Factors Associated With the Production of Export Quality Fruit by Small Banana Farmers of the Rio Grande Valley, Portland, Jamaica.

Terrence W. Thomas
Louisiana State University and Agricultural & Mechanical College
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Factors associated with the production of export quality fruit by small banana farmers of the Rio Grande Valley, Portland, Jamaica

Thomas, Terrence W., Ph.D.
The Louisiana State University and Agricultural and Mechanical Col., 1989

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Factors Associated with the Production of Export Quality Fruit by Small Banana Farmers of the Rio Grande Valley, Portland, Jamaica

A Dissertation

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Doctor of Philosophy

in

The School of Vocational Education

by

Terrence W. Thomas
B.S., University of the West Indies, 1974
M.S. University of Wisconsin-Madison, 1981
August 1989
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ABSTRACT

The objectives of this study of small banana farmers in the Rio Grande Valley, Jamaica, were to determine the relationship between production variables—technology use and production of export quality fruit—and selected socioeconomic, personal characteristic and opinion variables, to assess the amount of variance in production variables explained by personal characteristic, socioeconomic and opinion variables, and to identify those socioeconomic, personal characteristic and opinion variables that moderate or mediate the relationship between the production variables—production of export quality fruit and technology use.

The target population was 120 farmers identified as growing bananas for sale to the public boxing plant at Fellowship in the valley. A random sample of non-banana farmers was used as a cross-validation check to make inferences to all farmers.

Farmers were interviewed using a pretested interview schedule. Stepwise multiple regression was used to develop models to explain the variance in technology use and production of export quality fruit, and the relationship between technology use and production of export quality fruit was analyzed to identify the moderator or mediational effect of selected personal characteristic, socioeconomic and opinion variables.

Findings indicated that banana farmers and non-banana farmers were more similar than they were different. Ten variables explained 46% of the variation in technology use. Socioeconomic variables were more important in explaining variation in technology use compared to opinion (attitudinal) variables. Sixty percent of the explained variance was accounted for by socioeconomic variables—farm size, rate of use of hired
labor, rejection rates, and number of visits by extension officers. Farmers' use of technology tended to increase with rate of use of hired labor, farm size, rejection rate, and number of visits by extension officers.

Four variables explained 34% of the variation in production of export quality fruits. These were technology use, farm size, complexity of recommended practices, and farmers' opinion of the role of extension in the farming system. Farmers' use of technology tended to increase with farm size and their use of technology.

Five variables were found to moderate the effect of technology use on production. These were farmers' opinions about providing credit, technology, extension, and reducing the number of extension officers, and the complexity of recommended practices. Two variables, farm size and rate of use of hired labor, were found to mediate the effect of technology on production.

It was recommended that level of extension activity among farmers be increased, improvements be made to the infrastructure of the valley, credit facilities for farmers be provided and the job of extension agents be redesigned so that more time is spent on educational activities as opposed to administrative duties. In addition, interventions to repair or modify the system should follow a unified approach which would capitalize on the synergy among interacting variables.
CHAPTER I
INTRODUCTION

Jamaica is essentially a mountainous island located in the Caribbean. The island is 4,411 square miles in area, 146 miles long, and 51 miles at its widest point.

The island was first inhabited by Arawak Indians before the arrival of Christopher Columbus in 1494. Jamaica was initially colonized by the Spanish in the 16th century. They were followed in the 17th century by the British who ruled the island for a period of 300 years. The slave trade which provided the labor for sugar plantations during the early period of colonization is largely responsible for the nearly ninety percent of Jamaicans who are of African origin (Manley, 1987). Other groups such as East Indians, Chinese, Caucasians and people of Middle Eastern origins constitute the remaining ten percent of the Jamaican population.

With the advent of universal suffrage in 1944, all Jamaicans were able to vote. Subsequent to universal suffrage, a parliamentary system fashioned after the Westminster model evolved. Parliament and politics in Jamaica have been dominated by two political parties; the People's National Party and the Jamaica Labor Party. Even with the institution of universal suffrage and the evolution of parliamentary democracy, Jamaica did not gain full independence until 1962.

Economy

Jamaica benefitted from good aggregate economic growth over the period 1950-1972 (Boyd, 1988; Looney, 1987). An important feature of
this period of economic growth was the decline in the relative contribution of agriculture to the gross domestic product (GDP). Agricultural output declined from 24 percent of gross domestic product in 1950 to 7 percent in 1969 (Boyd, 1988; Looney, 1987).

There was a slight recovery of agriculture's contribution to the gross domestic product over the period 1976-85. Bauxite's contribution to the GDP increased from 2 percent in 1953 to 13 percent in 1974, after which there was a steady decline through 1985.

After 1972, the Jamaican economy experienced a steady decline, except for a brief period of recovery during 1981-83 (Boyd, 1988). Following this extended period of economic decline, the government devised and implemented a structural adjustment program (Boyd, 1988; Looney, 1987; Driever, 1987).

The primary goal of this program was to redesign the structure of the economy to increase the country's capacity to earn foreign exchange. Foreign exchange reserves had been depleted as a result of reduced earnings from bauxite, sugar and bananas, along with rapid increase in oil prices during the early seventies. The slight increase in agricultural contribution to gross domestic product over the period 1976-85 resulted from an increase in domestic food crop production (Looney, 1987). Traditional export crops such as bananas, however, continued to lag in production. The extent of decline in banana production is evident in Table 1. It shows that production declined from a peak of 360,000 tons in 1937 to a mere 11,000 tons in 1984. In 1970-72 banana production was calculated to be 4 percent of GDP. Similar calculations in 1980-82 showed banana's contribution to GDP to be 0.7 percent.
To facilitate the achievement of its goals under the structural adjustment program, the government chose, among other things, to

Table 1
Profile of Banana Production 1915-1982

<table>
<thead>
<tr>
<th>Year</th>
<th>Production</th>
</tr>
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<tbody>
<tr>
<td>1929\textsuperscript{a}</td>
<td>5,234,773 (bunches)\textsuperscript{a}</td>
</tr>
<tr>
<td>1930</td>
<td>7,277,000 (bunches)\textsuperscript{a}</td>
</tr>
<tr>
<td>1937</td>
<td>360,000 (tons)\textsuperscript{b}</td>
</tr>
<tr>
<td>1966</td>
<td>200,000 (tons)\textsuperscript{b}</td>
</tr>
<tr>
<td>1969</td>
<td>150,000 (tons)\textsuperscript{c}</td>
</tr>
<tr>
<td>1970</td>
<td>136,000 (tons)\textsuperscript{d}</td>
</tr>
<tr>
<td>1973</td>
<td>107,000 (tons)\textsuperscript{b}</td>
</tr>
<tr>
<td>1980</td>
<td>18,000 (tons)</td>
</tr>
<tr>
<td>1982</td>
<td>22,000 (tons)\textsuperscript{b}</td>
</tr>
<tr>
<td>1984</td>
<td>11,000 (tons)\textsuperscript{b}</td>
</tr>
</tbody>
</table>

Source: \textsuperscript{a}Kepner et al. (1935); \textsuperscript{b}Thompson (1987); \textsuperscript{c}Looney (1987); \textsuperscript{d}Goldsmith (1986).

rejuvenate the flagging banana industry. To arrest the decline in export banana production, government adopted the strategy to restrict production to large estates using high technology (Looney, 1987; Driever, 1987; Thompson, 1987; Pesson, 1986). Government officials argued that this would facilitate the provision of effective and economic services such as leaf spot control, mechanical harvesting, irrigation, transportation, and shipping (Looney, 1987). Thompson (1987) also pointed out that an USAID
working paper of 1984 entitled "The Banana Export Industry Jamaica" recommended "the reorganization of the industry, reserving export production for a few large estates and relegating peasant production to supply the domestic market," (p. 80). Looney's (1987) analysis of structural adjustment program supports Thompson's interpretation of the USAID document. The current role depicted for small planters in the production of export bananas within the scheme of structural adjustment stands in stark contrast to the historical role played by small planters.

History of Banana Production

According to Kepner and Soothill (1935) and Thompson (1987), the small farmer played a pivotal role in the production of bananas for export. Kepner and Soothill (1935) reported that in 1915 there were more than 10,000 small planters. Many of these small planters possessed no more than 12 plants. They wrote that, "on April 1, 1929, 6,145 persons, large Negro planters operating small plots of land, joined forces in the Jamaica Banana Producers Association, Ltd.," (p. 296). The association was processing over 35 percent of Jamaican banana export. In December 1932, there were 14,066 members cultivating bananas on 62,776 acres of land.

Kepner and Soothill (1935) further argued that "The land in which the cooperative movement has been most successful is the island of Jamaica . . . Certain local features have counteracted monopolistic tendencies, thus protecting the independence of the banana planters and the people as a whole . . . Without avail were the influences of the United Fruit Company and a threat to cut its passenger service when it was seeking to obtain such monopolistic privileges as exclusive use of a
new pier and control over a railroad . . . Because of material improve-
ments, Jamaica is freer than Central America from control of great
corporations . . . With liberal land laws it is easy for the Negro
peasant to secure a plot to cultivate as his own," (p. 294-295).

The foregoing review of the banana industry indicates that small
farmers produced 35 percent of the banana exported in the thirties.
Driever (1987) and Bromwell (personal communication, December 1987)
report that small farmers produced most of the bananas exported in the
sixties, but under the structural adjustment program, large estates
employing high technology are slated to produce most, if not all, of the
bananas to be exported. Pesson (1986) reported that one large estate
shipped approximately 65 percent of 12,742 tons produced in 1985.

Available figures indicate that structural adjustment in the banana
industry has not produced substantial increase in the amount of bananas
produced for export. Efforts should therefore be made to encourage small
farmers to return to export banana production given their previous record
of participation and willingness to participate in the industry (Pesson,
1986).

Impact of Structural Adjustment Program

Agriculture has always been an important sector of the Jamaican
refer to the importance of agriculture to the Jamaican economy. Prior to
the development of the bauxite industry, agriculture accounted for 24
percent of Jamaica's GDP. Current statistics show agriculture's contri-
bution to GDP to be 9 percent (Boyd, 1987). The sector also employs 36
percent of the labor force and is responsible for 7 percent of exported
merchandise (Looney, 1987). Pesson (1986) reported that agriculture in the past contributed as much as 40 percent of total exports. The general decline in the agricultural sector, and in particular the decline in banana production, has resulted in high rates of unemployment and economic hardship in the rural areas, especially those areas that were traditional banana growing areas. A major goal of the structural adjustment program as it relates to the banana industry is to relieve the economic hardship by providing employment for small farmers on the large estates.

Structural adjustment has not increased employment in the rural areas or improved significantly the amount of bananas produced for export as illustrated in Table 2. According to Thompson (1987), the Jamaican industry has failed to produce the anticipated recovery. He argues, "Rather than help the small farmers improve their cultivation or renegotiate the contract to ensure that savings go to the producer and not to the marketing firm or the U.K. consumer, government encourages large scale capital investment estate production, and therefore, reduced employment in the industry" (p. 81).

Driever (1987) concludes that the structural adjustment program has failed to rejuvenate the agricultural sector, except for a few investors who were able to apply high technology on large farms. He argues that if the trend continues, rural Jamaica could be transformed into a dual economy with serious sociopolitical outcomes. Boyd (1988), on the other hand, argues that dualism already exists. He has identified such features of dualism as inequality in distribution of income between rural and urban sectors of the population and inequality in income distribution within the agricultural sector. He points out that agriculture had the
lowest average income of any sector, the average income in mining and manufacturing being seven times the average income in agriculture. He explains that the inequality in agricultural income is primarily a function of the structure of agricultural production. Structural features such as the unequal distribution of land (Table 2), and the tendency for the profitable export crop production to be concentrated on large estates, while small farmers tend to produce the

Table 2

Distribution of Agricultural Land in Jamaica

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<tr>
<td>Total Number</td>
<td>193,359 farms</td>
<td>1,489,188 acres</td>
<td>183,988 farms</td>
<td>1,327,045 acres</td>
</tr>
<tr>
<td>0-5</td>
<td>78.55 %</td>
<td>14.85 %</td>
<td>81.87 %</td>
<td>16.01 %</td>
</tr>
<tr>
<td>5-25</td>
<td>19.35 %</td>
<td>22.13 %</td>
<td>16.22 %</td>
<td>19.28 %</td>
</tr>
<tr>
<td>25&gt;</td>
<td>2.10 %</td>
<td>63.12 %</td>
<td>1.90 %</td>
<td>64.70 %</td>
</tr>
</tbody>
</table>


less profitable domestic crops are primary contributors to inequality in income distribution in the agricultural sector.

Given the enunciated policy of structural adjustment as it relates to the banana industry, small farmers will be relegated to the production of the less lucrative domestic crops and to the supply of farm labor to large estates. From arguments presented by Boyd (1988), it is reasonable
to infer that the inequality in distribution of income between rural and urban sectors of the population as well as within the agricultural sector will deteriorate if this policy is pursued without due regard for its effect on the small farming community and could lead to serious socio-political consequences.

Significance of the Study

Traditional export crops such as bananas earned substantial amounts of foreign exchange for Jamaica up to 1969 and provided economic support for the small farming community. However, over the period 1966-80, export production of bananas fell from 151,000 to 11,000 tons. This resulted in severe economic hardship for the small farming community.

The Rio Grande Valley in northeastern Jamaica has many small banana farmers who, during the years of peak banana production, contributed significantly to export earnings. However, with the current emphasis on production utilizing high technology on large estates small producers have been denied an opportunity to participate in an industry in which they once played a pivotal role.

Very little or no extension activity has been noted among banana farmers in the valley ever since the government started to focus on high technology, large-scale commercial banana production and made a general cutback in social services including agricultural extension. It is generally felt that these actions stemmed from the belief that small farmers in Jamaica are inefficient, steeped in tradition, do not appreciate the role of technology in the production process, and consequently resist change and introduction of new technology. This view is contradicted by scholars of agricultural development in developing countries.
Mellor (1986), and Adams and Graham (1984), for example, maintain that these individuals are prepared to change and do respond positively to new technology and agricultural incentives. In addition, scholars of the farming system approach to the analysis of "small farming systems" or resource poor agriculture have shown that small farming systems are complex systems, much more so than can be accurately described and evaluated by superficial examination guided by traditional stereotype. Norman (1978) argues that several factors, classified as social, biological and physical, interact to determine performance of the small farming system. This study seeks to identify factors which influence performance of the small farmer in the banana production system of the Rio Grande Valley.

Problem Statement

Small farmers of Jamaica and the Rio Grande Valley of Portland Parish in particular, contributed significantly to the production and export of bananas over the period 1935-1972.

Currently, only a relatively small number of farmers in the Rio Grande Valley are producing for the export market. This results from government policy which emphasizes production for export by large estates. Given the status of rural unemployment and the low income potential of domestic crops a program should be developed to encourage the participation of small farmers in the Rio Grande Valley in export banana production where the income earning potential is greater.

Many studies including one by the U.S. Congress Office of Technology Assessment (1988) have indicated that certain personal characteristics, socioeconomic factors and the extent of technology use influence the
productivity of the farming system. A knowledge of the relationship among these variables and their effect on the production of the small farmer banana production system in the Rio Grande Valley would be valuable input in designing the program mentioned above.

Purpose and Objectives

The purpose of the study was to determine the relationship among selected personal characteristic and socioeconomic variables, farmers' opinions and production variables, and to examine the effect of these personal characteristic and socioeconomic factors, and farmers' opinions on production variables.

The specific objectives were:

(1) To identify the relationship between level of technology use, socioeconomic factors, farmers' opinions, and selected personal characteristic variables and production variables.

(2) To determine the effect of selected personal characteristic and socioeconomic variables, and farmers' opinions on technology use.

(3) To determine the effect of selected personal characteristic and socioeconomic variables, and farmers' opinions on the production of export quality fruit.

(4) To determine the moderating and mediational effects of personal characteristic and socioeconomic variables and farmers' opinion of socioeconomic variables on the relationship between technology use and production of export quality fruit.
Definition of Terms

The following definitions are presented to clarify terminology used in this study.

Boxing Plant - The facility at which bananas are processed and packed for shipping.

Extension Officers - Personnel employed by the Ministry of Agriculture or parastatal bodies (statutory bodies, e.g. Jamaica Agricultural Society, Banana Board) to provide extension service to farmers. These professionals discharge duties similar to county level extension agents in the United States.

LDC - Denotes less developed countries.

GDP. Gross Domestic Product - Gross value of goods and services produced by economy of a country.
CHAPTER II
REVIEW OF LITERATURE

Introduction

The production of agricultural products is a function of the interaction among a number of interdependent factors. For example, the production of bananas by small farmers in the Windward Island (Thompson, 1987), and by small farmers in the Rio Grande Valley of northeastern Jamaica (Pesson, 1986) depends on the combination of the factors, land, labor, capital, and the skill of the farmer.

Norman (1978) defines an agricultural system as the product of complex interaction among several interdependent factors. Thus, small banana farms in the Rio Grande Valley of northeastern Jamaica can be described as small farming systems amenable to analysis using the systems approach.

Haverkort (1988) argues that agricultural systems evolve as a result of adaptation to and manipulation of the physical environment. Therefore, agricultural systems are specific to their own location and environment, and different environments will produce dissimilar agricultural systems. Furthermore, agricultural systems will vary in the nature, level and components of the systems.

Variations in agricultural systems should be taken into consideration when planning development programs. The systems approach for studying small farm operations in less developed countries (LDCs) recognizes the peculiarity of small farming systems in LDCs. The systems approach has developed over the last decade in response to a number of shortcomings in the traditional design of development programs for small farmers in LDCs (Norman, 1978; Byerlee et al., 1984; Shaner et al.,
1982). Norman (1978) cites the following shortcomings of the traditional top-down approach. (1) Knowing what is best for LDCs which resulted in the transfer of technology from high income countries to LDCs; (2) developing technology using elements that had made technology change successful in high income countries; (3) failure to replace the top-down approach with the more desirable bottom-up approach; and (4) failure to recognize the complexity of the small farming systems in LDCs. Shaner et al. (1982) and Norman (1978) argue that previous efforts to improve the lot of the small farmer in LDCs have failed because programs were designed and implemented without a thorough knowledge of the small farmer and the system he operates. They contend that the farming systems approach starts with the farmer and his situation and, as such, is a better approach than the traditional top-down approach.

