

THE RELATIONSHIPS BETWEEN AVERAGE COSTS AND SCALE OF  
OPERATION IN THE PRODUCTION OF SUGARCANE IN PUERTO RICO

by

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## INTRODUCTION

The sugarcane industry is the most important agricultural enterprise of Puerto Rico, accounting for 33 percent of the net income from agriculture in 1960. However, the importance of sugarcane production is not restricted to agriculture alone, since it provides the base from which other Puerto Rican industries have evolved. Examples of major industries outside of agriculture, yet dependent upon the efficient production of sugarcane, include rum, candies, malt liquors, alcohol, and paper. Agricultural industries dependent upon the sugarcane industry for their livelihood are: livestock formula feed, raw sugar and molasses processing, warehousing, and machinery. The extent to which Puerto Rico is dependent upon sugarcane production is shown in Table 1.

Table 1. The importance of the sugarcane industry in terms of net income, exported products, and employed workers, Puerto Rico, 1960.\*

Item	Total for		
	: Puerto Rico	: Agriculture	: Sugarcane
Net income	\$1,311,000,000	\$177,000,000	\$59,000,000
Value of exported products	\$594,996,712	\$344,559,393	\$127,477,205
Employed workers	543,000	124,000	45,000

\* Sources: External Trade Statistics, 1960, Bureau of Economics and Statistics, Puerto Rico Planning Board. Informe Economico al Gobernador, 1960. Nagociado de Economia y Estadisticas, Junta de Planificacion de Puerto Rico.

Sugarcane and by-products ranked first in terms of exported value, surpassing such agricultural export products as tobacco, coffee, pineapples, coconuts, animal products, etc. In 1960, sugar and related products exported to the United States had a value of more than 127 million dollars, and accounted for 21 percent of all such exports. Another facet of the sugar industry of Puerto Rico is its effect upon the level of employment. In the Spring of 1960, the peak of the harvesting season, it employed 45,000 field workers, including farm operators. In addition, it was a source of employment for many workers in allied fields, including mill or factory workers, professional, and administrative personnel.

The economy of small-scale farming has remained the same through the years in Puerto Rico. This fact is not realistically portrayed in Table 2 which is based upon census data. The census considered only farms containing three or more cuerdas, whereas in actuality, there are many farms containing less than three cuerdas of cane.<sup>1</sup> Data from the U.S.D.A. Commodity Stabilization Service give a more realistic view of the scope of sugarcane production in Puerto Rico. This report shows that out of 14,973 sugarcane farms, 8,748 had an acreage devoted to sugarcane that ranged from one-tenth to five acres in 1960.<sup>2</sup> This is 58 percent of the total sugarcane farms as defined by the U.S.D.A. Commodity Stabilization Service. Of course, it must be considered that not

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<sup>1</sup> One cuerda is equivalent to 0.9712 acre.

<sup>2</sup> A.S.C. Annual Report, Caribbean Area Office, Washington: U.S.D.A. Commodity Stabilization Service, 1960.

all these farms are strictly devoted to sugar cane production.

According to Table 2, there are 8,394 sugarcane farms of three cuerdas or more, accounting for 24 percent of the total. With respect to all farm lands, sugarcane is grown on 646,127 cuerdas or approximately 19 percent of the total land devoted to agricultural use. More importantly, sugarcane requires the best cropland on the Island, taking up 53 percent of such land in 1959. In addition, the sugarcane industry had a farm value of 87 million dollars for the fiscal year 1959-60 and accounted for 37 percent of the total farm value for the Commonwealth.<sup>1</sup>

Table 2. Importance of the sugarcane industry in terms of number of farms, crop acres, and land in farms, Puerto Rico, 1960.\*

Item	Unit	Total for		:Sugarcane :as percent : of total
		:Puerto Rico	: Sugarcane	
Number of farms	Number	35,428	8,394	24
Land in farms	Cuerdas	1,573,532	646,127	19
Crop land	Cuerdas	704,229	372,003	53

\* Source: United States Bureau of the Census, United States Census of Agriculture, Puerto Rico: 1959. Vol. 1, Part 53. Washington: Government Printing Office, 1961.

Due to the importance of the sugarcane industry in Puerto Rico and the small scale in which production is carried out on each farm, the need for knowledge in techniques of efficiency,

<sup>1</sup> Estadísticas Agrícolas, Departamento de Agricultura de Puerto Rico, 1960.

management, and least cost production becomes a primary consideration. This study will try to realize this goal.

#### PURPOSE AND OBJECTIVES OF THE STUDY

This study is a subdivision of a broad project undertaken by the Agricultural Experiment Station of the University of Puerto Rico, entitled "Economic Analysis of the Mechanization of Sugarcane Farms in Puerto Rico" (Appendix A). The main purpose of the entire project was to identify and analyze the many production problems growing out of attempts to introduce more mechanization into the sugarcane field operations. This is a very complex undertaking since there are many interrelated problems. Examples of the difficulties encountered in attempts to modernize sugarcane production in Puerto Rico are: small scale of farm units, high interest rates on borrowed capital, high investment cost of machinery, large number of unskilled workers, high land rents, and lands not suitable for machinery use.

Paramount to these varied but related problems is the attempt to mechanize sugarcane production. There is little doubt as to the need or feasibility of such an undertaking; however, the "stumbling block" in the program is increased cost of production. This is complicated by small returns to scale realized in relation to the necessary machinery investment required to achieve any increase in efficiency. Attempts to increase investment in machinery for production and harvesting of sugarcane adds directly to fixed costs, and consequently increase total costs.

Evidence of cost problems in sugarcane production are exemplified by income and cost figures presented in Table 3. They show that for the years 1953 and 1955, farmers have had negative returns. In 1946, the average cost of production per cuerda of sugarcane was \$201.68. In 1953 it was \$300.06, and two years later \$308.01. In 1946, farmers obtained a net return of \$37.24 per cuerda, but in the years 1953 and 1955 they lost money, \$25.47 and \$37.83, respectively.

In Table 3, the most significant cost item, both in terms of major field operations and total production costs, is wages paid for human labor. This is a very difficult problem to correct in Puerto Rico since the rural workers depend primarily upon employment in the sugarcane fields for their livelihood. Nevertheless, an industry faced with continually increasing costs now exists in Puerto Rico's agriculture. Excessive use of human labor represents a major barrier in the struggle to improve efficiency and reduce the costs of sugarcane production. In 1960, the Island had the highest labor requirements per ton of sugar (raw value) produced of any of the American domestic producing areas. In Puerto Rico it took 89 man-hours to produce one ton of sugar as compared to Hawaii's 17 and Florida's 22 man-hours per ton of sugar.<sup>1</sup> These figures would seem to suggest that some adjustments must be made to decrease labor costs and increase overall efficiency.

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<sup>1</sup> U. S. Department of Agriculture, Recent Developments in the U. S. Sugar Industry, E R S-74, May 1962.

Table 3. Costs and returns of producing sugarcane, Puerto Rico, 1946, 1953, 1955,\* dollars per cuerda.

Item	: 1946**	: 1953**	: 1955**
	: Dollars		
<b>Cultivating costs</b>			
Human labor	53.02	93.00	75.35
Animal labor	1.91	3.50	0.45
Use of machinery	2.80	3.80	6.04
Fertilizer	25.79	36.00	38.51
Seedlings	3.97	7.00	9.00
Use of land	17.06	21.75	22.65
Others	0.35	1.25	7.19
Total	104.90	166.30	159.19
<b>Harvesting costs</b>			
Human labor	43.78	60.98	67.97
Animal labor	3.21	4.25	0.93
Use of machinery	4.54	6.20	17.19
Others	8.10	10.50	4.80
Total	59.63	81.93	90.89
<b>General expenses</b>			
Management			
Paid	8.06	10.00	18.00
Unpaid	9.94	13.00	7.42
Interest	8.25	11.25	11.61
Labor insurance	4.10	6.37	6.36
Unemployment insurance		6.21	6.72
Others	6.80	5.00	7.82
Total	37.15	51.83	57.93
Total costs	201.68	300.06	308.01
Total income	238.92	274.59	270.18
Net income or loss	37.24	-25.47	-37.83

\* Source: Jos. B. Candelas, "Some Effects of the Sugar Programs on the Sugar Industry of Puerto Rico," Puerto Rico Agricultural Experiment Station Bulletin 151, October 1959.

\*\* Yields per cuerda: 1946, 1953, 1955; 24, 27, and 28.5 tons, respectively.

In order to make needed adjustments, farmers must know in which field operation and in which way they can reduce labor costs without affecting production. Therefore, the purpose of this thesis was to evaluate and determine the costs of sugarcane production in Puerto Rico. The objectives were to:

1. Determine which phase of the field operations costs most in producing sugarcane.
2. Evaluate the influence of farm size upon total cost of production per cuerda and per ton.
3. Analyze the feasibility of introducing more machinery in the production of cane.
4. Analyze the difference in costs between irrigated and non-irrigated lands for producing sugarcane.

#### DESCRIPTION OF THE AREA

Puerto Rico is the smallest and most easterly of the Great Antilles which screen the Atlantic Ocean proper from the Caribbean Sea. It lies between  $17^{\circ} 55'$  and  $18^{\circ} 3'$  N. and  $65^{\circ} 35'$  and  $67^{\circ} 17'$  W., being separated from the Dominican Republic on the Island of Hispaniola to the west by the 75-mile-wide Mona Passage and from the Virgin Islands on the east by Vieques Sound and the Virgin Passage. Roughly rectangular with its long axis running east and west, Puerto Rico is about 100 miles long and 35 miles wide.

The Commonwealth, established in 1952, is one of the most densely populated areas of the world. It has a total population

of 2,349,544 people or 683 inhabitants per square mile. This population is centered around the largest cities: San Juan (432,377); Ponce (114,286); Mayaguez (50,147); Caguas (32,015); and Arecibo (28,828) (Fig. 1). San Juan, the Island's capital, alone contains 18.4 percent of the total population, and the five cities listed above have 28 percent. This large and expanding population concentrated in urban areas constitutes a ready market for agricultural products.

The agriculture of Puerto Rico is favored by a very mild tropical climate which is moderated by the surrounding sea, making seasonal variations slight. Mean temperatures range from 75.4° F. (January) to 81.1° (July) on the southern coast to 74.8° (January) to 80° (July) on the northern coast. Rainfall is carried to the Island by the northeast trade winds, but its distribution is affected by the topography. Puerto Rico is crossed by mountain ranges, the most important being the "Cordillera Central" which serves to divide the country into two parts - North and South. Mean annual rainfall varies from 35.4 inches on the southern coast to 61.34 inches on the northern coast and on the northern mountain slopes. Precipitation is much greater in the interior region, often totaling over 100 inches per year.

Agricultural production tends to follow a regionalized pattern due to the influence of topography and rainfall. The hilly area located in the interior region comprises 45 percent of the Island's total area. Farming in this region is very diversified. On better soils some combinations of tobacco, starchy vegetables,



# MAPA DE LA DIVISION ELECTORAL DE PUERTO RICO

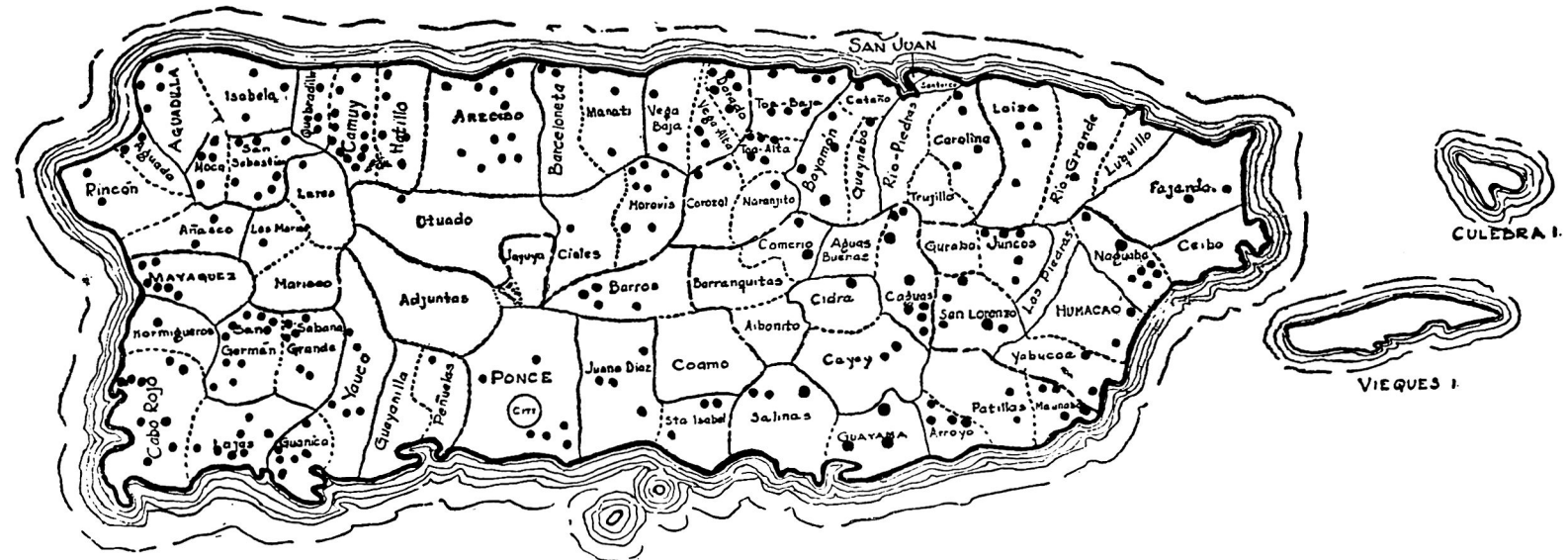


Fig. 1. Major cities of Puerto Rico and location of survey farms.

