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Multipurpose shade trees in coffee and cocoa plantations in Côte d'Ivoire*

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Abstract. Coffee and cocoa are the main cash crops of Côte d'Ivoire. They are mainly produced by small farmers in a rather extensive way. The shade trees used are mostly wild forest species yielding many different products. In the Baoulé region, an inventory of those trees and their, often multiple, uses was established. Of the 41 tree species, 22 are used as firewood and 16 as timber for local constructions. Nineteen furnish pharmaceutical products for traditional medicine and 15 have edible parts (fruits, leaves, flowers, palm wine). Those products are essential in daily life and play an important role in the local economy. The plantations can therefore be considered as agroforestry systems. Part of the world-wide research on coffee and cocoa should be reoriented to such systems, adapted to small farmer holdings, where few inputs are available and conditions of production are less favourable.

Résumé. Le café et le cacao sont les biens d'exportation les plus importants de Côte d'Ivoire. Ils sont surtout produits de manière extensive dans des plantations villageoises. La majorité des arbres d'ombrage utilisés sont des espèces forestières sauvages. En plus de l'ombre, ils fournissent une multitude de produits. Dans deux villages de la région Baoulé, un inventaire de ces arbres et de leurs multiples utilisations a été établi. De l'ensemble des 41 arbres recensés, 22 servent comme bois de chauffe et 16 comme bois d'oeuvre, 19 sont utilisés dans la médecine traditionnelle et 15 fournissent des produits alimentaires (fruits, feuilles, fleurs, vin de palme). Ces produits sont indispensables dans la vie quotidienne et jouent un rôle important dans l'économie villageoise. Il est alors proposé de considérer les plantations de caféiers et de cacaoyers comme des systèmes agroforestiers et de réorienter une partie de la recherche effectuée partout dans le monde sur des systèmes de production adaptés aux petits cultivateurs qui produisent avec peu de moyens dans des conditions sub-optimales.

1. Introduction

Coffee and cocoa are the main cash crops of Côte d'Ivoire. In 1984–1985, on about 1.2 million ha, and 1.3 million ha, respectively, coffee and cocoa for a total of 317×10^9 CFA (about 750 million US$) were produced [MEF, 1988]. In the meantime, the gain from these crops has considerably dimin-

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ished due to the collapse of prices on the international stock market. This has affected not only governmental finances but also the budgets of tens of thousands of farmers, for whom coffee and cocoa are the main source of income.

In Côte d'Ivoire, coffee and cocoa are produced on small- and medium-size plantations, 95% of them ranging between 3 and 20 ha, with an average of 7 to 8 ha [Jarrige and Ruf, 1990]. Both crops are perfectly integrated into traditional agricultural systems (bush fallow system with two to three years of cultivation, followed by a fallow period of ideally 12–15 years). "The colonialist (. . .) has created monospecific fruit gardens. (He has) cut the forest, cleared the land, liberating the soil for the coffee plant, sometimes accompanied by shade trees. But the African, although forced labour had familiarised him with these 'superior' techniques, has resolutely decided to integrate coffee and cocoa into his agricultural system. The land is cleared for the main food crop, plantain, yams, rice, or less often cassava. Coffee is planted only after the food crop (. . .). Ivorian coffee and cocoa plantations have nothing spectacular, dispersed as they are (. . .), hidden by the cover of the forest, or resembling to underwood under the high crowns of the kapok or iroko trees, difficult to make out even from a low flying helicopter" (translated from Sawadogo [1977]).

Since Sawadogo's description, the situation has slowly been changing. 'Self shading' production systems for cocoa have been developed allowing for a more intensive production (in the following, the terms 'intensive' and 'extensive' are used with regard to the yield of coffee/cocoa per ha). Shade trees are being removed from the plantations to increase yields and intensify production. But the collapse of prices and the increasing concern about the ecological impacts of intensive agriculture have lead to the question, whether this development really lies in the interest for the Ivorian farmer and what its ecological consequences will be.

The present investigation shows that, when comparing extensive to intensive ways of production, other factors than just the yield of coffee and cocoa must be taken into consideration. It is based on several years of research on wild food plants in the Baoulé-region in central Côte d'Ivoire [Gautier-Béguin, 1992; Herzog, 1992; Herzog and Bachmann, 1992].

