# CORN PRODUCTION BY TENURE TYPES IN NICARAGUA

by

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Since pre-colonial times corn has been the most important food crop in Nicaragua. It continues to be one of the main staples in the diet. In addition, increasing amounts of it are being used as an ingredient in dairy rations, especially during the dry season. Another source of increasing demand for corn are the many commercial eggs and broilers operations recently established.

In 1971, the area planted to corn accounted for approximately 41 percent of the total area in crops. The area has been increasing at an annual rate of 7.2 percent during the period of 1960-71 as compared to a rate of increase of 1.8 percent for the total area in crops (Warnken). In spite of this increase corn had to be imported at an increasing rate and the balance of payments deficit caused by these imports has increased at an annual rate of approximately 33 percent. This continuous deficit is not only due to the increasing demand but also by stagnant corn yields (Warnken).

This paper is an attempt to examine just one aspect of the problem, namely, the effect upon productivity of different tenure types. This focus is taken with the clear understanding that the tenure system is just one of many factors affecting productivity.

## OBJECTIVES

The objective of this paper is to determine if there are any significant differences in the yields, as a measure of productivity, of corn under different types of tenure. The study of tenure systems has always been a concern to agricultural economists because, as Schickel has observed, "tenure arrangements govern the way in which economic opportunities, managerial responsibility and farm income are distributed among the people."

(Schickele) Further, production functions are fitted subsequently to indicate the contribution of selected inputs to corn yields.

A study of the effects of the tenure system upon efficiency in agricultural production is especially significant in countries such as Nicaragua where most of the land suitable for agriculture is owned by a small proportion of the population. This gives rise to a land market structure that is 1) highly concentrated on the sellers' side and 2) essentially atomistic on the buyer's side. This type of sellers' market permits the landlords to claim a disproportionately large share of the returns as rent. This contributes to an inequitable distribution of income with its consequent social unrest.

## DATA AND METHODOLOGY

This study is based on a survey of 293 corn producing farms in western and central Nicaragua in 1971-72. The eastern region of the country is not included in the sample because production in this area is insignificant. Data were collected by extension agents who had previously been trained in interviewing techniques.

Note that type of tenure was not used as a criteria in selecting the sample. However, this was not possible because the data were to be used for several analyses, not just this one.

## ANALYSIS OF DATA

The farms in the survey were divided into five tenure types as shown in Table 1. Also shown are the average yields in hundred weights per manzana. The tenure types have been identified by numbers from one to five for future reference in this paper.

Table 1. Number and Percent of Sample in Each Tenure Type and Average Yields of Corn per Tenure Type, Nicaragua, 1971-72.

| Type of Tenure | Number of farms in sample | Percent of total sample | Average Yield (cwt/manzana) |
|---|---|---|---|
| Owner Operated | 129 | 44.0 | 22.89 |
| No Title | 12 | 4.1 | 13.17 |
| Cash-lease | 103 | 35.2 | 24.49 |
| Share-lease | 13 | 4.4 | 15.00 |
| Other | 36 | 12.3 | 17.69 |
| Total | 293 | 100.0 | |

Tenure type 1 are farms that were owner operated. Farms included in this tenure type are those were the operator had a legal title to the land.

Tenure type 2 refers to those farms where the operators had no title to the land or leasing arrangement with the owners. This type of situation is frequent in areas where landlords have very large holdings some of which are not used for his production but rather by squatters who use small plots for one or two years.

The farms included in tenure type 3 are those where rent is paid in cash (kind) for the use of the land regardless of the amount produced on the farm. This type of lease is the most frequent in Nicaragua because the landlords with vast tracts of land do not have time to manage share lesses.

Farms included under tenure type 4 are those where production was shared in the manner that is mutually agreed upon by the tenant and landlord (crop share leasee). This type of lease is not common in Nicaragua. Where it is found there is usually some family relationship between landlord and tenant or the

tenant is a trusted employee of the landlord. Under this relationship the landlord furnishes the land and may furnish some inputs such as seed and fertilizer or permits the tenant to use his machinery when it is idle. Landlords usually demand from 40 to 60 percent of the total output, depending upon the amount of inputs that are furnished. However, because either the landlords cannot supervise the farming or because they mistrust their tenants, they usually furnish only the land in exchange for 40 percent of output.

Finally, under tenure type 5 are included the farms in the sample that did not fit in any of the above categories. No single description can be given of this type of tenure because the arrangements are very heterogenous. Due to this heterogeneity, no evaluation of this type of tenure will be attempted.

The first part of the statistical analysis was an analysis of variance to test the null hypothesis that tenure types are not associated with differences in yields. The results are summarized in Table 2. The results show that the F-ratio is highly significant. Therefore, the null hypothesis is rejected.

