TOWARDS ESTABLISHING AGROFORESTRY RESEARCH PRIORITIES FOR CENTRAL AMAZONIA

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Outline

"Agroforestry is a new word for the old practice of growing woody plants with agricultural crops and/or livestock together on the same land" (Anon., 1982). Agroforestry can in a certain way be an "alternative" to deforestation, when it mimics the high biomass, permanent, dense root net, and permanent canopy of the forest.

The difficulty of defining priorities

Several hundred plant species, which can be combined in a multitude of ways, are of potential interest for agroforestry in Amazonia. As a consequence there are a great many options for research. For most species, little or no agronomic information is available, which increases the number of variables to be studied.

Research programs are necessarily limited in size. With trees this is much truer than with annual crops, as trees need large, long lasting field trials. If, for example, pejibaye palm (*Bactris gasipaes*) is planted at 5 x 5 meter, a recommended spacing for fruit production, and maize (*Zea mays*) at 0,8 x 0,3 meter, one pejibaye palm will occupy the same area as 104 maize plants. A maize trial is planted and harvested within half a year. Thus 15, or even 30, successive maize trials can be done in the same period required for a 15-year duration agroforestry trial.

As annual crop trials are renewed at least every year, it is possible to change lines of research within a short period of time, benefitting from newly acquired knowledge and insight. Agroforestry research decisions, on the contrary, have long lasting consequences as field trials have to be maintained for many years.

Shifting cultivation

New agricultural techniques are only of interest if they will be adopted by the farmers. The main agricultural activity in Central Amazonia is by smallholders. A smallholder is a Third World farmer, whose low income obliges him to produce for himself the main part of his needs (food, shelter, fuel). His farm consists of small fields with annual crops (roças) and in many cases a homegarden with different tree species. Most farms have fowl (chickens, ducks) and one or more pigs, and some have pasture and cattle. Smallholders are also engaged in fishing, hunting, and in the collection of forest products such as rubber and Brazil nuts. Originally, rubber tappers (seringueiros) were forbidden to practice agriculture. Today most seringueiros are farmers, smallholders, with forest rubber as their main source of cash (see, for instance, Anon. 1989).

The main annual crop is generally cassava (*Manihot esculenta*), whose meal (farinha) is the farmer's staple food and frequently his most important source of cash. Cassava is a crop with important advantages. It is an easy and never failing crop. Its tubers can be harvested for farinha preparation at any time of the year, once the plants are sufficiently mature. Farinha can be stored on-farm, and is an important traditional product with a stable, local market.

To establish a roça the forest is cut and burned. After one to three harvests the field is no longer productive and is left fallow or abandoned. Saldiarraga (1987) studied the recovery of soil and vegetation following shifting cultivation on Oxisols and Ultisols in the San Carlos region of the upper Rio Negro (Venezuela). After slash-and-burn agriculture 80 years without disturbance was not enough to completely rebuild the nutrient stocks to levels found in mature forest. According to Mutsaers (1981) stable shifting cultivation systems in tropical rain forest areas need at least a 15-year fallow period to accumulate sufficient fertility for a two-year cropping period. Shifting cultivation requires large areas of forest. The fundamental question is how to reduce the smallholder's need for new land, or, in other words, how to decrease his dependence on annual crops.

The "food forest": trees to substitute cassava as a subsistence crop

In 1977, at Brazilian's National Institute for Research of Amazonia (INPA) in Manaus, the concept of the "food forest" was conceived as an alternative to shifting cultivation and attendant problems (Arkcoll, 1982a, 1982b). The food forest should produce "all of a family's starch, most protein, vitamins and minerals from tree fruits and associated animals" (Clement, 1986); an 1-2 hectare mixture of food forest species should be sufficient for one family (Clement, 1989). Arkcoll (1982a) points out that tree fruits are the main starch source for human consumption in a few small parts of the world. He mentions, among others, breadfruit in the South Pacific (see also Purseglove, 1979) and pejibaye in some parts of Amazonia and Central America. Certain Indian tribes in the upper Amazon region of Brazil and Colombia make farinha from pejibaye fruit to replace cassava farinha (Arkcoll & Aguiar, 1984; Clement, 1988). Although neither Arkcoll & Aguiar (1984) nor Clement (1988) mention this explicitly, complete substitution of cassava farinha by pejibaye was apparently not encountered, as this would certainly have received special attention.

