A multiple-species participatory domestication programme in the Peruvian Amazon: experiences and results to date

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Abstract
In 1995, the World Agroforestry Centre (ICRAF) and partners initiated a participatory agroforestry domestication programme in the Aguaytía Watershed and Alto Amazonas province of the Peruvian Amazon. The programme, aimed primarily at conservation-through-use of genetic diversity, began with formal, participatory prioritization, leading to selection of four species: bolaina blanca (*Guazuma crinita* Martius: Sterculiaceae), capirona (*Calycophyllum spruceanum* (Bentham) Hooker f. Ex Schumann)), guaba (*Inga edulis* C. Martius: Leguminosae (Mimosoideae)), peach palm (Bactris gasipaes Kunth: Palmae). Open-pollinated seed of each was collected from farmer-selected mother trees, and used in the establishment of a series of seedling seed orchards / progeny tests, the individual blocks of which were dispersed on lands of individual collaborating farmers. Almost ten years later these trials are beginning to produce seed, the Aguaytían famers have organized themselves into a wood and seed producers' cooperative, the technology developed is being adopted more widely, and genetic results are becoming available. We describe the programme and its results in detail, with special emphasis on its innovative features. Subsequently, we evaluate success to date in relation both to initial objectives and the programme's response to the evolving local forestry and development environment. Finally, we consider future priorities.

Introduction

With more than 1,200,000 km^2, the total land area of Peru is greater than that of France and Spain combined. Of this area, more than 60% lies in the Amazon region. In recent decades, the combination of extreme poverty and political violence in the Andean region, coupled with land availability and improved accessibility due to road construction in the Amazon region, have led to high levels of immigration to the Amazon. Although it is likely that many immigrants have been able to improve their livelihoods, they nevertheless face formidable problems. As the typically acidic soils lack sufficient nutrients for sustainable repeated harvests of annual crops, most practise slash-and-burn agriculture (Denevan and Padoch 1988): the burnt forest is their fertilizer. After one to three years of cropping (rice, maize, cassava), the fields are left to fallow or are converted to pasture. After about 20 years, fertility is restored (J.C. Alegre, personal communication). However, since average farm size is only around 30 ha, a 20-year rotation is not an option for most farmers. Consequently, farmers either decrease the fallow period to 5 years or less, or simply fell new areas of virgin forest. In doing so, they ensure short-term subsistence, but at the expense of their own long-term productive base.

The World Agroforestry Centre (ICRAF) and partners such as Peru's National Institute for Agrarian Research and Extension (INIEA) have been working on biophysical and socioeconomic aspects of this problem since 1993. Here we describe one element of this collaborative research effort: an ongoing programme of participatory agroforestry domestication. The work is centred on the Aguaytía watershed in the Ucayali region of Peru, a 'forest margins' area considered representative in many ways of agricultural frontier sites throughout the Amazon. Soil and climatic conditions vary between lower, middle and upper parts of the watershed (Table 1). Table 1 also includes information on conditions near Yurimaguas, >300km km to the north, where additional work was carried out with two of the species.

Rationale for the programme

ICRAF studies revealed that farming communities in the Peruvian Amazon depend upon more than 250 tree species for construction material, fence posts, energy, fibres, resins, fruits, medicines, and service functions such as soil conservation and shade (Sotelo Montes and Weber 1997). However, slash-and-burn agriculture fragments and disturbs forest habitat. Thus, even when loggers inadvertently leave seed trees, natural regeneration of many valuable tree species is poor. Consequently, the diversity, quality and availability of these resources were declining around many rural communities, resulting in often severe losses to local communities in income, self-reliance, and nutritional security. In addition, forest degradation results in lower levels of national and global environmental benefits (Weber et al. 1997). The ICRAF-INIEA domestication programme was designed to respond to these problems, by (a) securing genetic resources of selected priority species; (b) developing high-quality seed sources to facilitate continued use by farmers of the selected species; (c) generating income derived from germplasm sale for participating farmers; (d) increasing awareness of the importance of intraspecific genetic variation in agroforestry tree species, and (e) providing a catalyst for tree domestication and a model programme suitable for uptake in other comparable zones of the Amazon (in Peru and elsewhere).

Description of the programme

The term 'domestication' has many meanings (Leakey and Newton 1994). We employ it to mean the identification, production, management, and adoption of desirable tree germplasm (Simons and Leakey 2004). We have approached these goals through a systematic approach to selection of target species, an innovative and flexible approach to tree improvement activities, the use of appropriate molecular techniques to answer specific questions of interest, and capacity building of collaborating farmers. We now describe these components.

