Economic and social impact of the technologies generated by the National Agricultural Research Institutes, Nigeria, vol. 4

Phillip, Dayo, Damian.O. Chikwendu, B.Y. Abubakar.

FINAL REPORT 2011

Table of Contents

List of Tables

List of Figures

Acknowledgement

The continuing drive for the unprecedented quantification of the impacts of agricultural research in Nigeria by the Executive Secretary of the Agricultural Research Council of Nigeria (ARCN), Professor B.Y Abubakar, is pleasantly acknowledged. The coordination of the impact assessment exercise since its inception in the year 2009 by Professor Damian Chikwendu, Director, Extension services, ARCN, is gratefully noted. Field data was collected with great zeal by staff of the concerned National Agricultural Research Institutes (NARIs), namely Dr (Mrs) Vivian Ojehomon (NCRI, Badeggi), Dr Kenneth C. Ekwe (NRCRI, Umudike), Dr Christian Nwawe (NIFOR, Benin City) and Mrs Funmilay Bosede Olajide-Taiwo (NIHORT, Ibadan). Mrs Oluwayemisi Adedipe, formally of the International Institute of Tropical Agriculture (IITA, Ibadan) keyed in and cleaned the entire data with great professionalism.

Executive Summary

In the 2011 edition of the ARCN-funded impact assessment study, the attention has been shifted to the household-level impact of agricultural technology adoption. This micro-approach to impact estimation is expected to complement the available evidence already provided in the previous (2009 and 2010) studies on the aggregate impact of the adoption of agricultural technologies in Nigeria.

The main objective of the 2011 impact assessment study is to provide qualitative and quantitative impacts of the adoption of selected agricultural technologies generated by the NARIs up to and including year 2010 in Nigeria. The specific objectives of the study include the following:

- (i) Description of the on-station characteristics of the technologies under study;
- (ii) Description of selected characteristics of the technologies from the beneficiaries' vewpoints;
- (iii) Estimation of the adoption rates of the agricultural technologies in the diffusion areas;
- (iv) Estimation of the relationship between adoption behavior and key determinants in the diffusion areas;
- (v) Description of poverty in relation to household adoption behavior in the diffusion areas;
- (vi) Estimation of the impact of technology adoption on expenditure and income of households in the diffusion areas;

Four agricultural technologies, corresponding to four commodities, were studied. These are the Green dwarf variety of Coconut, TGX- 1448-2E variety of Soyabeans, JM94/54 variety of Tomato, and Yam miniset.

A total of 400 respondents (adopters and non-adopters) were surveyed for the results presented in this report across the four technologies, but 9 questionnaire was eventually lost to attrition.

Several statistical tools were employed to derive the results presented later in this report. These include frequency tables, logit regression analysis, poverty decomposition methods, column charts in both 2-D and 3-D dimensions and nearest neighbour matching methods.

With the exception of the JM94/54 variety of Tomato, the trend among the adopters was a much longer continuous cultivation of land and very short fallow periods, possibly reflecting underlying population pressure in the study areas.

The indication was that recommended and actual practice of cropping systems did not tally, except in the case of the coconut variety. The overwhelming beneficiary assessment was that the costs of adopting the technologies under study are medium to high among the adopters. The easiest of the varieties to adopt, in the technical sense, was the Soyabeans variety, while the most difficult to adopt was the coconut variety.

The explanatory variables that statistically affected the adoption of the TGX- 1448-2E variety of Soyabeans are seed cost perception, seed access, number of extension visits, respondent's visit to extension stations, availability of credit extension advice and availability of extension advice on crop variety.

The explanatory variables that statistically affected the adoption of the JM94/54 variety of Tomato are years of experience with the crop, village distance to the nearest good road, time to seed source, time to fertilizer source, seed cost perception and number of extension visits. These coefficients are noted to conform to the a priori expectations about their signs.

The explanatory variables that statistically affected the adoption of the Yam minisett are village distance to the fertilizer source, seed cost perception, visit to an agricultural research station, availability of information on the crop variety and membership of farmer association. These coefficients conform to the a priori expectations about their algebraic signs.

The results relating to food insecurity assessments are largely mixed. All the adopters and non-adopters of the coconut variety under study experience food insecurity in some months of the year, while slightly more non-adopters of the yam minisett indicate experience of food insecurity in some months of the year. The results for the Soyabean and tomato varieties under study appear to conform to our stated expectations that food insecurity should prevail more for the non-adopters.

Both expenditure- and income-based poverty gap indices indicate worsening poverty towards the non-adopters across all technologies. However, it is significant that the income-based analysis portrays less poverty than the expenditure-based analysis, using all the indices available. It is not clear which of the welfare indicators to prefer, but it is generally expected that households will be more forthcoming with their expenditure than their income information.

The impact of technology adoption on the households was further analyzed using two welfare indicators, income and expenditure. Both average treatment effect (ATE) and average treatment effect on the treated (ATT) were estimated for all the technologies, using both income and expenditure data. Estimation of the ATE and ATT was based on STATA's nearest neighbour matching procedures.

Both the expenditure- and income-based estimates for the tomato variety were statistically not significant. The same goes for the income-based ATE estimate for the Yam minisett. The income-based ATT estimates for the varieties of Soyabeans, Tomato and Yam minisett were either not computable or statistically insignificant. These results are therefore excluded from further discussion.
Green dwarf (coconut)

Beginning with the ATE estimates, the average effect of Green dwarf adoption is an increase in expenditure by N69,374.27 and increase in income by N178,620, while the average effect of the TGX-1448-2E adoption is an increase in expenditure by N91,620.44 and increase in income by N142,239.60. The average effect of the yam minisett adoption is an increase in expenditure by N406,982.80.

Turning to the ATT estimates the average expenditure of the adopters increases by N78,656.90, while the income increases by N150,726.70 for adopting the Green dwarf variety of Coconut. The effect of the TGX- 1448-2E adoption on the adopter's expenditure is an increase of N120,851.40, while on the average, the expenditure of the JM94/54 adopters increases by N139,532.90. The expenditure of the Yam minisett adopters increases, on the average, by N432,649.30.

1. Introduction

1.1 Background to the study

The prevailing view is that domestic food production in Nigeria has been unable to keep pace with increase in population. This has been attributed to such factors as productivity decline, inconsistent or unclear macroeconomic policies and the failure of the National Agricultural Research System (NARS) to show the impact of the agricultural sector (Idachaba, 2006).

The objectives of agricultural research include the desire to increase farm productivity and smallholders' income. These must however be achieved within the context of environmental sustainability, food security, overall standard of living and macroeconomic stability. Research outputs are measured in terms of the generation of new or improved inputs and availability of information. To this extent therefore, agricultural research is at the heart of any economic growth and development. New technologies will enable farmers to obtain more outputs from either the same or less amount of resources, hence ensuring resource conservation (Masters, 1996).

The conduct of agricultural research/adoption impact study amounts to an attempt to measure the effects of research outputs on research objects or end-users and society. Several benefits accrue to carrying out impact assessment of agricultural technology adoption, either with a micro- or macro perspective. One, There is growing pressure nationally and internationally to justify the huge funds received for agricultural research activities. At the national level, it is increasingly imperative to justify public and private investments in agricultural research, since agricultural research funds are increasingly scarce. Two, evidence of adoption of technologies by farmers is the only way to measure research benefits to society. Indeed, it has been shown that the expected benefits to society from any innovation depend linearly on adoption (Alston et al, 1995; Batz et al, 2003). Thus, studies must seek to measure adoption with diligent accuracy.

1.2 Context of the study

The Agricultural Research Council of Nigeria (ARCN) in 2009 began the funding of studies that seek to quantify the social and economic impacts of agricultural research in Nigeria. Pursuant of this, two studies covering nine (9) agricultural technologies were commissioned and completed in the year 2009. A third impact assessment study was funded and executed in the year 2010. The present study seeks to advance the scope, methods and results already obtained from the previous impact studies.

The impact assessment studies funded by ARCN in 2009 to date focused primarily on the estimation of the social and aggregate economic impacts of the identified agricultural technologies in Nigeria. In the 2010 edition of the impact studies, efforts were made to trace gains from agricultural research from initial varieties through the most current releases by each participating NARI. In Short, the 2010 economic impact assessment exercise accounted for the history of varietal or breed improvement for each relevant technology.

In the 2011 edition of the study, the attention was shifted to assess the household-level impact of agricultural technology adoption. This micro-approach to impact estimation is expected to complement the available evidence already provided in the previous studies on the aggregate impact of the adoption of agricultural technologies in Nigeria.

1.3 Objectives of the study

The main objective of the 2011 impact assessment is to provide qualitative and quantitative impacts of the adoption of the agricultural technologies generated from up to and including year 2010 in Nigeria.

The specific objectives of the study include the following:

(vii) Description of the on-station characteristics of the technologies under study;
(viii) Description of selected characteristics of the technologies from the beneficiaries' vewpoints;
(ix) Estimation of the adoption rates of the agricultural technologies in the diffusion areas;
(x) Estimation of the relationship between adoption behavior and key determinants in the diffusion areas;
(xi) Description of poverty in relation to household adoption behavior in the diffusion areas;
(xii) Estimation of the impact of technology adoption on expenditure and income of households in the diffusion areas;

2. Methodology

2.1 Scope of the study

Four agricultural technologies, corresponding to four commodities, were studied. These are the Green dwarf variety of Coconut, TGX- 1448-2E variety of Soyabeans, JM94/54 variety of Tomato, and Yam miniset. These technologies are developed by the Nigerian Institute for oil palm Research (NIFOR), National Cereals Research Institute (NCRI), National Horticultural Research Institute (NIHORT), and National Root Crops Research Institute (NRCRI), respectively.

2.2 Sample selection and sample size

The study - surveyed both adopters and non-adopters of each agricultural technology. A total of 50 adopters and 50 non-adopters were proposed for each technology. These samples were achieved for three of the technologies, but not for the Tomato variety. Specifically, the questionnaire of nine (9) of the adopters had to be jettisoned due to poor quality. Thus a total of 391 respondents were analyzed for the results presented in this report across the four technologies.

2.3 Data analysis

Several statistical tools were employed to derive the results presented later in this report. These include frequency tables, logit regression analysis, poverty decomposition methods, column charts in both 2-D and 3-D presentations and nearest neighbour matching methods.

Modeling Agricultural Technology Adoption Decisions

Several studies have focused on whether or not farmers adopt a technology item and/or the level of use of the technology, given that it was adopted. In these studies, decision is measured in most cases as 1 (adoption) and 0 (non-adoption). Then attempts are made to determine those factors that might have contributed to the observed adoption behaviour. Sample of statistical tools investigated have included the logit, probit and tobit regression analysis. Specifically, adoption/non-adoption decision studies have used either probit or logit regression models, while adoption level/intensity studies have used tobit/truncated or censored regression (using non-zero responses). Model fit has been evaluated using such criteria as Pseudo R-square, likelihood ratio Chi-square, and t-values of the independent variables.

Explanatory variables have tended to vary between studies, while some variables have featured more frequently, irrespective of the technology under study. Some authors have found it convenient and expedient to group adoption determinants. For example, Gebremedhin and Swinton [2003] proposed the measures of market access to include village distance to nearest market, village distance to nearest good road and commodity and factor prices. Other studies classify as institutional and demographic factors such variables as extension contact, dependency ratio, age of household head, sex of household head , and education of household head . Lapar and Pandey (1999) specified distance of village to main road and distance of village to farm as measures of market access. Several other studies simply specify adoption determinants without classifying them.

Age

Age is assumed to positively influence adoption behaviour especially among growing members of the household. On the other hand, as years pass by, old age could become a liability to adoption decisions. The aged are likely to become more reluctant to take chances on new technologies. Age has been widely tested in technology adoption models (Lapar and Pandey, 1999; Doss and Morris, 2001; Gebremedhin and Swinton, 2003;).

Gender

The prevalent view is that the influence of sex on adoption depends on whether the male or the female is the first contact person with the technology and the associated extension messages. The expectation is that adoption decision is likely to tilt in favour of the individual receiving the technology first. For the same reason, where the dummy variable for sex is 0 for male and 1 for female (1), the a priori sign on the sex variable is a negative.

Farming experience:

This variable, which measures the total number of years in the farming business, is assumed to positively influence technology adoption decision. A farmer with years of experience is more likely to adopt a new farm technology than a new farmer. Of course, age might complicate this prediction, as time pass by.

Experience with the crop:

This is the total number of years for which the farmer has planted the crop associated with the technology being studied. This variable, like farming experience, is assumed to positively influence technology adoption decision (Herath and Takeya, 2003).

Education:

This variable is assumed to positively influence adoption decision by enhancing general and specific knowledge about the technology (Lapar and Pandey, 1999; Doss and Morris, 2001; Gebremedhin and Swinton, 2003; Herath and Takeya, 2003). Education was alternatively measured in this study as either the cumulative years of formal schooling or the highest attained level of formal schooling as at survey time. These variables were alternately specified in the models tested.

Household size:

This is a proxy for labour availability (Doss and Morris, 2001) or capacity of a farmer to invest (Gebremedhin and Swinton, 2003). The variable is assumed to positively influence technology adoption.

Headship of the household:

Being the household head is assumed to relate positively to adoption, with the caveat that the household head is the first point of contact for the messages associated with the technology.

Farm size:

This is assumed to positively influence adoption decision, serves as a proxy for wealth (Doss and Morris, 2001) and indicates farmer's capacity to invest (Gebremedhin and Swinton, 2003)

Market access:

Gebremedhin and Swinton (2003) maintains that market access is aproxy for returns to investment as well as incentives to invest in a new technology. Variables often investigated in the market access variable group include distance from village to the nearest market, distance from village to the nearest good road, distance from village farm to the nearest good road, distance from village to the nearest certified seed, distance from village to the nearest fertilizer source, time from village to seed source, time from village to fertilizer source, distance from village to the nearest major commodity market, seed cost perception, fertilizer cost perception, seed accessibility and fertilizer accessibility. It should be stressed that the distance from village to the nearest market and the distance from village to the nearest major commodity market need not be empirically the same.

Empirically, the variable pairs distance from village to the nearest certified seed/ time from village to seed source and distance from village to the nearest fertilizer source/ time from village to fertilizer source were alternately included in the various adoption models tested to avoid multicollinearity. A priori, each of the 'distance from village' or 'time to input source' variables are assumed to exert negative influences on technology adoption decisions. On the other hand suitable measures of input accessibility (seed and fertilizer, in this study) are expected to positively influence adoption decisions.

Institutional factors:

Membership of associations:
Lapar and Pandey (1999) and Herath and Takeya (2003), among other studies hypothesize a positive relationship of social participation or association membership to adoption decision. The expectation is that benefits from group membership are higher than acting alone.

Land tenure system:
Farmland tenure security is widely assumed to positively affect technology adoption. Tenure is a proxy for investment risk, since owned farmlands will generally be more secured than rented or borrowed farmlands (Gebremedhin and Swinton, 2003).

Extension contact:
Adoption decision is assumed to be positively influenced by extension contact. Extension contact serves as proxy for input or or information availability (Doss and Morris, 2001; Herath and Takeya, 2003). The variable has been widely used in this composite form (e.g., Belbase, 1992). In the present study, we have attempted to disaggregate extension contact into component activities or services, namely availability of market information on commodity prices, availability of market information on commodity supply situation, visit to agricultural research stations, visit to agricultural extension office, availability of credit extension advice , availability of fertilizer use extension advice, availability of advice on improved variety use, availability of pesticide management extension services. The availability of each component was measured on (0,1) scale.

Table 1 presents the list of the suggested determinants of agricultural technology in this study, drawing heavily on the literature reviewed.

