Ex-Ante Adoption of New Cooking Banana (Matooke) Hybrids in Uganda Based on Farmers' Perceptions

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ABSTRACT

Despite the research efforts to introduce the newly developed, improved banana 'Matooke' hybrids to the farming communities in Uganda, to date no attempt has been made to document the likelihood of farmer adoption of these hybrid bananas in Uganda. The paper has analyzed farmers' perceptions regarding the newly developed improved Matooke hybrid banana attributes in Uganda to ex ante understand farmers' likelihood of adoption of these varieties. Descriptive statistics and data reduction techniques (like factor analysis) were used to define the potential explanatory variables affecting adoption. Following this, a Zero Inflated Poisson (ZIP) regression model was applied to estimate the effect of farmers' perceptions about the hybrid banana attributes and other factors on the likelihood of adoption of the Matooke hybrid banana variety. The results show that, compared to Mbwazirume – a local variety used as a reference, four of the hybrid banana varieties considered are perceived to be better in terms of production characteristics (resistance to sigatoka, weevils, nematodes, tolerance to poor soils, good bunch size, sucker production) but are regarded as inferior in terms of consumption characteristics (taste, colour when cooked, flavour). The hybrid M9 is regarded as having a relatively good performance with respect to most of the production and consumption characteristics. The results of the ZIP regression analysis, including farmer characteristics like gender, family size, age and farmer perceptions of varietal attributes, disease and pests, yield and agronomic attributes, were positively associated with the likely adoption of most of the hybrid bananas. In collaboration with extension agents, variety M9 could be disseminated to a wider farming community targeting, larger households, younger farmers and relatively farmers with large size of land.
Keywords: Banana (Matooke) hybrids; Ex-ante, Farmers' Perceptions; ZIP Models; Uganda

1. **Introduction**

Uganda is the world's largest producer and consumer of bananas (10.5 million tons per annum), accounting for about 10% of total global production (FAOSTAT, 2006). According to the National Agricultural Research Organization (NARO), bananas occupy 38% of total planted area to crops in Uganda, the largest cultivated area among the staple food crops in the country (NARO, 2001; FAO, 2004). Approximately, 75% of Ugandan farmers grow bananas on 1.5 million hectares (Zake et al., 2000). The area planted to bananas in Uganda currently averages about 142,095 ha per year (FAO, 2009). Banana production in Uganda is mainly practiced by smallholder farmers with the total number of plots being 2,695,000, averaging 0.24ha, and making it the most widely cultivated crop in the country (Bagamba, 2007). Most of this production takes place with low input farming methods (Gold *et al.*, 1998; Johnson and Ives, 2001).

Banana production is characterized by a continuous growing season due to the all year-round fruiting nature of the crop. It is grown across diverse agro-ecological environments and socio-economic conditions in Uganda. It represents an important source of income and food security for resource-poor farmers (Karamura *et al.,* 1998). Banana is consumed as a staple food crop for more than half of the people living in the country. The rapid urban market demand and increase in population (Bagamba *et al*., 1998) has led cooking bananas to become a major source of income for many people, especially the rural poor. In all markets across the capital Kampala, most of the truckloads of cooking bananas are brought in from producing areas such as Mbarara, Masaka and Busheyi districts, and a bunch sells for about Ush25,000-50,000(26/4/2011Ush: 2,754.4= 1$) (East African business Week, 2011).

Despite the importance of bananas as both cash and food crop in Uganda, the banana farmer is currently facing major challenges from soil exhaustion, pests and diseases (such as weevils, nematodes, Black sigatoka) and socio-economic constraints (such as high costs of managing the crop and competition for labour with other enterprises) (Baganba *et al*.,1998). This has reduced the yields of cooking bananas considerably and thereby threatens food security in the country. In response, NARO's National Banana Research Programme (NBRP) initiated a breeding program in 1994. The program has so far developed new banana 'matooke' hybrid varieties (M2, M9, M14, and M17). These have been under evaluation in different agro-ecological regions of Uganda with Mbwazirume as a local check (control) since 2008.

Despite the research efforts to introduce the newly developed improved Matooke hybrid bananas to the farming communities in Uganda, to date, no attempt has been made to document the likelihood of farmers' adoption of these varieties in Uganda. The demand for improved banana varieties is likely to increase if, among others, varieties are designed to include end users' preferred traits. The objective of this study, therefore, is to analyze farmers' perceptions regarding varietal attributes and assesses how these perceptions, along with farm and farmer specific characteristics, determine the variations in the levels of potential adoption of hybrid banana varieties. The potential adoption was measured as the number of banana mats of a variety grown by a particular farmer since the inception of the project. Bananas are grown in a mat consisting of the mother plant and suckers from which they are vegetatively propagated (Thomas, 1998). To achieve this objective, a number of techniques like descriptive statistics, factor analysis, and Zero Inflated Poisson count model were applied.

The remainder of the paper is organized as follows: The following section presents the research methodology with details of the study area and sampling procedure. In Section 3, the theoretical framework is presented while Section 4 discusses the empirical model and data sources. Section 5 reports the empirical results while section 6 presents conclusions and implications of the results to future breeding priority setting and variety dissemination policies.

2. RESEARCH METHODOLOGY

2.1 Study areas and sampling procedures

The study was conducted in four regions of Uganda (namely Mid-Western, Central, Western and Eastern) representing six major Agro-Ecological Zones, including the Lake Albert crescent area, Lake Victoria crescent, Western highlands, Southern highlands, South-east and Eastern Agro-ecology (Wortmann and Eledu, 1999). These are the Regions where the NBRP of NARO is evaluating the new hybrid banana varieties under the project "Multiplication and Promotion of Black-Sigatoka Resistant Banana Genotypes in Uganda". While selecting the above Regions and agro-ecological Zones of the project, the programme considered disease/pest severity as a major factor. Hence, the main objective of hybrid banana development was to develop banana varieties resistant to Black Sigatoka, a disease that has negatively affected banana production in these major areas. The following criteria were used to select the participating farmers: knowledge in banana growing, sufficient resources to run the plot (about a quarter of an acre), willingness to host and maintain the trial (including fencing / protection), willingness to allow other farmers to learn from the farm, and accessibility of the farmer's trial site. Consequently, new varieties (M2, M9, M14, and M17) and Mbwazirume (a local variety) were planted. Mbwazirume was included so that farmers can compare and make informed decisions. These varieties are being evaluated under farmer managed conditions across all the Agro-Ecologic zones in the four major regions. The four banana hybrids were introduced to 312 farmers in 39 Districts covering all the above Agro- ecological Zones. Eight farmers were selected in each District.

2.2 Data collection

The paper is based on primary data collected from a survey of 149 participating farmers (host farmers of the demonstration plots) and 305 non-participating farmers (neighbours with no demonstration plots) located across the six Agro-Ecologic Zones in the four Regions. These farmers were purposively and randomly selected and interviewed. A structured and pre-tested questionnaire was used as an instrument. Data were collected between May 2010 and April 2011.The questionnaire was administered through personal interviews with the assistance of trained enumerators. Data on socio-economic characteristics, market-related characteristics (like walking time to the dry weather road and nearest market), total land owned by the farmers (Acre[1]), and other institutional variables (like whether a farmer receives extension visits, access to credit and whether a farmer belonged to a farmer group) were collected. Data were also collected on household asset ownership (values of radio sets, bicycle, chairs, tables, car, mobile phones, television sets, and sofa sets). The livestock assets included cows / oxen, goats, chicken, ducks, turkeys, and pigs. The values of all these assets were estimated in current Ugandan Shillings. The PCA method through factor analysis was used to construct an overall household wealth index (Filmer and Pritchett, 2001).