Theoretical Foundation of the Farming Systems Approach

Small farmers in LDCs operate a complex farming system (Shaner et al., 1982; Byerlee et al., 1984; Norman, 1978). Systems theory as espoused by Checkland (1982), Dent et al. (1975) and Spedding (1975) considers a system to be an entity with several interdependent, interacting components. They argue that the components of the system interact to impart characteristics to the whole (system) that are totally distinct from the characteristics of the individual components. A basic tenet of systems theory is that the whole is greater than the sum of the parts. This characteristic of systems is referred to as the synergistic effect. Systems theory considers the whole rather than the parts of the system. According to Dent et al. (1975) components cannot be thought of as having a separate existence or independent function within the system. A system
is not a mere aggregation of components, and so, the system cannot be completely understood if it is disaggregated and the components studied separately.

Checkland (1982) maintains that systems vary in complexity and can be slotted into an hierarchy on the basis of their relative complexity. The complexity of a system is related to the number of interdependent subsystems that constitutes the particular system, the density of connections among these subsystems, and the relationship of the system to other systems. Some systems can be considered as subsystems of larger complex systems. Dent et al. (1975) offer the following scheme to illustrate the hierarchical nature of and relationships among subsystems within a complex agricultural system.

Level 1. **Biochemical and physical systems**

(i) Soil nutrient/plant growth relationships (Beek and Frizzel, 1973; de Wit and van Keulen, 1972).


(iii) Animal metabolic studies (Baker, 1969; Baldwin and Smith, 1971; Smith, 1971).

Level 2. **Plant and animal systems**

(i) Plant and crop growth (Bryne and Tognetti, 1967).

(ii) Growth and development in livestock (Bywater, 1973).


Level 3. **Farm business systems**

(i) Farm enterprise management (Anderson, 1971; Blackie and Dent, 1974; Halter and Dean, 1965).
(ii) Farm business management (Hutton and Hinman, 1968; Eisgruber and Lee, 1971; Maxwell et al., 1973).

Level 4. National and international systems

(i) National agricultural demand/supply studies (McFarquhar and Evans, 1971).

(ii) International food supply models (Forrester, 1971; Meadows et al., 1972).

As one proceeds from Level 1 through Level 4 the system becomes more complex. The nature of systems at Level 4 depends on the interaction of subsystems from Level 1 through Level 3 which combine to form the system at Level 4.

Checkland (1982) points out that the scientific method which is based on reductionism, repeatability and refutation will be ineffectual when applied to extremely complex phenomena such as agricultural systems. He argues that complex systems contain more interacting variables than the scientist can cope with in an experiment. The strategy of the scientific method is to reduce complex systems to simple ones so that control can be exercised over the experiment. This reductionist approach makes two assumptions.

1. The division of a complex system into its components does not distort the complex system being studied.

2. The components of the whole being studied singly are the same as when they are together as the whole and the principle of aggregating the components into the whole are known and fully understood.

The strategy of reduction seems to work best for the physical sciences but less well for the social sciences. In complex systems, such
as agricultural systems, the number of variables and the numerous connections among interacting variables make it difficult to achieve the level of reduction that is necessary to establish a meaningful controlled environment so that experiments could be conducted to produce unequivocal results.

**Implications of Systems Theory for Agricultural Systems**

In agricultural systems where there are many interacting variables, it is not very clear which ones are to be left in and which ones are to be left out of models developed to explain and improve understanding of agricultural systems. Moreover, there are many more variables than it is technically feasible to include in any model. Those included depend on the purpose of the study (Van Dyne and Ambrosky, 1975).

The difficulty with complex human activity systems is further manifested in the relatively larger amount of variance accounted for by explanatory models used in the study of natural sciences compared with explanatory models applied to complex human systems. This is partly due to the numerous variables influencing system phenomena as well as the difficulty of exercising control. For example, the complexity of small farming systems is evident when the components of the system and their interrelationships are examined. Factors such as extension, technology, credit, education, farm size and farmers' attitudes are recognized by various authors as important components (Mellor, 1986; Schultz, 1981; Norman, 1978; Haverkort, 1988). The interrelationships among these components have been discussed by a number of scholars. Norton et al. (1988) report that extension and research influence production. Haverkort (1988) lists components of technology as education, extension and research. Schultz (1981) recognizes education as a factor in
population quality, and argues that population quality influences production. Mellor (1986) and Schultz (1981) report that technology is a critical factor in explaining production. Igodan et al. (1988) indicate that levels of education, literacy, social participation and contacts with extension agents significantly influence technology adoption. Seabrook and Higgins (1988) report that self concept of the farmer influences the effectiveness of extension and training. This brief review shows how a single variable in the system relates to several other variables. Education, for instance, plays a role in technology generation, technology adoption, and population quality. Likewise, technology adoption, population quality, extension and research are related to production. According to systems theory, the many connections among variables in the system impart distinct characteristics to a system. Since the reductionist approach applies the analytical method to study the system it destroys the integrity of the system (wholeness); as such, little or no information is gathered that will facilitate understanding of the system as a "whole system". Dent et al. (1975), Spedding (1975), Norman (1978), Shaner et al. (1982), and Byerlee et al. (1984) espouse the virtues of the synthesis approach of the systems technique in the study of small farming systems. Dent et al. (1975) further argue that the individual components cannot be considered to have a separate existence or an independent function, nor can they be fully understood when they are studied in the abstract, away from the complete system. The reductionist approach, he contends, is undertaken without consideration of the impact of individual components on the system.

The farming systems approach facilitates synthesis and integration of the components in the system. The reductionist approach, in an
attempt to clear the web of interaction to view the components more carefully, becomes too narrowly focused or specific and, as a result, less is learned of the variables as an integrated whole. Norman (1978) cites the introduction of a new variety of cotton in Turkey and the growing of cotton in Nigeria as examples which demonstrate the weakness of the narrowly focused reductionist approach to develop and introduce technology in a small farming system. In the case of Turkey, there was serious disruption in the farming system, while in Nigeria, the technology was not adopted. Illustration of the shortcoming of the reductionist approach to improving the farming system in Turkey follows.

The deltapine variety of cotton introduced to small farmers in Turkey matured so quickly that small farmers who depended on family labor were unable to complete the harvesting of the cotton crop, and failed to make sufficient money from this new variety. To supplement their income, small farmers worked as part-time labor for the larger farmers. As time progressed some small farmers had to sell their land to the larger farmers. This example illustrates the relationship among factors in the farming system and how these factors interact to define the system. In this instance, the biological subsystem (varietal characteristic of cotton) which was developed and offered to farmers, demanded that labor be available in sufficient quantities over a short period of time. The social subsystem could not respond to this demand. Small farmers were unable to supply the labor by traditional means. In addition, they did not possess the cash resource to purchase the required labor. Thus, the introduction of a new technology (embodied in the new variety), even though well-intentioned, failed to produce the predicted result, because the new technology was not developed in an integrative fashion that would
permit synthesis into the whole. The narrowly focused reductionist approach failed to take into account the effects of change in one variable (technology) on other relevant variables - labor, pattern of providing labor, and cash resources, credit availability and credit worthiness of farmers.

The above example lends support to the proposition of Spedding (1975). He posited that extracting components from a system and subjecting them to experimentation without the interactions connecting these components to the whole cannot be expected to necessarily produce or lead to improved understanding of the system as a whole. He argued that before such subsystems are extracted and subjected to study, it should be ascertained that they possess two characteristics. Firstly, they should produce the same output as the whole. Secondly, each subsystem should contain all the essential lines of interactions between it and the main output including those of intermediate output. Use of such a strategy will increase the likelihood that investigation conducted on components extracted from the system will maintain relevance to the system into which they will be reintroduced.

The purpose of this study is to investigate the role of personal characteristics, socioeconomic, opinion and production variables in the production of export quality bananas by small farmers of the Rio Grande Valley. A knowledge of the relationship among these variables and how they affect production is an essential input in the process of developing a program for the renaissance of small farmer banana production. This knowledge will facilitate understanding of the farming system of small farmers in the Rio Grande Valley. Understanding gleaned from such knowledge will be a useful guide in designing strategies of intervention
that will lead to increased banana production by small farmers. The examples cited earlier in the case of Turkey and Nigeria, where intervention resulted in adverse effects on the farming system, illustrates the need to develop an understanding of the farming system before taking action to repair or modify the system. Norman (1978), Byerlee et al. (1984), Haverkort (1988), Shaner et al. (1982), and U.S. Congress Office of Technology Assessment (1988) have reported instances of well-intentioned intervention that have failed because of lack of understanding of the particular farming system.

Modelling Agricultural Systems

Models have been used in the study of agricultural systems (Van Dyne et al., 1975). Models are used to represent a particular view of reality. A model tries to capture the events or workings of a system in terms of mathematical representations or verbal/graphic descriptions. The type of model and the components or elements included will depend on the purpose of the study (Spedding, 1975).

Whatever the nature of the model chosen to describe, analyze and permit synthesis of information in a farming system, an essential prerequisite is that these models have a theoretical foundation. It is the theory associated with the model which permits perceptive interpretation of relationships among variables, allows the derivation of hypotheses, offers explanation of and predicts future course of events within the system. Thus, the utility of a model depends on the power of the theory that underlies its formulation.

Mathematical or quantitative models quantify relationships and interactions. Given input data, they allow hypotheses to be tested and
Van Dyne et al. (1975) listed three types of quantitative models used to study agricultural systems. They are simulation models that set out to depict the dynamics of the system, optimization models which manipulate controllable variables to give the maximum value of an objective function, and statistical, mainly regression, models that are used to derive relationships between the dependent variable and a number of independent variables.

Word models depict the systems by providing what Spedding calls a word picture of the system. Relationships among variables are described verbally with the aid of diagrams. This is usually the first step in model development. It is necessary to capture the reality with a verbal description before a mathematical representation is made (Spedding, 1975).

Small Farm Agricultural System Model

A farming system model is shown in Figure 1. This model posits that a farming system can be described by a technical element and a human element. The types and potential of livestock and plants are determined by the technical element. They provide the necessary condition for the existence of the farming system. The technical element indicates what is possible. The human element provides the sufficient condition for the existence of a particular farming system.

Components of the technical element and the human element shape the actual farming system that evolves. These components include types of livestock, crops, farmers' resources, his attitudes and values, community structures and external institutional structures. The farmer is the decision maker in the system. His efforts are either facilitated or constrained by the components of the technical element (roads, irrigation,
Figure 1. Small farm agricultural system model.

soil type, topography of land, variety of crops, breeds of livestock, insects and diseases), endogenous components (attitudes, tradition, perceptions, values, cash resources, education, experience, age) and exogenous components (extension service, technology, research, price, credit, government policies).

**Extension, Education, and Research in a Farming System**

Extension, education and research (technology generation) in a farming system can be thought of as the central driving variables of a farming system. The central role of extension, education and research (technology) in a farming system is illustrated by the Research-Education-Extension (REE) system of the United States as represented by the land grant colleges, experiment stations and the Cooperative Extension Service. This triad epitomizes an integrated system of research, extension and education.

Zmolek and Foster (1983) provide an excellent review of the interrelationships among the components of the REE system. They observed that at the time the land grant colleges were established, farmers of the day had knowledge derived only from experience, observation and tradition. Knowledge derived from these sources was inadequate to meet the demand of a developing agricultural industry. In addition, it was soon realized that the agricultural colleges lacked a body of scientific and relevant subject matter to teach. So, in 1887, the Hatch Act, establishing the agricultural experiment stations was passed. These experiment stations, through their research activities, generated useful, effective and dependable knowledge which served as the basis for teaching. Initially, demonstration farms were associated with the experiment stations. Their purpose was to disseminate information and the new technologies to
farmers. However, the pioneering work of Seaman Knapp (1833-1911) resulted in the establishment of the Cooperative Extension Service in 1914. This was a more effective mechanism designed to disseminate information among farmers, educate them in the use of this information, and serve as a link between farmers and researchers.

Before Knapp's pioneering work in the U.S., the University of Cambridge in Britain was the first to use the term extension education to denote the dissemination of the university's work among off-campus communities (Swanson, 1984). This extension service provided the benefits of the university to clients who were unable to attend regular classes on campus. Swanson (1984) points out the first modern extension service was established in Ireland during the great potato famine. It was initiated in 1847 as a result of a letter from the Earl of Clarendon, the Lord Lieutenant of Ireland, to the president of the Royal Agricultural Improvement Society of Ireland.

This letter explicitly recognized that the factors, extension, education and know-how (technology) are essential elements in the formulation of solutions to the production problems of farmers. The effect of the land grant university system on American society is aptly captured in the following statement by Tom Lyon, as cited by Zmolek and Foster (1983). "... the single greatest reason the citizens of the United States are the most affluent in the world is the land grant university system ..." (p. 199).

In the case of LDCs, Haverkort (1988) argues that research and extension have had less impact on production because fewer resources have been committed to these activities. He points out that a comparison of expenditures on research and extension reveals that:
(a) Almost half of the total yearly expenditures on agricultural research (approximately US $7 billion) is made by the western countries.

(b) The ratio of expenditures for research and extension in agriculture is 2:1 and 3:1 in Europe and Asia respectively, but for Africa and Latin America it is 1:1. This is one of the reasons that in Africa the extension workers frequently do not have a proper extension message.

(c) Of the total agricultural research expenditures in the world, only some six percent is spent in Africa and Latin America.

(d) Expenditures on research and extension as a percentage of the gross value of agricultural produce in developing countries is 0.4 percent, while in developed countries it is 1.5 percent.

(e) The number of extension workers per researchers in East and West Europe is around 1:1; in Asia 1:3; in Africa 1:10 and in Latin America 1:4. In Africa the policy has been to appoint extension staff rather than the more expensive research workers.

(f) The number of farmers per extension worker is much greater in developing countries (1:1000) than in western countries (1:500) (Haverkort, 1988).

Haverkort also argues that a comparison of expenditures on research and extension shows that apart from the quantity of research and extension effort the quality of these efforts may be more important in determining changes in productive resources in these countries.

Even though expenditures on extension and research (technology generation) in LDCs have been less than optimal, these factors along with education play a critical role in increasing productivity of small

In the case of technology, the Office of Technology Assessment contends that it is a critical factor in the process of intensification of resource-poor agriculture.

Schultz (1981) argues that through research, technology is developed which enables man to nullify or remove constraints to production. He contends that the original soils of Finland were less productive than the adjacent soils of the western parts of the Soviet Union but they are much more productive today. Japanese farmland was also inferior to that of northern India but it is far superior today. These changes, according to Schultz, are the partial result of agricultural research which produced the technology that resulted in the transformation noted above. The Green Revolution is another example of technological innovation which had considerable impact on the agriculture of many countries in Asia, for example India (OTA, 1988; Mellor, 1986).

Lewis (1962), Mellor (1966), and Schultz (1964) have extolled the virtues of informal adult education (extension) in improving the productive capacity of farms in LDCs. Studies conducted in Peru by Norton et al. (1987) and in India by Feder, Lau, and Slade (1988), indicate that investment in extension services produced substantial increases in agricultural production. Both studies also demonstrated that investment in research and extension resulted in substantial rates of return.

Even though extension may extend knowledge to farmers, Schultz (1964) contends that the effective use of modern factors of production depends on the educational level of farmers. Farmers should possess a minimum level of knowledge and skills related to the use of these modern
factors if they are to be efficient and effective. To illustrate, suppose the modern factors of production that characterize U.S. agriculture were transferred to or made available to the small farmers of Jamaica, it is doubtful that these farmers with their current level of skills would be able to apply these factors efficiently and effectively to the process of production. This implies that the factors of production employed in the production process should be compatible with the level of knowledge and skill of farmers. However, the traditional approach of modeling the process of agricultural production identifies the factors of land, labor and capital, where labor is conceptualized as homogenous units. By so doing, the model does not consider the compatibility of technology with education level. Debeauvais (1962) maintained that this model does not consider the variation in skill, experience and knowledge of the individual supplying the labor and its implications for the process of production. Physical inputs by themselves are useless. Human capital is required to convert these physical inputs into units of production. The effectiveness and efficiency of this process depends, among other things, upon the quality of the human capital employed in the conversion process. Schultz (1964) maintains that the educational capacities of farm people like capital goods are factors of production. Furthermore, the ability of farm people to effectively utilize modern factors of production depends on their level of knowledge and skills. Farmers without the requisite knowledge and skills will find it difficult to apply such factors effectively and efficiently. This in turn will result in low returns to these factors which eventually results in farmers discontinuing the use of these particular factors. In such instances extension plays a valuable role. It provides farmers with the
knowledge and skills needed to exploit the potential of modern factors to increase production.

The preceding discussion supports the generally accepted view that education, extension and technology are central pillars on which the productive foundation of the farming system rests.

Theoretical Base Supporting Education, Extension, and Research

Observations that confirm the value of education, extension and technology in the farming system are valuable, and knowledge of the relationships among factors is also an essential ingredient in program planning and development, but having insight into the reason for the effect of one variable or the other is even more important. Kerlinger (1986) and Pedhazor (1982) indicate that pure correlation coefficients are of little help in developing useful insight into the behavior of variables. Correlations do not unequivocally indicate causation; one has to be guided by the theory connecting the variables in question. It is the theory which posits a reason for the relationship among variables which, in turn, facilitates explanation and prediction of outcome.

These reasoned points of view or theories provide insight into the mechanics of operation of those factors which enable program planners to understand why education, technology and extension tend to have a positive effect on the productivity of the system. Knowing why and how a process works expands our options in utilizing information about relationships among factors involved in the process. It provides us with a sense of control over the process through which factors produce their
effects. Having this type of control implies that one is able to direct and influence the process to produce desirable outcomes.