Table 1: Generalized variable names and labels for all the logit models tested

variable	variable label	a priori sign
adopt	adopt technology (0=no, 1=yes)	Dependent
resphhh	respondent is household head (0=no, 1=yes)	+
gender	Gender of household	?
Age	Age of respondent (years)	?
farmexp	Farming experience of respondent (years)	+
expcrop	Experience with the crop under study (years)	+
highedu	Highest attained education by respondent (ordinal)	+
yrssch	Years of formal schooling	+
vil2mkt	Distance from village to nearest market (km)	-
vil2road	Distance from village to nearest good road (km)	-
fam2road	Distance from farm to nearest good road (km)	-
vil2seed	Distance from village to nearest seed source (km)	-
vil2fert	Distance from village to nearest fertilizer source (km)	-
tim2seed	Time from village to nearest seed source (hours)	-
tm2fert	Time from village to nearest fertilizer source (hours)	-
vil2comk	Distance from village to nearest commodity market (km)	-
sdcoperc	Seed cost perception (ordinal)	-
fercoper	Fertilizer cost perception (ordinal)	-
sdaccess	Access to seed (increasing difficulty)	-
feracces	Access to fertilizer (increasing difficulty)	-
nextvst	Number of visits by extension agents to respondent per month	+
prcinfo	Receive market information on commodity prices (0=no, 1=yes)	+
suplinfo	Receive market information on commodity supply situation in markets (0=no, 1=yes)	+
visres	Visits agricultural research stations (yes=1, no=0)	+
visext	Visits agricultural extension organizations (yes=1, no=0)	+
credext	Credit advice extension available (yes=1, no=0)	+
fertext	Fertilizer extension advice available (yes=1, no=0)	+
varext	Technology specific extension available (yes=1, no=0)	+
pestext	Pest management extension available (yes=1, no=0)	+
membshp	Membership of farmer organization (yes=1, no=0)	+
tenure	Tenure of farmland (secure =1, insecure = 0)	+
hhsize	Household size	+

?=ambiguous sign

Logit regression analysis of technology adoption decision

Most studies assume that technology adoption/non adoption is a discrete decision. The decision to adopt or not to adopt a new technology is based on the expectation of deriving incremental benefit (Herath and Takeya ,2003; Batz et al 2003;Baidu_Forson ,1999). The farmer derives utility from some measure of monetary benefits accruing from technology adoption. The relationship between utility and adoption benefits is assumed to be governed by the following monotonic linear specifications:

$$V_{1Z} = Z\xi_1 + u_{1Z} \qquad (1)$$

$$V_{0Z} = Z\xi_0 + u_{0Z} \qquad (2)$$

In Equations (1) and (2), V_{1X} is the farmer's utility from adopting the new variety, Z is the vector governing adoption, V_{0X} is the utility associated with non- adoption, ξ_1 , ξ_0 are regression coefficients, and u_{1z} , u_{0z} are noise terms.

The rule for scoring adoption/non adoption decision W may be specified as follows:

$$W = \begin{cases} 1 & \text{if the farmer adopts technology} \\ 0 & \text{otherwise} \end{cases}$$

If we define the underlying probability function as P, the incremental benefit from adopting the relevant technology is derived as:

$$P(W=1) = P(V_{1Z} > V_{0Z}) = P(Z\xi_1 + \varepsilon_{1Z} > Z\xi_0 + \varepsilon_{0Z})$$

$$= P[Z(\xi_1 - \xi_0) > \varepsilon_{1Z} - \varepsilon_{0Z}] = P(Z\xi > \phi)$$

$$= F(Z\beta)$$

where $\phi = u_{1z} - u_{0z}$ and $\xi = \xi_1 - \xi_0$ is some measure of the net influence of vector Z on adoption likelihood.

$F(Z\xi)$ is the cumulative distribution function for ϕ evaluated at $Z\xi$.

The probability of adoption P may now be specified as

$$P(W=1|Z) = \exp(Z\xi + \phi) / [1 + \exp(Z\xi + \phi)] , \quad -\infty < Z\xi < \infty$$

and $P(W=0|Z) = 1 - P(W=1|Z)$.

The natural logarithm of the ratio of $P(W=1|Z)$ to $P(W=0|Z)$ is a logistic relationship which can be estimated using the MLE approach, that is:

$$\ln \{ \exp(Z\xi + \phi) / [1 + \exp(Z\xi + \phi)]\}/ \{1/ [1 + \exp(X\beta + \phi)] \} = Z\xi + \phi)$$

The technologies for which the logit regression analysis was undertaken are the varieties of Coconut, Soyabeans, Tomato and Yam. The set of adoption determinants investigated and the a priori sign expectations are already presented in Table xxx.

Poverty decomposition analysis

The poverty decomposition method proposed by Foster, Greer and Thorbecke (1984) was adopted in this study. This method disaggregates poverty into incidence or head count, poverty gap and poverty severity (Datt et al, 2001).

The proposition at the level of individual household i is that:

$$P_\alpha = \{\max [(1-x_i/y), 0]\}^\alpha \quad , \alpha = 0,1,2$$

where x_i is the income or expenditure level of household i, y is the poverty line and α is some non-negative parameter conditioning poverty index P. An alternative proposition of the formula is that

$$P_\alpha = n^{-1}\sum[1-x_i/y]^\alpha ,$$

where n is the number of poor households in the sample. An α value of 0 essentially reduces the formula to the proportion of the households that are below the poverty line or are poor. For $\alpha=1$, P_1 is the poverty gap while, P_2, corresponding to $\alpha=2$, is the severity of poverty. As computed, P_0 is measured in percentage, while P_1 and P_2 are computed and interpreted on (0,1) scale. Either of these indices indicates worsening poverty as 1 is approached and decreasing poverty towards 0. $P_1 > P_2$, conceptually since P_2 is the square of P_1. In this study, poverty was decomposed using both household income and expenditure data. The poverty line was defined using the standard USD1.25 spending per capita per day. This was mapped into its annual value for an average household size of 7 (based on available household data), and using an exchange rate of USD1.00 = N160.00.

Program impact evaluation methods

The evaluation of the effects of households' participation in welfare-enhancing programs has long been of interest. Social experiment is widely regarded as the ideal procedure for program impact evaluation (Bloom et al, 2002). This procedure is however complicated by individuals' freedom to opt out of voluntary programs (Diaz and Handa, 2004) .

It is often assumed that a binary treatment variable affects some continuous welfare outcome variable, such as income. In most evaluation procedures, the key concern is that treated and untreated groups may differ on factors other than the binary treatment variable. Hence, there is the need to control for the non-treatment factors (Angrist, 1990; Angrist, 1991; Angrist, 1998).

Two causal effects are computed in most program impact evaluation studies, namely, average treatment effect (ATE) and average treatment effect on the treated (ATET or ATT). Let us define

Y_{1i} = potential outcome with program
Y_{0i} = outcome without program
i = individual or household
D_i = treatment status, such that $D_i = 1$, if treated or $D_i = 0$ if untreated

The effect of treatment on outcome of any individual or household i is $Y_{1i} – Y_{0i}$. Over all individuals (treated and untreated), ATE is computed as (Angrist and Imbens,1994) :

$$ATE = E(Y_{1i} – Y_{0i})$$

In practice, not all potential program participants eventually participate or get treated. For those actually treated, ATT is very relevant, i.e.

$$ATT = E(Y_{1i} – Y_{0i} |Di=1)$$
$$= E(Y_{1i} | D_i=1) – E(Y_{0i} |D_i=1)$$

The first component (Y_{1i}) is potentially observable. The second component is unobserved or counterfactual. But, $Y_{0i}|D_i=0$ is observable (Angrist and Imbens,1994). A usually convenient assumption is that a vector of observable covariates X_i is the only source of omitted variables bias. Thus, individuals with similar covariates from treated and untreated groups are matched for the detection of program impacts. Stated differently treatment assignment is independence of outcomes, conditional on all observables (covariates) that determine treatment assignment and outcomes (conditional independence / selection on observables). Matching methods assume conditional independence (Heckman and Robb, 1985; Heckman et al, 1997; Heckman et al, 1998).

Formally, $Y0 \perp D/X$

This helps in the identification of ATT. Under random assignment of treatments, both ATE and ATT are indeed identified since

$$E(Y_{0i} | D_i=1) = E(Y_{0i} |D_i=0) \text{ and } E(Y_{1i} | D_i=1) = E(Y_{1i} |D_i=0)$$

Thus,

$ATE = E(Y_{1i} - Y_{0i})$
$ATE = E(Y_{1i} \mid D_i{=}1) - E(Y_{0i} \mid D_i{=}0)$

Under random treatment assignment, there is no need to control for the effect of non-treatment factors / covariates. In practice, random treatment assignment is rarely achieved. But, controlling for X can still conditionally enable independence between D_i and potential outcome (Angrist and Imbens,1994).

Non-experimental program evaluation includes regression, matching, propensity score, and instrumental variable estimators. The nearest neighbour estimator is available for ATE and ATT (Abadie et al, 2001).

Our discussion thus far is summarized in in Figure 1, **A** and **D** and **B** and **E** can be observed but not **C** and **F** As already noted, a convenient assumption is that **E=F**, to nullify self-selection among program participants.

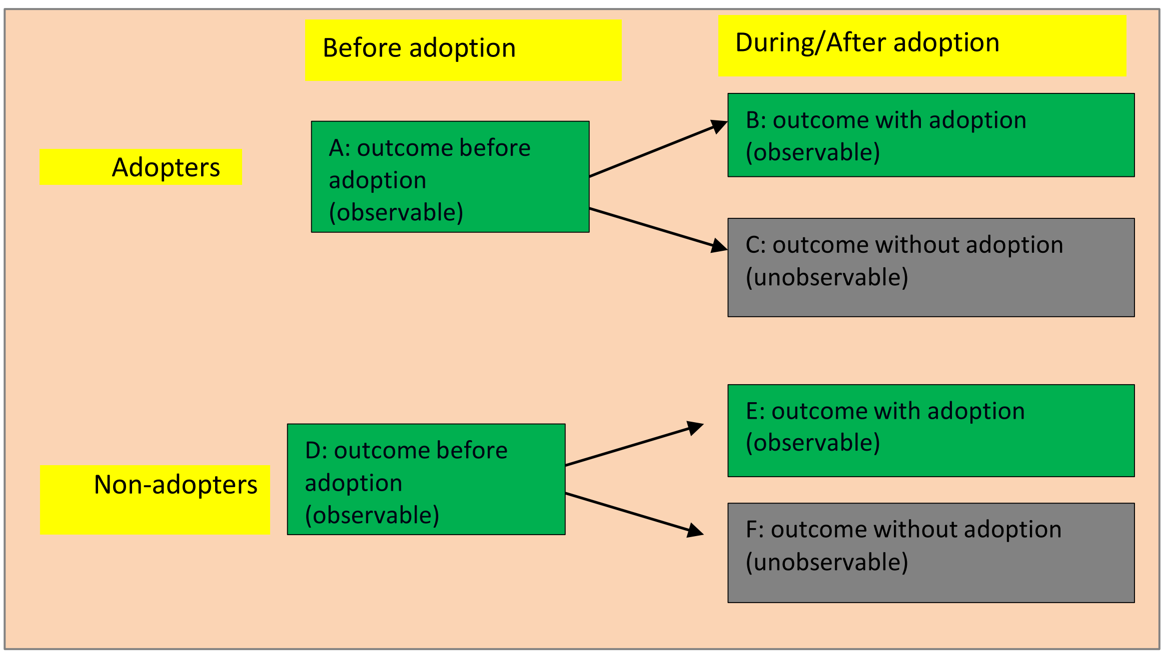

Figure 1: Program impact evaluation options

3. Results and Discussion

3.1 On-station characteristics of the technologies

In this section we present in a series of tables the on-station characteristics of the technologies studied, as provided by the respective NARIs.

Table 2: On-station characteristics of the Green dwarf (Coconut)

<table>
<tr><td>Commodity: Coconut</td><td>Technology /variety: Green dwarf</td></tr>
<tr><td colspan="2">Scientific name: Cocos nucifera
Description of parameters /qualities: 81 nuts per year, flowers 3-4 years after planting
Conditions favouring adoption: tolerant to the lethal yellowing disease of Coconut; suitable replacement for the susceptible west African tall
States adopting technology till date : Lagos and Rivers
History of technology development:
The national Institute for Oilpalm Research (NIFOR) made the first planting of coconut in May, 1967, at its main station , Benin city. In the same year, dwarf varieties were imported from Malaysia. Evaluation for fruit quality was carried out on nuts from selected parent trees of four cultivars, namely West African tall (WAT), Malaysian Red Dwarf (MRD), Malaysian Yellow Dwarf (MYD) and Malaysian Green Dwarf (MGD), planted on a 10-hectare on the NIFOR main station in 1987.</td></tr>
</table>

Table 3: On-station characteristics of JM94/54 (Tomato)

Commodity : Tomato	**Technology / variety**: JM94/54
Year released: not indicated **Scientific name**: Lycopersicon esculentum **Description of parameters /qualities**: it has four lobes; tolerant to tomato bacterial wilt disease; high yielding ; stores longer due to low water content and firmness **Conditions favouring adoption**: high yielding, early maturing, longer storage and tolerance to wilt disease **States adopting technology till date**: Ogun **History of technology development**: not indicated	

Table 4: On-station characteristics of the Minisett (Yam)

Commodity: Yam	**Technology**: Yam minisett
Year released: 1982 **Scientific name**: **Description of parameters /qualities**: Rapid multiplication of seed yam; addresses the constraints of seed yam scarcity; guarantees very high productivity of seed yam; increases farmer's capacity for large scale production of yam; efficient means of multiplying new yam varieties; high propensity for income generation and commercialization; requires fertilizer application; best result under sole cropping; best result under rain establishment **Conditions favouring adoption**: Rapid multiplication of seed yam; addresses the constraints of seed yam scarcity; guarantees very high productivity of seed yam; increases farmer's capacity for large scale production of yam; efficient means of multiplying new yam varieties; high propensity for income generation and commercialization. **History of technology development**: The yam minisett technology was developed by the national Root Crops Research Institute (NRCRI), Umudike, in collaboration with IITA, Ibadan. The minisett was developed in 1982, and has been improved upon over the years.	

3.2 Selected on-farm and plot-level characteristics of the technologies

Land use practices

Table 5 shows the average duration (in years) of fallow and continuous cultivation among the adopters of the technologies studied.

Green dwarf (coconut)
Among the adopters of the Green dwarf variety of coconut, fallow period averaged 1.1 years while land was continuously cultivated for an average period of 14.8 years.

TGX- 1448-2E (Soyabeans)
The average duration of fallow is 2 years while land was cultivated continuously for an avwrage period of 8.8 years, for among the growers of this variety of Soyabeans .

JM94/54 (tomato)
For this variety of tomato, land was cultivated continuously for an average period of 1.8 years, while fallow was practiced for an average period of 4.2 years.

Minisett (yam)
The Yam minisett adopters practice continuous cultivation for an average of 7.7 years and fallow for an average of 2.9 years.

Looking across the results in Table 5, and with the exception of the JM94/54 variety of Tomato, the trend among the adopters was much longer continuous cultivation of land with very short fallow periods, possibly reflecting underlying population pressure in the study areas.

Table 5: Average duration of fallow and continuous cultivation of the plot under the technology studied (years)

Cultivation practice	Green dwarf (coconut)	TGX- 1448-2E (Soyabeans)	JM94/54 (tomato)	Minisett (yam)
Continuous	14.8	8.8	1.8	7.7
Fallow	1.14	2.0	4.2	2.9
	N=50	N=50	N=41	N=50

Assessment of farmland slopes

In Table 6 we present the adopters' assessment of their farmland slopes. This nature of the farmland clearly have implications for investing in such activities as drainage or erosion control, which may in turn negate adoption decisions if such costs are significant.

Green dwarf (coconut)
Among the adopters sampled, 94% assessed their farmland as flat while 6% considered their farmland to be located along a slope.

TGX- 1448-2E (Soyabeans)
Sixty percent (60%) of the adopters assessed their farmland as flat while 40% assessed their farmland as located along a slope.

JM94/54 (tomato)
In Table xxx, 87.8% of the sample of adopters indicates that their farmland is flat while 12.2% of them assess their farmland as slopy.

Minisett (yam)
For the Yam minisett adopters, 68% of the sample cultivated flat farmlands while 32% cultivate farmlands along slopes.

