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Adoption behaviour of private cocoa farmers in Trinidad and Tobago

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Black pod disease, (*Phytophthora palmivora*) causes as much as 70% losses on cocoa holdings in Trinidad and Tobago. A package of control practices has been recommended for its control for a long time. Evidence has shown that many farmers have not adopted the package although they still experience severe losses. This study investigated the technological and farming system variables that have affected the adoption of this control package. A survey was conducted with a sample of 140 farmers drawn from a population of approximately 6000 cocoa farmers by stratified random sampling. Multiple regression analysis was used to determine the significance of the factors influencing adoption levels. The results showed that no farmer adopted the entire package and selective adoption at varying levels was dominant. The technological variables were by far more important explanatory variables of adoption levels than farming system variables. Perceived riskiness was the most important explanatory variable generally explaining over 60% of the variation in adoption levels.

Keywords: Adoption behaviour; Cocoa farmers; Technological adoption; Technological variables; Trinidad and Tobago

This study looks at the adoption behaviour of small cocoa farmers in the eastern and central counties of Trinidad, the major cocoa producing areas of Trinidad and Tobago.

Adoption of technological innovations in agriculture has for many years attracted considerable attention among development economists. This is because the majority of the populations of Less Developed Countries (LDCs) derive their livelihood from agricultural production and new technologies seem to offer opportunities to increase production and productivity (Feder *et al.*, 1985). The analytical framework on adoption behaviour of the study was as follows:

Analytical Framework

The package approach

In efforts to increase agricultural productivity, researchers and extensionists in developing countries have typically promoted a technological package consisting of a number of components such as improved crop varieties, fertilizers, new planting methods, and weed control. Walker (1981) reported that a package is necessary to capture the positive interactions between several components. A package may also be convincing by emphasizing the large yield differences between traditional and improved practices.

Selective and(or) stepwise adoption

Farmers tend to selectively adopt components of a package in a stepwise fashion based on various factors. Ryan and Subrahmanyam (1975) in studies in India, showed limited adoption of complete packages but high levels of adoption of selective components, with the elements initially adopted showing the highest return on capital expenditure. Mann (1978) cited by Merrill-Sands (1986) after studying Turkish wheat farmers' selective and sequential adoption of components of a recommended package of practices, concluded that farmers adopt practices in an agronomically and economically logical sequence. Mann (1978) suggested that packages of improved technologies can be broken down into clusters of practices which can be adopted in a stepwise fashion in accordance with farm-

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ers' resources and experiences with the technology. Byerlee and Hesse de Polanco (1982), Horton (1984), and Tripp *et al.* (1986) demonstrated that packages can usually be disaggregated into subsets or clusters of one or two components which allow critical interactions to be exploited and which enable adoption to follow a stepwise pattern. They showed that elements initially adopted are those that provide the highest return on capital expenditure.

Variables affecting the adoption of technology

Farming system variables

Many studies have analysed patterns of adoption in terms of different socio-economic characteristics of farmers. According to Rogers (1983) these characteristics (referred to as the farming system variables in this study) are significant in explaining adoption behaviour, only at the knowledge stage in the innovation–decision process model.

Adoption studies done locally and regionally (Matura, 1973; Andrews, 1975; Ramjohn, 1975; Barker, 1981; Clarke, 1985) have examined the socio-economic characteristics of farmers and neglected the characteristics of the technologies themselves. Typical farming systems variables investigated have been (a) Personal characteristics of the farmer; (b) Farm-related characteristics; (c) Situational factors; and (d) Communicational factors.

Technological variables

Rogers (1983) stated that the perceived characteristics of the technology are the key determinants of adoption behaviour at the persuasion stage in the innovation–decision process model. Rogers (1983) found that between 49 and 87% of the variance in the rate of adoption was explained by the perceived attributes of the innovation. Byerlee *et al.* (1986) related the adoption of technological components to the characteristics of the technological components, and demonstrated that farmers followed a stepwise approach to the adoption of a technological package that depends upon the characteristics of each component and the interaction among them. The characteristics of the technological variables that are typically studied are: profitability, riskiness, divisibility, complexity, and availability of necessary inputs.

