Controlling Cassava Root Rots with the Participation of Tukano Communities in the Mitú Area of the Colombian Amazon

By

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Abstract

Land pressure around Mitú, a town in the Colombian Amazon, has disrupted traditional agricultural systems, thus favoring the development of crop pests and diseases. Our general goal was to evaluate, using participatory research methodology, management practices for these pathogens. Specifically, we sought to discover a sustainable way of controlling Phytophthora species, a complex of fungal pathogens that cause root rots in cassava (Manihot esculenta Crantz), a staple food in Mitú. We describe the research carried out with the collaboration of 14 communities settled around Mitú, the innovations introduced, and the farmers' reactions as they evaluated, adopted, and disseminated the innovations. We also examined the potential these innovations had in terms of the magnitude of the social problems facing the communities in the Mitú area and for scaling up to other regions suffering similar problems.

Research findings

- The Tukano women farmers preferred to select cassava varieties for the quality of their starch and final products over yield and plant health.
- Improved varieties, previously identified as resistant to rots, were integrated into the diversity of local varieties already existing on the farms. The adoption rate for improved varieties was 27%.
- The farmers most preferred a CIAT-improved variety that combined two of their favorite traits—yellow-flesh roots with a sweet flavor—which are not found together in native varieties. The resulting toasted flour was also highly appreciated by the Tukanos.
- The idea of modifying the traditional use of ashes by mixing in organic matter was readily accepted as improving yields and reducing rots by the older, more traditionally oriented, farmers, but rejected by the younger, more modern, farmers as being time consuming.
- Although the Tukano farmers considered stake selection to be a good practice for reducing rots, this practice went against their religious beliefs and was not readily adopted.
- Although cowpea was regarded as an appropriate food and the cowpea/cassava association improved yields and reduced cassava rots, the Tukano farmers had no custom of planting legumes and, hence, did not readily adopt the innovation of cultivating cowpea.
- A committee for local agricultural research (CIAL) was successfully established, evaluating crops such as maize and rice. This innovation is expected to help improve the agricultural productivity of this socially marginal area.

Policy implications

- To improve production conditions and encourage indigenous community development, the official entities stationed in Mitú must improve the technical assistance and transfer of appropriate technology that they offer for cassava and other crops.
- For the same reasons, investment in development projects must be arranged with the communities through the participatory diagnosis and prioritization of their problems.
- The success of the Macaquiño CIAL in encouraging farmers of the Mitú area to focus on what they see as their agricultural problems and potential solutions suggests that governmental entities and NGOs should incorporate the CIAL methodology into their activities on a permanent basis to encourage the area's agricultural progress.
- The State must invest in projects on sustainable production under Amazonian conditions and encourage more market-oriented attitudes that include tapping the large urban markets of Villavicencio and Bogotá. If need be, air transport should be subsidized.
- The Departmental Farm of Vaupés should include, among its activities, the multiplication of resistant cassava varieties, both introduced and local, to ensure a constant supply of adapted materials. If possible, the multiplication of adapted varieties should also be carried out for other crops.

Acknowledgments

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Tables

chagras belonging to Tukano women farmers around Mitú, Vaupés, Colombia

Table 2 Criteria used by Tukano women farmers to select cassava genotypes (with resistance to root rots) under the conditions of the Mitú area, Vaupés, Colombia. The criteria are listed in descending order of importance to the farmers

Table 3 Effects of five innovative treatments on cassava production and incidence of root rots in four Tukano communities around Mitú, Vaupés, Colombia

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Figure 1 Preparing a trial on a chagra in the forest of the Mitú–Monfort Road area, Vaupés, Colombia. First-cycle cassava is seen in the background. As plants are daily harvested, space is left to plant second-cycle cassava. The photo corresponds to a trial for evaluating the effect of ashes and organic matter on second-cycle cassava yields and presence of root rots. A Tukano couple are laying out the trial and marking out treatment plots. On the left of the man and beside the plantain, stakes of second-cycle cassava can be seen. These are usually planted longer at 40–80 cm long and closer to each other than are first-cycle cassava stakes, which are 20–30 cm long

Figure 2 A section of the Spanish-language pictograph used in the surveys conducted for the participatory diagnosis carried out with indigenous and settler farmers in the Mitú–Monfort Road area, Vaupés, Colombia. The pictograph enabled discussions with farmers on their farming practices, including crops grown, land preparation methods, planting systems, cassava types grown, selection of planting materials and manner of planting (e.g. vertically, horizontally, stake length), cultural practices, use of inputs, harvesting, new plantings, and the time to market (significant because cassava roots, once harvested, are highly perishable)

Figure 3 Ranking order of 10 cassava genotypes evaluated by Tukano women farmers (A) using different criteria at harvest and (B) according to starch quality after processing, Mitú area, Vaupés, Colombia. Participatory research techniques were applied. Ranking order: 1 = high acceptability; 10 = low acceptability. Poly. = polynomial curve

Acronyms and abbreviations

AMUDEVA	Asociación de Mujeres Indígenas del Vaupés
CDA	Corporación para el Desarrollo Sostenible del Norte y Oriente Amazónico
CIAL	Comité de Investigación Agrícola Local
CIAT	Centro Internacional de Agricultura Tropical
CRIVA	Consejo Regional Indígena del Vaupés
HCN	Hydrogen cyanide, also hydrocyanic acid
NGOs	Nongovernmental organizations
PRONATTA	Programa Nacional de Transferencia de Tecnología Agropecuaria
SENA	Servicio Nacional de Aprendizaje
UMATA	Unidad Municipal de Asistencia Técnica Agropecuaria

Glossary

Most of the following Spanish words have no adequate equivalent in English, and are therefore listed below with their descriptions for the reader's benefit. Many show influence from neighboring Brazil where Portuguese is spoken.

Barbasco (lit. "fish poison"), a name applied to many plants whose sap contains rotenone and is used to stun and then catch fish. The communities around Mitú use the leguminous Tephrosia spp.

Casabe, a flat toasted bread made from cassava roots

Chagra, a small family farming plot cleared in either primary or secondary forest

Chicha, an alcoholic beverage made from fermented cassava roots

Chivé, a beverage made by mixing water with fariña

Fariña, a toasted coarse-grained flour made from cassava roots

Fogones, wood stoves

Habichuela brasilera (lit. "Brazilian bean"), Vigna unguiculata (L.) Walp. or cowpea

Hoguereo, a practice whereby Tukano women farmers light small fires within the chagra to produce ashes that they then apply to cassava plants

Lulo, a fruit; two types are grown: Solanum sessiliflorum Dunal or cocona, which has a large acid fruit and is planted around the house, and S. stramonifolium Jacq. or lulito or coconilla, which has a small sweet fruit and is planted in the chagra for eating while working

Manicuera, a beverage made by cooking the liquid extracted during cassava processing

Matafrío (lit. "kills cold") or cebucán, a tubular cane basket used to extract hydrocyanic acid from cassava pulp

Mingao, a beverage made by mixing water with cassava starch

Muñica, a porridge-like dish of fish and cassava starch

Palo gordo (lit. "fat stick"), thick stems of a cassava plant

Panela, a type of jaggery made from sugar cane

Pepa (lit. "fruit"), the mature, fully fleshed cassava root

Pupuña (Bactris gasipaes Kunth), peach palm, chontaduro, or pejibaye

Uvilla (Pourouma cecropiifolia Mart.), Amazon tree-grape, uva caimarona, or cucura. The name "cucura" is sometimes used as an element of the name of a geographic feature

Yuca (Manihot esculenta Crantz), cassava, manioc, or tapioca. Its starchy roots provide the staple source of carbohydrates in the diets of many farming communities throughout the tropics

Background

Geography of the Mitú area

Our study was carried out with communities living around Mitú, the capital of the Department of Vaupés, itself situated in the Colombian Amazon, bordering Brazil. The terrain is slightly undulating, with altitudes at about 207 m above sea level. Many low-lying areas are prone to relatively prolonged flooding. The climate is tropical, with an average annual rainfall of 3329 mm, distributed over 209 days. The average annual temperature is 25°C, and relative humidity is 83%. The vegetation comprises very humid, dense, rain forest, typical of tropical lowlands. Although some secondary forests are found, the area has received little human intervention.