Table 6: percent distribution of respondents by farmland's slope assessment

	Green dwarf (coconut)	TGX- 1448-2E (Soyabeans)	JM94/54 (tomato)	Minisett (yam)
Flat land	94.0	60.0	87.8	68.0
Sloped land	6.0	40.0	12.2	32.0
	N=50	N=50	N=41	N=50

Assessment of cropping systems

Table 7 shows the adopters' assessment of the recommended cropping system for the varieties under study, while Table 8 shows the adopters' assessment of the preferred cropping system for the varieties.

Green dwarf (coconut)
In Tables 7 and 8, 96% indicates that mixed cropping is recommended and 94% actually practice mixed cropping for growing this variety of coconut.

TGX- 1448-2E (Soyabeans)
Sole cropping is indicated as the recommendation by 94% of the sample, 58% actually practice mixed cropping with respect to this variety of Soyabeans . The remaining 42% of the sample embrace the recommended cropping system.

JM94/54 (tomato)
Following closely to the Soyabeans result, sole cropping is indicated as the recommendation by 92.9% of the sample, 53.7% actually practice mixed cropping with respect to this variety of Tomato. The remaining 46.3% of the sample embrace the recommended cropping system.

Minisett (yam)
For the Yam minisett, 58% of the adopting sample indicates sole cropping as the recommended practice. However, 92% of the sample actually practice mixed cropping with the Yam minisett.

The indication from Tables 7 and 8 is that recommendation and actual practice of cropping system did not tally, may be with the exception of the coconut variety. It will be of policy relevance to know the factors in the disparities.

Table 7: percent distribution of respondents by the recommended cropping system for the technology studied

Recommended	Green dwarf (coconut)	TGX- 1448-2E (Soyabeans)	JM94/54 (tomato)	Minisett (yam)
Mixed	96.0	6.0	17.1	42.0
Sole	4.0	94.0	92.9	58.0
	N=50	N=50	N=41	N=50

Table 8: percent distribution of respondents by the preferred/practiced cropping system for the technology studied

Preferred	Green dwarf (coconut)	TGX- 1448-2E (Soyabeans)	JM94/54 (tomato)	Minisett (yam)
Mixed	94.0	58.0	46.3	92.0
Sole	6.0	42.0	53.7	8.0
	N=50	N=50	N=41	N=50

Access to variety/technology before release

This assessment contributes to the extent of on-farm evaluation of the technologies before they were formally released. Of course, zero access from a given sample of adopters does not lead to the conclusion that there was no on-farm evaluation, since such activities may have been conducted with some other samples of farmers elsewhere in the region. Table 9 shows the indicated access to the technologies ahead of release.

Green dwarf (coconut)
Only 2% of the sample had access to the coconut variety under study before its official release.

TGX- 1448-2E (Soyabeans)
For the Soyabeans , only 4% of the sample had access to the variety under study before the official release.

JM94/54 (tomato)
Table xxx shows that 19.5% of the adopters had access to the tomato variety under study before its release.

Minisett (yam)
At 36%, the Yam minisett had the highest access by the respondents before official release.

There is no existing rule mandating access to unreleased improved crop varieties. However, prior access by prospective adopters could enhance familiarity with the technology, enhance necessary feedbacks for varietal improvements and overall adoption after official release.

Table 9: percent distribution of respondents by planting of the technology before release and at survey time

	Green dwarf (coconut)	TGX- 1448-2E (Soyabeans)	JM94/54 (tomato)	Minisett (yam)
Planted before release (% yes)	2.0	4.0	19.5	36.0
Planted now/survey time (% yes)	100.0	100.0	100.0	100.0
	N=50	N=50	N=41	N=50

Note: each result entry was computed separately relative to the sample size.

3.3 Beneficiary assessments of selected characteristics of the technologies

Fertilizer access constraints

Table 10 shows the responses to the suggested list of fertilizer access constraints among both adopters and non-adopters.

Green dwarf (coconut)
Among the non-adopters, the most important fertilizer access constraints were identified as non-availability (45.5%) and high cost (43.2%). And, among the adopters, the top constraints were also non-availability (54.2%) and high cost (33.3%).

TGX- 1448-2E (Soyabeans)
Among the non-adopters, an overwhelming 77.6% identified high cost as the fertilizer access constraint, followed by non-availability (16.3%). And, among the adopters, the similar trend was that 88% identified high cost as the main constraint to access, while 10% identified non-availability as the next most important access constraint.

JM94/54 (tomato)
For the tomato variety under study, 55.1% of the non-adopters rated non-availability as the main fertilizer access constraint, followed by high cost (30.6%). Among the adopters high cost was implicated by 46.2% and non-availability by 35.9% of the respondents.

Minisett (yam)
High cost was identified as the main the main access constraint among both non-adopters (91.5%) and adopters (84.2%).

Figure 2 further illustrates the results in Table 10.

Table 10: Percentage distribution of respondents by fertilizer access constraints

Constraint	Green dwarf (coconut)		TGX- 1448-2E (Soyabeans)		JM94/54 (tomato)		Minisett (yam)	
	Non-adopters (n=44)	Adopters (n=48)	Non-adopters (n=49)	Adopters (n=50)	Non-adopters (n=49)	Adopters (n=39)**	Non-adopters (n=47)	Adopters (n=48)
Non-availability	45.5	54.2	16.3	10.0	55.1	35.9	8.5	8.3
Distance to source	0	0	0	0	8.2	0	0	0
Bad roads	9.1	10.4	0	0	2.0	5.1	0	0
High cost of input	43.2	33.3	77.6	88.0	30.6	46.2	91.5	84.2
Access to finance	2.3	2.1	6.1	2.0	4.1	12.8	0	7.4
Other constraints	0	0	0	0	0.0	0.0	0	0
Total	44	48	49	50	49	39	47	48

**attrition problem

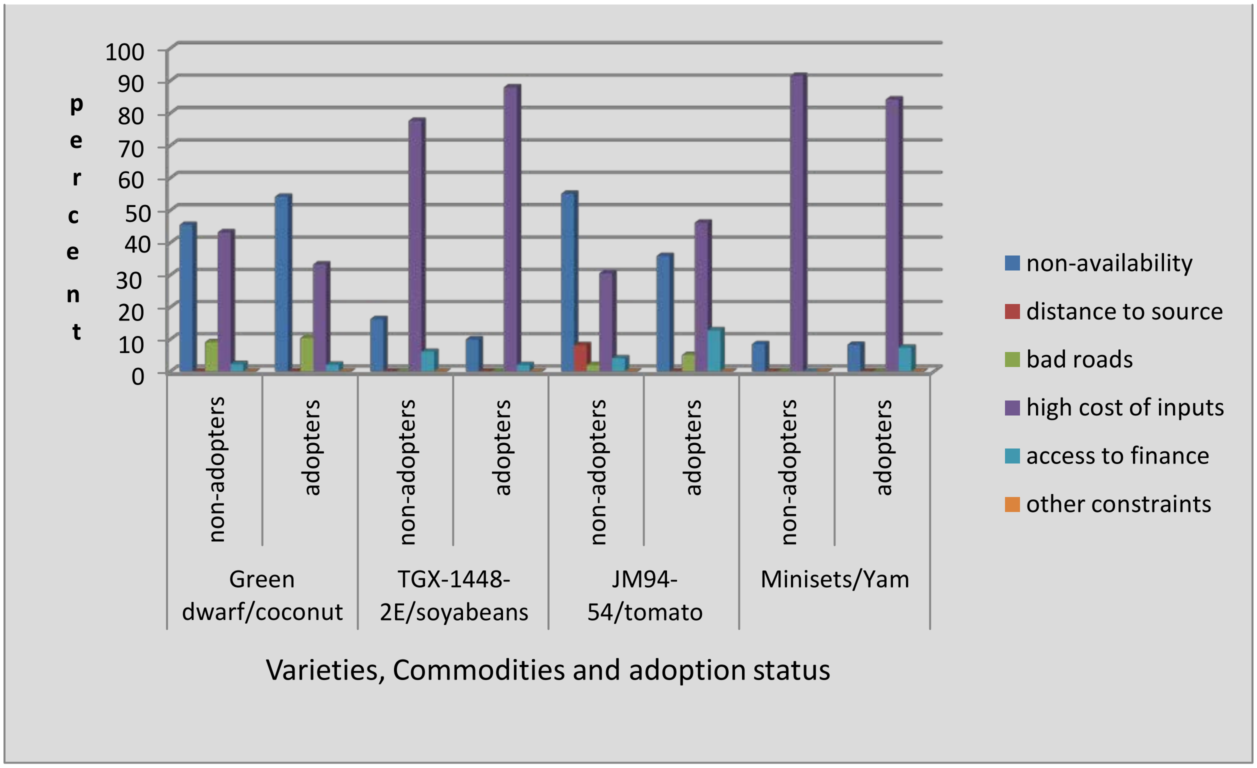

Fig 2: Column charts of % distribution of respondents by fertilizer access constraints

Seed access constraints

Table 11 shows the responses to the suggested list of seed access constraints among both adopters and non-adopters.

Green dwarf (coconut)
Among the non-adopters, the most important seed access constraints were identified as non-availability (54%) and high cost (26%). And, among the adopters, the top constraints were identically non-availability (54%) and high cost (26%).

TGX- 1448-2E (Soyabeans)
Among the non-adopters, an overwhelming 65.2% identified bad road as the seed access constraint, followed by non-availability (18.6%), and high cost (14%), respectively. And, among the adopters, non-availability was identified by 36.4% while bad road was indicated by another 36.4%, followed by high cost (21.2%).

JM94/54 (tomato)
For the tomato variety under study, 59.6% of the non-adopters rated non-availability as the main seed access constraint, followed by high cost (29.8%). Among the adopters high cost was implicated by 26.7% and non-availability by 60% of the respondents.

Minisett (yam)
Among the non-adopters, 39.5% identified high cost as the seed access constraint, followed by non-availability (29%), and bad road (23.7%), respectively. And, among the adopters, high cost was identified by 44.7% while non-availability was indicated by another 23.7%, followed by bad road (21.1%).

Figure 3 further illustrates the results in Table 11.

Table 11: Percentage distribution of respondents by seed access constraints

Constraint	Green dwarf (coconut)		TGX- 1448-2E (Soyabeans)		JM94/54 (tomato)		Minisett (yam)	
	Non-adopters (n=50)	Adopters (n=50)	Non-adopters (n=43)	Adopters (n=33)	Non-adopters (n=47)	Adopters (n=30)**	Non-adopters (n=38)	Adopters (n=38)
Non-availability	54.0	54.0	18.6	36.4	59.6	60.0	29.0	23.7
Distance to source	10.0	10.0	0	3.0	4.3	0.0	7.9	3.9
Bad roads	10.0	10.0	65.2	36.4	4.3	3.3	23.7	21.1
High cost of input	26.0	26.0	14.0	21.2	29.8	26.7	39.5	44.7
Access to finance	0.0	0.0	2.3	3.0	2.1	10.0	0	3.9
Other constraints	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	50	50	43	33	47	30	38	38

**attrition problem

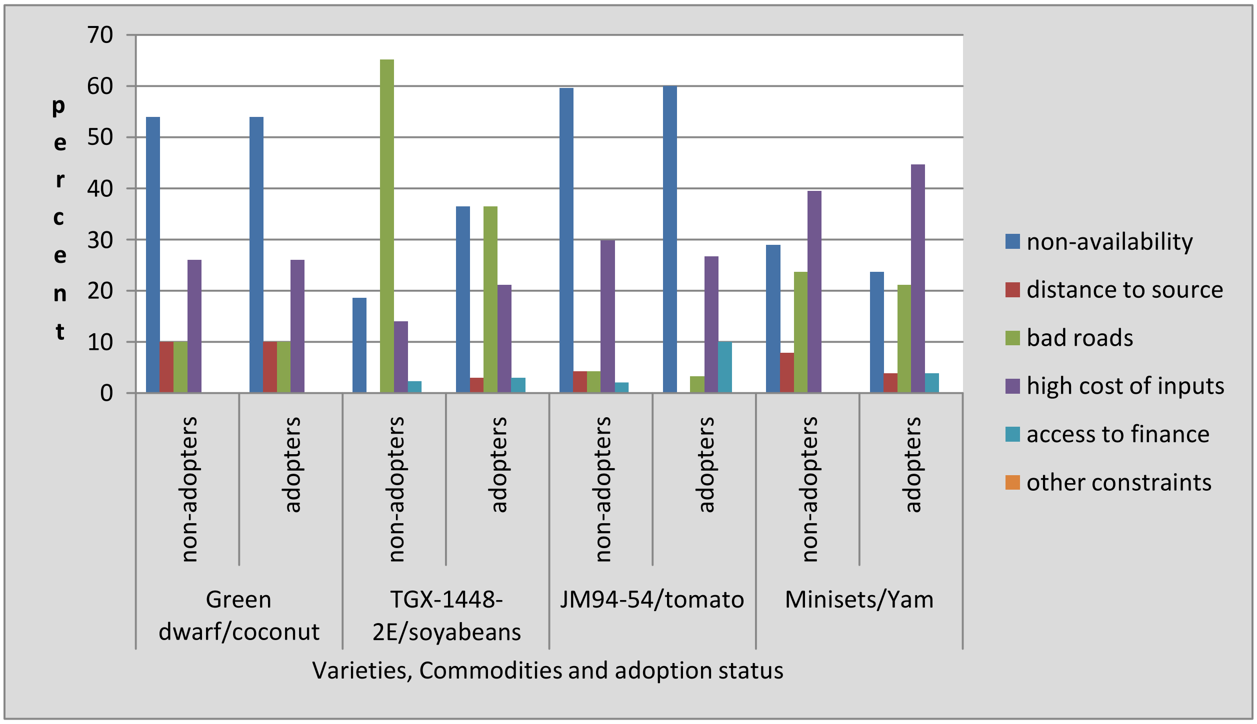

Fig 3: Column charts of % distribution of respondents by seed access constraints

Assessment of risks associated with technology adoption

Event-by-event assessment

Table 12 shows the percentage of respondents that indicated each of the events/perils as a risk factor. The results relates to only the adopters of the technologies under study.

Green dwarf (coconut)
The perils for which at least 50% of the respondents rates as a risk factor are flood, pests, unstable government policies, theft of product, fire, initial investments and insecure land tenure.

TGX- 1448-2E (Soyabeans)
In Table 12, the perils for which at least 50% of the respondents rated as a risk factor are only death of crop and initial costs/investments.

JM94/54 (tomato)
For the tomato variety under study, the perils for which at least 50% of the respondents rates as a risk factor are drought, disease, pests, insecure land tenure and product spoilage.

Minisett (yam)
The perils for which at least 50% of the respondents rates as a risk factor are drought, disease, pests, low yield, unstable government policies, theft of product, fire, death of crop, initial investments/costs and product spoilage.

As may be expected, the importance attached to each peril tended to be related to the commodity and the ecological locations within which the commodities are raised. Figure 4 further illustrates the results in Table 12.

Table 12: Percentage of respondents who rated the indicated perils/events as "a risk factor" in relation to technology adoption

Peril / Event	Green dwarf (coconut)	TGX- 1448-2E (Soyabeans)	JM94/54 (tomato)	Minisett (yam)
Drought	16.0	20.0	80.5	64.0
Disease	20.0	8.0	78.0	84.0
Flood	52.0	16.0	19.5	44.0
Pests	94.0	10.0	75.6	86.0
Low yield	18.0	12.0	36.6	52.0
Unstable govt policies	86.0	24.0	43.9	52.0
Theft of product	98.0	14.0	12.2	56.0
Fire	100.0	6.0	7.3	52.0
Death of crop	18.0	52.0	48.8	68.0
Initial cost/investment	92.0	54.0	46.3	74.0
Insecure land tenure	80.0	6.0	51.2	36.0
Farmland slope	6.0	22.0	4.9	16.0
Product spoilage	6.0	12.0	68.3	50.0
	N=50	N=50	N=41	N=50

Note: each result entry was computed separately relative to the sample size.