• Survey farms.

and fruits predominate. On steeper and less productive soils, livestock and coffee provide the bulk of agricultural production and income.

The most productive agricultural land is located in the coastal plain which encircles the Island. This coastal plain is only 15 miles wide at its broadest point and contains 45 percent of the Island's arable land. It is in this fertile belt that sugarcane production is concentrated. In general terms, the coastal plain can be divided into two geographic regions: the northern coast and the southern coast. In the northern coast, sugarcane cultivation is accompanied by crops such as pineapple, cotton, and grass. Second to sugarcane production, dairy cattle has become a major livestock enterprise in this region. Little irrigation is used in this area since there is an adequate amount of moisture. The southern coast, in addition to sugarcane, produces corn, grass, and chewing tobacco. Beef cattle and hogs also supplement the crop enterprises. Most irrigated land is located in this region. Contrary to the northern coast, this region requires a considerable amount of irrigation for production of sugarcane.

The determinant factor for both regions is the soil which favors production of sugarcane. The most important sugarcane soils in the south coast are those of the "Santa Isabel" and "San Anton" soil series. "San Anton" soils are best adapted for cultivating cane in Puerto Rico. They have a granular, friable, brown surface, and are very easily plowed and cultivated.

The two most important soil series in the north coast are "Toa" and "Coloso." "Toa" soils are the most fertile of the two, and they follow the "San Anton" in their adaptability for growing cane. They have a fine texture and vary from brown-gray to brown color. They are loose soils which provide adequate drainage and easy cultivation. These soils have a high content of organic matter, but generally require the use of commercial fertilizers for top production.

When all factors are taken into consideration - climate, rainfall, soils, etc.; production of sugarcane has a decided comparative advantage over all other crops that can be grown on the coastal plains. To obtain a representative island survey, samples taken for this study were centered mainly in these two coastal regions, northern and southern, with a lesser number from the hilly interior (Fig. 1).

#### METHOD OF STUDY AND ANALYSIS

##### Sample Design and Source of Data

To carry out the objectives of this study, it was necessary to draw a sample of approximately 200 farms. Farms included in the sample were limited to those having 50 or more cuerdas of land, the slope of which did not exceed 15 percent.

Due to time and money limitations, the possibility of using an area sample for this study was rejected. In Puerto Rico, this is the only design which permits assigning a probability other than zero to each farm's chance of being selected from the

universe under study.

The most important variables in this study were acreage in cane and land slope. Therefore, the farms were arranged so as to obtain the advantage of a stratification in respect to these two factors. To achieve this objective, the 905 sugarcane farms included in the original list were classified into 45 groups as shown in Table 1 of Appendix B. Later, a sampling rate of one in every four farms was applied. This resulted in a sample composed of 226 farms. The distribution of farms in the sample by acreage in sugarcane and slope of the land is shown in Table 2 of Appendix B. Although it was known that there were no differences among the several geographical zones in Puerto Rico with respect to such variables as land, slope, planting method, and type of machinery, a geographical distribution of both the universe and the sample was prepared in order to insure that each zone would be represented in the sample.

Table 3 in Appendix B indicates that the sample was well distributed by areas. Although an analysis by geographical area was not foreseen, this variable could be included in the event that some important factor was found which varies significantly from zone to zone.

Information recorded by the offices of the Federal Soil Conservation Service and the Office of Scientific Assessment of the Commonwealth Department of the Treasury was used to prepare the above list. Although the list included a majority of the farms pertaining to the universe, it did not include all the farms

because some became qualified for the universe during the interim between preparation of the list and the actual completion of field work. Nevertheless, this factor would introduce little bias since the number of these farms would not be great, and, in addition, the greater part of these farms would have representation in the sample as was explained above.

#### Collection of Data

The farms studied were distributed through the entire Island. Information was obtained from farmers by means of questionnaires (Appendix C) which were filled out during personal interviews. Only 143 questionnaires were completed. Some farmers refused to give information and others could not be found for the interview. Other farmers in the same area were substituted for some of these. The data were gathered from August to December in 1960, while the cost figures obtained were for the fiscal year 1959-60.

#### Classification of Data

According to the description of the area, a common agronomic practice in Puerto Rico is to cultivate sugarcane both on irrigated land and on land receiving only natural rainfall. For this reason, the data were classified according to irrigated and non-irrigated land. Both classifications were made for planted cane and for ratoon cane.<sup>1</sup>

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<sup>1</sup> Planted cane is cut from 12 to 18 months from date of planting. Ratoon cane sprouts from the roots of the previous year's plantings, and is cut at 12 months of age.

Non-irrigated land was classified into three farm sizes according to cuerdas of cultivated cane for the year 1960. These farm sizes were 50 to 99 cuerdas, 100 to 199 cuerdas, and 200 or more cuerdas.

Because a smaller number of farmers reported the use of irrigation, a broader grouping was necessary, and land was classified into two farm sizes. These also were based on cuerdas of cultivated cane for the year 1960. The farm sizes were 50 to 149 cuerdas, and 150 cuerdas or more.

The costs of operating the sugarcane farms were divided into three main groups as follows: (1) field operations, (2) materials, and (3) overhead expenses. These groupings were determined largely to facilitate analysis of the data. Each of the three main groups was subdivided into its component parts to provide more detailed information. Since very few farmers maintained records, it was necessary to make estimates so as to allocate cost items under the different headings. In such cases, these estimates were made by the farmer or some official of the farm unit. Such allocations affect the distribution of costs between items, but do not affect the total costs of any farm.

#### Methods of Determining Costs and Statistical Analysis

The questionnaires were edited in the Department of Agricultural Economics at the Agricultural Experiment Station of the University of Puerto Rico. Statistical analysis and data processing were carried out in the Department of Economics and Sociology

at Kansas State University. The steps taken in composing this thesis were as follows:

First, total individual cost for each farm was obtained by interviewing the farmers. Total production in tons and total number of cuerdas growing cane were also obtained.

Second, both average cost per cuerda and per ton were calculated. Average cost per cuerda on each farm was obtained by dividing the total cost of each farm by the total number of cuerdas in each farm. Then the average costs were summed. This sum was divided by the number of farms reporting in order to determine the arithmetic mean of the average costs on a per cuerda basis for all farms. A similar procedure was then followed in order to obtain the arithmetic mean of the average costs on a per ton basis for all farms. The arithmetic mean was computed by using the formula

$$\bar{x} = \sum_{i=1}^n X_i/n, \text{ where}$$

$X_i$  = the average cost per cuerda or per ton on the  $i$ th farm,

$\sum_{i=1}^n X_i$  = the sum of the cost on a per cuerda or a per ton basis for all farms under the same field operation,

$n$  = the number of farms reported, and

$\bar{x}$  = the average cost per cuerda per farm, or per ton per farm, whichever the case may be.

Third, the standard error of the mean was computed for each field operation to determine the degree of variability in cost among the same group of farms. The standard error of the mean

indicates how much sample means can be expected to vary from sample to sample on farms. This statistical measure was calculated by using the IBM 1620 computer following the formulas:

$$\text{standard deviation} = S = \sqrt{\frac{\sum X^2 - (\sum X)^2/n}{n - 1}} \quad \text{and}$$

$$\text{standard error} = S_{\bar{X}} = \sqrt{\frac{S^2}{n}}, \quad \text{where}$$

$\sum X^2$  = the sum of squares of the means per cuerda and per ton

$\frac{(\sum X)^2}{n}$  = the correction factor for the sum of squares, and

$n - 1$  = the degrees of freedom.

Standard errors of the means were calculated by extracting the square root of the standard deviation squared (variance) divided by the number of farms reporting in each field operation.

Fourth, an approximate "t" test<sup>1</sup> was used to test the hypothesis that size of farms does not affect the cost of production of sugarcane in Puerto Rico. This test was used at varying levels of significance to test the difference between means of the field operations for different farm sizes. The levels of significance used were .10, .05, .01, and .001, indicating significance at 10, 5, 1, and .1 percent levels.

The formula used to calculate "t" in this study was

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{S_{\bar{X}_1}^2 + S_{\bar{X}_2}^2}}, \quad \text{where}$$

$\bar{X}_1$  = the mean for one group of farms to be compared,

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<sup>1</sup> The "t" is the deviation of the estimated mean from that of the population, measured in terms of  $S/\sqrt{n}$  as the unit." Definition taken from George W. Snedecor, Statistical Methods, fifth edition, page 45.



$\bar{x}_2$  = the mean for the other group of farms to be compared,

$S_{\bar{x}_1}^2$  = the squared standard error for the mean of one group of farms,

$S_{\bar{x}_2}^2$  = the squared standard error for the mean of the other group of farms, and

t = the computed deviation of the estimated mean from that of the population.

#### THE INFLUENCE OF FARM SIZES AND THE METHOD OF PRODUCTION ON TOTAL AVERAGE COSTS

The survey data were analyzed and several different divisions studied to determine the most useful method of presenting the findings. For cost analysis it was decided that the major division should be centered around irrigated and non-irrigated methods of production. The justification for this type of division is obvious since there will logically be higher costs associated with the introduction of field irrigation practices. Within these two major divisions it was necessary to subdivide the data in accordance with the two methods of harvesting sugarcane - planted cane and ratoon cane. Since the planted cane requires several field operations beyond those of the ratoon cane, it was felt that this breakdown was more than justified. In addition, as explained in the preceding discussion, there was a second subdivision based upon the size of the production unit.

#### Average Costs on Non-irrigated Land

Planted Cane. In attempting to present cost data for the production of sugarcane, one can quickly become lost in a mass of detailed figures if each and every individual step or process is described. Therefore, there is a need to aggregate the individual steps and processes into concise, yet meaningful, categories which will adequately portray the cost involved.

The most important category to be presented in this analysis is field operations. The field operations category for planted cane may be thought of as consisting of three separate phases: (1) the seedbed preparation phase which includes plowing, disk-ing, and furrowing; (2) the cultivating phase which includes planting, replanting, hoeing, and applying fertilizers and herbicides; and (3) the harvesting phase which includes cutting, loading, and hauling.

Detailed data for field operations are presented in Appendix D; however, tables are given in the text for a summary of these costs. Perhaps the most significant cost of production to be considered in this survey analysis is labor as opposed to machinery cost. It should be pointed out that the machinery cost in this analysis was determined by assuming that all machinery used by farm operators in the production of sugarcane was rented. This, in effect, serves to hold the machinery cost relatively constant for both per cuerda and per ton computations for all sizes of farms. The only variation allowed would be in the quantity of machinery used among the different sizes of producing units.

According to Tables 1 and 2 in Appendix D, the total average labor cost per cuerda stood at \$182.00 for the smaller surveyed units, or 71 percent of the total field operating costs. Labor costs as a proportion of total average costs remained relatively constant, but the absolute total labor costs decreased substantially as the size of the producing unit increased. The same trend also was true on a per ton basis; however, in relative terms there was a 9 percent greater decrease in total labor cost per ton of production over the decrease per cuerda. This undoubtedly was due to the fact that the larger production units were able to take advantage of returns to scale in the use of fertilizers and herbicides, which increased their absolute yield per cuerda.

The individual field operation that required the greater use of labor in terms of cost was cutting, both on a per cuerda and a per ton basis. This is to be expected since there is, as yet, no practical mechanical substitute for labor in cutting sugarcane. It is interesting to note that there was little variation in the average labor cost of cutting for the different size of farms, whether considered per cuerda (\$53.00) or per ton (\$1.34).

The second highest individual field operation as measured by average labor cost was cultivating (with hoe). Again, the non-adaptability of this field operation to mechanical implements explains the high labor cost. Average labor cost per cuerda of cultivating (with hoe) decreased with farm size, and this decrease

was found to be significant (.05)<sup>1</sup>. The "t" test performed for this field operation revealed that the computed "t" had a value of 2.372 which is greater than Table t<sub>.05</sub> value of 2.008. In other words, there was a substantial decrease in this cost item from small to large farms. The labor cost per ton of production for cultivating (with hoe) also decreased significantly (.05) as size of farms increased.

The third most costly labor item for the smaller farms was loading and hauling, which, although wholly adaptable to mechanization, continues to utilize unskilled labor. Even for the medium- and large-size production units - units that could more justifiably make the investments required to mechanize these operations - labor is still a significant cost. However, as the scale of the producing unit increased, there was a significant (.05) decrease in the average labor cost for loading and hauling. For the same field operation, the average labor cost per ton decreased more significantly (.01), reflecting the increased yield received by the largest units.

