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Participatory Cassava Breeding in Northeast Brazil: **Who Adopts and Why?**

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Participatory Cassava Breeding in Northeast Brazil: Who Adopts and Why?

Nadine Saad*, Nina Lilja** and Wania Fukuda***

1. INTRODUCTION

This study examines the participatory research methodology implemented by a cassava-breeding project in four communities of Northeast Brazil over an 8-year period. The study assesses the soundness of the project methodology by testing whether participant farmers were representative of the farming communities where the project was implemented. The study also investigates the adoption potential of the cassava varieties developed in the project, perceived benefits accrued from adoption, and the time spent on project activities by the participating farmers.

2. BACKGROUND

Cassava and the Brazilian Northeast

Cassava (*Manihot esculenta* Crantz) is the quintessential poor-farmer's crop. Its roots contain one of the highest concentrations of starch on a dry-weight basis among food crops, and its leaves are rich in protein (8%-10% F.W.) (O'Hair, 1995). Cassava roots and leaves provide nourishment for both people and animals, and the crop can be used for its starch and fiber. Cassava is propagated vegetatively, thus reproducing true-to-type, season after season. It can be harvested as needed, requiring little storage facility, and allowing harvests to be staggered and/or planned for when labor is available and market prices favorable. However, what makes cassava most attractive to many of the world's resource-poor farmers is that it is a hardy crop that will grow where most other crops will not.

This is the case of Northeast Brazil, a region characterized by arid and semi-arid conditions (400-750 mm/yr distributed over a 3-4 month period), and by variable, but mostly low-fertility soils. Comprising almost 19% of the nation's land, and straddling nine states, the northeast produces 58% of Brazil's cassava[1]. Nevertheless, it has the lowest productivity in the country—10.7 t/ha compared to the national average of 17.1 t/ha (Ospina et al., 1999). Most of the rural population of Northeast Brazil lives in poverty, some in extreme poverty, and almost all depend on cassava for sustenance.

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[1] Brazil's national production of cassava in 2001 was 22,577,100 mt, yields were 135,421 hg/ha, and the area harvested was 1,667,180 ha (FAOSTAT).

Northeast Brazil is also characterized by highly disparate land distribution. Around 70% of farms in the region are less than 10 ha in size, and together account for only 6% of farmland. In fact, most of the population is tenant farmers, producing and processing cassava with traditional methods and technologies on plots approximately 1 ha in size. Often, they enter into sharecropping arrangements whereby they halve the harvest with the owner and have no choice in what to grow. Meanwhile, 6% of the total number of farms are larger than 100 ha and account for 40% of the total agricultural land available (IBGE, 1989, cited in Pires de Matos et al., 1997).

While cassava provides sustenance for most of Northeast Brazil's resource-poor farmers, it is not always an unproblematic crop. On a national level, cassava yields have fluctuated, but have improved little since 1961. Similarly, cassava production was 18,058,384 mt in 1961 and only 23,131,2000 mt in 2001, 40 years later (FAOSTAT). Today, farmers in the northeast increasingly see their food security and livelihoods threatened as their main crop succumbs to a number of diseases such as root rots, witches' broom and super-elongation, and drought. Production losses from these diseases can be as high as 100% of the harvest (Fukuda et al., 2000). The vegetative propagation of the crop worsens the situation since viruses accumulate in the planting material season after season. The lack of alternate sources of planting material is a major constraint. Drought is also a strong limiting factor in the northeast, killing some of the varieties and delaying harvests of others up to 18 months after planting. These problems have driven many farmers to seek off-farm employment, and/or to abandon cassava farming. The limited efforts of agricultural research and extension agencies to solve these problems have been relatively fruitless until recently because farmers have adopted few if any of the technical solutions developed. The characteristics of this region make it a particularly important area for the implementation of a participatory cassava breeding project, and for a study of the potential impacts of such a project.

Participatory Plant Breeding

Over the last 20 years, there has been a proliferation of participatory plant breeding (PPB) projects involving small-scale, resource-poor farmers in marginal areas. In these projects, breeders work closely with farmers at different stages of the research process to develop crop varieties tailored to farmers' needs and to the requirements of their difficult crop-growing conditions (Eyzaguire and Iwanaga, 1996). Emerging as a remedy to the low adoption rates of improved crop varieties, participatory approaches promise to address the needs of the poorest of the poor, including women and the most marginalized members of communities. More precisely, these approaches help elucidate farmers' varietal preferences, and in some cases help empower and enhance the skills of farmers. Participatory approaches also promise to be more efficient and effective than conventional ones in terms of research costs (including time required to develop and test new varieties) and adoption rates. This approach to breeding has been tried on a range of crops (self- and cross-pollinated as well as vegetatively propagated), biophysical conditions (favorable and unfavorable), and type of production systems (subsistence and market oriented).

Different methods and modes of participation, organization, and institutional arrangements are implemented in PPB (Weltzien et al., 2003). By far the most common type of project has been labeled *formal-led participatory research*. Projects of this type are planned, led, and implemented by formal agricultural research institutes (either national or international), which are mandated to provide solutions to rural poverty in particular regions and/or production systems. Trials are established on farmers' plots, and farmers' participation is sought predominantly in a consultative form. Researchers seek to incorporate farmers' knowledge into their research process, requiring that information derived from the trials be fed back into the formal institutions in order to improve the formal sectors' responsiveness to farmers' needs. The main goals of most formal-led PPB projects are often production oriented, much like the goals of classical breeding programs; and the products are expected to be broadly applicable to people and areas beyond the participants and their communities. In addition, the new plant varieties that are developed with this type of participatory research are expected to be released through the formal varietal release and planting material production systems (Weltzien et al., 2003).

Most formal-led PPB projects to date have been relatively small in scale. They work in a small number of sites, with a reduced number of improved varieties, and often feature intensive interaction among farmers and scientists (Weltzien et al., 2003). However, as projects gain more experience and confidence with participatory approaches, the tendency has been to scale-up the efforts, and to work in larger areas, and with many more farmers (Fukuda and Saad, 2000; Lilja and Erenstein, 2002*)*. This allows many breeding programs to address their extensive mandates, but it has also changed the ways in which projects are implemented. For example, these expansive projects require the involvement of extension agencies in work that was previously the sole terrain of national and international breeding programs, the establishment of a greater number of regional experimental stations, and the active involvement of farmers' organizations and associations. This scaling-up has meant a decentralization of breeding programs and devolution of responsibility for on-farm trials to extension agents and farmers. Typically, the core of these projects consists of one or two national or international breeders and their staff at an agricultural research station, supported by a multitude of extension agents and farmer paraprofessionals, and nongovernmental organization (NGO) staff. This is exactly the form of the Northeast Brazil Cassava Project under study (Fukuda and Saad, 2000).

The impacts of participatory research approaches vary depending on the type of participatory research used[2] and on the stage of the research process when farmers and other end-users are involved (Lilja and Ashby, 1999). Impacts are generally classified as *product* impacts (those directly related to the varieties developed, and the economic and other benefits derived from them) and *process* impacts (those occurring as a result of the participatory process itself rather than the technology). A number of impacts, of both types, have been observed in PPB projects to date (Weltzien et al., 2003). They include:

- Shifts in the orientation formal breeding programs towards participatory approaches. Many breeding programs that try out participatory methods choose to continue using them because collaboration with farmers allows them to focus their efforts more specifically.