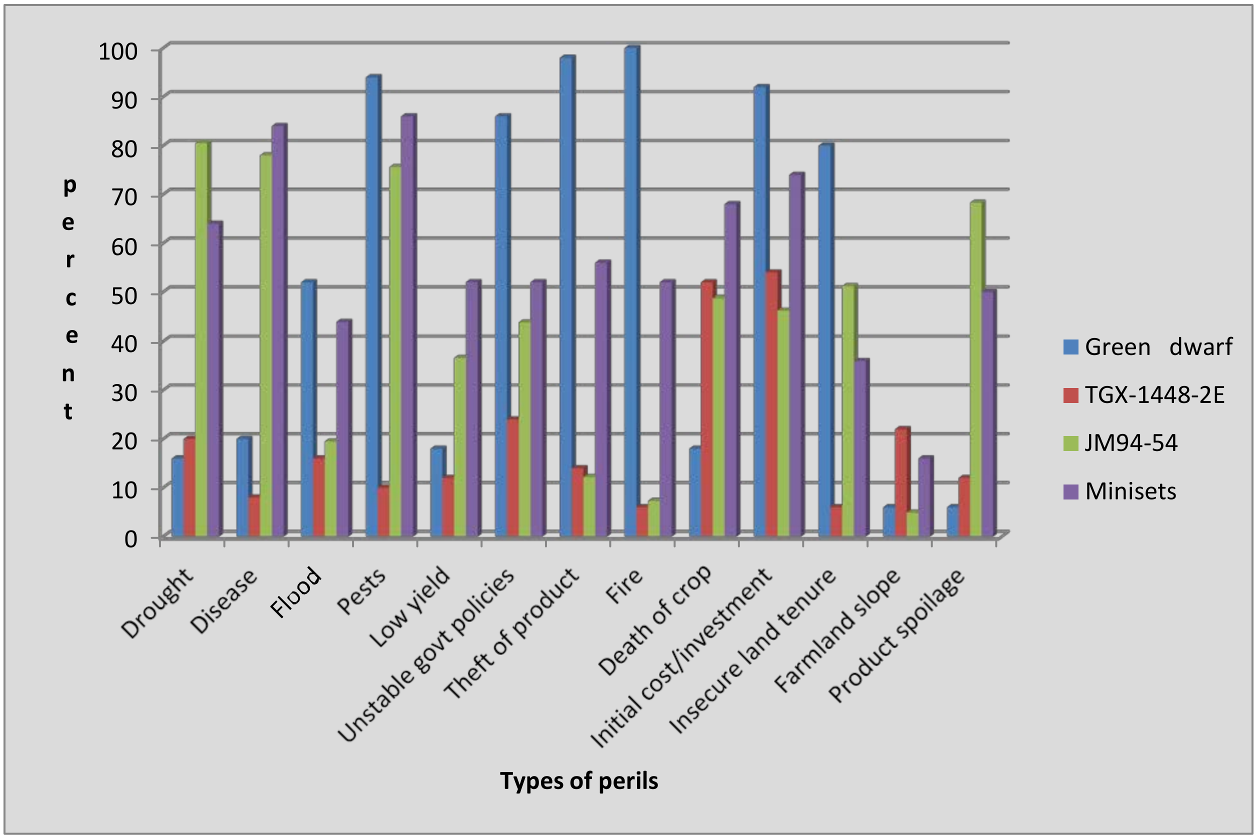

Fig 4: Percentage of adopters who rated the indicated perils/events as "a risk factor" in relation to technology adoption

Broad assessment of technology risks

The adopters were asked to assess in broad terms the risk associated with each crop and its variety under study. The assessment categories presented were "low", "medium' and "high", respectively. The results are presented in Table 13.

Green dwarf (coconut)
The risks associated with the crop were rated as low or medium by combined 88% of the adopters. For the coconut variety, 86% of the respondents rated the risks as either low or medium.

TGX- 1448-2E (Soyabeans)
The risks associated with Soyabean as a crop were rated as low or medium by combined 92% of the adopters. For the variety under study, 94% of the respondents rated the risks as either low or medium.

JM94/54 (tomato)
The risks associated with Tomato crop and the variety under study was rated as low or medium identically by 78% of the adopters.

Minisett (yam)
The risks associated with Yam were rated as low or medium by combined 82% of the adopters. For the variety under study, 80% of the respondents rated the risks as either low or medium.

Table 13: percent distribution of respondents by the broad rating of the risks associated with technology and crop adoption

Crop / technology	Risk assessment	Green dwarf (coconut)	TGX- 1448-2E (Soyabeans)	JM94/54 (tomato)	Minisett (yam)
Technology	Low	46.0	62.0	26.8	12.0
	Medium	40.0	32.0	51.2	68.0
	High	14.0	6.0	22.0	20.0
Crop	Low	42.0	72.0	26.8	30.0
	Medium	46.0	20.0	51.2	52.0
	High	12.0	8.0	22.0	18.0
		N=50	N=50	N=41	N=50

Assessment of the costs associated with technology adoption

The adopters were asked to assess in broad terms the costs associated with each variety under study. The assessment categories presented were “low”, “medium’ and “high”, respectively. The results are presented in Table 14

Green dwarf (coconut)
The costs associated with varietal adoption were rated as medium by 60% and as high by 40% of the adopters. No one rated the costs as low.

TGX- 1448-2E (Soyabeans)
The costs associated with varietal adoption were rated as medium by 52% and as high by 40% of the adopters. The costs were rated as low by only 8% of the adopters.

JM94/54 (tomato)
The costs associated with varietal adoption were rated as medium by 41.5% and as high by 22% of the adopters. The costs were rated as low by 36.6% of the adopters.

Minisett (yam)
The costs associated with Yam minisett adoption were rated as medium by 72% and as high by 24% of the adopters. The costs were rated as low by only 4% of the adopters.

The overwhelming outlook from Table 14 is that the costs of adopting the technologies under study are rated as medium to high by the adopters.

Table 14: percent distribution of respondents by the rating of the costs associated with technology adoption

Cost assessment	Green dwarf (coconut)	TGX- 1448-2E (Soyabeans)	JM94/54 (tomato)	Minisett (yam)
Low	0.0	8.0	36.6	4.0
Medium	60.0	52.0	41.5	72.0
High	40.0	40.0	22.0	24.0
	N=50	N=50	N=41	N=50

Assessment of the complexity / technical difficulties associated with technology adoption

The adopters were asked to assess in broad terms the complexity / technical difficulties associated with each variety under study. The assessment categories presented were “low”, “medium’ and “high”, respectively. The results are presented in Table 15.

Green dwarf (coconut)
The technical difficulties associated with the coconut variety under study were rated as medium by 64% and as high by 16% of the adopters. The technical difficulties were rated as low by 20% of the adopters.

TGX- 1448-2E (Soyabeans)
The technical difficulties associated with the Soyabeans variety under study were rated as medium by 16% and as high by only 8% of the adopters. The technical difficulties were rated as low by overwhelming 76% of the adopters.

JM94/54 (tomato)
The technical difficulties associated with the tomato variety under study were rated as medium by 41.5% and as high by 22% of the adopters. The technical difficulties were rated as low by 36.6% of the adopters.

Minisett (yam)
The technical difficulties associated with the Yam minisett were rated as medium by 50% and as high by 26% of the adopters. The technical difficulties were rated as low by 24% of the adopters.

From the results in Table 15, the easiest of the varieties to adopt, in a technical sense, was the Soyabeans variety. The most difficult to adopt was the coconut variety.

Table 15: percent distribution of respondents by the complexity / technical difficulties associated with technology adoption

Cost assessment	Green dwarf (coconut)	TGX- 1448-2E (Soyabeans)	JM94/54 (tomato)	Minisett (yam)
Low	20.0	76.0	36.6	24.0
Medium	64.0	16.0	41.5	50.0
High	16.0	8.0	22.0	26.0
	N=50	N=50	N=41	N=50

Assessment of the profitability of technology adoption

The adopters were asked to assess in broad terms the profitability associated with each variety under study. The assessment categories presented were "low", "medium' and "high", respectively. The results are presented in Table 16.

Green dwarf (coconut)
The profits associated with the coconut varietal adoption were rated as high by 66% and as medium by 34% of the adopters. No respondent rated profitability as low.

TGX- 1448-2E (Soyabeans)
The profits associated with the Soyabeans varietal adoption were rated as high by 82% and as medium by 12% of the adopters. Only 6% of the respondents rated profitability as low.

JM94/54 (tomato)
The profits associated with the tomato varietal adoption were rated as high by 82.9% and as medium by 14.6% of the adopters. Only 2.4% of the respondents rated profitability as low.

Minisett (yam)
The profits associated with the minisett adoption were rated as high by 86% and as medium by 14% of the adopters. No respondent rated profitability as low.

The profitability assessments in Table 16 provide strong justifications for the adoption of the indicated varieties in the first instance.

Table 16: percent distribution of respondents by profitability of technology adoption

Profitability	Green dwarf (coconut)	TGX- 1448-2E (Soyabeans)	JM94/54 (tomato)	Minisett (yam)
Low	0.0	6.0	2.4	0.0
Medium	34.0	12.0	14.6	14.0
High	66.0	82.0	82.9	86.0
	N=50	N=50	N=41	N=50

Note: 1-3 = low, 4-6 = medium, 7 – 10 = high from a scoring scale of 1 to 10 (10 = highest)

Assessment of selected physical characteristics of technologies

Assessment of crop yield

Table 17 shows the beneficiary assessment of the yields associated with the varieties under study.

Green dwarf (coconut)
The yield of this variety was rated as either satisfactory (62%) or very satisfactory (36%) by the responding adopters. Only 2% of the respondents rated the yield as unsatisfactory.

TGX- 1448-2E (Soyabeans)
The yield of the Soyabeans variety was rated as either satisfactory (48%) or very satisfactory (52%) by the responding adopters.

JM94/54 (tomato)
The yield of this Tomato variety was rated as either satisfactory (34.1%) or very satisfactory (63.4%) by the responding adopters. Only 2.4% of the respondents rated the yield as very unsatisfactory.

Minisett (yam)
The yield of the Yam minisett was rated as either satisfactory (62%) or very satisfactory (36%) by the responding adopters. Only 2% of the respondents were not sure about the ratings of yield.

Table 17: percent distribution of respondents by the rating of yield

Technology characteristics	Assessment	Green dwarf (coconut) (n=50)	TGX- 1448-2E (Soyabeans) (n=50)	JM94/54 (tomato) (n=41)	Minisett (yam) (n=50)
Yield	Not relevant	0	0	0	0
	Very unsatisfactory	0	0	2.4	0
	Unsatisfactory	2.0	0		0
	Not sure	0	0		2.0
	Satisfactory	62.0	48.0	34.1	62.0
	Very satisfactory	36.0	52.0	63.4	36.0

Assessment of date to maturity

Table 18 shows the beneficiary assessment of the date to maturity of the varieties under study.

Green dwarf (coconut)
The date to maturity of this variety was rated as either satisfactory (76%) or very satisfactory (16%) by the responding adopters.

TGX- 1448-2E (Soyabeans)
The date to maturity of the Soyabeans variety was rated as either satisfactory (86%) or very satisfactory (4%) by the responding adopters.

JM94/54 (tomato)
The date to maturity of this Tomato variety was rated as either satisfactory (41.5%) or very satisfactory (56.1%) by the responding adopters. Only 2.4% of the respondents rated the date to maturity as unsatisfactory.

Minisett (yam)
The date to maturity of the Yam minisett was rated as either satisfactory (70%) or very satisfactory (4%) by the responding adopters. Up to 22% of the respondents were not sure about the ratings of date to maturity .

Table 18: percent distribution of respondents by the rating of Time to maturity

Technology characteristics	Assessment	Green dwarf (coconut) (n=50)	TGX- 1448-2E (Soyabeans) (n=50)	JM94/54 (tomato) (n=41)	Minisett (yam) (n=50)
Time to maturity	Not relevant	0	0	0	0
	Very unsatisfactory	0	0	0	0
	Unsatisfactory	2.0	4.0	2.4	4.0
	Not sure	6.0	6.0		22.0
	Satisfactory	76.0	86.0	41.5	70.0
	Very satisfactory	16.0	4.0	56.1	4.0

Assessment of drought resistance

Table 19 shows the beneficiary assessment of the drought resistance of the varieties under study.

Green dwarf (coconut)
The drought resistance of this coconut variety was rated as satisfactory (76%) by the responding adopters. Up to 24% of the respondents were not sure about the ratings of drought resistance .

TGX- 1448-2E (Soyabeans)
The drought resistance of the Soyabeans variety was rated as either satisfactory (42%) or very satisfactory (2%) by the responding adopters. A significant number of the respondents were either not sure (52%) or unsatisfied (4%) about the variety's drought resistance.

JM94/54 (tomato)
The drought resistance of this Tomato variety was rated as satisfactory by only 17.1% of the responding adopters. Most of the respondents were either unsatisfied (70.7%), very unsatisfied (4.9%) or unsure (7.3%) about the variety's drought resistance.

Minisett (yam)
The drought resistance of minisett was rated as satisfactory by 42% of the responding adopters. The remaining respondents were either unsatisfied (12%), very unsatisfied (4%) or unsure (42%) about the variety's drought resistance.

Table 19: percent distribution of respondents by the rating of Drought resistance

Technology characteristics	Assessment	Green dwarf (coconut) (n=50)	TGX- 1448-2E (Soyabeans) (n=50)	JM94/54 (tomato) (n=41)	Minisett (yam) (n=50)
Drought resistance	Not relevant	0	0	0	0
	Very unsatisfactory	0	0	4.9	4.0
	Unsatisfactory	0	4.0	70.7	12.0
	Not sure	24.0	52.0	7.3	42.0
	Satisfactory	76.0	42.0	17.1	42.0
	Very satisfactory	0	2.0	0	0

Assessment of Insect resistance

Table 20 shows the beneficiary assessment of the insect resistance of the varieties under study.

Green dwarf (coconut)
The insect resistance of this coconut variety was rated as satisfactory (46%) by the responding adopters. Up to 52% of the respondents were not sure about the ratings of insect resistance .

TGX- 1448-2E (Soyabeans)
The insect resistance of the Soyabeans variety was rated as either satisfactory (50%) or very satisfactory (8%) by the responding adopters. A significant number of the respondents were not sure (42%) about the variety's drought resistance.

JM94/54 (tomato)
The insect resistance of the tomato variety was rated as either satisfactory (34.1%) or very satisfactory (2.4%) by the responding adopters. A significant number of the respondents were either unsatisfied (53.7%) or very unsatisfied (4.9%) about the variety's drought resistance.

Minisett (yam)
The insect resistance of minisett was rated as satisfactory by 34% of the responding adopters. The remaining respondents were either unsatisfied (20%), very unsatisfied (6%) or unsure (40%) about the variety's insect resistance.

Table 20: percent distribution of respondents by the rating of Insect resistance

Technology characteristics	Assessment	Green dwarf (coconut) (n=50)	TGX- 1448-2E (Soyabeans) (n=50)	JM94/54 (tomato) (n=41)	Minisett (yam) (n=50)
Insect resistance	Not relevant	0	0	0	0
	Very unsatisfactory	0	0	4.9	6.0
	Unsatisfactory	2.0	0	53.7	20.0
	Not sure	52.0	42.0	4.9	40.0
	Satisfactory	46.0	50.0	34.1	34.0
	Very satisfactory	0	8.0	2.4	

Assessment of lodging resistance

Table 21 shows the beneficiary assessment of the lodging resistance of the varieties under study.

Green dwarf (coconut)
The lodging resistance of this coconut variety was rated as satisfactory (18%) or very satisfactory (4%) by the responding adopters. Most of the respondents were either unsatisfied (4%) or unsure (74%) about the variety's lodging resistance.

TGX- 1448-2E (Soyabeans)
The lodging resistance of the Soyabeans variety was rated as either satisfactory (56%) or very satisfactory (10%) by the responding adopters. Up to 34% of the respondents were not sure about the variety's lodging resistance.

