CHAPTER 9

Use of Hybrid Cultivars in Kagera Region, Tanzania, and Their Impact

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As described in Chapter 5, the formal introduction of new banana cultivars to Kagera Region began in 1997 with KCDP. Preliminary studies by the project indicate rapid and extensive uptake of these materials. This chapter re-examines the use of introduced banana hybrids and one aspect of their social and economic impact: reduced vulnerability to production losses from biotic pressures. A treatment model is used to identify the determinants of adoption and the effects of adoption on expected yield losses from pests and diseases, while controlling for other factors. Findings demonstrate that the intended impact of growing hybrids on production vulnerability was achieved, which lends justification to research efforts aimed at developing resistance materials. Like other analyses in this report, this study shows the preeminence of farmer-based systems for diffusing planting material, as compared to formal systems.

The agriculture of Kagera Region, located in the northwestern corner of Tanzania on the western shores of Lake Victoria, is based largely on banana/coffee farming systems.[1] About 43.8 percent of the total acreage under banana production in Tanzania is found in this region. Over the past decades, Kagera Region has experienced serious decline in the production of bananas and other traditional crops, including coffee, because of declining soil fertility and increasing infestations of pests and diseases (Bosch et al. 1996; Baijukya and Folmer 1999). The situation has also been made worse by the persistence of outdated methods of crop husbandry practiced by banana growers and the lack of reliable local and external markets for bananas, leading to frequent periods of food insecurity.

As detailed in Chapter 4, banana growers, national and international research institutions, and NGOs have sought to formulate strategies to mitigate production decreases. One of these strategies was the introduction of new banana cultivars into the region. Since the 1960s, several exotic cultivars have been introduced by farmers into the region from other banana growing areas within and outside the country. The formal introduction of new banana cultivars into the region began in 1997, when KCDP was established. One of its objectives was to acquire, multiply, and disseminate new banana cultivars to farmers.

On-farm testing of the new cultivars commenced in 1997 and was conducted concurrently with their multiplication and dissemination of planting materials to farmers in the region

[1] This chapter is drawn from a selected paper presented at the international conference Economics of Poverty, Environment, and Natural Resource Use, May 2006, Wageningen University, The Netherlands.

(Nkuba et al. 1999). The results of on-farm testing showed that on average the new banana cultivars yielded a bunch weight of 18.9 kg, compared with 9.7 kg for local cultivars (Byabachwezi, Steenhuijesen, and Rwezaula 1997; Nkuba, Ndege, and Mkulila 2002). Initial assessment revealed that these cultivars are acceptable to farmers for their multiple uses (cooking, dessert, roasting, and brewing) and good marketability. From 1997 to 2002 about 2.5 million suckers (or planting material) from the new banana cultivars had already been distributed to farmers. Knowledge gaps remain, however. For example, although KCDP analyzes initial adoption rates and acceptability in project reports, more systematic information about the extent and determinants of adoption, as well as the economic impacts of adoption, is needed.

In Tanzania, there is increasing need for investment in the improvement of crops and livestock, which is one of the government strategies on reduction of rural poverty (MAFS 2001). Similar to other developing economies, despite the large financial resources spent on development programs each year, there is limited awareness of the actual impact of programs on the poor (Baker 2000). This situation poses basic questions about whether targeted interventions have achieved the intended benefits and their effectiveness and efficiency. Although banana growers in Tanzania have participated in a number of extension and research programs, there is little documentation of program impact.

This chapter focuses on identifying the determinants of use of the new banana cultivars and assessing the impacts of use on production vulnerability. The new banana cultivars are the hybrids (from FHIA) formally introduced by KCDP in the region. The analysis is used to better understand the characteristics and production potential of adopters compared to nonadopters in areas exposed to the program interventions. Other aspects of adoption and impact are analyzed in Nkuba (2007).

The next section describes household income-earning strategies and the resource base of household farms in the banana-based production system of Kagera Region. The conceptual approach is the theoretical framework of the agricultural household, presented in Chapter 2. The econometric approach is a treatment effects model, described below. The model is applied to data collected through a stratified random sample of households (Chapter 2 and Appendix D). Stratifying variables include exposure to new cultivars through programs, to control for treatment effects, and elevation. Elevation is related to pest and disease pressures. We contend that pest and disease pressures have driven farmers to seek new, disease-free planting material.