[2] Participatory research approaches have been variously categorized. Biggs (1989) uses an ascending scale starting at "contractual" and moves through "consultative", "collaborative", and "collegiate" participation. Farrington (1998) denominates cases as "functional/extractive" (focusing mainly on the product of research) or "empowering/enriching" (emphasizing also the process of research). Yet another classification adds dimension by considering not only these different classifications, but also the institutional environment in which participatory research is implemented (PRGA Progam, 1996), and the stages of the research process during which different types of participation are used (Lilja and Ashby, 1999).

- The development of improved varieties for marginal areas in which conventional breeding programs have traditionally had limited success. By collaborating with farmers who are familiar with the farming constraints in these areas, and purposefully seeking traits of their preference, breeders have been able to develop materials tailored to marginal areas and their inhabitants. Often this has been achieved in less time than is required for developing new varieties using conventional methods. In an impact study of a participatory barley breeding project for example, Lilja and Aw-Hassan (2002) found that new lines that were acceptable to farmers were developed 3 to 4 years faster than ones developed through conventional methods, mostly due to the decentralization of breeding activities.
- Immediate adoption and spread of favorable varieties by participating farmers. Often, farmers will keep, multiply, and distribute experimental materials that they like, even before the end of the research process, and before breeders and formal institutes can formally release the materials. While this can be problematic institutionally, for farmers the benefits of early adoption include higher yields, greater resistance to diseases and abiotic stresses, more flexibility for multiple uses, and increased varietal diversity.
- The design and adoption of new varieties suited to the needs of different members of communities—women and the poor. In cases where the participatory methods implemented seek the participation of a range of local stakeholders, or a representative set of farmers, materials can be selected to meet a range of different local needs.
- Increased varietal diversity in farmers' fields.
- Changes in institutional organization, variety release, and planting material production. The partnerships required for the scaling-up of participatory breeding efforts have meant changes in the organization of some breeding programs. The trend has been toward decentralization. Similarly, early farmer adoption of experimental materials has highlighted the need for changes in variety release and planting material production mechanisms. One of the main changes suggested is the use of a broader and more flexible set of criteria in determining the worthiness of a material for formal release (Weltzien et al., 2003).

The Case of Brazil – PPB with Cassava

By the mid-1990s, it had become evident to some international donors that the use of participatory approaches to crop development could help overcome the chronic lack of adoption of improved varieties by resource-poor farmers. Wania Maria Goncalves Fukuda, a cassava breeder at the Empresa Brasileira de Pesquisa Agroprecuária / Centro Nacional de Pesquisa de Mandioca e Fruticultura Tropical (EMBRAPA/CNPMF) decided to implement a project aimed at addressing the needs of resource-poor cassava farmers of Northeast Brazil using PPB methods (Fukuda and Saad, 2000). Financial support came from the International Fund for Agricultural Development (IFAD), and technical support from the International Center for Tropical Agriculture (CIAT, the Spanish acronym).

Although participatory approaches had been tried in the region in other fields, including integrated pest management and postharvest technology development, participatory approaches to breeding were first implemented in Northeast Brazil in the early 1990s. This experience was one of the first projects in Latin America to use the participatory procedure designed by researchers at CIAT and CORPOICA (Corporación Colombiana de Investigación Agropecuária) specifically for cassava breeding (called the IPMY Procedure) (Hernández, 1992; Hernández and

Saad, 2003). Although referred to in this study as “the project”, the Brazil participatory cassava breeding experience actually consists of a number of projects implemented by the same breeder from the national program in various phases and in various regions of the northeast. The donors and partner organizations also vary in the different phases of the project.

The project consisted of five phases of expansion. The first phase was implemented in the semi-arid zone of the state of Bahia. In these first sites, a communal trial plot was established, similar to a demonstration plot, from which farmers selected their nine favorite clones to test on their own plots in the next season. They also selected one local variety to serve as a control. Farmers told the extension agents and breeders why they liked these clones, thus formally establishing, or at least communicating, their preferences. Meanwhile, extension agents and breeders also recorded their own observations regarding the performance of the experimental materials. The breeder decided which clones to test in the next season based on the farmers’ preferences and on the project team’s field observations.

While in the first phase of the project many farmers participated in the initial screening of materials, in subsequent seasons, trials were established on one farmer’s, or a few farmers’, land. Only 10 farmers participated in the evaluations. These participant farmers were selected based on the land they had available for the trials, their experience with the crop, their interest in new varieties, their communication abilities, and their influence in the communities. The farmers’ representativeness of the broader community was not considered a selection criterion (Fukuda and Saad, 2000). This is because biophysical conditions, particularly soils, are so variable in the region that it was assumed that no farmer’s plot could be representative of all farmers’ plots. In addition, since most farmers in the region are subsistence farmers, the project team assumed that there were no other significant differences among farmers. Moreover, the IPMY procedure or methodology transferred from CIAT, and implemented with exactness in the early phases of the Brazilian experience, did not recommend the differentiation of participants (Hernández and Saad, 2003). In subsequent phases of the project, the criteria for farmer participation were more flexible and in some places whole communities, including women and children, took part in the evaluations.

The project initiated in the center of the state of Bahia and later expanded to various other parts of Bahia, and to the states of Sergipe, Pernambuco, and Ceará. As the project grew, the project team—the principal breeder and her immediate colleagues—began to rely more and more heavily on partnerships with state extension agencies and development projects. While scaling-up allowed the project to reach many more farmers than had been possible in the first phase, an important part of the responsibility for the project and its results was transferred to partners who were not officially part of the project team. The project team traveled to all sites at least once or twice a year; however, the day-to-day operations in the field were put in the hands of extension agents and farmers. The expansion of the project presented another challenge in the huge amount of information generated by the trials. This created an important need for information management and processing capability within the project team (Fukuda and Saad, 2000).

Today, the Brazilian participatory cassava-breeding project is one of the most extensive PPB projects in the world. It is 8 years old, has worked in over 70 communities in four states, and has conducted more than 300 participatory trials. It has formally released 10 varieties and identified a number of others with high probability of acceptance by farmers. Farmers are multiplying and distributing many of these clones (Fukuda and Saad, 2000). This early adoption (observed in the field, but not yet formally measured in an adoption study) is presumed to be benefiting farmers through increased yields and associated incomes.

3. OBJECTIVES AND RESEARCH QUESTIONS

The main objectives of this study are to assess (1) the participatory methodology used in terms of representativeness of the participants; (2) adoption potential of the cassava varieties introduced through the participatory project, and more specifically who adopts and why; and (3) perceived benefits and costs, in terms of time spent on project activities by the participating farmers.

