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Traditional taro monoculture in the swamp forest of Guadeloupe

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Photo 1.
Corms of *madère noir* taro.
Photo E. Saur.

After a presentation of taro (*Colocasia esculenta*) and the native swamp forest of Guadeloupe dominated by *Pterocarpus officinalis*, the authors describe the agrosystem and discuss tree-crop interactions. They conclude that the agrosystem is sustainable and profitable in terms of cropping and forest conservation. This social and agricultural heritage could enhance the prospects for flooded agriculture involving water-tolerant nitrogen-fixing tree associations.

Introduction

Agriculture in the West Indies diverged in two different directions during the European colonisation period. Export crops were developed on a large-scale, with few commercially interesting species such as sugarcane, coffee, cacao and spices. Food crop production emerged, by necessity influenced by African and later Indian traditions, involving imported and neotropical species and combining various traditional practices, including those implemented by Amerindians. The wide range of cultural backgrounds and environmental situations in the Caribbean islands gave rise to very diversified agricultural systems.

Swampy areas inhospitable for human activities have, whenever possible, been widely reclaimed for cattle grazing and export crop production, or otherwise devoted to resource extraction (wood, crabs, game). In Guadeloupe, where large areas of swamp forest have remained fairly undisturbed, the Creole community has in quite an original way developed flooded taro monocultures under the forest cover, thus giving rise to a remarkable agroforestry practice.

Taro (*Colocasia esculenta*) in Guadeloupe

Taro corms (photo 1) are used in traditional Creole cooking and consumed boiled like yams, sweet potatoes or bananas. Unrolled leaves (photo 2) are commonly cooked as a vegetable or served in a local soup called *calalu*. The local name is *madère* (*chou de Chine* or *dachine* in Martinique) and seven cultivars are known to grow in Guadeloupe (Risède, 1984).

Taro was clearly mentioned by Duss (1897), but probably introduced as a crop in Guadeloupe earlier in the colonial times. Du Terte (1667) mentioned "*fausse racine de Chine*" but did not provide enough details to definitely relate it to taro. Throughout history, cultivation knowledge seems to have been perpetuated via family traditions.

During the 20th century, interest in this crop dramatically decreased and total cultivated areas ranged from 500-600 ha in the 1950s, 150-250 ha in 1980 (Braux, 1981), to less then 100 ha today (personal data). Administrative authorisations for taro cultivation under the swamp forest just concerned 74.7 ha in 1999 (Office National des Forêts data).

Taro is grown in three types of farming systems in Guadeloupe, i.e. monocultures under swamp forest cover, homegardens and upland monocultures, but monocultures under swamp forest cover is the system that generates the highest total crop yield.

Monocultures under swamp forest cover

Flooded taro monocultures under the swamp forest is the most traditional system encountered in Guadeloupe. Local farmers consider that the peaty swamp forest soils are good for taro cropping (*terre à madère*) when the hydrological conditions are suitable.

Homegardens

Tropical homegardens consist of assemblies of plants, which may include trees, shrubs, vines and herbaceous plants adjacent to a homestead. These gardens are planted and maintained by members of the household and their products are intended primarily for household consumption. In Guadeloupe, this system, which is called *jardin créole*, averages 0.5 ha in area and contains up to 40 plant species overall. Taro is planted annually in shaded environments under the same conditions as *Xanthosoma sagittifolium,* another Araceae that is locally called *malanga*. Total area and yield are very difficult to evaluate for the whole island of Guadeloupe, but taro production in homegardens is certainly marginal in terms of quantities produced.

Upland monocultures

Locally, taro monocultures were established after clear-felling the native forest on the lower slopes of the Basse-Terre volcanic mountain range. The crop is planted once a year after tillage and includes fertilisation, weed control and pest management. Taro cropping units of several ha are collectively managed by smallholder farmers with intensification objectives. This relatively recent type of farming is presently limited in area, presumably well under 50 ha for the whole island of Guadeloupe.

The swamp forest

The swamp forest covers about 2 600 ha of coastal wetlands in Guadeloupe (Bonhême *et al.*, 1998; Imbert *et al.*, 2000), mostly along the landward edge of the mangrove forest where the soil is flooded by freshwater. *Pterocarpus officinalis* (photo 3) is the dominant tree species of the forest, forming a dense, almost evenly flat canopy.