Moreover, farmers' perceptions about the consumption and agronomic attributes of the hybrid banana varieties were collected. Farmers were asked to rate their preferences based on their evaluations of the varieties with respect to their agronomic (tolerance to drought, yield, performance in good season, early maturity, bunch size, finger size, sucker production, plant height, resistance to wind, performance with poor soils, resistance to black sigatoka,

[1] 1 Acre = 0.404685 Hectares

resistance to weevils, and resistance to nematodes) and consumption (taste, texture, colour when cooked, flavour, storability after harvest, suitability to local dishes, skin colour and easiness to peel) attributes. Each hybrid variety was evaluated by farmers for each attribute on a 5-point likert scale, namely, 1= very poor, 2 = Poor, 3 = Fair, 4 = Good, and 5 = Very good.

3. Theoretical framework

The conceptual framework presented here is based on the theory of agricultural household models (Singh *et al*., 1986) as applied by other researchers (Cavatassi *et al.*, 2010; Wale and Yalew, 2007; Smale *et al.*, 2001; Benin *et al.*, 2004; Hints *et al.*, 2003; and Adesina and Zinnah, 1993). In this model, decisions of a farmer in a given period to adopt a new technology are assumed to be derived from the maximization of expected utility subject to land availability, credit, and other constraints (Feder *et al.*, 1985). In what is now called the characteristics theory of consumer choice, Lancaster (1966) has argued that goods are preferred based on their characteristics. Accordingly, goods are as good as their desirable and undesirable characteristics and the characteristics embedded therein give rise to utility. Drawing from this model, farmers' demand for the hybrid banana plants is derived from the utility that farm households derive from the banana attributes rather than from the bananas themselves. Therefore, crop variety adoption is driven by farmers' demand for a number of variety traits (Smale *et al.*, 2001). As discussed in the previous section, banana hybrids have bundles of both production and consumption attributes. Farmers are unlikely to adopt these varieties if they fail to offer the attributes they demand. Therefore, a farmer's demand for a hybrid banana variety is derived from the demand for consumption and production attributes supplied by the variety, among other exogenous factors (Edmeads *et al.*, 2006).

The decision of whether or not to adopt a new technology hinges upon a careful evaluation of a large number of technical, institutional and socio-economic factors (Alene *et al.*, 2000). In this study, we incorporate farmers' perceptions about the characteristics embedded in the hybrid banana varieties and socio-economic characteristics into the analysis of *ex ante* adoption decisions. Not only adoption but also rejection (before or after use) of hybrid bananas can be explained using the characteristics model. According to Sinja *et al.* (2004), for instance, users will reject a technology that is not relevant to their needs, not suited to their work environment and one that may interfere with other activities that are considered to be important.

Education of the respondent was also included in the model. At the technical level, information acquisition as well as the capacity to process, understand, and use the technical aspects and returns related to different technologies is largely determined by the education levels of the farmer. Moreover, educated farmers are expected to be more involved in market oriented enterprises and, therefore, are more likely to adopt a new technology (Isgin *et al.*, 2008). We include education level (Educ) in the model, measured in terms of the number of years spent in school, and is expected to influence positively the number of plants per variety planted from the project inception up to the time of this study. Studies like Hossain and Croach (1992) on improved farming practices in Bangladesh, and Zavale *et al. (*2005) on improved maize seed in Mozambique, have reported that farmers with higher levels of education have a higher probability of adopting the technology.

The effect of farmers' age (AGE) could be positive or negative depending on the farmer's position in the life cycle. That is why the expected sign remains an empirical question (Adesina and Baidu-Forson 1995; Zavale, *et al.*, 2005). Farmer's age may influence adoption in one of several ways. Older farmers may have more experience, resources, or authority that would allow them more possibilities for trying a new technology (CIMMYT, 1993). Another case could be that older farmers may have more experience in cultivation and are better able to assess the characteristics of modern technology than younger farmers. On the other hand, it could also be that older farmers are more conservative (risk averse) than younger farmers and therefore have a lesser likelihood of adopting new technologies.

Family size (total number of household members) was another variable considered. There is no agreement in the adoption literature regarding the direction of influence of this variable (Ajewole, 2010). A larger family size could be an indicator of food consumption requirement. Also, many members in a household imply labour availability that is frequently associated with the adoption of a new technology. In this case, the variable was predicted to be positively related to the demand for hybrid banana varieties as banana production is labour-intensive and is a dominant food crop in Uganda.

Farm size (FSIZE) and household wealth were also considered in this study. Farm size was measured as the total acres available to the farmer. It has been found to be positively related to technology adoption as those operating larger farms have more land to allocate to the improved technologies (Feder and Slade, 1984; Nkoya *et al.,* 1997; Wubeneh and Sanders, 2006; García, 2007). Farmers with a larger size of land may be more willing to devote portions of the land to an untried variety compared with those with smaller areas. In Uganda, it takes time for farmers to gain confidence in the performance of new technologies and hybrid bananas, especially in terms of palatability, market availability and other input costs. Wealth is also expected to have a positive effect on the likelihood of adoption as wealthier farmers are more likely to afford bearing the risk of the new technology (Doss, 2003).

Agricultural extension is regarded as one of the most important sources of information dissemination (Sall *et al.,* 2000) for agricultural production, particularly in Uganda where farmers have very limited access to information. The number of extension visits received by the farmer is expected to be positively related with the probability of the number of hybrid banana plants the farmer will plant. This is because the stock of information made available to farmers increases with extension efforts (Wubeneh and Sanders, 2006; Feleke and Zegeye, 2006). Another variable included in the model and expected to have a positive effect is farmers' membership to a farmer group. In Uganda, farmer groups are the main focal points for delivery of extension technical advice. According to Hussein (2001), farmer groups help to achieve economies of scale as they could lower transactions costs by pooling resources.

Regarding gender, it is hypothesized that male farmers have a better chance to adopt hybrid bananas. Based on previous empirical adoption studies (Doss and Moriis, 2001; Adesina, *et al.,* 2000; Ajewole, 2010), female farmers are more constrained to accumulate assets, and have limited access to productive resources (such as credit and land). Consequently, their access to improved technologies is negatively affected.

The time it takes to reach dry weather road and markets is expected to have a negative impact on adoption of hybrid bananas. This is because the farther away farmers are from markets the less likely they would be seeking for high yielding crop varieties to produce marketable surplus.

Hybrid banana variety attributes included in the model are expected to be positively associated with the likely adoption of the new banana hybrids. A positive relationship is expected for a hybrid banana variety with attributes farmers perceives to be better relative to their traditional varieties. If a variety is perceived to better meet desirable consumption and production attributes relative to traditional varieties, then it will be highly demanded by farmers. On the other hand, when the undesirable varieties of a new variety are perceived to outway its attractive features, in comparison to the existing traditional varieties, then the demand for that variety is expected to be low.