An important challenge in participatory research to date has been the acknowledgement and treatment of intra-community differences (Cornwall et al. 1993; Mosse, 1994). Rural societies, like most other societies, are not homogeneous. Rather they consist of people with different socio-economic and political status, gender, age, ethnicity, access to resources, livelihoods, etc. The effects of these differences in roles and identities on farmers' varietal selections have been documented in various instances (Kornegay et al., 1996; Weltzien et al., 1996) and have become a familiar flag of caution among participatory research practitioners. Thus a corollary question is, do participant farmers' varietal preferences reflect those of the community at large? Therefore the first objective, the participatory methodology assessment, is tested by examining whether participating farmers are representative of the community at large in terms of their personal and family characteristics, or whether they are a select group within their communities. This will influence whose preferences are selected and promoted, one important measure of the soundness of the methodology implemented[3]. In order for the method to be considered sound and for the varieties which the project generates to have a wide reach, we would expect that the farmers testing the cassava varieties and providing feedback to the breeding are as representative as possible of the general cassava producing population (the intended users).

The second study objective is to assess the perceived adoption potential[4] of the new varieties produced by the participatory breeding. As discussed earlier, higher adoption rates is one of the main promises in the implementation of participatory approaches.

Furthermore, it is particularly important to ask why the varieties were adopted in the case of the PPB experience in Brazil, because some of the trials were initiated specifically as a response to farmers' expressed demand for varieties resistant to locally important pests and diseases (Fukuda and Saad, 2000). Were the characteristics of the new varieties of most interest to adopting farmers? Or was the determinant for adoption in this case the opportunity for farmers to test the varieties on their own land? Were they perhaps spurred to adopt by their need for clean planting

[3] The soundness of a methodology is a broad concept that includes questions about whether or not the project accomplished its objectives that are beyond the scope of this study and include the quality, rigor and objectivity of the procedure and how it was implemented. To further assess the soundness of methodology it would be important to address (a) Who is the project reaching? (b) What is the genetic quality and local adaptation of the clones that are being tested and released? And (c) Did the research team implement the methodology appropriately? For reasons of time and resources in data collection, the present study will only look at the first point.
[4] It is too early in the project to measure actual adoption.

material—now considered one of the principal demands of farmers in the region (Fukuda and Saad, 2000).

The third research objective is related to the perceived benefits of adoption and the implications for the well-being of adopters. If farmers adopt a cassava variety developed in the project, what difference does it make to them? Were there any changes in production? Were there changes in income associated with this? What were the costs of participation for farmers? Do the time and resources committed by farmers to the participatory trials get "paid back" as yield advantages or other benefits from adoption?

4. DATA AND SAMPLE COMMUNITIES

Methods

The main method used in this study was a survey conducted in April 2002.[5] It consisted of 30 questions grouped into four general areas of inquiry:

- Farmer characteristics and household agricultural activities, production and income;
- Uses of cassava, percentage of production used for consumption and for sale, varietal preferences, varieties grown, experimented, abandoned, planting material sources, willingness to pay for planting material of new varieties;
- Involvement in participatory trials and other agricultural research, costs of participation; and
- Changes in production and income from new varieties.

Sample selection

Four communities in Northeast Brazil were selected for this study: Lagoa do Barro and Tanquinho in the municipality of Maniacu, southwest Bahia; Cajuero dos Potes in the municipality of Simao Diaz and Muniz in the municipality of Aquidabá, both in the state of Sergipe. All four communities are principally cassava producers.

The study communities were selected based on several criteria. First, the project starting date (1997) is constant in the four communities. This is important because by 2002, when the surveys were conducted, the four communities were in the middle of their second season of participatory breeding. The four communities are also similar to one another with regard to the phase of expansion of the northeast-wide PPB effort[6] (Fukuda and Saad, 2000). In this way, any differences observed among communities cannot be attributed to the project teams' experience and confidence with the participatory approach and methodology (new to them at first). Other variables that were considered important to have similar among the communities selected were the breeding phase of the materials tested, and the existence and strength of local farmers' associations.

[5] The survey instrument is available from the authors on request.
[6] The PPB effort in Northeast Brazil was expanded to different areas of the region in a series of five phases.

Three elements differed among the communities selected. The most evident is the institutional arrangement through which the project team implemented the work. Muniz and Cajuero dos Potes communities in the state of Sergipe are within the area of operation of a large, multilaterally funded integrated rural development project called PRÓ-SERTÃO, which is very active in the communities. Participatory breeding is only one of its many activities. Other areas of action include establishment of rural agro-enterprises, farm credits, craft-making skills and market development, water supply, and land redistribution. An important focus of this project, promoted in all its activities, is the organization of its beneficiaries who are mostly small-scale farm communities. In stark contrast to this, Lagoa do Barro and Tanquinho communities in southwest Bahia are attended by an under-funded and poorly staffed state extension service. For this reason, the participation of the community in the PPB project, and the intensity of interaction and familiarity among farmers and extension staff, was far greater in Sergipe than in southwest Bahia.

The second difference related to the institutional setup is the relative proximity of the sites in Sergipe to the headquarters (in Cruz das Almas) of the region-wide PPB project where the breeder and her project team work. While the actual distance of the sites in Bahia is similar, the road conditions make a field trip to Sergipe much more amenable than the 8-hour drive to the communities in southwest Bahia. Generally, the breeder visited the communities in Sergipe about four times a year, and those in southwest Bahia about twice a year.

Another important difference among the communities is the biophysical conditions, particularly the biotic and abiotic stress affecting cassava cultivation. The southwest region of Bahia is characterized by unfavorable production conditions, which contribute to the fact that cassava is an 18-month crop in this region, and the main biophysical constraint for cassava production is lack of water. On the other hand, in the state of Sergipe, rainfall is more abundant. Here, the main problem faced by cassava farmers is root rots (*Phytophthora* spp., *Fusarium* spp., *Pythium* spp.)—the greatest limiting factor for cassava production in Northeast Brazil. In the state of Sergipe, production losses caused by this disease are as high as 50% (Fukuda, 1993). Losses due to bacteriosis (witches' broom) caused by *Xanthomonas campestris* pv *manihotis* decimates up to 100% of cassava production in southwest Bahia (Fukuda and Fortunato, 1997, cited in Fukuda et al., 2000).

Sample size

In each of the four communities, an average of 30 farmers were interviewed, making a sample size of 122. Only 18 of these were women. This is because the PPB project did not target or seek to work with women because they are not the main cassava cultivators in the study area[7].
In Lagoa do Barro, there were only 31 farmers in the community, 12 of whom participated in the PPB trials and two as trial hosts. In Tanquinho, 30 farmers were available for interview. The community consisted of approximately 34 families, but four of these were unavailable on the 2-day visit. There were 11 participants (including two trial hosts) and 19 non-participants. In

[7] Women do, however, have an important stake in the varieties of cassava cultivated because they do most of the peeling of cassava roots before they are processed in local *casas de farinha* (processing facilities). Women also commercialize the starch that is extracted from the roots before making *farinha* (toasted cassava flour); and they tend to the crop while their husbands/fathers/brothers leave the farm for seasonal work.

Muniz, only 30 farmers were available for interview. The community consisted of approximately 36 families but four were unavailable on the days of the visit, and two had stopped planting cassava because of root rots. Twenty-one were participants, two as trial hosts; nine did not participate.

A wealth ranking was performed of Lagoa de Barro, Tanquinho, and Muniz communities, but did not affect sampling because of the small numbers involved.