Theoretical propositions regarding education, extension and technology follow. Meyer (1977) writes about allocation and socialization theories. Allocation theory states that education (school experience) provides individuals with the knowledge, skills, attitudes and values that result in revised and enlarged personal capacities, and enable them to achieve more and extract more from their roles in society. One theory is that individuals who benefitted from an educational experience should perform and achieve more than others performing a similar role but with relatively less education. This postulate of the theory is consistent with conclusions derived from the literature reviewed above. A corollary of the socialization theory is that the performance of individuals should vary with the quality of the educational experience to which they are exposed. Howard (1986) reports that research has failed to support this corollary. This difficulty with the socialization theory led to the proposition of an alternative theory dubbed the allocation theory. This theory posits that education tends to select, sort and allocate more than it socializes so that individuals are assigned to roles based on the number of years and type of education, separate and apart from whatever skills, attitudes and values they may have learned. Howard (1986) reports that the greater awards offered college graduates with higher degrees may be out of proportion to the measured differences in quality, which suggests allocation effects.

In Jamaica, the negative attitude associated with agriculture (United States Agency for International Development, 1984) results in the relegation of students perceived to be low achievers into agricultural
science courses. This suggests that sorting and allocating students to a vocation is based on educational level and not on the quality of skills demanded by the particular vocation. The effects of education may also be explained by reference to Bandura's (1982) self-efficacy theory, which states that education which provides skills may lead to increased self-efficacy judgements - confidence in one's self and ability which may motivate individuals possessing required skills to perform at high levels.

These differing views of the role of education in society may not be able by themselves to explain all the variations in the farming system that can be attributed to education. But individually they may be able to explain aspects of this variation. For example, in Jamaica one reason advanced for the low productivity in agriculture is low educational level of farmers and the lack of trained professionals. This implies that there is a deficiency in skills needed to operate and manage the system. Here the socialization theory is being used as the basis of analysis. On the other hand, the tendency to assign students to vocational agriculture on the basis of the type of educational experience and the general belief that agriculture does not require schooling in science (Riley, 1982) can be explained by the allocation theory. Students are sorted and allocated on the basis of the type of education rather than on possession of requisite skills.

Technology is the second major component of the Education-Technology-Extension triad. Technology can be defined as a means to an end which is transferable and which achieves the end an acceptable proportion of the time. Popham (1975) defines technology as a set of verifiable rules and
procedures based on science that can be applied to produce some product or achieve some objective.

Both definitions provide valuable insight into the nature of technology. The first alludes to transferability of technology and the scientific inductive nature of technology development. The fact that technology can be transferred distinguishes it from subjective practice, as an "art", or based in intuition. This property of technology makes it amenable to the extension process, and amplifies the value of extension and education in improving the productive capacity of the farming system.

The second definition of technology deals with its success rate. Because technology is based on scientific principles which are inductively derived, there may be circumstances and conditions yet unknown under which the particular technology may not function as efficiently as first prescribed. In addition, technology which is derived from pure science, to be useful, must interact with the values and culture of the system which will be applying this technology. Since both technology and culture are to be synthesized into a compatible working unit, adjustments are called for. Such adjustment may reduce the yield of the technology or its success rate. Thus, the means may not achieve the prescribed end an acceptable number of times in a particular culture, as compared to the laboratory, the experiment station, or other cultures. In situations where technology and culture are incompatible the success rate of the technology may be critically curtailed, and a particular technology even precluded from adoption. Because of the possibility of incompatibility of technology with culture and/or other factors, the mechanism of adaptive research was evolved to reconcile transferred technology with local circumstances (Onazi, 1982).
Technology developed through research expands the options available to mankind in the face of shrinking resources. According to Schultz (1981) there are two views which describe the relationship between mankind and resources available to him in his environment.

The first view contends that the amount of land rated as suitable for growing food is virtually fixed, and so it will be impossible to produce sufficient food in the future for a growing world population. The second view maintains that man is capable of reducing his dependence on crop land, traditional agriculture, diminishing sources of energy and the real cost of producing food for an expanding world population.

The first view disregards the capacity of man to be innovative, while the second view believes that the innovativeness of man through the research process would lead to the development of technologies, which would provide alternatives to shrinking resources and/or remove constraints to the production process.

The positive effects of the Green Revolution on the agricultural economy of India and other Asian nations (Mellor, 1986), the increase in efficiency of the livestock industry in the U.S. (Zmolek and Foster, 1983), and the increase in productivity of corn where 33 million less acres in 1979 produced three times the amount produced in 1932 (Schultz, 1981) are good examples of the effectiveness of technology.

Technology operates to increase production by providing the means to use less resources or use resources more efficiently to produce more output, as in the example of corn production in the U.S. In other instances, new products such as fertilizers and pesticides are developed, or vastly improved varieties of crops and breeds of animals are produced through selection and breeding. Because of the capacity of man to
develop new techniques to accomplish his objectives the future of mankind is not necessarily inextricably bound to limited supply of natural resources as we know them, nor to traditional ways of doing things. Margaret Mead, (cited in Schultz, 1981) states that "Future of mankind is open ended" and Schultz (1981) posits that "Mankind's future is not foreordained by space, energy, and crop land. It will be determined by the intelligent evolution of humanity" (p. 6). John Naisbitt (1984) argues that during the industrial era, capital resources were the critical factors of production but currently the ability to innovate and develop technology has eclipsed capital as a critical resource.

The ability of the farmer to exploit the productive capacity of the farming system depends on his status with regard to educational level and extent of technology use given that other factors are not limiting. Extension is the mechanism or the process that is used in agriculture to raise the status of the human agent with respect to educational level and technology use. Mellor (1986) argues that the development of a technology system and technically competent extension system are essential to agricultural growth. Lewis (1962) identifies two types of education from the standpoint of economic development: (a) education that increases productivity, and (b) education that does not increase productivity. He believes that the quickest way to increase productivity in developing countries is to train the adults who are already on the job. Lewis contends that there is ample evidence as to what adult education can achieve, whether it is in the form of evening classes, training in industry or agricultural extension. Mellor (1986) believes that many countries failed to benefit from the Green Revolution because they did not invest sufficiently in building an extension service.
Agricultural extension education provides farmers and rural small farmers in particular with an educational opportunity. Agricultural extension provides useful information to farmers according to their need, develops and updates farmers' skills and helps them adapt to a dynamic technological environment. Most, if not all, farmers are unable to attend school or regularly scheduled classes. In addition, adults have different learning needs. Their needs are immediate, and they need information and skills to solve current problems. In addition, their orientation to learning is not compatible with methodologies applied in regular schooling (Knowles, 1982).

According to Knowles (1982), the relationship between technological change and the lifetime of an individual follows a pattern. Technological changes occur several times over the lifetime of the individual in modern times. Because technological change is essential to agricultural growth if sufficient food is to be produced at reasonable prices (Mellor, 1986; Schultz, 1982), and given that farmers are unable to accommodate the requirements of a regular school schedule or adapt their orientation to learning to the pedagogic style of regular school, some mechanism must be established to educate and train farmers in new technological procedures and skills. Extension education provides this mechanism.

The role of education in society as explained by the socialization theory provides individuals with the attitudes, skills and values needed to discharge effectively and efficiently their role in society. The skills developed through educational experiences are applied in research pursuits to develop technology which permits farmers to increase production notwithstanding the constraints of limited resources. Extension keeps farmers who are unable to attend regular school retooled and
current, extends the results of research and technology development to farmers, and helps them adapt to changes in their environment. This relationship among education, extension and technology keeps the farming system attuned to its environment. The relationship also guarantees that human capital (skills and knowledge of farmers) does not become obsolete. As Schultz (1981) notes, "The decisive factors of production in improving the welfare of poor people are not space, energy and crop land; the decisive factors are improvement in population quality and advances in knowledge and skills (improvement in education and advances in technology)" (p. 4).

Notwithstanding the central role of education, extension and research in increasing production of the farming system, by themselves they do not provide sufficient condition for increasing the productivity of the system. They provide the necessary condition, and other factors such as the personal characteristics of the farmers themselves, and socioeconomic factors influence the productivity of the system (OTA, 1988).

These factors, it can be argued, provide the other dimension needed for the farming system to produce "the sufficient condition". Many of these personal and socioeconomic factors may be thought of as operating as moderators that define the extent and range over which the variables education, extension and technology will be effective in increasing production. In other words, they set and define the conditions under which these variables operate to influence production. Baron and Kenny (1986) define a moderator variable as a "variable which partitions a focal independent variable into subgroups that establish its domains of maximal effectiveness in regard to a given dependent variable" (p. 1173).
Several studies have identified various personal and socioeconomic variables that have a moderator effect on technology use (adoption) in its relationship to production. These studies are commonly referred to as adoption studies. Voh (1982) cited work by Clark and Akinbode (1968), Galjant (1968), Rahini (1961), Lakshminarayana (1970), and Singh and Shankariah (1967), indicating that a variety of personal and socioeconomic variables affected extent of technology use or adoption. Variables such as levels of literacy, urban contact, contact with various sources of extension and advice, empathy and leadership role were positively and strongly related to the extent of technology use. Socioeconomic status was also found to be strongly and positively related to technology adoption.

Hooks, Napier, and Carter (1983) point out that diffusionists assume that farmers can and will act once they become aware that it is desirable to adopt a particular technology. This assumption they argue may not be defensible, given that economic barriers may exist that prevent the diffusion model from operating effectively. While their study showed that individual characteristics of farmers correlated positively with adoption behavior, they found that the "economic constraints model" appears to have greater validity, since economic constraint variables showed the highest correlations. The economic constraints model also has a high degree of face validity considering that most technological innovation has to be purchased in the form of inputs such as improved seeds, fertilizers, pesticides, tractor hours and other inputs, and that farmers in LDCs do not usually possess the cash resource to make these purchases.
A Synthetic Two-Stage Farming System Model

The effect of the variables extension, education and technology on the farming system is conceptualized by the researcher as a two-stage model, comprising a primary, macro level stage and a secondary, micro level stage.

The model in Figure 2 proposes that education produces the human resource capital with developed skills and capabilities. These are used in the process of research to generate technologies, operate the farm and organize extension activities to transfer technologies, educate farmers and provide feedback to researchers. Technologies when they are first produced may not be compatible with the existing farming system given the complement of resources and other factors needed to apply them. Through an iterative process facilitated by extension, incompatible technologies are modified so they become compatible. Research also generates information which is utilized in the first stage to develop the skill and capacities of the human resource capital.

During the first stage, therefore, human resource capital and technology needed to drive the system are produced. In the second stage extension, education, human resource capital and several incidental factors interact with technology to produce a desired output. In this stage, education and extension operate more or less as moderators of the relationship between technology and production. The farming systems approach posits that the output of the system is influenced by a large number of variables. Describing such a system with a regression model enables one to quantify the relationships among these variables and estimate the effect of one variable on the other and on the output of the system.
MACRO LEVEL

Education → Human Capital → Research (Technology Generation)

At the macro level factors operate to produce and transfer technology to the farm level. Extension serves as the interface between macro and micro levels.

Feedback
production problems, need for innovation

MICRO LEVEL

Technology → Production

Personal factors

Attitudinal factors –
Opinion on the role of education, technology extension

Economic factors –
Number of extension visits, hours of hired labor used, size of farm

At the micro level – a number of factors operate to either moderate or mediate the relationship between technology and production.

Figure 2. Two stage synthetic model of farming system.
Knowledge derived from this process would allow program planners to make adjustments to the system by manipulating particular variables. The decision to adjust a particular variable or variables will depend on the reliability of the model, size of the coefficients generated by the model, the theory that guides the interpretation of the model and the objectives of the program planner. The objective of this study was to determine the relationship among personal characteristic, socioeconomic, and opinion variables and technology use, and to determine the effect of these variables on the production of farming systems in the Rio Grande Valley. The information generated by the study should provide a more reliable source of information on which to base decisions about the system as opposed to relying on information that is based on traditional stereotypes.
CHAPTER III

METHODOLOGY

Population

Bronwell (1987) reported that 120 farmers were growing bananas for sale to the public boxing plant at Fellowship for export by the Banana Export Company. This group of farmers was defined as the accessible target population for this study. The register of farmers kept by the supervisor of the boxing plant was used as the frame to identify them.

It was anticipated that the results of this study would have implications for other farmers and residents in the valley. For one, it is desirable to encourage non-exporting farmers to produce bananas for export; secondly, it is likely that over time some members of the general population would voluntarily make the decision to start producing bananas. Considering these possibilities, a random sample of non-banana farmers as prepared by Winnen (personal communication, March 1987) was used as a cross-validation check to determine whether or not the results of the study with banana farmers could be generalized to non-banana farmers of the valley. The same instrument was used to collect information from both groups of farmers. Mitchell (1985) indicated that a cross-validation check is a means of checking variations in measurements across settings and subpopulations.

The adequacy of the sample size taken of non-banana farmers was determined using Cochran's formula. Calculations follow:

\[
\text{Number} = \frac{t^2s^2}{d^2}
\]

Criteria

\(t = \text{risk of 5\% or 1.97 probability}\)
\[ s^2 = \text{estimated variance } (4.166)^2 \]
\[ d = \text{acceptable difference, set at 2\% of scale} \]
\[ N = \text{total population 1950.} \]
\[ n_0 = \frac{(1.97)^2 (4.166)^2}{(.02) (30 \text{ pt. scale})} = 113 \]

Adjusted sample size \[= \frac{n_0}{n_0 + \frac{N}{N}} = \frac{113}{1950} = 107 \]

The random sample of 182 non-banana farmers was deemed to be adequate given the results of calculations done above and anticipating a 95\% response rate.

Because the study has implications for other farmers in the Rio Grande Valley a comparison was made between banana farmers and non-banana farmers to ascertain the degree of similarity between both groups on the variables of focus. A high degree of correspondence in response trends between both groups would indicate that non-banana farmers tend to respond to focal variables in a similar fashion, and would, therefore, indicate that the results of the study conducted with banana farmers can be applied to other farmers in the valley with increased confidence in the validity of such a generalization.

This procedure is akin to that used in establishing the equivalence of control and experimental groups in a quasi experimental study (Cook and Campbell, 1979).

Instrumentation

The interview schedule for both groups of farmers, banana growers, and non-banana growers, was focused on personal characteristics of
farmers, their opinion of the role of credit, price received, education, extension and technology in farming; their opinion of the effects of selected activities on the banana industry, specifically the provision of roads, transportation and water supply; reduction of the number of extension officers; provision of credit and their use of technology and the viability of the banana industry. Other variables measured were average number of hours worked daily on the farm, average rate of use of hired labor, type of credit used and frequency of extension visits and production of export quality fruit.

The instrument was checked for content validity by five faculty members of the Jamaica College of Agriculture, which is located in the vicinity of the valley and the managers of the Fellowship boxing plant and the Banana Export Company. It was then field tested at the local marketplace among 20 farmers from the valley. (These farmers were not among those interviewed subsequently.)

A copy of the final schedule is at Appendix B.

Collection of Data

Four senior students of the College of Agriculture were trained as enumerators. The data were collected through personal interviews with farmers over the period June to August of 1987. The interviews lasted for nine weeks. Most banana farmers were interviewed at the boxing plant; other banana farmers and non-banana farmers were interviewed on their farms, at their homes and at community centers in their neighborhoods.
Operationalization of Variables

The variables analysed to achieve the objectives of the study are operationalized below.

Production of Export Quality Bananas

The number of pounds of bananas purchased by the Banana Export Company from farmers for the period January 1 through August 31, 1987, as shown in the records kept by the supervisor at the Fellowship boxing plant.

Extension

Lewis (1962) referred to adult education targeted to farmers as extension education. Mellor (1966) stated that farmers are the primary clientele of adult or extension education in rural areas, and that such programs are oriented to farmer production problems. Akinola (1986) and Okuneye (1985) in separate investigations operationalized the independent variable extension as the number of visits made to a farmer's holding by extension officers.

In this study, extension is operationalized as: (a) the level of individual contact received by farmers through visits from extension officers over a six month period, and (b) the opinion of farmers regarding the role of agricultural extension officers as measured by a five point agree-disagree Likert type scale; four items were used in this scale.

Education

Lewis (1962) referred to two types of education - education that improves productive capacity and education which does not. Mellor (1967) and Dejene (1980) referred to the low literacy rate among rural people in developing countries as a factor that contributed to the low productivity of these farmers. Mellor (1967) observed "that the increasing complexity
of innovation places heavier and heavier burdens on the memory. Writing
and subsequent reading provides a basis for considerable improvement over
normal powers of memory. Easy to read clear recommendations can be noted
and kept on hand as ever present extension agent" (pp. 352). Education
in this study is operationalized as a) farmers' opinion of the role of
education (reading, writing, and counting) in farming as measured by a
five point, agree-disagree Likert type scale, using six items; and
b) number of years of schooling (Hooks et al., 1983; Voh, 1982).

Credit
Mellor (1966) refers to production credit as credit used to purchase
instruments of production. Adams and Graham (1984) refer to another
aspect of credit which is pervasive among farming systems in LDC, namely
credit in kind, such as fertilizers, seeds, spraying materials and
others. For the purpose of this study credit is operationalized as
a) money loaned to purchase inputs, or inputs materials received on
credit; b) farmers' opinion of the role of credit in farming as measured
by a five point agree-disagree Likert type scale, using four items.

Price
This variable was operationalized as farmers' opinion of the amount
actually paid to farmers by the Banana Export Company for a pound of
bananas purchased.

Technology
Popham (1975) defines technology as a set of verifiable rules and
procedures that are applied to achieve some objective or produce some
product. Okuneye (1985) and Akinola (1986) refer to technology as a
package of practices applied in the production process by farmers. In this study, technology was operationalized in two ways.

Firstly, as the set of practices recommended by the authorities growing bananas (Banana Board, Ministry of Agriculture). Twenty-one of these practices were included in the set. If a farmer used a practice, he was given a score of one point; if he did not use a practice, he was given a score of zero. Appendix D presents frequency of use of each practice by farmers. These items were assessed for their discriminating power. This was done by regressing total scale score on each item score. Any item that explained less than 6.25% of variance in the total scale score was deleted from the scale. Ary et al. (1985) suggested that items retained in the scale should correlate at least 0.25 with the total scale score. This is equivalent to explaining 6.25% of scale variance.