4. The empirical model

Using the ratings given by farmers, a paired sample t-test was used to compare the attribute score of each hybrid variety with Mbwazirume. Following Katungi et al. (2011) ; Birol et al. (2009), each of the five varieties was then subjected to a factor analysis using principal components to establish correlations among them and to determine whether they could be represented by a smaller number of principal components. Variety attributes were then grouped into independent attributes for each variety based on the criterion of an Eigen value greater than unity (Kaiser, 1961). The effect of farmers' perception of banana attributes and other factors on the adoption of hybrid banana varieties were estimated taking into account the number of banana plant mats grown by the household since the inception of the project from 2008 to 2010 as the dependent variable. This was chosen considering the short period of farmer assessment of hybrid banana varieties from the time they were recruited into a trial programme (year 2008), the subsequent establishment of hybrid trials and also considering the nature of the banana crop which takes a period of one year after planting to begin producing a fruiting. Thus, the likely demand for a variety is expressed as a count of plant mats (Edmeads et al., 2006). Banana farming is characterized by a number of plant mats which can be easily counted in a given plot by the farmers and farmers are aware of the number of plant mats for each of the varieties they currently grow in positive numbers. Moreover, some farmers may choose to plant many or few plant mats of a given variety based on the it's desirable and un desirable attributes, and farmer needs and preferences.

The count approach used in this paper has advantages for understanding the likely demand for the hybrid banana varieties. Instead of depicting an "adoption" decision, with associated problems of choosing whether to use a zero-one dependent variable (logit) or a censored variable that represents the extent of adoption (tobit), the count approach is more general and allows to combine the categorical data (adoption or not of any innovation) with the count data (number of plant mats). When the likely adoption (dependent variable) is measured as the number of plant mats planted by farmers, observations on the dependent variable are represented by non-negative integer quantities, and failure to account for the integer nature of the data can bias results (Haab and McConnell, 1996; Isgin et al., 2008). Furthermore, any resulting policy measure based on continuous demand models (e.g., OLS, or Tobit), when the variable is a non-negative integer is inaccurate and misleading (Ganguly.et al., 2010). Moreover, the presence of many zeros in the dependent variable could not allow application of the ordinary Count Models like Poisson. Zero-inflated Negative Binomial Regression models do better with over-dispersed data (variance much larger than the mean) (Cameron and Trivedi, 1998). In the presence of excess zero values in the discrete count variable, Lambert (1992) and Green (2003) suggest the application of Zero-Inflated Poisson (ZIP) regression. There was a prevalence of excessive zeros in the outcome variables (64.9% for M2, 71.9% for M9, 85.75% for M14, 85.75% for M17, and 73.25% for Mbwazirume). The

Inability to account for the extra "pull" exerted by the disproportionately high response of zeros may result in biased parameter estimates and misleading inferences (Ganguly.etal., 2010). For this reason, the ZIP regression model (Vuong 1989) was applied in this study. The model allows combining the categorical data (adoption or not) with the count data (number of plant mats planted) and takes care of the excessive amount of zero values in a discrete count variable (Lambert, 1992; Cameron and Trevedi, 1998). The existence of many zeros in the response variable could have been due to the fact that some non-participating farmers may not have had an opportunity to access the planting materials because hybrid bananas have recently been introduced among the farming communities in Uganda. Following Mullahy (1986) and Lambert (1992), the detailed model is defined as follows:

$$Pr[y = 0] = f_1(0)$$

$$\Pr[y = j] = \frac{1 - f_1(0)}{1 - f_2(0)} f_2(y), j > 0 \quad (1)$$

This collapses to the standard normal model only if $f_1(.) = f_2 = (.)$ (Cameron and Trivedi, 1998). In the ZIP model a proportion of zeros (φ_i) is added to the $\Pr[\mu_i]$ distribution, and other frequencies are reduced by a corresponding amount:

$$\Pr[y_i = 0] = \varphi_1 + (1 - \varphi_i)e^{-\mu_i}$$

$$\Pr[y_i = \mathrm{r}] = (1 - \varphi_1)\frac{e^{-\mu_i}\mu_i^{\mathrm{r}}}{\mathrm{r}!}$$

$$\mathrm{r} = 1,2,\ldots \quad (2)$$

For the hybrid banana varieties adoption, we write;

$$Y[HBAN] = Exp\left(\beta_0 + \sum_{k=1}^{20} \beta_k \mathrm{X}_i\right) \quad (3)$$

Where $HBAN$ refers to the number of plant mats planted by i, and X_i is a vector of covariates that are expected to determine the *ex-ante* adoption.

Five equations were estimated; one for each hybrid variety because each variety has different production and consumption attributes and responds differently to farmers' preferences.

5. Results and discussions

Table 1 defines the variables considered to explain the determinants of the *ex-ante* adoption of hybrid banana varieties in terms of the number of plant mats planted for each variety from 2008 to 2010.

Table 1.Variables included in the analysis and the summary of descriptive statistics

Variable	Variable description	Total farmers (N = 456)	Participating farmers (N = 149)	Non- participating farmers (N = 307)
		Mean (standard deviation)		
Educ	Years of schooling of the respondent	7.91 (4.669)	9.40 (4.657)	7.19 (4.507)
HHsize	Total number of household members	6.24 (3.540)	6.54 (3.356)	6.10 (3.62)
Age	Respondent age (Years)	46.11 (15.963)	48.37 (15.755)	45.01 (15.97)
Age2	Respondent age squared	2380.37 (1483.43)	2586.13 (1492.076)	2280.51 (1471.294)
Farm size	Total Land owned in acres	9.22 (9.979)	10.27 (10.7853)	8.82 (9.5989)
Wealth	An index derived from factor analysis of the total values in (Ush) for household assets and livestock)	0.000 (1.00)	0.3094 (1.555)	-0.1502 (0.4981)
Road	Hours of walking to the dry weather road (in minutes)	22.21 (63.693)	28.94 (89.77)	18.95 (45.85)
Market	Hours of walking to nearest market to the nearest market (in minutes)	43.08 (56.55)	42.42 (54.71)	43.41 (57.506)
		%		
Gender	Dummy (I: if household head is male; 0 if female)	50.66	57.05	47.56
Farmer group	Dummy(1: if a farmers is in a farming group and 0 other wise)	53.95	67.11	47.56
Credit	Dummy(1: if a farmer have access to credit, 0 other wise)	28.95	38.93	24.10
Extension	Dummy(1: if a farmer was visited by extension agents in two years; 0 otherwise)	54.61	80.54	42.02
Farming	Dummy(1: if farming is as a major economic activity for the respondent: 0 other wise)	76.54	74.50	77.52

Source: Survey data (May 2010 - April 2011)

Participating farmers had a slightly higher age than non-participating farmers (Table1).The average family size of participating farmers was almost the same as the non-participating ones. On average, respondents had spent 7.91 years in school which is slightly higher for participating farmers. The majority of the respondents reported farming as their major economic activity with participating farmers having slightly larger more land compared to the non-participating farmers (Table 1). The results further show that the majority of the respondents reported that they could not obtain credit. The majority of the respondents reported to have been visited by extension agents, the percentage being much higher for participating farmers. The results also show that half of the respondents were in farmer groups of whom the majority were hosting the banana hybrid demonstration plots (Table 1).