Arckoll (1982b) mentions for Manaus the following impressive production figures for potential food forest species: breadfruit (Artocarpus altilis), 600 kg/year/tree; jackfruit (*Artocarpus heterophyllus*), 1800 kg/year/tree; and pejibaye, 264 kg/year/clump . It seems obvious that these data are not mean values, but top yields. Besides, they refer to trees in backyard gardens, where availability of water and nutrients can be well above normal. Garden trees may also have a larger crown diameter and receive more light than plantation trees. All these factors can increase yields of single trees.

In the rainy season of 1978/79 a small food forest experiment was planted in Manaus, with pejibaye, jackfruit, and breadfruit (INPA, 1985; Clement, 1986). The initial production of pejibaye in the food forest trial was promising (INPA, 1985; Clement, 1986), but in later years pejibaye presented severe fruit abortion (Clement, 1990, pers. comm.; Arckoll, 1990, pers. comm.), causing the loss of 85-90% of the expected production in 1988 (Clement, 1989). Clement (1989) mentions also a 100% yield loss in one small area in Rondônia, caused by a seed borer. In traditional agriculture, which uses only 3-20 pejibaye plants/ha (Clement, 1989), serious fruit drop has not been encountered (Clement, 1990). Serious yield losses by fruit abortion, after initial years of good production, may be a general problem in Amazonia, if pejibaye is planted at normal plantation densities (Clement, 1990, pers. comm.). Sufficient information on the relation between production, age and density of pejibaye in Amazonia is not yet available.

Besides the question of appropriate species and husbandry, other, probably even more difficult, problems have also to be addressed. In Manaus pejibaye fruits from the end of December to March (Clement, 1990). The fruits are highly perishable and have to be transformed into farinha within a few days after harvest (Clement, 1989, pers. comm.). The labor consuming activity of farinha preparation will thus be concentrated in a part of the rainy season, when other farm tasks must also be executed. Will the introduction of such an important constraint on the labor calendar be acceptable? Will pejibaye farinha be accepted by the farmer as his new basic food? Changing food habits is not at all easy! What to do with excesses of pejibaye farinha? Can these be sold as easily as cassava farinha?

The food forest concept looks very attractive, but cannot be applied in Amazonia at the moment. It will probably take many years to develop adequate food forest technology. Once available, introduction of such technology will need a tremendous effort during a long period, as it implies a fundamental change in food habits and agricultural customs. The food forest constitutes a fascinating scientific challenge, but should not get high research priority.

Trees to substitute cassava as a cash crop

Cassava is often also the smallholder's most important cash crop. It will be a big step forward if trees could substitute cassava as such. The type of tree product will depend of the location.

Where access is very difficult and products have to reach markets over large distances by forest trail, only certain species are of interest. Transport by human beings or pack-animals makes it necessary to divide the produce in compact units. The product should store well on-farm and not deteriorate during transport. Examples are: Brazil nut (*Bertholletia excelsa*), cacao (*Theobroma cacao*) beans, and honey. These products can, of course, also be produced where access is easier.

Products with a larger unit volume, as timber and plantain (Musa cvs) bunches, can only be transported over larger distances if produced close to waterways or roads.