The remainder of the field operations (plowing, disking, furrowing, seed preparation, planting, and applying fertilizers and herbicides) required a much smaller individual share of the labor cost and did not show any significant difference in labor cost in relation to variation in farm size. Therefore, data analysis indicates that within field operations, there is a significant inverse relationship between the size of farms and

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<sup>1</sup> p values: .001 means one chance in 1000 results were due to sampling (.05 is 5 in 100, .01 is 1 in 100, and .1 is 10 in 100).

total average labor cost per cuerda and per ton. Summarized figures for this analysis are shown in Table 4.

Machinery cost data presented in Tables 1 and 2, Appendix D, show that there were no significant differences in the quantity of machinery used in the field operations per cuerda of sugarcane regardless of the scale of production. Variation in the quantity of machinery utilized per ton of sugarcane produced was significant only in plowing, and loading and hauling operations. Plowing costs showed a significant (.05) decrease in machinery cost; i.e., a significant increase in the quantity of machinery used per ton of sugarcane produced.

Loading and hauling operations gave a significant (.10) decrease in the average machinery cost which again indicates in this study an increase in the use of mechanical equipment. In considering machinery costs per ton in the major field operations such as plowing, and loading and hauling, they became substantially less on larger farms, but for the remaining field operations the results were not significantly different. However, when differences on the basis of size of producing unit and per ton for all operations combined were considered, the larger farms showed significantly lower costs. Even the larger units which could more nearly afford modern equipment have not taken advantage of the cost savings made possible by the efficient use of mechanization.

The second category of cost items analyzed in this study was "materials." There are only three items included in the materials

category - fertilizers, herbicides, and seed cane. Table 9, Appendix D, illustrates that the average materials cost is lowered from \$67.00 per cuerda to \$63.00 per cuerda by increasing the size of the cane farms. However, the degree of reduction is slight on an individual item basis.

The combined total cost for materials show the greatest reduction on a per ton basis. Farms in the 50 to 99 cuerda range reported a total materials cost of \$2.33 per ton of cane production as compared to \$2.00 per ton on units of 200 or more cuerdas. This is due largely to the fact that larger units were better able to take advantage of bulk rates in purchasing their materials. Also they received a slightly higher yield per cuerda over which they could spread the total materials cost.

The final cost category to be analyzed was a "catch-all" grouping in which a variety of cost items were aggregated. The major items included in "overhead expenses" category were: Social Security, unemployment insurance, workman's liability insurance, land costs, interest on loans, wages for management, and other miscellaneous costs. These are cost items which normally increase as the size of the production unit increases. For example, the larger farms must hire administrative personnel - accounting clerks, field foreman, and year-around laborers - to administer and assist operation of the more complex farm businesses. Such cost items are totally unnecessary on farms with less than 100 cuerdas, since the farm operator can adequately perform these tasks himself.

Data in Table 9, Appendix D, demonstrate the increasing average cost incurred as the magnitude of the farm operation becomes greater. The most significant individual item is embraced in the other costs grouping (i.e., cost for accounting clerks, office supplies, repair of fences and roads, etc.). These costs amounted to only \$2.46 per cuerda or \$0.07 per ton on the smaller-sized study farms, but increased to \$67.26 per cuerda or \$2.24 per ton of cane produced on the largest-sized units. The only other individual cost item in the overhead expenses category to show a significant increase with an increase scale of operation was land cost. This is due, in part, to the high valuation per cuerda of land on the larger units, and, in part, to the more modernized buildings and land improvements on the large sugarcane plantations. The combination of these two factors forces up the rates of land rent and taxes paid for land utilization.

It should be noted that not all the individual items in the overhead expenses category increased with the scale farm units, but actually register some decrease. However, the average cost decreases were not significant except on those units which made more extensive use of mechanization. The farm operator who makes use of modern machinery in his field operations is not required, therefore, to hire as many laborers. Thus, the absolute quantity of money which he must pay out for Social Security, unemployment insurance, and workman's liability insurance is consequently reduced.

A brief summary of the total average cost for the three major categories applicable to non-irrigated land for planted cane is presented in Table 4. Undoubtedly the cardinal need in any attempt to reduce the component costs of sugarcane production on non-irrigated land should be centered around the field operations. Such costs amounted to 65 percent of total cost on the smaller survey units down to 50 percent in the largest survey units as measured per cuerda. Even spreading these costs over the total production leaves 59 percent of the per ton expenses charged to field operations on the smaller units, but the proportion is reduced to 43 percent on the largest units.

Table 4. Total average costs per cuerda and per ton for planted cane by size of farms (cuerdas), non-irrigated land, Puerto Rico, 1960.

Item	Total average cost per cuerda			Total average cost per ton		
	50- 99	100- 199	200 :or more	50- 99	100- 199	200 :or more
Field oper- ations	\$255.87	\$220.86	\$202.75	\$7.12	\$5.33	\$5.05
Materials	66.66	69.00	62.69	2.23	2.14	2.00
Overhead expenses	69.77	77.14	139.44	2.64	2.46	4.56
Total	\$392.30	\$367.00	\$404.88	\$11.99	\$9.93	\$11.61

Total materials costs are fairly constant and account for an average of \$66.12 per producing unit per cuerda, or 17 percent of the total average cost. Overhead expenses exhibited the greatest



degree of variability, ranging from 18 percent on the smaller units to 34 percent on the largest farms on a per cuerda basis. Therefore, the most efficient sugarcane producing units as measured by total average cost per cuerda and per ton for the initial cutting were the medium-scale study units; i.e., 100 to 199 cuerdas of cane.

Ratoon Cane. After cutting the cane, it is the practice to cultivate, replant the roots that have died during the year, and then let the cane stand and re-propagate itself from the roots of the previous year's cutting. This practice eliminates the need for repeating the costly seedbed preparation phase, and the planting operation in the cultivating phase. Therefore, the ratoon is not as costly as the planted cane. The number of ratoons that a farmer may harvest depends upon many factors, but the norm for Puerto Rico varies from three to six harvests and even more.

Field operations eliminated in the ratoon were those which required extensive use of mechanized equipment, and therefore, smaller amounts of labor. This served to reduce total average cost both per cuerda and per ton, but increased the relative importance of labor with respect to the total overall cost structure. In terms of labor cost; cutting, cultivating (with hoe), and loading and hauling remained the dominant field operations. According to Table 4, Appendix D, the average labor cost per ton for cutting was \$1.56, or \$0.22 more than the corresponding figures for planted cane on all farms. This is due to the decreased

yield per cuerda as the ratoons increased in age. There was no significant change in the labor cost per ton or per cuerda as the scale of the producing unit was increased for the ratoon. Nevertheless, the relative share of the total production cost increased significantly - from 32 percent in the planted cane to 40 percent in the ratoon.

Cultivating (with hoe), the other non-mechanized production field operation, showed a substantial increase in labor costs as scale of the farm unit was increased from small to medium size on a per cuerda basis. The total average labor cost per cuerda was reduced from an average of \$33.65 in planted cane to \$24.75 in ratoon for all farms. This is a 26 percent reduction in the total average cost, demonstrating the justification for the ratoon production method.

Loading and hauling labor cost, contrary to the patterns of cutting and cultivating (with hoe), showed a significant decrease in average labor cost through increased scale of operations. This is the same pattern as followed in the planted cane, and demonstrates the fact that the method of production has little relation to labor cost in loading and hauling. Again, there was a substantial reduction (27 percent) in the total average labor cost per cuerda between the planted cane and ratoon expenses for all farms.

Other field operations required only \$11.92 per cuerda or 11 percent of the total expenses per cuerda. Moreover, there was a significant difference in the per cuerda or per ton cost over

the entire sized range of the producing units. There was, however, a considerable reduction in the total average labor cost for all farm businesses between the planted cane and the ratoon.

In general, the ratoon method of production provided the sugarcane farmers with a 35 percent savings in total labor costs for the field operations per cuerda of cane produced. This is an impressive saving, but is the cause of much misguided advisement because it does not consider the reduction in yields resulting from the ratoon production practices. For all farms, the savings and total labor cost on a per ton basis amounted to only 7 percent within the field operations. This is more nearly in line with the figures quoted in Appendix D, and suggests that the labor cost savings attributed to the ratoon method of production can be easily overstated.

As to be expected, machinery cost for the field operations provided very little variation. It exhibited a significant (.10) decrease in average cost per cuerda of sugarcane for loading and hauling, and applying fertilizers as the scale of the farm producing unit increased. Thus, on the larger farm units, the quantity of machinery used in the ratoon method of producing cane has shown a slight decrease over the level established in the planted cane method.

Material costs for the ratoon followed the same pattern as for the planted cane (Table 10, Appendix D). In fact, average costs for fertilizers and herbicides were exactly the same as for the planted cane. The significant savings provided by the ratoon

method of production was in the reduction or elimination of the seed cane expenses. Only the smaller survey units reported any seed cane expenses. The absence of seed cane expenses on the medium and larger units indicates that these farmers can afford to produce their own replacement cane while the smaller units find it more economical to purchase their seed cane for replanting. Overall, the materials cost category realized a reduction in average total cost of \$25.74 per cuerda or \$0.64 per ton under the cost of planted cane.

Overhead expenses were the same as for the planted cane (Table 10, Appendix D). Charges made against the farm business are relatively stable regardless of the method of production. Therefore, overhead expenses increased with the scale of production.

A summary of the total average costs for the ratoon method of producing sugarcane is given by major cost categories in Table 5. This table differs only from the planted cane summary table (Table 4) in the lower magnitude of the cost figures, and the proportionate share of the total cost by major categories. First, there was a significant reduction in total average cost per category for the ratoon. The field operations category had the largest net decrease in average total cost, amounting to a 45 percent decrease. Materials category also had a decrease from planted cane of 37 percent. Overhead expenses were decreased only 2 percent by the ratoon method.

Table 5. Total average costs per cuerda and per ton for ratoon by size of farms (cuerdas), non-irrigated land, Puerto Rico, 1960.

Item	Total average cost per cuerda			Total average cost per ton		
	50- 99	100- 199	200 :or more	50- 99	100- 199	200 :or more
Field operations	\$129.81	\$139.81	\$107.28	\$4.97	\$4.93	\$4.08
Materials	45.87	40.88	37.40	1.80	1.38	1.28
Overhead expenses	67.27	75.09	139.44	2.57	2.40	4.56
Total	\$242.95	\$255.88	\$284.12	\$9.34	\$8.71	\$9.92

Secondly, the elimination of several field operations changed the percentage proportion that each category was of the total average costs. The largest percent of the total cost per cuerda was still within the field operations category, but this percentage was reduced from 65 to 53 by the ratoon. Overhead expenses category absorbed the percentage lost by the field operations, and thus increased from 18 to 28 percent on a per cuerda basis. The same trend is applicable to the cost per ton between planted cane and ratoon.

#### Average Costs on Irrigated Land

Planted Cane: There were only 15 farm operators who reported the use of irrigation in the production of sugarcane. This small number necessitated a broader grouping than was used in analyzing the non-irrigated farm units. Therefore, the number

of subdivisions based upon the size of the producing units was reduced from three to two - 50 to 149 cuerdas, and 150 or more cuerdas. This subdivision breakdown equalized the irrigated units for analytical study.

As was true for the non-irrigated farms, the field operations proved to be the most important category in terms of total average cost. Using the three field operation phases - seedbed preparation, cultivating, and harvesting - the same analysis procedure will be followed. The only change being the addition of the irrigation cost (includes the labor and equipment charges) to the cultivating phase.

According to Tables 5 and 6 in Appendix D, the individual field operation that showed the most significant labor cost change in relation to the scale of the producing unit was cutting. Remembering that cutting and cultivating (with hoe) are not yet mechanized, this is not surprising. Average labor cost per cuerda for cutting cane was \$49.26 on the smaller irrigated units and increased to \$68.82 on the larger farms; a statistically significant (.05) increase. On a per ton comparison, the increase in labor cost was not nearly so significant (.10), reflecting the increase yields obtained on the larger units.

The average labor cost per cuerda for cultivating (with hoe) showed a decrease, but it was not significant. However, on a per ton basis there was a significant (.10) decrease in labor costs as the scale of production was increased. Presented within the size of farm subdivisions, cultivating (with hoe) averaged \$0.81

per ton for the farms of 50 to 149 cuerdas, and decreased to \$0.42 per ton on the units of 150 cuerdas or more. Detailed study of the survey schedules indicates that this reduction in average labor cost per ton of production may be due to increased application of herbicides which materially reduces the number of hand cultivations.

Turning to the field operations in which mechanized equipment can be utilized at least to some degree, Table 5, Appendix D, reveals that the introduction of irrigation for the production of sugarcane did not affect labor cost among the field operations in a consistent manner. The labor cost for irrigation increased significantly (.05) with the scale of operation. The average labor cost per cuerda was \$5.74 on the smaller survey farms and increased to \$10.61 on the larger farm units. This means that the larger farms must hire additional workers to manage the irrigating pumps, canals, and feeder lines. However, due to the increased yield resulting from the irrigation practices, labor cost per ton of production increased, but not significantly.