Interaction effects

Adoption studies, e.g., Byerlee and Hesse de Polanco (1982) have analysed the relationship between individual variables and adoption behaviour, but have generally ignored possible interaction effects among variables which can occur. This study therefore investigated these interaction effects.

Statement of the Problem

Over 85% of the cocoa farmers in Trinidad and Tobago are small farmers with farms less than five hectares, producing an average of 100 kg ha^{-1}, using mainly traditional farming practices. This study examined the adoption behaviour among these cocoa farmers in response to a technological package, introduced more than five years ago, for the control of black pod disease.

Black pod disease, caused by the fungus *Phytophthora palmivora* is considered the most important cocoa disease throughout the world. Lass (1984) estimated that this disease accounts for losses between 20 and 30% of cocoa pods or 300 000–450 000 t of cocoa annually. In Costa Rica and Mexico, the annual crop loss is between 45 and 90%, respectively (Lass, 1984). In Trinidad and Tobago, losses can be in excess of 70% annually (Griffith, 1987). After numerous years of research on black pod disease control in Trinidad, in 1986 the Cocoa Research Unit of the Central Experimental Station, concluded that the most economical means of controlling this disease is with an integrated approach to control (Persad, 1986). The recommended package of practices consists of 10 components (a) Use of fungicides; (b) Frequent harvesting and removal of diseased pods; (c) Frequent pruning; (d) Use of varieties tolerant to black pod disease; (e) Adequate drainage; (f) Adequate weed control; (g) Reduction of overhead shade; (h) Use of closer spacing to reduce weed growth; (i) Use of fertilizers to increase yield; and (j) Use of insecticides.

Extension officers of the Ministry of Agriculture have since conducted numerous educational programmes in the control of black pod disease based on this package. A series of rapid reconnaisance surveys conducted in 1987–88 revealed, however, that most farmers do not practice many of the control measures listed above and are still experiencing severe losses due to the disease (Dolly, 1988; Dolly and Young, 1990a, b, 1991a, b, c).

In an effort to reduce cost, the current practice carried out by most cocoa farmers is one of minimum maintenance. Most farmers carry out manual weed control (cutlassing) at least twice per year. Trees are pruned soon after the final harvest at March–April each year. Drains are cleaned or re-done in the dry season. Farmers are very reluctant to use chemicals in their fields and, hence, very little fungicides are used in disease control. Even in cases where farmers own mist-blowers, fungicide use is restricted to the other crops such as citrus, which may or may not be intercropped with cocoa. Research has shown that fertilizer uptake is minimal in fields with heavy overhead shade, and farmers therefore do not use fertilizers. Harvesting and removal of diseased pods are combined in one operation. However, farmers do not dispose of the diseased pods. They remain in the field as a source of re-infection.

Objectives and Hypotheses

The innovation–decision process model of Rogers (1983) and the methodology of Byerlee and Hesse de Polanco (1982) were used to:

(1) investigate the adoption pattern of the recommended package for black pod control;
(2) determine the relationships between: (a) technological variables and levels of adoption of the package; (b) technological variables and levels of adoption of components of the recommended package; and (c) farming system variables and levels of adoption of components of the recommended package; and
(3) determine whether technological variables are more important in determining adoption levels than farming system variables.

Empirical Procedures

Adoption scores

Since researchers have found that farmers tend to selectively adopt components of a package in a stepwise fashion, it is conceivable that one would find a continuum between non-adoption and full adoption, e.g., none (0%), low (≤34%), medium (≤68%), and high (≤100%).

The association between levels of adoption of the technological package and the variables under study, was found by developing an adoption index for each component of the recommended package and for the recommended package itself. These adoption indices for the components were determined in consultation with the cocoa agronomist at the Cocoa Research Unit, The University of the West Indies (UWI). For the index of adoption of the package, a score of 4 points was given for full adoption of each component of the package, and partial scores of between 1 and 3 were awarded for partial adoption. A maximum of 40 points was therefore awarded for full adoption of the overall package, and between 1 and 39 points for partial adoption of the overall package.