JM94/54 (tomato)
The lodging resistance of this Tomato variety was rated as either satisfactory (12.2%) or very satisfactory (2.4%) by the responding adopters. Most of the respondents were either unsatisfied (78%), very unsatisfied (4.9%) or unsure (2.4%) about the variety's lodging resistance.

Minisett (yam)
The lodging resistance of minisett was rated as either satisfactory (52%) or very satisfactory (2%) by the responding adopters. The remaining respondents were either unsatisfied (10%) or unsure (32%) about the variety's lodging resistance.

Table 21: percent distribution of respondents by the rating of Lodging resistance

Technology characteristics	Assessment	Green dwarf (coconut) (n=50)	TGX- 1448-2E (Soyabeans) (n=50)	JM94/54 (tomato) (n=41)	Minisett (yam) (n=50)
Lodging resistance	Not relevant	0	0	0	4.0
	Very unsatisfactory	0	0	4.9	0
	Unsatisfactory	4.0	0	78.0	10.0
	Not sure	74.0	34.0	2.4	32.0
	Satisfactory	18.0	56.0	12.2	52.0
	Very satisfactory	4.0	10.0	2.4	2.0

Assessment of crop weight

Table 22 shows the beneficiary assessment of the crop weight associated with the varieties under study.

Green dwarf (coconut)
The crop weight was rated as satisfactory (34%) or very satisfactory (60%) by the responding adopters. Only 6% of the respondents were not sure of this rating.

TGX- 1448-2E (Soyabeans)
The crop weight of the Soyabeans variety was rated as either satisfactory (70%) or very satisfactory (22%) by the responding adopters. Only 8% of the respondents were not sure of this rating.

JM94/54 (tomato)
The crop weight of this Tomato variety was rated as either satisfactory (43.9%) or very satisfactory (46.3%) by the responding adopters. Few respondents were either unsatisfied (4.9%), very unsatisfied (2.4%) or unsure (2.4%) about the variety's crop weight.

Minisett (yam)
The crop weight of the minisett was rated as either satisfactory (60%) or very satisfactory (34%) by the responding adopters. Only 6% of the respondents were not sure of this rating.

Table 22: percent distribution of respondents by the rating of Crop weight

Technology characteristics	Assessment	Green dwarf (coconut) (n=50)	TGX- 1448-2E (Soyabeans) (n=50)	JM94/54 (tomato) (n=41)	Minisett (yam) (n=50)
Crop weight	Not relevant	0	0	0	0
	Very unsatisfactory	0	0	2.4	0
	Unsatisfactory	0	0	4.9	0
	Not sure	6.0	8.0	2.4	6.0
	Satisfactory	34.0	70.0	43.9	60.0
	Very satisfactory	60.0	22.0	46.3	34.0

Assessment of taste

Table 23 shows the beneficiary assessment of the taste associated with the varieties under study.

Green dwarf (coconut)
The taste was rated as satisfactory (58%) or very satisfactory (38%) by the responding adopters. Only 4% of the respondents were not sure of this rating.

TGX- 1448-2E (Soyabeans)
The taste of the Soyabeans variety was rated as either satisfactory (62%) or very satisfactory (2%) by the responding adopters. The remaining respondents (36%) were not sure of this rating.

JM94/54 (tomato)
The taste of this Tomato variety was rated as either satisfactory (39%) or very satisfactory (51.2%) by the responding adopters. Fewer respondents were either unsatisfied (2.4%) or unsure (7.3%) about this rating.

Minisett (yam)
The taste of the yam from minisetts was rated as either satisfactory (64%) or very satisfactory (36%) by the responding adopters.

Table 23: percent distribution of respondents by the rating of Taste

Technology characteristics	Assessment	Green dwarf (coconut) (n=50)	TGX- 1448-2E (Soyabeans) (n=50)	JM94/54 (tomato) (n=41)	Minisett (yam) (n=50)
Taste	Not relevant	0	0	0	0
	Very unsatisfactory	0	0	0	0
	Unsatisfactory	0	0	2.4	0
	Not sure	4.0	36.0	7.3	0
	Satisfactory	58.0	62.0	39.0	64.0
	Very satisfactory	38.0	2.0	51.2	36.0

Assessment of crop storability

Table 24 shows the beneficiary assessment of the storability of the varieties under study.

Green dwarf (coconut)
The storability of this coconut variety was rated as satisfactory (48%) or very satisfactory (34%) by the responding adopters. Up to 18% of the respondents were unsure about the variety's storability.

TGX- 1448-2E (Soyabeans)
The storability of the Soyabeans variety was rated as either satisfactory (76%) or very satisfactory (10%) by the responding adopters. Few of the respondents were not sure (12%) or were unsatisfied (2%) about the variety's storability.

JM94/54 (tomato)
The storability of this Tomato variety was rated as either satisfactory (43.9%) or very satisfactory (7.3%) by the responding adopters. A significant number of the respondents were either unsatisfied (39%) or very unsatisfied (9.8%) about the variety's storability.

Minisett (yam)
The storability of the yams from minisett was rated as either satisfactory (80%) or very satisfactory (8%) by the responding adopters. The remaining respondents were either unsatisfied (2%), very unsatisfied (2%) or unsure (8%) about this rating.

Table 24: percent distribution of respondents by the rating of Storability

Technology characteristics	Assessment	Green dwarf (coconut) (n=50)	TGX- 1448-2E (Soyabeans) (n=50)	JM94/54 (tomato) (n=41)	Minisett (yam) (n=50)
Storability	Not relevant	0	0	0	0
	Very unsatisfactory	0	0	9.8	2.0
	Unsatisfactory	0	2.0	39.0	2.0
	Not sure	18.0	12.0	0	8.0
	Satisfactory	48.0	76.0	43.9	80.0
	Very satisfactory	34.0	10.0	7.3	8.0

Assessment of fodder quality

Table 25 shows the beneficiary assessment of the fodder quality of the varieties under study.

Green dwarf (coconut)
The fodder quality of this coconut variety was rated as satisfactory by only 6% of the responding adopters. The remaining respondents were either unsatisfied (20%) or unsure (74%) about this rating.

TGX- 1448-2E (Soyabeans)
The fodder quality of the Soyabeans variety was rated as either satisfactory (62%) or very satisfactory (10%) by the responding adopters. The remaining respondents (28%) were not sure about the variety's fodder quality.

JM94/54 (tomato)
The fodder quality of this Tomato variety was rated as either satisfactory (4.9%) or very satisfactory (39%) by the responding adopters. A significant number of the respondents were either unsatisfied (39%) or or unsure (17.1%) about the variety's fodder quality.

Minisett (yam)
The fodder quality of the minisett was rated as either satisfactory (26%) or very satisfactory (2%) by the responding adopters. A significant number of the respondents were either unsatisfied (28%), very unsatisfied (32%) or unsure (8%) about the variety's fodder quality.

Table 25: percent distribution of respondents by the rating of Fodder quality

Technology characteristics	Assessment	Green dwarf (coconut) (n=50)	TGX- 1448-2E (Soyabeans) (n=50)	JM94/54 (tomato) (n=41)	Minisett (yam) (n=50)
Fodder quality	Not relevant	0	0	0	4.0
	Very unsatisfactory	0	0	0	32.0
	Unsatisfactory	20.0		39.0	28.0
	Not sure	74.0	28.0	17.1	8.0
	Satisfactory	6.0	62.0	4.9	26.0
	Very satisfactory	0	10.0	39.0	2.0

Assessment of the ease of processing

Table 26 shows the beneficiary assessment of the ease of processing of the varieties under study.

Green dwarf (coconut)
The ease of processing of this coconut variety was rated as satisfactory (26%) or very satisfactory (4%) by the responding adopters. A significant number of the respondents were either unsatisfied (4%), very unsatisfied (48%) or unsure (18%) about the variety's ease of processing.

TGX- 1448-2E (Soyabeans)
The ease of processing of the Soyabeans variety was rated as either satisfactory (92%) or very satisfactory (6%) by the responding adopters. The few remaining respondents (2%) were not sure about the variety's ease of processing.

JM94/54 (tomato)
The ease of processing of this Tomato variety was rated as either satisfactory (56.1%) or very satisfactory (9.8%) by the responding adopters. The remaining respondents were either unsatisfied (9.8%), very unsatisfied (2.4%) or or unsure (22%) about the variety's ease of processing.

Minisett (yam)
The ease of processing of the yam from the minisett was rated as either satisfactory (66%) or very satisfactory (4%) by the responding adopters. The remaining respondents were either unsatisfied (6%) or unsure (24%) about the variety's ease of processing.

Table 26: percent distribution of respondents by the rating of Processing

Technology characteristics	Assessment	Green dwarf (coconut) (n=50)	TGX- 1448-2E (Soyabeans) (n=50)	JM94/54 (tomato) (n=41)	Minisett (yam) (n=50)
Processing	Not relevant	0	0	0	0
	Very unsatisfactory	48.0	0	2.4	0
	Unsatisfactory	4.0	0	9.8	6.0
	Not sure	18.0	2.0	22.0	24.0
	Satisfactory	26.0	92.0	56.1	66.0
	Very satisfactory	4.0	6.0	9.8	4.0

Assessment of labour requirement

Table 27 shows the beneficiary assessment of the labour requirement of the varieties under study.

Green dwarf (coconut)
The labour requirement of this coconut variety was rated as satisfactory (66%) or very satisfactory (10%) by the responding adopters. The remaining respondents were either unsatisfied (2%) or unsure (22%) about the variety's labour requirement.

TGX- 1448-2E (Soyabeans)
The labour requirement of the Soyabeans variety was rated as either satisfactory (70%) or very satisfactory (4%) by the responding adopters. The remaining respondents were either unsatisfied (2%), very unsatisfied (2%) or unsure (22%) about the variety's labour requirement.

JM94/54 (tomato)
The labour requirement of this Tomato variety was rated as either satisfactory (48.8%) or very satisfactory (4.9%) by the responding adopters. The remaining respondents were either unsatisfied (41.5%) or unsure (4.9%) about the variety's labour requirement.

Minisett (yam)
The labour requirement of the minisett was rated as either satisfactory (82%) or very satisfactory (2%) by the responding adopters. The remaining respondents were either unsatisfied (6%) or unsure (10%) about the variety's labour requirement.

Table 27: percent distribution of respondents by the rating of Labour requirement

Technology characteristics	Assessment	Green dwarf (coconut) (n=50)	TGX- 1448-2E (Soyabeans) (n=50)	JM94/54 (tomato) (n=41)	Minisett (yam) (n=50)
Labour requirement	Not relevant	0	0	0	0
	Very unsatisfactory	0	2.0	0	0
	Unsatisfactory	2.0	2.0	41.5	6.0
	Not sure	22.0	22.0	4.9	10.0
	Satisfactory	66.0	70.0	48.8	82.0
	Very satisfactory	10.0	4.0	4.9	2.0

Assessment of the non-labour requirements

Table 28 shows the beneficiary assessment of the non-labour requirements of the varieties under study.

Green dwarf (coconut)
The non-labour requirements of this coconut variety was rated as satisfactory by 46% of the responding adopters. The remaining respondents were either unsatisfied (10%) or not sure (44%) about the variety's non-labour requirements .

TGX- 1448-2E (Soyabeans)
The non-labour requirements of the Soyabeans variety was rated as either satisfactory (34%) or very satisfactory (4%) by the responding adopters. The remaining respondents were either unsatisfied (24%), very unsatisfied (2%) or unsure (36%) about the variety's non-labour requirements .

JM94/54 (tomato)
The non-labour requirements of this Tomato variety was rated as either satisfactory (41.5%) or very satisfactory (9.8%) by the responding adopters. The remaining respondents were either unsatisfied (36.6%), very unsatisfied (4.9%) or unsure (7.3%) about the variety's non-labour requirements .

Minisett (yam)
The non-labour requirements of the minisett was rated as either satisfactory (22%) or very satisfactory (32%) by the responding adopters. The remaining respondents were either unsatisfied (22%), very unsatisfied (4%) or unsure (8%) about the variety's non-labour requirements.

Table 28: percent distribution of respondents by the rating of Non-labour requirement

Technology characteristics	Assessment	Green dwarf (coconut) (n=50)	TGX- 1448-2E (Soyabeans) (n=50)	JM94/54 (tomato) (n=41)	Minisett (yam) (n=50)
Non-labour requirement	Not relevant	0	0	0	12.0
	Very unsatisfactory	0	2.0	4.9	4.0
	Unsatisfactory	10.0	24.0	36.6	22.0
	Not sure	44.0	36.0	7.3	8.0
	Satisfactory	46.0	34.0	41.5	22.0
	Very satisfactory	0	4.0	9.8	32.0

Assessment of the ease of harvesting

Table 29 shows the beneficiary assessment of the ease of harvesting of the varieties under study.

Green dwarf (coconut)
The ease of harvesting of this coconut variety was rated as satisfactory (40%) or very satisfactory (54%) by the responding adopters. A few of the respondents were either unsatisfied (2%) or unsure (4%) about the variety's ease of harvesting.

TGX- 1448-2E (Soyabeans)
The ease of harvesting of the Soyabeans variety was rated as either satisfactory (94%) or very satisfactory (6%) by all the responding adopters.

JM94/54 (tomato)
The ease of harvesting of this Tomato variety was rated as either satisfactory (39%) or very satisfactory (36.6%) by the responding adopters. The remaining respondents were either unsatisfied (22%) or unsure (2.4%) about the variety's ease of harvesting.

Minisett (yam)
The ease of harvesting of the yam from the minisett was rated as either satisfactory (54%) or very satisfactory (28%) by the responding adopters. The remaining respondents were either unsatisfied (4%), very unsatisfied (2%) or unsure (12%) about the variety's ease of harvesting.

Table 29: percent distribution of respondents by the rating of ease of harvesting

Technology characteristics	Assessment	Green dwarf (coconut) (n=50)	TGX- 1448-2E (Soyabeans) (n=50)	JM94/54 (tomato) (n=41)	Minisett (yam) (n=50)
Ease of harvesting	Not relevant	0	0	0	0
	Very unsatisfactory	0	0	0	2.0
	Unsatisfactory	2.0	0	22.0	4.0
	Not sure	4.0	0	2.4	12.0
	Satisfactory	40.0	94.0	39.0	54.0
	Very satisfactory	54.0	6.0	36.6	28.0

3.4 Technology adoption

Profiles of technology adoption

Table 30 presents the profiles of the adoption of the technologies under study. It is significant that all the adopters have been accounted for in the row for 'adopted'. Thus, the remaining distribution of the respondents is essentially for the non-adopters.

Green dwarf (coconut)
The non-adopters consist of those not aware (14%) or aware but have not tried this variety of coconut (36%).

TGX- 1448-2E (Soyabeans)
Among the non-adopters of this Soyabeans variety, 35% are not aware of the variety, while 15% are aware but have not tried it.

JM94/54 (tomato)
The non-adopters of this tomato variety consist of those not aware (41.7%) or aware but have not tried this variety of coconut (13.2%).

Minisett (yam)
The non-adopters of the minisett distributes into those not aware (6%), aware but have not tried (19%), have tried and dropped the minisett (12%), and those who have tried but yet to decide (13%).

Figure 5 further illustrates the results in Table 30.

