An Economic Analysis on the Adoption of Integrated Pest Management Techniques by Coconut Growers in Sri Lanka

K.H.M.E. ILLIPANGAMUWA and J.M.U.K. JAYASINGHE

Department of Agribusiness Management, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP).

ABSTRACT

This study examines the factors influencing the adoption of Integrated Pest Management (IPM) techniques by coconut growers in Sri Lanka based on their willingness to adopt such advanced techniques. Their willingness to adopt was characterized on a scale of "five different adopter categories" ranging from "Innovators" to "Laggards".

The primary data collected using a questionnaire-based survey with a sample of 127 coconut growers in selected areas in the Kurunegala district were analyzed using Ordered Logistic Regression techniques, in which five-ordered variables were set to reflect their level of willingness. The results suggest that factors such as farmer exposure to extension media, income earned from coconut cultivation, and hired labor used for supervisory works where the owner was not presence in their estates increase the probability of switching a farmer from the category of "laggards" to "innovators". Further, the results indicate that the probability of adoption of IPM by these farmers was affected significantly by the human capital like higher education, risk averseness of farmers and other physical factors such as cost of labor, practicing intercropping, large size of the land. Logistic regression analysis used to compare the non adopters and laggards. The results suggest that probability of adoption by non adopters was affected significantly by the risk averseness and income of coconut cultivation promoted the adoption of IPM.

The results highlight the need of an effective extension program that understands this varying behavior of farmers and the associated factors.

KEYWORDS: Adoption, Agricultural Extension, Coconut Growers, Innovation, Integrated Pest Management.

INTRODUCTION

Sri Lanka is a fourth largest coconut (*Cocos nucifera L.*) producing country of the world. The value of coconut to the people in Sri Lanka is boundless due to its food value and the ability to provide various types of raw materials for industries. Coconut also plays an important role in the economy of the country in respect of 3.4 percent of foreign exchange earning, 500,000 of direct and indirect job opportunities in production, processing and marketing sectors (Liyanage, 1999).

But the national coconut production has remained stagnant at around 2500 million nuts during past several decades. If this trend continues, it is very likely that domestic demand fresh coconuts would outstrip supply in the near future (Liyanage, 1999). One of major constraints in the coconut sector at present is poor adoption of protection technologies that has largely contributed to the low productivity (Liyanage, 1999). Coconut production dropped marginally by 0.2 percent in 2004, following a 7 percent increase in 2003 (Central Bank Report, 2004). An economic loss of production of 10-13 percent occurred due to the pest attacks (Peiris *et al.*, 2003). In this current scenario, managing pests have become a serious problem for many decades. At a magnitude of control effectively, economically, and in a sustainable manner is itself a challenging exercise in developing countries like Sri Lanka due to Socio-economic factors of coconut grower, nature of pest and crop biology, factors of pest control measures. Considering above factors it is strongly felt that pests should be managed by an integrated pest management (IPM) program (Fernando, 2004).

Integrated pest management is essentially a system of management of pest population utilizing all suitable techniques (such as cultural, chemical, and biological) harmoniously and blending them in a compatible manner so as to minimize the pest population to levels below those causing economic injury. In order to manage the pests effectively, farmers must be aware of the pests' biology, use of pest control measures, etc. This can be achieved by providing community level programs. So that management of the pests can be done in a federal approach (Brian, 2002).

Although Coconut Research Institute (CRI) and Coconut Cultivation Board (CCB) have been implementing various programs and extension practitioners, lack of adequate information on farmers' perception about pest control measures lead to meet partial success. A comparative understanding of the growers' socio-economic, demographic and communication behavior on adoption of IPM technology is necessary to design appropriate strategies to harness their potential benefits in target domains. Reisenberg and Gor (1989) found that knowing farmers preferences for receiving information would help program planners to transfer information about innovative farming practices more effectively. In order to be an effective channel for the diffusion of information, extension agents must be aware of their clients' innovativeness.