Of the 78 farmers in Cajuero dos Potes community, 48 had participated in the earlier trials; 31 farmers were interviewed, of which 18 participated. The two trial hosts worked separately. The sample was drawn from a group of farmers made available for interview at the invitation of the trial host. An equal number of farmers from each wealth category were selected and the participants were over-sampled.[8]

Sample descriptive statistics[9]

The average farmer was a 50-year-old male, who had cultivated cassava for over 30 years. Three-quarters of the survey participants had some level of literacy, and most (92%) did not have any previous experience with EMBRAPA. An average household had two adult women, two adult men, and one child.

The farmers consume part of their harvest and sell the rest—usually processed as *farinha* (toasted cassava flour) or starch. An average of 41% of family income comes from the sale of cassava, reflecting its importance in the region. *Casas de farinha* (processing facilities) are located in each community and are sometimes owned by each individual family (particularly in southwest Bahia) and sometimes are communal (mostly in the state of Sergipe). Other crops grown include maize (*Zea mays* L.), beans (*Phaseolus vulgaris* L.), and various species of forages. Average income from the sale of these crops combined is only 5% of family income, reflecting low agricultural prices. Many farmers also own animals such as cows, oxen, and chickens. The sale of these (and/or their products such as milk and meat) in the four communities contributes an average of 12% of family income. Most farmers own their own land or rent it in an arrangement whereby they halve their harvest with the owner. Other farmers work as day laborers on other farms. This source of income represents an average of 12% of family incomes in the sample.

Since cassava is an 18-month crop in this region, many farmers also have seasonal non-agricultural jobs. In the two communities in southwest Bahia, this is relatively common and includes work in a nearby uranium mine, and industrial and construction work in São Paulo, the

[8] A random sample of participants was not possible in this community because the trial host had a group of people waiting to be interviewed upon our arrival. They were either self-selected, or selected by the trial host, and most were from the top two wealth categories. The remaining people interviewed (participants and non-participants) were selected equally from the four different wealth categories. In order to do this, given the number of people who had been selected for interview by the trial host, the group of participants had to be over-sampled. Later analysis confirmed that the wealth distribution in the Cajuero sample was sufficiently similar to wealth distribution in the other three samples.

[9] See descriptive statistics in Appendix 1.

closest city. Another important source of non-agricultural income in the four communities is government pensions, representing an average of 20% of family incomes.

The analysis of variance (ANOVA) test was conducted to identify any significant differences between farmer and farm characteristics between the four study communities.[10] There were no significant differences in farmer and household characteristics between the four sample communities. However, there were significant differences in total farm area and cropping patterns between the four study communities. There were no differences in number of large livestock holdings, but there was a significant difference between communities in small livestock (chicken) holdings.

There were no significant differences in other sources of income, that is the salaried income and income earned from sale of non-crop products, but there was a significant difference in source of income from the sale of cassava and other crops, and government pensions, between the four communities. There were also significant differences in uses of cassava production in terms of percentage consumed at home and used as animal feed, and percentage that was sold as processed starch. There was no significant difference in terms of portion of production that was sold as fresh root.

5. RESULTS

This section is organized according to the three main research objectives:

- Assessment of participatory methodology
    a. Were farmer-participants representative of their communities?
- Adoption potential
    a. What is the adoption potential of the cassava varieties developed?
    b. Who is adopting (or is likely to adopt) the new cassava varieties?
    c. Why are the new varieties being adopted?
- What are the benefits and costs?
    a. What are the benefits from adoption? (Production changes)
    b. What are the costs of participation in the trials?

5.1. Assessment of participatory methodology: Were participating farmers representative of their communities?

The representativeness of farmer participants is often questioned in participatory research. Many researchers assume that those farmers who participate are in a better position to take part in projects than other farmers, because they are better-off, dispose of more time, land, agricultural inputs, education, and/or political power. However, as stated above, it is assumed that participatory research is effective in targeting the poor. If participants are indeed the better-off segment of their communities, then PPB is not likely to serve all the intended beneficiaries. In order to test if participating farmers were in fact representative of farmers in the community at

[10] See Appendix 2 for the analysis.

large, we compared individual and household characteristics, sources of income, crop production, and animal ownership for the pooled data of participants and non-participants from all four communities (122 farmers total: 62 participants and 60 non-participants). The results of this analysis are presented below.

Wealth ranking

A wealth ranking exercise was conducted in each community (Thomas-Slayter et al., 1995). The names of all the community members were written on small cards and two to four key informants in each community sorted them into separate piles according to their perceptions of each person's well-being. The farmers who performed the wealth ranking decided into how many piles to divide the cards, and on their definition of wealth or well-being. Results were tabulated by assigning each category a score out of 100. The wealthiest categories got the highest scores and the least well-off the lowest (i.e., if there were three categories, the best-off would score 99, middle range 66, and least well-off 33). The scores given to each community member were then added and divided by the number of times s/he had been ranked, resulting in an average rank. Table 1 presents the number of people in each rank, by community.

Table 1. Wealth ranking results (%) in the four communities sampled

Wealth ranking community[a]	Population	Participants	Non-participants
Lagoa do Barro			
Poor	8	5	3
Medium	11	6	5
Wealthy	12	7	5
Total	31	18	13
Tanquinho			
Poor	4	3	1
Medium	7	4	3
Wealthy	18	10	8
Total	29	17	12
Muniz			
Poor	8	3	5
Medium	10	3	7
Wealthy	12	11	1
Total	30	17	13
Cajuero dos Potes			
Poor	8	3	5
Medium	8	4	4
Wealthy	15	6	9
Total	31	13	18

a. Poor = ranking score of 0-33, medium = 34-66, and rich = 67-100.

The designation of categories in each of the communities differed substantially according to the key informant. One similarity across all the communities, however, was that people who received government pensions were considered to be among the wealthiest because they did not depend on agriculture; and those who did not own land and had to work as day-laborers were considered among the poorest. For example, in Cajuero dos Potes (Sergipe), one of the key informants established four categories of which the wealthiest were only those who received government pensions. The second grouping consisted of those who had their own land and house. Third were "professionals" who had off-farm employment (e.g., stonemason, brick maker, carpenter, etc.) and little land; and fourth were those who did not have their own land or house and worked as day-laborers for other farmers. In Tanquinho (Bahia), one of the key informants established five groups. The best off were the "business people" as he called them—farmers who commercialized their crops. The second and third categories consisted of people with pensions; the distinction between the two being that the former also cultivated cassava. The fourth group contained those with no pensions who lived solely from agriculture, and the fifth were "the poorest".

The results imply that, in three of the four communities, the distribution of families to different incomes is similar among the participating and non-participating farmers. In Muniz, most participating farmers were characterized as "wealthy" and non-participating farmers as "medium" in terms of their wealth status. Because key informants in each community conducted wealth ranking, the results are community-specific and cross-community comparisons cannot be made based on these results.

Farmer characteristics - participants vs. non-participants

Table 2 shows means for age, gender, number of years cultivating cassava, and household size for the pooled data of farmers from the four communities. It shows no significant differences in these variables among participant and non-participant farmers. Farmers interviewed have an average age of 50, and they have cultivated cassava for an average of 34 years. Each household has approximately five members.