Prioritization

Forest industries are frequently based on one or a few species. As illustrated above, the situation of smallholder farmers in the Peruvian Amazon is quite different. Nevertheless, it was obviously impractical to work with all species of interest to smallholders. For this reason, we carried out a systematic prioritization process, based on guidelines developed by ICRAF and the International Service for National Agricultural Research (Franzel et al., 1996), to select a reduced group of species. Farmers in the survey identified more than 150 tree species as being of value for wood products, energy, fibres, food, medicines, soil improvement and conservation, shade and other uses (Sotelo-Montes and Weber 1997). Based on these preferences and advice from experts in marketing, development and other disciplines, we ranked these species according to their potential for agroforestry research and development projects in the region (the top 20 species are listed in Table 2). Finally, we selected four of the highest-ranked species for inclusion in the domestication programme: peach palm (*Bactris gasipaes*), guaba (*Inga edulis*), capirona (*Calycophyllum spruceanum*) and bolaina (*Guazuma crinita*). Their principal ecological and socioeconomic characteristics are described in Table 3. The second and third ranked species were excluded because of unavailability of suitable planting sites within the study zone (tornillo) and because of limiting pest problems, i.e. *Hypsipyla grandella* (Spanish cedar).

Tree improvement activities

A total of 141 individual field plantings of these species have been established, 41 in Yurimaguas (40 of these of peach palm) and 100 in the Aguaytia watershed near Pucallpa (including all the bolaina and capirona work). Most of the plantings are individual components (i.e. individual randomized blocks) of experiments, and combine this function with those of genetic conservation (*circa situ*) and improved seed production. Field activities differed to some extent for the different species. They are summarized in Table 4 and described in more detail below. Farmers participate in all key decisions, effect cultural practices (Table 5) and are in frequent contact with ICRAF personnel. Quarterly meetings between ICRAF and PROSEMA (see below) allow further interchange of views and information. Farmers receive payment for weeding. As well as ensuring relatively consistent levels of maintenance between blocks, these subsidies also recognize that, in addressing wider development and conservation objectives, the programme generates public benefits, the costs of which should not be borne by the collaborating smallholders.

Provenance-testing

Provenance tests were carried out in the case of bolaina and capirona, using a similar design in each. Ten (capirona) or twelve (bolaina) provenances were included, sampling a wide geographic area with quite variable conditions (4°S to 10°S latitude, 71° to 77° W longitude, 1800 to 4000 mm $year^{-1}$ precipitation, 100-300 m a.s.l.). Trees were selected randomly in each collection area. The experimental design was randomized complete blocks, with 36-tree and 16-tree plots in bolaina and capirona, respectively. The blocks were planted separately from each other on farmers' lands throughout the Aguaytía watershed, i.e. in lower, middle and upper parts of the watershed. Some advantages of this design are discussed more fully below (see 'Progeny-testing and seedling seed orchards').

Participatory selection of mother-trees

Farmers were involved directly in the selection of mother-trees in all four species. In the case of peach palm, the collaborating farmers selected mother trees of the spineless Pampa Hermosa landrace, primarily based on fruit characteristics (quantity, exocarp colour, oil and starch content, texture, size). Open-pollinated seed was collected from 100 mother-plants in 1997 (four localities along the Cuiparillo River, east of the city of Yurimaguas) and 302 in 1999 (12 localities along the Paranapura River, west of Yurimaguas). For bolaina, 209 plus-trees in 14 Aguaytía watershed localities were selected in collaboration with farmers in 1998. Selection criteria included stem and crown form. In the same year, 208 plus-trees and 75 randomly selected trees case of capirona were selected, again from 14 Aguaytia watershed. As for bolaina, selection criteria included stem and crown form. For all the species, selection intensities were kept low (≈1 in 20) to ensure relatively high genetic variation in all traits at programme inception. In the case of guaba, thirty-five mother-trees were selected for each of three selection criteria (selection for fruiting, selection for shade/biomass, and random selections) by farmers in the Aguaytia watershed in 1997.