This study examines the socio economic and communication factors influencing adoption of IPM techniques by the coconut growers based on their willingness to adoption in selected CDO divisions of Kurunegala district.

METHODS

In this section, the methods used to examine the influence of socio-economic, physical and communication factors on different adopter categories of growers.

Conceptual Framework

A new technology will likely be adopted if its perceived value is higher than the perceived value of the old technology. Choice model developed in consumer theory have been used to motivate adoption decision models (McFadden, 1974). In this study, coconut growers are assumed to make their decisions by choosing the alternative that maximizes their perceived utility. Thus the i[th] grower will adopt IPM if the utility of adopting, U_{i1} is larger than the utility of not adopting, U_{i0}. Because there are errors in optimization and perception, the utility function is assumed to be random (McFadden, 1974).

Thus, $U_{ij} = V_{ij} + e_{ij}, j = 1, 0$ (1)

Where, Vij is a function of profits. (Which generally depend on a vector of choice characteristics, a vector of individual grower attributes) e_{ij} is random disturbance that accounts for unobserved variations in preferences and errors in perception and optimization. The probability of adoption is then,

$P_{i1} = P(U_{i1} > U_{i0}) = P(V_{i1} . V_{i0} > e_{i0} - e_{i1})$ (2)

Assuming that the stochastic components e_{i1} and e_{i0} are independently and identically distributed with a Weibull distribution, and then their difference follows a logistic distribution (Maddala, 1983).Thus the adopt ion decision may be analyzed using a logit model. Because to study the adoption behavior, limited dependent variable model provide a good framework. Due to the limitations in the data, it is often assumed that choice probabilities only depend on observed individual-specific characteristics (Judge *et al.*, 1983). In this case, taking a first-order Taylor series expansion of the functions V_{ij} in the parameters β, the log of relative odds of adopting IPM are:

$L_i = \ln (P_{i1} / P_{i0}) = \beta$ (3)

Where the parameter vector β is alternative-specific. For continuous variables, the change in the probability of adoption relative to the k[th] individual attribute is just the derivative of P_i with respect to Z_{ik}. In the discrete case, the change in probability attributable to the k[th] variable or attribute is equal to the difference in probability.

$P_i (Z_{ik} = 1) - P_i (Z_{ik} = 0)$ (4)

(Putler and Zilbeman, 1988)

In this study, logit models were estimated using the Maximum Likelihood (ML) method to analyze factors affect on different IPM adopter categories of farmers.

Estimation of Adopter Categories

Growers' willingness to adopt was characterized on a scale of five different adopter categories ranging from innovators to laggards based on their innovativeness. Innovativeness is the degree to which an individual is relatively earlier in adopting new ideas than other members of his social system (Rogers and Shoemaker, 1971). The Individual Innovativeness theory (Rogers, 1995) states individuals who are predisposed to being innovative will adopt an innovation earlier than those who are less predisposed. Figure 1 shows the bell shaped distribution of individual innovativeness and the percentage of potential adapters theorized to fall into each category. The five categories of adopters based upon innovativeness: laggards, late and early majority adopters, early adopters, and innovators. (Figure 1) On one extreme of the distribution are the Innovators. Innovators are the risk takers and pioneers who adopt an innovation very early in the diffusion process. On the other extreme are the Laggards who resist adopting an innovation until rather late in the diffusion process (Daniel, 1997).

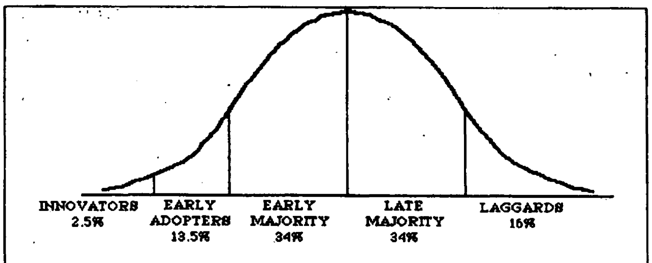

Figure 1. Bell shaped curve showing categories of individual innovativeness and percentages within each category

Figure 1. Different categories of adoption
Source: Daniel, 1997.

