

Early-Stage Adoption of Improved Banana “Matooke” Hybrids in Uganda: A Count Data Analysis Based on Farmers’ Perceptions

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This paper analyzes farmers’ perceptions regarding the consumption and production attributes of new banana hybrids in Uganda. The data were collected from a sample of 454 farmers. Following descriptive statistics and a factor analysis, a zero-inflated poisson (ZIP) regression model was estimated to understand the effect of farmers’ perceptions and other factors on the likelihood of adopting the new hybrids. The results show that, compared to a local variety (Mbwazirume), four of the hybrids are preferred in terms of production attributes but regarded as inferior with respect to consumption characteristics. Resistance to nematodes, tolerance to weevils and high performance in good seasons in terms of bunch size mainly explain early-stage adoption of the hybrid banana varieties. Hybrid M9 is regarded as having a relatively good performance with respect to most of the production and consumption characteristics. In collaboration with extension agents, variety M9 could be disseminated to a wider farming community that targets larger households, younger farmers and farmers with relatively large sizes of land.

Keywords: Banana (Matooke) hybrids; farmers’ perceptions; ZIP models; Uganda.

1. Introduction

For most of the world’s poorest countries, agriculture provides a source of livelihood for an estimated 86% of rural people [World Bank (2008)]. The size and rate of

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population increase has been the single most important factor influencing the growth in the demand for food in the poorer countries in the world [Borlaug and Dowswell (2005)]. It is estimated that, if Africa's food supplies do not increase, it will spend about \$150 billion per year on food imports by 2030 [Asenso-Okyere and Jemaneh (2012)]. To feed the world's growing population, which is projected to exceed nine billion people by 2050 [United Nations (2013)], it is estimated that food production will have to grow from 70% to 100% [Asenso-Okyere and Jemaneh (2012)] from lands already under cultivation [FAO (2011a)]. In order to satisfy the growing demand for food, productivity on existing farmland needs to be improved by enhancing the yields of food crops per unit area through the advancement of science and technology [Edgerton (2009)]. In areas where agriculture faces large challenges (such as drought, pest and disease pressure), a growing need exists for improved crop varieties that can tolerate stress [FAO (2011a)].

Banana and plantain (*Musa* spp.), commonly called as banana, is an important world food security crop for the livelihood of millions of smallholders in tropical countries [Lorenzen et al. (2010)]. The crop is grown in over 120 countries, with an annual world production of around 104 million tons [Tripathi et al. (2010)]. East Africa is the largest producing and consuming region of banana in Africa [Tripathi et al. (2010)], with Uganda being the world's second leading producer, after India, with about 10.2 million tons per year [FAO (2011b)]. It is estimated that 75% of Ugandan farming households grow this crop on about 1.5 million hectares, which amounts to over 38% of utilized arable land [FAO (2004)]. The continuous production of bananas all the year round offers a significant income generation advantage over traditional cash crops for many smallholder farmers who grow the bulk of the crop in Uganda [Spilsbury et al. (2004)]. Household surveys [see, e.g. UBOS (2010)] indicate that areas where banana production is the main activity never experience famine and are relatively stable in terms of household income.

Despite the crop's importance as food security, its productivity has been declining over time, particularly in central Uganda where plantation life has reduced to less than five years compared with 50 years or more in south-western Uganda [Tushemereirwe et al. (2003b)]. The banana yield in Uganda is low (5–30 t/ha/year) compared with the potential yield (70 t/ha/year) and it is still declining [Asten et al. (2005); Barekye (2009)]. Banana bunch weights at farm level have dropped from 60 kg to 10 kg or even less [Barekye (2009)]. A countrywide rural appraisal conducted in June 1991 [Gold et al. (1993); Tushemereirwe et al. (1996)] and subsequent surveys [Tushemereirwe et al. (2003a)] revealed that the leading factors responsible for the decline in productivity of the East African highland cooking bananas (*Musa* genome group AAA-EA) include, among others, pests (banana weevil and nematodes), diseases (black Sigatoka, banana bacterial wilt), soil fertility decline, socio-economic constraints (high costs of managing crops, competition for labor with other enterprises, marketing difficulties) and low genetic diversity. All these constraints affect banana production, leading to significant production and income losses [Gold et al. (1993); Tushemereirwe et al. (1996); Bagamba et al. (1998)]. The decline in banana productivity has contributed to food shortages, causing consumers to be heavily dependent on banana at risk of food insecurity, particularly in areas where

the crop is regarded as a staple food. In order to reverse this trend, NARO's National Banana Research Program (NBRP) initiated a breeding program in 1994, using a participatory plant breeding approach. The program has so far developed new banana "Matooke" hybrid varieties (M2, M9, M14 and M17). These varieties have been under evaluation in different agroecological regions of Uganda since 2008, with Mbwarzirume (a traditional variety) as a local check.

Despite the research and extension efforts to popularize these hybrids in Uganda, to date no attempt has been made to document the likelihood of their adoption. The objective of this study is, therefore, to analyze farmers' perceptions of varietal attributes and to assess how these perceptions, along with farm and farmer characteristics, determine the variations in the levels of potential adoption. Although a few studies have considered consumption and production attributes as explanatory variables in empirical adoption models [Abebe *et al.* (2013); Adesina and Baidu-Forson (1995); Edmeades *et al.* (2008, 2005); Hintze *et al.* (2003); Kikulwe (2011); Wale and Yalew (2007)], the determinants of farmers' early-stage adoption of new banana hybrid varieties have not been investigated in Uganda. The study is, therefore, one of only a few that has included variety characteristics as factors influencing early-stage banana variety adoption. Furthermore, the analysis conducted in this study uses information obtained from on-farm trials to evaluate farmers' preferences of varietal traits and has considered farm characteristics in the early-stage adoption of the newly-developed hybrid bananas. Considering that farmers are the final decision-makers on the adoption of any technology, it is important for banana breeders to know farmers' reaction to these hybrids.

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

2. Theoretical Framework

Relevant literature and secondary data sources were used to develop the theoretical framework. The conceptual framework presented here is based on the theory of agricultural household models [Singh *et al.* (1986)]. According to these models, decisions of a farmer to adopt a new technology in a given period are assumed to be derived from the maximization of expected utility subject to input constraints [Feder *et al.* (1985)]. In what is now called the "characteristics theory of consumer choice", Lancaster [1966] argued that goods are as good as their desirable and undesirable characteristics, and their attributes 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 their consumption and production attributes [Edmeades and Smale (2006)]. Therefore, crop variety adoption is derived from farmers' demand for variety traits [Smale *et al.* (2001)]. Farmers are unlikely to adopt these varieties if they fail to offer the attributes that the farmers demand.