Taro-*Pterocarpus* association

Cultivation practices

Traditional taro cultivation is conducted in the coastal swamp forest after partial clearing of the native forest (photos 4 and 5). Long-term clearing operations and control of the forest structure involve hand-cutting (young trees) and burning (larger ones) (photo 6). A study of this type of agroforestry system was conducted in Belle-Plaine area (Morne-à-l'Eau). Mapping of a taro cropping unit highlighted the spatial distribution of a few large *Pterocarpus* trees that were evenly distributed throughout the plantation (figure 1). On this site, some young *Pterocarpus* trees (1-2 m tall) were noted between taro plants, representing potential future trees. *Pterocarpus* tree densities (160 stems/ha) were far lower than those of the undisturbed forest, which meant that there was only partial shade at the soil level. On a broader scale, the cultivated forest areas appeared as a mosaic of taro cropping units intermingled with patches of forest cover. Such areas have been studied along four 5x100 m transects (Imbert *et al.*, 2003). Generally, the basal area and especially the stem density (GBH>10 cm) were lower in cultivated forests than in closed

Photo 3.
Pterocarpus officinalis buttress roots.
Photo E. Saur.

forests, and the number of vascular plants increased due to the establishment of light-demanding species (table I). The physical soil properties seemed to remain nearly unchanged under taro cropping conditions because there was very little tillage of the top peat layer. Farmers maintain natural drainage of the forest soil by cleaning the small streams. Investigation of seven sites over the November to April 2000 period (table II) revealed that the characteristics of the surface water feeding these crops spatiotemporally varied to a considerable extent, but this was compatible with healthy taro development.

The average taro plantation area is small (0.2–2 ha) and generally cultivated by one person. Nowadays, taro production provides a complementary source of cash income. The fieldwork is done mainly in the early morning for 2-3 h/day, when the temperature is reasonably low. Products are sold daily to retailers or directly through family markets. The farmer population is ageing (57 years-old, 1980), as youths have abandoned this activity because of the strenuous work required in muddy environments.

Two main cultivars (*madère* or *dachine noir* and *madère* or *dachine blanc*) are planted, and both are characterised by a brown colour patch in the middle of the lamina, brown petiole and dark-brown corms with white flesh. The flesh of *madère noir* turns purple-grey after cooking.

Harvest, plantation and weed control are generally completed in single manual operations distributed throughout the year depending on the market demand (photo 7). However, these activities are enhanced during the dry season when accessibility is better. When traditionally conducted, this crop requires no tillage, fertiliser or organic amendments, and no pest and disease control chemicals.

Offshoots from the main corm or cormels ensure propagation. The material is planted at 20-30 cm depth and planting density ranges from 10 000 to 30 000/ha. The crop cycle lasts for 6-12 months and the annual yield ranges from 5 to 30 t of corms per hectare. No major pest and disease problems affect swamp forest taro, in contrast to upland taro and *Xanthosoma* crops.

Photo 2.
Madère noir taro in flooded cropping conditions.
Photo E. Saur.

Photo 4.
Taro-*Pterocarpus* cropping unit in Guadeloupe with isolated trees.
Photo E. Saur.

Table I.
Mean structural characteristics of closed/cultivated swamp forests in the Belle-Paine sector (Morne-à-l'Eau, Guadeloupe).

Forest type	Number of trees (n/ha*)	Basal area (m^2/ha*)	Number of vascular plants (n/50 m^2)
Closed forest	2 400 (1 620)	51 (23)	16 (6)
Cultivated forest	338 (310)	31 (24)	22 (5)

Standard deviations are given in parenthesis
* Stems GBH > 10 cm

Table II.
Chemical characteristics of surface water in taro-*Pterocarpus* associations.

	Temperature (°C)	pH	Salinity (mg/l)	Conductivity (mS)	Dioxygen (% saturation)	Redox (mV)
Minimum	21.2	6.7	0.0	0.01	9	-145
Maximum	35.5	8.3	0.4	1.23	100	163
Mean	28.2	7.3	0.2	0.60	51	25

Table III.
Mineral contents of *Pterocarpus officinalis* tissues.