Assessment of Factors Influence on Different Adopter Categories (Empirical Model 1)

Ordered logistic regression analysis was used to determine the factors affect on switching a farmer from laggards to innovators (Model 1). Following specification empirical model was applied:

$$D_i = \beta_0 + \beta_1 * LAS_1 + \beta_2 * LAS_2 + \beta_3 * WTH + \beta_4 * MTM + \beta_5 * ITC + \beta_6 * LBC + \beta_7 * CNI + \beta_8 * SUB + \beta_9 * EDU_1 + \beta_{10} * EDU_2 + \beta_{11} * RSK + \beta_{12} * EXT + \varepsilon_i \quad (5)$$

Where D_i is the decision variable that describes the level of IPM techniques adopted by coconut grower i. In an attempt to identify the factors that maximize the decision maker's utility with respect to IPM adoption are demonstrated in Table1, and εi is the error term.

Comparison of Laggards and Non Adopters (Empirical Model 2)

Logistic regression model was run to estimate the factors that influence on switching a farmer from category of non adaptors to laggards who are the poorest adopters (Model 2).

$$Yi = \beta_0 + \beta_1 * LAS_1 + \beta_2 * LAS_2 + \beta_3 * WTH + \beta_4 * MTM + \beta_5 * ITC + \beta_6 * LBC + \beta_7 * CNI + \beta_8 * SUB + \beta_9 * EDU_1 + \beta_{10} * EDU_2 + \beta_{11} * RSK + \beta_{12} * EXT + \varepsilon_i \ (6)$$

Where, Yi = 1; if grower being a Laggards.
Yi = 0; if grower not being a laggards.

The study was hypothesized that the grower's adoption behavior on IPM associated with vis-à-vis socio-economic, farm factors, and communication characteristics used in model 1 and model 2 as Demonstrated in Table 1.

Table 1 . Variables defined in the empirical models

Symbol	Corresponding Variable	Remarks
D_i	Ordered variables derived from time taken to begin IPM techniques	Di =1 to 5
Farm structure	Dummy variables	
LAS_1	Land size(10-40 Ac)	LAS_1=1;otherwise=0
LAS_2	Land size(>40Ac)	LAS_2=1; otherwise=0
WTH	Hired labor for supervisory work.	WTH=1 ; otherwise=0
MTM	Managerial time	MTM=1;fulltime farming; Otherwise=0
ITC	Intercropping	ITC=1: intercropping; otherwise=0
Socio-economic factors	Continuous variables	
LBC	Labor cost(Rs/Ac/Yr)	
CNI	Income from coconut(Rs/Ac/Yr)	
	Dummy variables	
SUB	Preference to take subsidies	SUB=1; otherwise=0
EDU_1	O/L – A/L Education level	EDU_1=1;otherwise=0
EDU_2	>A/L Education level	EDU_2=1;otherwise=0
RSK	Preference to take crop insurance(Risk)	RSK=1;otherwise=0
Communication factors		
EXT	Exposure to extension	Continuous variable

Predicted Probabilities for Independent Variables

The log odds of *P* (*i.e.*, the logit before the change in the independent variable) were calculated. The logistic regression coefficient for the variable to the starting logit was added and the probability for this new logit was calculated. Then the starting probability (at *X*) was subtracted from the second probability (at *X*+1) shows the effect of a one-unit change in *X* on the predicted probability at *P* (Borooah, 2002).

Data Collection

The data for this study were collected from 127 farmers selected from four CDO (Coconut Development Officer) Divisions of Kurunegala District during April-May by using a pre-tested questionnaire. The questionnaire was pre-tested with 10 farm operators selected from the population prior to selection of the initial sample. Based upon their responses the questionnaire was modified.