Multiple-site progeny-testing and seedling seed orchards

The centrepiece of the domestication programme is the network of on-farm progeny-tests *cum* seedling seed orchards of bolaina, capirona and peach palm. One experiment was established in the case of bolaina, and two each for capirona and peach palm. A randomized complete block design was used in all the experiments. The blocks are distributed on different farmers' properties and are nested within the zones-in-regions described in Table 1. Sites were selected by farmers and ICRAF-INIEA based on soil characteristics and distance to potential sources of extraneous pollen (minimum accepted distance was 100m). Each block consists of 50-200 families, planted in two-tree plots at 2.5m x 5m spacing for pijuayo, and 2.5 x 2.5m for bolaina and capirona. The use of two-tree plots reflects the genetic conservation objective, as the 50% thinning to a final spacing can be effected by removing one tree per family, thereby minimizing the reduction of genetic variation. It also permits preliminary evaluation of coppicing ability, which is of special interest in peach palm because heart-of-palm is harvested from coppice shoots. This innovative design was chosen partly for pragmatic reasons: the area of each block (around 0.5 ha) is small enough to be manageable by individual farm families. However, it also has specific advantages, particularly (i) that a wider range of conditions, including varying farmer practice, can be sampled than if blocks-within-zone were concentrated on one site and (ii) it permits the implementation of different selection criteria and intensities in different individual blocks, so that different tests may be converted to seedling seed orchards with different emphases on gain *versus* conservation and different emphases on specific traits.

<u>Testing of specific farmer hypotheses</u>

A number of specific hypotheses derived from local knowledge or perceptions are being experimentally tested within the programme. For example, farmers consider that peach palm fruits with red, waxy coats have higher oil content than fruits with red or yellow, non-waxy coats. Similarly, in one case study (Potters 1997), women recognized six varieties of guaba, which they would cultivate specifically for fruit, shade or firewood. They distinguished the varieties based on pod size and on the size, shape, and colour of the leaves. According to their experience, certain varieties have tastier fruits, while others are better for shade, The women also perceived a correlation between seed colour and fruit production. In their experience, trees that develop from black seeds produce many fruits, but trees from yellow seeds do not produce much fruit. Finally, some male farmers consider that capirona trees with dark reddish-brown bark and few knots on the stem have dense wood and are best for sawn timber, whereas the wood of trees with light-coloured bark is not dense, is easy to split with an axe, and is best for firewood and charcoal. If these hypotheses are confirmed by the experimental results, the information would allow farmers and researchers to quickly and inexpensively select the best genetic material for multiplication.

<u>Molecular genetic variation</u>

Three studies of molecular genetic variation have been carried out under the aegis of the programme. Adin *et al*. (2004) sampled DNA from 203 progeny plants derived from the two peach palm collections. They then estimated population genetic parameters using AFLP markers, in order to estimate levels of genetic diversity, to test for differences in populations located in indigenous and colonist communities, and to test for the presence isolation-by-distance effects on genetic structure. Russell *et al*. (1999) sampled DNA from 89 individuals from the provenance collections of capirona. Genetic parameters were estimated using AFLP markers, in order to assess the partitioning of genetic variation within and among populations. Finally, Hollingsworth *et al*. (2005), using SSR markers, looked at relative diversity in planted and natural stands of guaba, in order to test for effects of domestication on genetic diversity.

Capacity-building of participating farmers

Farmers' involvement in a productive activity (plantation forestry, relatively large-scale peach palm cultivation) that in many respects is new to them has in itself raised their awareness and capacity to engage in alternative productive options. However, we appreciate that lasting benefits require a much more purposeful approach. For this reason, ICRAF has implemented a series of activities aimed at building capacities in a number of fields related to agroforestry production, including small business organization and administration and training in specific productive techniques. In 1999, collaborating farmers in Ucayali formed a civil association, the Aguaytía Watershed High Quality Seed and Wood Producers' Association (PROSEMA). More recently, PROSEMA and the

Ucayali Rural Women's Association (AMUCAU), again with ICRAF's support, have united to form two limited companies that will supply agroforestry services and goods, including seed and plants. The individual shareholders in these companies have received training in diverse themes, including basic accountancy, business administration, postharvest management of peach palm, timber plantation thinning, forest seed management and handicrafts with agroforestry products (e.g.. leaf collages, home-made paper).

Experiences and results to date

Our experiences to date have confirmed the feasibility of implementing a participatory, spatially-distributed, farm-based agroforestry domestication programme. To date, only one farmer has withdrawn from the programme, and growth and development of the trials has generally been highly satisfactory. This has been partly due to a generally adequate level of funding and the dedication of the personnel involved. At the same time, it is obvious that the financial support given to the farmers has constituted a precondition to the success of the programme. In the absence of short-term benefits from the plantations, and given their scarce familiarity with the productive systems in question, it would be futile to try to implement a programme of this sort without providing direct support to the collaborating farmers.