5.1 Analysis of farmers' perception of hybrid banana variety attributes

Using the farmers' perception ratings for the hybrid banana varieties, t-tests were conducted to compare farmer assessments of individual varieties. Separate analyses were conducted for each hybrid variety, compared to Mbwazirume. The results of these analyses are summarised in Tables 2 and 3. The results indicate that, in general, farmers perceive significant differences among the hybrid banana varieties with respect to the local variety. Hybrid banana varieties are perceived to be better in terms of production characteristics and disease resistance but are regarded as inferior in terms of consumption characteristics compared to Mbwazirume. Farmers indicated a clear preference for the traditional variety with regard to characteristics like flavour, taste, texture (softness) and colour when cooked. The results further reveal that, with the exception of Hybrid M14, all the Matooke hybrid bananas were scored above 3.0 in terms of the cooking attributes, implying that they have acceptable cooking qualities. Hybrid M9 was closest to the reference variety in regard to all cooking quality traits (Table 2). In terms of storability after harvest, variety M9 is perceived to last longer after harvest compared to Mbwazirume. This is typically an important attribute for consumers. In general, hybrid M9 is regarded as having a relatively good performance with respect to most of the characteristics in relation to Mbwazirume (Table 2).

Table 2. Average rating of respondents' preferences for the attributes of hybrid bananas M2 and M9 in relation to Mbwazirume in Uganda (Paired t-test)

Variables	M2	Mbwz	Mean Difference	P Value	M9	Mbwz	Mean difference	P Value
Yield	3.760	3.770	-0.013	0.935	4.276	3.736	0.540	0.000
Tolerant to drought	3.986	3.690	0.296	0.036	3.986	3.690	0.296	0.036
Early Maturity	3.740	4.169	-0.429	0.018	3.978	4.121	1.313	0.302
Bunch size	3.731	3.615	0.115	0.482	4.438	3.607	0.832	0.000
Sucker production	3.823	3.798	0.025	0.881	4.171	3.784	0.386	0.003
Plant height	3.684	3.776	-0.092	0.525	4.157	3.775	0.382	0.008
Resistance to wind	3.592	3.803	-0.211	0.181	4.000	3.791	0.209	0.072
Performance in good season	4.000	4.027	-0.027	0.853	4.405	3.988	0.417	0.001
Resistance to black sigatoka	3.987	3.122	0.865	0.000	4.091	3.125	0.966	0.000

Resistance to weevils	4.096	3.233	0.863	0.000	4.226	3.250	0.976	0.000
Resistance to nematodes	4.014	3.333	0.865	0.000	4.119	3.333	0.786	0.000
Tolerance to poor soils	3.680	3.440	0.240	0.101	3.919	3.372	0.547	0.000
Taste	3.685	4.685	1.118	0.000	4.037	4.598	-0.561	0.000
Texture(softness) when cooked	3.606	4.563	-0.958	0.000	3.988	4.488	-0.500	0.001
Colour when cooked	3.580	4.638	1.058	0.000	3.795	4.577	-0.782	0.000
Flavour	3.700	4.514	-0.814	0.000	3.800	4.488	-0.688	0.000
Longer storage after harvest	3.819	3.819	0.000	1.000	3.975	3.810	0.165	0.255
Skin colour	3.527	4.446	-0.919	0.000	3.842	4.451	-0.610	0.000
Easy to peel	3.806	4.583	-0.778	0.000	3.949	4.590	-0.641	0.000
Suitability for Matooke	4.281	4.317	-0.037	0.770	3.951	4.354	-0.402	0.001

Source: See Table 1

Notes: The hypothesis was that there is no difference between each hybrid variety compared to local check regarding the farmer perceptions. Mbwz denote Mbwazirume

Among the new varieties, respondents reported that M9 was the most preferred for nearly all the attributes (high yield potential, tolerance to drought, early maturity, bunch size, sucker production, plant height, resistance to wind, performance in good season, resistance to black sigatoka, resistance to weevils, resistance to nematodes and performance in poor soils) and the differences were statistically significant at the 5% and 10% levels of probability compared to the local variety (Table 2). Notable for all the hybrid banana varieties was that all of them significantly outperformed the Mbwazirume with respect to resistance to pests (banana weevils, nematodes and disease (black sigatoka). This suggests that the breeding program has achieved its intended purpose of addressing these production constraints in Uganda. Among all the hybrid banana varieties, hybrids M9 and M17 are perceived to significantly outperform Mbwazirume in terms of good performance in poor soils. This could have been due to tolerance to diseases like sigatoka, an attribute farmers are associating with tolerance to poor soils. Among the diverse factors responsible for declining banana production in Uganda, farmers report poor soils as a major factor affecting yield (Bagamba *et al*., 1998).

Table 3. Average score rating of farmer preferences for the attributes of hybrid bananas M14 and M17 in relation to Mbwazirume in Uganda (paired t-test)

Variables	M14	Mbwz	Mean difference	P Value	M17	Mbwaz	Mean difference	P Value
Yield	3.667	3.729	-0.063	0.666	4.000	3.674	0.326	0.031
Tolerance to drought	3.667	3.729	0.286	0.142	3.800	3.460	0.340	0.078
Early Maturity	3.510	4.204	-0.694	0.000	3.560	4.040	-0.480	0.017
Bunch size	3.653	3.592	0.061	0.759	3.792	3.708	0.083	0.667
Sucker production	3.000	3.857	-0.857	0.000	3.729	3.729	0.000	1.000
Plant height	3.755	3.816	-0.061	0.777	3.520	3.800	-0.280	0.164
Resistance to wind	3.500	4.020	-0.520	0.004	3.660	3.840	-0.180	0.310
Performance in good season	3.820	3.980	-0.160	0.252	4.044	3.978	0.067	0.660
Resistance to black sigatoka	3.898	3.143	0.755	0.001	3.920	3.160	0.760	0.001
Resistance to weevils	4.167	3.188	0.979	0.000	3.979	3.128	0.851	0.000
Resistance to nematodes	4.000	3.188	0.813	0.000	3.935	3.174	0.761	0.000
Tolerance to poor soils	3.674	3.490	0.184	0.345	3.854	3.354	0.500	0.014
Taste	3.860	4.640	-0.780	0.000	3.277	4.596	-1.319	0.000
Texture(softness) when cooked	2.938	4.563	-1.625	0.000	3.000	4.556	1.391	0.000
Colour when cooked	3.217	4.587	-1.370	0.000	3.116	4.558	1.240	0.000
Flavour	3.277	4.660	-1.383	0.000	3.467	4.533	1.176	0.000
Longer storage after harvest	3.292	3.708	-0.417	0.015	3.422	3.756	-0.333	0.153
Skin colour	3.354	4.542	-1.188	0.000	3.449	4.490	-1.041	0.000
Easy to peel	3.625	4.688	-1.063	0.000	3.622	4.689	-1.067	0.000
Suitability to Matooke	3.490	4.347	-0.857	0.000	3.265	4.367	1.295	0.000

Source: See Table 1 Mbwz denotes Mbwazirume

Farms' perceptions of the hybrid banana variety attributes towards the likely demand for the hybrid banana varieties.