The predominant soils are Hapludoxes, Quartzipsamments, Psammaquents, and Tropaquods. Typically high in quartzose sand, they are igneous-metamorphic in origin, with high contents of sesquioxides and plinthites, coarse texture, high acidity, low natural fertility, and little organic matter. These soils' mineralogical poverty and fragility are caused by heavy weathering, aggravated further by erosion and leaching. Because of the humid tropical climate's great potential for enabling symbioses between roots and mycorrhizal fungi, nutrients are recycled with minimum losses—with most occurring through cropping.

The human population

Indigenous communities

About 85% of the area's population comprises numerous small indigenous communities, who still live mostly according to their traditional cultures. They belong to the larger cultural clusters of the eastern Tukano group, the Cubeo (central Tukano group), and the Makú (an aboriginal people). Traditionally, the communities are self-sufficient, subsisting on farming, hunting, fishing, and gathering forest fruits. (Dufour 1990)

Settlers

Settlers, who are white or mestizo, also live around Mitú. While some settlers follow subsistence activities such as agriculture, fruit collection, hunting, fishing, and creating handcrafts on a minor scale (León, 2001), most focus on commercial activities. These include monocropping and marketing rubber, cacao, plantain, banana, maize, sweet cassava (Manihot esculenta Crantz), fruit trees, vegetables, and yam; fish farming; and poultry and livestock production. Farm sizes range between 6 and 20 ha.

Armed groups

A third group comprises drug traffickers, guerrilla groups, and groups from the Government's armed forces. As with the rest of the Department, the growing of illicit crops is widespread. In 1998, a guerrilla group occupied the Mitú township for some days, kidnapping policemen. In response, the Government established an army battalion in the town. Since then, security in the region has been unstable, with some indigenous families fleeing to nearby Brazil or other regions in the Department.

The traditional Tukano subsistence system

Traditional chagra cropping

Tukano communities use their traditional knowledge to manage the area's poor soils. They practice subsistence agriculture, based on a shifting or slash-and-burn agriculture, combined with forest use such as hunting, fishing, and gathering of fruits and other forest products from which food, medicines, and other products can be extracted. The result of their agroforestry practices is a mosaic of vegetation patches in different stages of reforestation. Women usually farm, while men fish, hunt (Dufour, 1990), and help with planting tasks. Girls collaborate from an early age. Some agricultural tasks are carried out by the entire community.

Each family first selects its land within the forest, which may be primary or regenerated forest, and closely observes, before slashing and burning, the species of plants present to thus conserve the potentially useful ones. Sites with the highest concentrations of dry and decomposing wood, and thus of the highest accumulations of organic matter are also examined. One to three plots, measuring anywhere between 0.5 and 1.5 ha, are then cleared. The chagras in primary forests (Figure 1), however, are considered as the family's main gardens and are characteristically planted with a greater diversity of crops than are chagras planted in clearings of regenerating forests (Dufour 1990).

Figure 1 Preparing a trial on a chagra in the forest of the Mitú–Monfort Road area, Vaupés, Colombia. First-cycle cassava is seen in the background. As plants are harvested daily, space is left to plant second-cycle cassava. The photo corresponds to a trial for evaluating the effect of ashes and organic matter on second-cycle cassava yields and presence of root rots. A Tukano couple are laying out the trial and marking out treatment plots. On the left of the man and beside the plantain, stakes of second-cycle cassava can be seen. These are usually planted longer at 40–80 cm long and closer to each other than are first-cycle cassava stakes, which are 20–30 cm long

Trees are cut down in December–January and left to decompose sufficiently to burn in March, just before the rains begin. The burning converts all the vegetation to ashes, leaving even trunks of the big trees only as cinders. Burning-off produces large quantities of ash (Sánchez, 1981) that normally contain (in ppm) 200 Ca, 390 Mg, 430 K, and 275 P, and high contents of minor elements (Restrepo, 2000). Such ash is used as fertilizer when planting. Ashes also help reduce the incidence of diseases caused, for example, by Phytophthora spp. (Torres, 2000).
The chagras are planted with a diversity of transitory short-cycle crops either in association with cassava or in a multistrata system. These crops include sweet cassava, maize, pineapple, sweet potato, cocona or lulo (Solanum sessiliflorum Dunal), coconilla or lulito (S. stramonifolium Jacq.), yam, peach palm (Bactris gasipaes Kunth), other palms, Capsicum peppers, plants used for dyes, and barbasco (Tephrosia spp.). Plantain and sugar cane are also planted in sites where ashes have accumulated, with sugar cane on the edges of the chagra in one or two patches, and plantain in the center, where conditions are more suitable (Dufour 1990).
Farmers prefer to plant maize in association with sweet cassava in a separate patch that occupies 5% to 10% of the chagra's area. Maize is often planted in the second planting season of the year, that is, around September.
Fruit trees provide the upper strata and are planted far apart from each other. Typical fruit trees include peach palm, seje or patabá palm (Jessenia bataua (Mart.) Burret), Amazon tree-grape or uvilla (Pourouma cecropiifolia Mart.), and papaya (Carica papaya L.). (Dufour 1990)
The intercropping of species with different architecture, crop planting density, and fallowing all help preserve the organic matter in the soils, a critical factor in maintaining soil fertility in the Amazon Region. The richness of species in the chagras also protects against pests (Dufour, 1990).
After two or three cropping cycles, the chagras are then abandoned to allow the forest to regenerate for 15 or more years before being used again, although fruits from the planted trees are harvested while the forest is regenerating. By leaving broad zones of untouched forest, the Tukano farmers cushion potential degradation and conserve the diversity of fauna and flora.
Except for Macaquiño, the communities in this study did not raise livestock. Coca is grown as a stimulant to reduce fatigue and dissipate hunger during work, and as a medicine. This crop is planted in rows to one side of the chagra or near the homestead. (Dufour 1990)

The importance of cassava in Tukano community life

Diversity of varieties and their uses
Cassava is a staple of the Tukano diet, being eaten in the form of casabe (a flat bread), fariña (toasted flour), and starch. Cassava is also an important source of beverages such as manicuera (made by cooking the liquid extracted during cassava processing), chivé (water mixed with fariña), chicha (an alcoholic beverage made from fermented cassava), and mingao (water mixed with starch) (Dufour, 1993).
The Tukanos classify cassava into two large groups: bitter and sweet. The first must be processed before consumption to extract the toxic hydrocyanic acid (HCN). The sweet varieties, which have low HCN content, are consumed boiled or fried, or processed to extract starch. (Dufour 1993)
Bitter cassava is much preferred because of its processing qualities, and is subgrouped into yellow- or white-flesh varieties. The yellow ones are preferred for making fariña, which is widely consumed and marketed throughout the zone. The white ones are used to extract starch and make casabe. They also yield larger quantities of starch, which improve the texture of casabe, making it finer and more palatable, and adding value when sold. Hence, the most important criterion for selecting a cassava variety, even over yield and plant health, is the amount and quality of food that can be obtained from it (Wilson, 1997).
Traditional farmers value diversity of cassava varieties as a resource, planting between 17 and 48 varieties in any one chagra (Dufour, 1990). Each variety is planted separately in a "monovarietal" patch, with sweet cassava planted away from bitter cassava.
Of the 100 or so varieties grown, some possess particularly desirable culinary properties that are related to, for example, starch quality, sweetness of flavor, and pulp color. Others have medicinal properties. Because of a probable allelopathic effect, some varieties help improve the development of better quality varieties grown for processed foods. Yet other varieties are grown for no apparent reason for preferring them.