The survey

A survey by personal interview was conducted among 140 cocoa farmers. This survey was conducted in 1990 in the major cocoa growing areas in north–east and Central Trinidad. The districts were Cumuto, Guiaco/Tamana, Matura, and Manzanilla in County St Andrew/St David; and Brasso, Tabaquite, and Gran Couva in County Caroni. In the absence of adequate record keeping, reliance was placed on the farmers' power of recall.

The technological variables investigated were: perceived profitability, riskiness, complexity, divisibility, and availability of necessary inputs.

The farming system variables investigated were:

(1) Personal variables—gender, farming status, time spent on farm, household size, age of farmer, education, and farming experience;
(2) Farm-related variables—farm size, tenancy, major enterprises, age of cocoa trees, and accessibility of farm;
(3) Situational variables—average yield of cocoa, percentage pod loss, record keeping practices, ownership of equipment, knowledge of causes of the disease, grade of cocoa beans sold, attitude to credit, and major sources of labour; and
(4) Communicational variables—farmer knowledge of extension officer.

Statistical analysis

The following statistical analyses were conducted using multiple regression techniques with the actual adoption points scored by each farmer:

(1) Stepwise regression—to determine the relationships between technological and farming system variables (as the independent variables) and adoption levels of the components and the overall package (as dependent variables). In this procedure, independent variables were selected in order of correlation with the dependent variable, with the variable showing the highest correlation being selected first. This correlation was measured by the R^2, so that the stepwise analysis allowed a determination of the contribution to R^2 (per cent of total variation explained) of each independent variable when added to the regression equation. In the special case of qualitative technological and farming system variables, dummy variables were used. These were: gender, farming status, education, tenancy, major enterprise, knowledge of causes of the disease, grade of cocoa beans, attitude to credit, and major sources of labour.
(2) Interaction tests—stepwise regression was used to determine significant interaction effects between the technological variables, farming system variables, and adoption levels of the components and the overall package.

Results and Discussion

Adoption levels

The vast majority of respondents were found to be non-adopters of the fungicide (87.8%), close spacing (84.2%), fertilizer (78.4%), and insecticide (79.9%) practices (Table 1). In general, the practices, which require major capital outlay were all found to be low-adoption components.

In contrast, the majority of farmers were high adopters of the frequent harvesting (87.8%), pruning (92.8%), and the shade reduction (76.3%) practices. These are generally low-cost practices which can also be considered traditional among most farmers.

Adoption levels were fairly evenly distributed among the other practices. The majority (77.7%) of the respondents were medium adopters of the overall package. The results therefore showed that farmers were selective in

Table 1 Adoption pattern of the overall package and its individual components for black pod control in cocoa (Trinidad and Tobago)

Components	% of Farmers				Mean adoption score	Mean adoption level
	Non-adoption	Low adoption	Medium adoption	High adoption		
Fungicide	87.5	—	2.2	10.1	10.07	Low
Harvesting	—	—	12.2	87.8	88.67	High
Pruning	1.4	—	5.8	92.8	95.50	High
Spacing	84.2	14.4	0.7	0.7	4.50	Low
Shade	22.3	—	1.4	76.3	76.98	Medium
Drainage	0.7	51.1	2.2	46.0	55.58	Medium
Fertilizer	78.4	0.7	2.9	18.0	17.09	Low
Weedicide	56.8	—	25.9	17.3	30.22	Low
Variety	9.4	—	41.7	48.9	57.91	Medium
Insecticide	79.9	—	3.6	16.5	16.19	Low
Overall package	—	19.4	77.7	2.9	45.27	Medium

the adoption of components of the overall package. This supports the work done by Ryan and Subrahmanyam (1975), Mann (1978), Horton (1984), and Byerlee and Hesse de Polanco (1982).

The farming system variables

Most of the farming systems variables did not significantly affect levels of adoption of the components and the overall package when analysed together with the technological variables. The highest percentage variance (4.34%) explained by a farming system variable was major labour source, in explaining close spacing adoption levels (Table 2).