To get a detailed picture about the likely influence of farmer perceptions of the variety attributes on the likely demand for a hybrid banana variety, farmers were asked about their perceptions towards each of the variety attributes. Loadings above 0.50 were considered as factoring together(Table 4 and b). Factor naming was based on variables that factored together and the relative magnitude of the factor loadings in absolute terms (Birol et al., 2009).

Table 4 . Factor Analysis of farmer perceptions of variety attributes at demand for the banana variety.

Farmer perceptions on variety	Factor Loadings for variety (M2)				Factor Loadings for variety (M9)				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Tolerant to drought	0.3345	0.2120	**0.5140**	0.3912	-0.0687	0.0009	0.2085	0.0182	**0.8256**
Yield	0.2828	0.2900	0.3940	**0.5827**	**0.6946**	0.0613	0.2657	0.1871	0.0632
Performance in good season	0.1393	0.2073	0.2551	**0.6190**	**0.7363**	0.2079	0.0135	0.0444	0.3055
Early Maturity	0.1477	-0.0546	0.0021	**0.7888**	0.2971	0.2100	0.4198	0.0490	-0.0491
Bunch size	0.1817	0.1009	**0.7747**	0.1846	**0.6651**	0.0197	0.3668	0.1030	-0.1520
Sucker production	0.1970	0.3837	0.1789	0.4305	**0.7122**	0.2861	0.2321	0.1874	-0.0751
Plant height	0.2192	0.0062	0.4184	**0.5787**	0.3292	0.1189	-0.0607	0.4596	0.3801
Resistance to wind	-0.1151	0.3339	0.4393	0.3521	0.1204	0.2516	0.0520	**0.7118**	0.0963
Tolerance to poor soils	0.2381	0.3594	**0.6416**	0.0342	0.1129	0.0585	0.3531	**0.7601**	0.0281
Resistance to black sigatoka	0.2904	0.2870	**0.5413**	0.2276	0.2040	0.0414	**0.5268**	0.4985	0.0538
Resistance to weevils	0.1752	**0.6730**	0.3188	-0.0187	0.3358	0.1606	**0.6294**	0.2725	0.1535
Resistance to nematodes	0.2307	**0.8366**	0.0595	0.0794	0.1260	0.2606	**0.7549**	0.1380	0.1431
Taste	0.2292	**0.8223**	0.1587	0.0740	0.2087	0.2398	**0.7115**	0.1293	0.2688
Texture(softness) when cooked	**0.7351**	0.2083	0.2852	0.2197	0.3167	**0.6264**	0.1364	0.2799	0.0353
Color when cooked	**0.7590**	0.0801	0.1981	0.1156	0.3488	**0.6293**	0.0785	0.3032	0.1194
Flavor	**0.7864**	0.1441	0.1979	0.1475	0.3177	**0.6919**	0.0754	0.1721	0.1784
Longer storage capability after harvest	**0.6677**	0.3348	0.0221	0.2573	0.0178	**0.6804**	0.2633	-0.0589	0.2215
Skin color	0.0894	**0.6519**	0.1100	0.1227	-0.0181	**0.7752**	0.2419	0.0239	-0.1268
Easy to peel	**0.6993**	0.3079	0.1884	-0.0266	0.3217	0.2160	0.1590	0.2109	**0.6264**
Exp. Var. (%)	0.1690	0.1597	0.1568	0.1208	0.1501	0.1421	0.1319	0.0998	**0.0817**

Source: See Table 1

Notes. Farmer perceptions on variety attributes coded according to the 5 point Linkert Scale 1= very poor, 2 = Poor, 3 = Fair, 4 = Good, and 5 = Very good.

Table 5. Factor Analysis of farmer perceptions of variety attributes at demand for the banana variety.

Farmer perceptions of the variety attributes	Factor Loadings for variety (M14)				Factor Loadings for variety (Mbwazirume)			
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 1	Factor 2	Factor 3	Factor 4
Tolerant to drought	0.4165	**0.5842**	0.0612	0.3472	-0.0731	0.6256	0.3357	0.1170
Yield	**0.7752**	0.2110	0.2505	0.0882	0.0333	0.2787	**0.7609**	0.0745
Performance in good season	**0.8070**	0.0476	0.1018	0.1133	0.0336	0.1180	**0.7332**	0.2042
Early Maturity	**0.6686**	0.0930	0.2398	0.1247	0.2881	0.0550	0.4267	0.4294
Bunch size	**0.7582**	0.2511	-0.0274	0.2579	0.0909	0.3081	**0.8093**	0.1131
Sucker production	**0.5440**	-0.0622	0.3276	0.3967	0.1102	0.1288	0.2169	**0.7501**
Plant height	0.4415	0.2772	-0.0183	**0.6005**	0.1914	0.1118	0.2945	**0.6537**
Resistance to wind	0.1676	0.0597	0.2758	**0.7698**	0.2605	0.5050	0.0012	0.4260
Tolerance to poor soils	-0.0157	**0.6967**	0.0734	0.3690	0.1042	**0.7238**	0.1788	0.1658
Resistance to black sigatoka	-0.0973	**0.7389**	0.2054	0.1997	0.0072	**0.8225**	0.1639	0.1512
Resistance to weevils	0.2049	**0.7699**	-0.0791	-0.1578	0.0298	**0.8774**	0.1671	0.0384
Resistance to nematodes	0.3658	**0.6845**	0.1602	0.0043	0.0390	**0.8639**	0.1047	-0.0188
Taste	0.2077	**0.6756**	0.2045	-0.0364	**0.7464**	-0.0296	0.1166	-0.0514
Texture(softness) when cooked	0.3113	0.0318	**0.5694**	0.4410	**0.7415**	0.0606	0.0971	0.1096
Color when cooked	0.1192	0.0475	**0.8236**	0.1641	**0.8039**	-0.0461	0.1698	0.0053
Flavor	0.1746	0.3862	**0.6286**	0.1328	**0.7597**	0.1188	0.1270	0.1410
Longer storage capability after harvest	0.0405	0.0595	**0.8545**	0.0738	0.1112	0.4864	0.4151	-0.1627
suitability to Matooke local food	0.1363	0.2731	**0.5135**	0.2148	**0.7745**	0.0551	-0.0223	0.1588
Skin color	0.4362	0.1195	**0.5450**	-0.0936	**0.6034**	0.0885	0.0691	0.3878
Easy to peel	0.3097	0.0697	0.3872	0.4797	**0.5315**	0.1711	0.0186	0.3774
Exp. Var. (%)	0.1822	0.1671	0.1639	0.1033	0.1862	0.1852	0.1460	0.0896

Source: See Table 1

Notes. Farmer perceptions on variety attributes coded according to the 5 point Linkert Scale 1= very poor, 2 = Poor, 3 = Fair, 4 = Good, and 5 = Very good.

Results show that in the hybrid banana variety M2, Varimax rotation suggested the existence of four factors and explained 60.63 Table 4.a). The first factor Labelled "Sensory qualities" explained the highest variation (18.22%) of the total and consisted of; texture, colour when cooked, flavour, longer storage after harvest and easy to peel (Table 4a). These are the banana consumption qualities farmers consider when evaluating a good cooking banana variety (Dadzie, 1997). The second factor “Biotic constraints” consisted of resistance to black sigatoka, weevils, nematodes, tolerance to poor soils and skin colour. The third factor “A biotic constraints” consisted of Bunch size, tolerance to poor soils, tolerance to drought and resistance to black sigatoka. Early maturity, Performance in good season, high yielding and plant height were factored together to form a forth factor labelled as “agronomic qualities”.