Economic value
Cassava is highly significant as a subsistence crop. Occasionally, however, surpluses are sold (Guevara, 1990), usually as casabe, fariña, starch, or chicha, together with maize, chilies, forest- or home-grown fruits, fish, animals obtained through hunting, and sometimes handcrafts. Mitú is the main market.

Traditional cassava planting
In the chagras of both forest types, bitter cassava predominates, occupying 80% or more of the area planted to cassava and the remainder planted to sweet cassava. (Dufour, 1990) Women plant cassava twice a year, although cropping is often not done in the second semester, because the rains prevent burning. Cassava stakes are immediately planted into fresh ashes, that is, while the land still smells of burning, thus guaranteeing that the nutrients contributed by the ashes are not lost to leaching by the rains and the plants will develop well. Stakes are also planted near decomposing wood. The planting season may extend over a month or more.
To plant cassava, the women cut stakes, 20 to 30 cm long, from other of their chagras, without selecting for either quality or health. Nor do they treat them for protection against diseases or pests. The stakes are planted in groups of two or three in holes opened up by the men using sharpened sticks. The groups of stakes are planted at distances of 70 to 80 cm from each other in those sites that have the most ashes or dry wood. Furrows are not necessarily followed. Over the next few days, the women plant other crops.
The cassava crop is harvested at 10 to 11 months old, beginning at one edge of the chagra. Between 20 and 30 plants are pulled up daily to fill a basket with about 20 to 25 kg of roots for grating. Successive harvests are carried out, following a spiral pattern around the chagra towards its center. The complete harvest of the chagra takes about a year, with cassava yields ranging from 5 to about 13 t/ha (Colombian Ministry of Agriculture and Rural Development, 1997, personal communication).
As they harvest the cassava, the farmers cut and plant new stakes—which then correspond to a second cropping cycle—in sites where harvest residues are burnt. Sometimes, the women practice the traditional hoguereo, that is, they would light small fires in different places within the chagra, and apply the resulting ashes to the plants. The farmers say this practice, particularly the smoke, favors plant growth in cassava. Usually, however, most Tukano farmers do not use ashes or other amendments for the second-cycle crop, because of the problem of burning in the rainy season.

The Project on Cassava Root Rots

The problems of change

The traditional ways of life in communities living around Mitú, are being changed by the incursion of white settlers and modernism. This region today is seen as remote, undeveloped, and impoverished, with the following problems:

A minimal economy
Because the economy is largely subsistent in nature and remote from significant urban markets, it is unable to generate surpluses to permit competitiveness on a national scale.

Lack of transport and other services
This minimal economy is exacerbated by the lack of transport and services. By land, the Mitú area, and Vaupés generally, is out of contact with the rest of the country. Only one road exists in the area: the Mitú–Monfort Road, which is about 60 km long. Three towns have small airports: Mitú, Monfort, and Acaricuara. (León 2001)
Mitú lies on the southern bank of the Vaupés River. From this town, the neighboring Department of Guaviare, lying to the west, can be reached by traveling upstream. Progress, however, is very slow because of the large number of rapids. Most transport is therefore by air, with the Department importing food and almost everything else required, including fuel and building materials, from Villavicencio and Bogotá. A network of footpaths connects communities, which usually lie at distances of several days' walking. (León 2001)
To go to Mitú or ship their produce there, including cassava, those living on the Mitú–Monfort Road can access either a communal truck or one subsidized by the Government. These trucks make one or two trips per week, depending on the community's position. Those living closest to the town, that is, 5 to 10 km, may opt to walk. Those living along the river travel by community motor canoes. (León 2001)
Some services and public utilities are offered by the Government and other entities in Mitú, but are otherwise deficient or nonexistent in other municipalities and communities. Despite the presence of a Municipal Unit for Agricultural and Livestock Technical Assistance (UMATA), the Secretariat of Agricultural and Livestock Development, and the Departmental Farm, technology transfer and technical assistance are practically nonexistent.

Modern influences
Particularly around Mitú, colonization has generally displaced slash-and-burn agriculture, changing, even degrading, the environment by wholescale clearing of forests, implementing permanent and unsustainable production systems—especially extensive cattle raising and monocropping—exploiting nonrenewable natural resources, reducing soil fertility and causing soil erosion, killing off endemic species, and reducing populations of game animals.
The increasingly degraded environment has not only led to the disappearance of the forest around Mitú, but it has also reduced the indigenous communities' capacity to follow their traditional agricultural practices. For example, instead of allowing their chagras to regenerate into forest over 15 years, they now permit a recovery period of only 3 years. Such a scenario favors the growing incidence of crop pests and diseases such as the leafcutting ant (Atta sp.) and cassava root rots.
The Government has attempted to mitigate the situation by executing production projects for communities to improve housing, install tanks to collect rainwater, establish production projects for pigs and poultry among others. However, these projects fail, mainly because of the paternal attitude of those executing them and the failure to take into account the communities' real needs and sensibilities. Neither are conditions ensured for self-management and self-sustainability.
Meanwhile, the more traditional indigenous communities fear their culture will disappear and attempt to recapture their customs. They commonly reject the practices adopted by the younger women and are unwilling to be taught by the young, who then cannot use what training they may have received from, for example, the National Apprenticeship Service (SENA).

Cassava root rots: a manifestation of change

The intense colonization around Mitú and along the Vaupés River and its tributaries has encouraged the development of cassava root rots. This disease, caused by several species of Phytophthora fungus, induces wasting and disintegration of root tissues. Since about 1995, the incidence of root and stem rots in cassava has increased, causing heavy losses of about 80% of production (Booth and Lozano, 1975). This, in turn, has led to food scarcity and economic losses for the population (UMATA–Mitú, 1997, personal communication). Root rots are widespread throughout the Department and, indeed, of the Amazon Region, including the Brazilian Amazon, wherever soils are poorly drained and clayey (Lopes et al., 1984).
The spread of the root-rot pathogen is further favored by the planting of susceptible varieties, inadequate agronomic practices, inappropriate use of fungicides, transport of infected material to areas previously free of the pathogen, and planting in compact or very clayey soils (Takatsu and Fukuda, 1990) that have low fertility and are K deficient. Other factors include weed invasion and associated crops that serve as hosts to the pathogen (Alvarez and Llano, 2002).
Despite the pathogen's great variability—seven species have been reported as attacking cassava, with variability also occurring within species and within localities (Alvarez et al., 1997a, b; Sánchez, 1998)—several authors have reported cassava as having genetic resistance to Phytophthora spp. (Barragán and Alvarez, 1998; Sánchez, 1998; Llano, 2003). The resistant Brazilian clones 'Mae Joana' (IM-175) and 'Zolhudinha' (IM-158) were adopted in northern Brazil, together with appropriate cultural practices. Root yields increased by over 80% (Lozano, 1991). This means that root rots can be managed by planting resistant varieties, together with other practices such as adequate selection of cuttings, improved soil fertility, and drainage of floodable land (Alvarez and Llano, 2002).
In 1997, the Tukano communities along the Mitú–Monfort Road, together with the local UMATA, petitioned for a project to find alternative ways of managing cassava root rots. Under the direction of the National Program for the Transfer of Agricultural and Livestock Technology (PRONATTA) and operating through the Indigenous Regional Council of Vaupés (CRIVA), they approached the Vaupés Departmental Node, integrated by various local governmental and nongovernmental organizations. The Departmental Node, in its turn, requested assistance from the International Center for Tropical Agriculture (CIAT).