In this study, farmers' perceptions about the characteristics embedded in the hybrid banana varieties and socioeconomic characteristics were incorporated into the analysis of early-stage adoption decisions. Not only adoption, but also rejection (before or after use) of hybrid bananas can be explained by using the characteristics model. For instance, according to Sinja et al. [2004], users will reject a technology that is not relevant to their needs and not suited to their work environment.

Education of respondents was included in the model. Technically, information acquisition, as well as the capacity to process, understanding and using the technical aspects and returns related to alternative and complementary technologies, is largely determined by formal education and indigenous knowledge. Hence, educated farmers are often more likely to adopt a new technology [Isgin et al. (2008)]. Education level in this study was measured in terms of the number of years spent in school, and was expected to positively influence the response variable.

The effect of farmers' age could be positive or negative, depending on their position in the life cycle. Both age and age-squared were included in the regression model because it allowed for diminishing or increasing effects of the additional year of age. By including age-squared, the effect of age is allowed to vary across different age brackets [Long and Freese (2001)]. Farmers' age may influence adoption in various ways. Older farmers may have more experience, resources or authority that would allow them more possibilities when trying a new technology [CIMMYT (1993)]. They may have more experience in farming, more indigenous knowledge and better skills to assess the characteristics of modern technology. However, it could also be that older farmers are more conservative (risk averse). They might want to continue with old methods and techniques, giving less value to the proven farming practices. That is why the expected sign remains an empirical question [Adesina and Baidu-Forson (1995); Zavale et al. (2005)].

Another variable considered was family size. There is no agreement in the adoption literature on the direction of this variable's influence on the decision of whether to use new techniques or not [Ajewole (2010)]. A larger family size could be an indicator of food consumption requirement. Also, many members in a household imply labor availability that is frequently associated with the adoption of a new technology [Feder et al. (1985)]. In this case, the variable was predicted to be positively related to the demand for hybrid banana varieties, as banana production, being a dominant food crop in Uganda, is labor-intensive.

Farm size and household wealth were also considered in this study. Farm size was measured as the total number of acres available to the farmer. This measurement was found to be positively related to technology adoption, as farmers managing more land are more likely to devote portions of the land to untested improved technologies [Feder and Slade (1984); García (2007); Nkonya et al. (1997); Wubeneh and Sanders (2006)]. Agricultural extension is often regarded as one of the most important sources of information for agricultural production [Sall et al. (2000)]. The number of extension visits received by a farmer is expected to be positively related with the response variable. The reason for this is because the stock of information made available to farmers increases with extension efforts [Wubeneh and Sanders (2006); Feleke and Zegeye (2006)].

Regarding gender, it is hypothesized that male farmers are better able to adopt hybrid bananas. Based on previous empirical adoption studies [Adesina *et al.* (2000); Ajewole (2010); Doss and Morris (2001)], women 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.

Hybrid banana variety attributes included in the model were expected to be positively associated with the likely early-stage adoption of the new hybrids. A positive relationship was expected for a hybrid banana variety, with attributes that farmers would perceive to be better related to their traditional varieties. On the other hand, when undesirable attributes of a new variety are perceived to outweigh its attractive features, in comparison to the existing traditional varieties, then the demand for that variety is expected to be low.

3. 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 Mbwarzirume. In order to identify the underlying dimensions among the variety attributes and to determine whether they could be represented by a smaller number of factors, a principal component analysis was performed based on the important attribute scores rated by farmers [Katungi *et al.* (2011); Birol *et al.* (2009)]. Variety attributes were then grouped into independent attributes for each variety based on the criterion of an eigenvalue greater than unity [Kaiser (1961)]. The dependent variable was measured as the number of banana plant mats (a plant mat is the whole set of banana plants emerging from the initial plant [Thomas (1998)] having been grown by the household since the inception of the project from 2008 to 2010. This variable was chosen because of the short period of farmer assessment of hybrid varieties from the time they were recruited into a trial program (in 2008); the subsequent establishment of hybrid trials; and also considering the nature of the banana crop which takes one year after planting to start fruiting. Thus, the likely demand for a variety is expressed as a count of plant mats [Edmeades and Smale (2006)]. Banana farming is characterized by the number of plant mats which can easily be counted on a given plot, and farmers are aware of the number of plant mats for each of the varieties they grow at a specific time. Moreover, some farmers may choose to plant many or few plant mats of a given variety, based on its desirable and undesirable attributes, and based on farmer's needs and preferences.

The count approach used in this paper has advantages in terms of understanding the likely demand for the hybrid banana varieties. An "adoption" decision, with associated problems of choosing whether to use a zero-one-dependent variable (logit or probit), or a censored variable that represents the extent of adoption (tobit), may be depicted. However, the count approach is more general and allows for the combination of the categorical data (adoption, or not of an 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 counts, and failure to account for the integer nature of the data can bias the results [Haab and McConnell

(1996); Isgin et al. (2008)]. Moreover, the presence of many zeros in the dependent variable could not allow the application of the ordinary count models like Poisson [Cameron and Trivedi (1998)].

In the presence of excess zero values in the discrete count variable, Lambert [1992] and Greene [2003] suggest the application of zero-inflated Poisson (ZIP) regression. This study showed an excessive number of 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 Mbwarzirume). The inability to account for the extra “pull” exerted by the disproportionately high response of zeros might result in biased parameter estimates and misleading inferences [Ganguly et al. (2010)]. For this reason, the ZIP regression model [Vuong (1989)] was applied in this study. The existence of many zeros in the response variable could have been due to the fact that some non-participating farmers might not have had an opportunity to access the planting materials, because hybrid bananas have only recently been introduced among the farming communities in Uganda. Following Mullahy [1986] and Lambert [1992], the detailed model takes the following form:

$$\begin{aligned}\Pr[y = 0] &= f_1(0), \\ \Pr[y = j] &= \frac{1 - f_1(0)}{1 - f_2(0)} f_2(j), \quad j > 0.\end{aligned}\tag{1}$$

This collapses to the standard normal model only if $f_1(\cdot) = f_2(\cdot)$ [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:

$$\begin{aligned}\Pr[y_i = 0] &= \varphi_1 + (1 - \varphi_i) e^{-\mu_i}, \\ \Pr[y_i = r] &= (1 - \varphi_1) \frac{e^{-\mu_i} \mu_i^r}{r!}, \\ r &= 1, 2, \dots\end{aligned}\tag{2}$$

For the adoption of hybrid banana varieties the model is

$$Y[\text{HBAN}] = \text{Exp}\left(\beta_0 + \sum_{k=1}^{13} \beta_k X_i\right),\tag{3}$$

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 early-stage adoption of hybrid banana varieties.