In Hybrid *Matooke Nine (M9),* five factors were identified and explained 60.55% of the common variance. The first factor labelled as “Agronomic qualities “consisted of (yield, performance in good season, sucker production, bunch size and sucker production. The second factor “sensory qualities” factored together; texture, colour when cooked, flavour, longer storage after harvest and skin colour. The third factor “Biotic constraints” consisted of; Resistance to black sigatoka, resistance to weevils, resistance to nematodes and taste. The fourth factor labelled as A biotic constraints consisted of; tolerant to poor soils, resistance to wind (Table 4 a).

For Hybrid *Matooke Fourteen (M14)*, four key factors were identified through factor analysis and explained 61.65% of the common variance and were interpreted as: (1) “Agronomic qualities” (yield, performance in good season, sucker production, bunch size, early maturity; (2) Biotic constraints (resistance to black sigatoka, resistance to weevils, resistance to nematodes, tolerance to drought and tolerance to poor soils); (3) “Sensory qualities” (texture, colour when cooked, flavour, longer storage capability after harvest, suitability for Matooke, and skin colour); and (4) A biotic constraints (plant height and, resistance to wind).

For variety Hybrid *Matooke Seventeen (M17)*, four key variables were identified through factor analysis and explained 64.95% of the variance, and were interpreted as: (1) sensory qualities (taste, texture, colour when cooked, flavour, suitability to Matooke, skin colour and easiness to peal); (2) Biotic constraints (resistance to black sigatoka, resistance to weevils and resistance to nematodes); (3) A biotic constraints (sucker production and tolerance to drought); and (4)Agronomic qualities High yielding (yield, performance in good season, bunch size and finger size).

For variety Mbwazirume, four key factors were also identified and explained 60.70% of the variance. The variables were interpreted as: (1) “Sensory qualities (taste, texture, colour when cooked, flavour, suitability to Matooke, skin colour and easiness to peal); (2) Biotic constraints (resistance to black sigatoka, resistance to weevils and resistance to nematodes, tolerance to drought and poor soils); (3) “Agronomic qualities” (yield performance in good season, bunch size and finger size); and (4) “Plant attributes” (sucker production and plant height).

5.2 Determinants of *potential* adoption of hybrid banana varieties

The banana hybrid varieties are still new among the Ugandan farming communities and the present study was undertaken during the second and third years of their on-farm evaluation currently on going. However, information on factors influencing farmers to plant these hybrids and their early adoption was generated through the ZIP regression results are presented in Tables 6.

Table 6. ZIP regression results for *ex ante* adoption of hybrid banana varieties in Uganda, 2008 - 2010 (N= 454) (standard errors in parentheses)

Variable	M2	M9	M14	M17	Mbwazirume
Educ	0.0196	-0.0439***	-0.0031	-0.0405***	0.0117**
	(0.0045)	(0.0048)	(0.0094)	(0.0105)	(0.0053)
HHsize	0.0265***	0.0968***	0.0185*	-0.0178	0.0109*
	(0.0062)	(0.0053)	(0.0104)	(0.0133)	(0.0063)
Gender	0.1244**	0.4466***	0.3208***	0.1252	0.0509
	(0.0390)	(0.0383)	(0.0740)	(0.0911)	(0.0437)
Age	0.0137**	-0.0255***	-0.0015	0.0103	0.0236**
	(0.0053)	(0.0051)	(0.0078)	(0.0106)	(0.0073)
Age^2	-0.0002***	0.0001	-0.0001	-0.0001	0.0001***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Farm size	0.0038**	0.0098***	0.0003	0.0185***	-0.0061**
	(0.0020)	(0.0019)	0.0040	(0.0049)	(0.0022)
Wealth index	-0.0595**	-0.0638**	-0.1655**	-0.2002**	0.0726**
	(0.0252)	(0.0255)	(0.0777)	(0.0691)	(0.0232)
Road	-0.0009***	0.0003**	0.0011***	-0.0002	-0.0001
	(0.0002)	(0.0002)	(0.0002)	(0.0004)	(0.0002)
Market	-0.0009**	-0.0019***	-0.0009	-0.0007	-0.0010**
	(0.0004)	(0.0004)	(0.0008)	(0.0009)	(0.0004)
Extension	-0.0206	0.3318***	0.0093	-0.4380**	0.1607**
	(0.0462)	(0.0511)	(0.1096)	(0.1298)	(0.0514)
Credit	-0.1593	-0.0191	0.1572**	0.2653**	-0.0761
	(0.0459)	(0.0424)	(0.0703)	(0.0921)	(0.0498)
Group	-0.34039	-0.4111***	-0.1402	-0.0159	-0.0604
membership	(0.0444)	(0.0452)	0.0952	(0.1108)	(0.0488)
Host farmer	-0.4741***	0.1365***	0.1422*	0.3376**	-0.0838*
	(0.0433)	(0.0437)	(0.0841)	(0.0989)	(0.0501)
Sensory qualities	-0.2038***	-0.0427	0.0127	0.1331	0.2895***
Index	(0.0372)	(0.0321)	(0.1093)	(0.1368)	(0.0435)
Biotic constraints	0.1313***	0.0394	0.3407***	0.1075	-0.0330
index	(0.0286)	(0.0325)	(0.1243)	(0.1827)	(0.0331)
A biotic	0.0811**	-0.0627	-0.0373	-0.1813	0.1110**
constraints	(0.0343)	(0.0383)	(0.1004)	(0.1325)	(0.0359)
Agronomic	NA	0.1099**	-0.3591	-0.1002	-0.0737
qualities Index		(0.0376)	(0.1439)	(0.1171)	(0.0345)
Farming as	-0.1763***	-0.4022***	-0.1402	-0.4515	-0.1353***
activity	(0.0446)	(0.0457)	(0.0952)	(0.0855)	(0.0501)
Constant	3.1542***	3.9271***	2.8065***	3.1640***	2.6740

	(0.1386)	(0.1358)	(0.2106)	(0.2641)	(0.1784)
Number of observations	425	428	431	431	431
Log likelihood	-1701.29	-1582.815	-503.6876	-460.997	-1227.93
Non-zero observations	153	125	62	63	120
Zero observations	272	303	369	368	311
LR chi^2	432.62	918.90	122.16	108.08	118.18
Prob > chi^2	0.0000	0.0000	0.0000	0.0000	0.0000
Vuong test of zip vs. z =	7.56	10.14	6.86	5.76	10.95
Pr>z =	0.0000	0.0000	0.0000	0.0000	0.0000

Source: See Table 1

***, **, * mean significance at the 1%, 5% and 10% levels of probability, respectively

Table 7. Marginal effects for the number of banana plant mats planted in Uganda, 2008 - 2010 (standard errors are shown in parentheses)