Table 2. Farmer characteristics of participants (n = 62) and non-participants (n = 60)

Farmer characteristics	Participants Mean (S. D.)	Non-participants Mean (S. D.)	*t*-statistic[a]
Age	49.20 (14.99)	50.24 (16.41)	-0.363
No. of years cultivating cassava	33.74 (15.86)	34.22 (18.83)	-0.151
Household size			
No of women	1.95 (1.65)	2.20 (1.56)	-0.853
No. of men	2.02 (1.36)	1.83 (1.22)	0.779
No. of children	1.10 (1.69)	1.35 (1.86)	0.789

a. None of the variables above were significant at $p<0.10$.

Table 3 compares the level of education of these two groups. Again, there are no significant differences with respect to this variable. Of the farmers interviewed, 24% were illiterate, and the remaining 76% had some education or were literate.

Table 3. Level of education of participant and non-participant farmers

Level of education	Participants	Non-participants	Total
Illiterate	16	13	29
Grade 1	4	7	11
2	3	3	6
3	6	5	11
4	9	6	15
5	10	6	16
6	-	1	1
7	2	-	2
Literate	12	18	30
Total	62	59[a]	121

Note: x^2=6.949, not significant at p<0.05.
a. One missing observation.

Sources of income – participants vs non-participants

Table 4 shows the percentage of household income from a number of different sources. All the variables were found to be similar among participants and non-participants with the exception of income from the sale of other crops. While participants derive almost 7.4% of their income from the sale of other crops, it only represents 2.5% of non-participants' income. The difference between the two is significant (t = 2.317, p<0.05). There were no significant differences in other sources of income between participants and non-participants; and, pooling the two samples, the average percentage of income from the sale of cassava was 41.3, animals (and products) 11.7, off-farm agricultural work 12.2, other work 7.4, and government pensions 20.3 for all farmers interviewed. The sample average income from selling other products was only 1.7%.

Table 5 compares participant and non-participant uses of cassava production in the year that the project began in their communities. It shows a significant difference between the two with regard to the percentage of total cassava production that was processed and sold as cassava flour or starch. While participants processed and sold almost 58% of their cassava production as starch and flour, non-participants only did so with 36% of their cassava production (t = 3.040, p<0.05).

Table 4. Percentage of total income from different sources of participant (n = 62) and non-participant (n = 60) farmers

Income sources	Participant Mean (S. D.)	Non-participants Mean (S. D.)	*t*-statistic[a]
Sale of cassava and products	39.89 (29.04)	42.78 (31.60)	-0.526
Sale of harvest of other crops	7.38 (14.0)	2.53 (8.51)	2.317**
Sale of animals and products	12.42 (21.86)	11.00 (17.29)	0.397
Sale of other products	2.58 (10.19)	0.72 (2.53)	1.396
Off-farm agricultural work (work for others)	12.18 (23.13)	12.24 (21.36)	-0.015
Other types of work (non agricultural)	9.11 (21.93)	5.58 (16.55)	1.004
Government pension	15.92 (27.04)	24.82 (35.05)	-1.567

a. ** significant at $p<0.05$.

Table 5. Uses of cassava production (1997) – participant vs non-participant farmers

Percentage of cassava production	Participant Mean (S. D.)	Non-participants Mean (S. D.)	*t*-statistic[a]
Consumed in household	24.35 (29.20)	21.52 (32.09)	0.511
Used as animal feed	4.93 (9.42)	3.18 (6.63)	0.117
Sold as fresh unprocessed root	2.50(13.81)	0.00 (0.00)	1.425
Processed and sold as flour or starch	57.87 (35.79)	36.90 (40.20)	3.040**
Put to other uses	1.14 (8.89)	0.00 (0.00)	1.014

a. **significant at $p<0.05$.

Area used for crop production – participants vs non-participants

The total allocation of land to different crops did not differ significantly among participant and non-participant farmers, except for the difference in area cultivated with maize. While participant farmers cultivate an average of 0.78 ha to maize, non-participant farmers cultivate an average of 0.47 ha ($t = 1.649$, $p<0.10$). Table 6 presents the data for these variables.

Table 6. Area used for crop production by participant (n = 62) vs. non-participant (n = 60) farmers

Area of land	Participant Mean (S. D.)	Non-participant Mean (S. D.)	*t*-statistic[a]
Total owned/used (ha)	12.03 (17.03)	12.79 (12.77)	-0.282
Cassava	1.73 (2.01)	1.93 (2.18)	-0.511
Beans	0.68 (1.05)	0.46 (0.62)	1.397
Maize	0.78 (1.05)	0.47 (0.96)	1.649*
Other crops	0.68 (2.78)	0.41 (1.49)	0.667
Fallow	4.72 (12.97)	6.08 (8.77)	-0.691
Pastures	3.14 (6.04)	3.38 (8.04)	-0.186
Animal rearing	0.30 (1.43)	0.05 (0.38)	1.293

a. **significant at $p<0.10$.

Animal ownership – participant vs non-participant farmers

Table 7 shows the mean number of animals owned by participants and non-participants in the four communities. None of the differences were found to be significant. The pooled sample mean number of cattle was 5.96, swine 1.62, chicken (or other birds) 18.48, horses 0.44, and other animals 0.39.

Table 7. Animal ownership – participant (n = 62) vs. non-participant (n – 60) farmers

Area of land	Participant Mean (S. D.)	Non-participant Mean (S. D.)	*t*-statistic[a]
Cattle	5.66 (7.77)	6.27 (9.64)	-0.383
Swine	2.05 (4.22)	1.18 (3.13)	1.283
Chickens (or other birds)	17.90 (13.86)	19.07 (13.58)	-0.468
Horses	0.55 (0.97)	0.33 (0.63)	1.458
Other	0.52 (1.51)	0.25 (1.87)	1.174

a. None of the variables above were significant at $p<0.10$.

In sum, the data in Tables 1 to 7 indicate that participant farmers were in fact representative of their communities in most of the characteristics measured. For the pooled data of the four communities, the only significant differences among a range of data on farmer characteristics were the area of land cultivated to maize, the percentage of household income derived from the sale of processed cassava prior to initiation of the project, and sources of income from other crops. Participant farmers tended to plant more area to maize, to derive a greater percentage of their income from processed cassava, and derive a larger share of income from the sale of other crops than cassava, as compared to non-participants.

5.2. Adoption potential of cassava varieties developed

At the time of collecting the data for this study, it was too early for the project to expect a solid adoption of the varieties that were being tested with farmers. Since cassava has an 18-month cycle in most parts of the region, and the first cycle of evaluations was performed on a communal plot with numerous clones, the participatory trials on farmers' fields was only midway into its second cycle when the data were collected (April 2002). Nevertheless, it is interesting to see the adoption potential of the experimental varieties.

Experimentation with the clones

Table 8 presents the number of people who tried the experimental clones on their farms and continued to plant them, and those who tried and discontinued. While it would be erroneous to add the number of those who continued and those who discontinued to observe the general interest in the clones (because some farmers tried more than one clone), it is possible to interpret these results as promising. For instance, 10% of non-participants sampled in the study tried and discontinued planting the clones while 7% tried and continued. Considering the project's lack of intentional involvement of non-participants, this spontaneous curiosity, diffusion, and limited acceptance of the clones indicates a considerable adoption potential among this group. The results are even more positive for participants and trial hosts.