The following variables were not found to be significant in every case in influencing adoption levels:

(1) Personal variables—gender, farming status, age of farmer, and farming experience;
(2) Farm-related variables—farm size; and
(3) Situational variables—average yield of cocoa, record-keeping practices, ownership of equipment, knowledge of causes of the disease, and grade of cocoa beans.

Table 2 Distribution of R^2 values from the stepwise regression showing the significant variables in determining adoption levels of the overall package and its components (%)[1]

Variables	1	2	3	4	5	6	7	8	9	10	11
Technological											
Riskiness	64.10	87.85	8.47	86.48	65.63	63.60	69.74	87.27	—	69.03	94.01
Profitability	—	0.59	7.23	—	—	6.79	6.86	6.64	50.67	12.57	—
Complexity	2.18	—	13.17	—	—	—	—	—	—	—	—
Availability	1.15 (Labour)	0.71 (Water)	—	—	1.45 (Trans.)	—	0.68 (Weedicide)	—	1.55 (Trans.)	0.52 (Labour)	—
Divisibility	—	—	11.04	—	—	—	—	—	—	3.15	—
Sub-total	67.43	89.15	39.91	86.48	67.08	70.39	77.28	93.91	52.22	85.27	94.01
Farming system											
Household size	—	—	—	0.40	—	—	—	—	—	—	—
Age of trees	1.03	—	—	—	1.03	—	—	—	—	—	—
Pod loss	—	—	—	0.41	—	—	—	—	—	—	—
Farm time	—	0.50	—	—	—	—	—	—	—	—	—
Education[2]	—	—	—	—	—	—	—	—	2.31	—	—
Tenancy[2]	—	—	—	—	2.46	—	—	—	—	—	—
Major enterprise[2]	—	—	—	—	—	—	—	—	—	—	0.31
Labour source[2]	—	—	—	—	—	—	—	—	4.34	—	—
Credit[2]	—	—	—	0.46	—	—	—	—	—	—	—
Accessibility[2]	—	—	—	—	—	—	—	—	—	1.74	0.27
Know. ext officer[2]	—	—	—	0.36	—	—	—	—	—	—	—
Sub-total	1.03	0.50	—	1.63	3.49	—	—	—	6.65	1.74	0.58
Total	68.46	89.65	39.91	88.11	70.57	70.39	77.28	93.91	58.87	87.01	94.59

[1]Variables which were not significant in determining adoption levels in any of the regression analyses are omitted from the Table
[2]Dummy variables
1, Overall; 2, Fungicide; 3, Harvesting; 4, Pruning; 5, Variety; 6, Drainage; 7, Weedicide; 8, Shade; 9, Spacing; 10, Fertilizer; 11, Insecticide

The technological variables

When multiple regression was carried out with all the independent variables, the technological characteristics accounted for most of the variations in adoption levels (Table 3). For example, in the fungicide component, of the 89.65% of the variation explained by the independent variables under study, the technological variables accounted for 89.15%. Among the technological characteristics, perceived riskiness was by far the most significant variable in explaining total variations in the levels of adoption of almost all the recommended practices of the package.

Contrary to expectations, perceived profitability explained very small percentages of the variations in adoption levels of most components when compared to perceived riskiness [except in the close spacing component (50.67%)]. The perceived riskiness of fungicide use alone accounted for 87.5% of the variation in explaining fungicide adoption levels, while only 0.6% of the total variation was explained by perceived profitability.

In general, irrespective of level of perceived profitability of most practices, the perceived riskiness accounted for a significantly greater percentage variation in their levels of adoption. The only exception was the close spacing practice where 50.67% of the total variation was explained by perceived profitability. This is supported by the fact that adoption of this practice requires a change from the traditional intercropping system of cocoa with bananas and citrus, which provides supplementary income, to one of pure-stand cocoa only.

Since the majority of respondents were full-time farmers, with less than five hectares of cocoa, it can be concluded that the probable risk involved in adopting a practice is more critical to the success of their farms and, by extension, their livelihood, than the returns to be generated. This is supported by Walker (1981) who concluded that poor farmers in developing countries are associated with a reluctance to take risks, presumably because risk-taking would jeopardize their subsistence and low-income farmers will not change their more stable, lower-return traditional techniques for riskier, more profitable practices and varieties. Byerlee *et al.* (1982) also found riskiness to be a major determinant of adoption, because adoption would be slower if it increases risk.