Production Systems and Income Sources

The banana/coffee-based farming system is dominated by smallholder farmers, with an average farm size ranging from 0.5 to 1.5 ha. There are three types of land use, locally known as *Kibanja*, *Kikamba*, and *Rweya*. *Kibanja* is a permanent field for cultivation of bananas. Often, bananas are intercropped with coffee and, during the rainy season, with beans. Although households sell surplus banana production for cash generation, coffee is the main cash crop, with the region leading in coffee production in the country. Tea is also grown along the lake shores of the region. Other crops intercropped in *Kibanja* are maize, and root and tuber crops, fruits, and vegetables. *Kibanja* provides food and income for the household. *Kikamba* is an area found adjacent to *Kibanja*, and it is used for cultivating annual crops (beans, maize, and groundnuts). *Rweya* is grassland used for grazing, cutting mulch grass, and shifting cultivation of annual crops, such as bambara nuts (Lorkeers 1995).

Among the banana cultivars grown in Kagera Region are the EAHBs, which have been endemic (or constantly present) in the

Table 9.1 Five-year average areas under crop production by district in Kagera Region, 1996/97–2000/01 (ha)

Crop type	Bukoba	Muleba	Biharamulo	Ngara	Karagwe	Total
Foodcrops						
Bananas	47,830	36,807	1,870	25,549	41,289	153,345
Maize	11,490	4,440	25,445	4,347	25,523	71,245
Sorghum	—	—	8,675	3,056	2,500	14,231
Sweet potatoes	15,970	6,060	13,647	151	6,961	42,669
Cassava	15,551	15,401	33,570	9,524	34,763	108,809
Paddy	—	—	1,826	—	—	1,826
Beans	21,560	8,631	16,795	5,786	32,856	85,628
Potatoes	—	—	—	—	361	361
Subtotal	112,401	71,339	101,829	48,292	144,254	478,115
Cash crops						
Coffee	31,434	19,374	617	762	15,895	68,082
Tea	1,129	133	—	—	—	1,262
Cotton	—	—	7,191	—	—	7,191
Subtotal	32,563	19,507	7,808	762	15,895	76,535
Total	144,964	90,846	109,637	49,054	160,149	554,650

Source: Regional Commissioner's Office, Bukoba, Kagera Region, 2003.
Note: — indicates none reported.

region since 500–1000 A.D. (Byabachwezi and Mbwana 1999), and other exotic and hybrid bananas. Based on their uses, bananas produced in the region can be classified into four use types: cooking, beer, roasting, and sweet (dessert) (see Chapter 3).

Bananas cover about 33 percent and 26 percent of the total land under crops in Bukoba and Karagwe districts, respectively, of Kagera Region, where this study was implemented (Table 9.1). During 1996–2001, annual average production of bananas was 919,995 tons (RCO 2003). Karagwe District contributed about 45 percent of the total production in the region, with the Bukoba contributing 23 percent, Muleba 20 percent, Ngara 11 percent, and Biharamulo 1 percent. Banana production is seasonal, with the peak season spanning between the months of June and August, and the lowest production levels attained during November.

Measuring Impacts

The literature about economic impacts of program intervention emphasizes the importance of establishing the appropriate counterfactual. As stated by Ravallion (1994, 4), "the essential problem of impact evaluation is that we do not observe the outcomes for participants if they had not participated." The appropriate counterfactual facilitates measurement of the correct causal relationship between the technology and the outcomes being measured, because other confounding factors may also have influenced the outcome (Ravallion 1994; Baker 2000; Doss 2003; Chapter 2).

Ravallion (1994) summarizes and compares the five main methods available for evaluating program impact. Using randomization, individuals are selected into treatment and comparison groups at random, so that the only measurement errors are associated with sampling. Sampling errors can be reduced through larger samples. In the matching approach, the comparison group is matched to the treatment group based on characteristics measured in data from a larger, representative sample survey. Propensity scores are tabulated to support the selection of individuals. Reflexive comparisons enable the "before and after" to be estimated for key parameters using a baseline, which serves as the comparison group. With the double difference method, the treatment and comparison group are compared both before and after the treatment. The fifth approach is the instrumental variables approach used in this chapter. Instrumental variables are those that matter to participation, but not to the outcome. They enable the identification of exogenous variation in outcomes that can be attributed to the program.