Certain perishable raw materials from trees can be transformed into storable products by special processing units. Such a unit will need a certain minimum supply of raw material, while the trees have to be sufficiently close. Among the products of this category are pejibaye palmheart, cupuaçu (*Theobroma grandiflorum*) fruit pulp, and oil palm (*Elaeis guineensis*) oil. Palmheart is storable after canning and pasteurization. A palmheart canning factory should produce at least 150 tons/year, which would require approximately 100 hectares of pejibaye (Clement, 1990, pers. comm.) at a special narrow palmheart production spacing (for example, 1,5 x 1,5m; Clement, 1989). Cupuaçu fruit pulp has a good national and international market. Within days after harvest the fruit has to be opened and the pulp separated from the seeds. This has to be done hygienically to avoid contamination of the pulp. The pulp is stored frozen. Oil palm bunches should be processed shortly after harvest (Purseglove, 1979). A modern power-operated oil mill, of the type used in Brazil, needs several thousands hectares of oil palm.

Close to urban centers the production of perishable fruit for the local market can be important. The largest city of Central Amazonia is Manaus; in its markets different types of locally grown, fresh fruit can be encountered. Among the species of interest are: citrus (*Citrus* spp.), mango (*Mangifera indica*), avocado (*Persea americana*), cupuaçu, papaya (*Carica papaya*), passion fruit (*Passiflora* edulis), and pineapple (*Ananas comosus*). Research and extension can contribute to the inclusion of new varieties and species in this category. The capacity of local markets is of course limited and it will normally not be economical to sell excess production elsewhere.

Crops can also be grown to substitute commodities which are otherwise bought. Smallholders often grow coffee (*Coffea arabica*), and in a lesser degree sugar cane (*Saccharum* cvs), for household use.

Presently, several of the above mentioned species are not very interesting for commercial planting. They were mentioned to illustrate how species choice will depend on farm location. Cacao, for instance, in Amazonia suffers from witches' broom (*Marasmius perniciosus*), and has had for several years a low market price. It is not good for a smallholder to depend on only one or two crops. The selection of new species to increase the number of options should be a high research priority. The main attention should go to species with products which store and transport well under relatively primitive circumstances, have a good price, and can do with little or no fertilizer. The development of village level technology of (pre)processing to obtain storable products can be decisive in determining success. Research results will also be of great interest for strengthening the economic basis of the extractive reserves (for details on extractive reserves see Fearnside, 1989).

Timber tree planting in flood plains

Planting trees for timber production is of interest in the flood plains (várzeas), where the commercial size trees of the economically interesting species are fast disappearing (Jansen & Alencar, in prep.; P. van Tommen, 1990, pers. comm.). Research on timber tree planting by farmers has not yet started, but deserves high priority. In the low water season várzeas are used for annual crops. Timber trees could be planted together with the annual crops for cheap and easy establishment. Proper techniques should be developed urgently. The farmer will only be interested in timber trees if his ownership is guaranteed and he can cut and sell the trees when he wants. Among the species which can be considered for planting in the várzeas are: sumaúma (*Ceiba pentandra*, Bombacaceae), andiroba (*Carapa guianensis*, Meliaceae), copaíba (*Copaifera* spp., Caesalpinaceae), cumaru (*Dipterex odorata*, Papilionaceae), jacareúba (*Calophyllum brasiliense* and *C.* spp., Guttiferae), macacarecuia (*Couroupita guianensis*, Lecythidaceae), muiratinga (*Maquira coriacea*, Moraceae), virola/ucuúba (*Virola surinamensis*, Myristicaceae) cedro, (*Cedrela odorata*, Meliaceae), and louro-inhamuí (*Ocotea cymbarum*, Lauraceae) (P. van Tommen, 1990, pers. comm.; Alencar, 1990, pers. comm.).

