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Impact of tissue culture banana technology on farm household income and food security in Kenya

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ABSTRACT

While tissue culture (TC) technology for vegetative plant propagation is gradually gaining in importance in Africa, rigorous assessment of broader welfare effects for adopting smallholder farm households is lacking. Using survey data and accounting for selection bias in technology adoption, we analyze the impact of TC banana technology on household income and food security in Kenya. To assess food security outcomes, we employ the Household Food Insecurity Access Scale (HFIAS) – a tool that has not been used for impact assessment before. Estimates of treatment-effects models show that TC banana adoption, combined with improved crop management, causes considerable increases in farm and household income. Technology adoption also reduces relative food insecurity in a significant way. These results indicate that TC technology can be welfare enhancing for adopting farm households. Adoption should be further promoted through upscaling appropriate technology delivery systems.

Introduction

While there is widespread consensus that agricultural technologies can play an important role for the reduction of food insecurity and poverty, there is less consensus on the type of technologies that may be appropriate for the small farm sector (Renkow and Byerlee, 2010). Moreover, especially in Africa, many available technologies are not adopted, or only very slowly, which may be due to unsuitable technological characteristics or unfavorable framework conditions (Suri, 2011; Smale and Tushemereirwe, 2007). Rigorous adoption and impact studies are required to better understand what type of technologies work under what conditions. Recent research has analyzed productivity, income, and poverty effects of different agricultural technologies (Kathage and Qaim, 2012; Christiaensen et al., 2011; Cunguara and Darnhofer, 2011; Subramanian and Qaim, 2010). But there is relatively little empirical evidence directly linking technologies to household food security outcomes. This may partly be due to data problems, because agricultural surveys often do not include variables that are suitable for food security assessment.

Here, we analyze the impact of tissue culture (TC) banana technology on household income and food security in Kenya, contributing to the existing literature methodologically and empirically. The methodological contribution is the use of the Household Food Insecurity Access Scale (HFIAS), a recently developed tool to measure household access to food (Coates et al., 2006a). To our knowledge this tool has not been used previously for impact assessment. One advantage of the HFIAS is that data collection is relatively easy and cheaper than for other approaches to measure food security or nutrition, such as dietary recalls or anthropometric indicators. The empirical contribution relates to the concrete example of TC banana technology. TC technology in banana and other vegetatively propagated crops has recently gained in importance in Sub-Saharan Africa (Obembe, 2010). While there is some debate about the potential and actual effects for farmers (Njuguna et al., 2010; Muyanga, 2009; Mbogoh et al., 2003), a rigorous assessment of broader welfare impacts has not been carried out. Our analysis builds on a survey of banana-growing households in Kenya, including adopters and non-adopters of TC technology. We use treatment-effects models to account for possible non-random selection bias.

The remainder of this article is organized as follows: in the next section, we present a brief background of TC banana cultivation in Kenya and describe the household survey. Then, we discuss descriptive statistics, followed by the analysis of food security aspects using the HFIAS tool. Subsequently, we develop the treatment-effects models and estimate the net impacts of TC technology adoption. The last section concludes.

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Background

Banana production and TC technology in Kenya

In Kenya, banana is almost exclusively grown by smallholder farmers for home consumption and local markets. The crop's perennial nature, the possibility of year-round harvest, and the fact that some yield can also be obtained without purchased inputs make banana a typical security crop in the local context (Smale and Tushemereirwe, 2007; Qaim, 1999). Recently, with strong fluctuations in coffee and tea prices, banana has also gained popularity as a cash crop in some regions, although this potential has not yet been fully tapped.

Due to pests, diseases, and poor crop management, banana yields have decreased in Kenya and other countries of East Africa over the last 30 years (Kahangi, 2010). The development and dissemination of pest- and disease-resistant cultivars would be an interesting approach, but edible bananas are seedless clones, which makes conventional breeding very difficult. Attempts to combine resistance traits with desirable quality characteristics based on conventional breeding techniques were so far not very successful (Tripathi et al., 2008). Traditionally, bananas are vegetatively propagated using suckers. This practice fosters the transfer of pests (especially weevils and nematodes) and diseases (especially fungi and bacteria), consequently reducing potential yield from the beginning in newly established banana plantations. Tissue culture is an alternative form of plant propagation using in vitro techniques in the laboratory. This results in pathogen-free plantlets, which have to be hardened before they can be transplanted into the field (Kahangi, 2010). TC bananas were shown to result in higher yields than traditional bananas under favorable conditions. They may also result in more uniform fruit production and higher quality, thus fetching higher market prices. This could positively impact farm income and food availability at the household level (Mbogoh et al., 2003).