Research results

<u>Tree improvement</u>

Initial results from the field trials, at present still confined principally to the capirona provenance data, also confirm the usefulness of the experimental approach.

Sotelo-Montes et al. (2003) and Weber and Sotelo Montes (2005)) reported on variation and correlations in stem growth at 18, 30 and 42 months, mean branch density at 18 months, wood density (in the lower and upper parts of the stem) at 30 months and mean heat content of stem wood at 18 and 32 months. Stem height varied significantly among provenances and planting zones, but zones accounted for much more variation than provenances. Stem wood traits did not vary significantly among provenances. Regarding the variation in wood density within the tree, wood density in the upper stem and the difference in density between the lower and upper stem varied significantly among planting zones: density in the upper stem was lowest, and the difference in density between the lower and upper stem was largest in the zone where trees grew most rapidly. Phenotypic correlation between branch-wood density and heat content was weak positive at 18 months. Phenotypic correlations between stem growth and wood density at 32 months differed in sign among planting zones, suggesting that selecting fast-growing trees could indirectly reduce wood density in environments where trees grow slowly, and increase the difference in wood density between the lower and upper stem in environments where trees grow very rapidly. Correlations between stem growth and wood heat content at 32 months were stable across zones, and indicated that larger trees tended to have wood with higher heat content. Stem-wood heat content varied with provenance latitude/longitude in the sample region, but none of the other traits varied clinally.

Boivin-Chabot et al. (2004) studied the variation in resprouts following a coppice cut in a provenance trial in capirona. The results showed significant differences in the number of resprouts among among some provenances, but there was no significant difference between the zones of plantation.

Three-year results are also available for the bolaina provenance trials (Sotelo et al., 2000). At 36 months, the most local provenance (Von Humboldt) had the highest height growth rate. Differences in diameter appear less well developed. Like the capirona results, the preliminary information supports the use of local material to form the breeding populations.

Results indicate that there is potential to select faster-growing provenances at an early age, but this could affect wood density in certain environments. However, they also suggest that provenance variation is relatively small, thus vindicating the project's parallel strategy of basing breeding populations on populations located in a relatively restricted zone (i.e. the Aguaytía watershed).

<u>Molecular studies</u>
Russell *et al*. (1999) found that AFLP variation was concentrated at the within-population, as is common in tropical forest trees (Hamrick et al. 1992). However, Fst levels were moderate (0.118) and in the AMOVA variation between populations was highly significant. These results suggest that it would be unwise to concentrate sampling and genetic conservation solely in very few populations. In the case of pijuayo (Adin *et al*., 2004), estimates of population differentiation were low (Gst of 0.03-0.04), suggesting a high level of gene flow between populations. Given the relatively low mobility of the pollen vectors of pijuayo, they suggested that this might imply that genetic differentiation has been prevented by farmer-mediated exchange of seed, as observed by Weber *et al*. (1997). Their comparison of diversity in indigenous and colonist populations did not reveal strong evidence for differences in diversity between the two groups (He of 0.26 *v*. 0.25, respectively).

Hollingsworth *et al.* (2005) found significantly lower allelic variation in planted stands of guaba compared with natural populations (31.3 v. and 39.3, p = 0.0091). They suggested that concerns regarding genetic erosion in planted Amazonian tree stands therefore appear valid. Although, as they mention, variation in SSR 'alleles' is still relatively high, the same is not necessarily true for variation at neutral or non-neutral gene loci.

Local socioeconomic effects
PROSEMA and its associated company ECOCUSA are beginning to generate significant income from the sale of seed and germplasm, including a sale to the Peruvian National Forestry Development Fund (FONDEBOSQUE). In addition, they are generating significant income from the sale of diverse agroforestry products and services, including home-made paper, fence posts, evaluation of plantations, and sale of products produced by non-members. PROSEMA is now seeking new members in order to strengthen its productive base, particularly beneficiaries of previous reforestation projects in the zone.

Wider effects of the programme

The domestication programme has spanned a period of change in the Peruvian foerstry scene. At its inception, levies on stumpage were financing an active reforestaion programme administered through local ‚reforestation committees’. These committees were abolished after the proclamation of the new forest law in 1999. With the new forest law, national and regional attention began to focus almost exclusively on the implementation of the new system of natural forest concessions, and interest in forest plantations waned in some sectors. More recently, the impressive growth in the ICRAF-INIEA trials, particularly those of bolaina, has stimulated interest in the species. Several local NGOs and other agencies are now involved in promotion of bolaina plantations as a productive option.