Table 30: Profile for the adoption of technologies across adopters and non-adopters

Profile	Green dwarf (coconut)		TGX- 1448-2E (Soyabeans)		JM94/54 (tomato)		Minisett (yam)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Not aware	14	14.0	35	35.0	38	41.7	6	6.0
Aware, not tried	36	36.0	15	15.0	12	13.2	19	19.0
Tried, dropped	0	0.0	0	0.0	0	0.0	12	12.0
Tried, undecided	0	0.0	0	0.0	0	0.0	13	13.0
Adopted	50	50.0	50	50.0	41	45.1	50	50.0
Total	100	100.0	100	100.0	91	100.0	100	100.0

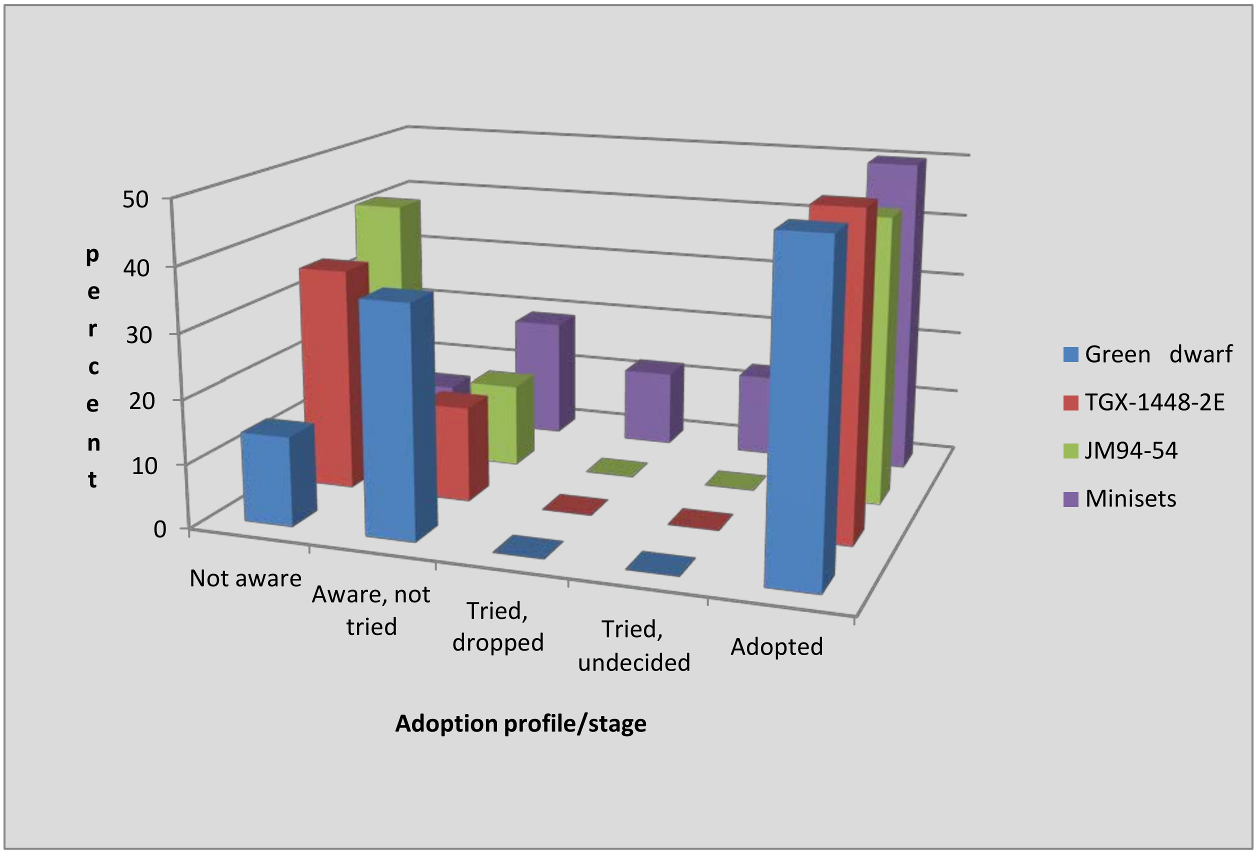

Fig. 5: Profile for the adoption of technologies across adopters and non-adopters

Plot allocation to crops and varieties

Table 31 shows the size of plots under the crops and varieties under study (in hectares).

Green dwarf (coconut)
An average of 4.65 ha was planted to coconut and 3.33 ha planted to the variety under study among the sample of respondents. Results relating to the minimum, maximum and total plot size for the coconut and the variety under study are also presented in Table 31.

TGX- 1448-2E (Soyabeans)

Table 31 shows that an average of 3.14 ha was planted to Soyabeans and 2.7 ha planted to the variety under study among the sample of respondents. The table also shows the results relating to the minimum, maximum and total plot size.

JM94/54 (tomato)
In Table 31, we show that an average of 1.18 ha was planted to Tomato and 0.73 ha planted to the variety under study. The table also shows the results relating to the minimum, maximum and total plot size.

Minisett (yam)
Table 31 shows the results relating to the minimum, maximum and total plot size of Yam minisett among the adopting sample. An average of 2.73 ha was planted to Yam and 1.94 ha planted to the minisett among the sample of respondents.

Table 31: Descriptive statistics of plot allocations to crops and varieties/ technologies (ha)

Plot allocation	Commodity : coconut (N=50)			
	Minimum	Maximum	Sum	Mean
Size of plot under the crop, all varieties (ha)	1.00	25.0	232.40	4.65
Size of plot under Green dwarf (ha)	0.50	21.00	166.50	3.33
	Commodity : Soyabeans (N=50)			
Size of plot under the crop, all varieties (ha)	0.50	7.00	157.45	3.14
Size of plot under TGX-1448-2E (ha)	0.50	6.00	135.15	2.70
	Commodity : tomato (N=41)			
Size of plot under the crop, all varieties (ha)	0.20	4.00	48.45	1.18
Size of plot under JM94/54 (ha)	0.01	2.00	30.02	0.73
	Commodity : Yam (N=50)			
Size of plot under the crop, all varieties (ha)	1.00	8.00	136.60	2.73
Size of plot under minisett (ha)	0.50	7.00	97.10	1.94

Crop and varietal adoption rates

Adoption of a technology remains the key determinant of the eventual benefit of technical change to society. Thus, it is very useful to estimate technology adoption rates, using appropriate methods. In this section, we present the adoption rates for both the varieties/technologies and the crops under study. The adoption rates for the crop is not core to this report, but merely provides additional information on the importance of on each crop within the portfolio of the crops raised by each respondent. Tables 32 and 33 presents, respectively, the adoption rates for the crops and varieties/technologies under study. The adoption rates (column 1 in each of Tables 32 and 33) are in proportional terms, convertible to percentages by multiplying with 100. The sample mean adoption rates for each crop and the associated variety are presented in Table 34.

Green dwarf (coconut)
In Table 32, 80% of the adopters attain at least 50% plot-level adoption of coconut, while in Table 33, 66% of the adopters attains at least 50% plot-level varietal adoption. The sample mean adoption rates for the crop and the variety are 67.1% and 68.7%, respectively.

TGX- 1448-2E (Soyabeans)
In Table 32, 68% of the adopters attain at least 50% plot-level adoption of Soyabeans, while in Table 33, 96% of the adopters attains at least 50% plot-level varietal adoption. The sample mean adoption rates for the crop and the variety are 63.1% and 87.5%, respectively.

JM94/54 (tomato)
In Table 32, 78.1% of the adopters attain less than 50% plot-level adoption of Tomato, while in Table 33, 63.5% of the adopters attains at least 50% plot-level varietal adoption. The sample mean adoption rates for the crop and the variety are 39.7% and 72.2%, respectively.

Minisett (yam)
In Table 32, 90% of the adopters attain at least 50% plot-level adoption of Yam, while in Table 33, 78% of the adopters attains at least 50% plot-level varietal adoption. The sample mean adoption rates for the crop and the variety are 83.7% and 78.5%, respectively.

Figure 6 provides further description of the results in Tables 32 and 33.

Table 32 : Plot-based adoption rates for the crops studied (proportion)

Adoption rate **	Coconut		Soyabeans		Tomato		Yam	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
0.25 or less	2	4.0	1	2.0	20	48.8	1	2.0
0.26 – 0.50	8	16.0	15	30.0	12	29.3	4	8.0
0.51 – 0.75	28	56.0	22	44.0	4	9.8	10	20.0
0.76 & above	12	24.0	12	24.0	5	12.2	35	70.0
Total	50	100.0	50	100.0	41	100.0	50	100.0

**in proportional terms

Table 33 : Plot-based adoption rates for the technologies / varieties studied (proportion)

Adoption rate **	Green dwarf (coconut)		TGX- 1448-2E (Soyabeans)		JM94/54 (tomato)		Minisett (yam)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
0.25 or less	1	2.0	0	0.0	4	9.8	1	2.0
0.26 – 0.50	16	32.0	2	4.0	11	26.8	10	20.0
0.51 – 0.75	12	24.0	9	18.0	4	9.8	19	38.0
0.76 & above	21	42.0	39	78.0	22	53.7	20	40.0
Total	50	100.0	50	100.0	41	100.0	50	100.0

**in proportional terms

Table 34: Mean adoption rates for crops and varieties / technologies under study

Variety/Crop	Mean adoption rates (proportion)**	
	Crop	Variety / technology
Green dwarf (coconut)	0.671	0.687
TGX- 1448-2E (Soyabeans)	0.631	0.875
JM94/54 (tomato)	0.397	0.722
Minisett (yam)	0.837	0.785

**convertible to percentageby multiplying with 100

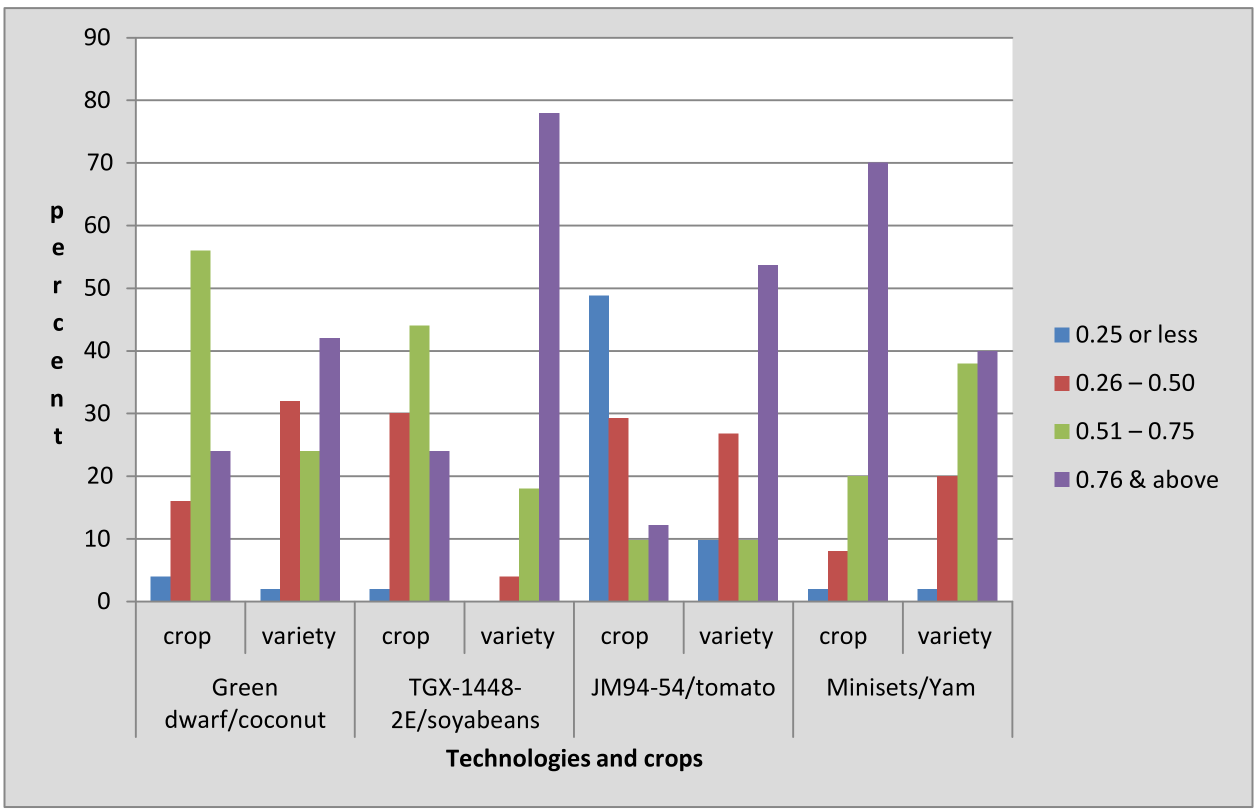

Fig. 6 : Distribution of adopters by plot-based adoption rates for the crops and technologies studied (proportions)

3.5 Explaining technology adoption behaviour

In this section the estimated logit regression results are presented for the technologies under study. The theoretical justifications and specifications are already presented in Table 1. The logit model for the coconut variety (Green dwarf) failed estimation because no convergence could be achieved at the default maximum iteration allowed. So, only the results for the varieties of Soyabeans, Tomato and Yam are presented in this section. In order to avoid linear relationship between pairs of the explanatory variables (e.g. age/farming experience, highest education/years of schooling, distance of village to fertilizer source / time to fertilizer source, etc) alternative models were tested. However, only two of the models tested are presented for each technology in Tables 35 to 37. For all the logit regression results in Tables 35 to 37, the likelihood ratios computed are statistically significant at the 1% level, giving credibility to further discussion of the constituent coefficients.

The TGX- 1448-2E variety of Soyabeans

In Table 35, model 1 has been selected as the lead equation based mainly on the number of statistically significant explanatory variables and empirical signs on the regression coefficients. The explanatory variables that are statistically significant at varying levels are seed cost perception, seed access, number of extension visits, respondent's visit to extension stations, availability of credit extension advice and availability of extension advice on crop variety.

Elasticities were computed at the means for those variables that were significant at no more than the 10% level, and presented in column 4 of Table 35. For example, a unit increase in the seed cost perception (ordinal scale) reduces the adoption of this variety by 1.16, while a unit increase in access to seed (ordinal scale) increase adoption by only 0.78. A unit increase in the number of extension visits increases adoption by 3.21, while visit to an agricultural extension station by the respondent increases adoption by 3.87 Availability of credit extension information increases adoption by 4.58, while availability of extension information on crop variety increases adoption by 5.29.

Table 35: Estimated logit models for the adoption of TGX- 1448-2E Soyabeans variety

variable	Model 1			Model 2		
	coef.	asy. t-value	elasticity at the mean(++)	coef.	asy. t-value	elasticity at the mean(++)
RESPHHH						
GENDER						
AGE	-.0063	-.083				
FARMEXP				-.065	-1.02	
EXPCROP						
HIGHEDU						
YRSSCH						
VIL2MKT	-.038	-.33		-.079	-2.04**	-.045
VIL2ROAD						
FAM2ROAD						
VIL2SEED						
VIL2FERT	-.12	-.82				
TIM2SEED						
TM2FERT				-.14	-.19	
VIL2COMK						
SDCOPERC	-1.88	-2.16**	-1.16	-2.54	-2.09**	-1.46
FERCOPER						
SDACCESS	1.22	1.91*	0.78	.11	.27	
FERACCES						
NEXTVST	5.09	1.82*	3.21			
PRCINFO	.34	.15		.010	.009	
SUPLINFO	2.66	1.09		1.44	1.17	
VISRES						
VISEXT	6.14	1.99**	3.87	3.72	2.84***	2.15
CREDEXT	7.26	1.76*	4.58	1.66	1.48	
FERTEXT	-9.82	-.089		.17	.13	
VAREXT	8.39	2.47***	5.29			
PESTEXT	1.11	.010				
MEMBSHP	3.29	1.42		2.16	1.52	
TENURE	-1.25	-.69				
HHSIZE	-.085	-.47		-.051	-.36	
CONSTANT	-3.04	-.74		2.50	1.03	
Log likelihood function:			-14.996			-24.801
Likelihood ratio test:		df=16	108.64***		df=12	89.03***
Estrella R-Square:			.880			.759

Maddala R-Square:	.663			.589
Graig-Uhler R-Square:	.883			.786
Mcfadden R-Square	.784			.642
Chow R-Square	.837			.702

++for only coefficients that are statistically significant at the 1%, 5% or 10% level.
***significant at the 1% level, **significant at the 5% level, *=significant at the 10% level

The JM94/54 variety of Tomato

Model 2 in Table 36 has been selected as the lead equation based mainly on the number of statistically significant explanatory variables and empirical signs on the regression coefficients. The explanatory variables that are statistically significant at varying levels are years of experience with the crop, village distance to the nearest good road, time to seed source, time to fertilizer source, seed cost perception and number of extension visits. These coefficients are noted to conform to the a priori expectations about their signs.

