^2 = 1,966,967.$	$SXY = 611,944.$
$(SX)^2/N = 182,785.$	$(SY)^2/N = 1,908,974.$	$(SX)(SY)/N = 590,704.$
$Sx^2 = 16,214.$	$Sy^2 = 57,993.$	$Sxy = 21,290.$

$$byx = \frac{Sxy}{Sx^2} = \frac{21,290}{16,214} = 1.313$$

$$bxy = \frac{Sxy}{Sy^2} = \frac{21,290}{57,993} = .3671$$

$r^2 = (byx)(bxy) = (1.313)(.3671) = .4820$

$r = \sqrt{r^2} = \sqrt{.4820} = .693$ Significant at 1% level

$a = \bar{y} - b\bar{x} = 193.47 - (1.313)(59.84) = 193.47 - 78.57 = a = 114.90$

$\hat{Y} = a + bX = 114.90 + (1.313)(100) = 114.90 + 131.30 = \hat{Y} = 246.20$

$Sdy{\cdot}x^2 = Sy^2 - (Sxy)^2/Sx^2 = 57993. - (21,290)^2/16,214 =$
$= 57,993. - 279.54 = 57,713.46$

$Syx^2 = Sdy{\cdot}x^2/N-2 = 57713.46/49 = 1177.8$ Variance

$Syx = \sqrt{Syx^2} = \sqrt{1177.825} = 34.32$ Standard error of estimate

$Sb^2 = Sy{\cdot}x^2/Sx^2 = 1177.825/16,214. = .0726$

$Sb = \sqrt{Sb^2} = \sqrt{.0726} = .269$ Standard error of byx

$t = \frac{b}{Sb} = \frac{1.313}{.269} = 4.881$ Significant at 1% level

$t.01 = 2.7895$ with 49 d.f.

Figure 10. Computation of regression between power and machine cost per acre (X) and total cost per acre (Y)