Item analysis isolated six items that met the criterion described above. The six practices isolated were 1) use of fertilizer, 2) de-flowering, 3) leaf spot control, 4) nematode control, 5) drainage, and 6) recording the number of bunches of bananas actually sold. The weighted values were summed to form a composite index of technology use (Hooks et al. 1983). This index was subsequently used in the data analysis. The second dimension operationalized was farmers' opinion of the role of technology in farming as measured by a five point agree-disagree Likert type scale, using five item statements.

Other Opinion Variables

Farmers' opinion of the effect of selected activities on the banana industry, e.g., reduction of extension officers, improvements needed in roads, water supply and transportation, and the provision of credit on easier terms were measured with a five point agree-disagree Likert type
scale. Farmers' opinion of the capacity of the banana industry to provide a living or make money was measured with a five point scale and anchored as follows: very poor, poor, not so good, good, very good.

Use of Hired Labor

The number of hours of hired labor used on the farm per day as reported by farmers.

Hours Worked on Farm

The number of hours worked per day on the farm as reported by farmers.

Rejection Rate

Farmers' estimate of the amount of bananas purchased from the amount offered for sale. The amount purchased was expressed as a percentage of the total amount offered for sale.

Age

Farmers' report of their age in years.

Size of Banana Farm

The portion of total farm size allocated to banana farming.

Experience in Banana Cultivation

Number of years farmer has been cultivating bananas as reported by farmer.

The variables use of hired labor, size of banana farm, hours worked on farm, rejection rate, technology, education, price, extension and credit were classified as socioeconomic variables. The variables technology use and production of export quality fruit were classified as production variables, while age and number of years of schooling and experience in banana cultivation were classified as personal characteristic variables.
Details of items included in each scale are provided in the interview schedule (Appendix B).

Analysis of Data

Exploratory factor analysis was done on multi-item Likert type scales. Following factor analysis the reliability of scales was calculated using Cronbach's alpha.

An alpha level of .05 was chosen a priori. The data were analyzed using the following statistical procedures.

(1) Correlational analysis was performed to establish the relationship among selected personal, attitudinal (farmers' opinion), socioeconomic, and production variables.

(2) Stepwise regression analysis using the maximum $R^2$ option was used to determine the amount of variance in production of export quality fruit and technology use explained by personal, attitudinal (farmers' opinion), and socioeconomic variables.

(3) Regression analysis as suggested by Baron and Kenny (1986) was used to assess the moderating and mediating effects of personal, socioeconomic and attitudinal (farmers' opinion) variables on the relationship between technology use and production of export quality fruit.

Baron and Kenny (1986) differentiated between a moderator role and a mediator role of a third variable that operates to influence the relationship between a dependent variable and an independent variable. They defined a moderator variable as "a variable which partitions a focal independent variable into subgroups that establish its domains of maximal effectiveness with regard to a given dependent variable" (p. 1173) and a
mediator variable as "a third variable which represents the generative mechanism through which the independent variable is able to influence the dependent variable" (p. 1173).

Schematic representations of these concepts are presented in Figure 3.

In mediator model paths 1 and 2 together represent the linkages through which the independent variable is able to affect the dependent variable (the generative mechanism). Path 3 is interpreted as representing a residual effect of the independent variable. In practical terms this would represent a weak or insignificant relationship between the independent variable and the dependent variable, or mediational effect of other variables. In a complex system such as a farming system, it is possible that there are several variables that operate to enhance or strengthen a relationship between an independent variable and a dependent variable. If there is a single strong mediator—the only mechanism through which the independent variable works to influence the dependent variable—then path three would be of negligible consequence.

Baron and Kenny stated that a moderator effect is observed when the interaction term (independent variable x moderator variable) is significant. They recommend the use of a regression model to assess the effects of a moderator variable. The structure of such an equation would be as follows:

\[
\text{Production} = \text{Technology use} + \text{rate of use of hired labor} + (\text{Technology use} \times \text{rate of use of hired labor})
\]

Here, rate of use of hired labor would be the hypothesized moderator variable.
Figure 3. Mediator moderator model.
In the case of mediation, they recommend using a series of regression equations. For example, mediation of the relationship between technology use and production by the number of extension visits can be analysed using three regression equations:

(1) Extension visits = Technology use
(2) Production = Technology use
(3) Production = Technology use + number of extension visits

A mediational linkage exists when all of the following conditions are met.

1. The independent variable (technology use) must affect the mediator (number of extension visits) in equation number one.
2. The independent variable must affect the dependent variable (production) in equation number two.
3. The mediator must affect the dependent variable in the third equation.

When these conditions are met the effect of the independent variable should be less in the third equation than in the second equation. This is observed by a change in the partial coefficient of the independent variable, or its contribution to R^2. Thus, a significant difference in size of the partial coefficient or R^2 contributed by the independent variable in the third equation indicates a mediational linkage. The joint hypothesis test as described by Berry and Feldman can be used to evaluate the significance of R^2 using the formula:

\[ F = \frac{R^2 - R^2_m/r}{(1-R^2)/(n-k-r-1)} \]

\( R^2 = \text{variance explained by full model} \)
\( R^2 \) = variance explained by variables left in the model

\( r \) = number of deleted variables

\( n \) = sample size [83]

\( k \) = number of variables used to specify model
CHAPTER IV
RESULTS AND DISCUSSION

Introduction

In Chapter II it was argued that many factors interact to determine the performance of a farming system. A knowledge of the relationship among these factors and the resultant effect on the performance of the farming system will provide valuable information for planning effective programs to promote banana production for export by small farmers.

Chapter IV will present and discuss results generated by analyses designed to determine relationships among selected variables and explain the effect of selected variables on farmers' use of technology and production of export quality fruit.

The results of analysis and discussion are presented in the order indicated below:

Exploratory Factor Analysis of Multi-Item Likert Type Scales. This result is presented first since this analysis verifies that scales used in subsequent data analyses were actually measuring the dimensions they were designed to measure.

A Comparison of Banana Farmers and Non-Banana Farmers to Determine the Degree of Similarity Between Both Groups. This has implications for generalizability of the study analysis as the mean score of farmers' opinion and technology use will show how the level of farmers' opinions relate to their level of technology use. Insight gained from this analysis will add to the understanding of the relationship among these variables as well as facilitate the interpretation of later analyses.

Correlational Analysis of Relationship Among Personal Characteristic, Farmers' Opinions (Attitudes), Socioeconomic and Production Variables.
This analysis establishes the size and direction of the relationship among these variables. Results of this analysis along with the theory of Chapter II will guide the selection of variables which will be used to specify regression models which will explain variation in technology use among farmers and the production of export quality fruit.

**Regression Analysis of Technology Use and Production of Export Quality Fruit.** This procedure identifies those variables that account for variation in technology use and production of export quality fruit among farmers.

Additionally, regression analysis as suggested by Baron and Kenny (1986) assesses the moderating and/or mediating effect of personal characteristic, farmers' opinions, and socioeconomic variables on the relationship between technology use and production of export quality fruits.

**Factor Analysis and Reliability Analysis of Instrument**

Exploratory factor analysis performed on multi-item Likert-type scales of farmers' opinion concerning the role and importance of education, extension, price, technology, and credit in farming yielded eight clusters. Each item that clustered to form a factor loaded on that factor above the .4 level.

Examination of the eight clusters showed that farmers' opinion of the role of price and education in the farming system was each measured by three items, while technology was measured by two items, all from the original scales designed to measure these constructs. A reconstituted scale that was interpreted to be measuring extension was composed of items drawn from the original credit and extension scales. While a
Table 3

Factors Derived From Factor Analysis of Attitudinal Variables

Farmers' Opinions of the Role of Education \((x_{11})\), Technology \((x_{12})\), Extension \((x_{13})\), and Price \((x_{14})\) in Farming

<table>
<thead>
<tr>
<th>Item Composition of Variables Before Factor Analysis</th>
<th>Item Composition of Variables After Factor Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) EXTENSION</td>
<td>1) EXTENSION</td>
</tr>
<tr>
<td>a Agricultural officers have conducted several useful demonstrations on important aspects of banana production.</td>
<td>a Agricultural officers are the most important source of information on banana production.</td>
</tr>
<tr>
<td>b Agricultural officers have not been making regular visits to farmers holdings.</td>
<td>b Most farmers are poor so they should be provided with loans to produce bananas.</td>
</tr>
<tr>
<td>c Agricultural officers are the most important source of information on banana production.</td>
<td>c Providing loans to farmers is very important because it allows those farmers with little or no money to get started in banana production so they can earn a living.</td>
</tr>
<tr>
<td>d Farmers can produce bananas successfully without help or advice from agricultural officers.</td>
<td>d The credit policy of banks should be adjusted so that farmers will be able to use the value of crops they produce as the major form of collateral to secure loans.</td>
</tr>
<tr>
<td>2) CREDIT</td>
<td></td>
</tr>
<tr>
<td>a Most farmers are poor so they should be provided with loans to produce bananas.</td>
<td></td>
</tr>
<tr>
<td>b The interest rate charged on loans is too high.</td>
<td></td>
</tr>
<tr>
<td>c Providing loans to farmers is very important because it allows those farmers with little or no money to get started in banana production so they can earn a living.</td>
<td></td>
</tr>
</tbody>
</table>
Table 3. (Continued)

d It is very difficult to access (qualify for credit or get a loan) credit. The credit policy of the banks should be adjusted so that farmers will be able to use the value of crops they produce as the major form of collateral to secure loans.

3) TECHNOLOGY

a Farmers will produce greater amount of good quality fruit if they rely on their own experience and use the old fashion (traditional) methods.

b If farmers fail to use the recommended practices (new ways), they will not be able to produce large quantities of good quality fruit.

c The method (way) recommended by the agricultural officers is too complex (hard to follow).

d The recommended practices (new ways) require too much money and effort from farmers.

e Only farmers with a high level of education can make use of the recommended practices (new ways) of producing bananas.

d The recommended practices (new ways) require too much money and effort from farmers.

e Only farmers with a high level of education can make use of the recommended practices (new ways) of producing bananas.

4) PRICE

a The price paid for bananas is reasonable.

3) TECHNOLOGY

a Farmers will produce greater amount of good quality fruit if they rely on their own experience and use the old fashion (traditional) methods.

b If farmers fail to use the recommended practices (new ways), they will not be able to produce large quantities of good quality fruit.

Complexity of Recommended Practices

2d The recommended practices require too much money and effort from farmers.

1d Farmers can produce bananas successfully without the help or advice from agricultural officers.

4) PRICE

a The price paid for bananas is reasonable.
factor designated as complexity of recommended practices was composed of two items, one each from the original extension and technology scales, other factors generated by the factor analytic process were not clearly interpretable. These factors were not used in subsequent analysis of the
data. Table 3 provides information on the composition of the factors which were subsequently used.

As shown in Table 3, the majority of the items measuring extension refers to credit activities. It can be argued that these items measured a dimension of the extension activity as it is performed in LDCs. In these countries the major tasks of extension officers include development of farm plans and the administration of credit or loan schemes (Food and Agriculture Organization of United Nations-Economic and Social Development Paper Number 46, 1984, and Pickering, 1983).

Subsequent to factor analysis, reliability analysis of the factor scales was performed using Cronbach's alpha. The results showed that the extension, price, and education scales had reliability coefficients of 0.71, 0.71 and 0.64 respectively. Diederich (1964) suggested that a reliability coefficient above 0.60 for "homemade" scales could be considered acceptable.

Comparison of Banana Farmers and Non-Banana Farmers

The rationale for including responses from non-banana farmers as explained in the methodology chapter, was to generalize the findings to all farmers in the valley.

Comparisons of the responses of banana farmers and non-banana farmers on personal and socioeconomic characteristics are presented in Table 4, their opinions concerning the role of technology, education, price, and extension, the complexity of recommended practices in the farming system in Table 5; and their opinion concerning the effects of selected activities on the banana industry in Table 6.
### Table 4

**Socioeconomic and Personal Characteristics of Banana Farmers and Non-Banana Farmers**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Banana Farmers</th>
<th>Non-Banana Farmers</th>
<th>t</th>
<th>P&lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>121 49 years</td>
<td>179 51 years</td>
<td>-1.08</td>
<td>.277</td>
</tr>
<tr>
<td>Size of banana farm</td>
<td>116 2.89 acres</td>
<td>136 0.85 acres</td>
<td>8.37</td>
<td>.000</td>
</tr>
<tr>
<td>Total farm size</td>
<td>121 5.90 acres</td>
<td>176 5.60 acres</td>
<td>0.45</td>
<td>.64</td>
</tr>
<tr>
<td>Number of years of schooling</td>
<td>119 7.18 years</td>
<td>176 7.21 years</td>
<td>0.27</td>
<td>.78</td>
</tr>
<tr>
<td>Distance from boxing plant</td>
<td>121 2.34 miles</td>
<td>169 7.90 miles</td>
<td>-12.52</td>
<td>.000</td>
</tr>
<tr>
<td>Number of hours worked on farm per day</td>
<td>114 8.23 hours</td>
<td>172 5.66 hours</td>
<td>8.08</td>
<td>.000</td>
</tr>
<tr>
<td>Hours hired labor used per day</td>
<td>120 1.64 hours</td>
<td>175 1.70 hours</td>
<td>-0.55</td>
<td>.58</td>
</tr>
<tr>
<td>Number of extension visits over last 6 months</td>
<td>1.1</td>
<td>1.0</td>
<td>2.32</td>
<td>.02</td>
</tr>
</tbody>
</table>

The information presented in Tables 4 through 6 indicate that both groups of farmers are more similar than they are different on the variables measured. Statistically significant differences were observed on five variables, the quantity of land allocated to banana farming, the distance from the boxing plant, number of hours worked on farm per day, number of extension visits, and reducing number of extension officers. It is natural that banana farmers would have more acreage under bananas (2.89
### Table 5

**Opinion of Banana Farmers and Non-Banana Farmers Concerning Role of Technology, Education, Price, Extension, and Complexity of Recommended Practices in the Farming System**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Maximum Scale Score</th>
<th>Banana Farmers</th>
<th>Non-Banana Farmers</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>10</td>
<td>118</td>
<td>7.2</td>
<td>179</td>
<td>6</td>
</tr>
<tr>
<td>Education</td>
<td>15</td>
<td>119</td>
<td>7.2</td>
<td>179</td>
<td>8.3</td>
</tr>
<tr>
<td>Price</td>
<td>15</td>
<td>118</td>
<td>8</td>
<td>179</td>
<td>10.8</td>
</tr>
<tr>
<td>Extension</td>
<td>25</td>
<td>118</td>
<td>20.4</td>
<td>179</td>
<td>17.4</td>
</tr>
<tr>
<td>Complexity of Recommended Practices</td>
<td>10</td>
<td>118</td>
<td>6.3</td>
<td>179</td>
<td>6.7</td>
</tr>
</tbody>
</table>

### Table 6

**Opinion of Banana Farmers and Non-Banana Farmers of the Effects of Selected Activities on Banana Industry**

<table>
<thead>
<tr>
<th>Activities</th>
<th>Maximum Scale Score</th>
<th>Banana Farmers</th>
<th>Non-Banana Farmers</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improving roads, water supply, transportation</td>
<td>5</td>
<td>120</td>
<td>4.75</td>
<td>179</td>
<td>4.78</td>
</tr>
<tr>
<td>Providing more credit</td>
<td>5</td>
<td>120</td>
<td>4.4</td>
<td>179</td>
<td>4.5</td>
</tr>
<tr>
<td>Reducing number of extension officers</td>
<td>5</td>
<td>120</td>
<td>2.4</td>
<td>178</td>
<td>2.17</td>
</tr>
</tbody>
</table>
acres) compared to non-banana farmers (0.85 acres). The greater distance from the boxing plant for non-banana farmers (7.90 miles) compared to banana farmers (2.34 miles) is more striking and perhaps constraining. Apart from these two variables, the differences observed between both groups on the other variables, even though statistically significant may not constitute a difference that is practically significant. For example, the differences between both groups on the opinion variable effects of reducing the number of extension officers and the socioeconomic variable number of extension visits are miniscule and in each case less than a single point. It can be argued that such minute differences do not indicate that non-banana farmers are different to the extent that results of this study may not apply to them, or predispose non-banana farmers to respond differently to programs designed and implemented on the basis of results from this study. The major similarities between both groups probably results from the exposure of these two groups of farmers to similar socializing influences since they live and work in the same small rural communities. On the basis of these data, therefore, it can be argued that the degree of observed similarity between banana and non-banana farmers on the measured variables may strengthen the argument for generalizing the results of this study conducted with banana farmers in the Rio Grande Valley of Portland, Jamaica to other farmers in the valley.

In addition to information presented in Tables 4, 5, and 6 above, farmers were asked to give their opinion of banana farming as a means of earning a livelihood. On a five point scale (1 = very poor; 2 = poor; 3 = not so good; 4 = good; 5 = very good), banana and non-banana farmers rated the income generating potential of the industry as 3.3 and 2.8,
respectively. In terms of the anchors used these figures translate into meaning "not so good". With respect to extension, banana farmers reported receiving 1.1 (very few) visits and non-banana farmers 1 (very few) visit from extension officers in the first six months of 1987. In the case of credit, 63% of non-banana farmers and 74% of banana farmers reported receiving no credit. As far as educational experience is concerned, both groups of farmers had similar experience, 90% of both groups having attended the same type of school, namely primary school.

Farmers' Opinion of Extension, Education, and Technology and Their Role in Technology Use

On the average farmers rated the role of extension, technology and education very favorably. Extension received a rating of 20 on a scale of 25, technology a rating of 7 on a scale of 10, and education a rating of 7 on a scale of 10 (Table 5). The average rate of technology use reported was 2.7 (Appendix C) out of a total score of 6 signifying that less than 50% of the recommended practices were used.

The results indicated that even though farmers seem to have a favorable attitude towards technology, their actual use is low. Rogers (1984) refers to this as the KAP-gap - knowledge attitude practice gap. Favorable attitude does not necessarily lead to use of technology. Okinola (1986), Okuneye (1985), Rogers (1984) have indicated that other factors such as credit, good roads, availability of inputs for purchase are factors that influence the adoption of technology. In addition, change agents are needed to facilitate the movement from persuasion to adoption in the decision adoption process (Rogers, 1984). Okuneye (1985)
also observed that extension will be most effective, as is the case with technology adoption, if the factors named above are present. Since farmers are aware of the role of technology and education in the farming system, given their rating of these two factors in Table 6, and given the postulate of Rogers that extension is needed to move farmers along the adoption innovation process, it can be argued that the relatively favorable rating of extension (20.4) displayed in Table 5 may be interpreted as an index of demand for extension services.