Elasticities were computed at the means for those variables that were significant at no more than the 10% level, and presented in column 7 of Table 36. A unit increase in the years of experience with the crop increases adoption by only 0.074, while a unit increase in the village distance to the nearest good road decreases adoption by 0.123. A unit increase in the time to seed source decreases adoption by 0.696, while a unit increase in the time to fertilizer source decreases adoption by 0.697. A unit increase in seed cost perception decreases adoption by 0.769, while a unit increase in the number of extension visits increases adoption by 0.211.

Table 36: Estimated logit models for the adoption of JM94/54 tomato variety

variable	Model 1			Model 2		
	coef.	asy. t-value	elasticity at the mean(++)	coef.	asy. t-value	elasticity at the mean(++)
RESPHHH	1.04	.48		.075	.035	
GENDER	-.075	-.038		.89	.45	
AGE	-.059	-1.12		-.049	-.99	
FARMEXP	.065	1.10		.039	.711	
EXPCROP	.13	1.97**	.078	.13	1.95*	.074
HIGHEDU				-.46	-.89	
YRSSCH	-.079	-.88				
VIL2MKT	.062	.66		.025	.29	
VIL2ROAD	-.20	-1.58		-.21	1.69*	-.123

FAM2ROAD	-.14	-1.21		-.11	-.96	
VIL2SEED	-.013	-.40				
VIL2FERT	-.017	-.47				
TIM2SEED				-1.20	-2.46***	-.696
TM2FERT				-1.21	-2.45***	-.697
VIL2COMK	.061	1.63		.055	1.39	
SDCOPERC	-1.10	-1.38		-1.34	-1.83*	-.769
FERCOPER	-.48	-.53		-.45	-.52	
SDACCESS	-.19	-.52		-.43	-.98	
FERACCES	-.20	-.51		-.14	-.32	
NEXTVST	.37	2.29**	.209	.37	2.43***	.211
PRCINFO	2.46	1.11		2.59	1.18	
SUPLINFO	-1.36	-.60		-1.26	-.55	
VISRES	-.47	-.23		-1.05	-.49	
VISEXT	-.82	-.79		-.67	-.62	
CREDEXT	-1.03	-.82		-1.69	-1.27	
FERTEXT	-.98	-.46		-.55	-.25	
VAREXT	-.61	-.40		-.69	-.42	
PESTEXT	2.01	1.03		1.99	1.03	
MEMBSHP	-.12	-.12		.14	.14	
TENURE	-.82	-.77		-.99	-.92	
HHSIZE	.14	.91		.10	.57	
CONSTANT	-.70	-.18		-.76	-.19	
Log likelihood function:			-35.348			-34.57
Likelihood ratio test:		df= 28	54.57***		df=28	56.11***
Estrella R-Square:			.545			.559
Maddala R-Square:			.451			.460
Graig-Uhler R-Square:			.603			.616
Mcfadden R-Square			.436			.448
Chow R-Square			.496			.507

++for only coefficients that are statistically significant at the 1%, 5% or 10% level.
***significant at the 1% level, **significant at the 5% level, *=significant at the 10% level

The Yam minisett

Model 1 in Table 37 has been selected as the lead equation based mainly on the number of statistically significant explanatory variables and empirical signs on the regression coefficients. The explanatory variables that are statistically significant at varying levels are village distance to the fertilizer source, seed cost perception, visit to an agricultural research station, availability of information on the crop variety and membership of farmer association. These coefficients conform to the a priori expectations about their algebraic signs.

Elasticities were computed at the means for those variables that were significant at no more than the 10% level, and presented in column 4 of Table 37. A unit increase in the village distance to the fertilizer source decreases adoption by 0.038, while a unit increase in seed cost perception decreases adoption by 0.80. A visit to an agricultural research station increases adoption by 1.03, while availability of information on the crop variety increases adoption by 1.36. Membership of farmer association increases adoption by 1.09.

Table 37: Estimated logit models for the adoption of yam minisett

variable	Model 1			Model 2		
	coef.	asy. t-value	elasticity at the mean(++)	coef.	asy. t-value	elasticity at the mean(++)
RESPHHH	1.79	1.07		2.20	1.36	
GENDER	-1.39	-1.22		-1.30	-1.17	
AGE	-.018	-.35		-.044	-.97	
FARMEXP	-.034	-.54		-.036	-.68	
EXPCROP	-.012	-.20		.0042	.077	
HIGHEDU	0.10	1.16		.50	1.09	
YRSSCH						
VIL2MKT	.12	.92		.097	.80	
VIL2ROAD	.045	.72		.047	.71	
FAM2ROAD	.045	.76		.040	.66	
VIL2SEED	.011	.19				
VIL2FERT	-.078	-1.64*	-.038			
TIM2SEED				.17	.57	
TM2FERT				-.25	-1.03	
VIL2COMK	.022	.32		.043	.68	
SDCOPERC	-1.65	-1.68*	-.80	-1.29	-1.42	
FERCOPER	.21	.12		-.24	-.14	
SDACCESS	-.37	-.84		-.52	-1.26	
FERACCES	.39	.78		.33	.69	
NEXTVST	.058	.23		-.011	-.046	
PRCINFO	-.046	-.026		-.061	-.035	
SUPLINFO	0.59	1.61		.61	.38	
VISRES	2.12	2.09**	1.03	2.14	2.19**	1.06
VISEXT	-.58	-.56		-.80	-.76	
CREDEXT	-.62	-.56		-.84	-.80	

FERTEXT	.12	.12		.02	.028	
VAREXT	1.86	2.36***	1.36	1.62	1.18	
PESTEXT	.89	.71		1.13	.91	
MEMBSHP	2.25	1.84*	1.09	1.99	1.67*	.987
TENURE	.20	.18		.20	.19	
HHSIZE	.12	.92		.11	.74	
CONSTANT	-9.78	-1.35		-5.52	-.88	
Log likelihood function:			-43.21			-44.18
Likelihood ratio test:	df=28		52.22***		df=28	50.26***
Estrella R-Square:			.481			.464
Maddala R-Square:			.407			.395
Graig-Uhler R-Square:			.542			.526
Mcfadden R-Square			.377			.363
Chow R-Square			.445			.415

++for only coefficients that are statistically significant at the 1%, 5% or 10% level.
***significant at the 1% level, **significant at the 5% level, *=significant at the 10% level

3.6 Qualitative and Quantitative impact assessments

Food security assessments

Two perceptions or assessments of food insecurity are presented in this report. Table 38 is a broad assessment of whether the respondent experience food insecurity any time during the year. Then, Table 39 attempts to show the months during which there is food insecurity. The assessments are obtained from both adopters and non-adopters of the technologies under study.

From the viewpoint of beneficiary impact assessment of an innovation, the expectation is that adopters should be less food insecure than the non-adopters. However, the results in both Tables 38and 39 are largely mixed and non-conforming to this expectation. In Table 38, all the adopters and non-adopters of the coconut variety under study experience food insecurity in some months of the year. In the same table, slightly more non-adopters of the yam minisett indicate experience of food insecurity in some months of the year. The results for the Soyabean and tomato varieties under study appear to conform to our stated expectations.

The results for the month-specific assessments (Table 39) are again mixed. Taking the average across the months (shown in the last row), the only conformity to our expectation is the assessment on the tomato variety. Figure 7 provides additional illustration of the results in Table 39.

Table 38: Percentage distribution of respondents by experience of food insecurity in some months of the year

Commodity / technology	Type of respondent	Number indicating "Yes"	Percent
Coconut / Green dwarf	Adopters (N=50)	50	100.0
	Non-adopters (N=50)	50	100.0
Soyabeans / TGX- 1448-2E	Adopters (N=50)	42	84.0
	Non-adopters (N=50)	43	86.0
Tomato / JM94/54	Adopters (N= 41)	32	78.0
	Non-adopters (N=50)	43	86.0
Yam / minisett	Adopters (N=50)	42	84.0
	Non-adopters (N=50)	35	70.0

Table 39: Percentage distribution of respondents by experience of food insecurity in specified months

Month	Green dwarf (coconut)		TGX- 1448-2E (Soyabeans)		JM94/54 (tomato)		Minisett (yam)	
	Adopters (n=50)	Non-adopters (n=50)	Adopters (n=50)	Non-adopters (n=50)	Adopters (n=41)	Non-adopters (n=50)	Adopters (n=50)	Non-adopters (n=50)
April	100.0	100.0	100.0	94.0	78.0	84.0	80.0	76.0
May	100.0	100.0	100.0	98.0	78.0	80.0	86.0	76.0
June	100.0	100.0	100.0	98.0	70.7	90.0	86.0	82.0
July	100.0	100.0	100.0	98.0	75.6	86.0	92.0	82.0
August	100.0	100.0	100.0	98.0	43.9	60.0	90.0	82.0
Sept	100.0	100.0	100.0	98.0	39.0	52.0	80.0	84.0
Oct	100.0	100.0	100.0	98.0	36.6	50.0	72.0	72.0
Nov	100.0	100.0	100.0	98.0	70.7	90.0	86.0	82.0
Dec	100.0	100.0	100.0	98.0	75.6	86.0	92.0	82.0
Jan	100.0	100.0	100.0	98.0	43.9	60.0	90.0	82.0
Feb	100.0	100.0	100.0	98.0	39.0	52.0	80.0	84.0
March	100.0	100.0	100.0	98.0	36.6	50.0	72.0	72.0
Average	100.0	100.0	100.0	97.7	57.3	70.0	83.8	79.7

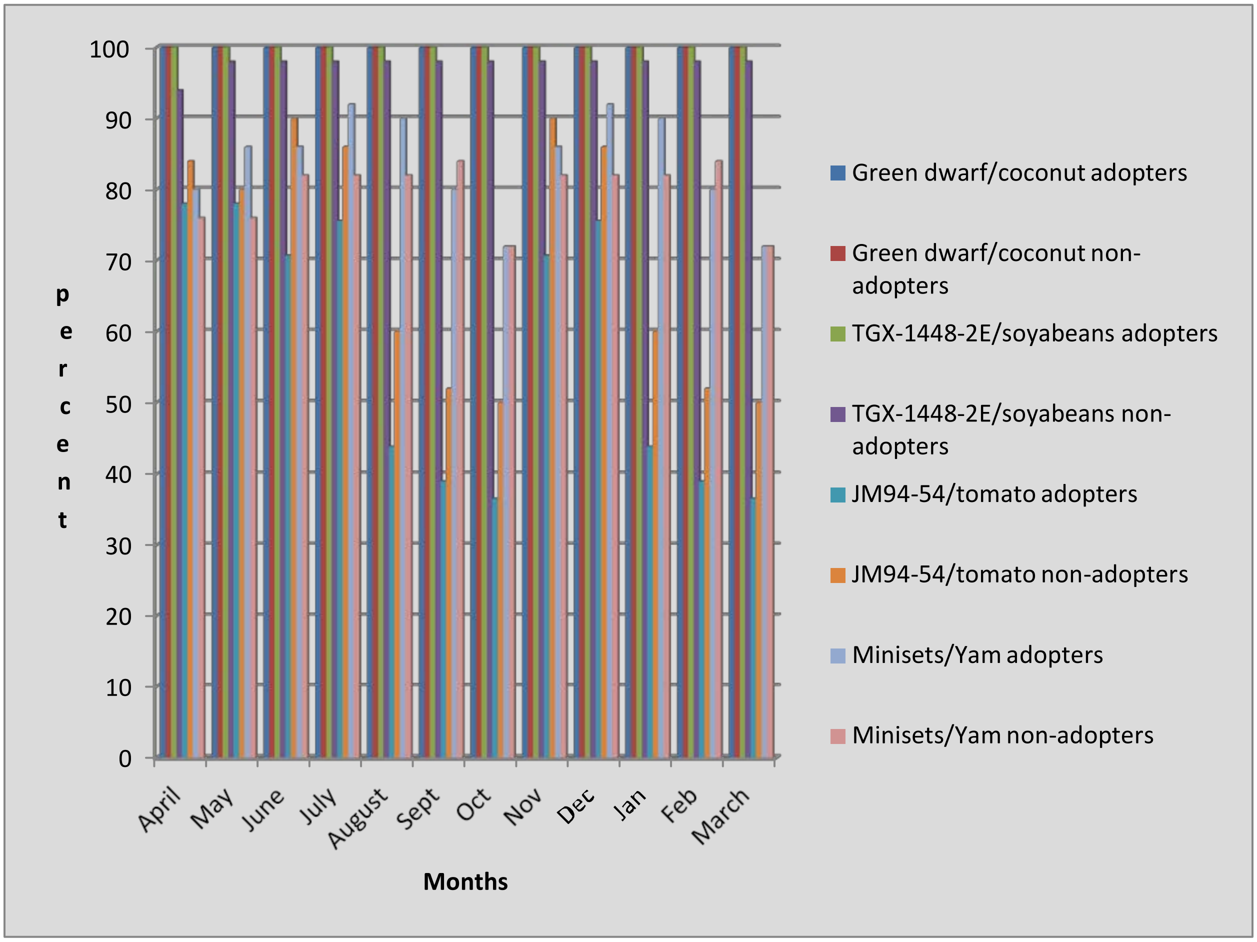

Fig. 7: percentage distribution of respondents by experience of food insecurity in specified months

Poverty analysis of technology adoption behavior

Table 40 shows the poverty decomposition among the adopters and non-adopters of the technologies under study. The poverty indices are computed following the procedures outlined under the methodology section. By way of reminder the poverty gap and severity indices indicate worsening poverty as they approach 1. A common poverty line was used across technologies and adoption behaviour, for ease of comparison. The analysis is often based on either expenditure or income data. But, since both sets of data were solicited and obtained, the analysis was based on both welfare data.

Green dwarf (coconut)
The expenditure-based analysis shows that 96% of the adopters are poor while all the non-adopters are poor. The income-based analysis shows that only 26% of the adopters are poor while 64% of the non-adopters are poor. Both expenditure- and income-based poverty gap indices indicate worsening poverty towards the non-adopters.

TGX- 1448-2E (Soyabeans)
The expenditure-based analysis shows that, relative to the poverty line, all the adopters and non-adopters are poor. The income-based analysis shows that 78% of the adopters are poor while all the non-adopters are poor. Both expenditure- and income-based poverty gap indices indicate worsening poverty towards the non-adopters.

JM94/54 (tomato)
The expenditure-based analysis shows that 92.7% of the adopters are poor while 94% of the non-adopters are poor. The income-based analysis shows that 63.4% of the adopters are poor while 78% of the non-adopters are poor. Both expenditure- and income-based poverty gap indices indicate worsening poverty towards the non-adopters.

Minisett (yam)
The expenditure-based analysis shows that 54% of the adopters are poor while 76% of the non-adopters are poor. The income-based analysis shows that 44% of the adopters are poor while 58% of the non-adopters are poor. Both expenditure- and income-based poverty gap indices indicate worsening poverty towards the non-adopters.

This report avoids comparing poverty indices between the technologies since the underlying data was collected from different agro-ecologies and the households do not share a common enterprise portfolio. However, it is significant that the income-based analysis portrays less poverty than the expenditure-based analysis, using all the indices available. It is not clear which of the welfare indicators to prefer, but it is generally expected that households will be more forthcoming with their expenditure than their income information.

Figures 8 and 9 provides the further presentation of the results in Table 40.