2. Materials and methods

In the south of the V-Baoulé, 12 coffee plantations in the village of Zougoussi and 18 cocoa plantations in the village of Bringakro were visited together with their owners, whom questions were asked about the plantations (size, yield, age) and about the shade trees (local names, uses, reasons why they were not eliminated). A sample of each tree species has been taken and identified at the 'Centre Suissee de Recherches Scientifiques' in Adiopodoumé.

3. Results and discussion

3.1. *The plantations*

Almost all cocoa plantations contain some coffee shrubs and vice versa. But in general, one of the two crops dominates. The characteristics of the plantations visited are resumed in Table 1.

Whereas on the coffee plantations in Zougoussi, the farmers hardly ever use external inputs, all cocoa plantations in Bringakro are treated more or less regularly against diseases and on five of them, fertilisers have been applied at least once. The mean yield of cocoa indicated with 400 kg/ha only refers to the main harvest. To obtain the total annual yield, the second (smaller) harvest, which makes up between a quarter and half of the main harvest, would have to be added.

Table 1. Characteristics of the 12 coffee and the 18 cocoa plantations visited.

	Coffee at Zougoussi		Cocoa at Bringakro	
	Mean	(min–max)	Mean	(min–max)
Age [a]	27	(20–40)	30	(15–40)
Surface [ha]	2.2	(1–3.5)	5.1	(1–14)
Yield [t/ha]	1.0	(0.3–1.8]	0.4	(0.05–1.0)
Shade trees [species/ha]	8.6	(4–14)	5.4	(0–13)

3.2. *Farmers' considerations concerning trees*

The trees found in the plantations are listed in Table 2. They are grouped according to the reasons why the farmers keep them. Obviously, shading is just one among other motivations to mix coffee and cocoa with other trees. Thus, quite a number of fruit trees were deliberately planted. The fruits are used for consumption or are sold on local markets. Although the farmers are conscious of the fact that those trees reduce the harvest of the main crop, they consider it more important to make use of the fruits. The commericialisation of cola nuts from *Cola nitida* for example can yield considerable amounts of money, the cola being very appreciated, especially by people from the north. This is why farmers plant cola trees, although, being of the same family of *Sterculiaceae*, they house the same parasites that also attack cocoa and can even develop allelopathic actions [SATMACI, 1984].

As for the planted trees, another five species of wild growing trees are left to grow in the plantations because the farmers are interested in obtaining their products, especially food and medicine. Again, they are ready to accept a reduction in the yield of coffee or cocoa for this.

All trees kept for shading are wild species from the original forest. They

Table 2. Tree species according to their overall frequency in coffee and cocoa plantations: scientific and local names, uses, frequency.

Scientific name	Baoulé name	Uses				Frequency [% of plantations]	
		W	M	F	C	Coffee	Cocoa
Planted trees							
Persea americana	avocat			*		42	67
Citrus reticulata	lomi-mandarine			*		17	78
Mangifera indica	amango			*		58	50
Citrus sinensis	lomi-orange			*		8	67
Cola nitida	wese	*	*	*		42	33
Cocos nucifera	kpako			*		25	0
Wild trees kept for their products							
Elaeis guineensis	me			*		83	100
Ricinodendron heudelotii ssp. heud.	akpi	*	*	*		50	28
Alstonia congensis	amie		*			8	6
Funtumia africana	potomo	*			*	0	6
Microdesmis puberula	floa		*			8	0
Wild trees kept for shading							
Antiaris welwitschii var. africanum	ofi tjendje	*			*	67	28
Spondias mombin	troma		*	*		67	11
Albizia adianthifolia	kpangban				*	42	0
Cola cordifolia	wale	*	*		*	8	17
Triplochiton scleroxylon	patabue	*	*	*	*	25	6
Anthocleista dialonensis	wowo niwo	*	*			17	6
Musanga cecropioides	adjoui	*				25	0
Spathodea campanulata	biebie srele	*	*			17	6
Sterculia tragacantha	koto tje		*			8	11
Ficus mucuso	logblo	*	*			8	6
Lannea acida	troma-ngban		*			17	0
Dialium guineense	moae	*		*	*	8	0
Diospyros mespiliformis	bla-ble	*		*	*	8	0
Morus mesozygia	agba fla tjetje	*	*		*	8	0
Terminalia superba	fla	*	*		*	8	0
Wild trees to big or not worthwile to be cut							
Ceiba pentandra	nie			*		83	56
Chlorophora excelsa	ago	*				58	28
Bombax buonopozense	puka		*	*		42	22
Dracaena manii	kissan kissan		*			42	6
Ficus exaspera	yengle	*	*			17	6
Celtis mildbraedii	assan	*			*	0	11
Cola gigantea	oale				*	17	0
Cordia senegalensis	ahounle	*			*	17	0
Blighia sapida	kaya	*	*		*	8	0
Bridelia ferruginea	gblo sea					8	0
Deinbollia pinnata	assia-bledi			*		8	0
Holarrhena floribunda	sebe	*			*	0	6
Hunteria eburnea	cacanu	*			*	8	0
Newbouldia laevis	tonzue	*	*		*	8	0
Pterygota macrocarpa	ofue wale					0	6