Five equations were estimated: one for each variety because each variety has different production and consumption attributes and farmers respond differently to each one. Because this has not been applied commonly, a model for each of the five varieties was preferred.

4. Research Methodology

4.1. Study areas

The study was conducted in four regions of Uganda (mid-western, central, western and eastern) representing six major agroecological zones, including the Lake Albert

crescent area, Lake Victoria crescent, western highlands, southern highlands, south-east and eastern agroecology [Wortmann and Eledu (1999)]. These are the regions where the NBRP is evaluating the new hybrid banana varieties. While selecting the above regions and agroecological zones of the project, the program considered disease and pest severity as a major factor. Hence, the main objective of hybrid banana development was to develop varieties resistant to black Sigatoka.

The data collection process was participatory from the outset, involving farmers and other stakeholders, particularly while selecting sub-counties and host farmers for demonstration plots. A national workshop was held to share the objectives of the project with the stakeholders. During this workshop, criteria for the selection of sub-counties and farmers to host the plots were developed. Four main banana-producing sub-counties were purposively selected in each district and, from these sub-counties, two villages were randomly selected.

The following criteria were used to select the participating farmers, i.e. farmers' knowledge in banana cultivation and consumption; availability of sufficient resources to maintain the plot (about a quarter of an acre); willingness to host and meet maintenance costs of the trial (including fencing/protection); willingness to allow other farmers to learn from the farm; and accessibility to the farmer's trial site. According to the above criteria, a list of banana-growing farmers was drawn at the village level. From this list, two farmers were randomly selected to host the demonstration plots. Considering the resources available to manage these plots throughout the country, the selection resulted in a total of eight farmers being assigned in each district. Consequently, 10 plants per variety of the four hybrids (M2, M9, M14 and M17) and a local check (Mbwazirume) were given to each of the selected host farmers. Each of the 10 plants were planted on a single plot (about a quarter of an acre), 3 m apart in lines along the slope, at the farmers' own expense. These farmers were introduced to 312 farmers in 39 districts, covering all the above agroecological zones.

4.2. Sampling procedures and data collection

The paper is based on primary data collected from a survey of 192 participating (host farmers of the demonstration plots) and 576 non-participating farmers (neighbors with no demonstration plots), located across the six agroecological zones in the four regions of Uganda. Out of the 39 districts where the project was being implemented, six districts from each of the four regions were randomly selected. In each district, eight farmers were selected for the interview, totaling 192 respondents. In addition, 24 non-participating farmers in each district were selected randomly from the villages where participating farmers are located, totaling 576 farmers. The interviews were held between May and September 2010 by means of a pre-tested questionnaire, with the assistance of trained enumerators.

Data was collected on socioeconomic characteristics, market-related characteristics, total land owned by the farmers (acres^a) and other institutional variables (e.g. extension visits, access to credit and membership in farmer groups). Data was also

^a 1 acre = 0.4046853 hectares.

collected on livestock and household asset ownership and their values. Due to missing responses (incomplete data), 149 participating and 305 non-participating farmers were included in the analysis, giving a total of 454 valid responses. The missing observations were from farmers who did not have an opportunity to access the new hybrids for their evaluations.

Farmers' perceptions about the consumption and agronomic attributes of the hybrid banana varieties were then elicited. Farmers evaluated each hybrid variety for each attribute on a 5-point Likert scale, namely 1 = very poor, 2 = poor, 3 = fair, 4 = good and 5 = very good. Early-stage adoption was measured as the number of banana mats of a hybrid 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, vegetatively propagated from a banana sucker [Thomas (1998)]. Thus, the demand for a variety is expressed as a variety's count of plant mats (each host farmer received 10 plants per variety, the five varieties being M9, M2, M14, M17 and Mbwarzirume) and all the mats were planted in a single plot of a 1/4 acre. Generally, the farmers multiplied a preferred variety, while a variety that was not preferred was either eliminated from the plot or not expanded at all. Since the response variable was "count" data, count data models were considered more appropriate in order to avoid biased and inefficient estimators. It was easy to count the plant mats per variety because each of them was completely unique.

5. Results and Discussion

Table 1 below defines the variables considered in order to explain the determinants of the early-stage adoption of hybrid banana varieties, in terms of the number of plant mats planted for each variety from 2008 to 2010.

With respect to education, the respondents had an average of eight years of schooling, while participating farmers had more (9.4 years). Eight years of schooling, equivalent to primary seven, is slightly higher than the last level of mandatory formal education in Uganda [Farrel et al. (2007)]. The household head's average age was 46 years, with the participating farmers being, on average, older than the non-participating farmers (48.4 years versus 45 years). The average family size of the participating farmers was almost the same as the non-participating ones. The majority of respondents (55%) reported to have been visited by extension agents, while the percentage for participating farmers was much higher (80.5%). About 51% of the respondents were male. In terms of market accessibility, the average walking time to the nearest market was 43 min, with slightly better market access for participating farmers. Participating farmers owned, on average, about one acre more land than their non-participating counterparts (Table 1).

5.1. Analysis of farmers' perception of hybrid banana variety attributes

The new hybrid banana varieties were compared with the local variety, Mbwarzirume, mostly by the participating farmers, for agronomic characteristics and quality traits. A paired sample *t*-test was applied to compare farmer assessments of

Table 1. Variables included in the analysis and summary of descriptive statistics, adoption of hybrid banana varieties, Uganda ($n = 454$).

Variable	Variable description	Total farmers ($n = 454$)	Participating farmers ($n = 149$)	Non-participating farmers ($n = 305$)
Mean (standard deviation)				
Educ	Years of schooling of the household head	7.91 (4.67)	9.40 (4.66)	7.19 (4.51)
Household size	Total number of household members	6.24 (3.54)	6.54 (3.36)	6.10 (3.62)
Working	Active household members between 15 and 64 years of age	3.04 (1.73)	3.61 (1.97)	2.79 (1.55)
Age	Age of the household head (years)	46.11 (15.96)	48.37 (15.76)	45.01 (15.97)
Age ²	Age-squared	2380.37 (1483.43)	2586.13 (1492.08)	2280.51 (1471.29)
Farm size	Total land owned in acres	9.24 (9.98)	9.88 (10.48)	8.92 (9.73)
Market access	Time of walking to the nearest market (in min)	43.08 (56.55)	42.42 (54.71)	43.41 (57.51)
Percentage				
Gender	Dummy (1 if household head is male; 0 if female)	50.66	57.05	47.56
Extension	Dummy (1 if the farmer was visited by extension agents in two years; 0 otherwise)	54.61	80.54	42.02

Note: Figures in parentheses show the standard deviations.