The potential of TC technology to contribute to productivity growth and food security in the small farm sector stimulated different organizations to promote this technology in East Africa (Smale and Tushemereirwe, 2007). In Kenya, the International Service for the Acquisition of Agri-biotech Applications (ISAAA) had started a project in the late-1990s, producing and disseminating TC plantlets to local banana farmers (Qaim, 1999). Later on, the Kenya Agricultural Research Institute (KARI) and Jomo Kenyatta University of Agriculture and Technology (JKUAT) also became involved in TC bananas. Since 2003, Africa Harvest, a Kenya-based international non-governmental organization (NGO), has promoted more widespread TC adoption, using innovative models of technology delivery.

Considering Kenya as a whole, less than 10% of all banana farmers have adopted TC so far, although in the Central and Eastern Provinces, where most of the recent dissemination programs took place, adoption rates are already higher (Njuguna et al., 2010). The TC adoption process has been relatively slow for two reasons. First, TC plantlets are fairly expensive. Second, they require proper plantation management and more inputs in order to yield successfully, implying a mentality change for local farmers, who often tend to neglect their banana crop (Qaim, 1999). Hence, wealthier farmers and those with better access to credit and input markets were among the first to adopt TC bananas in the early dissemination phase. Not all of these early adopters were satisfied, especially not when they had adopted the technology spontaneously without proper information and training (Kabunga et al., 2012a). In the absence of specific extension, problems were sometimes associated with low-quality planting material or insufficient crop management. Such problems were explicitly addressed by NGOs during the last 10 years. Africa Harvest, in particular, promotes the formation of farmer groups to which it provides technical training. These smallholder groups are also linked to input and output markets and to certified TC laboratories and nurseries. Fischer and Qaim (2012a) showed that smallholder farmers who are organized in groups nowadays have significantly higher TC adoption rates and better access to markets.

Household survey

A survey of banana farm households was carried out in the major banana-growing areas of Central and Eastern Provinces of Kenya in the second half of 2009. The districts of Meru, Embu, Kirinyaga, Kiambu, Murang'a, and Thika were purposively selected based on information on the distribution of TC plantlets provided by different organizations. Furthermore, agro-ecological factors were taken into account, as these can matter much for banana yield potentials and problems with pests and diseases. Based on climate data, altitude, and information about soil conditions, we differentiate between high-potential and low-potential areas. High-potential areas are mainly located on the slopes of Mount Kenya; they receive relatively more rainfall and are at higher altitudes, with terrain dominated by ridges and fairly fertile volcanic soils. High-potential areas include the districts of Embu, Meru, and the northern half of Kirinyaga. Low-potential areas are Thika, Murang'a, Maragua, and the southern half of Kirinyaga, dominated by the undulating Mwea plains. Kiambu is outside of this classification. Although agro-ecological production conditions are favorable there, Kiambu District was chosen because of its closeness to Nairobi and the peri-urban nature of farming. All sampled districts were classified as moderately or severely food-insecure in 2009 (KFSSG, 2009).

Within each district, banana-growing villages, specifically those where TC dissemination activities had taken place, were purposively selected. Within the villages, farm households were sampled randomly. However, due to relatively low TC adoption rates, separate village lists of adopters and non-adopters were prepared, and adopters were oversampled to have a sufficient number of observations for robust impact assessment. In total, 385 banana farmers, composed of 223 adopters and 162 non-adopters, were sampled. All sample households are diversified smallholders, most of them with farm sizes of less than 5 acres. In addition to banana, sample farms grow maize for home consumption and different horticultural crops. Many also have some livestock activities such as raising chicken and small ruminants, and some grow cash crops such as coffee on a small scale.[2]

Household heads were interviewed using a structured questionnaire specifically designed for this purpose. The questionnaire was pretested prior to formal data collection to ensure content validity and clarity. Interviews were carried out in the local language by trained enumerators, who were supervised by the researchers. We collected both qualitative and quantitative data on household human capital and demographic characteristics, banana cultivation practices, details for other farm enterprises, as well as off-farm economic activities. Sample descriptive statistics are provided in the next section. The questionnaire also included a HFIAS module to explore household food insecurity, details of which are described further below.

[2] In other regions of Central and Eastern Kenya, there are also more specialized commercial farms focusing on dairy or horticultural products for the export sector. Such specialized commercial farming was not observed in the banana-growing villages sampled here.