The project's goals

With the Departmental Node, we developed a participatory research project in which we sought the cooperation of the Tukano communities to participate in the diagnosis, plan trials and activities, evaluate resulting crops, and provide feedback. By involving farmers, we hoped to understand farmers' priorities and criteria, and thus generate technologies that were more appropriate to their needs (Ashby, 1991). With the farmers' active participation, our goals were to:

i. Conduct a diagnosis of crop management practices related to the incidence of cassava root rots around Mitú. This would permit the discovery of appropriate and acceptable strategies for managing root rots such as incorporating organic matter and ashes into the soil, selection of good-quality stakes, and association with cowpea.

ii. Evaluate, using participatory methodology, not only the adaptation of cassava clones (already resistant to Phytophthora spp.) to Amazonian conditions, but also their acceptability to the Tukano communities for the quality of final products derived from them, their starch quality, and other traits.

iii. Evaluate, through participatory methodology, management practices that would permit better crop development and productivity, and reduce incidence of root rots. Their acceptability to the Tukano farmers would also be assessed.

iv. Train Tukano women farmers in participatory research, so they can solve production problems through community research, thus reducing their dependence on outsiders. This would be achieved by establishing a committee for local agricultural research (CIAL) made up of local farmers.

v. From an organizational viewpoint, help improve the dynamics between governmental entities and NGOs and their targeted communities, thus enhancing the rural development of indigenous communities.

Materials and Methods

The study area

Although the focus of our study area was around Mitú, in fact it comprised disparate ribbons of land, varying between 1 and 3 km wide. Most were found along 56 km of the Mitú–Monfort Road. The others followed the banks of the River Vaupés and its tributaries near Mitú.

Selecting communities

Nine of the communities who had settled along the Mitú–Monfort Road were selected for their relatively easy access. Because these communities are relatively "accessible" by the Road, they are subject to intense colonization, principally from uprooted indigenous communities and mestizo settlers. The communities—Seima Central, Seima Cachivera, San Juan de Cucura, Pueblo Nuevo, Tucandira, Murutinga, Timbó, Puerto Palomas, and Bogotá Cachivera—belong to eight language groups of the Tukano cultural complex. The 9 communities comprise 243 families, totaling 952 people, with a density of 0.47 inhabitants per square kilometer. They grow both bitter and sweet cassava on 444 hectares. About 93% of the population lives in absolute poverty. The illiteracy rate is 40%.

We began our 3-year study in 1997, completing it in 2000. For comparison purposes, we checked our findings with the initial nine communities against another five communities that had similar characteristics, but were situated on the Vaupés River. These communities were Bocas del Yí, Mituceño, Tucunaré, Macaquiño, and Trubón, comprising 118 families, that is, 638 habitants. This second 3-year study began in 2000 and was completed in 2003.

Research approaches

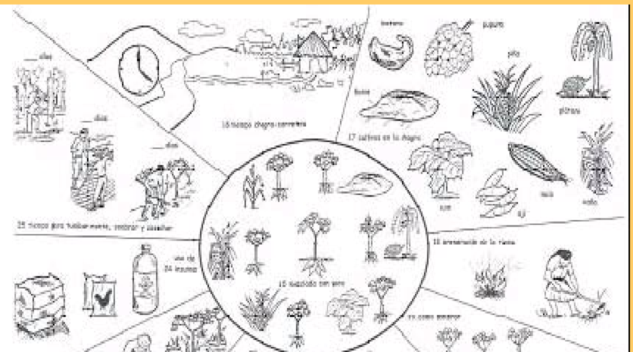
We carried out research along several lines, working with either all nine communities or with some of them. The approaches we discuss here are participatory diagnosis; evaluating varieties with farmers; and introducing innovations for managing root rots, either directly through new farming practices or indirectly by introducing social innovations that would lead to reduced incidence of root rots.

Participatory diagnosis of cassava production

Initially, the indigenous communities of Vaupés, together with the Vaupés Departmental Node, had carried out a diagnosis of the area's agricultural and livestock production. The diagnosis enabled them to define research priorities, one of which was to control cassava root rots. CIAT and the Universidad Nacional de Colombia–Palmira intensified this diagnosis in the first nine communities listed above to identify crop management practices that either favored root rots in cassava or contributed to their control.

With the communities' active participation, CIAT and the University conducted meetings, surveys, and samplings of diseased plants and infested soils. Overall, we conducted 35 surveys of Tukano women cassava growers in the nine selected communities. These surveys examined the region's land use systems, cultural practices, disease management, the farmers' knowledge of root rots and the importance they gave them, and the expectations they had of new clones resistant to Phytophthora spp. Pictographs (Figure 2) were used to facilitate communication with the women farmers. In meetings held with the communities, alternatives for managing the pathogen causing root rots were analyzed and the decision made to evaluate cassava varieties with resistance to the disease.

With the farmers' cooperation, we took 23 samples from infected plants, placing infected roots and items in plastic or paper bags. We also took 17 soil samples at depths between 0 and 30 cm from chagras where the disease was observed. Finally, we took 9 soil samples from healthy crops for comparisons to discover those factors that encourage disease development.



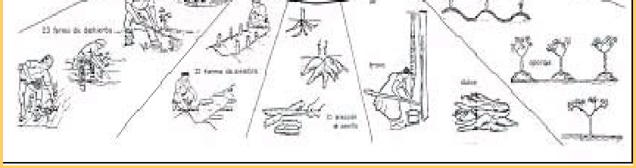


Figure 2 A section of the Spanish-language pictograph used in the surveys conducted for the participatory diagnosis carried out with indigenous and settler farmers in the Mitú–Monfort Road area, Vaupés, Colombia. The pictograph enabled discussions with farmers on their farming practices, including crops grown, land preparation methods, planting systems, cassava types grown, selection of planting materials and manner of planting (e.g. vertically, horizontally, stake length), cultural practices, use of inputs, harvesting, new plantings, and the time to market (significant because cassava roots, once harvested, are highly perishable)

Evaluating varieties with farmers

To evaluate cassava varieties with farmers, we chose four communities—Seima Central, Seima Cachivera, San Juan de Cucura, and Puerto Palomas. Findings were later verified in Macaquiño. With the help of the women farmers, we selected four chagras, one per community, to conduct trials to:

i. Verify the root-rot-resistant clones' adaptation to Amazonian conditions and confirm their resistance to root rots in the Mitú area.

ii. Test the root-rot-resistant clones' acceptability to farmers as crop plants.

iii. Evaluate the root-rot-resistant clones' acceptability for processing and cooking qualities, quality of final products, and starch production.

iv. Introduce and evaluate innovations to improve crop productivity and reduce root rot incidence.

The establishment and evaluation of clones took about 18 months, considering that, in San Juan de Cucura, Seima Central, and Seima Cachivera, the clones were established in April of the first year of research, whereas, in Puerto Palomas, they were established in September. Hence, harvesting was carried out during the second year of research. The experimental design was randomized complete block, with three replications. The experimental unit consisted of 16 plants in a plot measuring 9 m2. Planting materials were selected for each experimental plot by lottery. Cards were made, each with a number to identify a given clone. Each farmer chose 10 cards, each at random and, according to the numbers on the cards, received 7 CIAT cassava genotypes and 3 local varieties (1 white, 1 yellow, and 1 sweet). In all, 18 genotypes were evaluated, together with a susceptible check (Table 1).