Source: Survey data (May 2010–April 2011).

individual varieties with a local variety (Tables 2(a) and 2(b)). Farmers perceived hybrid varieties to be better than the local variety in terms of production characteristics and disease resistance, however, the hybrid varieties were regarded as inferior in terms of consumption characteristics. Farmers indicated a clear preference for the traditional variety with regard to characteristics like flavor, taste, texture (softness) and color, when cooked. The results further revealed that, with the exception of hybrid M14, all the Matooke hybrid bananas scored above 3 in terms of the cooking attributes, implying that they have acceptable cooking qualities. Hybrid M9 was closest to the reference variety with regard to all cooking quality traits (Table 2(a)). In terms of storability after harvest, the variety M9 was perceived to last longer after harvest when compared with Mbwarzirume. 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 Mbwarzirume (Table 2(a)).

Among the new varieties, respondents reported that M9 was the most preferred variety for nearly all the attributes except taste, texture, color when cooked, flavor, skin color, ease of peeling and suitability for Matooke, and the differences were

Table 2(a). Average score rating of respondents' preferences for the attributes of hybrid bananas M2 and M9 in relation to Mbwazirume, Uganda (paired *t*-test), 2010/11 ($n = 149$).

Variables	M2	Mbwz	Mean difference	P-value	M9	Mbwz	Mean difference	P-value
Yield	3.76	3.77	-0.01	0.94	4.28	3.74	0.54	0.00
Tolerance to drought	3.99	3.69	0.30	0.04	3.99	3.69	0.30	0.04
Early maturity	3.74	4.17	-0.43	0.02	3.98	4.12	1.31	0.30
Bunch size	3.73	3.62	0.12	0.48	4.44	3.61	0.83	0.00
Sucker production	3.82	3.80	0.03	0.88	4.17	3.78	0.39	0.00
Plant height	3.68	3.78	-0.09	0.53	4.16	3.78	0.38	0.01
Resistance to wind	3.59	3.80	-0.21	0.18	4.00	3.79	0.21	0.07
Performance in good season	4.00	4.03	-0.03	0.85	4.41	3.99	0.42	0.00
Resistance to black Sigatoka	3.99	3.12	0.87	0.00	4.09	3.13	0.97	0.00
Resistance to weevils	4.10	3.23	0.86	0.00	4.23	3.25	0.98	0.00
Resistance to nematodes	4.01	3.33	0.87	0.00	4.12	3.33	0.79	0.00
Tolerance to poor soils	3.68	3.44	0.24	0.10	3.92	3.37	0.55	0.00
Taste	3.69	4.69	1.12	0.00	4.04	4.60	-0.56	0.00
Texture (softness) when cooked	3.61	4.56	-0.96	0.00	3.99	4.49	-0.50	0.00
Color when cooked	3.58	4.64	1.06	0.00	3.80	4.58	-0.78	0.00
Flavor	3.70	4.51	-0.81	0.00	3.80	4.49	-0.69	0.00
Longer storage after harvest	3.82	3.82	0.00	1.00	3.98	3.81	0.17	0.26
Skin color	3.53	4.45	-0.92	0.00	3.84	4.45	-0.61	0.00
Ease of peeling	3.81	4.58	-0.78	0.00	3.95	4.59	-0.64	0.00
Suitability for Matooke	4.28	4.32	-0.04	0.77	3.95	4.35	-0.40	0.00

Note: Mbwz denotes Mbwazirume. Farmers' perceptions on variety attributes are coded by means of a 5-point Likert scale, where 1 = very poor, 2 = poor, 3 = fair, 4 = good and 5 = very good.

Source: Survey data (May 2010–April 2011).

Table 2(b). Average score rating of farmer preferences for the attributes of hybrid bananas M14 and M17 in relation to Mwazirume, Uganda (paired *t*-test), 2010/11 (*n* = 149).

Variables	M14	Mbwz	Mean difference	<i>P</i> -value	M17	Mbwz	Mean difference	<i>P</i> -value
Yield	3.67	3.73	-0.06	0.67	4.00	3.67	0.33	0.03
Tolerance to drought	3.67	3.73	0.29	0.14	3.80	3.46	0.34	0.08
Early maturity	3.51	4.20	-0.69	0.00	3.56	4.04	-0.48	0.02
Bunch size	3.65	3.59	0.06	0.76	3.79	3.71	0.08	0.67
Sucker production	3.00	3.86	-0.86	0.00	3.73	3.73	0.00	1.00
Plant height	3.76	3.82	-0.06	0.78	3.52	3.80	-0.28	0.16
Resistance to wind	3.50	4.02	-0.52	0.00	3.66	3.84	-0.18	0.31
Performance in good season	3.82	3.98	-0.16	0.25	4.04	3.98	0.07	0.66
Resistance to black Sigatoka	3.90	3.14	0.76	0.00	3.92	3.16	0.76	0.00
Resistance to weevils	4.17	3.19	0.98	0.00	3.98	3.13	0.85	0.00
Resistance to nematodes	4.00	3.19	0.81	0.00	3.94	3.17	0.76	0.00
Tolerance to poor soils	3.67	3.49	0.18	0.35	3.85	3.35	0.50	0.01
Taste	3.86	4.64	-0.78	0.00	3.28	4.60	-1.32	0.00
Texture (softness) when cooked	2.94	4.56	-1.63	0.00	3.00	4.56	1.39	0.00
Color when cooked	3.22	4.59	-1.37	0.00	3.12	4.56	1.24	0.00
Flavor	3.28	4.66	-1.38	0.00	3.47	4.53	1.18	0.00
Longer storage after harvest	3.29	3.71	-0.42	0.02	3.42	3.76	-0.33	0.15
Skin color	3.35	4.54	-1.19	0.00	3.45	4.49	-1.04	0.00
Easy to peel	3.63	4.69	-1.06	0.00	3.62	4.69	-1.07	0.00
Suitability to Matooke	3.49	4.35	-0.86	0.00	3.27	4.37	1.30	0.00

Note: Mbwz denotes Mwazirume. Farmers' perceptions on variety attributes are coded by means of a 5-point Likert scale, where 1 = very poor, 2 = poor, 3 = fair, 4 = good and 5 = very good.