A stratified sampling technique was used to draw the sample into strata based on the land holding size and each stratum is a mutually exclusive set of lands. Farmers were randomly selected from each stratum. With respect to IPM technique, each interviewed farmer was asked about pest control practices that have already been applied and going to be applied such as use of chemicals, cultural practices, bio chemical or microbial agents (Ex: Pheromone) which are usually considered to be IPM Techniques.. In this study the use of any of these practices assumed the farmer as a user of IPM Technique. In addition to data were collected from farmers on farmer's socio-economic characteristics such as, education level, use of extension media such as CDO officer, mass media, printed materials, research institute, and farm structure such as land size, intercropping, managerial time, and risk perception such as financial risk.

RESULTS AND DISCUSSION

This study examines the distribution of adopter categories and different factors influence on different IPM categories of the study.

Estimation of Adopter Categories

Diffusion of adoption curve for instructional technology in a population has already been developed by Rogers (1962). It was consisted of five adopter categories such as 2.5 percent of innovators,13.5 percent of early adopters, 34 percent of early majority adopters, 34 percent of late majority adopters, and 15 percent of laggards (Figure 2). Results showed that the diffusion curve of IPM of the sample with the percentage of 14 of innovators, 20 percent of early adopters 21 percent of early majority, 23 percent of late majority and 21 percent of laggards (Figure 2). Furthermore, the results indicated that diffusion curve of sample was significantly deviated from the theoretical model. Percentage of innovators in the sample was greater than the percentage of innovators in the population. It may be due to responses of farmer who were willing to adopt the IPM. Percentages of early majority and late majority adopter of the sample were less than that of the theoretical curve categories respectively. Further, percentage of laggards of the sample was higher than the theoretical curve laggards (Figure 2). Because 21 percent of growers were willing to adopt any pest control practices after implementing more than half of the farmers in the area.

Assessment of the Factors Influence on Adoption of IPM techniques

Five ordered dependent variables (D = 1 to 5) were developed for the purpose of the ordered logistic analysis using lower level adopters and upper level adopters due to dichotomous nature of the dependent variable (Table 2). These five categories exemplify that, as else being equal, it is more that a grower included in a higher category is more willing to adopt IPM than a grower included in a lower category.