In our case, the participation variable is the decision to use new banana hybrids. The econometric approach for measuring the impact of using these new banana hybrids is described next.

Econometric Approach

Use of banana hybrids and their impact on smallholder farmers are tested with a treatment effects model (defined in Maddala 1983). The model is designed to capture the effect of an endogenously chosen binary treatment (use of banana hybrids) on another continuous observed variable that expresses a social or economic impact on households. The approach controls for the potential endogeneity of hybrid use decisions and outcomes through the use of two stratification variables: elevation (correlated with biotic pressures) and exposure of the surrounding area to program interventions. Stratification variables can be used as instruments for the identification of one of the behavioral outcomes—in this case, hybrid use. In one equation of the simultaneous system, the determinants of hybrid use are identified. The factors influencing an outcome variable are identified in the second equation, while taking into account the use of banana hybrids and its determinants.

The decision to use a banana hybrid is defined as a binary outcome (z_j) of an unobserved latent variable (z_j*). The latent variable underlying this decision is a linear function of its observed ($\mathbf{w}_j$) and unobserved (u_j) determinants, such that:

$$z_j = 1 \text{ if } z_j^* = \mathbf{w}_j'\boldsymbol{\Phi}_j + u_j > 0,$$
$$z_j = 0 \text{ otherwise.}$$

The impact of growing a banana hybrid, expressed as a continuous outcome (y_j), is conditional on a set of independent variables ($\mathbf{x}_j$) and the endogenous binary variable (z_j) indicating whether a hybrid is used:

$$y_j = \mathbf{x}_j'\boldsymbol{\beta}_j + \lambda z_j + \varepsilon_j \,.$$

These equations are the basis for regression analysis, estimated with maximum likelihood methods. To allow for the identification of the impact of hybrid use on production vulnerability, the decision to grow banana hybrids is estimated with a set of instruments and other covariates hypothesized to influence this choice (all represented by the vector $\mathbf{w}_j$).

Variable Definition

Dependent Variables

The data used for analysis include 260 banana-growing households in Tanzania. Of the sampled households, 20 percent are using one or more banana hybrids in their groves. Following the approach outlined above, the dependent variable for the decision to grow banana hybrids is binary (1 = grow any hybrid; 0 otherwise). Clearly, the dependent variable in the impact equation could be formulated in a number of different ways. The immediate purpose of introducing hybrids was to reduce the vulnerability of households to production losses from banana pests and diseases. In turn, reducing production vulnerability can have important ramifications for consumption and income vulnerability. Reducing production vulnerability could lead to higher or more consistent consumption levels, either directly through meeting subsistence needs or indirectly, through more regular or increased sales and market purchases. Over time, smoother banana production and/or income can accumulate, contributing to changes in wealth status in the community.

In this single-year cross-sectional study, we have measured production vulnerability in terms of expected yield losses from pests and diseases. The dependent variable is defined as the average yield loss expected from biotic pressures considered jointly, including weevils, black Sigatoka, and *Fusarium* wilt. Yield loss is a continuous variable that has been composed from the raw data. First, farmers were asked the incidence of the biotic pressure (in years) they had experienced during their involvement in banana production. Next, enumerators elicited from farmers triangular yield distributions (minimum, maximum, and mode) in the presence and absence of the biotic pressures. Physical differences in the effects of pathogens on different banana cultivars were readily observable to farmers, and photos were provided to assist them in recognition. Expected yield losses were calculated, per biotic constraint and cultivar, from the elicited yield distributions (Hardaker, Huirne, and Anderson 1997). Once composed, the expected yield loss per constraint was averaged across the cultivars grown for each household. Finally, the maximum average expected yield across the three biotic constraints was chosen as a measure of production vulnerability, providing a single indicator of yield loss per household.