Source: Survey data (May 2010–April 2011).

statistically significant at the 5% and 10% levels of probability compared with the local variety (Table 2(a)). The results also suggest that hybrid M2 was significantly better than the local variety in terms of attributes like tolerance to drought, resistance to black Sigatoka, weevils and nematodes.

Notable of all the hybrid banana varieties is that they have all been evaluated to significantly outperform Mbwaizirume with respect to resistance to pests (banana weevils and nematodes) and diseases (black Sigatoka). Among these hybrid banana varieties, hybrids M9 and M17 were perceived to significantly outperform Mbwaizirume in terms of good performance in poor soils (Tables 2(a) and 2(b)). This could have been due to tolerance to diseases like Sigatoka, an attribute that farmers associate with tolerance to poor soil. According to Bagamba et al. [1998], farmers reported poor soils as the major factor responsible for the declining banana production in Uganda.

5.2. Farmers' perceived demand for hybrid banana varieties

In order to obtain a detailed picture about the likely influence of farmers' perceptions of the variety attributes on the demand for a hybrid banana variety, farmers were asked about their perceptions towards each of the variety attributes. A principal component analysis was performed, retaining some principal components based on the criterion of eigenvalues being greater than 1 [Kaiser (1961)]. This analysis was performed to identify the underlying dimensions among the farmers' perceptions of the hybrid banana attributes (Tables 3(a) and 3(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)]. Principal components for M17 are given in Appendix A.

Generally, for each variety (M2, M9, M14 and Mbwaizirume) four principal components were identified through varimax rotation and explained 60.63%, 60.55%, 61.65% and 64.95%, respectively, of the total variation in the data (Tables 3(a) and 3(b)). Accordingly, the components were named as *sensory qualities*, *biotic constraints*, *abiotic constraints* and *agronomic qualities*.

The sensory qualities grouping consists of attributes like texture, color when cooked, flavor, storage duration after harvest, ease of peeling, and suitability for Matooke (Tables 3(a) and 3(b) and Table A.1 in Appendix A). For hybrids M2 and M17, flavor had the highest loading, while the skin color of the fruit had the highest loading for hybrid M9. These observations imply that farmers attached great importance to these hybrid attributes. The storage duration after harvest attribute had the highest loading in variety M14, while the color of the food when cooked was highest for Mbwaizirume. These are the banana consumption qualities farmers consider when evaluating a good cooking banana variety [Dadzie and Orchard (1997)].

Another grouping that appeared across all the hybrids was biotic constraints. This grouping consisted of attributes like resistance to black Sigatoka, weevils and nematodes, tolerance to poor soils and tolerance to drought (Tables 3(a) and 3(b) and Table A.1 in Appendix A). Resistance to nematodes had the highest loadings for varieties M2 and M9 (Table 3(a)), while tolerance to weevils was highest for M14,

Table 3(a). Factor analysis of farmers' perceptions of variety attributes on demand for the banana variety, Uganda ($n = 149$).

Variety attribute	Factor loadings for variety M2				Factor loadings for variety M9			
	Factor 1 sensory	Factor 2 biotic	Factor 3 abiotic	Factor 4 agrono	Factor 1 agrono	Factor 2 sensory	Factor 3 biotic	Factor 4 abiotic
Tolerance to drought	—	—	0.51	—	—	—	—	—
Yield	—	—	—	0.58	0.69	—	—	—
Performance in good season	—	—	—	0.62	0.74	—	—	—
Early maturity	—	—	—	0.79	—	—	0.42	—
Bunch size	—	—	0.77	—	0.67	—	—	—
Sucker production	—	—	—	0.43	0.71	—	—	—
Plant height	—	—	0.42	0.58	—	—	—	0.46
Resistance to wind	—	—	0.44	—	—	—	—	0.71
Tolerance to poor soils	—	—	0.64	—	—	—	—	0.76
Resistance to black Sigatoka	—	—	0.54	—	—	—	0.53	0.50
Resistance to weevils	—	0.67	—	—	—	—	0.63	—
Resistance to nematodes	—	0.84	—	—	—	—	0.75	—
Taste	—	0.82	—	—	—	—	0.71	—
Texture (softness) when cooked	0.74	—	—	—	—	0.63	—	—
Color when cooked	0.76	—	—	—	—	0.63	—	—
Flavor	0.79	—	—	—	—	0.69	—	—
Longer storage capability after harvest	0.67	—	—	—	—	0.68	—	—
Skin color	—	0.65	—	—	—	0.78	—	—
Ease of peeling	—	—	—	—	—	—	—	—
% of variance explained	0.17	0.16	0.16	0.12	0.15	0.14	0.13	0.10
Eigenvalues	7.73	1.78	1.50	1.13	7.02	1.50	1.34	1.19

Note: Farmers' perceptions of variety attributes are coded using a 5-point Likert scale, where 1 = very poor, 2 = poor, 3 = fair, 4 = good and 5 = very good. Only attributes with absolute factor loadings > 0.4 are included.
Source: Survey data (May 2010–April 2011).

Table 3(b). Factor analysis of farmers' perceptions of variety attributes on demand for the banana variety, Uganda ($n = 149$).

Variety attribute	Factor loadings for variety M14				Factor loadings for variety Mwazirume			
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 1	Factor 2	Factor 3	Factor 4
	agrono	biotic	sensory	abiotic	sensory	biotic	agrono	plant attributes
Tolerance to drought	0.42	0.58	—	—	—	0.63	—	—
Yield	0.78	—	—	—	—	—	0.76	—
Performance in good season	0.81	—	—	—	—	—	0.73	—
Early maturity	0.67	—	—	—	—	—	0.43	0.43
Bunch size	0.76	—	—	—	—	—	0.81	—
Sucker production	0.54	—	—	—	—	—	—	0.75
Plant height	0.67	—	—	0.60	—	—	—	0.65
Resistance to wind	—	—	—	0.77	—	0.51	—	0.43
Tolerance to poor soils	—	0.70	—	—	—	0.72	—	—
Resistance to black Sigatoka	—	0.74	—	—	—	0.82	—	—
Resistance to weevils	—	0.77	—	—	—	0.88	—	—
Resistance to nematodes	—	0.68	—	—	—	0.86	—	—
Taste	—	0.68	—	—	0.75	—	—	—
Texture (softness) when cooked	—	—	0.57	—	0.74	—	—	—
Color when cooked	—	—	0.82	—	0.80	—	—	—
Flavor	—	—	0.63	—	0.76	—	—	—
Longer storage capability after harvest	—	—	0.85	—	—	0.49	0.42	—
Suitability to Matooke local food	—	—	0.51	—	0.77	—	—	—
Skin color	0.44	—	0.55	—	0.60	—	—	—
Ease of peeling	—	—	—	0.48	0.53	—	—	—
% of variance explained	0.18	0.17	0.16	0.10	0.19	0.19	0.15	0.09
Eigenvalues	7.08	2.30	1.83	1.12	6.54	3.35	1.72	1.13