Variable	**M2**	**M9**	**M14**	**M17**	**Mbwazirume**
Educ	0.2092	-0.1508	0.0241	-0.0282	0.1134
	(0.1158)	(0.1305)	(0.0555)	(0.0533)	(0.1136)
HHsize	0.0175	0.6157	0.1014	-0.0207	0.1161
	(0.1492)	(0.1680)	(0.0660)	(0.0659)	(0.1380)
Gender	1.0830	3.2472	0.2197	0.1294	0.3250
	(1.0329)	(1.1768)	(0.4918)	(0.4677)	(0.9854)
Age	0.1778	0.0985	-0.0308	0.0775	0.2589
	(0.1362)	(0.1697)	(0.0577)	(0.0668)	(0.1421)
Age^2	-0.0028	-0.0022	0.0002	-0.0008	-0.0029
	(0.0014)	(0.0018)	(0.0006)	(0.0007)	(0.0015)
Farm size	0.0430	0.0484	-0.0231	0.0006	-0.0353
	(0.0489)	(0.0542)	(0.0257)	(0.0258)	(0.0465)
Wealth index	-0.2638	-0.5782	-0.4839	-0.5966	0.2342
	(0.4930)	(0.5500)	(0.2940)	(0.2823)	(0.4811)
Road	-0.0096	0.0020	0.0027	-0.0021	-0.0015
	(0.0047)	(0.0029)	(0.0010)	(0.0025)	(0.0030)
Market	-0.0025	-0.0206	-0.0028	-0.0023	-0.0027
	(0.0085)	(0.0105)	(0.0038)	(0.0043)	(0.0074)
Extension	3.6784	4.2986	1.3280	0.2546	2.7689
	(1.0565)	(1.2606)	(0.5356)	(0.5644)	(1.0736)
Credit	-0.9666	0.3482	1.3186	0.3913	-0.5940
	(1.0656)	(1.2481)	(0.6408)	(0.5516)	(1.0389)
Group membership	-0.4726	0.4937	0.8531	1.0131	1.7367
	(1.1403)	(1.2443)	(0.5339)	(0.5064)	(1.0394)
Host farmer	-3.1156	2.2838	0.2587	2.2138	-0.0130
	(0.3593)	(1.3641)	(0.1602)	(0.7359)	(1.0937)
Sensory qualities Index	-1.0581	0.0715	0.6392	-0.0486	0.8788
	(0.8680)	(0.9223)	(0.4901)	(0.4997)	(0.8037)

Biotic constraints index	-0.05868	1.4414	-0.0877	0.0689	-1.7213
	(0.84145)	(0.9777)	(0.4393)	(0.5295)	(0.8004)
A biotic constraints	0.0991	-0.9078	-0.1180	0.1030	1.6066
	(0.8369)	(0.9286)	(0.4787)	(0.5378)	(0.8273)
Agronomic qualities	NA	0.0906	-0.5491	-0.3793	0.4380
Index		(0.9379)	(0.5326)	(0.5080)	(0.7983)
Farming as activity	-2.8024	-1.0452	-0.9529	-1.2815	-0.3753
	(1.3461)	(1.5448)	(0.7268)	(0.7464)	(1.1990)

Source: See Table 1

Notes: Marginal effects of the explanatory variables on the dependent variables are calculated for a one unit change holding all other variables constant at their mean, but of dummy variables for a discrete change from zero to one

Furthermore an attempt was made to investigate empirically whether ZIP model was preferable to the Poisson model by using Vuong's statistic (Vuong 1989). This statistic has a standard normal distribution with large positive values $V > 1.96$ distinctly favoring the zero-inflated model, and with large negative values $V < -1.96$ values favoring the nonzero-inflated version. Values close to zero in absolute value favor neither model (Greene, 2003). In this study, the Vuong test supported the ZIP model over the Poisson model with all models having values greater than 1.96 (Table 6).

The ZIP model estimates show that the education level of respondents have a negative and significant effect on the probability of increased demand for plants of varieties M9, M117, and a positive effect on Mbwazirume (Table 6). There is a contrasting result in regards to Hybrid M9, suggesting that farmers with relatively low levels of education are more likely to demand more of this particular variety. This implies that the likely adoption of hybrid M9 increases among the farmers with low level of education. A possible explanation could be that relatively less educated farmers have farming as their major economic activity. The study findings suggest that when education of the farmer increases by one unit, the expected likelihood of farmers planting more plants of variety M2 increases by 20.92%, Mbwazirume by 11.34% and decreases for M9 by 15.08% other factors held constant (Table 7).

The estimated coefficient of respondent's age was statistically significant and negative on the adoption of hybrid M9 and positive for M2 and Mbwazirume (Table 4). Empirical evidence suggests that farmer's age can be either positively or negatively related to the decision of adopting new technology (Adesina and Baidu-Forson 1995; Zavale, *et al.*, 2005). The results show that older farmers are less likely to plant variety M9 than younger ones. The age-squared variable is positively associated with variety M9 and negatively related to M2. This suggests that the likelihood of taking risks associated with hybrid banana varieties is different between younger and older farmers. This may be due to the fact that younger farmers tend to favour new innovations and may have a lower risk aversion (Zavale, *et al.,* 2005). The marginal values show that a one unit increase in farmers' age will increase the number of plant mats likely to be planted for (M2) by 17.780% and 9.85% for M9, respectively.

Family size as an indicator of availability of farm labour and food consumption requirement is significantly associated with the demand for all hybrid bananas with the exception of variety M17. The positive and significant sign for this variable indicates that the larger the household size, the more the likelihood of planting more plant mats of the hybrid bananas varieties M2, M9 and M14. A possible explanation could be that these hybrid banana varieties are perceived to have good production attributes, tolerant to pests, good performance in poor soils and produce good bunch sizes (Tables 2 &3).These attributes are perhaps likely to attract households with large families to grow more banana plants, especially to increase banana production for food security. similar findings have also been reported by Krishna and Qaim (2007), who estimated the adoption of Bt Eggplant in India and found that larger households were associated with a higher probability of adopting BT hybrids over open-pollinated varieties.The results further suggest that if the family size increases by one unit (one member), the likelihood of farmers increasing planting of variety (M9) increases by 61.57%, (M2) by 1.75% and (M14) by 10.14%. With the high rate of Uganda's current growth rate at 3.1 percent and about 27.7 million people, projected to explode to 130 million by 2050 (World watch Institute, 2011), there is need for these hybrid bananas to coup up with demand for food that is also likely to double.

Results show that farm size (total land area in acres) has a significant negative association with the probability of demand for Mbwazirume, while it is positively associated with the likely adoption of hybrids M2, M9, and M17. This implies that farmers with larger land sizes are the potential adopters of these hybrids compared to Mbwazirume. According to Wale and Yalew (2007), risk vulnerable farmers will go for local varieties with preferred attributes. The results further show that if the Land size increases by one unit(in acres), the likelihood of farmers increasing planting of variety (M2) increases by 4.30%, (M9) by 4.84% and (M17) by 0.06% and decrease for Mbwazirume 3.53% . A possible reason for this could be that the farmers with a larger size of land may be more willing to devote portions of the land to an untried variety compared with those with smaller areas.Theory suggests that households with larger farms have more land to allocate to the improved technologies (Feder and Slade, 1984).