Table 1 Agronomic traits of 18 resistant cassava genotypes—9 developed by CIAT and 9 local landraces. They were evaluated, applying participatory research methodologies, on four farm plots or chagras belonging to Tukano women farmers around Mitú, Vaupés, Colombia

Genotype	Origin	Flesh color[a]	Root rot (%)	Yield (t/ha)	HCN[b]	Plant height (m)	Branches (no.)	Stakes per plant	Starch (%)[c]	Starch quality[d]	Preference[e]
CM 2772-3	CIAT	Y	0.0	5.4	7	1.5	2.0	3.9	28.1	1	H
Mirití	Mitú	Y	0.0	7.7	8	1.5	2.3	4.0	29.7	1	H
M Bra 97	CIAT	W	0.0	3.5	6	1.3	1.3	2.9	31.8	2	H
ICA Catumare	CIAT	W	1.5	7.9	7	2.3	3.6	8.7	32.8	2	H
Abeja	Mitú	W	0.0	3.8	8	2.0	1.3	6.0	27.8	2	H
CG 165-7	CIAT	W	0.0	4.6	8	1.7	3.1	3.8	30.2	1	I
M Bra 71	CIAT	W	0.2	7.6	8	2.1	3.0	5.9	28.6	2	I
M Ven 25	CIAT	W	0.6	6.0	8	1.7	2.1	5.2	32.3	2	I
M Bra 532	CIAT	W	0.0	10.7	7	1.8	3.8	7.8	32.4	3	I
Blanca	Mitú	W	0.0	11.1	8	2.1	2.7	6.7	32.0	3	I
Abiyú	Mitú	Y	0.0	8.9	8	1.5	2.5	3.0	30.0	3	L
Lapa	Mitú	W	3.6	17.3	9	2.8	0.5	10.0	29.6	3	L
M Bra 1044	CIAT	Y	0.0	6.8	7	1.8	2.8	7.0	34.1	3	L
M Arg 6	CIAT	C	0.0	3.0	7	0.9	1.8	1.3	32.8	3	L
Santa Catalina	Mitú	W	1.7	8.1	6	2.2	3.1	7.8	28.5	3	L
Wasaí	Mitú	Y	0.0	3.7	8	1.1	0.7	3.7	30.0	4	L
Brava Blanca	Mitú	W	0.0	19.9	7	3.5	3.0	16.7	31.7	4	L
Brava Amarilla	Mitú	Y	0.0	12.2	8	2.9	4.0	10.0	30.4	5	L
Susceptible check:											
CG 402-11	CIAT	W	4.3	3.9	6	1.7	2.4	4.7	26.0	2	I

a. The color of the root's flesh may be yellow (Y), white (W), or cream (C)
b. HCN refers to hydrocyanic acid contents, which are determined qualitatively by using toluene and alkaline picrate on a color scale, where 1 = <10 ppm and 9 = >150 ppm
c. The percentage of starch in fresh roots is calculated, using the gravimetric method
d. Starch quality is scored according to farmers' preferences, where 1 = high and 5 = low
e. Preference refers to the level of acceptability to farmers, taking into account all the criteria they use to select a clone; H indicates high; I, intermediate; and L, low acceptability

The farmers, together with their families, evaluated their respective clones five times—four times during the vegetative stage and once at harvest—to assess the development and adaptation of the different varieties to the conditions of each site. The women made open evaluations, indicating their criteria for preferring (i.e. ranking) some clones over others. The percentage frequency with which each criterion was applied was then calculated.

To accommodate certain sociocultural mores, the chagra in San Juan de Cucura was cleared on common land and not on family land. It was then evaluated by a larger group of women, belonging to different families in the community. They first observed germination and vigor in the young plants, and then traits such as plant development, stem size, and leaf color. The women made both open and directed comments to the researchers from CIAT and the University, who sought reasons for why one variety would be preferred over another.

At harvest, researchers measured plant height and recorded the degree of branching, together with the number of stakes per plant, root flesh color, yield, percentage of root rot, and starch content. HCN levels in fresh roots were also determined, using the colorimetric method with toluene (which frees the acid) and paper soaked in alkaline picrate, which becomes reddish to dark coffee colored, depending on HCN level. The percentage of starch in fresh roots was determined by the gravimetric method described by Toro and Cañas (1985).

Once the roots were harvested, they were taken to each community, where a group of Tukano women and girls separated them according to variety, grated them, and evaluated the resulting pulps according to the quantity and quality of starch produced. They then prepared casabe, and both women and men tested the texture and flavor. A ranking order of preference was established.

To analyze the ranking of clones, the logistic regression program designed by Hernández (2000) was used. This analysis enabled us to quantify the probability of each variety occupying a determined position according to a ranking of farmer preferences. A graph was then made with the probability value of each position in the ranking for each variety evaluated. The statistical analysis of yield and other variables was done with the SAS package (SAS Institute, 1985).

Farming innovations

As mentioned in the previous section (point iv), the opportunity was taken to introduce and evaluate innovations for effectively managing root rots and improving crop productivity. Suitable innovations, that is, appropriate to the sociocultural conditions of the Mitú–Monfort Road area, were determined through surveys and dialogue.

The Tukano farmers selected the chagras; managed the trials with their own resources and the simple technology commensurate with their socioeconomic conditions; and analyzed the results, using a simple design that would take measurements according to their own criteria. The cassava varieties used were the white- and yellow-flesh local varieties selected by each community according to local preferences.

Applying soil amendments

Six trials were carried out over 2 years (1999/00 to 2001/02) to evaluate the effect of applying soil amendments in the second and third cropping cycles, that is, when the forest had already been cleared and burnt 2 or 3 years previously. Treatments were (i) controlled dosages of ashes from traditional burn-offs, (ii) organic matter, consisting of leaf litter, decomposing wood, and other decomposing materials taken from the forest floor, and (iii) ashes and organic matter, mixed in a ratio of 1:1 and incorporated into the soil. For all three treatments, the dosage was 200 g per plant, added immediately before planting. The trials were organized in a randomized complete block design with three replications established in the different communities. The control was traditional management of first-cycle cassava and no soil amendments in the second and third cycles.

The interaction variety × amendment was not assessed because each community was free to plant its preferred varieties, which, in the traditional planting scheme in the chagra, involved a mixture of different varieties. The yellow-flesh varieties, however, were separated from the white-flesh varieties and assessed independently.

Each farmer managing a trial evaluated the plots twice during the vegetative cycle, comparing treatments with each other and with the traditional control. She also recorded the best treatments and her reasons for selection. These evaluations were recorded on a scale of 1 to 5, where 1 = the most vigorous and best vegetative development, and 5 the worst.

At harvest, the plants in each plot were counted, and the entire harvest of roots was weighed as a whole. The healthy roots were then weighed separately from the rotten ones. With this information, the production per hectare was calculated for each plot.

Stake selection

An effective farming practice for reducing root rots is stake selection. Stakes were selected from the third middle of healthy and vigorous plants of the same chagra, eliminating stakes of poor quality or showing presence of pests or medulla blight. A control—unselected stakes (as traditionally done)—was also planted.

Cowpea association

The cowpea association was expected to improve the soil through nitrogen fixation by the symbiotic bacterium Rhizobium. The association was also designed to help increase the protein component of the Tukano diet. The local variety of the legume, known as habichuela brasilera (lit. “Brazilian bean”), was planted, intercalating with cassava at distances of about 20 × 10 cm between cowpea plants.

Social innovations

Establishing committees for local agricultural research (CIALs)

To take advantage of the contact that the communities have had with participatory research for almost 4 years, we conducted 17 workshops to show the communities the advantages of creating CIALs. Specifically, the CIALs would help them identify and prioritize production problems and define strategies for research to solve these problems, thus supporting the technicians in the area. All 14 communities participated (i.e. the 9 Mitú–Monfort Road and 5 Vaupés River communities) in workshops that were held in the following places: Mitú, Seima Central, Seima Cachivera, San Juan de Cucura, Tucandira, Bocas del Yí, Mituceño, and Macaquiño.