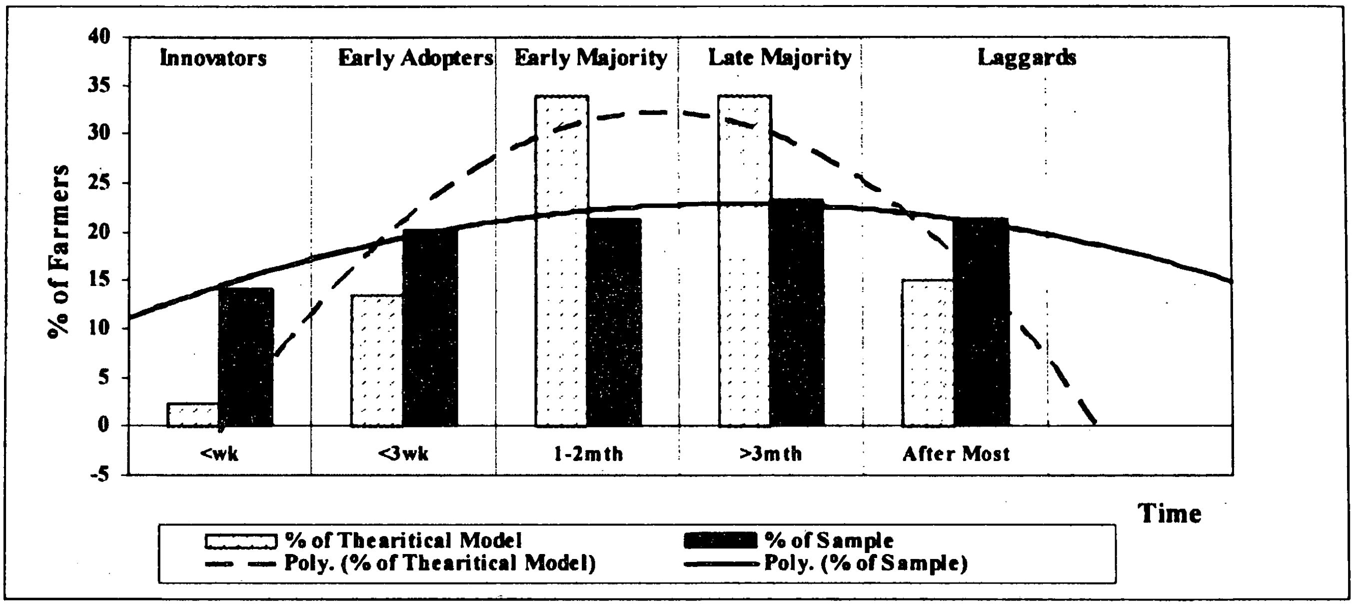

Figure 2. Different IPM adopter categories

Table 2 . Ordered dependent variables to represent Grower's willingness for adoption

Variable Name	Degree of Responsiveness	Number of Adapted Growers	Percentage
		(N=99)	(%)
D=1	Innovators	14	14.14
D=2	Early adopters	20	20.2
D=3	Early Majority	21	21.2
D=4	Late Majority	23	23.2
D=5	Laggards	21	21.2

Then socioeconomic factors, farm structure characters, and communication characters were included as explanatory variables in model 1. Result of ordered logistic regression shows the logg odds of each factors associated with adoption of switching a farmer from laggards to innovators (Table 3).

Table 3. Results of ordered logistic regression analysis (Model 1)

Parameter	Estimated Coefficient	Standard Error.	Significance
D=1	3.2625	1.7713	0.0655*
D=2	4.7837	1.8017	0.0079**
D=3	6.0836	1.8423	0.0010**
D=4	7.7347	1.9037	<.0001**
LAS1	-0.0622	0.4431	0.8884
LAS2	-1.6566	0.7481	0.0268**
WTH	0.896	0.4854	0.0649*
MTM	-0.1177	0.4236	0.7811
ITC	-1.0435	0.4364	0.0168**
LBC	-0.00004	0.00002	0.0334**
INC	8.19E-06	3.21E-06	0.0108
SUB	0.1402	0.4325	0.7458
EDU1	-0.7383	0.8361	0.3772
EDU2	-1.613	0.8045	0.0450**
RSK	-0.7411	0.4059	0.0679*
EXT	0.6741	0.1958	0.0006**

*Likelihood ratio: <0.0001. Note: ** and * denote respectively, statistical significance at 0.05 and 0.10 levels.*

The effects on logg odds were next transformed to the effects on instantaneous (marginal) probabilities[1] (Table 4). In the case of dummy variables, a change in one unit implicitly compares the indicator group to the reference or omitted group (Borooah, 2002).The outcome suggested that hired labor for supervisory work in estate where owner is not present in the estate significantly increased the probability of adoption, moving laggards to innovators by 21 percent. Due to the fact that Land size being in more than 40Ac category, the probability of adoption of IPM significantly reduced by 34 percent, when switching a grower from laggards to innovators (Table 3). It may be due to the practical difficulties to implement different pest control measures to large extent. Further, practicing intercropping significantly decreased the probability value of moving from laggards to innovator by 24 percent. It may due to growers have given their attention on short term income sources such as cultivation of Pineapple, Banana, Ginger, etc., than the coconut cultivation. Further grower who belongs to above A/L group and grower's risk averseness significantly decreased the probability of switching a grower from laggards to innovators by 33 and 18 percents respectively (Table 4). Because growers who belong to above advanced level education group were the part time farming growers and they have been engaging professional jobs.