Table 8. Comparison of trial hosts' (n = 9), participant (n = 53) and non-participant (n = 60) farmers' adoption of experimental clones

Number who:	Trial hosts no. (%)	Participants no. (%)	Non-participants no. (%)	Total no. (%)
Tried and discontinued	5 (56)	25 (47)	6 (10)	36 (30)
Tried and continued	6 (67)	30 (57)	4 (7)	40 (33)

It is interesting to observe that roughly as many farmers tried and abandoned the clones as those who tried and kept the clones; however, this is only partially correct as some farmers tried more than one clone and selected some to keep, and abandoned the others. This indicates a strong interest in the experimental varieties. The farmers are actively and consciously experimenting with the clones and are being selective about which they keep and which they discard. This is a promising indication that the adoption potential reflected in the data is solid adoption and not just preliminary experimentation with new materials, nor a generalized need for planting material.

Willingness to pay for planting material

Another indicator used to reveal adoption potential is the farmers' desire to obtain planting material of the new clones, and particularly, their willingness to pay for this (Table 9). The results show that most farmers (45%) responded positively, while 32% said they would not be willing to pay for planting material of the new clones, and 23% were undecided. This pattern was evident among participants, but even more so among non-participants. When the differences between participants and non-participants were compared, the cross tabulation counts was not significant (x^2 = 4.153, at $p<0.05$).

Table 9. Farmer willingness to pay for planting material of experimental clones

Willingness	Participant no. (%)	Non-participant no. (%)	Total no. (%)
No	16 (26)	22 (37)	38 (32)
Yes	33 (53)	21 (35)	54 (45)
Maybe	12 (19)	16 (27)	28 (23)
Total[a]	61 (100)	59 (100)	120 (100)

Note: x^2=4.153, not significant at p<0.05.
a. Two missing observations.

Why farmers are adopting the new varieties

In the study area, it is not safe to assume that varieties are adopted just because farmers liked their characteristics, nor because the new varieties are superior overall to the local varieties. This is because (as stated above) pests compromise up to 100% of cassava production in the region due to the accumulation of viruses in vegetative planting material that is used year after year. Farmers in the study area keep their own planting material for the next cycle, and they exchange amongst themselves. Planting material is only rarely bought (or sold), and doing so is looked down upon. Given the remoteness of the area, and the minimal contact with extension agents, clean planting material is hard to come by in the study area. This opens a serious question as to whether interest in the new varieties is because of their resistance to pests (in part this could be because the planting material is clean and not because it is actually resistant), or because of the other characteristics of the new varieties. Would farmers prefer to keep their own local materials if they could clean them?

Although cassava planting material is rarely bought and sold, our survey results above showed a substantial demand and willingness to pay for planting material of the new clones. In a previous study of the area (Fukuda and Saad, 2000), a farmer who had not been involved in the participatory trials was observed appropriating and planting the clones that had been rejected and discarded by the experimenting farmers. This implies a demand for clean planting materials, even of those discarded clones assumed inferior to existing cultivars.

Table 10 presents the main reasons why farmers decided to try the experimental clones on their land, and Table 11 why they decided to continue their cultivation. Table 10 shows that the main reason for trying the clones was the need for new varieties. Interestingly, the need for new varieties was by far the most frequent reason for non-participants, while curiosity was the most frequent for participants, closely followed by the need for new varieties. The need for planting material was only cited by participants, and not by trial hosts and non-participants.

Table 10. Farmer's main reasons for trying experimental clones

Main reason	Trial hosts no. (%)	Participants no. (%)	Non-participants no. (%)	Total respondents no. (%)
Curiosity/ to experiment	2 (40)	10 (40)	1 (16)	13 (36)
Need for new varieties	2 (40)	9 (36)	5 (83)	16 (44)
Need for new planting material	0 (0)	3 (12)	0 (0)	3 (8)
Liked the clones' qualities	1 (20)	3 (12)	0 (0)	4 (11)

Table 11 shows the reason most frequently given for *cultivating* the new clones is curiosity, closely followed by liking the clone's qualities. The need for new planting materials and for new varieties were each only cited by 15% of those who are cultivating the clones. These results contrast interestingly with the results for trying the new clones. Whereas the need for new varieties was the most frequently given reason for trying the experimental clones, it was not the main reason for keeping them. Likewise, whereas liking the qualities of the new clones was only cited as a main reason by 11% of the farmers who tried them, it was the second most frequently cited reason (30%) for cultivating them. This implies that after the initial experimentation, continuing to cultivate the clones is motivated by continuous experimentation with the variety and "curiosity" as to its lasting performance in subsequent seasons.

Table 11. Farmers' main reasons for continued cultivation of experimental clones

Main reason	Trial hosts no. (%)	Participants no. (%)	Non-participants no. (%)	Total respondents no. (%)
Curiosity/ to experiment	3 (50)	11 (37)	2 (50)	16 (40)
Need for new varieties	0 (0)	5 (17)	1 (25)	6 (15)
Need for new planting material	0 (0)	6 (20)	0 (0)	6 (15)
Liked the clones' qualities	3 (50)	8 (27)	1 (25)	12 (30)

It is also interesting to note that among those who tried the experimental clones, and those who kept them, the need for new planting material was the least frequent priority reason given. It is important to add that although this lessens the concern that the need for new planting material may have been driving the interest in the PPB trials, it does not discard it as an important motivation as the four reasons being evaluated here are those that were ranked highest for farmers.

In addition to looking at reasons for adoption, it is also interesting to mention the priority reasons why some of the experimental clones that were tried were not continued into a second cycle. Unfortunately, the number of farmers who answered this question in the survey is negligible (n = 12). However, it is interesting that among these 12, several answers were characteristics of the varieties per se—including that it "died a lot", had small roots, was hard to harvest, and to process. Other reasons mentioned were lack of planting material, and an accidental and circumstantial "loss" of the variety.

5.3. Benefits and costs of adoption

What difference will adopting the new clones make to farmers' well-being? Again, keeping in mind the early stage at which this impact study was conducted, three indicators were used to assess the benefits from adoption. They are: the changes in cassava production, in revenue and in uses of cassava from 1997 to 2001, and time spent in cassava production.

Table 12 shows that most farmers (both participants and non-participants) did not perceive a change in cassava production when the trials were implemented (from 1998, 1999, and 2000). On the other hand, most perceived a decrease in production in the year 1997. It is important that there is no difference between participants and non-participants in this observation. Important differences between these two groups appear, however, with regard to those who did perceive a change in production. In 1999, among participants, most of those who did perceive a difference in production, perceived an increase. Among non-participants, they perceived a decrease. Likewise, in the year 2000 among participants, most of those who did perceive a difference in production perceived an increase (26.7%), while only 1.7% reported a decrease. In 2001, the direction of change in production perceived among the participants was, similarly to the previous year, more (20%) rather than less (16.7%). The trend was similar among the non-participants.