Note: Farmers' perceptions on variety attributes are coded by using a 5-point Likert scale, where 1 = very poor, 2 = poor, 3 = fair, 4 = good and 5 = very good. Only attributes with absolute factor loadings > 0.4 are included.

Source: Survey data (May 2010–April 2011).

M17 and Mbwarzirume (Table 3(b) and Table A.1 in Appendix A). These observations indicate that farmers considered these varieties as being tolerant to nematodes. Speijer and Kajumba [1996] reported a yield reduction of up to 50% in banana production in Uganda due to nematodes.

The third grouping, named “abiotic” constraints, factored together across all the variety attributes like bunch size, tolerance to poor soils, tolerance to drought, resistance to wind and sucker production (Tables 3(a) and 3(b)). Tolerance to poor soils had the highest loading for M9, while resistance to wind registered the highest loadings for hybrid M14.

The fourth grouping common across all the varieties was named agronomic qualities. Attributes that featured in all the varieties under this grouping include early maturity, performance in a good season, high yielding, plant height, sucker production, bunch size and finger size (Tables 3(a) and 3(b)). This attribute’s performance in a good season had the highest loadings for varieties M9 and M14, while early maturity had the highest loading for hybrid M2. The loadings for plant height and early maturity were less than 0.4 in the agronomic index for M9.

5.3. Determinants of early-stage adoption of hybrid banana varieties

The banana hybrid varieties are still new among the Ugandan farming communities. The present study was undertaken during the second and third years of their on-farm evaluation. The results of the ZIP regression explaining early-stage adoption are presented in Table 4. Marginal effects are summarized in Table A.2 in Appendix B.

The model estimates show that the effect of education level of the household head was positive and significant for variety M2 and Mbwarzirume, while negative and significant for M9. This result implies that educated farmers are more likely to plant more banana mats of the M2 and Mbwarzirume hybrids, and less of the M9 hybrid (this finding may be due to the fact that hybrids M2 and Mbwarzirume look alike in terms of external bunch appearance). A possible explanation for the less educated farmers considering it more important to rather plant hybrid M9, in comparison with the educated farmers, could be the importance of production attributes like bunch size, resistance to black Sigatoka and tolerance to poor soils associated with hybrid M9.

The marginal effects (Table A.2 in Appendix B) suggest that, when education of the farmer increases by a unit and other factors are held constant, the expected likelihood of farmers planting more plant mats increases by 0.25 and 0.16 for varieties M2 and Mbwarzirume, respectively, and decreases by 0.01 for M9. Related studies like Hossain and Crouch [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.

Household size, as an indicator of the availability of farm labor and the food consumption requirement, is significantly and positively associated with the demand for hybrids M9 and M14. A possible explanation could be that these hybrids are

Table 4. ZIP regression results for early-stage adoption of hybrid banana varieties in Uganda, 2010/11 ($n = 454$) (figures in parentheses are Z -values).

Variable	M2 coefficient estimate (Z)	M9 coefficient estimate (Z)	M14 coefficient estimate (Z)	M17 coefficient estimate (Z)	Mbwazirume coefficient estimate (Z)
Educ	0.025*** (5.67)	0.035*** (-7.56)	0.004 (0.41)	-0.003 (-0.31)	0.016*** (3.10)
Household size	0.000 (-0.07)	0.090*** (18.24)	0.033*** (3.55)	-0.010 (-0.85)	0.006 (1.00)
Working age group	-0.110*** (-9.94)	-0.047*** (-4.05)	-0.043** (-2.05)	-0.100*** (-4.48)	-0.006 (-0.46)
Gender	0.106*** (2.73)	0.355*** (9.39)	0.162*** (2.21)	-0.149** (-1.85)	0.047 (1.11)
Age	0.012** (2.46)	-0.014** (-2.76)	-0.004 (-0.50)	-0.003 (-0.36)	0.025*** (3.60)
Age ²	0.000*** (-3.66)	-2.950E-05 (-0.51)	-2.120E-05 (-0.25)	-3.760E-05 (-0.33)	-3.061*** (-4.16)
Farm size	0.000 (-0.15)	0.009*** (4.91)	0.005 (1.13)	0.018*** (4.30)	-0.004*** (-2.13)
Market access	-0.002*** (-4.44)	0.001*** (4.38)	-0.001 (-1.02)	-0.002** (-2.55)	-0.001 (-2.69)
Extension	-0.355*** (-8.97)	0.142*** (3.44)	-0.129 (-1.53)	-0.045 (-0.51)	9.630*** (2.18)
Sensory qualities index	-0.100** (-2.85)	0.087** (2.89)	0.077 (0.73)	0.078 (0.82)	0.253*** (6.56)
Biotic constraints index	0.073*** (2.71)	0.273*** (10.24)	3.221*** (2.79)	0.233** (1.69)	-0.014 (-0.45)
Abiotic constraints	0.084*** (2.37)	0.228*** (10.27)	-0.213 (-1.60)	-0.164** (-1.68)	—
Agronomic qualities index	0.056** (1.99)	0.101*** (3.83)	0.020 (0.22)	-3.905 (-0.31)	0.105*** (3.06)
Constant	3.195*** (24.48)	3.271*** (26.55)	2.883*** (15.99)	3.327*** (14.34)	2.441*** (14.27)
Number of observations	425	425	431	431	431
Log likelihood	-1776.317	-1551.268	-547.8183	-496.7308	-1248.291
Nonzero observations	154	127	63	64	121
Zero observations	271	298	368	367	310
LR chi ²	294.33	1013.04	55.50	65.61	90.22
Prob > chi ²	0.0000	0.0000	0.0000	0.0000	0.0000
Vuong test of ZIP versus $Z =$	0.0000	0.0000	0.0000	0.0000	0.0000
Pr > $Z =$	8.56	10.93	6.66	6.25	11.15

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels of probability, respectively. A validity test for the ZIP model was undertaken by using Vuong's statistic [Vuong (1989)]. The test supported the ZIP model over the Poisson model with all models having values greater than 1.96 (Table 4).