The results highlighted that farmer's exposure to extension media and income of coconut cultivation, distinctly increased log odds of parameters by 0.00001 and 0.6741 respectively as moving a farmer from laggards to innovators. Furthermore, probability of adoption was significantly increased due to farmer

[1] Since the relationship between the independent variables and probabilities are non-linear and non-additive, they cannot be fully represented by a single coefficient. The effect on the probabilities has to be identified at a particular value or set of values. For the purpose of this analysis, 0.5 was taken as the started probability of the dependent variable (P) for all models.

exposure to extension and income of coconut cultivation by 16 percent and 0.02 percent respectively as switching a grower from laggards to innovators (Table 4). However, with respect to the labor cost, there was a significance decrease of logg odds by 0.0004, when switching from laggards to innovators of adoption where as the probability of adoption was reduced by 0.01 percent significantly.

Table 4. Instantaneous/Marginal probabilities (Partial Derivatives)

Parameter	Estimates of Model 1	Marginal Probabilities
D=1	3.26255	.
D=2	4.7837	.
D=3	6.0836	.
D=4	7.7347	.
LAS1	0.0622	-0.016
LAS2	1.6566	-0.34
WTH	0.896	0.21
MTM	0.1177	-0.03
ITC	-1.0435	-0.24
LBC	-0.0004	-0.0001
INC	8.19E-06	0.0002
SUB	0.1402	0.035
EDU1	-0.7383	-0.18
EDU2	-1.613	-0.334
RSK	-0.7411	-0.18
EXT	0.6741	0.16

Comparison of Laggards and Non Adaptors

Logistic regression model was run to estimate the factors that influence on switching from non adopters to laggards who are the poorest adopters. Logistic regression results showed that the model was significant at a level of 0.05.Further; the relatively lower likelihood ratio suggested that the models performed well (Table 5).

Table 5. Results of logistic regression analysis (Model 2):

Parameter	Estimate	Significance	Marginal Probabilities
Intercept	-0.6037 (0.6942)	0.3845	.
RSK	-2.5167 (0.9407)	0.0075**	-0.4253
INC	0.00008 (0.0004)	0.0316**	0.00002

*Likelihood ratio: <0.0001. Notes: ** denotes statistical significance at 0.05. Numbers in the parenthesis are standard errors.*

Results showed that only risk and income of coconut cultivation were significantly affected to the adoption. Further, preference to take risk showed negative log odds of switching non adopters to laggards and probability of adoption significantly reduced by 0.43.With the income earned from coconut cultivation, probability of adoption of switching from non adopter to laggards, increased by 0.00002 (Table 5).

CONCLUSIONS AND POLICY IMPLICATIONS

As stated by Rogers (1962), there has been estimated a curve for diffusion of adoption of an instructional technology. It consisted of five adopter categories such as innovators, early adopters, early majority, late majority and laggards in a particular population. Results of the study show that there is a significant deviation of the adoption curve of sample from the theoretical curve. The outcomes of study suggest that there are increments of innovators, early Adopters and laggards and reduction of early and late majority of the sample than theoretical curve. Because of the influence of particular factors on different adopter categories of growers vary significantly. Grower exposure to extension, income earned from coconut cultivation, hired labor for supervisory work in estate which owner was not present in the estate, increase the adoption probability of switching a grower from laggards to innovators. Therefore appropriate extension can increase the rate of adoption. Conversely, intercropping, large size of land, labor cost, higher education level of grower, and risk averseness behavior significantly decrease the probability of adoption of switching a farmer from laggards to innovators. Due to the fact that higher labor cost have an aversion to implement of IPM techniques and risk aversion highlights the financial risk, seasonality risk of the farmer negatively affect towards the adoption.

Although income of coconut cultivation promotes the non adopter's willingness to adopt IPM, risk aversion had a negative impact as moving to laggards. The challenge for policy makers is, therefore to implement an incentive-based regulatory system such as subsidies to increase the coconut production, implementation of stable/floor wholesale price throughout the year, introduction of crop insurance programs to minimize the financial and seasonality risk, implementation of appropriate extension programs to aware the growers who are not practicing fulltime farming.