Determinants of Hybrid Use

As noted in Chapters 6 and 7, the model of the agricultural household and a broad literature on technology adoption provide the basis for the choice of explanatory variables, comprising individual, household, and physical farm characteristics. Variables are defined and summary statistics provided in Table 9.2.

Among the variables hypothesized to influence the use of banana hybrids are individual and household characteristics, as well as an instrument that aids with the identification of the effect of hybrid use on vulnerability. The gender of the banana production decisionmaker[2] reflects preferences for banana attributes and use. Banana hybrids are multiuse cultivars that can be used for cooking purposes. While women tend to prefer cultivars destined for consumption, men are more likely to use hybrids, which are useful for beer brewing and sale. Years of experience of the banana production decisionmaker in tending for the banana grove, formal education of household members (as an average number of years), as well as the number of extension visits are indicators of acquired human capital in banana-related decisions. Acquired human capital may be positively associated with use of hybrids, providing greater knowledge of the potential benefits associated with them in terms of food provision and income generation. The ratio of dependents (children and the elderly) to active adults reflects the consumption needs of the household. The value of livestock assets and exogenous income are used as proxies for household wealth. In the literature on agricultural innovations, wealthier households are often found to be more likely to grow hybrids, either because of better access to inputs and information or because of greater willingness to bear any risks with new planting material. Among the physical farm characteristics is the size

[2] The banana production decisionmaker is not necessarily the household head, but the person in charge of banana production and management decisions in the household. As in Uganda, this person is often a woman.

Table 9.2 Summary statistics and hypothesized effects of variables used in the analysis

Variable	Description	Mean	Standard deviation
Dependent variables			
Hybrid use	Household grows a hybrid cultivar (yes = 1; no = 0)	0.19	0.39
Yield loss	Average expected yield loss to joint biotic pressures (percent)	4.23	7.31
Explanatory variables			
Gender	Gender of primary production decisionmaker (1 = male)	0.70	0.46
Education	Average aggregate household education level (years of schooling)	6.30	1.98
Experience	Years of experience tending for the banana grove	20.57	13.87
Dependency ratio	Ratio of children and elderly to active adult household members	0.48	0.22
Extension	Number of contacts with extension agents	1.63	4.01
Exogenous income	Income received in previous period (ten thousand Tsh)	20.34	62.69
Livestock assets	Value of total livestock assets (ten thousand Tsh)	20.28	43.92
Farm size	Size of landholding (acres)	1.72	1.43
Elevation	Elevation (stratification variable; 1 = low)	0.85	0.36
Probability BS	Perceived frequency of occurrence of black Sigatoka disease	0.09	0.18
Probability FW	Perceived frequency of occurrence of *Fusarium* wilt disease	0.23	0.23
Probability WE	Perceived frequency of occurrence of weevils	0.34	0.28

of the landholding, another indicator of wealth and the scale of production.

Exposure to banana hybrids and elevation are two stratification variables. Only elevation is included as an instrument in the use equation, allowing for the identification of the treatment effect in the impact equation. The strength of the exposure variable in capturing the effect of use of formally distributed hybrids was compromised by the markedly informal means of transfer of planting material from one farmer to another (this interpretation is supported by descriptive information summarized in Chapter 5). With as many as 20 percent of farmers in nonexposed areas reported to grow banana hybrids, the treatment effect of exposure was dissipated. Geographical location is believed to better explain use behavior, with 96 percent of households growing banana hybrids (that is, 48 of the 50 households using hybrids) residing in low-elevation areas.

Determinants of Production Vulnerability

Among the variables hypothesized to have an effect on production vulnerability are the acquired human capital variables and scale of production (farm size). These characteristics are intended to capture preferences for management of the banana grove and scale of production, which have implications for yield loss, whereas the frequencies of occurrence of the three biotic pressures reflect the direct effects of disease and pest constraints on production vulnerability. Production vulnerability is also hypothesized to depend on the use of banana hybrids. As hybrids are bred for resistance to biotic pressures (in particular to black Sigatoka and weevils), they are expected to reduce the average production vulnerability for households that grow them.