Source: Survey data (May 2010–April 2011).

perceived to have good production attributes, like tolerance to pests, good performance in poor soils and capacity to produce good bunch sizes (Tables 2(a) and 2(b)). These attributes are perhaps likely to attract households with large families in terms of harvesting more and achieving household food security. The marginal effects

(Table A.2 in Appendix B) further suggest that, if family size increases by one member, the likelihood of farmers increasing the number of plant mats of variety M9 increases by 0.53, and for M14 by 0.18.

The gender of the household head was found to positively and significantly influence the demand for all hybrid banana varieties, with the exception of M17, implying that male farmers are more likely to plant more mats of most of these hybrids. This finding could be due to the fact that banana is a perennial crop and requires land to which men have more access than women. Also, the banana crop in Uganda is regarded as an important source of income for most of the resource-poor farmers [Karamura *et al.* (1998)]. This fact attracts men to participate in its production and they would, therefore, particularly plant more of the varieties that are suitable for commercial purposes.

The estimated coefficient of a respondent's age was statistically significant and negative on the early-stage adoption of hybrid M9 and positive for M2 and Mbwarzirume (Table 4). These results suggest that older farmers are less likely to plant more mats of variety M9 and more likely to plant more mats of M2 and Mbwarzirume. A possible explanation for this finding could be that the younger farmers are relatively more adventurous compared with the old farmers who might want Matooke to look and taste the way it has always been. The Matooke from M2 is relatively yellow in appearance and therefore looks closer to what Matooke has always been. The estimated age-squared variable is positively and negatively related to M2 and Mbwarzirume, respectively. These results suggest that, for the older farmers, early-stage adoption increases with age for hybrid M2 but decreases for Mbwarzirume. This finding may be due to the fact that younger farmers tend to favor new innovations and may have a lower risk aversion. The marginal effects of the age variable show that a one unit increase in a farmer's age will increase the number of plant mats likely to be planted of M2 by 0.16 and of Mbwarzirume by 2.68, and reduce M9 by 0.17. The marginal effects for the age-squared variable (Table A.2 in Appendix B) suggest that a one unit increase in older age range will increase the number of plant mats likely to be planted of M2 by 0.002 and of M9 by 0.002. For Mbwarzirume, the results suggest that the number of plant mats increases until a certain age threshold whereafter it decreases. This finding suggests that the number of plant mats for Mbwarzirume will decrease with age at an increasing rate of 0.003.

The results further show that there is a significant negative association between the total land area (in acres) and the probability of demand for Mbwarzirume, while it is positively associated with the likely early-stage adoption of hybrids M9 and M17. These results imply that farmers managing bigger land-holdings are the potential early adopters of these hybrids, in comparison with farmers with less land. The marginal effects further suggest that, if land size increases by one acre, the likelihood of farmers planting variety M9 increases by 0.02 and by 0.004 for M17, while it decreases by 0.02 for Mbwarzirume. A possible explanation for this finding could be that producers with larger farms may be more willing to take risks and devote portions of their land to an untried variety, compared with those with smaller land areas. According to Feder and Slade [1984], households with larger farms have more land to allocate to improved technologies.

The walking distance to the nearest market (market access) appears to affect the number of M2 and M17 plant mats that farmers are likely to plant negatively and significantly. However, this coefficient for M9 is positive and significant. This finding implies that farmers located farther away from markets are less likely to plant the new hybrid banana varieties (M2 and M17) in large quantities. A possible explanation could be that these two particular hybrids look like the local bananas that dominate the market, in terms of external bunch and finger appearance. Hybrid M9 is perceived to produce good bunch sizes that are likely to attract households that strive to meet their subsistent household consumption needs. The marginal values indicate that, with each unit increase in the time taken to walk to the nearest market (in min), the likelihood of planting more mats of M2 and M17 reduces by 0.011 and 0.006, respectively, while it increases by 0.016 for M9. A possible explanation for this finding could be that farmers far away from market centers will tend to be less market-oriented [Feleke and Zegeye (2006)] and focus more on meeting their subsistent household consumption needs.

Keeping other factors constant, farmers' contact with extension workers is positively and significantly related to the number of M9 and Mbwarzirume plants that farmers are likely to plant. The negative sign for M2 implies that farmers are likely to plant less of this hybrid, given the services of extension agents. Each additional unit increase in extension contacts is estimated to increase the number of plant mats that farmers are likely to plant by 4.26 and by 3.38 for M9 and Mbwarzirume, respectively (Table A.2 in Appendix B). This finding is consistent with Feleke and Zegeye [2006], who found that farmers with more extension contacts are more likely to be adopters of improved maize varieties than those with less extension contacts. Perhaps this finding could be attributed to the technical knowledge associated with the factors that correlated with the variety preferences received from the contacts. The result for M2 is unexpected because the majority of the respondents have not had an opportunity to plant this particular variety in their demonstration plots and, therefore, may not have fully evaluated its characteristics, in comparison with the other varieties.

With reference to the sensory qualities index, the estimated coefficients for varieties M9 and Mbwarzirume showed positive and significant signs. The index for M2 was negative and significant. This finding implies that respondents seem to prefer M9 and Mbwarzirume to M2, in terms of sensory qualities. Farmers are, therefore, more likely to plant more mats of these varieties. A possible explanation could be that farmers are used to their local varieties and may often consider them to be better than this new hybrid, especially in terms of the desirable attributes such as soft food and color when cooked. The majority of farmers planting these hybrids suggests that M9 is close to the local varieties, with reference to these desirable attributes.

The results also suggest that the biotic constraints index has a positive and significant effect on the likelihood of farmers' demand for all the hybrids. This finding implies that, with respect to biotic constraints (diseases and pests like black Sigatoka, weevils and nematodes), there was a general perception that all the hybrids perform better compared with the local variety. The original purpose of introducing hybrid bananas to the farming communities was to counter mainly black

Sigatoka disease. Pests and diseases have been cited as important constraints to banana production in several studies [Gold *et al.* (1999); Tushemereirwe *et al.* (2006)]. However, more evaluation of these hybrids are required to confirm farmers' perceptions about resistance to the major pests and disease (such as weevils, nematodes and black Sigatoka), because these hybrid varieties have been among the farming communities for a relatively short period of time.