Table 40: Decomposition of poverty based on expenditure and income among adopters and non-adopters of technologies

Commodity/ Technology	Type of respondent	Expenditure-based poverty decomposition			Income-based poverty decomposition		
		Incidence **	Gap	Severity	Incidence **	Gap	Severity
Coconut/ Green dwarf	Adopters	0.96	0.608	0.407	0.26	0.076	0.031
	Non-adopters	1.00	0.715	0.526	0.64	0.299	0.149
Soyabeans / TGX- 1448-2E	Adopters	1.00	0.591	0.418	0.78	0.329	0.194
	Non-adopters	1.00	0.838	0.721	1.00	0.681	0.522
Tomato / JM94/54	Adopters	0.927	0.632	0.476	0.634	0.325	0.253
	Non-adopters	0.94	0.774	0.672	0.78	0.537	0.411

Yam/ Yam minisett	Adopters	0.54	0.317	0.219	0.44	0.224	0.132
	Non-adopters	0.76	0.466	0.345	0.58	0.319	0.209

**converted to percentage by multiplying by 100.

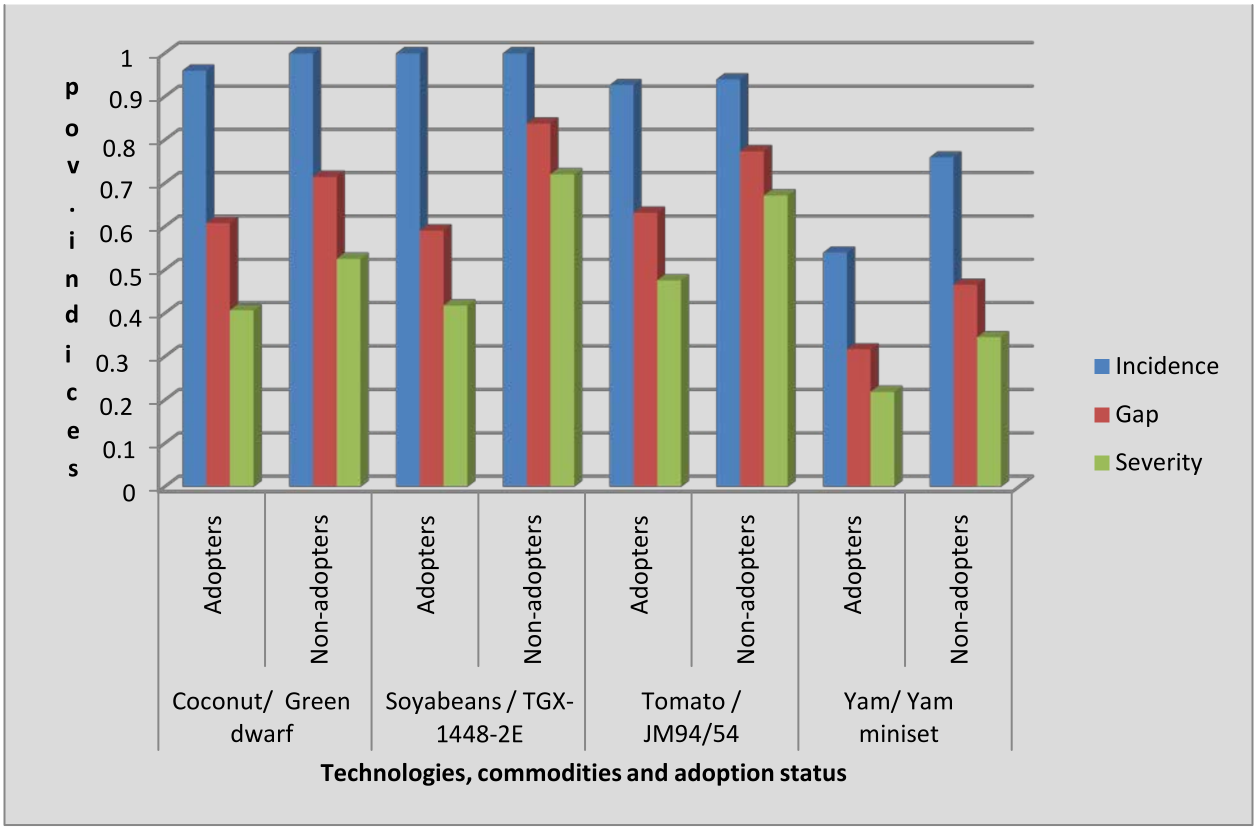

Fig. 8: Decomposition of poverty based on expenditure among adopters and non-adopters of indicated technologies

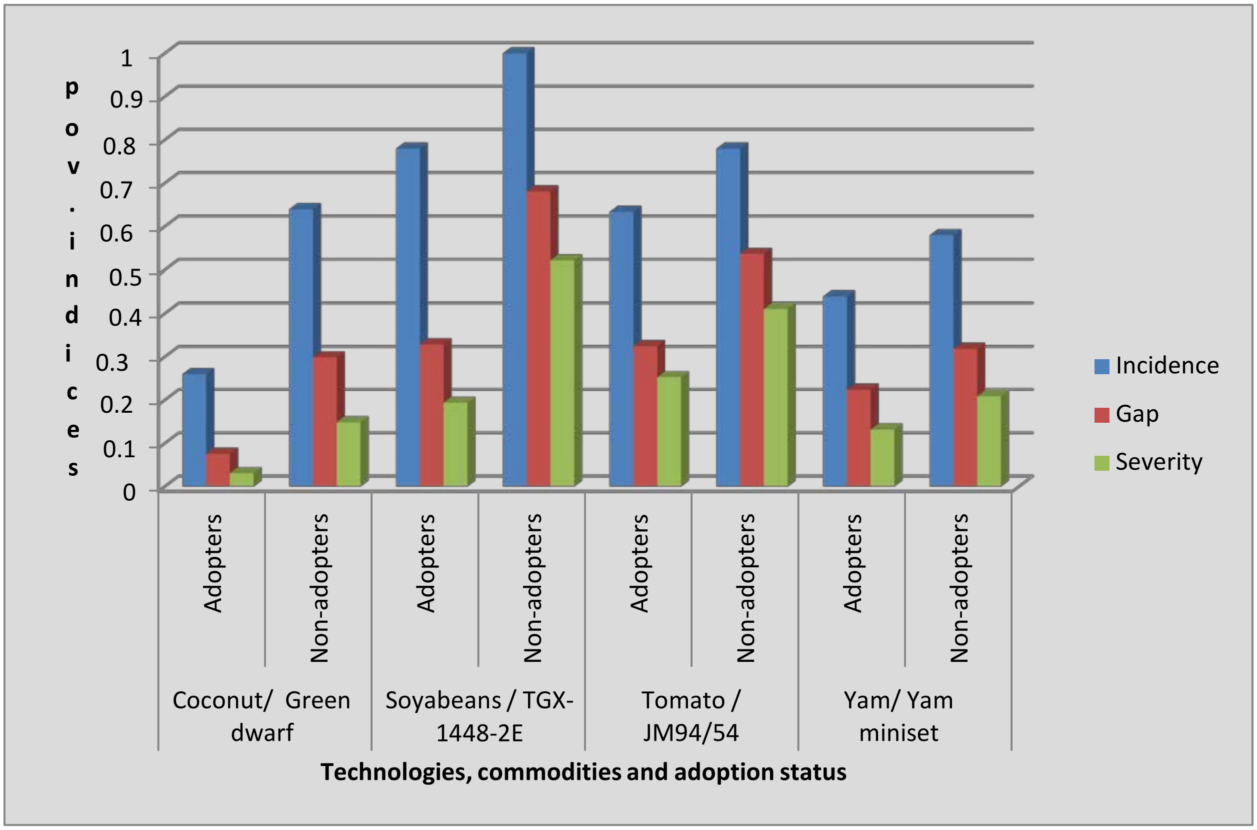

Fig. 9: Decomposition of poverty based on income among adopters and non-adopters of indicated technologies

Impact of technology adoption on expenditure and income of households

The impact of technology adoption on the households was further analyzed using two welfare indicators, income and expenditure. Income is the most commonly used indicator for the analysis undertaken, but expenditure was analyzed since the data was elicited and obtained. Both average treatment effect (ATE) and average treatment effect on the treated (ATT) were estimated for all the technologies, using both income and expenditure data. Estimation of the ATE and ATT was based on STATA's nearest neighbour matching procedures.

For the ATE results in Table 41, both the expenditure- and income-based estimates for the tomato variety were statistically not significant. The same goes for the income-based ATE estimate for the Yam minisett. Turning to Table 42, it is noted that the income-based ATT estimates for the varieties of Soyabeans, Tomato and Yam minisett were either not computable or statistically insignificant. These results are therefore excluded from further discussion.

Average treatment effects (ATE)

Green dwarf (coconut)
In Table 41, the average effect of adoption is an increase in expenditure by N69,374.27 and increase in income by N178,620.

TGX- 1448-2E (Soyabeans)
Table 41 shows that the average effect of adoption is an increase in expenditure by N91,620.44 and increase in income by N142,239.60.

Minisett (yam)
Table 41 shows that the average effect of adoption is an increase in expenditure by N406,982.80.

Table 41: Estimated Average Treatment Effect (ATE) using the nearest neighbour matching method

Commodity/ Technology	Outcome variable: total expenditure (household)**				Outcome variable: total income (household) **			
	Coef.	Std. err.	Z score	P > |z|	Coef.	Std. err.	Z score	P > |z|
Coconut/ Green dwarf	69,374.27	21,019.92	3.30	.001	178,620.00	80,567.14	2.22	.027
Soyabeans / TGX- 1448-2E	91,620.44	28,125.85	3.26	.001	142,239.60	43,713.09	3.25	.001
Tomato / JM94/54	105,353.30	71,380.40	1.48	.140	-132,226.70	235,986.80	-0.56	.575
Yam/ Yam minisett	406,982.80	222,453.60	1.83	.067	119,040.40	137,059.20	.870	.385

**Matching variables: headship of household, age, household size, farming experience, experience with the crop, years of formal schooling

Average treatment effects on the treated (ATT)

While ATE is computed across both beneficiaries and non-beneficiaries of a program intervention, the ATT is computed relative to only beneficiaries.

Green dwarf (coconut)
In Table 42, it has been shown that on the average, the expenditure of the adopters increases by N78,656.90, while the income increases by N150,726.70.

TGX- 1448-2E (Soyabeans)
As shown in Table 42, the effect of adoption on the adopter's expenditure is an increase of N120,851.40. The average increase in income could not be computed with the available data.

JM94/54 (tomato)
On the average, the expenditure of adopters increases by N139,532.90. The average increase in income is not significant statistically.

Minisett (yam)
The expenditure of the adopters increases, on the average, by N432,649.30. The average increase in income is not significant statistically.

Looking at both Tables 41 and 42 we see that, for the expenditure-based impact estimation, the adoption of the Yam minisett yielded the largest average effect on the household's expenditure. A similar inference cannot be drawn from the income ATT and ATE estimates since they were mostly either non-computable or non-significant statistically.

Table 42: Estimated Average Treatment Effect on the Treated (ATT) using the nearest neighbour matching method

Commodity/ Technology	Outcome variable: total expenditure (household)**				Outcome variable: total income (household)**			
	Coef.	Std. err.	Z score	P > |z|	Coef.	Std. err.	Z score	P > |z|
Coconut/ Green dwarf	78,656.90	30,013.85	2.62	.009	150,726.70	81,181.05	1.86	.063
Soyabeans / TGX- 1448-2E	120,851.40	30,392.47	3.98	.000	ATT option not allowed by available data			
Tomato / JM94/54	139,532.90	60,147.51	2.32	.020	83,849.59	143,799.20	.580	.560
Yam/ Yam minisett	432,649.30	216,878.20	1.99	.046	187,980.00	136,914.90	1.37	.170

**Matching variables: headship of household, age, household size, farming experience, experience with the crop, years of formal schooling

4. Conclusions

Continuous cultivation is still prevalent under the various farming systems supporting the technologies studied. The cropping systems recommended for the adoption of the technologies were not adhered to by the adopters. It will be of policy relevance to determine the factors responsible for this divergence.

Across the technologies studied, the adoption-enhancing factors were determined to include access to seeds, visits by agricultural extension agents, visits to agricultural research and extension stations, availability of extension advice / information on credit, varieties and membership of farmer organizations. The factors that negate the adoption of the technologies studied include seed cost, distance to good roads, and time to input sources.

The overall indication from the poverty analysis undertaken is that poverty among the households worsened towards non-adoption. Similarly, significant monetary benefits were found to be associated with technology adoption by households, based on the available impact estimation methods.

References

Alberto Abadie, David Drukker, Jane Leber Herr, Guido W. Imbens. 2001. Implementing Matching Estimators for Average Treatment Effects in Stata, The Stata Journa,lNumber 1, pp. 1–18

Alston, J.M., Norton, G.W. and Pandey, P.G. 1995. Science under scarcity: Principles and practices for agricultural research evaluation and priority setting. Cornell University Press, Ithaca.

Angrist, J. 1990. Lifetime earnings and the Vietnam era draft lottery: evidence from social security administrative records. American Economic Review 80, 313–35.

Angrist, J. 1991. Grouped-data estimation and testing in simple labor-supply models. Journal of Econometrics 47, 243-266.

Angrist, J. 1998. Estimating the labor market impact of voluntary military service using Social Security data on military applicants. Econometrica 66, 249–88.

Batz, F.J., Jansen, W. and Peters K.J. 2003. Predicting technology adoption to improve research priority setting, Agricultural Economics 28: 151-164

Batz, F.J., Peters,K.J. and Jansen, W. 1999. The influence of technology characteristics on the rate and speed of adoption, Agricultural Economics 21(2): 121-130.

Bloom, Howard, Charles Michalopoulos, Carolyn Hill and Ying Lei, (20002), "Can Non Experimental Comparison Group Methods Match the Findings from a Random Assignment Evaluation of Mandatory Welfare-to-Work Programs?" , MDRC Working Papers on Research Methodology.

Belbase, K.P. 1992. Agricultural technology, income and nutrition: A study of farm households in the middle hills of Nepal, Dissertation Abstracts International, Humanities and Social Sciences Vol. 52 (8):pp3008.

Diaz, Juan Jose & Handa, Sudhanshu. 2004. An Assessment of Propensity Score Matching as a Non Experimental Impact Estimator: Evidence from a Mexican Poverty Program.

Doss, C.R. and Morris, M.L. 2001. How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana, Agricultural Economics 25(1):27-39.

Floyd, C.N., Harding, A.H., Paddle, K.C., Rasali, D.P., Subedi, K.D., Subedi, P.P. 1999. The adoption and associated impact of technologies in the western hills of Nepal. Overseas Development Institute Agricultural Research and Extension Network Paper # 90.

Gebreemedhin, B. and Swinton, S.C. 2003. Investment in soil conservation in northern Ethiopia- the role of land tenure security and public programs, Agricultural Economics 29: 69-84.

Heckman, James, Hidehiko Ichimura, and Petra Todd (1997) "Matching as an Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Program,." Review of Economic Studies. 64: 605-654.

Heckman, James, Hidehiko Ichimura, and Petra Todd (1998) "Matching as an Econometric Evaluation Estimator." Review of Economic Studies. 65: 261-294.

Heckman, James J. and Robb, R. 1985. Alternative methods for evaluating the impact of interventions. In J. Heckman & B. Singer (Eds.), Longitudinal Analysis of Labor Market Data (pp. 156-245). New York: Cambridge University Press.

Herath, P.H.M.U. and Tekeya, H. 2003. Factors determining intercropping by rubber smallholders in Sri Lanka: a Logit analysis, Agricultural Economics 29: 159-168.

Jeff Wooldridge. J. 2009. Estimating Average Treatment Effects:Introduction, BGSE/IZA Course in Microeconometrics, Michigan State University.

Idachaba, F.S. 2006. Good intentions are not enough, Collected Essays on Government and Agriculture, vol.3: Agricultural Research, Uncertainty and Diversification, Ibadan: University Press PLC, 292pp.

Lapar, M.A. and Pandey, S. 1999. Adoption of soil conservation: the case of the Philippine uplands, Agricultural Economics 21(2):241-256.

Malla, P.B. 1993. Logit analysis of technology adoption by rice farmers in Dhanusha District, Nepal. HMG-USAID-ADC project on strengthening institutional capacity in the food and agricultural sector in Nepal, Research paper Series # 22.

Masters W.A. 1996. The Economic Impact of Agricultural Research: A Practical Guide. Department of Agricultural Economics, Purdue University.

Narayan-Parker, D., with R. Patel, K. Schafft, A. Rademacher, and S. Koch-Schulte. 2000. *Can anyone hear us? Voices of the poor*. Washington, D.C.: World Bank.

Shakya, P.B. and Flinn, J.C. 1985. Adoption of modern varieties and fertilizer use on rice in eastern tarai of Nepal, Journal of Agricultural Economics 36(3): 409-419.