Keeping other factors constant, the extension workers contact with respondents is positively and significantly related to the number of M9 and Mbwazirume plants farmers are likely to plant. A negative sign for the hybrid M17 implies that farmers are likely to plant less of this hybrid variety, given the services of the extension agents. Perhaps this could be due to better technical knowledge associated with each variety received from extension agents. During the extension visits, farmers get exposed to new technologies and their interactions with extension staff stimulates communication thereby reducing the information irregularity often associated with new technologies.

Gender of the household head was found to be positively and significantly influencing the demand for all hybrid banana varieties with the exception of variety M17, implying that male farmers are likely to plant more plant mats of all these hybrid banana varieties. The positive and significant sign suggests that the probability for adoption of hybrid banana varieties is likely to be higher for men than for women farmers. This could be due to the fact that banana is a perennial crop and requires land of which men have more access compared to women. Also, the banana crop in Uganda is regarded an important source of income for most of the resource poor farmers (Karamura *et al.*, 1998) and this attracts men to participate in its production for commercial purposes.

With the exception of hybrid M9 and M14 distance from the nearest dry weather road seems to negatively affect the number of hybrid plants farmers are likely to plant. The estimated coefficient of distance from the nearest dry weather road has a negative and significant sign for hybrid banana M2 and positive and significant for M9 and M14. This suggests that respondents located near the dry weather road were less likely to plant more plant mats of the hybrid banana varieties M2 and more of M9 and M14. The marginal values indicate that if the distances to walk to the nearest dry weather road increases by one unit(in minutes), the likelihood of farmers increasing planting of variety (M2) decreases by 0.96% and increases for hybrid (M9) by 0.20%, (M14) by0.27%. With regards to the time of walking to the nearest market in minutes, all hybrids had a negative coefficient and significant for hybrid hybrids M2 and M9. This could be linked to the respondents' perceptions as to how well the hybrid bananas meet their needs in terms of varietal characteristics suitable for the market. Another possible explanation could be that farmers located farther from the market and main dry weather road are likely to plant bananas to meet their immediate consumption needs compared to those located near the road or market.

Access to credit was negatively associated with the demand for all hybrid banana varieties with the exception of M14 and M17. This result was unexpected and suggests that the more farmers get access to credit the smaller the probability of planting hybrid banana varieties. A possible explanation could be the risk farmer's associate with the unfamiliar new hybrid banana varieties. Farmers fear that the potential benefits for the hybrids might not be realized compared to their local varieties, especially in terms of consumption attributes. Also, in most cases, financial institutions are reluctant to provide loans to poor rural households, characterized by low levels of asset ownership (lack of collateral), high transaction costs associated with the small loans and other risks associated with farming.

With reference to the respondents' perception on Sensory qualities Index, the estimated coefficient show that variety M2 had a negative and significant sign while the rest of the hybrid bananas had no significant signs. The index for Mbwazirume was positive and significant. This implies that all the hybrid bananas are still regarded as inferior to Mbwazirume in terms of Sensory qualities and, therefore, needs to be improved to the level of Mbwazirume. The result for M2 Sensory qualities is unexpected and may be due to the fact that the majority of the respondents have not had an opportunity of planting this particular variety in their demonstration plots and, therefore, may not have fully evaluated its characteristics. Secondly, farmers are used to the taste of their local varieties and may often consider them better than any new hybrid banana variety. Therefore, breeders' conventional approach should increase more focus on including food quality characteristics in their breeding programmes for these hybrid banana varieties to the level of Mbwazirume.

The results also suggest that the Biotic constraints index is having a positive effect on the likelihood of farmers' demand for all the hybrid banana varieties with a significant impact on hybrid M2 and M14. The effect was not significant for variety M9, although it had a correct sign. This implies that with respect to diseases and pests, there was a general perception that hybrid banana varieties perform better compared to the local variety. The original purpose of introducing hybrid banana varieties to the farming communities was to avail and expose the broader community of Ugandan banana farmers whose plantations are badly mainly affected by black Sigatoka disease. This result answers the original objective of the study although more evaluation of these hybrids for resistance to these major pests and disease (weevils, nematodes, black Sigatoka) are required to confirm farmer's perceptions. Also, in terms of the tolerance to poor Soils and wind attributes index, results show that among all the hybrid varieties, M9 had positive and significant sign. This implies that the probability of adoption of this particular hybrid is higher in respect with tolerance to pests and diseases.

6. Conclusions and implications for policy

Banana is consumed as a staple food crop by more than half of the people in Uganda, and is mainly produced for home consumption. Considering the efforts by the Ugandan National Research Programme to introduce new banana hybrids, this paper has analysed the factors that are likely to motivate farmers to adopt these new banana varieties. Evaluating the socioeconomic and farmer perceptions that are likely to influence the up-take of the hybrid bananas is critical to improve the long-term banana breeding efficacy in Uganda. The determinants of farmers' technology preferences are also consistent with the findings of the adoption literature in terms of the importance of household size, Age and farm size, and gender.

Based on the early experiences of farmer perceptions and adoption of the hybrid banana varieties, it may be concluded that hybrid banana varieties are perceived to have better production characteristics (tolerance to sigatoka, weevils, and nematodes, and good agronomic and yield attributes) but are regarded as slightly inferior in regards to consumption characteristics (taste, flavour, skin colour, suitability to Matooke) compared to Mbwazirume.

The results further reveal that with the exception of hybrid M14, all the Matooke hybrid bananas considered in this study were scored above 3.0 (out of a maximum of 5.0) regarding their cooking attributes, implying that they have acceptable cooking qualities. Hybrid M9 was closest to the reference variety in regard to all cooking quality traits. In terms of storability after harvest, variety M9 is perceived to last longer after harvest compared to Mbwazirume. This is an important attribute for consumers that regard this particular variety as suitable for the market. In general, hybrid M9 is regarded as performing well compared to Mbwazirume.

The study also shows that the hybrid banana varieties need to be further refined for consumption attributes to better substitute the local varieties that seem to have a lesser advantage in terms of production attributes. However, since the hybrid bananas have only been with the farming communities since 2008, and given that the study is based only on the second year of the project, more research is needed over a longer period to confirm or reject the results of the present study. The findings, however, demonstrate that among all the hybrid banana varieties considered, variety M9 is perceived as having a relatively good performance with respect to most of the characteristics of Mbwazirume. This suggests that M9 could be widely disseminated to a wider farming community targeting especially the large family households and the wealthier and younger farmers.The study also suggests that farmer access to extension services is likely to have a relatively large impact on the probability of adoption of the hybrid banana varieties. This implies that coordination between researchers and extension agents should be strengthened and more emphasis should be placed on more involvement of extension services in promoting these hybrid bananas to the farming communities. This involvement could include effective provision of appropriate information concerning the hybrid bananas in order to increase knowledge and farmer awareness about the potential benefits of the hybrids. The study has also demonstrated that the hybrid banana varieties combining the desirable characteristics of pests and disease tolerance and yield and consumption attributes M2, M9 and M17 can be more successful in terms of adoption by farming communities in Uganda. These hybrid varieties could be massively disseminated targeting farmers in growing areas of the country which are currently prone to these threats that have reduced banana production in Uganda. However, substantial further work is required to systematically elicit farmers' views on these hybrid bananas design and bananas considering farmers' desired modifications.

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