Objective 1

As discussed in Chapter II, personal characteristics, and socio-economic and attitudinal variables (farmers' opinions) influence the capacity of the farming system to produce. Furthermore, a knowledge of the relationship among these variables will guide program planners to focus effort in areas where such effort will produce the greatest benefit. Intercorrelations between farmers' opinions of selected aspects of the farming system, selected personal characteristics, and production variables are presented in Appendix A. Davis (1971) suggested a schema to be used as a guide for evaluating the size of correlation coefficients. This schema presented below will be used to assess the relative magnitude of correlations in this study.

.01 - .09 Negligible
.10 - .29 Low
.30 - .49 Moderate
.59 - .69 Substantial
>.7 Very strong
Relationship Between Personal Characteristic Variables and Production Variables. The data in the correlation matrix (Table 7) shows that relationship between age and technology use ($r=-.17$) is low, negative, and significant. Voh (1982) and Igodan et al. (1988) reported similar findings. The data in Table 5 indicate that the average age of farmers in the valley is close to 50 years. The Jamaica educational sector survey (1975) reported the average age of the Jamaican farmer to be 55 years. There is general concern expressed about the aged farming population and its possible effect on production and modernization of the small farming sector (USAID, Agricultural Education Project Paper, 1985). It is believed that the aging small farmer population is a constraint to modernization since they are believed to be steeped in tradition. However, the data in the correlation matrix of Table 7 does not offer strong support for this thesis as it relates to small banana farmers of the Rio Grande Valley, since there is only a low relationship between age, technology use, and production of export quality fruit.

The other personal characteristic variable examined by the study was educational level—number of years of schooling. Voh (1982) and Hooks et al. (1983) reported low but significant relationships between educational level of farmers and technology use ($r=0.20$ and 0.14 respectively). The data in Table 7 show a low but non-significant relationship between education, technology use and production of export quality fruit. From arguments presented in Chapter 2, it would be expected that education would show at least a moderate relationship with technology use. This is not the case in this study and the two others cited above. However, Igodan et al. (1988) reported a moderate relationship between education and technology adoption among small farmers in Nigeria ($r=.43$).
Table 7
Relationship Among Personal Characteristic Variables and Production Variables

<table>
<thead>
<tr>
<th>Production Variables</th>
<th>Personal Characteristic Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age</td>
</tr>
<tr>
<td>Technology Use</td>
<td>-.17*</td>
</tr>
<tr>
<td>Production of Export Fruit</td>
<td>.05</td>
</tr>
</tbody>
</table>

*P<.05.

Haverkort (1988) argues that each farming system evolves under the influence of a peculiar set of factors, to the extent that farming systems are unique because of the nature of their development over time, the same factors (e.g. educational level) may behave inconsistently with generally accepted theory across farming systems. This inconsistency does not necessarily indicate that the theory is invalid. The particular case of small banana farmers in this study illustrated this point. Almost all of the banana farmers share similar educational experience. That is, they attend the same type of school, and over 95% attend all-age schools for the full duration of the program. The USAID Agricultural Education Project Paper (1985) indicates that Jamaican small farmers are relatively well educated, with over 90% of them completing primary school (all-age school). Because of the homogeneity of farmers on the educational level variable the correlation between education level and technology use would be low. Viewed from the perspective of the...
allocation theory of education as proposed by Meyer (1977) and the socio-cultural context in which agriculture develops in the Caribbean, one can glean additional insight into the reason for the observed relationship between education level and technology use. Agriculture in the Caribbean and Jamaica is associated with negative attitudes and the belief that high levels of education are not required for success in this pursuit (Henderson et al., 1980; USAID Agricultural Education Project Paper, 1985). This belief results in the relegation (allocation) of members of the population with relatively low levels of education. This phenomenon accounts for the homogeneity of educational level among the small farmers and thus the observed low correlation between educational level and technology use in this case.

Education (number of years of schooling) also shows a low and non-significant correlation with production of export quality fruits. The model proposed in Chapter 2 offers an explanation for this observation. The model proposes that education facilitates the adoption of technology and technology, in turn, is applied to influence production. It is, therefore, reasonable to infer that since technology and education are not related, levels of education and production of export quality fruit would not be related. It is also possible that even if education and technology were related, education level might not have shown any relationship with production since the model postulates that education operates exogenously to the relationship between education level and technology use. Finally, neither education level nor age shows any relationship with the attitudinal variables examined in this study. This is probably due in part to the common socialization experience of these farmers.
The correlation matrix table at Appendix A shows no relationship between the farmers' attitude towards technology and technology use. The relationship with quantity of export quality fruit is low and negative (r=-.18). No relationship was observed between farmers' opinion of technology and other socioeconomic, attitudinal or personal characteristic variables, except for a low positive relationship with farmers' attitude to extension and provision of credit (r=.24 and .25, respectively) and a low negative relationship with reduction of number of extension officers (r=-.23). The farmers' attitude to price shows a low negative relationship with technology (r=-.21), but no relationship is observed with yield or other focal variables (variables in the matrix), while there is no observed relationship between their attitude to education and the other focal variables except attitude to extension (r=-.31). Farmers' attitude to extension shows no relationship to technology use, but shows a low negative relationship with production of export quality fruit and a slight moderate negative relationship with attitude to education as noted above.

Relationship Between Production Variables and Opinion Variables.

Table 8 shows correlations between attitudinal variables and production variables.

Table 8 shows four statistically significant relationships with low negative correlation coefficients. Reducing the number of extension officers and farmers' opinion of the fairness of price are negatively related to technology use. Although attitude to extension and complexity of recommended practices were the only attitudinal variables related to production, they showed a low negative relationship (r=-.19 and r=-.21, respectively).
The signs of the correlations are consistent with the theoretical discussion of Chapter II. Predictions from the theory would indicate that as price increases the ability of farmers to purchase technology would be adversely affected, thus limiting their use of technology. Technology use is also adversely affected as farmers perceive an increased rate of withdrawal of extension officers from the farming system. Extension's role is to educate farmers in the use of technology; reducing extension officers will, in the mind of farmers, affect their ability to use

Table 8

Relationship Between Production Variables and Opinion Variables (Attitudinal Variables)

<table>
<thead>
<tr>
<th>Production Variables</th>
<th>Attitudinal Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Improve-</td>
</tr>
<tr>
<td></td>
<td>ments to</td>
</tr>
<tr>
<td>Roads, Water &amp;</td>
<td>Roads, &amp;</td>
</tr>
<tr>
<td></td>
<td>Credit</td>
</tr>
<tr>
<td></td>
<td>Price</td>
</tr>
<tr>
<td>Prod. of Export Fruit</td>
<td></td>
</tr>
</tbody>
</table>

Table 8:

Relationship Between Production Variables and Opinion Variables (Attitudinal Variables)

<table>
<thead>
<tr>
<th>Production Variables</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Improve-</td>
</tr>
<tr>
<td></td>
<td>ments to</td>
</tr>
<tr>
<td>Prod. of Export Fruit</td>
<td></td>
</tr>
</tbody>
</table>

Note: *P<.03; **P<.02; ***P<.01.

Farmers' opinion on improvement of roads, water supply and transportation; providing credit; reducing the number of extension officers; and farmers' opinion on the role of education, extension, technology, and fairness of price received for bananas sold.
technology. The negative relationship between complexity of recommended practices and production of export quality fruit indicates that as practices increase in complexity farmers would have difficulty using these practices. Such an experience may discourage the use of complex technologies and thus result in reduced yields. In cases where technology involves complex operations extension through its facilitating role would promote the use and successful application of such technologies. The low level of extension activity, 1.1 visits per farmer over the period January to June 1987, probably accounts for the negative relationship between production and the complexity of the technologies to be applied. It is noted that a farmer's opinion on the reduction of the number of extension officers is negatively related to technology use. This result is consistent with the relationship between complexity of practices and yield and the low level of extension activity in the valley. From the above, it appears that attitudinal variables operate mainly through technology to affect production within the farming system. Hooks et al. (1983) contend that a basic tenet of the diffusion theory is that attitudes are important determinants of technology adoption.

The model proposed in Chapter II asserts that technology is the central driving force of the farming system—that is, it has a major impact on production. This relationship between production and technology is either moderated or mediated by attitudinal and/or socioeconomic variables. Alternatively, technology use may operate through a two-phase process, where the adoption of technology or technology use is determined by attitudinal variables, and technology adoption in turn determines production. The mediator and moderator proposition will be examined in objective four.
Relationship Between Socioeconomic Variables and Production Variables.

From Table 9 it can be observed that the relationships between production variables and socioeconomic variables are much stronger than the observed correlations with attitudinal and personal characteristic variables (Tables 7 and 8). With respect to technology adoption, Hooks et al. (1983) explained that the traditional diffusion model operates on two assumptions:

(i) That exposure to information promotes the adoption process, because once people are aware of the potential benefits of adopting technologies they will move to adopt these technologies.

(ii) That certain psychological states predispose the farmer to adopt technologies.

Table 9
Relationship Between Socioeconomic Variables and Production Variables

<table>
<thead>
<tr>
<th>Production Variables</th>
<th>Socioeconomic Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size of Banana Farm</td>
</tr>
<tr>
<td>Technology Use</td>
<td>.34*</td>
</tr>
<tr>
<td>Production of Export Quality Fruit</td>
<td>.38*</td>
</tr>
</tbody>
</table>

*p<.01; **p<.001.
They argue that based on these assumptions the diffusion model posits that farmers will adopt technologies once awareness leads to the formation of the appropriate attitude. They noted that attitudes do influence behavior, but economic constraints may prevent a farmer from acting even when the farmer is aware of the advantages of acting.

The results of a study by Hooks et al. (1983) showed that economic constraint variables were the best predictors of technology adoption. These predictors had higher correlation coefficients than the attitude measures used in the study. Thus the information in Tables 8 and 9 supports the proposition of Hooks et al. (1983). In the resource poor environment that small farmers operate in developing countries (Office of Technology Assessment, 1983), one would expect that economic constraint variables would be more critical in determining the adoption of technology as compared to attitudinal and personal characteristic variables.

Because of the intercorrelations among the variables as shown in Table 9, the moderating effect of farm size and rate of use of hired labor on the relationship between technology use and production of export quality fruit would not be clearly interpretable, as explained by Baron and Kenny (1986). An alternative model may be a mediating model. This possibility will be explored in objective four.

The correlation between technology and the socioeconomic variables, Table 9, are as predicted by the theoretical framework of Chapter II. Even though the relationship between the number of extension visits and technology use is low (r=.21), this positive and highly significant (P<.01) relationship indicates that technology use tends to increase with increasing number of farm visits by extension officers. The theory
proposes that extension serves to educate the farmers in the use of technology and help move farmers along the innovation decision process of knowledge, persuasion, decision making, implementation and confirmation as suggested by Rogers (1983). Farmers who are educated about the technology and who receive support in its adoption are more likely to adopt the particular technology (Rogers, 1983; Zaltman and Duncan, 1977).

The relationship between technology use and rate of use of hired labor is moderate and positive, indicating that farmers who are able to provide supplemental labor tend to adopt technology. As was illustrated in Chapter 2, Turkish farmers failed to adopt a certain technology primarily because they could not supply the extra labor that was demanded by the new technology. Mellor's (1967) case studies in India indicated that the farmer who was able to increase his labor input had the highest production. Mellor (1967) argued that many traditional practices demand high inputs of labor. The USAID Agricultural Education Project Paper (1984) indicated that small farmers in Jamaica use a fair amount of hired labor. In the case of banana production, aspects of the technology such as those related to bunch care, pruning and reaping are labor intensive (Pesson, 1986; Thompson, 1988). Thus, to apply banana production technology the farmer must provide increased input of labor. This argument would predict that labor would be a significant mediator of technology use that is a primary mechanism through which technology operates to influence production. The pattern of correlations in Table 9 suggests that the mediator proposition would be more tenable, since rate of labor use is positively related to both production and technology, a necessary condition according to Baron and Kenny (1986) (see Figure 3, Chapter 3). The moderator hypothesis, even though plausible, would be eliminated on the
grounds of parsimony given that rate of hired labor use is correlated with technology use, a predictor variable. This situation complicates the interpretation of the moderator effect (Baron and Kenny, 1986).

Farm size is positively related to technology use. This relationship indicates that as farm size increases technology use also tends to increase, or that farmers with larger farms tend to adopt technology. Studies by Hooks et al. (1983), Igodan (1988), and Akinola (1987) report a positive effect of farm size on technology adoption. However, Voh (1982) reports a negative relationship. Farm size probably provides farmers with the economy of scale needed to adopt technology, most of which comes in the form of packaged inputs which must be purchased (e.g. fertilizers and insecticides).

Two socioeconomic variables were positively related to production of export quality fruit: size of banana farm and rate of use of hired labor. Hooks et al. (1983), Igodan et al. (1988), and Akinola (1987) report moderate to high correlations between farm size and yield. As mentioned earlier, in terms of the proposed model, farm size probably serves as a moderator or mediator of the relationship between technology use and yield. Although land is necessary for the production of bananas, it is not a sufficient condition. It is difficult to visualize the production of bananas or any other crop increasing with farm size independent of the application of technology. From the pattern of correlations in Table 9 one could argue that the relationship between production and technology is the result of the relationship observed between farm size and production, given that technology is also related to farm size. This alternate view may be tenable statistically but given the theoretical framework of Chapter II this is not a reasonable proposition. The low
positive relationship between rate of use of hired labor and production of export quality fruit indicates that as production increases the farmer uses more hired labor. Extension activity as illustrated in Table 9 is not related to yield. This is probably because of the low level of extension activity among farmers in the valley or as postulated by the proposed model, extension activity operates primarily through technology to increase production. The general pattern of relationships reported in Tables 7 through 9 are consistent with the theoretical propositions of Chapter 2. These propositions hold that extension facilitates technology use and technology use in turn promotes increased production. The positive significant relationships between technology use and extension; and technology use and production tend to support these propositions. In addition the proposed model postulates that certain attitudinal, socioeconomic, and personal characteristic variables tend to enhance and encourage technology use. These postulates also received tentative support as is illustrated by the observed correlation coefficients in Tables 7, 8, and 9. As noted earlier, few of the attitudinal variables showed significant relationships with technology use and even where these relationships were significant the coefficients tended to be smaller than the coefficients of relationship between the socioeconomic variables and technology use. The negative relationships observed between technology use, reduction of extension agents, and farmers' attitude to unfavorable price for their products is consistent with the predictions of the model as explained earlier.
Objective 2

Regression of Production Variable, Technology Use, on Socioeconomic, Personal Characteristic and Opinion Variables. The purpose of objective two was to determine the extent to which selected variables were able to explain variation in technology use. Variables were selected based on the theoretical framework of Chapter II as well as reported research in this area. Previous work by Hooks et al. (1983), Voh (1982), Akinola (1986), Igodan (1988), and Okuneye (1985) have investigated the predictive and/or explanatory power with respect to technology use, using various combinations of the following variables—farm size, age of farmers, educational level, frequency of extension visits, product prices, farm income, cost of inputs. In addition, Okuneye (1985) argued that poor roads reduced the effectiveness of extension agents in Southwest Nigeria.

In this study the following variables were used to construct a regression model—size of banana farm, age of farmer, rejection rate of bananas, years of schooling, number of extension visits, rate of use of hired labor, farmers' opinion of technology, reduction of number of extension officers, fairness of price received for products, provision of credit, improving and providing roads, and water supply, and number of hours worked on farm. The maximum R² option was chosen from procedures for stepwise regression analysis contained in the manual of the Statistical Analysis System (1982). The maximum R² option of the stepwise procedure compares all variables entered and searches for the best model. Once the significance level is met all variables will be included in the model if they contribute to the improvement of R² however small (SAS Manual, 1982). All twelve variables met the significance level for entry into the model which was set at .15. Two variables, years of
schooling and number of hours worked on farm, individually explained less than 1% (.003) of the variation in technology use. The ten-variable model was therefore chosen as the best explanatory model. The results presented in Table 10 indicate that these ten variables explained 46% of the variance in technology use.

Table 10

Stepwise Multiple Regression of Technology Use on Personal Characteristic, Socioeconomic, and Opinion Variables (Attitudinal Variables)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cumulative R²</th>
<th>Partial Slope Coefficient</th>
<th>Standard Error</th>
<th>F</th>
<th>P&lt; n=83</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of Use of Hired Labor</td>
<td>.185</td>
<td>.318</td>
<td>.113</td>
<td>7.92</td>
<td>.006</td>
</tr>
<tr>
<td>Opinion of Price</td>
<td>.248</td>
<td>-.257</td>
<td>.099</td>
<td>6.72</td>
<td>.011</td>
</tr>
<tr>
<td>Number of Ext. Visits</td>
<td>.299</td>
<td>.325</td>
<td>.127</td>
<td>6.57</td>
<td>.012</td>
</tr>
<tr>
<td>Opinion of Improvements Needed to Roads, Water Supply, and Transp.</td>
<td>.346</td>
<td>-.551</td>
<td>.246</td>
<td>5.03</td>
<td>.264</td>
</tr>
<tr>
<td>Size of Banana Farm</td>
<td>.369</td>
<td>.137</td>
<td>.010</td>
<td>3.28</td>
<td>.027</td>
</tr>
<tr>
<td>Rejection Rate</td>
<td>.393</td>
<td>.010</td>
<td>.005</td>
<td>6.57</td>
<td>.060</td>
</tr>
<tr>
<td>Opinion of Technology</td>
<td>.414</td>
<td>.116</td>
<td>.070</td>
<td>2.68</td>
<td>.105</td>
</tr>
<tr>
<td>Age</td>
<td>.431</td>
<td>-.020</td>
<td>.010</td>
<td>3.58</td>
<td>.062</td>
</tr>
<tr>
<td>Opinion of Credit</td>
<td>.450</td>
<td>-.336</td>
<td>.206</td>
<td>2.66</td>
<td>.107</td>
</tr>
<tr>
<td>Reducing Number of Ext. Off.</td>
<td>.460</td>
<td>-.163</td>
<td>1.44</td>
<td>1.29</td>
<td>.260</td>
</tr>
</tbody>
</table>
The multiple coefficient of determination \( R^2 \) for the overall model met the significance level of .05 set a priori, \( F=6.21 \) at the .0001 level. It will be observed that even though the overall model is significant, a number of the parameter estimates ("b" values) are not significantly different from zero. This could be indicating a problem with multicollinearity. According to Berry and Feldman (1985), multicollinearity reduces the reliability of the regression coefficients; that is, these coefficients will vary with repeated sampling using the same sample size. In addition, it will not be possible to separate the effects of those independent variables that are highly related to each other. They have suggested two procedures for determining the degree of multicollinearity:

(1) Making a paired comparison of correlation coefficients among independent variables. If there are variables with a coefficient greater than .7 this indicates that multicollinearity is a serious problem.