W: Fuelwood; M: Medicine; F: Food; C: Construction.
[% of plantations]: percentage of plantations on which a species was found.

have either not been cut when the plantation was installed, or they grew up together with the crop. There are fewer such trees in the cocoa plantations in Bringakro than in the coffee plantations. Although the motivation of the farmer lies in the shading aspect of those trees, they all yield one or several 'minor' products.

Quite a number of trees have been 'tolerated' in the plantations either because they were too big to be eliminated (*Bombax buonopozense, Ceiba pentandra, Chlorophora excelsa, Pterygota macrocarpa*) or because the farmer did not consider it important enough to cut them. Most of these species furnish secondary products, although not considered so important by the farmers.

Both tables show that there are generally fewer trees in the cocoa plantations of Bringakro than in the coffee plantations of Zougoussi. This is mainly due to the fact that an extension worker of the Ivorian agriculture extension service SATMACI (Société d'Assistance Technique pour la Modernisation de l'Agriculture en Côte d'Ivoire) resides in Bringakro. His task is to promote an intensification of coffee and cocoa production amongst the farmers, which goes together with a reduction of shading.

3.3. *Uses*

The four main products obtained from the trees listed in Table 2 are firewood, medicine, food and wood for construction. Almost all trees yield one or several of them.

3.3.1. *Fuelwood*

On village level, wood is the only source of energy. The wood of 54% of the tree species is used as firewood. Good quality firewood is very much appreciated. This is illustrated by the fact that the women carry heavy loads of it over long distances, although there may be wood available closer to the village, but which is of lesser quality.

3.3.2. *Medicine*

Leaves, bark, sap, wood or roots of 46% of the tree species are used as medicine. This is an important point and the impact of traditional medicine should not be underestimated. According to WHO, about 80% of the world's population essentially rely on traditional medicine and have hardly any access to modern western medicine [Fleuretin and Pelt, 1990]. This is also the case in Côte d'Ivoire [Ake Assi, 1983], pharmaceuticals being very expensive. Thus, two tree species have been kept on the plantations because of their effectiveness against malaria (*Alstonia congensis, Microdesmis puberula*).

3.3.3. *Food*

In addition to the fruits from the planted trees, another nine wild growing trees furnish edible products. Special attention is due to the oilpalm (*Elaeis guineensis*). As *Elaeis* originates from West Africa, wild palms grow spon-

taneously in the secondary forest. When a plantation is established, they are protected and allowed to develop. Their oil is preferred to the oil of modern cultivars because of its taste and consistency. Unrefined red palm oil is the food with the overall highest carotene (pro-vitamin A) content [Cottrell, 1991] and 5 g daily are enough to cover the Recommended Dietary Allowance (RDA) in vitamin A of an adult. Red palm oil is used in a number of appreciated and frequently prepared traditional dishes [Böni et al., 1994].