Table 2. Results of Analysis of Variance Between Mean Yields of Corn Under Five Different Tenure Types for Farms in a survey in Nicaragua, 1971-72.

| Source | D.F. | Sum of Squares | Mean Squares | F-ratio |
|---|---|---|---|---|
| Between Types | 4 | 2978.12 | 744.53 | 3.95** |
| Within Types | 288 | 54323.75 | 188.62 | |
| Total | 292 | 57301.87 | | |

**Significant at 99% level of probability

The analysis of variance model requires that the five populations have equal variance. To see if this requirement was satisfied, Bartlett's test for homogeneity of variance was

performed and the results show that variance in yields were equal in all tenure types with more than 99 percent of probability.

Hence, at least two of the mean yields by tenure type are not equal. Therefore, means must be analyzed to establish which are statistically equal and which are different. To compare mean yields that are based on samples of unequal size the least significant difference procedure to separate the means into subsets, no pair of which have means that differ by more than the shortest significant range, was used. This procedure divided the mean yields into two subsets as follows:

Subset 1

| Tenure Type | No lease or title | Share lease | Other |
|---|---|---|---|
| Mean Yield | 13.17 | 15.00 | 17.69 |

Subset 2

| Tenure Type | Owner-Operated | Cash lease |
|---|---|---|
| Mean Yield | 22.89 | 24.49 |

These results indicate that in Nicaragua corn farms that are operated by owners or under a cash lease have no significant differences in productivity but are more efficient than those farms under the other three types of tenure. This is in accordance with what economic theory would lead us to expect.

Now that differences in productivity are established, causes of these differences will be investigated. Production functions fitted to the data for farms in subset 1 and subset 2 will be used for this purpose.

Before fitting a production function a regression model had to be chosen. The dependent variable in yields expressed in hundred-weights per manzana and the independent variables are as follows:

$X_1$= cost of fertilizer in cordobas per manzana

$X_2$=cost of seed in cordobas per manzana

$X_3$=cost of labor in cordobas per manzana

$X_4$=cost of machine units in cordobas per manzana

$X_5$=cost of animal units in cordobas per manzana

$X_6$=cost of insecticides in cordobas per manzana

$X_7$=cost of other inputs in cordobas per manzana

These may not be the only variables which will explain variations in yields. Because of data restrictions, however, many variables such as soil type, level of management and other ecological factors which may have significant effects on yields were not included.

An examination of the plots of yields versus the independent variables showed no definite clue as to what type of regression model would be more appropriate. Therefore, the conventional two models were fitted to the overall data to determine which explained more of the variation.

Model 1

$$Y=B_o+B_1X_1+B_2X_2+B_3X_3+B_4X_4+B_4X_4+B_5X_5+B_6X_6+B_7X_7+E$$

Model 2

$$\log Y=\log B_o+X_1 \log B_1+X_2 \log B_2+X_2 \log B_3+X_4 \log B_4 +X_5 \log B_5+X_6 \log B_6+X_7 \log B_7+ \log E$$

Both models were fitted to the overall data using stepwise regression and the linear model yielded an $R^2 = 0.33$ for the log model. Hence, the linear model was used for further analysis.

The stepwise procedure included all the variables in the function with the exception of cost of insecticides ($X_6$). To have more confidence in the results, t-tests were performed

to test the hypotheses that the coefficients of regression were equal to zero versus the alternative hypotheses that they are not equal to zero. In all cases, with the exception of $B_6$, cost of insecticides, the tests were significant.

An analysis of variance, as shown in Table 3, was also performed to test the hypothesis that a regression function with all variables except insecticides contributes toward explaining the variation in yields. The F-ration shows that the test was highly significant.

Table 3. Results of Analysis of Variance to Test Whether The Contribution of Regression Towards Explaining Variations in Yield is Significant In a Linear Model Fitted to Data from Farms in a Survey in Nicaragua, 1971-72.

| Source | D.F. | Sum of Squares | Mean Squares | F-ratio |
|---|---|---|---|---|
| Regression | 6 | 24586.20 | 4097.70 | 35.82** |
| Error | 286 | 31715.57 | 114.39 | |
| Total | 292 | 57301.77 | | |

**Significant at 99% level of probability

The cost of insecticides was not included in the function probably due to its high correlation with most of the other variables. Hence, the variation caused by the use of insecticides was probably explained by the other variables. The correlation between yields and cost of insecticides was 0.41.

The next step was to fit production functions to farms in subset 1 and in subset 2. The same procedures as explained above for the overall data were used to fit the production functions and the results are shown in Table 4. The $R^2$ for the overall data was 0.43, for subset 2 it was 0.44 and for subset 1 it was 0.57. The table also shows those variables excluded from the production functions.