The concept of planned domestication has also taken root in Peru, with at least one domestication programme being implemented by national institutions independently of ICRAF (i.e. the programme with the palm *Mauritia flexuosa* (aguaje), currently being implemented by the Instituto de Investigaciones de la Amazonia Peruana).

Results in relation to initial objectives

The programme has substantially achieved its initial stated objectives. It has shown one means by which genetic resources of priority species may be secured. High-quality seed sources, whether from the point of view of diversity or productivity, have been established. Farmers have begun to generate income from sale of germplasm. Awareness of the importance of intraspecific genetic variation in agroforestry tree species is still incipient in the Peruvian Amazon, but will grow as research results become available and are disseminated.

The future

As outlined above, the flexibility of the experimental design permits various options in terms of future genetic management. For example, different selection criteria for peach palm fruits could be applied in different orchards, e.g. for production of flour, animal feed or specific consumer preferences. Similarly, different strategies with regard to the balance between genetic conservation and genetic gain could be applied. The latter aspect has been explored by Cornelius *et al*. (2005). Although they considered the specific case of the peach palm programme, their conclusion that, with appropriate measures (e.g. seed exchange between subpopulations) gain and diversity could be reconciled in at least the medium term also applies to the bolaina and capirona programmes. Genotypic selections will be carried out in the trials over the next two years. Selection criteria will be set in consultation with the farmers. In the case of peach palm, information on consumer preferences from a demand study will also be taken into account in fixing criteria for each trial.

One explicit objective of the programme has been to act as a model and catalyst for wider activities in the Peruvian Amazon and beyond. Its influence is already being felt, and will grow as more results become available. The key priority to be addressed now is to increase the number and diversity of species covered by formal domestication programmes, in order to ensure that smallholders continue to have access to the wide diversity of species that form part of their livelihood strategies. The programme represents a solid example of what can be achieved in collaboration with smallholder farmers. However, to increase the number of species covered by domestication programmes, in many cases smaller-scale options, e.g. individual seed stands on farmers' lands, will be needed. As we disseminate further the results of the present programme,we will be working with partners in Peru and other regions of the Amazon in designing suitable options for their diverse circumstances.

A number of wider challenges also needs to be addressed. Adoption of agroforestry practices in Peru and elsewhere in the Amazon remains low. Lack of quality germplasm is just one of the responsible factors (Walters *et al*., 2005). To achieve results with substantial development impact, work in domestication needs to be closely linked with a wider agenda. The strengthening of such interdisciplinary linkages is one of the objetives of the Amazon Initiative for Sustainable Use and Conservation of Natural Resources (AI), an international consortium of research organizations formalized in 2004 (Porro *et al*., 2005). The AI links producers' organizations, researchers, extension workers and others through ten thematic networks, one of which is concerned with agroforestry germplasm. The networks will serve both as fora for discussions and as platforms for preparation of research and development proposals. By working through the AI networks, ICRAF and INIEA will strengthen the links of their work in domestication with wider aspects affecting agroforestry adoption, e.g. natural resources policy, education and training.

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Table 1. Location and environmental characteristics of study sites in the Peruvian Amazon

Region[1]	Zone[2]	Environmental characteristics
Ucayali	Nueva Requena	Soils well-drained, highly acidic, sandy; annual rainfall ~1600 mm, pronounced dry season
Ucayali	Curimaná	Soils with varying texture (clayey loams, silty loams), drainage average, highly acidic; annual rainfall ~2600 mm
Ucayali	San Alejandro	Soils with varying texture (clayey loams, silty clays, clayey silts), drainage average to poor, slightly acid; annual rainfall >3000 mm
Loreto	Yurimaguas - Munichis road	Soils with varying texture (sand to clayey loam), drainage average to good, slightly acid; annual rainfall >2000 mm
Loreto	Yurimaguas - Tarapoto road	Soils with varying texture (sand to silty clay), drainage average to good, slightly acid; annual rainfall >2500 mm

[1]Peruvian political division ('región'), geographically equivalent to former department
[2]Project designation for each spatial-environmental grouping of blocks

Table 2. Priority tree species for agroforestry research and development in the Peruvian Amazon