Improving institutional links

To improve and strengthen the participation of governmental institutions and CRIVA, 11 meetings were organized in Mitú, from the project’s beginning, between the different components of the Departmental

Node and the Tukano communities. They were kept informed of the project's activities and research progress.
We also held 6 meetings and 7 field days, at which Tukano women farmers described their experiences in clone selection, soil amendments, stake selection, and crop association to researchers and communities. In their turn, the farmers received technology from CIAT and the University.
Two pictograph pamphlets were also prepared to disseminate research results.

Results

Participatory diagnosis of cassava production

The surveys helped identify those cassava traits preferred by the farmers: tall plants that are slightly branched, good stake production, a vegetative cycle between 10 and 12 months, good starch content (regardless of the level of HCN contents), and resistance to pests and root rots. Although the Tukano farmers preferred bitter varieties with yellow flesh, they showed great interest in sweet varieties, with a view to selling surpluses in Mitú. The farmers also highlighted the importance of the multicropping system, with its genetically diverse cassava in the chagras, for guaranteeing food security as they perceived it.
The diagnosis confirmed the earlier diagnosis carried out by the Vaupés Departmental Node: that the farmers were aware of root rots and that 65% believed they comprised the biggest problem of cassava production. The diagnosis also helped identify those characteristics, some of them a result of modern pressures, of the cropping system that led to the increased incidence of cassava rots. Examples included:

- To establish the second-cycle crop, the farmers would, without selecting for quality, use stakes from the plants that they had just harvested and plant them in groups per site.
- An increasingly common practice is to plant in flood-prone or nutrient-poor land, where soils are characterized by high moisture retention, low hydraulic conductivity, low porosity percentage, high apparent density, and the presence of a clayey layer at 20 to 30 cm deep in their profiles.
- Failure to eliminate residues and diseased plants.
- Reducing the period of forest regeneration from 15 years to 3. Called rastrojos or "stubbles", these chagras have not had sufficient time to re-incorporate nutrients into the soil. Accordingly, the cassava crop develops poorly, and is more exposed to pests and diseases such as the leafcutting ant (Atta sp.), root rots (Phytophthora spp.), and anthracnose (Colletotrichum gloeosporioides). Yields can be as low as 5 t/ha.
- Failure to maintain traditional customs and skills, for example, the protective traditional custom of hoguereo, which is being lost, despite its being particularly favorable for second-cycle planting.

Evaluating varieties with farmers

The farmers chose those varieties that best answered their needs and preferences, using their own criteria. For the vegetative stage, these criteria were vigor, health, plant height, number of stems per plant, and earliness. At harvest, the farmers looked at yield, root hardness (quantity of starch), plant height (production of planting stakes), health, and earliness (Table 2). These identified criteria were used to prepare a field book for future germplasm evaluations in the area and for other evaluations in cassava development and production.
The roots were then processed and evaluated for their quality as casabe and starch. Each woman then ranked, from 1 to 10, the clones according to overall preference. A matrix was then generated, where rows corresponded to clones, columns to the women, and the data to the rank of each clone according to each woman's opinion, based on the accumulated evaluations for each trait.

The improved clone that the Tukano farmers most preferred in terms of starch, yield, health, and plant size for obtaining planting stakes was line CM 2772-3. This genotype was greatly appreciated for its yellow flesh and low HCN contents—traits that are not found together in the other varieties cultivated. This hybrid, developed by CIAT, adapts well to acid soils and high rainfall. The other improved varieties were generally well accepted for their high starch content and quality. Starch quality was visually evaluated by the Tukano women in terms of fine texture and low moisture content before drying. These characteristics probably related to particle size and starch density.

The second most preferred genotype was the local landrace Mirití (bitter, yellow flesh), followed by two improved lines M Bra 97 and ICA Catumare, the local landrace Abeja, and CIAT line CG 165-7. This last had high HCN content and therefore intermediate acceptability.

Table 2 Criteria used by Tukano women farmers to select cassava genotypes (with resistance to root rots) under the conditions of the Mitú area, Vaupés, Colombia. The criteria are listed in descending order of importance to the farmers

Criterion: Name	Criterion: Description[a]	Frequency of use (%)
For the vegetative stage[b]		
Planting material	Height, palos gordos (thick stems) or, nodes, plants per site	27.9
Vigor	Strong growth	23.4
Vigor, health, looks	Leaf appearance: "sad", "pretty"	20.9
Earliness	Rapid root thickening, short plant with good pepa, i.e. production	11.6
Crop uniformity	Growth uniform with other plants	9.4
Health	Dry and rotten leaves, dry branches	6.8
Total		100.0
At harvest[c]		
Yield	Good pepa (fully fleshed root)	21.4
Vigor, health	Leaf appearance: "sad" or "pretty"	16.1
Vigor, size, yield	Plant height	15.9
Yield, planting material	Stem growth	12.5
Starch content	Hardness on scratching with a fingernail	10.7
Health	Presence of grubs and diseases	5.7

Branching height	High branches	5.0
Flesh color	Color of the yuca, i.e. cassava root	4.7
Earliness	Harvest time	3.4
Root appearance	Root appearance	2.4
Foliage	Quantity of leaves	1.1
Ease of harvesting roots	Ease of harvesting roots	1.1
Total		100.0

a. Phrases in italics are farmers' terms
b. For the vegetative stage, data came from 15 farmers in four communities
c. Harvest data came from 18 farmers in four communities

The farmers consistently showed that, while they regarded yield as an important criterion, they saw as more important the quality of both starch and pulp for preparing casabe (Table 2). Indeed, the ranking order assigned by the Tukano farmers to clones in the vegetative stage did not correlate with rankings at harvest or by starch quality, except for CM 2772-3 and M Bra 97 (data not shown). Our finding that starch quality and the quality of final products were more important criteria than quantities obtained, crop health, or other agronomic traits is corroborated by Wilson (1997).

Figure 3A shows the accumulated probability of acceptability for each clone, according to evaluations done at harvest, when the Tukano farmers applied the criteria as described in Table 2. Figure 3B shows the accumulated probability by which a clone will have a determined rank by starch quality, according to the evaluations made after roots were processed. That is, variety CM 2772-3 had a 50% chance of being given first place, and 50% second (i.e. 100% cumulative probability, based on the second position), according to the selection criteria at harvest. And, according to the quality of extracted starch, the variety had a 50% chance to be given first place and 50% fourth position. In contrast, clone ICA Catumare, a hybrid developed by CIAT and released by the national program for the Colombian Eastern Plains where soils are acid and annual rainfall is 2000 mm, had a low ranking at harvest (20% of probability of occupying second place). Its starch quality, however, was highly acceptable to the farmers, giving it a 67% probability of occupying first ranking position.

(A)

(B)

Figure 3 Ranking order of 10 cassava genotypes evaluated by Tukano women farmers (A) using different criteria at harvest and (B) according to starch quality after processing, Mitú area, Vaupés, Colombia. Participatory research techniques were applied. Ranking order: 1 = high acceptability; 10 = low acceptability. Poly. = polynomial curve

High-yielding local varieties such as Blanca, Lapa, Brava Blanca, and Brava Amarilla had comparatively low acceptability, mainly because their starch quality was surpassed by several improved clones (Table 1).

Three years after the trials had been planted, many of the region's communities, including some with whom the project had not worked, were planting the evaluated improved varieties. Adoption of even those that had received low ranking during evaluations increased, so that 27% of Tukano farmers had at least one evaluated improved variety in their chagras. These new varieties became part of the complex of cassava genotypes normally found in chagras and highly accepted local varieties such as Mirití also conserved their space.