(2) The second test, which is recommended over the first, involves regressing each independent variable on the others. If any one set of the other variables explains close to 100% of the variance of the other independent variable (which is now the dependent variable) then multicollinearity can be considered to be a problem.

However, Berry and Feldman (1985) believe that collecting more information by increasing sample size is the best way for addressing the problem of multicollinearity. They argue that other procedures are fraught with shortcomings.
Table 11

Test for Multicollinearity—Regression of Each Independent Variable Alternately on the Others Used to Specify the Model

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>( R^2 ) Explained By Other Independent Variables Serving As Regressors</th>
<th>( P &lt; )</th>
<th>( n = 83 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.108</td>
<td>.036</td>
<td></td>
</tr>
<tr>
<td>Rejection Rate</td>
<td>-.061</td>
<td>.890</td>
<td></td>
</tr>
<tr>
<td>Years of Schooling</td>
<td>-.040</td>
<td>.760</td>
<td></td>
</tr>
<tr>
<td>Number of Extension Visits</td>
<td>.221</td>
<td>.007</td>
<td></td>
</tr>
<tr>
<td>Opinion of Technology</td>
<td>.077</td>
<td>.087</td>
<td></td>
</tr>
<tr>
<td>Rate of Use of Hired Labor</td>
<td>.210</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>Opinion of Effects of Reduction of Extension Officers</td>
<td>.088</td>
<td>.064</td>
<td></td>
</tr>
<tr>
<td>Opinion of Fairness of Price</td>
<td>.055</td>
<td>.148</td>
<td></td>
</tr>
<tr>
<td>Opinion of Improvements Needed to Roads, Water Supply, and Transportation</td>
<td>.030</td>
<td>.257</td>
<td></td>
</tr>
<tr>
<td>Opinion of Improvements Needed to Credit Facility</td>
<td>.132</td>
<td>.017</td>
<td></td>
</tr>
</tbody>
</table>

Both tests discussed above were applied to the independent variables used to predict technology use. An examination of the correlation matrix of Appendix A indicates that the independent variables used in the regression model met the minimum criterion as per Berry and Feldman.
(1987). Notwithstanding this, however, the second test was done. The results are presented in Table 11. The results above would seem to confirm that multicollinearity is not a problem with the regression model constructed for explanation of technology use even though there is some degree of redundancy among variables in explaining technology use.

It can be observed from Table 10 that even though ten variables were included in the model and they explained 46% of the variance in technology use, only four variables have partial slope coefficients that are significantly different from zero. Berry and Feldman (1985) recommended a joint hypothesis test of partial slope coefficients of variables with non-significant partial slope coefficients, after deleting those with significant partial slope coefficients. The variables deleted were rate of use of hired labor, farmers' opinion of price, number of extension visits, and size of banana farm (Table 10). This test will indicate whether or not the variables with non-significant partial slope coefficients taken jointly, have contributed significantly to the explanatory capacity of the model. Applying the formula --

\[
F = \frac{(R^2 - R_{m}^2) r}{(1-R^2) (n-k-r-1)}
\]

\(R^2 = \text{variance explained by full model}
\quad [\text{The original ten variables used to specify the model.}]\)

\(R_{m}^2 = \text{variance explained by variables left in the model}
\quad [\text{Those 6 variables with non-significant partial slope coefficient.}]\)

\(r = \text{number of deleted variables}
\quad [\text{Those 4 variables with significant partial slope coefficient, see Table 10.}]\)

\(n = \text{sample size [83.]}\)

\(k = \text{number of variables used to specify model}
\quad [\text{Number of variables in full model equal 10.}]\)
Thus, the remaining variables did contribute significantly to the model.

The stepwise procedure revealed that six variables explained 39.2% of the variance in technology use out of the 46.0% explained by ten variables. Thus, four additional variables accounted for a mere 6.8%. It is observed that the socioeconomic variables are relatively more important in predicting the use of technology. Of the six variables accounting for the majority of the variance in technology use four are socioeconomic variables, namely number of extension visits, age of farmer, rate of use of hired labor, and rejection rate of fruits.

Even though the relationship between farm size and technology use was moderately high, given that land is not a limiting factor in the production of export quality fruit, (farmers are currently using just 50% of their available land) other factors may be more important determinants of technology use under current circumstances. As indicated by the stepwise procedure, after controlling for rate of use of hired labor, number of extension visits, farmers' attitude to providing more credit and improvements to roads and water supply, farm size accounted for only an additional 2.2% of the variance in technology use.

Objective 3

Regression of Production Variable, Production of Export Quality Fruit, on Personal Characteristic, Opinion (Attitudinal) and Socioeconomic Variables. The purpose of this objective was to identify those personal characteristic, attitudinal and socioeconomic variables which are associated with the variance in production of export quality fruit. The
variables used to construct the regression model were selected based on their relationship with production of export quality fruit as indicated by the correlation matrix and supported by the theoretical propositions of Chapter II. The following variables were chosen for entry into the model, size of banana farm, farmers' opinion of technology, farmers' opinion of extension, farmers' opinion of recommended practices, rejection rate and technology use. Significance level for entry into the model was set at .15. Four variables met this significance level. Tests for multicollinearity were done. The results in Table 13 indicate that there is no problem with multicollinearity using criteria suggested by Barry and Feldman (1987). The degree of correlation among independent variables does not interfere with the interpretation of the results of regression analysis in Table 12. It was not necessary to perform the joint hypothesis test, since all the variables in the model contributed significantly to the explanatory power of the model. The proposed model postulated that technology is the primary driving force of production in the farming system. Thus, it would be expected that technology should account for a major portion of the variance of production in farming systems. In one study among farmers in Nigeria, Okuneye (1985) reported technology (adoption of innovation) as accounting for 71% of the variation in yield of rice farmers. In this study, technology use accounted for 18% of the explained variance. It was observed in Table 9 that the socioeconomic variables tended to be more strongly related to production than the attitudinal and personal characteristic variables. As indicated earlier, labor is a critical resource in traditional agriculture and farm size, in terms of land area, is an indispensable factor in the production process.
Table 12

**Stepwise Multiple Regression of Production of Export Quality Fruit on Socioeconomic, Personal Characteristic and Opinion Variables**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cumulative R²</th>
<th>Partial Slope Coeff.</th>
<th>Standard Error</th>
<th>F</th>
<th>P&lt;</th>
<th>n=83</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech. Use</td>
<td>0.179</td>
<td>88.46</td>
<td>25.024</td>
<td>12.50</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Size of Banana Farm</td>
<td>0.262</td>
<td>106.23</td>
<td>43.272</td>
<td>6.03</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Comp. of Recom. Practices</td>
<td>0.305</td>
<td>-90.1</td>
<td>46.212</td>
<td>3.80</td>
<td>.02</td>
<td></td>
</tr>
<tr>
<td>Opinion of Ext.</td>
<td>0.337</td>
<td>-54.38</td>
<td>27.948</td>
<td>3.79</td>
<td>.05</td>
<td></td>
</tr>
</tbody>
</table>

Table 13

**Test for Multicollinearity--Regression of Each Independent Variable Alternately on the Others Used to Specify the Model**

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>R² Explained By Other Independent Variables Serving as Regressors</th>
<th>P&lt;</th>
<th>n=83</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of Banana Farm</td>
<td>.122</td>
<td>.0026</td>
<td></td>
</tr>
<tr>
<td>Technology Use</td>
<td>.135</td>
<td>.0012</td>
<td></td>
</tr>
<tr>
<td>Complexity of Recom. Practices</td>
<td>.029</td>
<td>.3507</td>
<td></td>
</tr>
<tr>
<td>Farmers' Opinion of Extension</td>
<td>.049</td>
<td>.1350</td>
<td></td>
</tr>
</tbody>
</table>
Table 12 reveals that technology use, farm size, the complexity of the recommended practices, and farmers' opinion of extension explained 34% of the variation in production of export quality fruit. All four variables contributed significantly to the explanation of variance in production of export quality fruit. All partial slope coefficients were significant at the .05 level.

The theory postulated was that farm size and other variables operate in concert with technology to enhance production. In Chapter II it was observed that the relatively unproductive soils of Japan and Eastern Europe were made very productive through the application of technology. The results presented in Table 12 confirm the relative importance of technology in the production process. After controlling for technology use, farm size only accounted for 8% of the variance in production. The negative partial slope coefficient of the complexity of recommended practices is consistent with theoretical predictions. It would be expected that as the complexity of recommended practices increases their efficacy of use by the farmers would decrease, thus leading to reduced production. The interpretation of the negative partial slope coefficient of opinion towards extension is not as straightforward as might be expected, given that farmers had a relatively favorable attitude to extension as indicated in Table 5. The mean rating was 20.4 on a scale of 25. The theory applied here would predict a positive relationship with production but the results indicate otherwise. Although this observation seems to be inconsistent with theoretical predictions, this might not be the case if it is interpreted within the wider context of the set of variables that were used to describe the farming system. From Table 5 it was observed that farmers rate the role of technology and
extension in production relatively high (7.2 on a scale of 10 and 20.4 on a scale of 25, respectively). However, the average number of visits of extension officers over the period January-June 1987 was only 1.1. In addition, the average rejection rate was observed to be 30% of fruit presented for purchase at the boxing plant.

Given the above pattern of data it can be argued that farmers recognize the importance of technology. They also believe that extension is important. However, the low rate of extension activity, combined with the observation that extension officers tend to spend a small proportion of time on educational activities, (results of factor analysis, Table 3) adversely affects the use of technology. It may so happen that those farmers who tend to give high ratings to the role of extension are the farmers who need and appreciate the services of extension—that is, these farmers tend to be the lower producers who could benefit most from extension services. Their high rating could be looked at as an index of demand. From the above perspective the observed relationship between farmers' attitude to extension in the process of production seems to be consistent with the theoretical propositions of Chapter II. The above arguments also support the postulate of Spedding (1975). Spedding argued that components of a system should be studied taking into consideration the interactions connecting the components to the rest of the system. Extracting components and subjecting them to experimentation without the connecting links cannot be expected to engender increased understanding of the system. In other words, the connecting links among variables facilitate interpretation of the behavior of individual variables.
Objective 4

Moderator and Mediator Effects of Personal Characteristic, Socioeconomic and Opinion Variables on the Relationship Between Production Variables, Technology Use and Production of Export Quality Fruit. The analyses performed with respect to this objective were done to establish the structure of the relationship among selected variables. The model proposed in Chapter II posited that the relationship between technology use and production might be mediated or moderated by other variables. The analytical procedures and conceptual models proposed by Baron and Kenny (1986) were used to analyze and interpret the data.

In Chapter III a resume of the analytical procedures was presented. From the theoretical discussions of Chapter II, technology was proposed as the central driving force of production in the farming system. The relationship between technology and production can be enhanced, weakened or severed altogether if a third variable is not present to couple or enhance this relationship. Based on the discussions of Chapter II, the proposed model and guidelines suggested by Baron and Kenny (1986), variables, as classified below, were selected to be tested for mediator and moderator effects.

Moderator variables--farmers' opinions of the importance of education \(x_{11}\), technology \(x_{12}\), price \(x_{14}\), and extension \(x_{13}\); farmers' opinions concerning improvement needed to provision of credit facilities \(x_{8}\), and improving roads, water supply and transportation \(x_{8}\); distance from boxing plant \(x_{18}\); complexity of recommended practices \(x_{15}\); and experience in banana farming \(x_{19}\).

Mediator variables--farm size \(x_{3}\) and rate of use of hired labor \(x_{4}\).
Results of analyses are presented in Tables 14 and 15. The results in Table 14 indicate that five variables moderate the effect of technology

<table>
<thead>
<tr>
<th>Moderator Variables</th>
<th>Equations</th>
<th>Significance Level</th>
<th>Partial Slope Coeff. of Moderator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Model P&lt;</td>
<td>Moder. Term P&lt;</td>
</tr>
<tr>
<td>Opinion of Improv. Needed to Cred. Fac. (x_9)</td>
<td>[ x_6 = x_5 + x_9 + (x_5 \cdot x_9) ]</td>
<td>.000</td>
<td>x_5 \cdot x_9</td>
</tr>
<tr>
<td>Opinion of Comp. of Recom. Pract. (x_15)</td>
<td>[ x_6 = x_5 + x_{15} + (x_5 \cdot x_{15}) ]</td>
<td>.000</td>
<td>x_5 \cdot x_{15}</td>
</tr>
<tr>
<td>Opinion of Role of Technology (x_{12})</td>
<td>[ x_6 = x_5 + x_{12} + (x_5 \cdot x_{12}) ]</td>
<td>.000</td>
<td>x_5 \cdot x_{12}</td>
</tr>
<tr>
<td>Opinion of Role of Ext. (x_{13})</td>
<td>[ x_6 = x_5 + x_{13} + (x_5 \cdot x_{13}) ]</td>
<td>.000</td>
<td>x_5 \cdot x_{13}</td>
</tr>
<tr>
<td>Rejection Rate (x_{16})</td>
<td>[ x_6 = x_5 + x_{16} + (x_5 \cdot x_{16}) ]</td>
<td>.000</td>
<td>x_5 \cdot x_{16}</td>
</tr>
<tr>
<td>Opinion of Effect of Reducing No. of Extension Officers (x_{10})</td>
<td>[ x_6 = x_5 + x_{10} + (x_5 \cdot x_{10}) ]</td>
<td>.003</td>
<td>x_5 \cdot x_{10}</td>
</tr>
<tr>
<td>Hours Worked on Farm (x_{17})</td>
<td>[ x_5 + x_{17} + (x_5 \cdot x_{17}) ]</td>
<td>.000</td>
<td>x_5 \cdot x_{17}</td>
</tr>
</tbody>
</table>
use on production of export quality fruit. This is indicated by a significant partial slope coefficient for the product term (moderator term) in the regression equation (Baron and Kenny, 1986). These variables specify the conditions and circumstances that will cause variation in the application of technology even though they have low correlations and in some cases no correlation with technology use. It should be noted that of the three terms in each regression equation, the moderator variable by itself did not meet the significance level (.15) for entry into the regression model. It was observed that all the variables with moderator effect are attitudinal variables. These variables determine the disposition of the farmer towards technology. They shape his tendency to act with regard to technology use. They operate exogenously to the process of actual application of technology or the desire to apply technology.

Table 15 shows that both size of banana farm and hired labor mediate the relationship between technology use (the independent variable) and production of export quality fruit (the dependent variable).

In Chapter III, the analytical procedures for establishing the mediational effect of a variable was discussed. Three conditions should be met. Firstly, the independent variable should be shown to affect the mediator in equation one; secondly, the independent variable should also be shown to affect the dependent variable in equation two; and thirdly, both the mediator and the independent variable must be shown to affect the dependent variable in the third equation. The effects of the independent variable and the mediator in these equations is indicated by significant regression coefficients for the independent variable in equations one and two, and significant partial slope coefficients for the
independent variable and the mediator in equation three. If the third condition holds the size of the partial slope coefficient of the independent variable will be smaller in the third equation than in the second equation. An examination of Table 15 will indicate that all three conditions were met. Mediational variables define the mechanics through which technology operates to influence production. The variables, banana farm size and rate of use of hired labor, establish the operational linkages with production.

Table 15

Mediational Effect of Selected Variables on the Relationship Between Technology Use and Production of Export Quality Fruit

<table>
<thead>
<tr>
<th>Mediator Variable</th>
<th>Equations</th>
<th>Independent Variables</th>
<th>Mediator Variables</th>
<th>R² for Model Eqs. 1, 2, 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of Banana Farm (x₃)</td>
<td>1. ( x₃ = x₅ )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. ( x₆ = x₅ )</td>
<td>44***</td>
<td>---</td>
<td>.12***</td>
</tr>
<tr>
<td></td>
<td>3. ( x₆ = x₅ + x₃ )</td>
<td>115**</td>
<td>118**</td>
<td>.18***</td>
</tr>
<tr>
<td>Rate of Use of Hired Labor (x₄)</td>
<td>1. ( x₄ = x₅ )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. ( x₆ = x₅ )</td>
<td>168***</td>
<td>---</td>
<td>.13***</td>
</tr>
<tr>
<td></td>
<td>3. ( x₆ = x₅ + x₄ )</td>
<td>135**</td>
<td>90*</td>
<td>.14***</td>
</tr>
</tbody>
</table>

Note: *P<.05; **P<.01; ***P<.00.

*aIndependent variable is technology use (x₅); dependent variable is production of export quality fruit (x₆).*
Figure 4 provides a schematic representation of the structure of the relationship among the attitudinal variables, socioeconomic variables, and production.

The model is similar to that proposed in Figure 2 (Chapter II), except that the relative positions of the variables with respect to the relationship between technology use and production were not specified. It can be inferred from the model that even though farmers may have a favorable opinion of technology, this may have no effect on production unless there is land and labor available to convert technology into production.

Summary

Farmers growing bananas are not substantively different from non-banana farmers. Banana farmers have a favorable opinion (attitude) of technology, education, and extension. Technology and education each received ratings of 7.2 on a scale of ten and extension 20.4 on a scale of 25. Even though farmers had a favorable opinion of extension, technology and education, their average use of technology was low (2.7 on a scale of 6). This is probably due to the very low number of visits of extension officers (1.1 over a six month period), the relative complexity of the recommended practices (6.3 on a scale of 10), and the observation that major portion of farmers have no access to credit (74% of farmers reported that they had no access to credit).