Table 12. Changes in cassava production (% of farmers who reported a change compared to previous year)

Year	Participants			Non-participants		
	More	Same	Less	More	Same	Less
2001	20.0	63.3	16.7	27.3	52.7	20.0
2000	26.7	71.7	1.7	16.7	68.5	14.8
1999	21.7	68.3	10.0	9.4	71.7	18.9
1998	5.2	67.2	27.6	16.7	60.4	22.9
1997	15.2	32.6	52.2	21.2	36.4	42.4

The results for changes in cassava revenue, presented in Table 13, are similar to the changes in production reported above in that most farmers found no change in 1998 to 2001. In 2001, more participant and non-participant farmers reported decreases in sale revenue than increases, and non-participant proportionately more than the participant farmers. Also, in 2000, among those who did perceive a difference, most reported a decrease in revenues. Again, this is for both groups. In 1999, however, most participants who perceived a change reported an increase, whereas non-participants reported a decrease. This was also the case in 1997, although in this year the percentage of decrease reported was much higher. In 1998, for both participants and non-participants, roughly the same percentage of respondents who reported a change perceived an increase as those who reported a decrease.

Table 13. Changes in cassava revenue (% of farmers who reported a change compared to previous year)

Year	Participants			Non-participants		
	More	Same	Less	More	Same	Less
2001	8.8	63.2	28.1	18.4	53.1	28.6
2000	15.5	67.2	17.2	14.6	62.5	22.9
1999	24.1	60.3	15.5	10.2	69.4	20.4
1998	14.8	66.7	18.5	14.6	68.8	16.7
1997	15.4	46.2	38.5	6.5	51.6	41.9

A possible impact of the PPB project and the adoption of new clones is that the uses of cassava production change. Table 14 shows the changes in participants' and non-participants' uses of cassava production from 1997 until 2001. It is difficult to assert with full certainty what type of change would mean a benefit as opposed to a harmful or a neutral change. For example, it is not known if selling a greater percentage of cassava production raw or processed is more beneficial. However, certain assumptions can be made. As cassava is the main subsistence crop in the region (and for many farmers it is one of the few crops that will grow on their land given the soil, climate, and phytosanitary conditions) it is quite safe to establish that a decrease in the percentage of cassava production consumed in the household *is* indicative that farmers are satisfying their basic needs and still have cassava left over for other uses. Table 14 shows that participants consumed less of their production in the household in the 2 years following the beginning of the project. However, in the following 2 years it increased to a level higher than it had been in 1997. Non-participants, on the other hand, increased the portion of their harvest that was consumed in the household in the 4 years following commencement of the project.

Table 14. Changes in cassava uses (% of cassava production), 1997-2001

Year	Consumed in household	Animal feed	Sold fresh unprocessed	Sold processed	Other use
Participants:					
1997	24.35	4.95	2.50	57.87	1.15
1998	21.40	4.74	2.50	60.45	1.15
1999	21.98	4.66	2.50	63.18	1.15
2000	25.60	6.11	2.66	61.50	0.82
2001	26.40	6.68	6.85	57.29	0.82
Non-participants:					
1997	22.61	3.33	0	37.21	0
1998	30.25	6.58	0	56.16	0
1999	30.25	7.02	0	55.72	0
2000	30.60	7.37	0	58.53	0
2001	31.12	7.40	1.75	57.96	0

If household consumption were replaced by greater percentage being used for other purposes (i.e., there was no drop in production), it is interesting to look at which cassava use was increased when home consumption was decreased.

Table 15 shows that most of the people in the study communities spend the same amount of time cultivating and processing cassava after the PPB trials as before. The same pattern was observed among participants and non-participants. When the results for participants and non-participants are cross-tabulated, the difference is significant (x^2 = 7.197, p<0.05). These results are not surprising because, as a consequence of farmers' participation and of their adoption of the new clones, their production has increased. Since the project did not introduce any labor-saving techniques, a rise in production necessarily means a rise in amount of time required to tend to the crop.

Table 15. Changes in time spent on cassava cultivation since the participatory plant breeding trials began

Time spent	Participants no. (%)	Non-participants no. (%)	Total no. (%)
More	13 (31.0)	3 (10.0)	16 (22.2)
Same	24 (57.1)	26 (86.7)	50 (69.4)
Less	5 (11.9)	1 (3.3)	6 (8.3)
Total	42 (100)	30 (100)	72 (100)

It is also possible that the difference in participant and non-participant farmers' perception about the time spent in cassava production, as described above, is due to the time spent in cassava PPB activities. Table 16 shows the amount of time dedicated to the participatory breeding project.

Table 16. Time dedicated by participants to participatory plant breeding project per season

Group	Activities	Time spent (mean no. of hours)	
		Trial hosts	Participants
1	Discussing the experience, planting, fertilizing	4.0	3.6
2	Evaluating, final selections, harvest, weighing yields, discussing results	5.7	4.6
3	Meetings, attending visits to the trials, other	5.1	1.8
	Total	14.8	10.0

6. CONCLUDING REMARKS

Representativity was not a factor in the selection of the project participants at the initiation of the project. Hernández and Saad (2003) note that this did not make much of a difference in the North Coast region of Colombia—where the IPMY procedure was first implemented—because the different stakeholders who participated in the project happened to select the same varieties. The results of the wealth ranking of the four study communities show that the project did not privilege any specific wealth category in any of the communities nor across most of the wealth categories. That is, both participant and non-participant poor, medium income, and wealthy were equally represented proportionate to the community's overall wealth distribution. Our results indicate that participant farmers were representative of their communities in most of the characteristics measured. The only significant differences between the two groups were that the participant farmers tended to plant more area to maize, to derive a greater percentage of their income from processed cassava, and derive a larger share of income from the sale of other crops than cassava, as compared to non-participants. However, the methodology overlooked women, who did not participate in the project and who were not represented in the survey, but who do play an important part in the selection of the cassava varieties that they use in the production of cassava dumplings. This is an important economic activity for women in that region, and is directly linked to cassava starch quality. Had they participated in the project, perhaps they would have selected a cassava variety that suited their specific needs for high-quality starch.

The results also indicate a potentially high degree of adoption success after 4 years of project activities; nearly half of the participating farmers initially adopted (tried and continued to cultivate) the experimental varieties they had seen on the participatory trials, and about 10% of the non-participant farmers did so. On the other hand, similar numbers of farmers tried some of the experimental varieties and discontinued their use. The interest in experimental varieties was also shown in most farmers (44%) being willing to pay for cassava planting material, which is not a typical practice in the region. Both the demonstrated willingness to experiment with varieties and willingness to pay for the planting material highlight the acute need for new clean planting material for cassava in the region.

Despite the rather high degree of the adoption of experimental cassava clones, these results show that farmers did not report large increases in cassava production nor cassava revenue. These results should be viewed in the context of the historical trend of declining cassava yields in the region. The fact that most participants and non-participants reported no change in cassava yield may imply the success of adoption of new cassava clones and maintaining of stable yields. The fact that participants also reported increase in time spent on cassava production may be due to the area expansion of cassava caused by project influence, or as mentioned earlier, time spent on project activities. Since the project did not introduce any labor-saving techniques, a rise in production necessarily means a rise in amount of time required to tend to the crop.