	N (g/kg)	P (g/kg)	K (g/kg)	Ca (g/kg)	Mg (g/kg)	Fe (g/kg)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	B (mg/kg)	Na (g/kg)
Leaf	33.6	1.4	10.9	16.3	5.1	0.1	5.4	29.4	116.7	90.7	0.5
Branch	8.5	1.0	3.8	12.7	1.9	0.2	3.8	8.3	23.5	10.5	1.9
Root	18.6	0.7	5.5	10.5	2.6	10.7	8.0	32.3	43.7	29.1	3.7
Nodule	48.8	3.0	7.2	8.9	4.2	4.1	7.0	27.0	24.1	32.1	4.5

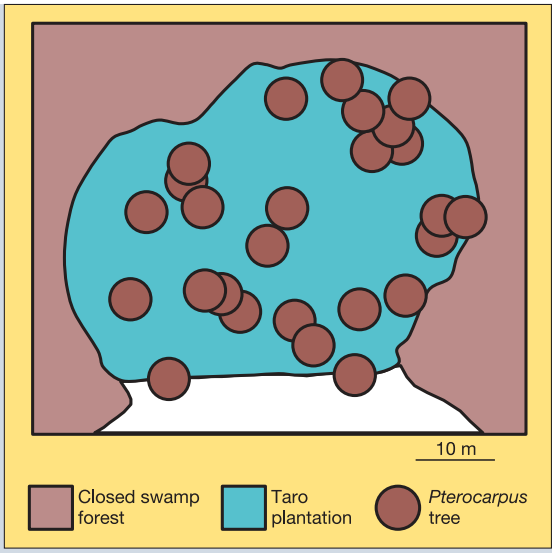

Figure 1.
Mapping of a 0.17 ha taro-*Pterocarpus* cropping unit in Belle-Paine (Morne-à-l'Eau, Guadeloupe).

Photo 5.
Taro-*Pterocarpus* cropping unit in Guadeloupe with aggregated trees.
Photo E. Saur.

Tree-crop interactions

Empirical practices of Guadeloupian farmers involve maintaining a suitable forest canopy opening so that the taro crops may benefit from optimum light interception. Competition for water is clearly not an important factor in this flooded environment. Tree vegetation is deliberately maintained at a certain level to benefit the crops, for many reasons, such as:

- to prevent excessive weed development and consequently reduce hand labour;
- to prevent excessive plant transpiration and dryness of the topsoil and allow cultivation, even during the dry season—taro is known to be very sensitive to water stress, especially the root system;
- to prevent excessive heating of the soil and surface water so as to limit the risk of corm rot before harvesting and taro dieback;
- to maintain soil fertility by continuous organic matter input. Fresh organic matter can enhance plant mineral nutrition during the soil mineralisation period when the soil is temporarily emerged. The high nitrogen content of *Pterocarpus* tissues (table III) offers some advantages with respect to nitrogen input at the stand level;
- to prevent hydraulic erosion and soil instability.

Pterocarpus buttresses and root system control hydraulic erosion of waterlogged peaty soils through mechanical stabilisation.

Discussion

Taro monocultures under native swamp forest cover could be considered as a traditional agrosystem developed locally in Guadeloupe, in contrast with other flooded taro cropping systems in other parts of the tropics (Wang, 1983).

Some physiological features of *Pterocarpus officinalis* and *Colocasia esculenta* species are presumably essential to the success of this wetland crop. Taro exhibits good tolerance to waterlogging and shade, contrary to several undesirable weeds and other tropical crops. *Pterocarpus* trees, which also tolerate flooding and waterlogging, very likely have a positive impact on the mineral budget (especially nitrogen) of the association through efficient symbiotic nitrogen-fixing (Saur *et al.*, 1998).

This 2-3 century old agrosystem ensures soil conservation and has a minimal impact on swamp forest vegetation, and should be regarded as sustainable and profitable in terms of crop production.

Moreover, we strongly believe that this system should be preserved as a social and agricultural heritage, and that it could enhance the prospects for flooded agriculture involving associations with flood-tolerant nitrogen-fixing trees.

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Photo 6.
Over-cleared *Pterocarpus* stand with visible hand-cutting and burning.
Photo E. Saur.

Photo 7.
Taro harvest and plantation, a single manual operation.
Photo E. Saur.