The only other field operation on irrigated land to show variation with respect to labor cost was loading and hauling sugarcane. For this operation, average labor cost decreased both on a per ton and per cuerda basis with an increase in the scale of the producing unit. The decrease was most significant (.05) on a per ton basis where the labor cost on farms of 50 to 149 cuerdas averaged \$0.99 per ton as compared to \$0.58 per ton on farms of 150 cuerdas or more. Loading and hauling labor costs

per cuerda were not so significant (.10), averaging \$38.93 on the smaller survey units and decreasing to \$29.08 per cuerda on the larger units.

The remaining field operations tended to show a small increase in average labor cost both per cuerda and per ton, but these increases were not significant. In other words, the addition of irrigation practices and scale of operation did not induce any change in the labor cost of these field operations for planting cane.

Machinery cost data presented in Tables 5 and 6, Appendix D, demonstrate that there were no significant differences in the quantity of machinery used in the field operations on irrigated land either per cuerda or per ton. There was a slight increase in total average machinery cost per cuerda and a slight decrease per ton as the size of farms increased. However, the obvious lack of mechanization, especially on the larger farms, prevented any large reduction in machinery cost per cuerda or per ton. The total average machinery cost per cuerda made up 31 percent of the total field operations costs on the smaller units and 32 percent for the larger units. This indicates the lack of variation in the amount of machinery used in the production of sugarcane in Puerto Rico, regardless of the scale of operation.

The overall average total cost for production of sugarcane (planted cane) on irrigated land increased \$2.04 per cuerda and decreased \$0.90 per ton, which for all practical purposes is not significant. Comparing total average cost for planted cane on



irrigated and non-irrigated land, there was an average increase of \$8.91 per cuerda for the irrigated farms over the non-irrigated units. On a per ton basis, the introduction of irrigation practices increased average total cost \$0.14 per ton of cane produced.

The second cost category to be analyzed for planted cane on irrigated land is materials. The only change to be made in the materials category is the addition of a water fee. This is a fixed cost, charged by the government, to retire the debts incurred in building the irrigation canals from the water reservoirs to the farm units. This water fee must be paid regardless of whether the water is utilized or not once the water canals have been constructed.

Table 11, Appendix D, shows that contrary to the case of planted cane on non-irrigated land where materials cost per cuerda decreased as size of farms increased, the material costs on irrigated land rose with the increase in farm size. However, this increase was offset by larger yields and higher quality of sugarcane, which equalized total average material cost per ton of cane produced. The cost per ton was \$2.23 on both the 50 to 149 cuerda category and the 150 cuerdas or more.

Overhead expenses, the third major cost category for planted cane, followed somewhat the same pattern as on non-irrigated land (Table 11, Appendix D). There were several changes in terms of individual items. For example, the interest paid on loans increased substantially on irrigated cane farms - from \$11.87 per cuerda for small non-irrigated farms to \$16.74 on the small

irrigated units. This indicates that the introduction of irrigation practices requires an increased use of credit and consequently higher interest charges. However, an increase in the scale of production brings the two costs, irrigated and non-irrigated, into close proximity on a per ton basis.

There was a very significant reduction in the cost item wages for management on irrigated sugarcane farms over the equivalent expenses on non-irrigated farms. Wages for management amounted to \$20.62 on the smaller non-irrigated farms and decreased with scale of operation. However, for the smaller irrigated units, the wages for management item was only \$5.15 per cuerda, a \$15.47 decrease, or 75 percent change. This cost item increased to \$13.54 per cuerda for the larger units which is only slightly below the cost on equivalent sized non-irrigated farms. The only explanation that can be offered for this drastic cost change is that the farms on which the owners have risked the investment necessary to irrigate the sugarcane are, therefore, either not willing, or not able, to trust or afford professional management. In this case they have no alternative but to manage the units themselves. This, evidently is not the case on the larger farms which have a broader credit base.

Again, as for the non-irrigated farms, other costs such as accounting clerks, office supplies, etc. were not important on the small farm units. These cost items became an item of major concern on irrigated farms of 150 or more cuerdas. The remainder of the overhead expense items exhibited some degree of variation

with farm sizes but not significantly.

A summary table of the total average costs for the planted cane on irrigated land is presented in Table 6. Total average cost for the field operations category showed no significant change with respect to the scale of operation. This is in direct contrast to the trend on non-irrigated planted cane where the cost decreased as size increased. The difference in cost between the two sugarcane producing methods can be attributed to the addition of irrigation costs plus higher cutting expenses. On a per ton basis, the effects of irrigation generated a substantial reduction on per ton cost through additional production per cuerda. Total average cost for field operations was reduced \$0.90 per ton between the smaller and the larger survey units.

Table 6. Total average costs per cuerda and per ton for planted cane by size of farms (cuerdas), irrigated land, Puerto Rico, 1960.

Item	Total average cost per cuerda		Total average cost per ton	
	50- 149	150 or more	50- 149	150 or more
Field operations	\$232.53	\$234.57	\$5.85	\$4.95
Materials	79.05	89.88	2.23	2.23
Overhead expenses	72.77	145.54	2.30	4.90
Total	\$384.35	\$469.99	\$10.38	\$12.08

Cost figures for materials exhibited almost the complete opposite trend as was shown by the field operations cost above.

Total average materials cost was \$2.23 for both the 50 to 149 cuerdas and for 150 cuerdas or more. However, these costs on a per cuerda basis increased from \$79.05 with the smaller units, to \$89.88 for the larger farms. This is a \$10.83 increase and is due to the higher rate of planting on the larger cane plantations plus the increased use of herbicides and irrigating water.

The overhead expenses category, reflecting the same pattern as on the non-irrigated farms, increased significantly both per cuerda and per ton. Total average cost was \$72.77 on the smaller units and \$145.54 on larger holdings. The majority of this increased cost may be explained by the need for bookkeeping and maintenance as the quantity of sugarcane produced is increased. In addition, wages for management and land cost also tend to increase with the scale of the producing unit. On a per ton basis the relative increase in total average overhead cost was approximately 3 percent less than on a per cuerda consideration.

Aggregating the total average costs for the three cost categories, Table 6 reveals a decided increase in the total cost of producing sugarcane by the introduction of irrigation practices. The cost per cuerda on the smaller farms stood at \$384.35 and increased to \$469.99 on the large sugarcane plantations. This is a difference of \$85.64 per cuerda, or an 18 percent increase to be attributed to a rise in the materials and overhead expenses categories as the size of the irrigated farm land increased. The same pattern is true for the per ton cost, where total average expenses rose 14 percent from the smaller to the larger sugarcane farms.

In this case the higher total yield induced by the addition of irrigation water lowered the per ton cost on all but the overhead expenses. Since overhead expenses rise rapidly with the scale of operation, regardless of the method of production, the increase in per ton cost cannot be wholly attributed to irrigation.

Ratoon Cane. The ratoon practice of growing sugarcane is exactly the same on irrigated farms as on the non-irrigated units. The only change is the addition of irrigation cost to the field operations, and materials categories. The elimination of the seedbed preparation phase of the field operation category materially reduced the average total cost for both machinery and labor as compared to the planted cane cost on irrigated land. As was true for the non-irrigated ratoon method of production, the relative importance of labor became greater. The reason for the increased importance of labor, however, was somewhat different than on the non-irrigated land.

There are, perhaps, three factors which explain the larger dependence upon labor in the ratoon system. First, as was true on non-irrigated land, the exclusion of the mechanized seedbed preparation phase along with the retention of the non-mechanized operations - cultivating with hoe and cutting - tended to place more emphasis on labor. Secondly, there were no farms using irrigation practices reporting the use of machinery for replacement planting. This is contrary to expectations, but is not a serious limitation since the only function performed by machinery is the transporting of the seed cane to the fields. Thus,

machinery cost is normally quite low for the replanting operation.

Finally, no machinery use was reported for the irrigation operation of the ratoon. Again, this is not to be expected, but is a possibility. Many of the government constructed irrigating canals are slightly elevated so that once the field channels are dug, the only expenses for supplying water to the fields is for laborers to open the canal gates and keep the field channels open. Therefore, the only machinery cost of significance was applying herbicides and loading and hauling. Labor, then becomes the dominant cost item accounting for 75 percent of the total average cost on the smaller survey units and 84 percent on the larger study farms.

Referring to Tables 7 and 8, Appendix D, loading and hauling was the only field operation that showed a significant (.05) reduction in average labor cost per cuerda. On a per ton basis the reduction in average labor cost was even more significant (.001), reflecting increased production over which to spread the labor charges.

Cultivating (with hoe) and cutting operations, the non-mechanized field tasks, followed opposed paths in terms of average labor cost. The labor cost for cultivating (with hoe) increased from \$14.55 to \$21.10 per cuerda as scale of operation increased. This was true on a per ton consideration where labor cost rose from \$0.58 to \$0.73. Nevertheless, neither of the above increases was significant. Cutting operation underwent a reduction in average labor cost as the quantity of production increased.

This reduction was not significant per cuerda or per ton.

Labor charges incurred in irrigation of sugarcane increased slightly per cuerda with increased scale, but decreased slightly on a per ton basis. Neither average labor cost variation was statistically significant. The remainder of the field operations - applying herbicides, replanting, and applying fertilizers - did not exhibit sufficient variation so as to be of importance or significance.

Machinery cost, which in this study is used to represent the variation in quantity of machinery used, did not sufficiently vary by scale of operations to yield any significant statistics. For example, the mean machinery cost per cuerda for the applying herbicides operation was \$18.01 on small units and decreased to \$2.13 on the larger units. This is a \$15.88 per cuerda decrease, but is not statistically significant because of a \$12.18 standard error. Such large variability among the mean machinery costs accompanied by large standard errors makes average cost fluctuations illusory. The same explanation may be made for the average machinery cost in the loading and hauling operations.

Total average field operation cost per cuerda was \$152.38 on the farms of 50 to 149 cuerdas and decreased to \$112.35 on the larger farms. The major proportion of this reduction in total cost was in the application of herbicides and fertilizers plus loading and hauling. On a per ton basis, total average cost for the field operations, irrigated ratoon production cost decreased from \$5.03 to \$3.49 from the smaller to the larger farms. This

smaller farm figure was somewhat larger than the comparable average cost on non-irrigated land, but decreased to \$0.59 below the same figure for larger farms. A part of this latter difference may be due to the non-reporting of some machinery costs as was explained earlier.

The materials cost category shown in Table 12, Appendix D, was essentially the same as for the planted cane on irrigated land except that the farm operators did not report seed cane cost. This may be due to the same reasons as reported for the ratoon on non-irrigated farms, where the larger cane farmers raised their own seed cane instead of purchasing. Nevertheless, total average materials cost is quite stable among the farms regardless of size. The average materials cost per cuerda was \$43.93 on small farms and \$47.29 on larger units, which is some \$35.12 to \$42.59 less than the comparable figures on irrigated planted cane.

Overhead expenses, the third and final cost category to be analyzed for the irrigated ratoon method of production, were more or less the same as that for irrigated planted cane. The only exception was in the other costs item. The small survey farm operators did not report any cost for this item, and the operators of the large sugarcane farms reported some \$13.54 less than in the planted cane. This can be explained by the fact that the smaller cane farm operators found it too costly to hire bookkeepers and maintenance personnel. Inversely, on the larger farms, the elimination of the seedbed preparation phase reduced the number of workers, and consequently, the need for additional accounting personnel.



Total average overhead expenses for the irrigated ratoon were reduced some 7 percent below the equivalent cost on planted cane. However, overhead expenses increased at an increasing rate as the size of farm units was increased. Total average cost per cuerda stood at \$69.33 on small farms and increased to \$134.01 on farms of 150 cuerdas or more. The same trend was true on a per ton basis, but the reduction in per ton cost from that of the planted cane was somewhat greater - an 8 percent decrease.

A summary of the ratoon cost on irrigated land is shown in Table 7. Note that in the ratoon field operations category there is a considerable reduction in total average cost per cuerda (26 percent) and per ton (31 percent) as the scale of operation increased. This is contrary to the field operation cost per cuerda for planted cane, which was constant through the distribution of farm sizes.

Table 7. Total average cost per cuerda and per ton for ratoon by size of farms (cuerdas), irrigated land, Puerto Rico, 1960.

Item	: Total average cost		: Total average cost	
	: per cuerda		: per ton	
	: 50- : 149	: 150 : or more	: 50- : 149	: 150 : or more
Field operations	\$152.38	\$112.35	\$5.03	\$3.49
Materials	43.93	47.29	1.39	1.35
Overhead expenses	69.33	134.00	2.20	4.45
Total	\$265.64	\$293.64	\$8.62	\$9.29

Materials cost did not show any significant change per cuerda or per ton as the quantity of irrigated ratoon production increased. This would seem to indicate that, once the cane planting has been established, the economies and diseconomies of scale equate each other, leaving the farm operators with a fairly constant materials cost on the irrigated ratoon.