Results

Before the treatment effect model was estimated, the exogeneity of the dichotomous variable for use of banana hybrids was tested in the impact equation. The test was achieved through several steps. First, the use equation was estimated using logit, and the residuals were saved. Then the impact equation was estimated using the actual observations for use of banana hybrids, as well as the saved residuals. No statistical indication of correlation between the errors of the impact and use equations was found (p-value = 0.194 for residuals), supporting the inclusion of use of banana hybrids as an explanatory variable in the impact equation (Woodridge 2001).

The treatment effect model is estimated using maximum likelihood methods. The statistical validity of a simultaneous estimation of both equations is evidenced by the significance of the hazard function (p-value = 0.045 for lambda). The information from one behavioral process (that is, treatment regression) influences the outcomes of another process (that is, the impact equation), similarly to the Mills ratio in a Heckman estimation approach. Estimated coefficients are presented in Table 9.3 separately for the use and impact equations.

The impact equation is the focus of this chapter. Production vulnerability appears to be scale neutral, as farm size has no apparent effect in the impact equation. Larger farmers suffer as much as smaller ones in terms of the percentages of banana production lost to biotic pressures. Nor does accumulated experience managing the banana grove counteract these pressures. The number of years growing bananas has no statistically significant effect on yield losses, illustrating the limited capacity of farmers to combat biotic constraints by applying only established management practices. Aggregate levels of education of the household appear to be positively related to loss, perhaps because it is related to the opportunity cost of labor in terms of managing the grove. Furthermore, higher losses appear to be associated with more extension visits. This finding perhaps is dictated by the need of extension workers to closely monitor the effects of biotic pressures on bananas and to suggest appropriate responses. As expected, more frequent occurrence of black Sigatoka disease and weevils increases the average yield loss. Given the low input practices for banana management, this result supports the dissemination of resistant cultivars in the region for mitigating biotic constraints. The most important result is the statistically significant effect of the use of new banana hybrids on expected yield losses. The magnitude of the effect of using FHIA hybrids is large, demonstrating the benefits to smallholder farmers in Tanzania in terms of reduced production vulnerability.

The probability that a household uses banana hybrids increases with years of schooling of household members, as is commonly found in hybrid adoption studies. More-educated households appear to be more likely to adopt new banana hybrids, which can be attributed to the fact that school curricula in the country address issues of agricultural production management. Wealthier households, in terms of value of owned livestock assets, appear to be more likely to use hybrids. However, rather than a wealth effect, this result likely reveals complementarities between use of hybrids and the provision of fodder (as a by-product of banana production) for animal feed. One key result is the pronounced use of hybrids in low-elevation areas where pest and disease pressures are higher and program intervention would have the highest impact. This result confirms previous work and the findings from this survey (Chapter 9).

Other factors most frequently associated with adoption of high-yielding cultivars are, on average, of no statistical significance for

Table 9.3 Coefficient estimates for the treatment effects model

Variable	Treatment equation (hybrid use)	Impact equation (average expected yield loss)
Gender (1 = male)	0.2069	
	(0.2844)	
Dependency ratio	–0.7227	
	(0.5609)	
Education	0.1764**	0.6709**
	(0.0740)	(0.3018)
Experience	–0.0158	0.0472
	(0.0115)	(0.0407)
Extension	0.0148	0.2158*
	(0.0237)	(0.1259)
Farm size	–0.0059	–0.6427
	(0.1029)	(0.4152)
Elevation (1 = low)	0.9486**	
	(0.4326)	
Probability BS		11.7009***
		(3.5097)
Probability FW		–0.2633
		(2.3900)
Probability WE		8.7904***
		(1.7214)
Exogenous income	0.0001	
	(0.0017)	
Livestock assets	0.0050*	
	(0.0026)	
Hybrid use		–12.2328**
		(5.5963)

Notes: Standard error in parentheses. ***, **, and * indicate statistical significance at the 1, 5, and 10 percent levels, respectively. See Table 9.2 for definitions of the variables.