Socioeconomic variables seem to be more useful in explaining variation in technology use. Socioeconomic variables accounted for 60% of the explained variance in technology use (.276 of .460 explained). In the
Figure 4. Empirical model depicting the structure of relationship between attitudinal and production variables.
case of production of export quality fruit, 77% of explained variance (.179 of .34) was accounted for by farm size and technology use.

Five attitudinal variables were found to be moderators of the relationship between independent variable technology use and dependent variable production of export quality fruit. These were opinion of need to provide more credit, opinion of complexity of recommended practices, farmers' opinion of extension and technology. Two socioeconomic variables were found to be mediators. These were rate of use of hired labor and size of banana farm.
CHAPTER V
SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of the study was to determine the relationship among selected personal characteristic and socioeconomic variables, farmers' opinions, and production variables, and to examine the effect of these personal characteristic and socioeconomic factors, and farmers' opinions on production variables.

The specific objectives were:

1. To identify the relationship between level of technology use, socioeconomic factors, farmers' opinions, and selected personal characteristic variables and production variables.

2. To determine the effect of selected personal characteristic and socioeconomic variables, and farmers' opinions on technology use.

3. To determine the effect of selected personal characteristic and socioeconomic variables and farmers' opinions on the production of export quality fruit.

4. To determine the moderating and mediational effects of personal characteristic and socioeconomic variables and farmers' opinions of socioeconomic variables on the relationship between technology use and production of export quality fruit.

Procedures

The target population was the 121 farmers reported to be growing bananas for sale to the public boxing plant at Fellowship in the Rio Grande Valley. Because the study would have implications for other
farmers and residents in the valley since it would be desirable to encourage other farmers and residents to produce bananas for export, a random sample of 182 non-banana farmers was used as a cross validation check.

A single instrument was used to collect information about farmers' pattern of technology use, their production of export quality fruit, personal characteristics, status on socioeconomic factors, and their opinion of the role of these socioeconomic factors in the farming system. Information was collected from non-banana farmers on all variables except technology use and production of export quality fruit.

Farmers were interviewed by four senior students of the College of Agriculture over a nine week period - June to August 1987. One hundred and twenty-one banana farmers and 182 non-banana farmers were interviewed.

A comparison was made between banana farmers and non-banana farmers on selected personal characteristic variables, their status on selected socioeconomic variables and their opinion of these variables. Correlation coefficients were calculated between production variables (technology use and production of export quality fruit) and personal characteristic and socioeconomic variables, and farmers' opinion of the role of these variables. Stepwise multiple regression analysis was performed to determine the amount of variance in production variables (technology use and production of export quality fruit) explained by personal characteristic and socioeconomic variables and farmers' opinion of these variables. In addition, an analysis of the relationship between technology use and production of export quality fruit was performed to identify the moderator and/or mediational effect of selected personal
characteristic and socioeconomic variables and farmers' opinion of these variables.

Findings

Comparison of Banana Farmers and Non-Banana Farmers. Banana farmers and non-banana farmers were not substantively different on the variables measured. The average age of banana farmers was 49 years, non-banana farmers 51 years; average size of farm, banana farmers 5.6 acres, non-banana farmers 5.9 acres; average number of years of schooling, banana farmers 7.18 years, non-banana farmers 7.21 years; average number of extension visits received, banana farmers 1.1, non-banana farmers 1.0; average number of hours of hired labor used per day, banana farmers 1.64 hours, non-banana farmers 1.70 hours.

Observations on farmers' opinion of socioeconomic variables fell in a similar pattern. The mean score of banana farmers and non-banana farmers, respectively, were: technology 7.2 and 6.0; education 7.2 and 8.3; complexity of recommended practices 6.3 and 6.7; price 8.0 and 10.8; extension 20.4 and 17.4; improving roads and water supply 4.8 and 4.8; providing more credit 4.4 and 4.5; reducing the number of extension officers 2.4 and 2.2.

Farmers Opinion of Extension, Education, and Technology and Their Role in Technology Use. Farmers had a relatively high opinion of the role of technology, education and extension in the farming system. Education and technology were each rated 7 on a scale of 10. Extension received a rating of 20.4 on a scale of 25, but farmers' use of technology was only 2.7 on a scale of 6. This result indicates that even though farmers are aware of the role of technology in the farming system,
their actual use of technology is low. Even though the reported number of extension visits was very low (1.1 over 6 months), farmers' rating of the role of extension in the farming system was relatively high. This finding may be indicating a demand for extension service given that farmers also gave a high rating to the complexity of recommended practices.

**Relationship Between Personal Characteristic and Farmers' Opinion Variables and Production Variables.** The personal characteristic variable, age, had a low negative relationship with technology use ($r=-.17$). The other personal characteristic variable, years of schooling, had no relationship with the production variables, technology use and production of export quality fruit.

Farmers' opinion of socioeconomic variables showed few significant relationships with production variables. Farmers' opinion of price and reducing the number of extension officers had low negative relationships with technology use ($r=-.21$ and $-.22$, respectively), while farmers' opinion of the role of extension showed a low negative relationship with production ($r=-.19$). Farmers' opinion of other socioeconomic variables showed no relationship with the production variables.

**Relationship Between Socioeconomic Variables and Production Variables.** A moderately positive relationship existed between technology use and the socioeconomic variables, size of banana farm and rate of use of hired labor ($r=.34$ and $.36$, respectively), while the relationship between technology use and the socioeconomic variable, number of extension visits, was low and positive ($r=.21$). The relationship between production of export quality fruit and size of banana farms was moderate and positive ($r=.38$), the relationship with rate of use of hired labor was
low and positive (r=+.28), and the relationship with complexity of recom-
mended practices was low and negative (r=-.21). Production of export
quality fruit had no relationship with number of extension visits, and
technology use had no relationship with complexity of recommended
practices.

Regression of Production Variable--Technology Use on Personal
Characteristic, Socioeconomic and Opinion Variables. Stepwise regression
analysis was performed to determine the amount of variance in technology
use that could be explained by selected personal characteristic variables,
socioeconomic variables, and farmers' opinions of socioeconomic variables.
Ten variables explained 46% of the variance in technology use. Six
variables accounted for 85% of the explained variance (39.3% of the total
variance of 46% explained by the ten variables). These six variables
were rate of use of hired labor, farmers' opinion of price, number of
extension visits, farmers' opinion of improvements needed to roads, water
supply and transportation, size of banana farm and rejection rate. The
other four variables--farmers' opinion of technology use, age, farmers'
opinion of credit, and reducing the number of extension officers accounted
for 15% (6.7%) of the total variance of 46% explained by the ten variables.
Socioeconomic variables accounted for 60% of the explained variance.
These were farm size, rate of use of hired labor, rejection rate, and
number of extension visits.

Regression of Production Variable--Production of Export Quality
Fruit on Personal Characteristic, Socioeconomic, and Opinion Variables.
Four variables explained 34% of the variance in production of export
quality fruit. These were technology use, farm size, complexity of
recommended practices and farmers' opinion of the role of extension in
the farming system. Technology use accounted for 52.6% (17.9% out of 34%) of the variance explained by the model. Technology use together with size of banana farm accounted for 77% of the explained variance (26.2% out of 34.0%).

**Moderator and Meditational Effects of Selected Variables on Relationship Between Technology Use and Production of Export Quality Fruit.** Five variables were found to be moderators of the relationship between technology use and production of export quality fruit. These variables were farmers' opinion of need to provide more credit, complexity of recommended practices, farmers' opinion of technology, farmers' opinion of extension, and farmers' opinion of reducing the number of extension officers. These variables interact with technology to influence the level of production of farmers.

Two variables were found to mediate the relationship between technology use and production of export quality fruit. These variables were size of banana farm and rate of use of hired labor. These two variables provide linkages or the mechanism through which technology influences production.

**Conclusions**

Conclusions are presented and discussed under the captions factors influencing farmers' use of technology, factors influencing the production of export quality fruits, and factors modifying the relationship between technology use and production of export quality fruit. Recommendations for the improvement of the farming system and further study follow the presentation of conclusions.

**Factors Associated With Farmers' Use of Technology.** The average age of banana farmers was 49 years. These farmers are slightly younger than
the average Jamaican farmer whose age is listed as 55 years (Jamaica Education Sector Survey, 1975). Concern has been expressed about the aging Jamaican farmer and the negative effect this may have on technology use (USAID Agricultural Education Project Paper, 1984). However, the findings of this study do not lend much support to this concern as far as banana farmers of the Rio Grande Valley are concerned, since age has only a low negative correlation with technology use ($r=-.17$).

It is also believed that the aging population of small farmers hinders the modernization of the small farming sector, primarily because they are thought to be steeped in tradition. However, the findings of this study showed that small farmers of the Rio Grande Valley had a favorable opinion of technology's role in farming. The findings of this study corroborate the views of Mellor (1967) and Adams and Graham (1984), that small farmers in LDCs are prepared and motivated to change and respond positively to technology.

Farmers' actual use of technology is low even though they have a favorable opinion of the role of technology in the farming system. This is based on the findings that farmers rate the role of technology a 7 on a scale of 10 but use only about 50% of the recommended practices (2.7 out of 6). Given the findings of this study the low rate of technology use may be attributed to: (a) farmers' belief that the recommended practices are complex; they gave recommended practices a complexity rating of 6 on a scale of 10, and (b) the low average number of visits of extension officers, 1.1, over a six month period. These two factors combined to reduce the ability of farmers to make use of the recommended practices.

Socioeconomic variables were more important than attitudinal variables (farmers' opinions) in explaining the variance in technology
use. This result is based on the finding that 85% of the explained variance in technology use was accounted for by socioeconomic variables. This finding is similar to results reported by Hooks et al. (1983).

Small banana farmers operate in a resource poor environment, and the large majority of these farmers have no access to credit, based on the finding that 74% of these farmers reported receiving no credit. These farmers would find it difficult to purchase factors such as hired labor which promote the application of certain technologies like bunch care, or to purchase packaged technologies such as fertilizers, planting materials, and insecticides. In addition to the reasons given above, the farmers' inability to purchase factors that embody technological innovation restrict their use of technology.

Of the ten variables used to specify the model, five had negative partial slope coefficients. The variables with negative partial slope coefficients are conversely related to technology use. These variables were farmers' opinion of price, the improvements needed to roads, water supply and transportation, need to provide more credit, reducing the number of extension officers, and the farmers age. The joint hypotheses test as suggested by Berry and Feldman (1985) indicated that variables with non-significant partial slope coefficient contributed significantly to the model. Therefore, their partial slope coefficients would be different from zero. Thus, it may be concluded that as farmers' opinion of these factors become more unfavorable, their use of technology is adversely affected. However, one should be cautious in applying this information since these variables individually account for a small portion of the variance in technology use.
The variables with positive partial slope coefficients included rate of use of hired labor, number of extension visits, banana farm size, farmers' opinion of technology use and rejection rate. Given these positive partial slope coefficients, one may conclude that as farm size, number of extension visits, rejection rate, and farmers' favorable opinion of technology increases the farmers' use of technology tends to increase. Again, one should be cautious in the use of this information since, except for rate of use of hired labor and number of extension visits, the other variables, rejection rate, farmers' opinion of technology and farm size, individually contribute very little to the amount of variance explained. In addition, these conclusions may only be used to explain the behavior of these variables over the range of data points used in the study.

Factors Associated with the Production of Export Quality Fruit.

Four variables, technology use, size of banana farm, complexity of recommended practices, and farmers' opinion of extension, accounted for 34% of the variation in technology use. The partial slope coefficients of all four variables were significant; one may, therefore, conclude that all four variables contributed significantly to the variance explained. Technology use and farm size had positive partial slope coefficients, while complexity of recommended practices and farmers' opinion of extension had negative partial slope coefficients. Thus, it may be concluded that as farm size and technology use increases, production of export quality fruit tends to increase; on the other hand, as the farmers' belief that the recommended practices are more complex and their opinion of extension becomes more unfavorable, their production of export quality fruit tends to decrease. As far as the effect of these two variables are
concerned, the results should be interpreted with caution since they account for only 4.3 and 3.2%, respectively, of the variation in production of export quality fruit. Technology use as a single variable accounts for slightly more than half (52.6%) of the explained variance in production of export quality fruit. Based on this finding, it may be concluded that technology is the most important single factor in the small farmer banana production system in the valley. Again, caution must be exercised in the application and generalization of these data. It should be remembered that the explanatory power of the model is limited to the range of data points used in the study.

In Chapter II, the theory postulated that extension is an important determinant of technology use, yet the number of extension visits has only a low positive correlation with technology use and explains only about 3% of the variance in technology use. If one restricts evaluation of the role of extension in this farming system to the indices of correlation and variance explained, then a minor role would be attributed to extension contrary to theoretical propositions.

When extension is examined in a wider context as it relates to other variables, its important role becomes apparent, considering the following pattern indicated by the data:

(1) Farmers give technology use a favorable rating but their actual use of technology is low.

(2) Farmers believe that the recommended practices are complex.

(3) Extension officers tend to spend a major portion of their time on non-educational activities.

(4) Farmers have a favorable opinion of extension's role in the farming system.
As indicated by theory, extension services are needed to educate farmers in the use of technology and move farmers along the innovation-decision process. The low level of extension visits precludes the above facilitative actions, thus farmers see practices as complex and are discouraged from using them. In addition, it may so happen that those farmers who gave extension services a high rating are the ones that need extension services the most, namely the low producers. This may explain the negative relationship between favorable ratings and production of export quality fruit.

Examined in the above context, the low extension activity among farmers in the valley has adversely affected their use of technology and the high opinion rating of extension may be viewed as an index of demand for extension services by the low producers. Thus, it may be concluded that extension plays an important role in the farming system through its effect on technology use.

Factors Modifying the Relationship Between Technology Use and Production of Export Quality Fruit. The findings of the study indicated that five variables, need to provide more credit, complexity of recommended practices, farmers' opinion of technology, farmers' opinion of extension, and farmers' opinion of reducing the number of extension officers, serve as moderators of the relationship between technology use and production of export quality fruit. Based on these findings it can be concluded that these variables operate as independent variables that interact with technology use to determine conditions and circumstances that will cause variation in technology use and thus variation in production of export quality fruit. The findings also indicated that two variables, size of banana farm and rate of use of hired labor, mediate the relationship
between technology use and production of export quality fruit. Based on these findings, it may be concluded that these variables establish the operational linkages between technology and production.

According to Baron and Kenny (1985), moderators always behave as independent variables while mediators switch roles between independent and dependent variables. Given this postulate and the indications of the findings that moderators are opinion or attitudinal variables and mediator variables are socioeconomic variables, it may be concluded that moderators operate exogenously to the relationship between technology use and production of export quality fruit. These variables determine disposition of the farmer to technology use, while the mediators are socioeconomic variables that operate internally providing the linkages between technology use and production of export fruit. Figure 4 (Chapter IV) illustrated the structure of the relationship.

Contributions to Theory. The current study provides data that supports a model that offers an explanation for the differences observed in correlation coefficients for relationships between production variables (technology use, production of export quality fruit), and personal characteristic, opinion and socioeconomic variables. Figure 4 on page 89 shows that the socioeconomic variables, banana farm size and rate of use of hired labor, mediate the relationship between technology use and production of export quality fruit. In contrast, attitudinal variables moderate the relationship between technology use and production. The mediational relationship represents a stronger and more direct relationship between variables since it defines the mechanism through which the independent variable and mediators affect the dependent variable. The mediational relationship explains the tendency to observe higher
correlations between socioeconomic variables and technology use compared to correlations between attitudinal variables and technology use. Hooks et al. (1983) noted that even though farmers may have favorable attitudes to technology, this does not guarantee technology adoption by farmers, since they may be unable to purchase the inputs which embodies modern technological innovation. Thus, the argument for the constraining effect of economic variables is explained by the model in Figure 4. They also argue that the economic constraint model has greater face validity than the attitudinal model used by diffusionists to explain variation in technology use. The basis for their argument is the relative size of the correlation coefficients. This study presents the underlying mechanism that accounts for the observed differences in size of correlations coefficients for relationships between socioeconomic variables and technology use on the one hand and attitudinal variables and technology use on the other.

The study also provides empirical support for the farming systems approach to development and research by providing a framework which illustrates that a number of attitudinal, personal characteristic, socioeconomic and production variables interact to determine the output of the system. Because variables are connected in an interacting framework, the system will benefit most from problem solving and developmental approaches which study variables while taking into consideration their interconnections with other variables of the system.
Recommendations

Boyd (1987) has agreed that the economic lot of small farmers in Jamaica will improve if they are encouraged to produce the more lucrative export crops. Persaud (1988) contends that an agricultural sector structured around large plantations does not provide the demand structure needed to stimulate rural development, while Beckford (1972) postulates that small farmers are a rich source of entrepreneurial talent which should be developed in order to stimulate rural economic development.

The argument proffered by these scholars supports the development of a viable small farm sector. Based on the findings of the study, this researcher believes that the following recommendations will promote an expansion and improvement of small farmer banana production in the Rio Grande Valley.

1. Restoration of the extension service to the level where it will be able to facilitate the adoption of technology. Increasing the level of extension service is indicated by the following findings. Farmers believe that the recommended practices are complex, one of the primary functions of extension is to educate farmers in the use of technologies and to present these technologies in a fashion that is easily understood and assimilated. Even though farmers gave favorable opinion ratings to technology’s role in the farming system, their actual use of technology is low. Rogers (1984) refers to this as the knowledge attitude practice gap. Rogers contends that extension is needed to move farmers along the decision innovation process to facilitate technology adoption. In Chapter IV, Table 5, it was shown that farmers also had a favorable opinion of the role extension in the farming system, nevertheless, at the same time farmers’ opinion of extension was negatively associated with
production. It was agreed in Chapter IV, page 52, that this may be indicative of a demand for extension service by the lower producers who could benefit most from extension's services. Given that the current level of extension is very low, the case for providing increased funding for extension, at least over the short run, is justified. Recommendation for investment in extension over the short run does not suggest that investment in research should be curtailed over the long run in favor of expenditure on extension. This is a short run remedy given the current level of technology adoption among farmers, and that there is considerable reservoir of unused research that needs to be disseminated by extension.