The overhead expense category followed the same pattern for the irrigated ratoon as was found in all the foregoing methods of production in which overhead expenses are found. Comparing overhead expenses for the irrigated ratoon with the non-irrigated ratoon cost presented in Table 5, there is no significant difference in cost per cuerda or per ton. This is not to say that the make-up of the component cost within the totals is the same, but rather through shifting and counterbalancing cost changes the total average overhead expenses turned out to be practically the same.

Total average cost for all cost categories came to \$265.64 per cuerda on smaller units and increased to \$293.64 on the larger farms for a rise of approximately 10 percent in per cuerda cost. On a per ton consideration, the increase in total average cost did not rise so rapidly with the increased scale of farms, but still registered a 7 percent change. In both cases, the field operation and material cost decreased, but was offset by an increase in the overhead expenses category. The result is that the total average cost for irrigated ratoon cane production is higher per cuerda but not per ton for the corresponding cost on non-irrigated ratoon production.

## SUMMARY AND CONCLUSIONS

Of the three major cost categories analyzed in this study - field operations, materials, and overhead expenses - the most important was the field operations. It is within this category that all the labor and machinery costs of producing sugarcane are concentrated. The degree to which these costs are influenced by the scale of operation depends upon whether the sugarcane is produced on irrigated or non-irrigated farmland and whether the harvest was from planted cane or ratoon.

For planted cane (non-irrigated), between 50 and 65 percent of the total costs incurred in the production of sugarcane fell within the field operations category. Moreover, approximately 70 percent of these costs were for human labor. Total average labor cost decreased as the scale of producing units increased. The two individual field operations which provided the bulk of the scale economies in terms of labor were cultivating (with hoe), and loading and hauling. Labor cost reductions associated with increased scale for these two field operations were statistically significant both per cuerda and per ton.

Machinery costs in this study were computed on a rented basis in order to evaluate the variation in mechanized equipment by scale of operation. It was found that for planted cane (non-irrigated) there was no significant variation in the quantity of machinery used as measured per cuerda or per ton.

In the ratoon (non-irrigated) method of production, the elimination of the seedbed preparation phase substantially reduced

total average costs of the field operations category. Because the eliminated field operations were those which have made greatest headway in the use of mechanical equipment in Puerto Rico, there was a decided shift in the percentage distribution of costs. Average labor costs increased in importance, and total machinery costs were reduced. Total average labor costs were higher per ton of production than on the planted cane (non-irrigated), but decreased with the increased scale of operation.

Average machinery costs for the ratoon (non-irrigated) remained at about the same level as reported for the planted cane, but in terms of total average costs there was a significant decrease with scale of production. This means, under the study definition of machinery cost, that the degree of mechanization is not great on larger farm units.

The second most important costs category as determined by this cost analysis, was the overhead expenses. Total average costs for this "catch-all" grouping rose at an increasing rate as the scale of production was increased for both the planted and ratoon methods of production. This trend can readily be explained in terms of common logic. Smaller farms with low production do not need and cannot afford such cost items as administrative personnel and maintenance workers, who become a necessity on the large sugarcane plantations.

The third cost category - materials - showed considerable difference between the costs on planted cane (non-irrigated) and ratoon (non-irrigated). For the planted cane, total average

material costs decreased with an increased scale of production, although the decrease was not significant on an individual item basis. Material costs for the ratoon followed the same pattern as for planted cane; however, total average material costs were significantly reduced by the elimination of the seed cane expenses.

As was the case for non-irrigated farms, the most important cost category for planted cane (irrigated) was the field operations. One additional operation cost was added to the field operations category with the introduction of irrigation practices. Again, labor made up approximately 70 percent of the total average cost for field operations, but the effect of scale upon individual labor cost items was quite varied.

The average labor cost of cutting cane increased significantly both per cuerda and per ton with the increase scale of operation. Conversely, the average labor cost of cultivating (with hoe) decreased significantly with increased scale on a per ton consideration but not on a per cuerda basis. Labor cost for irrigation increased significantly with scale of operation while at the other extreme, labor costs for loading and hauling decreased significantly per ton and per cuerda. Overall, the sum total of this wide variation in average labor cost equalized, leaving total average labor cost constant over the entire range of the surveyed units.

The machinery costs for planted cane (irrigated) revealed no significant differences in the quantity of machinery used in the

field operations either per cuerda or per ton. The obvious lack of mechanization, especially on the larger farms, points out the promising possibilities of reducing total average field cost through mechanized production practices. However, since mechanization is not widely practiced in Puerto Rico, the total average field operation costs increased \$8.99 per cuerda or \$0.14 per ton over that recorded on the non-irrigated farms.

The irrigated ratoon method of production differs from the non-irrigated ratoon only with respect to the additional cost items incurred through the addition of irrigation water. Labor costs ascribed to the field operation category increased to 75 to 84 percent of the total average cost. This increased emphasis upon labor in the ratoon (irrigated) was due to the absence of reported machinery cost for replanting and irrigation field operations.

Individually, the average labor costs associated with the specific field operations exhibited considerable variation, but did not prove to be statistically significant. Overall, the total average labor costs for the field operation category decreased with scale of operation, per cuerda, and per ton.

Machinery costs for the ratoon (irrigated) field operations gave the most extreme variability found in this study. However, these wide variations were accompanied by large standard errors which prevented any statistically significant differences. The only safe statement which can be made concerning machinery used on the ratoon (irrigated) is that the smaller survey units

"apparently" are more mechanized than the larger sugarcane farms.

Overhead expenses for both planted cane (irrigated) followed more or less the same pattern as the corresponding non-irrigated cost category. These expenses increased at an increasing rate with the increased scale of operation for the same reason as on the non-irrigated farms.

The addition of a fixed water fee, imposed by the government, to the material cost category resulted in an increase in the planted cane (irrigated) materials cost per cuerda with increased farm size. However, this result was offset by an increased yield which tended to equate the materials cost per ton of production regardless of size. For the ratoon (irrigated) method of sugarcane production, the materials cost was some 30 percent less than for planted cane (irrigated) and increased slightly with farm scale. This increase was, however, statistically non-significant.

A complete summary of the overall cost analysis is shown in Table 8. Here one is able visually to compare the cost differentials per cuerda and per ton for the study production classifications. An additional cost computation in Table 8 is the total sugarcane production cost per farm as well as the aggregated total average cost for all farms. Perhaps the more important implications to be drawn from this table are: (1) total average costs are, in all cases, higher on irrigated land; (2) total average costs are, in all cases, lower for the ratoon than for the planted cane; (3) average size of the sugarcane farms (cuerdas) are

Table 8. Total average costs incurred in the production of sugarcane by size of farm, method of production, per cuerda, and per ton on sample farms, Puerto Rico, 1961.

Item	Total average costs for producing sugarcane on:							
	Non-irrigated farmland				Irrigated farmland			
	50-90 cuerdas	100-199 cuerdas	200 or more cuerdas	All farms	50-149 cuerdas	150 or more cuerdas	All farms	All survey farms
Costs per cuerda of: <sup>1</sup>								
Planted cane	\$392.30	\$367.00	\$404.88	\$388.06	\$384.35	\$469.99	\$427.17	\$407.62
Ratoon	242.95	255.88	284.12	260.98	265.64	293.64	279.64	270.31
Total production per farm	265.83	277.93	303.94	282.57	293.52	316.23	304.88	293.72
All farms				292.53			310.65	301.59
Costs per ton of: <sup>2</sup>								
Planted cane	\$11.99	\$ 9.93	\$11.61	\$11.18	\$10.38	\$12.08	\$11.23	\$11.21
Ratoon	9.34	8.71	9.92	9.32	8.62	9.29	8.96	9.14
Total production per farm	10.87	9.44	10.97	10.43	9.46	10.93	10.28	10.36
All farms				10.41			10.33	10.37

<sup>1</sup> Average size of non-irrigated farms 95.5 cuerdas, irrigated 113.8, and all farms 104.65 cuerdas.

<sup>2</sup> Average yield per cuerda 31.2 tons for non-irrigated, 33.5 tons for irrigated farms, and all farms 32.35 tons.



highest for the irrigated units; and (4) average yield of sugarcane per cuerda was greatest on the irrigated farm units.

Based upon the findings as presented in this analysis, the production of sugarcane in Puerto Rico is heavily dependent upon the intensive use of human labor. This dependence places the Puerto Rican sugarcane farmers at a cost disadvantage compared to the farmers of the other American domestic producing areas.

The surveyed farms analyzed in this study were able to receive cost savings through increased scale of operation. However, total average labor costs decreased at a decreasing rate, indicating that the larger farms are limited in the degree of cost saving attainable.

The ratoon method of production decreases total average costs, but this decrease tends to be offset by annually reduced yields. Thus, the relative cost savings by the ratoon method of sugarcane production tends to be overstated.

The introduction of irrigation practices to increase sugarcane output and therefore total revenue, tends to be self defeating if not accompanied by increased diligence upon the part of labor and management. This is because of the accelerated need for investment capital which, once incurred, becomes fixed and must be matched with an increase in income.

Mechanization of the field operations, especially on the larger farms, offers the most promise for reducing total average production costs.

According to summary Table 8, the total average cost for producing a ton of sugarcane was \$10.37 for all farms. During the same year as this survey, the price paid to Puerto Rican cane growers, including both molasses bonus and Sugar Act payments, was \$8.87 per ton of cane.<sup>1</sup> Therefore, in view of the survey results, the base price for sugarcane as set by the above-mentioned programs would seem to be too low. Either the farmers must increase their production efficiency or the governmental sugar programs must be brought in line with the cost situation in Puerto Rico. Perhaps the best that can be hoped for in the near future would be a compromise between these two choices.

In the final analysis, data presented in this study definitely illustrate that the cost of sugarcane production is influenced by the scale of operation. Therefore, the hypothesis that "size of farms does not affect the cost of production of sugarcane in Puerto Rico" is rejected.

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<sup>1</sup> United States Bureau of the Census, United States Census of Agriculture, Puerto Rico, 1959. Vol. 1, Part 53. Washington: Government Printing Office, 1961.

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APPENDICES

## Appendix A

## Project Statement of the Master Study

University of Puerto Rico  
AGRICULTURAL EXPERIMENT STATION  
Rio Piedras, Puerto Rico

TITLE: ECONOMIC ANALYSIS OF THE MECHANIZATION OF SUGARCANE FARMS  
IN PUERTO RICO

## OBJECTIVES:

1. To study the general organization of sugarcane farms under various degrees of mechanization as currently practiced in Puerto Rico.
2. To determine operation costs of tractors and other power equipment currently used in the production and harvest of sugarcane in Puerto Rico.
3. To determine the most economical farm unit for mechanized production of sugarcane under various degrees of mechanization.
4. To obtain basic data which may serve as a basis for further studies.

JUSTIFICATION: The sugar industry plays a very important role in the economy of Puerto Rico. It is the most important source of agricultural income and the largest employer of labor on the Island. It has been under a constant pressure by other competitive areas, especially Hawaii and the mainland producers. These areas have some advantage due to a higher degree of mechanization. The mechanization of sugarcane production involves the use by farm people of tractors and other power equipment in performing the various field operations on the farm. The industry is now undergoing a critical situation as a result of increasing costs of production coupled with a relatively stable price of sugar for the last few years. Therefore, some adjustments appear to be necessary in order to reduce production costs as a means to avert a possible collapse of the sugar industry in Puerto Rico.

In general, field operations in sugarcane production in Puerto Rico are largely under-mechanized. It is

expected that the present economical situation of the sugar industry can be considerably improved with the more extensive adoption of power equipment.

It is realized that a considerable amount of the land that is devoted to sugarcane production at present is adaptable to complete mechanization of field practices. Full mechanization of sugarcane plantations will bring the industry to a more favorable competitive position in relation to other producing areas.

PREVIOUS WORK AND PRESENT OUTLOOK: No previous studies have been made on the mechanization of sugarcane in Puerto Rico. However, the Department of Economics and Rural Sociology of this station has published some studies which are sources of background information relative to production, management, and labor efficiency in Puerto Rico. These studies are:

1. Pinero, M. and Calderon, J. R., Estudio Sobre la Explotacion Economica de 134 Fincas de Cana de Azucar en Puerto Rico, Bull. 132, April 1956, Agricultural Experiment Station, University of Puerto Rico.
2. Silva, E. and Pinero, M., Labor Efficiency in Harvesting Sugarcane in Puerto Rico, 1950, E. & R. S. #24, January 1953, Agricultural Experiment Station, University of Puerto Rico.

Since sugarcane plays an important part in the economy of the Island, and the cost of production factors are increasing continuously, it will be beneficial for the whole economy to search for accurate and reliable information along the objectives of this study.

PROCEDURE:

1. The budget system will be used to attain the objectives of the study. The budget or farm plans, is a formal device for setting down the different crops which can be produced and in deciding which alternatives are most profitable. It is also used for the purpose of determining the effects of proposed changes in organization such as changes in layout, the kind and amount of power and equipment to decide on optimum production methods. In setting up a budget or plan, we will set down the prospective areas of each crop, evaluate farming practices, and estimate the yields and production; compute income and costs; and



finally estimate net income. By making up budgets for several systems of farming, we will predict which one will be the most profitable (see an example in Annex #1).