Rank	Botanical name (common name)	Family	Principal products or services
1	*Bactris gasipaes* (pijuayo, peach palm)	Arecaceae	Food
2	*Cedrelinga catanaeformis* (tornillo)	Leguminosae	Timber
3	*Cedrela odorata* (cedro, Spanish cedar)	Meliaceae	Timber
4	*Inga edulis* (guaba)	Leguminosae	Shade, firewood, food
5	*Calycophyllum spruceanum* (capirona)	Rubiaceae	timber
6	*Guazuma crinita* (bolaina)	Sterculiaceae	Timber
7	*Mauritia flexuosa* (aguaje)	Arecaceae	Food
8	*Phytelephas macrocarpa* (yarina)	Arecaceae	Roofing material, food, 'vegetable ivory'
9	*Bertholettia excelsa* (castaña, Brazil-nut)	Lecythidaceae	food
10	*Poraqueiba sericea* (umarí)	Icacinaceae	Food
11	*Pouteria caimito* (caimito)	Sapotaceae	Food
12	*Tabebuia serratifolia* (tahuari)	Bignoniaceae	timber
13	*Spondias mombin* (ubos)	Anacardiaceae	food
14	*Ficus anthelmintica* (oje)	Moraceae	Medicine
15	*Sheelea scheelea* (shebon)	Arecaceae	Roofing material
16	*Euterpe precatoria* (huasaí)	Arecaceae	Food
17	*Pollalesta discolor* (yanavara)	Asteraceae	Firewood
18	*Croton matourensis* (ciprana)	Euphorbiaceae	Timber
19	*Caryodaphnopsis fosteri*, *Ocotea* spp (moena)	Lauraceae	Timber
20	*Lepidocaryum tessmannii* (iripay)	Arecaceae	Roofing material

Table 3. Principal characteristics of the selected priority species

Species	Principal characteristicss	
	Ecological	***Socioeconomic***
Bolaina blanca (*Guazuma crinita*)	Fast-growing pioneer species, demands relatively high pH, fertile soils, often found in alluvial zones	Can produce saleable timber in 6 years. Timber in high demand in Pucallpa (interiors), supplied from natural alluvial stands
Capirona (*Calycophyllum spruceanum*)	Slower-growing pioneer species, more tolerant than bolaina of flooding, predominantly riparian	Rotation >15 years, produces heavier timber, heavy demand locally and in Lima (e.g. cheap furniture)
Guaba (*Inga edulis*)	Semi-domesticate species, very plastic in terms of site requirements	Valued for several functions: shade around houses and in cacao plantations, N_2 fixer, firewood and (relatively low-grade) fruit
Peach palm (*Bactris gasipaes*)	Domesticate, generally occurring in home-gardens and swidden fields	'Ancestral' Amazonian tree crop and only domesticated neotropical palm. Nutritionally, fruit resembles a 'tree potato' (Clement et al., 2004). After cooking, it is consumed as a savoury. It can also be processed into a variety of products, including flour for infant formula and baked goods, cooking oil and animal feed (Mora-Urpi *et al*., 1997). Tree has many other uses. Current principal economic use is in the heart-of-palm agroindustry, strongest in Costa Rica, Ecuador and Brasil (Sao Paulo)

Table 4. Field activities implemented for four species in the ICRAF-INIEA agroforestry domestication programme in the Peruvian Amazon

	Bolaina	Capirona	Guaba	Peach-palm
Provenance testing	1	1	0	0
Participatory selection of mother-trees	1	1	1	1
Multiple-site progeny-testing	1	1	0	1
Testing of specific farmer hypotheses	0	1	1	0
Seedling seed orchards	1	1	0	1

Table 5. Farmer and institutional participation in activities and decisions of the ICRAF-INIEA domestication program in the Peruvian Amazon.

Activity / decision	Participation*	
	Farmer	ICRAF/INIEA
Past / present		
Selection of target species	1	1
Determination of selection criteria for mother-tree selection	1	1
Tree selection, seed collection	1	1
Seedling production	1	1
Experimental design	0	1
Site selection	1	1
Provision of experimental areas	1	0
Trial establishment	1	1
Daily / weekly monitoring	1	0
Monthly monitoring	1	1
Trial maintenance	1	1
Trial measurement	0	1
Statistical analysis and interpretation	0	1
Future		
Identification of thinning / roguing criteria	1	1
Thinning	1	1
Seed collection in orchards	1	1

* 1 = major participation; 0 = little or no participation