The perceived complexity, divisibility, and the availability of inputs were also found to be significant explanatory variables in determining adoption levels of many of the components. Their contributions to explaining the total variations were, however, quite small when compared to perceived riskiness and profitability (Table 2). Together, all technological variables accounted for 39.91–94.01% of the total variations in adoption levels of the 10 components of the package and 67.43% of the overall package (Table 2).

Interaction effects

Several farming system variables were insignificant in determining adoption levels (Table 2). However, when interaction tests were conducted, most of these variables showed significant interaction effects with technological variables, with respect to the adoption of components of the technological package, but not with respect to the adoption of the overall package. Those variables, showing such interactions are given in Table 3. For example, in explaining the adoption of the fungicide component, level of education showed significant interaction with several variables such as riskiness, water availability, and farm time, while it was not significant in the stepwise regression in

Table 3 Technological and farming system variables showing significant interaction in determining landscape levels of adoption of the components of the package[1]

Variables	Riskiness	Profitability	Availability[2]	Household size	% Pod loss	Farm time
Divisibility	F, D, Fe	F, D, S	Fe	—	—	F
Mist-blower	F	F	—	—	—	F
Sprayer	W	W	W	—	—	—
Farming status	F, D	D	F	—	—	—
Education	F	S	F, S	—	—	F
Tenancy	F, W, Fe	W, S, Fe	F, S, Fe	—	—	—
Major enterprise	F, P, I	S	S	P	P	F
Labour source	F	F, S	F, S	—	—	F
Credit	F, P	—	F	P	P	F
Awareness	P, Fe	—	Fe	P	P	—
Accessibility	F, P, Fe, I	F, S, Fe	F, S, Fe	P	P	F
Age of trees	V	—	V	—	—	—
Know. ext officer	P	—	—	P	P	—

[1]A letter code indicates interaction between the row variable and the column variable with respect to explaining variation in the adoption of the package components given by the following codes:
F = Fungicide; S = Spacing; D = Drainage; P = Pruning; Fe = Fertilizer; W = Weedicide; and I = Insecticide
[2]Availability with respect to (1) Fungicide = availability of water; (2) Variety = availability of transportation; (3) Weedicide = availability of weedicides; (4) Spacing = availability of transportation; and (5) Fertilizer = availability of labour

Table 2. Similarly, major farm enterprise showed significant interaction with other variables (Table 3) in determining the adoption of fungicide, pruning, insecticide, and spacing, while it showed no significance in the regressions except with respect to insecticide adoption in Table 2.

Implications of the Findings

The results of this study highlighted several important issues, which must be taken into consideration by extension research, and policy personnel in Trinidad and Tobago.

Extension

(1) The farmers' perceptions of the technology are much more important in determining the adoption of new technologies than the characteristics of the farmer themselves. Extension personnel must therefore be aware of these perceptions, before attempting to introduce new technologies. This can be determined by a simple survey among the target group of farmers prior to introduction of the technology.

(2) The interaction effects among variables in influencing adoption as demonstrated in this study should be borne in mind at all times by extension personnel.

Research

(1) Since the perceived riskiness of the technology is by far the most significant determinant of adoption among cocoa farmers, research personnel must ensure that the technology is thoroughly researched, replicated, and demonstrated among farmers preferably through on-farm trials. This could serve to reduce the fears of the farmers, encourage positive perceptions about riskiness, and motivate them to at least try the technology on a limited scale.

(2) The interactive effects of the technological package have not been sufficiently demonstrated to the farmers. Collaboration of researchers with extension personnel and farmers in on-farm trials can have a good demonstration impact.

Policy

Incentives in the form of reduced or controlled prices of inputs or additional price support payments are policy options that may assist farmers to overcome the fear of adoption of new or unfamiliar risky technologies or practices requiring significant outlay of capital.

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