2. A list will be prepared of all the sugarcane farms that use tractors and power equipment in their production operations. This list will include all the farms above 50 cuerdas (a cuerda is 0.9712 of an acre). The population will be stratified into municipalities and within the municipalities, and classified according to size of farms. A proportional random sample will be taken. A sufficiently larger number of farmers will be included in the sample to obtain a representative cross section of the universe.
3. All the farmers in the sample will be visited to get the necessary information in relation to their operation practices on the sugarcane farm to comply with the main objectives of the study.
4. Although every farmer has a different problem at his farm, some basic information will be worked out to find the most economical farm unit assuming full or some degree of mechanization.
5. All this information will be tabulated and analyzed. Findings and recommendations will be published in bulletin form.

PROBABLE DURATION: Two years

PERSONNEL: L. Hernandez, Jose A. Molina, J. H. Rodriguez Arias

INSTITUTIONAL UNITS INVOLVED: Department of Agricultural Economics and Rural Sociology and Department of Agricultural Engineering.

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Arturo Roque, Director  
Agricultural Experiment Station

APPROVED:

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## Annex #1

## Operations Costs Incurred Per Acre While Preparing Land for Planting Sugarcane

## Alternative #1

Machinery (Tractor)

Wages .....	\$ 5.00
Depreciation .....	.67
Repairs .....	.17
Fuel .....	5.00
Tires .....	.17
Housing .....	.42
Interest .....	.20
Oil, lubrication, and washing .....	<u>.32</u>
Total costs	\$11.95

## Alternative #2

Human and Animal Costs

Wages .....	\$37.50
Depreciation of plow .....	.06
Repairs of plow .....	.17
Depreciation of rake .....	.01
Depreciation of oxen-team .....	1.05
Animal feed .....	<u>2.00</u>
Total costs	\$40.79

Total saved while using machinery ..... \$28.84

## Appendix B

## Questionnaire for the Master Study

University of Puerto Rico  
 AGRICULTURAL EXPERIMENT STATION  
 Rio Piedras, Puerto Rico

Confidential information                      Number of questionnaire \_\_\_\_\_

ECONOMIC ANALYSIS OF MECHANIZATION ON SUGARCANE FARMS  
 IN PUERTO RICO

Name of Farmer \_\_\_\_\_

Age \_\_\_\_\_ years

Municipality \_\_\_\_\_

Burrow \_\_\_\_\_

Date \_\_\_\_\_

Enumerator \_\_\_\_\_

Education \_\_\_\_\_

Experience \_\_\_\_\_ years

Land tenure:

a) Land owned \_\_\_\_\_ cuerdas

b) Land rented \_\_\_\_\_ cuerdas

c) Land farmed for shares \_\_\_\_\_ cuerdas

Land use:

a) Total acreage \_\_\_\_\_ cuerdas

b) Land in cane \_\_\_\_\_ cuerdas

c) Land in other crops \_\_\_\_\_ cuerdas

d) Waste land, roads, farmstead, woods, etc. \_\_\_\_\_ cuerdas

Average value of land per cuerda \_\_\_\_\_ dollars

Taxes on land and buildings \_\_\_\_\_ dollars

Irrigation fees \_\_\_\_\_ dollars

Rental fees \_\_\_\_\_ dollars

Other: \_\_\_\_\_

Social Security \_\_\_\_\_ dollars

Workman's liability insurance \_\_\_\_\_ dollars

Unemployment insurance \_\_\_\_\_ dollars

Interest paid by loans \_\_\_\_\_ dollars

Miscellaneous \_\_\_\_\_ dollars

Topography:

Level \_\_\_\_\_

Hillsides \_\_\_\_\_

Soil types \_\_\_\_\_

Farm practices \_\_\_\_\_

a) Seeds:

Varieties \_\_\_\_\_

Origin \_\_\_\_\_

Method of selection \_\_\_\_\_

b) Seeding:

Practice: 1. Louisiana Modified Method \_\_\_\_\_

2. Furrow \_\_\_\_\_

Distance: \_\_\_\_\_

c) Practices used to prevent diseases and plaques

\_\_\_\_\_

d) Damage caused by insects \_\_\_\_\_

Method of control \_\_\_\_\_

Use of tractor and equipment \_\_\_\_\_



I. Farm Practices used in Planting Cane: Number of Cuerdas \_\_\_\_\_.

Item	Cost of labor				Animals		Machinery and equipment		
	Paid		Unpaid		Days	Dollars	Type	Days	Dollars
	Days	Dollars	Days	Dollars					
Preparation of seedbeds	:	:	:	:	:	:	:	:	:
Plowing:	:	:	:	:	:	:	:	:	:
First	:	:	:	:	:	:	:	:	:
Second	:	:	:	:	:	:	:	:	:
Other	:	:	:	:	:	:	:	:	:
Disking:	:	:	:	:	:	:	:	:	:
First	:	:	:	:	:	:	:	:	:
Second	:	:	:	:	:	:	:	:	:
Other	:	:	:	:	:	:	:	:	:
Use of soil conditioners:	:	:	:	:	:	:	:	:	:
Sulfur	:	:	:	:	:	:	:	:	:
Lime	:	:	:	:	:	:	:	:	:
Fertilizers	:	:	:	:	:	:	:	:	:
Furrowing:	:	:	:	:	:	:	:	:	:
Leveling	:	:	:	:	:	:	:	:	:

(cont.)

Item	Cost of labor				Animals		Machinery and equipment		
	Paid		Unpaid		Days	Dollars	Type	Days	Dollars
	Days	Dollars	Days	Dollars					
Furrowing (cont.)	:	:	:	:	:	:	:	:	:
Ditching for irrigation	:	:	:	:	:	:	:	:	:
Locks	:	:	:	:	:	:	:	:	:
Ditches	:	:	:	:	:	:	:	:	:
Cleaning canals	:	:	:	:	:	:	:	:	:
Total	:	:	:	:	:	:	:	:	:
Preparation of cuttings:	:	:	:	:	:	:	:	:	:
Collection	:	:	:	:	:	:	:	:	:
Cleaning seeds	:	:	:	:	:	:	:	:	:
Treating for diseases and plagues	:	:	:	:	:	:	:	:	:
Planting:	:	:	:	:	:	:	:	:	:
Distributing cuttings	:	:	:	:	:	:	:	:	:
Covering	:	:	:	:	:	:	:	:	:
Replanting	:	:	:	:	:	:	:	:	:

(cont.)

Item	Cost of labor				Animals		Machinery and equipment		
	Paid		Unpaid		Days	Dollars	Type	Days	Dollars
	Days	Dollars	Days	Dollars					
Preparation of cuttings (cont.)	:	:	:	:	:	:	:	:	:
Distributing cuttings	:	:	:	:	:	:	:	:	:
Covering	:	:	:	:	:	:	:	:	:
Total	:	:	:	:	:	:	:	:	:
Irrigation	:	:	:	:	:	:	:	:	:
Cultivating:	:	:	:	:	:	:	:	:	:
Hoeing	:	:	:	:	:	:	:	:	:
First	:	:	:	:	:	:	:	:	:
Second	:	:	:	:	:	:	:	:	:
Other	:	:	:	:	:	:	:	:	:
Fertilizing	:	:	:	:	:	:	:	:	:
First	:	:	:	:	:	:	:	:	:
Placing sacs	:	:	:	:	:	:	:	:	:
Sowing	:	:	:	:	:	:	:	:	:
Second	:	:	:	:	:	:	:	:	:



(concl.)

Item	Cost of labor				Animals		Machinery and equipment		
	Paid		Unpaid				Type	Days	Dollars
	Days	Dollars	Days	Dollars	Days	Dollars			
Cultivation (cont.)	:	:	:	:	:	:	:	:	:
Placing sacs	:	:	:	:	:	:	:	:	:
Sowing	:	:	:	:	:	:	:	:	:
Total for cultivation	:	:	:	:	:	:	:	:	:
Harvest:	:	:	:	:	:	:	:	:	:
Cutting	:	:	:	:	:	:	:	:	:
Loading	:	:	:	:	:	:	:	:	:
Hauling	:	:	:	:	:	:	:	:	:
Total	:	:	:	:	:	:	:	:	:
Other expenses in planting cane	:	:	:	:	:	:	:	:	:
Foreman	:	:	:	:	:	:	:	:	:
Waterboys	:	:	:	:	:	:	:	:	:
Clerk	:	:	:	:	:	:	:	:	:
Others (specify)	:	:	:	:	:	:	:	:	:
Total	:	:	:	:	:	:	:	:	:
Grand total	:	:	:	:	:	:	:	:	:

II. Farm Practices used in Ratoon.

Item	Cost of labor				Animals	Machinery and equipment		
	Paid		Unpaid					
	Days	Dollars	Days	Dollars			Type	Days
Cultivating	:	:	:	:	:	:	:	:
Replanting	:	:	:	:	:	:	:	:
Hoeing	:	:	:	:	:	:	:	:
Mechanized cultivation	:	:	:	:	:	:	:	:
Use of herbicides	:	:	:	:	:	:	:	:
Cultivators	:	:	:	:	:	:	:	:
Fertilizers	:	:	:	:	:	:	:	:
Irrigation	:	:	:	:	:	:	:	:
Total	:	:	:	:	:	:	:	:
Harvesting	:	:	:	:	:	:	:	:
Cutting	:	:	:	:	:	:	:	:
Loading	:	:	:	:	:	:	:	:
Hauling	:	:	:	:	:	:	:	:
Total	:	:	:	:	:	:	:	:
Total for all field operations	:	:	:	:	:	:	:	:

## III. Use of Machinery and Equipment.

Item	: Auto- : mobiles	: Trucks	: Station : wagons	: Tractors
Model and year	:	:	:	:
Original value	:	:	:	:
Value at the begin- ning of the year	:	:	:	:
Purchases	:	:	:	:
Value at the end of the year	:	:	:	:
Average investment	:	:	:	:
Other expenses	:	:	:	:
Net depreciation	:	:	:	:
Interest at 6% <sup>1</sup>	:	:	:	:
License plates	:	:	:	:
Insurances	:	:	:	:
Taxes	:	:	:	:
Tires	:	:	:	:
Oil	:	:	:	:
Gas	:	:	:	:
Grease	:	:	:	:
Repairs	:	:	:	:
Total	:	:	:	:
No. of days work on farm	:	:	:	:
No. of days work on sugarcane field	:	:	:	:
Rent <sup>2</sup>	:	:	:	:

<sup>1</sup> Office work.

<sup>2</sup> Determine if rent includes payments of drivers and laborers.  
Explain in details on footnotes.

Other equipment.

Type	Orig- inal value	Begin- ning of year	Pur- chases	Sales	End of year	Aver- age	Inter- est at 6%	Re- pairs	Grease	Total cost
	\$	No.	\$	\$	No.	\$	\$	\$	\$	\$
eed drill	:	:	:	:	:	:	:	:	:	:
x carts	:	:	:	:	:	:	:	:	:	:
ractor carts	:	:	:	:	:	:	:	:	:	:
lows	:	:	:	:	:	:	:	:	:	:
Disk	:	:	:	:	:	:	:	:	:	:
Gang	:	:	:	:	:	:	:	:	:	:
Subsoiler	:	:	:	:	:	:	:	:	:	:
urrow moldboard plow	:	:	:	:	:	:	:	:	:	:
ine harrow	:	:	:	:	:	:	:	:	:	:
ugarcane chopper	:	:	:	:	:	:	:	:	:	:
ugarcane picker	:	:	:	:	:	:	:	:	:	:
railers	:	:	:	:	:	:	:	:	:	:
hains	:	:	:	:	:	:	:	:	:	:
pray pump	:	:	:	:	:	:	:	:	:	:
rrigation pump furrow system	:	:	:	:	:	:	:	:	:	:
anure spreader	:	:	:	:	:	:	:	:	:	:
thers (specify)	:	:	:	:	:	:	:	:	:	:

## Appendix C

## Classification Tables for the Master Sample

Table 1. Number of farms by size group and percent of slope, Puerto Rico, 1960.

Cuerdas on cane	Slope in percent		
	0-5	5-12	0-12
	Number		
50 - 59	53	49	46
60 - 69	36	43	36
70 - 79	22	33	16
80 - 89	14	32	16
90 - 99	18	15	18
100 - 119	38	18	27
120 - 139	19	15	22
140 - 159	23	14	9
160 - 179	17	22	8
180 - 199	9	6	18
200 - 249	15	10	21
250 - 299	21	4	16
300 - 399	23	8	9
400 - 499	19	8	6
500 or more	19	3	11
Total	346	280	279

Table 2. Number of sample farms by size group and percent of slope, Puerto Rico, 1960.

Cuerdas on cane	Slope in percent			Totals
	0-5	5-12	0-12	
	Number			
50 - 59	13	13	12	38
60 - 69	9	10	9	28
70 - 79	5	9	4	18
80 - 89	4	8	4	16
90 - 99	4	3	4	11
100 - 119	10	4	7	21
120 - 139	5	4	5	14
140 - 159	6	3	3	12
160 - 179	4	5	2	11
180 - 199	2	2	4	8
200 - 249	4	3	5	12
250 - 299	5	1	4	10
300 - 399	6	2	2	10
400 - 499	5	2	1	8
500 or more	5	1	3	9

Table 3. All farms and sample farms by areas, Puerto Rico, 1960.