Table 4. Results of Fitting Production Functions to the Overall Data, Subset 1 and Subset 2 using the Stepwise Regression Procedure on data from farms in a Survey in Nicaragua, 1971, 1972.

| Variables | Coefficients for Overall Data | Coefficients for Subset 2 | Coefficients for Subset 1 |
|---|---|---|---|
| Fertilizer | 0.075 | 0.076 | NS |
| Seed | 0.157 | 0.141 | 0.343 |
| Labor | 0.004 | NS | 0.013 |
| Machine Units | 0.084 | 0.074 | 0.148 |
| Animal Units | 0.030 | NS | 0.055 |
| Insecticides | NS | NS | NS |
| Other Inputs | 0.078 | 0.133 | NS |
| Intercept | 11.400 | 10.850 | 5.810 |

NS=variable did not contribute significantly (95% level) to explaining variation in yields

As explained above, the independent variables were expressed in cordobas per manzana and the dependent variable in hundred-weights per manzana. Therefore, the coefficients shown in Table 4 are the marginal products for each variable when the remaining variables are held at their arithmetic means. In addition, the marginal value products were calculated to show the increase in income to the farmer for each additional cordoba spent on each factor when the remaining factors are held at their arithmetic means. Table 5 shows the means and the MVP's that resulted.

Table 5. Arithmetic Means and Marginal Value Products for Overall Data, Subset 1, and Subset 2, (in cordobas per manzana) farmes in a Survey in Nicaragua, 1971-72.

| Variables | Overall Data | | Subset 2 | | Subset 1 | |
|---|---|---|---|---|---|---|
| | Means | MVP | Means | MVP | Means | MVP |
| Fertilizer | 37.89 | 2.25 | 42.18 | 2.28 | 21.50 | NS |
| Seed | 15.34 | 4.71 | 16.02 | 4.23 | 12.77 | 10.29 |
| Labor | 260.48 | 0.12 | 253.31 | NS | 253.26 | 0.39 |
| Machine Units | 26.43 | 2.52 | 31.28 | 2.22 | 7.98 | 4.44 |
| Animal Units | 45.79 | 0.90 | 45.85 | NS | 45.56 | 1.65 |
| Insect. | 10.45 | NS | 11.72 | NS | 5.61 | NS |
| Other Input | 7.87 | 2.34 | 8.11 | 3.99 | 6.96 | NS |

NS=Not significant and was not included in the production functions.

## IMPLICATIONS OF STATISTICAL ANALYSES

The results shown above are interesting to a country that is trying to decide on a strategy for agricultural development. Farms that are operated by owners or under a cash leases had average yields of 23.60 hundred-weights per manzana as compared with 16.23 for farms under the other types of tenure. Just by eliminating this difference would contribute significantly toward solving the country's present corn deficit.

The marginal value product of labor in the overall data and in subset 1 was near zero and even lower in subset 2. These results are not surprising.

One of the most indicative results is the difference in the use of fertilizer. The owner-operated and cash lease farms in Subset 2 used almost two times as much fertilizer as the farms under other types of tenure. The MVP of fertilizer on the latter farms was almost zero while on the owner-operated and cash-rented farms had an MVP of 2.28.

The cost of seed was greater on farms in Subset 2 but the MVP of seed was greater on farms in Subset 1. The high MVP of seed in the latter may be a relection of the low levels of other inputs which causes the relative importance of seed to increase. The same can be said for the cost of machine units.

A plot of the residuals was made and analyzed visually. In general, the error terms are well distributed around the zero means. However, during short intervals some constantly positive or negative residuals were observed. Reexamination of the original data indicates that these farms are in the same geographical area and were probably surveyed by the same person. It was not possible to determine if these observations are caused by an ecological factor or human error.

## CONCLUSIONS

1. There are significant differences in productivity between corn farms that are owner operated or under cash lease as compared to farms under other types of tenure. These differences on the average amount to approximately 6.7 hundred-weights per manzana. If this difference could be eliminated, it would contribute significantly toward solving the problem of corn deficits in Nicaragua.

2. The use of all inputs, with the exception of labor and animal power, was much greater on owner-operated farms or those under cash leases than others. The results indicate that these other types of leases in Nicaragua cause an inefficient allocation of resources.

3. The bargaining power of landlords has permitted them to obtain a disproportionate share of the returns while assuming very little risk. This in turn has worsened instead of improving the country's income distribution problem and has affected the general welfare of consumers by causing an inefficient allocation of resources. The implications for agrarian reform are clear.

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