banana hybrids in Kagera Region. For example, the gender of the production decisionmaker appears to bear no relationship to hybrid adoption when other factors are taken into account. This finding probably reflects the extensive involvement of both men and women in various aspects of banana production and marketing (Chapter 5). Nor does wealth, measured in terms of exogenous income or farm size, affect the adoption decision. Scale and wealth effects in Asia's Green Revolution were often associated with access to water and fertilizer, complementary inputs recommended along with improved wheat or rice seed (Feder 1982). In this case, though labor-intensive management practices had been recommended, the only introduced input was new planting material. Furthermore, the program intervention was a focused, locally organized dissemination effort that distributed planting material free of charge. Consistent with this explanation, extension visits have no perceptible effect on the use of hybrids, because the emphasis of extension agents has been on management practices. Experience with banana production of the primary decisionmaker does not appear to influence the likelihood of using banana hybrids. Neither does the composition of households in terms of the proportion of dependents to active members.

Regression analysis shows the marginal effect of factors on adoption and impact in terms of the average relationship for the sample of households. A comparison of households with a high statistical likelihood of growing banana hybrids and those with a low likelihood of using them, in areas exposed to program interventions, provides different insights into adoption patterns in study villages. Other indications of program impact are revealed through comparing the characteristics of households in the exposed areas, given adoption, and those located in nonexposed areas. These comparisons, made by combining the fitted regression model with descriptive statistics, are presented in the next two sections.

Comparisons of Adopters and Nonadopters in Exposed Areas

First, the fitted model was used to predict hybrid use for the 260 households in the sample. The top and bottom tails of the distribution of predicted values for hybrid use are used to represent the profiles of likely adopters and nonadopters' of the hybrids, considering initially only the subset of 220 households located in the exposed areas. The cutoff point used is 20 percent, with 44 households representing each group, respectively. Mean comparisons are summarized in Table 9.4 for outcomes related to productivity, consumption and sale of bananas, as well as general household-related characteristics.

The comparisons are based on actual values of the outcome variables, with the exception of average yield loss. The treatment model allows us to use predicted values for the estimated outcome variable to control for the effects of treatment on the outcome. Hence, two comparisons are made for the outcome variable: one using the actual values and the other using the predicted values of average yield loss. Although the predicted vulnerability levels are lower than actual vulnerability levels, no significant differences are found between the means for adopters and nonadopters, perhaps because of the wide variation in the sample data. The magnitude of the mean (actual) yield loss is 30 percent higher for nonadopters.

The insights obtained from comparing other outcomes are interesting. The average yield of potential adopters is higher than those less likely to adopt the new hybrids, which is not surprising, given the larger bunch size of hybrids. The total banana production (in number of bunches) is also larger for likely adopters, as their scale of production tends to be larger. No significant differences are found between levels of total and per capita consumption of adopters and nonadopters. However, there is lower consumption per adult in adopting households. These households tend to be larger and have lower dependency ratios, suggesting that consumption is spread across the larger proportion of active members. No differences in consumption per dependent are identified between the two groups.

Market participation behavior of adopters and nonadopters appears to be similar, as is the volume of bunches sold. However, there are significant differences in the distribution of produced bananas in terms of the share the household consumes and sells, although they are similar in the levels they consume and sell. Although no differences in banana income are identified, the farm income and the value of livestock assets of adopting households are higher than those for nonadopters, as adopters also tend to have higher expenditure levels. This result has implications for the dissemination and use of new hybrids in the exposed areas of Kagera Region. Targeting relatively deprived (in terms of income and wealth) households may increase adoption rates of hybrids and could have positive income effects on poor

Table 9.4 Mean comparisons between likely nonadopters and adopters in exposed areas