The pattern of correlations in Tables 8, 9, and 10 demonstrates that the small banana production system in the Rio Grande Valley is a complex system—many factors interacting to determine the nature and output of the system. The farming systems approach to research and development proposes that efforts to develop the system or seek solutions to problems that arise in the system should follow an interdisciplinary approach. The developmental needs of a complex system requires the application of expertise that spans many disciplines. Extension officers, other social scientists and physical scientists should be trained to work as a team. A team based approach to development and problem solving in small farm systems takes advantage of possible synergistic effects among factors and is consistent with the philosophy of the farming system approach to research and development.

(2) Redesign the job of extension agents to allow tasks to be focused on educational activities instead of administrative duties. The findings of this study indicate that extension officers allocate a major portion of their time to non-educational activities. The rapid rate of
technology evolution and the complex nature of these technologies demand that the role of extension be redefined to emphasize educational development of the farmer.

(3) Credit facilities should be provided to allow farmers to purchase needed inputs. The findings of the study indicated that 74% of the farmers receive no credit. The study also indicated that socioeconomic factors and technology interact to determine farmers' level of production. This means that for farmers to apply technology, they need to purchase factors such as labor, fertilizers, insecticide, plastic sleeves, and other inputs. Many of the farmers indicated that there is a need to make more credit available on easier terms. It may be that many farmers are unable to allocate cash resource to purchase these inputs.

(4) The infrastructure of the farming systems (roads, transportation, and water supply) should be improved. The findings of the study indicate that farmers feel there is need for improvement in infrastructure and better use of technology. This researcher has observed that the infrastructure of the Rio Grande Valley is in a state of severe disrepair. This condition of disrepair, roads in particular, prohibits the distribution of inputs, impedes the delivery of bananas to the boxing plant, and makes access of extension officers to farmers difficult.

(5) Table 9 shows that farm size is moderately related to production (r=.38). Table 9 also shows that the partial slope coefficient of farm size is positive, indicating that as the amount of land allocated to banana production increases production of export quality fruit increases. Given this information, farmers should be encouraged to allocate more land to banana cultivation. In cases where farmers have already allocated all their land to banana cultivation, extra land should be provided
through the land reform program operated by government. If it is not possible to allocate additional lands to farmers, a cooperative system could be developed where small units are merged so that farmers with smaller lots would be able to take advantage of the economies of scale provided by increased farm size.

One should exercise caution in the implementation of this recommendation since the relationship observed between farm size and production may be specific to the data points used in this study.

(6) The moderator variables in Table 1A are farmers' opinion of the need to provide more credit, farmers' opinion of reducing the number of extension officers, farmer's opinion of the complexity of recommended practices, farmers' opinion of the role of extension and technology in the farming system. If farmers develop unfavorable opinions of these factors then technology adoption will be adversely affected, which eventually affect the production of export quality fruit.

Culbertson (1968) and Gibson, Ivancevich and Donnelly (1988) argue that attitudes influence behaviors and the attitude developed by individuals is related to their experience with the object of the particular attitude as well as the nature of the information they have concerning the object of the specific attitude. Given the above, if farmers have favorable experience and positive information relative to an object of their attitude, then it is likely that they will develop a favorable attitudes.

Given the theoretical propositions of Culbertson (1968) and Gibson et al. (1988), the following recommendations are made with respect to the moderating variables of Table 14.
(a) The findings of the study indicate that farmers tend to have favorable attitudes toward extension and technology. Educational programs should be designed to demonstrate in tangible ways the benefits derived by the farming system from extension services and technological innovations so as to maintain these favorable attitudes and effect improvements where necessary.

(b) With respect to the practices recommended for adoption, more effective teaching methods should be utilized to present these methods to farmers so that their efficacy in the use of these skills can be increased, and with it their confidence and attitude.

(c) In the case of credit less complicated procedures should be devised to be used in the process of credit application and processing. In addition farmers should be trained to accept and use these procedures. Increasing the level of extension activities and redesigning the job of extension officers as recommended earlier will ensure that the educational needs of farmers are met and advantage is taken of the opportunity to develop desirable attitudes in farmers with respect to the opinion (attitudinal) variables that moderate the relationship between technology use and production of export quality fruit.

(7) The results of the mediational analyses indicated that technology use operates through farm size and rate of use of hired labor to influence production. Given that technology use accounts for slightly more than fifty percent of the variation in production (Table 10) and that farmers use of technology is low (Appendix C), it would therefore be desirable to encourage farmers to adopt technology, and provide them with the means to purchase technology. Because the relationship between production and
technology use is mediated as described above, efforts to increase production by encouraging farmers to adopt technology must also take into account the need to make adjustments to the mediators.

The following recommendations are made given the above arguments:

(a) Improve the capacity of farmers to purchase or provide labor, in addition to measures suggested in recommendation 6 for increasing the size of farm under banana cultivation.

(b) Develop an integrated plan for increasing banana production. The mediator/moderator model suggests that several factors interact to influence the production of export quality fruit. Efforts to encourage increased production should be focused on all the relevant factors in a coordinated fashion so as to take advantage of possible synergistic effects of these interdependent factors. A singular approach may not produce the level of increase in production of export quality fruit as would an approach that takes advantage of the effects of all the relevant factors. Implementing such an approach would mean adopting the team approach to development and problem solving. To accomplish this, professionals such as extension officers, economists, sociologists, and physical scientists should be trained to work as a team. A team approach increases the possibility that all relevant factors that influence the output of the system will receive consideration in the development process.

Further Study

(1) Similar studies should be conducted among small farmers in other areas growing other crops. The findings of these studies will add to the understanding of small farming systems in Jamaica and facilitate comprehensive planning and efficient allocation of resources.
(2) The term technology more often than not refers to a discrete set of practices or procedures. Each practice has a particular level of skill and cost associated with its use. Studies should be conducted among small farmers to determine how the level of skill and the cost associated with particular practices determine the pattern of adoption of practices presented as a composite to the farmer.

(3) Follow-up studies should be conducted in the Rio Grande Valley to trace changes in variables measured by this study as well as to identify other variables that might be affecting the system in important ways but which were not included in this study. The high variability of production observed in this study (see Appendix C) suggests that other variables might be affecting the farming system. These additional studies will provide further insight into the dynamics of the small farming system in the valley.
REFERENCES


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<td>-.007</td>
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<td>.010</td>
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<td>91$^c$</td>
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<td>91</td>
<td>91</td>
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<td>90</td>
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<td>90</td>
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</tr>
</tbody>
</table>

**Note:**

$a$ Pearson r.

$b$ Level of significance.

$c$ Number of respondents.
APPENDIX B
Cornwall Barracks

INTERVIEW SCHEDULE

INTRODUCTION:
We are studying the system of banana production in the Rio Grande Valley. Our aim is to determine the factors that influence the production of bananas. We will be asking you a number of questions about banana farming. Please feel free to give your honest opinion on any matter raised by the questions you will be asked.

(1) How long have you been cultivating bananas? ____________ years

(2) How many acres of land do you cultivate (farm)? ____________ acres

(3) How much of this land is cultivated in bananas? ____________ acres

(4) How old were you on your last birthday? ____________ years old

(5) What is your opinion of banana farming as a means of earning a living or making money?

Your answer to this question could be: (1) very poor; (2) poor; (3) not so good; (4) good; (5) very good. 1 2 3 4 5
Please circle the answer selected by farmer.

(6) How many bunches or boxes of bananas do you offer for sale on a sale day? ____________ boxes

(7) On the average, how many boxes or bunches of your banana does the boxing plant purchase from the amount you offered for sale? ____________ bunches
(8) What is your current quality rating?

(9) What type of school did you attend?

(10) How many years altogether did you attend school?

(11) How far is your farm from the boxing plant?

(12) We would like you to indicate the number of visits you have had in the past six months from:

(a) Extension Officer
(b) Banana Company Officer
(c) AIBGA Representative
(d) JAS Representative

(check one only)

1 2 3 4 5

Your answer could either be (1) none; (2) very few; (3) few; (4) an adequate number; (5) many.

(13) Have you made use of any credit facility in establishing your (banana) farm? Please explain the nature of credit, that is whether cash or kind.

(14) The major source of funds invested in your banana farm is: (1) personal; (2) loan funds.

[ ] Personal  [ ] Loan

(check one only)
(15) How do you provide the labor for cultivating bananas? Check one of the following?

(a) Farmer as the only source of labor.
(b) Farmer supported by one or more family members.
(c) Farmer supported by family member and hired help.
(d) Farmer and hired help.  

(16) On the average, how many hours do you work on your banana farm each day (including family members)? 

_________________________ hours

(17) On the average, how many hours of hired labor do you use on your farm each day/week/month?

_________________________ hours

(18) We believe you might have suggestions of your own concerning things that can be done to improve the capacity of the banana industry to provide a secure income for small farmers and encourage more farmers to produce bananas. We would like to get your opinion in this regard. We are therefore asking you to rate the factors (things to be done) listed below in terms of their effectiveness in contributing to the capacity of the banana industry to provide a secure income for small farmers in the future. Your answer could either be

(1) strongly disagree; (2) disagree; (3) neutral; (4) agree; (5) strongly agree. Please check one only.

SD   D   N   A   SA (check one only)

(a) Reducing the number of extension officers available to advise farmers.

1  2  3  4  5

(b) Increasing the price paid for bananas.

1  2  3  4  5

(c) Providing more land to farmers to grow bananas.

1  2  3  4  5
(18) **TECHNOLOGY**

We are interested in determining the range of cultural practices used by farmers in growing their bananas. A number of cultural practices used in the cultivation of bananas will be read to you. Please indicate those practices you are currently using on your farm to produce bananas.

(a) Do you use fertilizer?  
   YES \ NO

(b) Soil testing to determine fertilizer requirement before application.  
   YES \ NO

(c) Split application of fertilizer (every three months 12:4:28).  
   YES \ NO

(d) Pruning to parent plant, follower and pepper.  
   YES \ NO
(10)

<table>
<thead>
<tr>
<th>(e)</th>
<th>Sleeving bunch.</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>(f)</td>
<td>De-budding.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>(g)</td>
<td>Pruning of leaves away from bunch to prevent scarring.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>(h)</td>
<td>Calipering of fingers and surveying of field to establish reaping date (high 3/4 inch).</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>(i)</td>
<td>Deflowering.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>(j)</td>
<td>Removal of neck tie.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>(k)</td>
<td>Borer control (every four months)</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>(l)</td>
<td>Leaf spot control by spray application (twelve cycles per year).</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>(m)</td>
<td>Nematode control (every four months).</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>(n)</td>
<td>Determine level of borer infestation before treatment.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>(o)</td>
<td>Trenching or draining (20 - 30 chains per acre).</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>(p)</td>
<td>Weed control.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>(q)</td>
<td>Providing of props to prevent toppling.</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>(r)</td>
<td>Recording of amounts and price of materials and labor used in production.</td>
<td>YES</td>
<td>NO</td>
</tr>
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</table>
We would like to get your opinion on the role or importance of the factors (certain things) listed below in the cultivation of bananas. We would like to have your honest opinion about these matters as they relate to banana production. Your answer could either be (1) strongly disagree; (2) disagree; (3) neutral; (4) agree; (5) strongly agree. Please check one only.

(20) EXTENSION

(a) Agricultural officers have conducted several useful demonstrations on important aspects of banana production. 1 2 3 4 5

(b) Agricultural officers (extension agents) have not been making regular visits to farmers' holding. 1 2 3 4 5

(c) Agricultural officers are the most important source of information on banana production. 1 2 3 4 5

(d) Farmers can produce bananas successfully without the help or advice from agricultural officers. 1 2 3 4 5

(21) TECHNOLOGY

(a) Farmers will produce greater amount (more) of good quality fruits if they rely on their own experience and use the old fashion (traditional ways) methods. 1 2 3 4 5
(21) SD D N A SA
(check one only)

(b) If farmers fail to use the recommended practices (new way), they will not be able to produce large quantities of good quality fruits.

1 2 3 4 5

(c) The method (way) recommended by the agricultural officer (extension officer) is too complex (hard to follow).

1 2 3 4 5

(d) The recommended practices (new way or method) require too much money and effort from farmers.

1 2 3 4 5

(e) Only farmers with a high level of education can make use of the recommended practices (new ways) of producing bananas.

1 2 3 4 5

(22) CREDIT

(a) Most farmers are poor so they should be provided with loans to produce bananas.

1 2 3 4 5

(b) The interest rate charged on loans is too high.

1 2 3 4 5

(c) Providing loans to farmers is very important because it allows those farmers with little or no money to get started in banana production so they can earn a living.

1 2 3 4 5

(d) It is very difficult for some farmers to access (credit or get a loan) credit.

1 2 3 4 5
(22) The credit policy of the banks should be adjusted so that farmers will be able to use the value of crops they produce as the major form of collateral to secure loans.

(check one only)

<table>
<thead>
<tr>
<th></th>
<th>SD</th>
<th>D</th>
<th>N</th>
<th>A</th>
<th>SA</th>
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<td>5</td>
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</tbody>
</table>

(23) PRICE

(a) The price paid for banana is reasonable.

(b) The price paid for banana is too low.

(c) A good price is the best incentive for producing bananas.

(d) Most farmers are satisfied with the current price being paid for bananas.

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</table>

(24) EDUCATION

(a) A farmer must be able to read, count, or write well (literate) if he is to be a good (banana) farmer.

(b) There are many farmers who are unable to read, write, or count but they are still able to produce (bananas) very well.

(c) Education (count, read, and write) is only important for those people who work in offices.

(d) A farmer who does not read, write, or count well will not be able to follow or apply the practices recommended by agricultural officers or BECO.

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<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
(e) Every effort should be made to improve the educational level of farmers because this will cause them to be better banana farmers.

(f) It is not possible to be a successful farmer in these modern days if you are not able to count, read, and write very well (educated).
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<tr>
<th>Variable</th>
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<th>Mean</th>
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<td>x2</td>
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<td>x3</td>
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<td>x16</td>
<td>114</td>
<td>8.23</td>
<td>1.46</td>
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x1 = Age; x2 = Years of schooling; x3 = Size of banana farm (portion of farm under banana cultivation); x4 = Hours of hired labor; x5 = Technology use; x6 = Production of export quality fruit; x7 = Number of extension visits; x8 = Farmers' opinion of improvements needed to roads, water supply and transportation; x9 = Farmers' opinion concerning provision of more credit; x10 = Farmers' opinion concerning reduction of number of extension officers; x11 = Farmers' opinion concerning the role or importance of education; x12 = Farmers' opinion concerning the role or importance of technology; x13 = Farmers' opinion concerning the role or importance of extension; x14 = Farmers' opinion on usefulness or complexity of recommended practices; x15 = Farmers' opinion on usefulness or complexity of recommended practices; x16 = Rejection rate; x17 = Rate of use of hired labor.
## APPENDIX D

### Percentage of Farmers Adopting Recommended Practices

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<tr>
<th>Practices</th>
<th>% of Farmers Adopting</th>
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<tr>
<td>Weed control</td>
<td>96.6</td>
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<tr>
<td>Providing props to prevent toppling</td>
<td>96.6</td>
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<tr>
<td>Pruning to parent plant, follower and peeper</td>
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<td>Pruning of leaves away from bunch to prevent scarring</td>
<td>86.6</td>
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<td>Debudding</td>
<td>84.0</td>
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<td>Nematode control (every four months)</td>
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<td>Borer control (every four months)</td>
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<tr>
<td>Fertilizer application</td>
<td>73.9</td>
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<tr>
<td>Removal of neck tie</td>
<td>70.6</td>
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<td>Split application of fertilizer (every three months)</td>
<td>58.8</td>
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<td>Trenching or draining (20-30 chains per acres)</td>
<td>58.5</td>
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<tr>
<td>Leaf spot control (spray application twelve cycles per year)</td>
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<td>Sleeving of bunch</td>
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<td>Caliperering of fingers and surveying of field to establish reaping date</td>
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<tr>
<td>Deflowering</td>
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<td>Recording amounts and price of materials and labor used in production</td>
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<tr>
<td>Recording number of bunches reaped</td>
<td>14.4</td>
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<tr>
<td>Recording number of bunches actually sold to boxing plants</td>
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<tr>
<td>Keeping records of quality rating</td>
<td>12.7</td>
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<tr>
<td>Determining level of borer infestation before treatment</td>
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<tr>
<td>Soil testing to determine fertilizer requirement before application</td>
<td>5.9</td>
</tr>
</tbody>
</table>
VITA

Terrence W. Thomas is Jamaican, born at Lluidasvale St. Catherine, Jamaica.

EDUCATION:

1963-1965  Knockalva Agricultural School
1967-1970  Diploma, Jamaica School of Agriculture
1971-1974  B.S., Agriculture, Option: Animal Science
           University of the West Indies, St. Augustine
           Trinidad and Tobago
1989-1981  M.S., Continuing and Vocational Education
           University of Wisconsin-Madison
1987-1989  Graduate student - School of Vocational and
           International Education
           Louisiana State University, Baton Rouge, La.

WORKING EXPERIENCE:

1970-1971  Science Teacher, Crescent Allage School,
           Demonstrator, Jamaica School of Agriculture
June 1974-
           September 1974  Assistant Lecturer (Animal Nutrition),
                        Jamaica School of Agriculture
September 1974-
           December 1981  Vice Principal, Knockalva Agricultural School
1982-1985  Principal, Knockalva Agricultural School
1985-1986  Acting Dean, College of Agriculture
           Passely Gardens, Portlan
1986-1987  Project Coordinator, Jamaica Agricultural
           Education Project - Ministry of Education
Candidate: Terrence W. Thomas

Major Field: Vocational Education

Title of Dissertation: Factors Associated with the Production of Export Quality Fruit by Small Banana Farmers of the Rio Grande Valley, Portland, Jamaica

Approved:

[Signatures]

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

[Signatures]

Date of Examination: