FARMERS' ADOPTION POTENTIAL OF IMPROVED BANANA PRODUCTION TECHNIQUES IN MALAWI

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ABSTRACT:

Bananas and plantains are important for food security and income, but they are beset with numerous abiotic and biotic challenges that drastically reduce yield. Consequently, a range of technologies have been developed to tackle the various constraints. This study was carried out to determine the adoption potential of improved banana cultivars by smallholder farmers in Malawi. The study was carried out in five major banana production districts of Mulanje, Thyolo, Nkhata Bay, Karonga and Chitipa. Structured questionnaires were administered to 118 farmers in order to obtain data on several variables including; education level, experience in banana farming, income from bananas, proportion of land given to bananas, names and number of cultivars grown, preferred cultivars, and willingness to adopt new cultivars. The results showed that the majority of farmers in the south, unlike in the north, are aware of and willing to adopt improved cultivars. Region, experience in banana farming and awareness of improved banana cultivars were significant predictors of adoption of modern banana cultivars ($p \leq 0.05$). The level of diversity of cultivars on the farm informed farmer's cultivar preferences and socio-economic needs met by such diversity. It was also evident, that levels of acceptance of a new agricultural technology hinges on how far it addresses farmers' agronomical problems and leads to increased production and profit.

Keywords: Bananas and Plantains cultivars, adoption, improved banana cultivars

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INTRODUCTION:

Socio-economic importance of bananas and plantains

In Malawi, bananas and plantains are a source of income to smallholder farmers, middlemen and transporters. Over 100,000 farmers are involved in banana production and more than 40% are women. In the northern parts of Malawi (Songwe and Misuku hills), bananas are a staple food. Cultivars used include cooking bananas (Bluggoe and Pisang awak, both ABB genome) and plantains (both French and Horn plantains, AABs). In Thyolo, Mulanje and Nkhata Bay, Cavendish cultivars (*Mulanje* and *Kabuthu*, with AAA genome) are major sources of cash to smallholder farmers (Gondwe, 2004, Laisnez, 2005). Bananas are ranked sixth in Malawi after maize, rice, groundnuts, vegetables and beans in terms of food security and income generation (Gondwe and Banda, 2002). Though bananas are important for food security and income, their production is strained by numerous abiotic and biotic challenges that drastically reduce yield. The challenges include drought, poor soils, inferior cultivars, poor crop husbandry practices, diseases and pests. Consequently, a range of technologies have been developed to tackle the various constraints threatening the banana industry.

Farmers' crop diversity and technology adoption

Adoption of any new technology carries with it an element of risk because of lack of familiarity and experience with the technology. Adoption models in agriculture emphasize the role of risk and uncertainty in the adoption decisions and demonstrate a tradeoff between yield mean and variance (Feder, 1980; Just and Zilberman, 1983). Depending on how farmers evaluate the tradeoff between yield and variance, they may choose to diversify their crop portfolio with lower-yielding traditional crops instead of adopting new varieties on a large scale (Arslan, 2005). Earlier studies have identified other determinants of crop technology adoption such as agro-ecological constraints, credit or cash access constraints, labour market constraints, safety-first considerations or traditional values; mental health of a farmer, age of farmer, extension contact (Zimmerer, 1991; Bellon and Taylor, 1993; Smale *et al*., 1994; Thangata and Alavalapati, 2003; Hounsome *et al*., 2006; Langyintuo and Mungoma, 2008).

Adoption of biotechnological innovations

Debate has raged on at international level as to whether biotechnology can make a difference in uplifting the living standards of the poor in the third world countries (Qaim and de Janvry, 2002). The first generation biotechnologies like tissue culture have proved useful elsewhere worldwide. In Kenya, results of a socio economic evaluation of the impact of the introduction and adoption of tissue-culture (tc) technology in banana production has shown that tc banana production is relatively more capital intensive than non-tc banana production (70% fixed costs for tc banana as opposed to 49% fixed costs for non-tc banana). However tc banana offered relatively higher financial returns than non-tc banana (Mbogoh *et al*., 2003). High profitability of tc banana despite relatively higher capital investment, resulted in farmer adoption of tc banana production. This means that new biotechnological innovations in farming could be adopted if they make a positive contribution to the socioeconomic status of poor farmers in a developing country.

Smale and De Groote (2003) contend that diagnostic research, the investigation of potential problems and their solution, is essential in helping to create an enabling environment for promising biotechnology products in smallholder agriculture well before release. The need for diagnostic research is supported by past lessons from conventional breeding which show that social and economic constraints on the part of the farmer can impede the adoption of promising new crop varieties (Tripp, 2003). The social and economic constraints are poorly developed markets for planting material, weak institutions for diffusing the technology, extreme poverty and cash flow problems such as those prevalent among smallholder farmers of Sub-Saharan Africa which have often thwarted their ability to benefit from varieties that perform well under their local conditions (Smale and Jayne, 2003). It is speculated that biotechnology products that hold promise for the poor in Sub-Saharan Africa are those that tackle economically important, biotic or abiotic problems not easily addressed through conventional plant breeding. This observation is likely to emerge in crops that serve for food as well as cash, while posing little risk or endangering trade (Smale and De Groote, 2003). For instance, Lemchi *et al*. (2005) found that a banana hybrid (PITA 14 produced by IITA) had high adoption potential because it was resistant to Black Sigatoka. Trials of the hybrid under farmer managed system, which involved 36 farmers proved that PITA 14 had higher resistance index to Black sigatoka (96%) against

Agbagba's (best landrace) (48%). Further, the mean bunch weight was 13.3 kg for PITA 14 and 7.0kg for Agbagba and each farmer got $8.62 from PITA 14 compared $ 4.33 from Agbagba. The superiority of the hybrid over the landrace in terms of disease resistance and economic outcomes was essential to its high adoption rate. Thus, farmers' subjective assessment and perceptions of agricultural technologies and their attributes influence adoption decisions and behaviour (Adesina and Baidu-Forson, 1995).

Rationale for studying adoption potential of banana farmers

The banana industry in Malawi encounters several production constraints and some means of controlling and minimizing the challenges have been applied by farmers including the use of highly priced chemicals for controlling pests and diseases. But generally, banana farmers in Malawi have done little or nothing to reduce the effects of the challenges to banana yields. This has been the case mostly because they are predominantly poor smallholder farmers who can not afford high-costing chemicals and methodologies to control pests and diseases. There is need to provide alternative long term solutions to the problems facing banana farmers. Coincidentary, there is an upsurging demand by farmers for new improved varieties with resistance to abiotic and biotic factors devastating the banana sector. Various technologies have been employed to improve bananas ranging from conventional breeding to genetic engineering resulting in variously performing cultivars awaiting farmer adoption. Lemchi *et al.* (2005) indicated that a combination of disease resistance and increased yield by improved cultivars was suggestive of high adoption potential. Contrary to the findings of Lemchi *et al*. (2005), Smale and De Groote (2003) argued that apart from the performance of the technology, many factors that have incidence at national, regional and farm levels will affect the likelihood that farmers will adopt improved cultivars specifically transgenic varieties. Given the intricacy of technology adoption issues, this study aimed assessing the adoption potential of improved banana cultivars by farmers in Malawi.

MATERIALS AND METHODS:

Data collection

The study was conducted in five major banana producing districts in Malawi; Mulanje, Thyolo in south and Nkhata Bay, Karonga and Chitipa in the north. A structured, questionnaire was used and respondents were identified at random based on ownership of a considerably big field of bananas. Using a Purposeful model of sampling, which according to Patton (1990) involves selection of information rich cases for in depth study, questionnaires were administered among farmers in different banana hotspots in all the five districts. A total of 118 questionnaires were administered (Table 1). Data on 108 variables were collected which included age, education level, experience in banana farming, income generated, proportion of land given to bananas, name and number of cultivars grown, preferred cultivars, constraints, diseases and pests known, indigenous knowledge used and willingness to adopt new improved cultivars.

Table 1 Number of questionnaires administered in the study areas.

District	Number of Respondents	Other Comments
Mulanje	32	Major banana growing area
Thyolo	33	Major banana growing area
Nkhata Bay	12	Mpamba area is a major banana area in Nkhata Bay but farmers were not interviewed because the Village Chief in T.A. Timbiri did not grant permission
Karonga	21	Farmers were very cooperative
Chitipa	20	Misuku Hills area was the only major banana growing area in the district

Data handling and analysis

Data collected were coded and entered into Statistical Package for Social Scientists (SPSS 13.0 for window). SPSS was used to analyse the data to come up with descriptive statistics, generate cross tabulations in order to examine relationships between variables and compute statistical tests of significance such as Fisher's Exact Test. Microsoft Excel and SPSS were used to generate graphs.

A Binary Logistic Regression Model (BLRM) was employed to identify predictor variables (Independent Variables) associated with adoption of improved modern banana cultivars. The model was suitable because adoption is a non-continuous dichotomous dependent variable. Additionally, the model was also relevant because the predictor variables were categorical. Given that the relationship between the predictor variables and the response variable (dependent variable) is not a linear function in logistic regression, therefore the predictor variables do not have to be normally distributed, linearly related or of equal variance within each group. This implies that any mixture of predictor variables can be used (Agresti, 1996; Tabachnick and Fidell, 1996; Hosmer and Lemeshow, 2000). The BLRM generated coefficients (and its standard errors and significance levels) which were used to predict a logit transformation of the probability of adoption of improved modern banana cultivars (Pampel, 2000):

$$\text{logit}(p) = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + \ldots + b_k X_k$$

where p is the probability of adoption of improved modern banana cultivars, b_0 is the constant of the equation, $b_{0\text{-}k}$ are the coefficients of the predictor variables and $X_{1\text{-}k}$ are predictor variables. The logit transformation is defined as the logged odds:

$$\text{odds} = \frac{p}{1-p} = \frac{\text{probability of presence of characteristic}}{\text{probability of absence of characteristic}}$$

$$\text{logit}(p) = \ln\left[\frac{p}{1-p}\right]$$

The predictor variables were:

X_1=Region of the respondent

X_2=Sex of the respondent

X_3=Age of the respondent

X_4=Marital status of the respondent

X_5=Educational level of the respondent

X_6=Household head of the home of the respondent

X_7=Banana farming experience of the respondent

X_8=Experience of any cropping pattern change by the respondent

X_9=Desire to improve banana yield by the respondent

X_{10}=Willingness to diversify farming methods by the respondent

X_{11}=Visitation by agricultural extensionists

X_{12}=Awareness of improved banana cultivars by the respondent

X_{13}=Awareness of GMOs by the respondent

It is generally agreed that a regression that uses multiple predictor variables should have a large number of observations (cases or respondents). The number of cases must substantially exceed the number of predictor variables used in the regression. A ratio of 10:1 (cases: predictor variables) is generally more acceptable though others prefer a 40:1 ratio (Brace *et al.*, 2006). In order to fit in with these recommendations, 13 predictor variables were used in this study. Within the 13 predictor variables, four were categorical with many levels which the model used to create dummy variables included in the model bringing the total to twenty-two. These were divided into three groups and used in three separate logistic regressions with the same outcome variable. The total number of cases in this study was 118. The first two groups of predictor variables had nine and eight variables each resulting in cases: predictor variables ratio of 13:1, 15:1, respectively, and the last group had five predictor variables with a 24:1 ratio.

RESULTS AND DISCUSSION:

Adoption potential of new banana production techniques products (Tetraploid hybrids, tissue culture bananas and genetically modified banana)

New technologies are employed in any field to address challenges faced by that field. In the case of banana production in Malawi, this study engaged farmers to find out from them whether they thought their traditional banana cultivars had deficiencies. In the north 52.8% and in the south 47.7% of the farmers identified deficiencies in their cultivars while 47.2% and 52.3% in the north and south respectively thought that the cultivars had no inadequacies. Among northern farmers who identified deficiencies with their cultivars, 22.6% and 30.2% cited low yield and lack of drought resistance, respectively. In the south, 20.0%, 20.0%, 6.2% and 1.5% cited late ripening, lack of drought resistance, low yield and unmarketability of some cultivars as deficiencies respectively. Admittance and identification of deficiencies of cultivars by farmers is part of a problem solving equation because it amounts to problem identification. De Groote *et al*. (2004) found that where farmers clearly discern a pest and the damage it does to produce, for instance stem borer and the resultant loss in maize, they are willing to take on a technology that will address the problem. Therefore correct identification of cause and effect of a pest or a disease is one step forward towards adoption of a preventive technology. A good example of incorrect identification of cause and effect of a disease in banana production is a case where farmers often attribute the visible damage caused by Fusarium wilt, a soil borne fungus, as well as nematodes, to banana weevils and vice versa (Gold *et al*., 1993). This kind of confusion makes farmers not to appreciate the dangers of *Fusarium wilt* and would therefore hinder quick adoption of *Fusarium wilt* resistant cultivars.

The farmers in study areas were asked if they were aware of improved banana cultivars through modern techniques such as conventional breeding, tissue culture and genetic modification which would address some of their cultivars deficiencies. In Mulanje 71.9% of farmers were aware, while in Thyolo 78.8% were aware of improved cultivars. In the north awareness was low with 91.7%, 100%, 95% of farmers in Nkhata Bay, Karonga and Chitipa respectively indicating lack of awareness of banana cultivars improved through modern science techniques.

In order to determine whether farmers knew about genetic modification as a way of improving crop varieties, farmers were asked to indicate if they had ever heard about genetically modified organisms (GMOs) in general and GM banana in particular. The majority of farmers in the north (98.1%) had heard nothing about GMOs while in the south, 50.8% knew about GMOs and 49.2% did not. Lower awareness of modern cultivars in the north than in the south cannot necessarily be attributed to insufficient extension services because 42.1% of farmers in the north and 57.9 % in south indicated that extensionists had ever visited them. It could be that the extensionists in the north do not frequently carry the message on modern cultivars while those of the south do. For instance, all farmers who knew about tissue culture bananas were from the south and they got tissue culture knowledge from BRS extension services yet there is a banana tissue culture facility at Lunyangwa in Mzuzu in the north. Alternatively, low awareness of modern cultivars in the north would be due to level of development of the management regime of bananas. It is subjective to subsistence farming practices as a supplementary crop to major staples for most farmers while in the south, bananas are a cash crop therefore farmers in the south are more likely to search for new technologies that would boost yields than their counterparts in the north. The low awareness of improved banana cultivars is more likely to hinder adoption of good cultivars in north as evidenced by only 18.9% of the farmers who were willing to adopt modern cultivars while 67.9% were undecided because they had no information.

The majority of farmers (89.2%) in the south showed willingness to grow improved banana cultivars on condition that the cultivars were; early maturing and on demand, high yielding, disease resistant and do no harm to the environment. It is apparent that farmers in the south are looking for cultivars that will yield more returns. Though farmers in the south maintain a diversity of cultivars, they are interested more in commercially important Cavendish cultivars whose image is reflected in the description of the kind of improved cultivar they want. While they would still maintain the diversity of cultivars in their fields, adoption of a single, high-yielding hybrid or GM banana is possible.

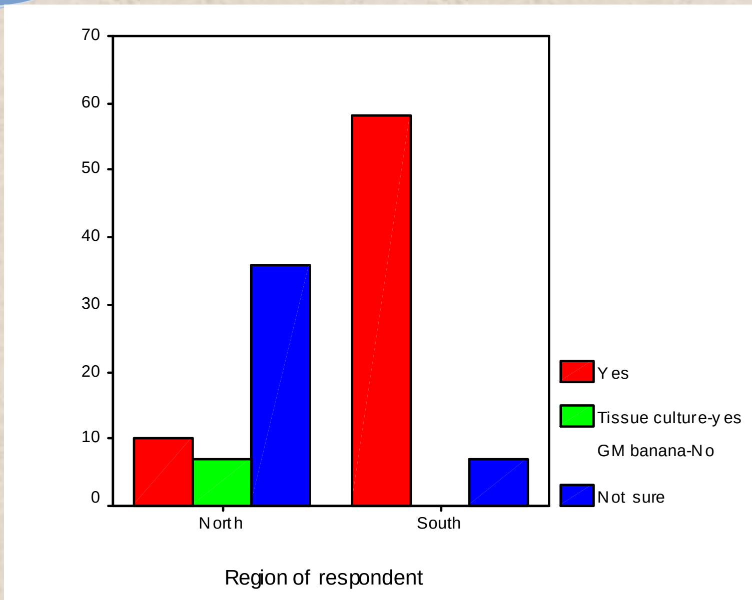

Figure 1 Farmers position on whether they would be willing to grow improved banana cultivars (Hybrids, Tissue culture banana or GM banana).

Table 2a shows banana farmer variable descriptors included in binary logistic regression analyses and Tables 2 (b-d) show the results of the binary logistic regression whose dependent variable was willingness by farmers to adopt improved banana cultivars made through modern techniques. The overall tests of the model in Tables 2(b-d) were statistically significant (LR chi-squared 76.521, p=0.000, with 6df) (LR chi-squared 24.996, p=0.002, with 8df) (LR chi-squared 49.239, p=0.000 with 5df), respectively.

Table 2a Banana farmer variable descriptors included in the analysis.

Farmer variables (dependent)	Name	Variable description
Willingness to adopt modern banana cultivars	Will	Binary variable: 1 Yes; 0 No

Farmer variable (predictor)	Name	Variable description
Region	Region	Binary variable: 1 North; 0 South
Sex	Sexrep	Binary variable: 1 Male; 0 Female
Age	Agerep	Ordinal variable: 1 15-30 years, 2 30-45 years, 3 45-60 years, 0 Above 60 years
Marital status	Maritals	Binary variable: 1 Married; 0 Others
Education level	Educalev	Ordinal variable: 1 Primary school, 2 Secondary

		School, 0 Not indicated
Household head	Namedhd	Binary variable: 1 Male headed; 0 Female headed
Banana experience	Banaexpe	Ordinal variable: 1 < 5years, 2 5-10years, 3 10-15years, 4 15-20years, 0 More than 20 years
Cropping pattern change	Croppach	Binary variable: 1 Yes; 0 No
Desire to improve your yield?	Improyie	Binary variable: 1 Yes; 0 No
Willingness to diversify farming methods	Diversif	Binary variable: 1 Yes; 0 No
Visitation by extensionist	Agrextvi	Binary variable: 1 Yes; 0 No
Awareness of improved banana cultivars	Improban	Binary variable: 1 Yes; 0 No
Knowledge of GMOs	GMO	Binary variable: 1 Yes; 0 No

Table 2b Adoption of improve banana cultivars binary logistic regression of predictor variables (variables in the equation).

Predictor variable	B	Std Error	Wald	df	*P* value	Exp (B)
Region (North)	-4.729	0.807	34.382	1	0.000	0.009
Sex (Male)	-0.018	0.601	0.001	1	0.976	0.982
Age			7.292	3	0.063	
Age (15-30 years)	2.624	1.028	6.517	1	0.011	13.785
Age (30-45 years)	1.149	0.934	1.515	1	0.218	3.155
Age (45-60 years)	1.040	0.989	1.105	1	0.293	2.829
Marital status (Married)	1.106	0.860	1.651	1	0.199	3.021
Constant	0.447	0.823	0.295	1	0.587	1.564

The results in Table 2b indicate that region was a significant predictor of adoption of improved modern banana cultivars. The negative coefficient value on region means that more farmers from north (86.0%) are more likely not to adopt modern cultivars while those of the south (85.3%) have high probability of adopting modern banana cultivars. Region of respondent as a significant predictor of adoption indicates that the south, where farmers are commercially minded and desire more to improve their production, is a place where new technologies will easily be taken up by farmers. In the north farmers are conservative and more rigid to change cultivars probably because familiarity with a cultivar is more important than productivity (data not shown) of the cultivars, since unlike in south banana and plantains are a staple food in the north.

Table 2c Adoption of improve banana cultivars binary logistic regression of predictor variables (variables in the equation).

Predictor variable	B	Std Error	Wald	Df	*P* value	Exp (B)
Education level			8.572	2	0.014	
Education level (Primary school)	-1.919	0.712	7.277	1	0.007	0.147
Education level (Secondary school)	-2.291	0.815	7.893	1	0.005	0.101
Household head (male headed)	-1.240	0.899	1.903	1	0.168	0.289
Banana farming experience			10.685	4	0.030	
Banana farming experience (<5 years)	2.490	0.846	8.657	1	0.003	12.066
Banana farming experience (5-10 years)	0.995	0.573	3.012	1	0.083	2.705
Banana farming experience (10-15 years)	-0.205	0.816	0.063	1	0.802	0.815
Banana farming experience (15-20 years)	0.435	0.608	0.512	1	0.474	1.545
Cropping pattern change (Yes)	-0.952	0.554	2.949	1	0.086	0.386
Constant	2.906	1.112	6.829	1	0.009	18.278

In Table 2c, education level and banana farming experience of the respondent in general were significant predictors of adoption. Within the group of those that did not disclose their education level, a higher percentage (83.3%) of farmers were likely to adopt modern banana cultivars than within the primary (54.1%) and secondary school (50.0%) categories hence negative coefficient values on primary and secondary school groups. Within banana farming experience years groups; <5years (88.2%), 5-10 years (66.7%), and 15-20 years (50%) more farmers are abound to adopt modern banana cultivars hence positive coefficient values while 10-15 years and >20 years groups have negative coefficient values because within these banana farming experience groups less farmers are likely to adopt modern cultivars, 44.4% and 49.1% respectively. The desire by young inexperienced farmers to realize more financial returns from bananas especially in the south would be the driving force towards adoption of new cultivars while the older and more experienced farmers would be contented and would want to maintain the present status in terms of cultivar types and market contacts.

Table 2d Adoption of improve banana cultivars binary logistic regression of predictor variables (variable in the equation).

Predictor variable	B	Std Error	Wald	Df	*P* value	Exp (B)
Desire to improve banana yield (Yes)	0.838	0.710	1.396	1	0.237	2.313
Willingness to diversify farming methods (Yes)	0.009	0.587	0.000	1	0.988	1.009
Visitation by extensionists (Yes)	0.337	0.502	0.452	1	0.502	1.401
Awareness of improved banana cultivars (Yes)	1.849	0.520	12.654	1	0.000	6.356
Knowledge on GMOs (Yes)	2.774	0.809	11.760	1	0.001	16.016
Constant	1.725	0.605	8.136	1	0.004	0.178

Awareness of improved banana cultivars and knowledge on GMOs were other significant predictors of adoption (Table 2d). The positive coefficients on both predictor variables show that more farmers with awareness of improved bananas (94.1%) and knowledge on GMOs (82.4%) were more likely to adopt modern cultivars. Awareness of improved banana cultivars and knowledge of GMOs were other significant predictors of adoption (Table 2d). There is more probability that more farmers (94.1%) with awareness of improved banana cultivars and knowledge of GMOs (82.4%) will adopt modern banana cultivars. Fisher's Exact Test showed a significant relationship between knowledge of GMOs and adoption of modern banana cultivars (Fisher's Exact Test=28.050, p=0.000). These findings suggest that increased exposure and awareness of improved banana cultivars influence farmers' willingness to try new technologies. Farmers in the south have the monopoly of technological exposure compared to those of the north hence their willingness to adopt modern banana cultivars. Another study done in Costa Rica on willingness of people to consume and produce transgenic bananas found that younger, wealthier, consumers with high education and smaller households were more likely to consume transgenic banana and that the consumer's willingness hinge on availability and exposure to information on the nature of the new products, their benefits and risks (Aguilar and Kohlmann, 2006).

Other factors such as age, gender, marital status, cropping pattern change, desire to improve banana yield, willingness to diversify farming methods, and visitations by extensionists were not significant predictors of adoption of modern cultivars. It is evident that commercial objectives are increasing potential for adoption of modern cultivars in the south while subsistence objectives dictate adoption in the north. The case in the north would possibly favour adoption of a group of new cultivars that meet the needs of various end users (Gold *et al*., 2002).

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CONCLUSIONS:

Considerable number of farmers in both regions is aware of the deficiencies of their present banana cultivars but more than 90% of farmers in the north are ignorant of modern improved banana cultivars developed to overcome the deficiencies such as low production, low tolerance to drought and low resistance to pests and diseases. The majority in the south is aware of improved cultivars and is more willing to adopt new cultivars. In general, more farmers from the south who are less experienced in banana farming (<10 years of banana farming), aware of improved banana cultivars and knowledgeable about GMOs are likely to adopt modern banana cultivars.

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