	Zone				Total
	North-	North	South-	South-	
	east	west	west	east	
Total number of farms in the population	340	237	211	117	905
Total number of farms in the sample	80	58	59	29	226
Proportion of the uni- verse in the sample	24	24	28	25	25

Appendix D

Detailed Study Tables on Cost of Production of Sugarcane in Puerto Rico

Table 1. Relation of average costs of labor and machinery per cuerda for planted cane by size of farms (cuerdas) and field operations, non-irrigated land, Puerto, Rico, 1960.

Field operations <sup>1</sup>	Average costs per cuerda <sup>2</sup>								
	50-99 cuerdas			100-199 cuerdas			200 and more cuerdas		
	Labor	Ma- chin- ery	Total	Labor	Ma- chin- ery	Total	Labor	Ma- chin- ery	Total
Plowing	\$5.17 (1.77)	\$14.01 (1.34)	\$19.18	\$2.83 (0.32)	\$13.28 (1.28)	\$16.11	\$2.59 (0.23)	\$10.94	\$13.53
Disking	1.59 (0.58)	5.78 (1.34)	7.37	1.22 (0.15)	5.67 (0.66)	6.89	1.11 (0.10)	5.22 (0.43)	6.33
Furrowing	1.45 (0.25)	4.90 (0.88)	6.35	4.03 (0.76)	5.44 (0.52)	9.47	3.37 (0.48)	4.55 (0.36)	7.92
Seed preparation	5.78 (1.00)	3.34 (2.10)	9.12	5.23 (0.66)	<u>3/</u>	5.23	5.35 (0.71)	3.42 (0.83)	8.77
Planting and re- planting	19.66 (2.34)	9.30 (2.62)	28.96	19.44 (2.65)	7.13 (2.23)	26.57	15.91 (0.23)	5.14 (0.91)	21.05
Cultivating (with hoe) .05, .01	45.99*,** (5.77)	00	45.99	29.06* (3.46)	00	29.06	25.90** (3.43)	00	25.90
Applying herbi- cides	6.81 (2.39)	8.39 (2.51)	15.20	6.08 (1.48)	7.78 (1.18)	13.82	6.07 (0.95)	6.66 (0.86)	12.73
Applying ferti- lizers	4.20 (0.36)	4.15 (1.93)	8.35	4.08 (0.55)	1.41 (0.31)	5.49	4.02 (0.39)	1.49 (0.27)	5.51
Cutting	53.16 (3.05)	00	53.16	52.94 (4.17)	00	52.94	53.91 (2.57)	00	53.91
Loading and hauling .05	38.13* (3.26)	24.06 (3.22)	62.19	34.01 (2.76)	21.27 (3.75)	55.28	27.61* (3.19)	19.49 (2.44)	47.10
Total	\$181.94	\$73.93	\$255.87	\$158.88	\$61.98	\$220.86	\$145.84	\$56.91	\$202.75

<sup>1</sup> .10, .05, .01, and .001 indicate significance at 10%, 5%, 1%, and .1% levels; others are not significant at 10% level.

<sup>2</sup> Figures in parentheses are standard errors.

<sup>3/</sup> Not reported.



Table 2. Relation of average costs of labor and machinery per ton for planted cane by size of farms (cuerdas) and field operations, non-irrigated land, Puerto Rico, 1960.

Field operations <sup>1</sup>	Average costs per ton <sup>2</sup>								
	50-99 cuerdas			100-199 cuerdas			200 and more cuerdas		
	Labor	Ma- chin- ery	Total	Labor	Ma- chin- ery	Total	Labor	Ma- chin- ery	Total
Plowing .10	\$0.13 (.04)	\$0.40 (.05)	\$0.53	\$0.07 (.01)	\$0.33 (.04)	\$0.40	\$0.06 (.01)	\$0.27 (.03)	\$0.33
Disking	0.04 (.01)	0.18 (.05)	0.22	0.03 (.01)	0.14 (.02)	0.17	0.02 (.002)	0.12 (.01)	0.14
Furrowing	0.04 (.01)	0.14 (.03)	0.18	0.11 (.02)	0.13 (.02)	0.24	0.09 (.02)	0.12 (.02)	0.21
Seed preparation	0.17 (.04)	0.08 (.04)	0.25	0.13 (.02)	<u>3/</u>	0.13	0.14 (.02)	0.11 (.03)	0.25
Planting and re- planting .10	0.69 <sup>+</sup> (.13)	0.28 <sup>+</sup> (.07)	0.97	0.52 (.08)	0.15 (.04)	0.67	0.42 <sup>+</sup> (.07)	0.13 <sup>+</sup> (.02)	0.55
Cultivating (with hoe) .05	1.27* (.16)	00	1.27	0.75* (.13)	00	0.75	0.64* (.11)	00	0.64
Applying herbi- cides	0.19 (.07)	0.16 (.06)	0.35	0.14 (.03)	0.16 (.03)	0.30	0.14 (.02)	0.14 (.02)	0.28
Applying ferti- lizers	0.12 (.01)	0.12 (.05)	0.24	0.10 (.01)	0.03 (.01)	0.13	0.11 (.02)	0.04 (.01)	0.15
Cutting	1.43 (.07)	00	1.43	1.26 (.07)	00	1.26	1.34 (.04)	00	1.34
Loading and hauling .01, .10	1.02** (.07)	0.66 <sup>+</sup> (.08)	1.68	0.80 (.06)	0.48 <sup>+</sup> (.07)	1.28	0.67** (.08)	0.49 (.08)	1.16
Total	\$5.10	\$2.02	\$7.12	\$3.91	\$1.42	\$5.33	\$3.63	\$1.42	\$5.05

<sup>1</sup> .10, .05, .01, and .001 indicate significance at 10%, 5%, 1%, and .1% levels; others are not significant at 10% level.

<sup>2</sup> Figures in parentheses are standard errors.

<sup>3/</sup> Not reported.

<sup>+</sup> 10% significance.

Table 3. Relation of average costs of labor and machinery per cuerda for ratoon by size of farms (cuerdas) and field operations, non-irrigated land, Puerto Rico, 1960.

Field operations <sup>1</sup>	Average costs per cuerda <sup>2</sup>								
	50-59 cuerdas			100-199 cuerdas			200 and more cuerdas		
	Labor	Ma- chin- ery	Total	Labor	Ma- chin- ery	Total	Labor	Ma- chin- ery	Total
Cultivating (with hoe) .05	\$21.18*	00	\$21.18	\$28.37*	00	\$28.37	\$24.72	00	\$24.72
	(2.20)			(2.66)			(3.22)		
Applying herbi- cides	4.05	\$1.57	5.62	4.54	\$2.33	6.87	4.39	\$0.88	5.27
	(.66)	(.52)		(.51)	(.97)		(.60)	(.22)	
Replanting	3.73	1.62	5.35	4.82	<u>3/</u>	4.82	3.12	0.64	3.76
	(2.27)	(.95)		(1.24)			(.62)	(.12)	
Applying ferti- lizers	4.53	4.22	8.75	2.21	0.95	6.16	4.37	1.00	5.37
	(.55)	(2.36)		(.44)	(.16)		(.38)	(.26)	
Cutting	41.72	00	41.72	47.53	00	47.53	40.68	00	40.68
	(2.40)			(2.99)			(3.00)		
Loading and hauling .01, .05	27.12**	20.07*	47.19	28.18**	17.98*	26.16	17.38**	10.10*	27.48
	(2.21)	(3.56)		(2.27)	(2.25)		(2.67)	(2.29)	
Total	\$102.33	\$27.48	\$129.81	\$118.65	\$21.26	\$139.91	\$94.66	\$12.62	\$107.28

<sup>1</sup> .10, .05, .01, and .001 indicate significance at 10%, 5%, 1%, and .1% levels; others are not significant at the 10% level.

<sup>2</sup> Figures in parentheses are standard errors.

<sup>3/</sup> Not reported.

Table 4. Relation of average costs of labor and machinery per ton for ratoon by size of farms (cuerdas) and field operations, non-irrigated land, Puerto Rico, 1960.

Field operations <sup>1</sup>	Average costs per ton <sup>2</sup>								
	50-99 cuerdas			100-199 cuerdas			200 and more cuerdas		
	Labor	Ma- chin- ery	Total	Labor	Ma- chin- ery	Total	Labor	Ma- chin- ery	Total
Cultivating (with hoe)	\$0.87 (.11)	00	\$0.87	\$1.13 (.16)	00	\$1.13	\$0.93 (.14)	00	\$0.93
Applying herbi- cides	0.16 (.03)	\$0.08 (.02)	0.24	0.15 (.02)	\$0.06 (.02)	0.21	0.17 (.03)	\$0.03 (.01)	0.23
Replanting	0.19 (.13)	0.09 (.05)	0.27	0.18 (.04)	<u>3/</u>	0.18	0.10 (.02)	0.02 (.004)	0.12
Applying ferti- lizers .10	0.18 (.03)	0.17 (.08)	0.35	0.19 (.02)	0.03 (0.01)	0.22	0.18 (.02)	0.04 (.01)	0.22
Cutting	1.57 (.08)	00	1.57	1.62 (.09)	00	1.62	1.50 (.13)	00	1.50
Loading and hauling .05, .10	0.96* (.05)	0.71+ (.11)	1.67	0.95+ (.07)	0.62 (.09)	1.57	0.69*+ (.12)	0.42+ (.11)	1.11
Total	\$3.93	\$1.04	\$4.97	\$4.22	\$0.71	\$4.93	\$3.57	\$0.51	\$4.08

<sup>1</sup> .10, .05, .01, and .001 indicate significance at 10%, 5%, 1%, and .1% levels; others are not significant at the 10% level.

<sup>2</sup> Figures in parentheses are standard errors.

<sup>3/</sup> Not reported.

+ Indicates significance at 10%.

Table 5. Relation of average costs of labor and machinery per cuerda for planted cane by size of farms (cuerdas) and field operations, irrigated land, Puerto Rico, 1960.

Field operations <sup>1</sup>	Average costs per cuerda <sup>2</sup>					
	50-149 cuerdas			150 and more cuerdas		
	Labor	Ma- chinery	Total	Labor	Ma- chinery	Total
Plowing	\$2.02 (.34)	\$14.64 (2.64)	\$16.66	\$2.22 (.45)	\$12.13 (2.21)	\$14.35
Disking	0.70 (.10)	4.95 (.91)	5.65	1.10 (.25)	5.99 (1.29)	7.09
Furrowing	1.16 (.18)	7.87 (1.26)	9.03	1.88 (.58)	7.21 (1.90)	9.09
Seed preparation	5.20 (1.62)	2.00	7.20	6.47 (1.22)	<u>3/</u>	6.47
Planting and replanting	18.60 (6.11)	6.63	25.23	12.68 (3.64)	12.52 (5.54)	25.20
Cultivating (with hoe)	31.32 (5.99)	00	31.32	20.33 (4.41)	00	20.33
Applying herbicides	3.26 (.86)	5.00	8.26	3.89 (.62)	7.77 (3.44)	11.66
Applying fertilizers	4.11 (.70)	3.43 (1.61)	7.54	3.35 (.45)	2.26 (.60)	5.61
Irrigation .05	5.74* (.81)	5.32 (2.76)	11.06	10.61* (1.68)	6.70 (5.22)	17.31
Cutting .05	49.26* (3.86)	00	49.26	68.82* (5.82)	00	68.82
Loading and hauling .10	38.93+ (3.74)	22.39 (6.83)	61.32	29.08+ (4.40)	19.56 (4.38)	48.64
Total	\$160.30	\$72.23	\$232.53	\$160.43	\$74.14	\$234.57

<sup>1</sup> .10, .05, .01, and .001 indicate significance at 10%, 5%, 1%, and .1% levels; others are not significant at the 10% level.

<sup>2</sup> Figures in parentheses are standard errors.

<sup>3/</sup> Not reported.

+ Indicates significance at 10%.

Table 6. Relation of average costs of labor and machinery per ton for planted cane by size of farms (cuerdas) and field operations, irrigated land, Puerto Rico, 1960.

Field operations <sup>1</sup>	Average costs per ton <sup>2</sup>					
	50-149 cuerdas			150 and more cuerdas		
	Labor	Ma- chin- ery	Total	Labor	Ma- chin- ery	Total
Plowing	\$0.05 (.002)	\$0.38 (.08)	\$0.43	\$0.05 (.01)	\$0.26 (.05)	\$0.31
Disking	0.02 (.003)	0.13 (.03)	0.15	0.02 (.011)	0.13 (.03)	0.15
Furrowing	0.03 (.01)	0.20 (.03)	0.23	0.04 (.01)	0.16 (.05)	0.20
Seed preparation	0.13 (.05)	0.04	0.17	0.13 (.01)	<u>3/</u>	0.13
Planting and replanting	0.50 (.18)	0.19	0.69	0.29 (.09)	0.26 (.11)	0.55
Cultivating (with hoe) .10	0.81 <sup>+</sup> (.18)	00	0.81	0.42 <sup>+</sup> (.10)	00	0.42
Applying herbi- cides	0.08 (.02)	0.11	0.19	0.09 (.01)	0.17 (.07)	0.25
Applying ferti- lizers	0.11 (.02)	0.10 (.04)	0.21	0.07 (.01)	0.04 (.01)	0.11
Irrigation	0.14 (.02)	0.14 (.08)	0.28	0.21 (.04)	0.24 (.21)	0.45
Cutting .10	1.14 <sup>+</sup> (.08)	00	1.14	1.40 <sup>+</sup> (.10)	00	1.40
Loading and hauling .05	.99* (.12)	0.56 (.20)	1.55	0.58* (.08)	0.40 (.08)	0.98
Total	\$4.00	\$1.85	\$5.85	\$3.29	\$1.66	\$4.95

<sup>1</sup> .10, .05, .01, and .001 indicate significance at 10%, 5%, 1%, and .01% levels; others are not significant at the 10% level.