Variables	Nonadopters (*N* = 44)	Adopters (*N* = 44)
Outcomes		
Average yield (kg)	15.45*	18.92*
Actual average yield loss (percent)	6.45	4.50
Predicted average yield loss (percent)	4.33	4.48
Total bunches harvested	171.25	192.25
Number of bunches consumed	95.75*	124.59*
Number of bunches consumed per person	26.66	23.49
Number of bunches consumed per adult	55.51**	34.28**
Number of bunches consumed per dependent	48.06	74.44
Share of bunches consumed (percent)	79.06**	68.06**
Number of bunches sold	71.52	67.73
Share of bunches sold (percent)	20.77**	32.39**
Farm income (ten thousand Tsh)	22.40*	43.08*
Banana income (ten thousand Tsh)	5.86	5.91
Household expenditure (ten thousand Tsh)	23.00*	37.74*
Other characteristics of households		
Exogenous income (ten thousand Tsh)	21.82	39.61
Livestock value (ten thousand Tsh)	8.53***	53.05***
Mean household education levels (years)	4.23***	7.70***
Farm size (acres)	1.38*	1.95*
Household size	5.25*	6.39*
Household dependency ratio	0.55***	0.32***
Number of extension service visits	0.95***	4.04***
Proportion of male-headed households	0.68	0.77
Proportion of households selling bananas	0.61	0.50
Proportion of households buying bananas	0.05	0.07

Note: ***, **, and * indicate statistical significance at the 1, 5, and 10 percent levels, respectively.

households. Adopters are also those households with more acquired human capital, in terms of formal education and contacts with extension agents. More targeted extension visits may be a useful tool for increasing adoption levels of hybrid bananas in the exposed areas. Gender roles are similar between both groups, with hybrid bananas being typically multiuse cultivars often sold, used for banana beer brewing, and, to a limited extent, used for cooking.

Comparisons of Households in Exposed and Nonexposed Areas

Comparisons of average vulnerability across households in exposed and nonexposed areas are presented in Table 9.5. When only those factors that affect the use of banana hybrids are considered, the impact of exposure to the program on expected yield losses from pests and diseases is statistically significant and very large in magnitude (a loss

Table 9.5 Mean vulnerability comparisons between farmers in exposed and nonexposed areas (percent)

Vulnerability outcome	Not exposed (N = 40)	Exposed (N = 220)
Expected yield loss, considering factors that affect hybrid use and yield loss	2.75	4.21
Expected yield loss, considering only factors that affect hybrid use	8.37***	3.35***

Note: *** indicates statistical significance at the 1 percent level.

of about 3 percent compared to 8 percent). Once hybrid use and other confounding factors affecting yield losses have been taken into account, however, any apparent difference between farmers who have been exposed to the program and those who have not is of no statistical importance. This finding is most likely attributable to the strong role that farmers themselves play in exchanging planting material.

Conclusions

This chapter builds on earlier efforts to document the uptake of newly developed banana hybrids in Tanzania. These hybrids, developed in Honduras, are higher yielding and resistant to the pests and diseases that ravaged banana production in the lakes region in recent decades. Kagera Region, studied here, was particularly affected. In response to this challenge, the governments of Tanzania and Belgium embarked on an ambitious program to introduce disease-free materials. An early paper on the impact of these efforts was produced by KCDP (KCDP 2002; Weedrt 2003).

Our analysis augments the understanding of this process in the following ways. First, the advantage of the treatment model is that it enables us to account for the effects of program exposure on use and to control for variables that affect both hybrid use and program impact. Second, the outcome variables can be used to express any one of numerous aspects of program impact in quantitative terms. Here, we have used expected yield losses from pests and diseases.

Findings demonstrate that the intended impact of reducing yield losses to pests and diseases has been achieved, supporting research efforts aimed at developing resistant planting material and the formal diffusion program. The research findings have important policy implications in favor of ongoing efforts to develop new resistant cultivars bred or engineered to withstand disease pressures. Smoothing production has implications for food security and banana marketing. To sustain these benefits, however, institutional aspects of disseminating new cultivars need to be addressed. In particular, the finding that exposure to formal dissemination programs bore no statistical relationship with uses of hybrids underscores the farmer-based nature of planting-material systems. In part, this finding reflects the mode of reproduction for the crop. Planting-material systems for clonally propagated crops are largely farmer-based. Nevertheless, the finding provides strong indication that for the impacts of introducing new materials to be sustainable, innovative, farmer-based systems should be encouraged and supported.

Improved cultivars that are genetically resistant to pests and disease may not be the best route out of poverty, but as suggested in this study, they do reduce farmers' vulnerability to their surrounding production environment. They also reduce the need for purchased pesticides and fungicides that are costly to farmers, bear health risks for farming communities, and degrade the environment when unregulated.

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