Farming innovations

Applying soil amendments

With amendments (ashes alone or mixed with organic matter), calcium contents in the soil increased after 12 months of cultivation, compared with traditional management. The amendments also reduced aluminum contents and slightly increased the soil's pH. Phosphorus also increased by 3 to 8 ppm under the same treatments. Magnesium and potassium maintained their levels after 12 months, although their contents rose shortly after applying the amendments, before being leached by rainfall and the low retention of cations in the chagras' clayey soils.

When ashes were incorporated into the soil, cassava performed better than under traditional management or when organic matter alone was incorporated. For the treatment incorporating a mixture of ashes and organic matter, measured over 2 years in four chagras, averages of 8.59 (white flesh) and 10 t/ha (yellow flesh) of cassava were obtained. Incidence of root rots in yellow-flesh varieties was 0.96%, whereas the white-flesh varieties showed no rot.

With ashes or organic matter separately, root yields were between 7.11 and 8.09 t/ha, and root rot incidence was between 0.35% and 7.81%, being higher in the white-flesh varieties. With traditional management, yields were 5.1 t/ha, with root rot incidence being 21.97% in white-flesh and 2.79% in yellow-flesh varieties. These results contradict those obtained under the controlled conditions of the greenhouse and farmers' experience, which indicated that the white-flesh varieties had better resistance (Table 3).

Table 3 Effects of five innovative treatments on cassava production and incidence of root rots in four Tukano communities around Mitú, Vaupés, Colombia[a]

Treatmentb	White-flesh roots		Yellow-flesh roots	
	Yield (t/ha)	Root rot (%)	Yield (t/ha)	Root rot (%)
Ashes	7.88 a	1.89 c	7.89 b	0.35 a
Organic matter	7.11 a	7.81 b	8.09 ab	2.16 a
Ashes + organic matter	8.59 a	0.00 c	10.02 a	0.96 a
Selection of planting stakes	6.83 a	3.10 c	4.43 c	0.91 a
Association with cowpea	4.99 b	0.00 c	7.23 bc	1.42 a
Traditional management	5.12 b	21.97 a	5.17 c	2.79 a

a. Data correspond to the average of four chagras (family farm plots) over 2 years, evaluating local varieties. Values within a column and followed by the same letter are not significantly different (LSD a = 5%)

b. "Traditional management" comprised planting untreated first-cycle cassava stakes wherever ashes were found after burning or near decomposing wood and no amendments for later cycle plantings

The treatment "Ashes" is very similar, but involved adding a controlled dosage of 200 g of ashes collected from burn-offs in later cycles. Stakes were planted in furrows in the ashes

In the treatment "Ashes + organic matter", ashes were mixed with organic matter at a ratio of 1:1

Stake selection

Despite farmers' reluctance, the researchers were able to encourage the communities to accept the idea of evaluating stake selection as a strategy for controlling rots. Stake selection without amendments increased yields to 6.83 t/ha for white-flesh varieties, and reduced root rots in cassava overall by more than 18%.

Many farmers preferred planting stakes of average thickness because more could be loaded into their baskets than if they were very thick. The farmers also chose, as planting materials, almost all lignified parts, including branches, even though these thinner stakes generated less vigorous plants. Plants producing two stems were usually preferred because of the larger quantity of planting material that would be produced, and hence of their greater value in maintaining the communities' food security.

In all cases, once they had selected their preferences, the women showed interest in sharing cassava stakes with women of their own community, thus strengthening internal community organization. Exchange between communities is more limited.

Despite observing higher yields and reduced incidence of rots, only about 5% of farmers considered stake selection to be a practice that they could adopt.

Cowpea association

In the cowpea association, production of white-flesh cassava varieties did not increase significantly, but neither were root rots present. In contrast, yield for yellow-flesh varieties was 7.23 t/ha, but root-rot incidence reached 1.42%. These values did not differ significantly from traditional management. Cowpea yield in the association reached 0.32 t/ha, constituting sufficient protein to improve the Tukano diet and increase soil fertility. Yet, only about 5% of the Tukano women farmers would cultivate cowpea in their chagras.

Social innovations

The Macaquiño CIAL

In response to the workshops held in different communities on the Road and Vaupés River, the Macaquiño Community established a CIAL, which conducted trials to evaluate the performance of maize and rice varieties. Traditionally, Macaquiño and the surrounding communities grow maize instead of cassava, but had never cultivated rice.

Feedback to the communities

The four communities where trials were established (Seima Central, Seima Cachivera, San Juan de Cucura, and Puerto Palomas) received feedback on trial results for varieties and innovations during field days, meetings, and workshops. Field days at individual chagras were difficult to conduct because the Tukanos believe that if women unrelated to the chagra's owner visit the crop, then it will rot. Field days were therefore conducted on the community's commons, where the four women who had evaluated the experiments could exchange experiences with other farmers.

The women showed great capacity in orally transmitting their experiences and their listeners seemed to understand with an ease that made them appear to have observed the crop itself. The listeners also provided feedback, describing their experiences, even though they had not directly participated in the evaluations.

During meetings, the farmers also handed out stakes of selected varieties for multiplication in different chagras. Many nonparticipating farmers were thus encouraged to plant the introduced varieties. In addition, meetings of more than 100 Tukano farmers each were held with other communities of the Road and Vaupés River, where one or another of the four women described their results and gave out stakes.

The communities participated in the preparation of two informative primers based on farmers' opinions expressed through drawings to improve understanding by other farmers. Their goal was to disseminate experiences acquired in managing root rots and solving production problems through research with community participation, and thus help farmers improve their farms' productivity. These were very well received.

Several meetings were also held to inform the Departmental Node of the results obtained.

Discussion of Results

Evaluating varieties with farmers

Traditionally, Tukano farmers greatly valued diversity of materials and constantly tried out new varieties obtained from other communities in Colombia or neighboring Brazil. The women participating in the project were willing to learn about, evaluate, and adopt the new varieties we offered as options, and willingly shared planting materials with women of other communities who had not participated in the project, thus strengthening community relationships.

The farmers were surprised and greatly attracted to the idea of trying out new varieties that excelled their own in terms of starch quality and for use in certain classes of casabe, muñica (a porridge-like dish of fish and cassava starch), and mingao. The different and sometimes superior qualities of the improved clones probably helped encourage them to try out the other innovations we attempted to introduce.

The farmers apparently did not use resistance to root rots as a criterion for evaluating the new varieties for two probable reasons: the varieties were resistant anyway, and, in the year in which the varieties were evaluated, disease pressure was low, preventing adequate selection for resistance in the field. Even the crop of the susceptible variety, CG 402-11, had barely 4.3% incidence of rots. Hence, farmers were probably influenced to emphasize traits other than resistance. However, according to Wilson and Dufour (2006), although yield and damage caused by pests and diseases may influence cultivar selection, the main criterion is the type of food products that can be made from each cultivar.

Innovations—their acceptability and adoption

Soil amendments

The use of soil amendments such as ashes in the second planting was, to some extent, an attempt to recover a thousand-year-old custom that was being lost in the agricultural systems of new generations of Tukano women farmers. However, collecting organic matter from the forest floor and taking it to where crops were planted was an innovation. Even so, the young women tended to reject the practice as demanding extra time and labor, whereas the older women considered it a viable practice. Neither group appeared worried by the deterioration of soils, and the forest generally, because they believed they had a lot of forest to use. That the reality is otherwise is shown by the groups who settled around Mitú. These have suffered an irreversible process of acculturation and now depend heavily on the town. They are unwilling to move to remote sites where the forest is little disturbed.

The contradictory results that showed yellow-flesh varieties as being more root-rot resistant than white-flesh varieties when given soil amendments may have been a result of our very small sample of chagras. The chagra with the highest incidence of root rots had only white-flesh varieties and had conditions that favored root rots such as high soil moisture. Moreover, the varieties used in this chagra are suspected of being genetically susceptible to the disease.