<sup>2</sup> Figures in parentheses are standard errors.

<sup>3/</sup> Not reported.

<sup>+</sup> Indicates significance at 10%.

Table 7. Relation of average costs of labor and machinery per cuerda for ratoon by size of farms (cuerdas) and field operations, irrigated land, Puerto Rico, 1960.

Field operations <sup>1</sup>	Average costs per cuerda <sup>2</sup>					
	50-149 cuerdas			150 and more cuerdas		
	Labor	Machinery	Total	Labor	Machinery	Total
Cultivating (with hoe)	\$14.55 (5.99)	00	\$14.55	\$21.10 (3.56)	00	\$21.10
Applying herbicides	7.23 (1.95)	\$18.01 (12.18)	25.24	3.38 (.79)	\$2.13 (.48)	5.51
Replanting	2.37 (.74)	<u>3/</u>	2.37	1.85 (.16)	<u>3/</u>	1.85
Applying fertilizers	3.86 (.38)	0.89	4.75	2.98 (.38)	2.80 (.72)	5.78
Irrigation	8.60 (2.35)	<u>3/</u>	8.60	9.62 (3.54)	<u>3/</u>	9.62
Cutting	48.74 (9.28)	00	48.74	43.03 (3.29)	00	43.03
Loading and hauling .05	28.78* (6.30)	19.35 (5.76)	48.13	11.81* (1.92)	13.65 (4.53)	25.46
Total	\$114.13	\$38.25	\$152.38	\$93.77	\$18.58	\$112.35

<sup>1</sup> .10, .05, .01, and .001 indicate significance at 10%, 5%, 1%, and .1% levels; others are not significant at the 10% level.

<sup>2</sup> Figures in parentheses are standard errors.

<sup>3/</sup> Not reported.

Table 8. Relation of average costs of labor and machinery per ton for ratoon by size of farms (cuerdas) and field operations, irrigated land, Puerto Rico, 1960.

	Average costs per ton <sup>2</sup>					
	50-149 cuerdas			150 and more cuerdas		
Field operations <sup>1</sup>	Labor	Ma- chin- ery	Total	Labor	Ma- chin- ery	Total
Cultivating (with hoe)	\$0.58 (.31)	00	\$0.58	\$0.73 (.16)	00	\$0.73
Applying herbi- cides	0.26 (.09)	\$0.56 (.33)	0.82	0.11 (.03)	\$0.06 (.01)	0.17
Replanting	0.08 (.02)	<u>3/</u>	0.08	0.07 (.01)	<u>3/</u>	
Applying ferti- lizers	0.14 (.03)	0.04	0.18	0.10 (.02)	0.07 (.02)	0.17
Irrigation	0.34 (.11)	<u>3/</u>	0.34	0.30 (.11)	<u>3/</u>	0.30
Cutting	1.52 (.13)	00	1.52	1.33 (.06)	00	1.33
Loading and hauling .001	0.91*** (.11)	0.60 (.14)	1.51	0.37*** (.06)	0.35 (.10)	0.72
Total	\$3.83	\$1.20	\$5.03	\$3.01	\$0.48	\$3.49

<sup>1</sup> .10, .05, .01, and .001 indicate significance at 10%, 5%, 1%, and .1% levels; others are not significant at the 10% level.

<sup>2</sup> Figures in parentheses are standard errors.

<sup>3/</sup> Not reported.

Table 9. Relation of average costs of materials and other expenses per cuerda and per ton for planting cane by size of farms (cuerdas), non-irrigated land, Puerto Rico, 1960.

Item	:Average cost per cuerda :			:Average cost per ton :		
	: 50- : : 99 :	: 100- : : 199 :	: 200 : : or more :	: 50- : : 99 :	: 100- : : 199 :	: 200 : : or more :
<b>Materials</b>						
Seed cane	\$29.38	\$28.12	\$25.29	\$0.83	\$0.76	\$0.72
Fertilizers	34.82	38.04	34.73	1.30	1.30	1.19
Herbicides	2.46	2.84	2.67	0.10	0.08	0.09
Total	\$66.66	\$69.00	\$62.69	\$2.23	\$2.14	\$2.00
<b>Other expenses</b>						
Social Security	\$ 4.62	\$ 5.90	\$ 3.85	\$0.17	\$0.19	\$0.13
Unemployment insurance	5.34	5.84	5.52	0.20	0.19	0.19
Workman's liability insurance	5.79	7.26	5.63	0.23	0.23	0.20
Use of land	21.12	26.60	29.17	0.81	0.82	0.96
Interest on loans	9.82	13.92	9.14	0.39	0.47	0.32
Wages for management	20.62	15.57	18.87	0.77	0.50	0.52
Other costs <sup>1</sup>	2.46	2.05	67.26	0.07	0.06	2.24
Total	\$69.77	\$77.14	\$139.44	\$2.64	\$2.46	\$4.56
Total for all items	\$136.43	\$146.14	\$202.13	\$4.87	\$4.60	\$6.56

<sup>1</sup> Includes: Accounting clerks, office supplies, repair of fences, repair of roads, and miscellaneous expenses such as light and first aid medicines.



Table 10. Relation of average costs of materials and other expenses per cuerda and per ton for ratoon by size of farms (cuerdas), non-irrigated land, Puerto Rico, 1960.

Item	Average cost per cuerda			Average cost per ton		
	50- 99	100- 199	200 or more	50- 99	100- 199	200 or more
<b>Materials</b>						
Seed cane	\$ 8.59	<u>1/</u>	<u>1/</u>	\$0.40	<u>1/</u>	<u>1/</u>
Fertilizers	34.82	\$38.04	\$34.73	1.30	\$1.30	\$1.19
Herbicides	2.46	2.84	2.67	0.10	0.08	0.09
Total	\$45.87	\$40.88	\$37.40	\$1.80	\$1.38	\$1.28
<b>Other expenses</b>						
Social Security	\$ 4.62	\$ 5.90	\$ 3.85	\$0.17	\$0.19	\$0.13
Unemployment insurance	5.34	5.84	5.52	0.20	0.19	0.19
Workman's liability insurance	5.75	7.26	5.63	0.23	0.23	0.20
Use of land	21.12	26.60	29.17	0.81	0.82	0.96
Interest on loans	9.82	13.92	9.14	0.39	0.47	0.32
Wages for management	20.62	15.57	18.87	0.77	0.50	0.52
Other costs <sup>2</sup>	<u>1/</u>	<u>1/</u>	67.26	<u>1/</u>	<u>1/</u>	2.24
Total	\$67.27	\$75.09	\$139.44	\$2.57	\$2.40	\$4.56
Total for all items	\$113.14	\$115.97	\$176.84	\$4.37	\$3.78	\$5.84

<sup>1/</sup> Not reported.

<sup>2</sup> Includes: Accounting clerks, office supplies, repair of fences, repair of roads, miscellaneous expenses such as light and first aid medicines.

Table 11. Relation of average costs of materials and other expenses per cuerda and per ton for planting cane by size of farms (cuerdas), irrigated land, Puerto Rico, 1960.

Item	Average cost per cuerda		Average cost per ton	
	50-149	150 or more	50-149	150 or more
<b>Materials</b>				
Seed cane	\$35.12	\$42.59	\$0.85	\$0.88
Fertilizers	33.89	33.08	1.10	0.91
Herbicides	2.79	3.64	0.05	0.11
Water fee	7.25	10.57	0.23	0.33
Total	\$79.05	\$89.88	\$2.23	\$2.23
<b>Other expenses</b>				
Social Security	\$ 4.47	\$ 4.74	\$0.14	\$0.14
Unemployment insurance	4.39	3.90	0.14	0.16
Workman's liability insurance	5.51	7.75	0.17	0.22
Use of land	33.07	33.07	0.99	0.99
Interest on loans	16.74	13.50	0.58	0.37
Wages for management	5.15	13.53	0.18	0.46
Other costs <sup>1</sup>	3.44	69.05	0.10	2.56
Total	\$72.77	\$145.54	\$2.30	\$4.90
Total for all items	\$151.82	\$235.42	\$4.53	\$7.13

<sup>1</sup> Includes: Accounting clerks, office supplies, repair of fences, repair of roads, and miscellaneous expenses such as light and first aid medicines.

Table 12. Relation of average costs of materials and other expenses per cuerda and per ton for ratoon by size of farms (cuerdas), irrigated land, Puerto Rico, 1960.

Item	Average cost per cuerda		Average cost per ton	
	50-149	150 or more	50-149	150 or more
<b>Materials</b>				
Seed cane	<u>1/</u>	<u>1/</u>	<u>1/</u>	<u>1/</u>
Fertilizers	\$33.89	\$33.08	\$1.10	\$0.91
Herbicides	2.79	3.64	0.05	0.11
Water fee	7.25	10.57	0.24	0.33
Total	\$43.93	\$47.29	\$1.39	\$1.35
<b>Other expenses</b>				
Social Security	\$ 4.47	\$ 4.74	\$0.14	\$0.14
Unemployment insurance	4.39	5.90	0.14	0.16
Workman's liability insurance	5.51	7.75	0.17	0.22
Use of land	33.07	33.07	0.99	0.99
Interest on loans	16.74	13.50	0.58	0.37
Wages for management	5.15	13.54	0.18	0.46
Other costs <sup>2</sup>	<u>1/</u>	55.51	<u>1/</u>	2.11
Total	\$69.33	\$134.01	\$2.20	\$4.45
Total for all items	\$113.26	\$181.30	\$3.59	\$5.80

<sup>1/</sup> Not reported.

<sup>2</sup> Includes: Accounting clerks, office supplies, repair of fences, repair of roads, and miscellaneous expenses such as light and first aid medicines.

THE RELATIONSHIPS BETWEEN AVERAGE COSTS AND SCALE OF  
OPERATION IN THE PRODUCTION OF SUGARCANE IN PUERTO RICO

by

JOSE ANTONIO MOLINA

B.S.A., College of Agriculture and Mechanical Arts  
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AN ABSTRACT OF A MASTER'S THESIS

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This study is part of a broad project entitled "Economic Analysis of the Mechanization of Sugarcane Farms in Puerto Rico." Objectives of this thesis were to: (1) determine which phase of the field operations cost most in producing sugarcane, (2) evaluate the influence of farm size upon the total cost of production per cuerda (0.9712 acre) and per ton, (3) analyze the feasibility of introducing more machinery into the production of sugarcane, and (4) analyze the difference in costs of irrigated and non-irrigated land.

Data to be analyzed in the study were obtained from farmers by personal interviews. Information obtained was classified as irrigated and non-irrigated land. Non-irrigated farms were divided into three sizes - 50 to 99 cuerdas, 100 to 199 cuerdas, and 200 cuerdas or more. Irrigated farms were divided into 50 to 149 cuerdas and 150 cuerdas or more. The costs of operating sugarcane farms were divided into three main groups - field operations, materials, and overhead expenses.

Both average cost per cuerda and per ton were calculated and later the arithmetic means were determined for each field operation. The standard errors of the means were computed to determine the degree of variability in cost among the same groups of farms. Finally, statistical tests of significance were run for the field operations, comparing the various sizes of farms.

The most important cost category analyzed in this study was the field operations, due to the high utilization of human labor. Approximately 70 percent of the total average cost incurred in

the field production of sugarcane was for human labor. The machinery costs were computed as rented in order to evaluate its variation by scale of operation. Machinery costs for the ratoon cane (irrigated) field operations had the most extreme variability, but there were no significant differences. Overhead expenses, the second cost category, rose at an increasing rate as the scale of production was increased. Material expenses, the third cost category, decreased with an increasing scale of production on the non-irrigated land; however, these costs showed an increase in costs per cuerda as farms increased in size on irrigated land.

The more important implications to be drawn from this study are: (1) total average costs per cuerda and per ton are higher on irrigated land; (2) total average costs per cuerda and per ton are lower for the ratoon than for the planted cane; (3) average size of the sugarcane farms (cuerdas) is highest for the irrigated units; and (4) average yield of sugarcane per cuerda was greatest on the irrigated farms.

According to this study, total average cost for producing a ton of sugarcane was \$10.37 for all farms. The average price paid to Puerto Rican sugarcane growers was \$8.87 per ton, which was too low in view of the survey results.