Factors such as lack of finance, lack of availability of data, difficulty to measure the effect of nature of pest control measures, and nature of pest biology were the limitations of this study. Therefore further studies are needed with large sample.

ACKNOWLEDGEMENT

Authors wish to express their sincere thanks to Dr. H. A. J. Gunathilake, Chairman, Buddi Jayasooriya, Head, Coconut Development Division, Coconut Cultivation Board for providing support and gratefully acknowledge Mr. R .M. Rathnayake, Regional Deputy Manager, Mr. Padmasiri, Coconut Development Officer (CDO), CCB, Kurunegala for providing technical assistance and information for the study.

REFERENCES

Asaduzzaman, M. (1979).Adoption of HYV Rice in Bangladesh, *Bangladesh Development Studies.* Vol 7. (No.3). pp: 23-25.

Borooah, V. K. (2002). *Logit and Probit: Ordered and Multinomial Models.* Series: Quantitative Applications in the Social Sciences. No. 138. Thousand Oaks: Sage Publication.

Brian, J. Wood (2002).Integrated Pest Management Reviews http://www.springerlink.com/app/home/search -Articles-results. Asp (Accessed: 6.3.2005)

Central Bank Report of Sri Lanka, (2004)

Daniel W. Surry (1997). Diffusion Theory and Instructional Technology in extension education. http://intro.base.org/docs/diffusion/;February 20, 1997 (Accessed: 3.5.2005).

Fernando, L. C. P. (2004). Achievements in Pest and Disease Management of Coconut in Sri Lanka. *Proceedings of the International Conference of the CRISL*, No.1.September, 148-162.

Judge, G. C., W. E. Griffiths, R. C. Hill, H. Lutkepohl, and Tsoung-Chao Lee. (1983). *The Theory and Practice of Econometrics*, second edition. New York: John Wilay & Sons.

Jayasinghe - Mudalige, U. K. and S. Henson (2004). Quantify the Impact of Economic incentives on firms' Food Safety Responsiveness. The case of Red meat and poultry processing sector in Canada. A selected paper presentation at the annual *American Agricultural Economics* Association meeting, Denver, Colorado... August, 1-4.

Liyanage, M. D E. S. (1999). A Guide to scientific Cultivation and Management of Coconut. pp:.40-45.

Maddala, G. S. (1983). *Limited -Dependent and Qualitative Variables in the Econometrics.* Cambridge University *Press.*

McFadden, D. (1974). Conditional Logit Analysis of Qualitative Choice Behavior. In Frontiers in Econometrics. Ed, P. Zaremka. New York: Academic Press.

Peiris, T. S. G., M. T. N. Fernando and S. R. Samaraweera (2003). Economic loss of mite infection of coconut to individual farmers in Puttlam District. Preliminary findings, *J. of National Institute of Plantation Management*, **19** (2) , 60-66.

Putler, D. S. and Zilberman, (1988) Computer use in Agriculture Evidence from Tulare Country, California. *Journal of Agricultural Economics*, **70**:790-802

Riesenberg , .L. E., C. O Gor. (1989).Farmers' preferences for methods of receiving information on new or Innovative farming practices. *Journal of Agricultural Education,* **30** (3), 7-13.

Roger, E. M. (1983). *Diffusion of Innovations*, third edition. New York: Free Press.

Rogers, E. M. and Shoemaker, F. F. (1971). Communication of Innovations; A Cross Cultural Approach. New York: The Free Press.

Rogers, E. M. (1962). *Diffusion of Innovations*. New York: The Free Press.

Rogers, E. M. (1995). Diffusion of Innovations. 4th Ed. New York: The Free Press.

Sarap, K. and D. C. Vashist (1994). Adoption of Modern Analysis. *Indian Journal of Agricultural Economics,* **49**, No.1 January-March, pp. 88-93.