Study of homegardens

Systematic scientific interest in agroforestry began less than fifteen years ago, but the practice itself is very old and widespread. The study of existing agroforestry systems may save years of research. In Central Amazonia homegardens are an important traditional form of agroforestry (Saragoussi et al., in print). Guillaumet et al. (1990) describe three homegardens in different parts of Central Amazonia and found 35 to 39 different species per homegarden. Among broad-leaved trees grown in homegardens for fresh fruit are: citrus, cashew (Anacardium occidentale), soursop (Annona muricata), biribá (*Rollinia mucosa*), mango, avocado, abiu (*Pouteria caimito*), guava (*Psidium guayava*), cacao, cupuaçu, and Inga spp. Palms grown for fruit include: tucum (*Astrocaryum tucuma*), pejibaye, coconut (*Cocos nucifera*), açaí (*Euterpe oleracea*) and *Oenocarpus* spp. Among other species encountered are: banana (*Musa* cvs), pineapple, Brazil nut, Pará rubber (*Hevea brasiliensis*), annatto (*Bixa orellana*, food colorant) and coffee (Guillaumet et al., 1990; Saragoussi et al., in press; observations of the author). The study of homegardens can provide important information on production and management of these species and the system as a whole, and can assist in the design of agroforestry systems which take into account farmers' skills and knowledge. Homegardens are extremely complicated systems, internally not at all uniform, and with large differences between one another (Guillaumet et al., 1990; observations of the author). Homegarden research should not focus on the detailed description of the particularities of a certain case, but concentrate on aspects which have general application and which are needed for the design of improved systems. Homegarden studies oriented towards practical applications deserve high priority. Possible subjects are: transformation of roças into homegardens; farm nurseries; planting techniques (direct sowing, replanting of spontaneous occurring seedlings, planting methods); species combinations; intraspecific variability; sequential planting and gradual renewal (tree elimination techniques, pruning, thinning, use of shade); (organic) fertilizer use; pests and diseases; techniques to promote fruit set and diminish fruit abortion; harvest methods and tools; production levels in relation to shading and crowding; and variation in productivity between years.

Annual cropping and pastures

Sustainability of annual cropping might be increased by: an improved (and shorter) fallow period using fast growing, N-fixing species; alley farming (for details on alley farming see Kang et al., 1990) in combination with improved fallow; selection and use of shade-tolerant species and varieties (Mutsaers, 1981); and combination of cassava with a cover species which protects the soil against the direct impact of sun and rain and eventually also fixes nitrogen. The sustainability and quality of pasture might be improved by the use of woody, N-fixing species for soil fertility improvement, protein-rich fodder, fodder for the dry period, and shade. These forms of agricultural intensification are of more interest for areas with reduced land availability, such as the colonization areas of the agricultural frontier in the Amazonian states of Pará, Rondônia and Acre. It is here that they should be studied primarily. Once concrete technologies acceptable to the farmer are available, these can be adapted to other local conditions and tried there.

Research methodology

Trials should be designed and executed in close collaboration with farmers. Even after careful selection, numerous species and species combinations will be of potential interest. The traditional scientific approach is to choose one system and to study it in a replicated field experiment. In this way very few systems can be studied and large amounts of time and money may be invested in systems which later prove to be irrelevant. Researchers will often do better not to replicate, but to try as many different systems as possible.

A species combination proposed for experimentation will, among others, be based on expectations about its development in time. The research project should contain indications for its management (pruning, pollarding, thinning). In practice the experimental species combination may develop differently than expected, as the behavior of many species is largely unknown. If this occurs the trial management should not stick to fixed rules, but adapt to the new situation, for instance by deciding to cut a species which proves to be undesirable.

Final observation

Agroforestry can contribute to the solution of Amazonian land use problems. This is not only the opinion of some scientists, but also of officials of several development and donor agencies. Unfortunately it is often not realized that proven agroforestry technologies are almost inexistent. To develop such technologies a serious program of applied research is necessary with, for instance, many field trials, both on-farm and on-station, which will require relatively large areas of land and intensive accompaniment during long periods. The necessary funds and qualified manpower for that purpose are not available at the moment. As Nair (1989) stated recently: "Today's trend in agroforestry development represents an unhealthy imbalance of vast development projects with inadequately low levels of scientific investigations."

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[1] Clement (1986) contributes slightly different production figures to Arckoll, but refers to an article (Arckoll 1982a) which does not give any production data.
[2]For the same case Clement (1990) mentions 70-80%.

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