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APPENDICES

APPENDIX 1: Sample Descriptive Statistics (n = 122)

Variable	Mean	S. D.
How many years have you cultivated cassava? (no.)	33.98	17.315
Age (years)	49.71	15.64021
Illiteracy rate of the sample (%)	24	-
Number of:		
respondents with previous experience[a] (%)	8	-
women in the household	2.07	1.607
men in the household	1.93	1.293
children in the household	1.22	1.770
cattle	5.96	8.707
swine/pigs	1.62	3.734
chickens or other birds	18.48	13.682
horses	0.44	0.824
other animals	0.39	1.263
Percentage of income from: selling cassava (products)	41.3074	30.23609
selling harvest of other crops	4.9943	11.83121
selling animals or products (milk, cheese)	11.7213	19.67474
selling other products	1.6639	7.50824
work for other farmers	12.2066	22.18566
other types of work	7.3746	19.46966
government pension	20.2975	31.42662
Percentage of cassava production:		
consumed in household in1997	22.9590	30.56125
used as animal feed in 1997	4.0738	8.18300
sold as fresh unprocessed root in 1997	1.2705	9.88700
processed and sold as cassava flour or starch in 1997	47.5574	39.30008
put to other use in 1997	0.5820	6.33740
Area cultivated in:		
cassava (ha)	1.8269	2.09070
beans (ha)	0.5689	0.86817
maize (ha)	0.6280	1.01618
other crops (ha)	0.5518	2.23470
Area in pasture (ha)	3.2626	7.06740
Area used for animal rearing (ha)	0.1773	1.06010
Fallow area (ha)	5.3883	10.91936
Total farm size (ha)	12.4038	15.03023

a. With Empresa Brasileira de Pesquisa Agroprecuária (EMBRAPA) projects.

APPENDIX 2: Analysis of Variance (ANOVA) of the Four Sample Communities

Variable	*F*	s^a
How many years have you cultivated cassava? (no.)	1.408	0.244
Age (years)	1.155	0.330
Number of:		
women in the household	1.204	0.311
men in the household	0.273	0.845
children in the household	1.872	0.138
cattle	1.848	0.142
swine/pigs	0.943	0.422
chickens or other birds	5.085	0.002*
horses	2.102	0.104
other animals	8.011	0.000*
Percentage of income from:		
selling cassava (products)	16.467	0.000*
selling harvest of other crops	12.495	0.000*
selling animals or their products (milk, cheese)	0.306	0.821
selling other products	1.468	0.227
work for other farmers	0.556	0.645
other types of work	0.422	0.738
government pension	2.386	0.073
Percentage of cassava production:		
consumed in household year, 1997	8.761	0.000*
used as animal feed in 1997	4.714	0.004*
sold as fresh unprocessed root in 1997	0.666	0.574
processed and sold as cassava flour or starch in 1997	3.789	0.012*
put to other use in1997	0.968	0.410
Area cultivated in:		
cassava (ha)	20.232	0.000*
beans (ha)	4.434	0.005*
maize (ha)	6.895	0.000*
other crops (ha)	3.380	0.021*
Area in pasture (ha)	1.375	0.254
Area used for animal rearing (ha)	1.920	0.130
Fallow area (ha)	6.120	0.001*
Total farm size (ha)	5.453	0.002*

a. * significant at $p<0.10$

APPENDIX 3: Descriptive Statistics per Community Subsample

Variable	Lagoa do Barro (n = 31)		Tanquinho (n = 30)		Muniz (n = 30)		Cajuero do Potes (n = 31)	
	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
How many years have you cultivated cassava? (no.)	29.32	15.670	37.53	17.152	36.33	19.340	32.90	16.610
Age (years)	46.7742	13.76883	50.1000	15.57042	54.0000	16.90496	48.3333	16.17434
Number of:								
women in the household	2.13	1.284	2.50	2.374	1.77	1.040	1.90	1.399
men in the household	1.81	1.223	2.03	1.629	1.83	1.117	2.03	1.197
children in the household	1.74	1.843	1.37	2.282	1.03	1.217	0.74	1.483
cattle	8.35	8.381	5.83	7.372	3.20	3.800	6.35	12.462
swine/pigs	1.77	3.074	2.40	4.591	0.80	1.955	1.52	4.625
chickens or other birds	15.71*	8.517	24.87	12.840	12.73	9.833	20.61	18.527
horses	0.23	0.560	0.30	0.750	0.67	0.844	0.58	1.025
other animals	0.00*	0.000	0.00	0.000	1.27	2.180	0.29	0.864
Percentage of income from:								
selling cassava (products)	57.0968*	31.13878	53.4000	30.95447	15.2500	11.41441	39.0323	24.02843
selling harvest of other crops	0.1613*	0.89803	2.3333	9.35261	14.9767	17.51972	2.7419	6.81160
selling animals or their products (milk, cheese)	12.9032	14.06972	9.5000	19.92875	13.8333	22.15476	10.6452	22.20142
selling other products	0.8065	3.18768	1.3333	3.45746	0.4333	1.88795	4.0323	13.92955
work for other farmers	11.2903	19.91514	8.3333	17.23736	14.1400	26.75653	15.0000	24.11777
other types of work	6.7742	19.89759	4.3333	14.06471	9.1567	23.09034	9.1935	20.25244
government pension	10.9677	23.43144	20.3333	32.66690	31.8767	36.85135	18.3871	29.36515
Percentage of cassava production:								
consumed in 1997	20.3226*	29.09569	7.0333	16.80206	43.5000	37.16575	21.1290	25.02364
used as animal feed in 1997	5.8065*	9.31815	7.5333	11.17798	1.8667	5.15774	1.1290	2.80169
sold as fresh unprocessed root in1997	0.0000	0.00000	0.0000	0.00000	2.5000	13.69306	2.5806	14.36842
processed and sold as cassava flour/ starch in 1997	32.4194*	36.83004	52.2667	41.88320	42.1333	36.37898	63.3871	36.75112
put to other use in 1997	0.0000	0.00000	0.0333	0.18257	0.0000	0.00000	2.2581	12.57237
Area cultivated in:								
cassava (ha)	2.5387	2.47315	3.4667	2.29574	0.6365	0.43717	0.6802	0.49576
beans (ha)	0.9887	1.21049	0.4750	0.72323	0.5765	0.79177	0.2325	0.39384
maize (ha)	0.4250	0.44024	0.2340	0.51636	1.2772	1.56940	0.5840	0.84333
other crops (ha)	1.5684	4.09219	0.5343	1.35743	0.0672	0.12114	0.0213	0.08241
Area in pasture (ha)	2.1052	5.96987	3.8917	5.27996	1.9688	3.92360	5.0631	10.82516
Area used for animal rearing (ha)	0.0968	0.53882	0.0000	0.00000	0.5717	2.02407	0.0479	0.26671
Fallow area (ha)	7.0968	8.51804	11.1667	17.32515	1.2523	3.83945	2.0906	6.26033
Total farm size (ha)	14.8195	12.55639	19.7684	19.84017	6.3501	8.71070	8.7197	13.73684