Stake selection

Although selecting quality planting stakes was considered a good practice, few farmers adopted it because, in their world view, they see the cassava plant as a human being. All planting materials that sprouted were therefore of great importance in that they produced new plants (new human beings). If they eliminated stakes, God would punish them by causing the cassava to rot and thus bringing hunger. All propagation materials, including thin stakes, were therefore planted. This same world view enabled them to see as invaluable the richness of diversity in cassava varieties.

Cowpea association

Although the farmers found that incorporating cowpea into chagras did slightly improve cassava production, reduced rots, and was acceptable for consumption, they did not readily adopt this practice.

Several wild legumes grow spontaneously on cropped land. The Tukano farmers frequently refer to them as “the cure for cassava” because their presence benefits plant development. Although cowpea is sometimes eaten, seeds are not conserved for new plantings.

The few women who adopted cowpea did so to improve soil fertility, even though they were encouraged to introduce it into their diet by the Vaupés Secretariat of Health, which aims to guarantee an adequate diet for schoolchildren. These women helped prepare school lunches and were therefore more inclined to adopt the new food in their diet.

CIAL methodology

Although the Macaquiño CIAL did not conduct research on cassava, the introduction of this innovation was considered a success. Never before had Tukano communities in the zone participated actively in a research project that so successfully enabled the community to assume leadership. Moreover, it was a tool that allowed them to continue, more independently, conducting research to solve their own production problems.

One reason for the CIAL’s decision to evaluate, as priority, rice as an option for a new crop in the zone stems from rice being part of the diet of students attending indigenous schools close to Mitú. The Secretariat of Education includes rice in the lunches they provide for schoolchildren. These lunches are prepared by women from the communities.

Improving institutional links

The Vaupés Secretariat of Agricultural and Livestock Development and the Corporation for the Sustainable Development of North and East Amazon (CDA) effectively participated in various activities. However, for the Secretariat, the changes of governors reduced resources for the Department, which, among other things, diminished the effectiveness of activities that could have strengthened community participation. For example, activities benefiting the agricultural and livestock development of indigenous communities and settlers in the region could have been encouraged at the Departmental Farm. The CDA, although more related to the conservation and management of natural resources, was able to approach the communities more closely.

Factors influencing the acceptability and adoption of innovations

Lack of services

Indigenous communities suffer a series of problems that make technological innovation difficult, for example, deficient and costly transport service from the communities to the Mitú township, scarce technical assistance, limited training of local entities, and the small market—limited to Mitú—for agricultural produce. The nearest urban markets are at Villavicencio and Bogotá, which can be reached only by air, making it too costly to permit competitive prices.

Apathy, organizational failures, and lack of credibility of entities, including indigenous NGOs, debilitate any interest or activity generated such as the CIAL of the Macaquiño Community. Interaction is also poor between the local indigenous entities (i.e. CRIVA, AMUDEVA, and the Indigenous Affairs Office) and the Tukano communities.

Problems of law and order

Armed groups and lack of governmental support have limited interaction between communities and municipal entities, reducing the potential for collaborative activities as might occur through, for example, technical assistance. At the end of 1998, when the guerrillas took the town of Mitú, many families were displaced towards other faraway communities and towns. One community, San Juan de Cucura, which was one of the best organized, practically disintegrated for this reason in 2000. The establishment of an army battalion outside Mitú has also led to frequent skirmishes with the guerrillas, maintaining the communities in a state of instability.

Conclusions

The project’s overall impact on the communities

The Tukano farmers learned to carry out a diagnosis of their crops’ production problems, and to select varieties according to their own criteria such as starch quality, plant size, yield, and crop health (Table 2). Farmers participated effectively throughout the research, expressing their needs, identifying crop problems, planning activities, applying their criteria for selecting clones in accordance with their preferences, and comparing improved clones with local landraces. In general, they understood the importance of their participation in research to improve their agricultural production and strengthen their indigenous organizations.

Integrating root-rot management practices, which included planting resistant varieties, selecting stakes, association with cowpea, and applying amendments to improve soil fertility, was successfully shown to keep levels of disease incidence low. Such strategy integration was also shown to permit planting to be carried out over more time in a single chagra, thus reducing the pressure to cut down the forest. However, the farmers’ world view did not permit widespread acceptance of most of these

practices.
Some farmers assisted in establishing a collection of local landraces at the Vaupés Departmental Farm. This collection would conserve the region's genetic diversity in cassava, which could be used to improve the crop's health and guarantee food security. The introduced varieties were also planted at this Farm to multiply stakes for planting in chagras whenever they should be in demand. The project therefore had the effect of encouraging some official entities to integrate more into the community, be more dynamic in their search for solutions, and so give impetus to the Tukano communities' agricultural and socioeconomic development.

Implications of the project's findings

For almost 6 years, we had the opportunity of accompanying the communities and of measuring the success of the evaluated innovations by the interest the Tukanos showed, whether through dialogue; attendance at meetings, workshops, and field days; or adoption of given innovations. We could verify the high acceptance of planting introduced varieties, the middling acceptance of applying soil amendments, and the low acceptance of selecting planting materials or using cowpea. Our observations of their customs lead us to believe that the Tukanos place great value on the diversity of cassava as a resource. We therefore expect that the introduced varieties will remain on many Tukano chagras where they will have a permanent impact.
Our research results, as obtained so far, also confirmed that the use of dialogue and the full participation of those in the know are indispensable for the successful adjustment of previously developed technology to the sociocultural conditions of societies such as those found around Mitú. Tukanos, especially women, should be encouraged to participate in the joint search and organization of solutions to problems felt by the communities. Women should also be recognized for their importance as channels for diffusion and innovation. Tukano knowledge, generally, should be used as a source of information for generating and corroborating scientific hypotheses.
Our results also confirmed the necessary influence of indigenous NGOs and local entities. In the case of the communities around Mitú, their participation was generally precarious, effectively weakening, over the short term, progress made during research, particularly that of local research groups that were as yet unconsolidated, such as the Macaquiño CIAL, which still needed some form of supervision. Nevertheless, the Tukano communities' social conditions and the lack of involvement of governmental entities in Tukano community development led to the program being well accepted because the Tukanos felt they were being supported by people outside their culture. Hence, methodologies such as those of the CIALs should be institutionalized in governmental and nongovernmental entities seeking to improve efficiency in transferring technology to Tukano communities.

Possibilities of scaling up

The process we developed together with the Tukano communities around Mitú to solve a specific agricultural problem can be extrapolated in its application to any Tukano community of the Amazon regions of Colombia, Brazil, Ecuador, or Peru, where slash-and-burn agriculture is practiced and where cassava forms the dietary staple. Moreover, with adjustments according to the respective environmental, social, and cultural conditions, this process can be applied to other Tukano or small-farmer communities in other areas in the world where slash-and-burn agriculture is also practiced.

The future

The impact of our work in the region was perhaps not as great as it could have been because of the presence of guerrilla and military groups, which de-stabilized not only the lives and activities of communities but also those of nearby urban centers. After we left in 2003, we have been unable to follow up possible changes our research might have made on the communities in the Mitú area. Indeed, much of the impact of our work may have since been wiped out as confrontations continued.

However, as peace negotiations also continue, we hope that the area will become socially stabilized again. We would then return to monitor the region's cassava crops, encourage awareness of the need to conserve community resources, and help institutionalize the principles of executing local research projects in both communities and local entities so that they can solve their agricultural problems without being heavily dependent on outsiders. Specifically, we would use the CIAL methodology to train technicians from local institutions and Tukano leaders. Most importantly, we hope to find that the willingness with which the communities had adopted the improved cassava clones and the relative success of the Macaquiño CIAL had indeed led to some long-lasting and positive impact in the region during our absence.

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