In terms of tolerance of the hybrids to abiotic constraints, the results suggest a positive and significant sign for M2 and M9. The index for M17 was negative and significant, implying that the probability of early-stage adoption of the hybrids is higher for M2 and M9 with respect to tolerance to abiotic constraints like poor soils, wind damage and drought. A possible explanation could be that these two hybrids have a strong pseudostem to support the bunch size and limit wind damage. Another explanation could be that these hybrids tolerate poor soils and disease pressure better than the local varieties. In the central region of Uganda, variety selection, in most cases, considers the tolerance to marginal soils and drought-prevalent characteristics [Edmeades *et al.* (2005)].

The results further show that the agronomic constraint index has a significant and positive association with the probability of demand for varieties M2, M9 and Mbwarzirume. This finding implies that, with respect to agronomic traits (early maturity, performance in good season, high yield and plant height), there was a general perception that M2 and M9 perform better among all the hybrids, with no significant difference from a local variety.

6. Conclusion and Policy Implications

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 Uganda National Banana Research Program to introduce new banana hybrids, this paper has analyzed the factors that are likely to induce early-stage adoption of these hybrids.

Based on the early experiences of farmer perceptions and adoption of the hybrid banana varieties, it may be concluded that, in comparison with Mbwarzirume, the hybrids are perceived to have better production characteristics (tolerance to Sigatoka, weevils, nematodes and good agronomic and yield attributes), but are regarded as slightly inferior in terms of consumption characteristics (taste, flavor, skin color and suitability as Matooke). The results further reveal that, with the exception of hybrid M14, all the Matooke hybrid bananas considered in this study had scored above 3 on an average (out of a maximum of 5) regarding their cooking attributes, implying that they have acceptable cooking qualities. Hybrid M9 was closest to the reference variety with regard to all cooking quality traits. However, the findings demonstrate that, among all the hybrid banana varieties considered, variety M9 is perceived as having a relatively good performance with respect to most production and consumption traits. This finding suggests that M9 could be disseminated to a wider farming community, targeting especially larger family households and 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 hybrid banana varieties. This finding implies that coordination between researchers and extension agents should be strengthened, and greater emphasis should be placed on more involvement of extension services in the promotion of these hybrid bananas in 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 also demonstrated that the hybrid bananas 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 disseminated by targeting farmers in the growing areas of the country which are currently prone to disease threats, being the original cause of the reduction in banana production in Uganda.

As 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, future research has to elicit farmers' experience-based perceptions and explain the dynamics of adoption and/or disadoption. Moreover, further work needs to be done to determine the impact of hybrid bananas on household income and food security. A panel data should be collected to capture the temporal and spatial dimensions of farmers' acceptance and consequent impact of the hybrids. The study has demonstrated that farmers have knowledge to select the varieties that potentially have traits that they prefer in deciding on the variety they wish to grow. The breeding programs, therefore, have to tap into this knowledge and translate it into their future varietal improvement programs.

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Appendix A.

Table A.1. Factor analysis of farmer perceptions of variety attributes on demand for the M17 banana variety, Uganda ($n = 149$).

Variety attribute	Factor loadings for variety M17			
	Factor 1 sensory	Factor 2 biotic	Factor 3 abiotic	Factor 4 agronomic
Tolerance to drought	—	0.43	—	0.52
Yield	—	—	0.67	—
Performance in good season	—	—	0.58	0.41
Early maturity	—	—	0.42	0.52
Bunch size	—	—	0.79	—
Finger size	—	—	0.72	—
Sucker production	—	—	—	0.81
Plant height	—	—	—	0.40
Resistance to wind	—	0.37	—	—
Tolerance to poor soils	—	0.20	—	—
Resistance to black Sigatoka	—	0.78	—	—
Resistance to weevils	—	0.87	—	—
Resistance to nematodes	—	0.82	—	—
Taste	0.74	—	—	—
Texture (softness) when cooked	0.77	—	—	—
Color when cooked	0.80	—	—	—
Flavor	0.81	—	—	—
Longer storage capability after harvest	—	0.50	—	0.42
Suitability to Matooke local food	0.64	0.46	—	—
Skin color	0.58	—	—	—
Ease of peeling	0.56	—	0.40	—
Exp. Var. (%)	0.20	0.15	0.13	0.09
Eigenvalues	7.01	2.50	1.67	1.35

Notes: Farmers' perceptions on variety attributes are coded using a 5-point Likert scale, where 1 = very poor, 2 = poor, 3 = fair, 4 = good and 5 = very good. Only attributes with absolute factor loadings > 0.4 are included.

Source: Survey data (May 2010–April 2011).

Appendix B.

Table B.1. Marginal effects from the ZIP regression results for early-stage adoption of hybrid banana varieties in Uganda, 2008–2010 ($n = 454$).

Variable	M2 dy/dx	M9 dy/dx	M14 dy/dx	M17 dy/dx	Mbwazirume dy/dx
Educ	0.254	−0.014	0.050	0.075	0.158
HH size	−0.128	0.534	0.182	0.024	0.121
Working age group	−0.394	−0.598	−0.191	−0.136	−0.076
Gender	0.715	2.255	0.337	−0.418	0.001
Age	0.160	−0.172	−0.045	0.048	2.686
Age ²	0.002	0.002	3.545	−0.001	−0.003
Farm size	0.019	0.020	−0.014	0.004	−0.022
Market	−0.011	0.015	−0.003	−0.006	−0.004
Extension	−1.851	4.261	−1.732	1.707	3.383
Population in labor force	−0.394	−0.598	−0.191	−0.136	−0.076
Sensory qualities index	−0.264	2.585	0.811	0.106	0.659
Biotic constraints index	−0.529	1.000	−6.878	0.074	−1.629
Abiotic constraints	0.183	3.115	−0.478	2.802	—
Agronomic qualities index	0.538	0.689	−0.123	−0.147	1.589

Source: Survey data (May 2010–April 2011).

Biography

Kenneth Akankwasa is currently working as a Research Officer (Socio-Economist) with the National Banana Research Program of the National Agricultural Research Organization (NARO), Kampala, Uganda. His recent research area has been focused upon “Evaluating farmers’ and consumers’ acceptance of new cooking banana hybrids in Uganda: Microeconomic analysis and policy implications” and he has earned a Ph.D. from the University of KwaZulu-Natal, South Africa. His other areas of research interest include technology adoption studies, impact assessment and market studies and he has published papers in peer-reviewed journals.

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