Another reason why oilpalms are held in such high esteem is their palm wine. When cut, the sap of the palm is collected and undergoes a short spontaneous fermentation. This results in a slightly alcoholic (3.0–5.7%), refreshing drink which is rich in vitamin C and several other vitamins and minerals. Nutritional studies in Zougoussi showed that the consumption of palm wine accounts for covering 8% of the populations RDA in energy, for 115% of RDA in vitamin C and for 17% of RDA in potash [Herzog et al., 1994a].

The leaves of the wild trees *Ceiba pentandra* and *Triplochiton scleroxylon*, as well as the fleshy bottoms of the flowers *Bombax buonopozense*, are used to make sticky sauces. Being used mostly in periods when other fresh vegetables are scarce, they contribute to food security [Herzog et al., 1993]. The fruits of *Rhicinodendron heudelotii* subsp. *heudelotii* are used for the preparation of a highly appreciated speciality dish. Dried fruits are sold on the markets throughout the year.

Fruits eaten raw, such as wild fruit from the trees of *Dialium guineense, Diospyros mespiliformis, Spondias mombin, Deinbollia pinnata* as well as the fruits from the planted trees, are frequently consumed and play an important role in varying the diet and as sources of vitamins and minerals [Herzog et al., 1994b].

3.3.4. *Construction and others*

The wood of 39% of the tree species present in the plantations is used for the construction of houses or fences or for the production of tools and domestic utensils. The wood of *Chlorophora excelsa*, although good for exportation, is too hard to be transformed locally.

Another plant worth mentioning is *Thaumatococcus daniellii*. This herbal plant covered at least part of the soil of most of the plantations visited. Its large leaves are collected by women and children to be sold on local markets, where they serve to wrap goods. The fruit of *Thaumatococcus* has a very sweet arillus that the children are fond of. The sweetness comes from a protein (thaumatine), which is 1600 times sweeter than sucrose [Franke, 1981]. Thaumatine is applied in the food and animal feeding industry, where it is used as a sweetener. For this purpose the fruits are collected in certain regions of Côte d'Ivoire by a British company and exported.

4. Conclusions and outlook

The plantations visited and described above can be considered as agroforestry systems consisting of a main crop and of a variety of multipurpose shade trees yielding 'minor' or 'secondary' products. They correspond to the definition for the 'plantation crop combination' type of an agroforestry system: 'Shade trees for plantation crops, shade trees scattered' [Nair, 1989].

But are those products really 'minor'? The farmers clearly attach importance not only to the cash crop but also to the products of the forest trees. This has also been observed in other regions of Côte d'Ivoire [De Rouw, 1987; Lecomte, 1990]. For all of West Africa, the huge variety of 'secondary' forest products and the important place they occupy in daily life in rural areas has been demonstrated in a recent FAO publication [Falconer, 1990].

The farmer producing on a low level of intensity has two options. He can continue the same way, using hardly any external inputs, obtaining a modest but rather regular yield of coffee or cocoa and in addition a number of 'minor' forest products that he can collect right on his plantation. Or he can intensify coffee and cocoa production by eliminating the shade trees and applying fertilisers and pesticides.

Which way of production is more profitable on medium or long term is an open question. To look only at the gain from the main crop (coffee, cocoa), as is usually done, is clearly insufficient. The results presented here show that the 'minor' products must also be considered, whether they are sold on local markets or serve for self-consumption. The value of the latter is difficult to assess in terms of money, but this does not make them less important to their user.

A number of farmers say that on the plantation, they want to produce coffee and cocoa and that they can get the other products from the forest. It needs to be mentioned here that, while men are responsible for the plantations, gathering is part of the women's obligations. They will have to spend additional time and energy in searching for those products, as non-utilised forest will become scarce due to the growth of the population and the extension of cash crop production. This may even lead to a shortage of those products, as is already the case in certain regions in Côte d'Ivoire, where villagers complain about the difficulty of obtaining them.

Two other points also need to be considered. One is risk management and the other is ecological impacts. Firstly, producing on a high level of intensity with a monoculture type of plantation is more risky for the farmer and especially for small farmers who hardly have any financial resources. While shade trees have an equalising effect, intensified plantations are more difficult to manage and over the years their yield shows greater variations. Working on a credit basis to buy the indispensable external inputs to obtain an uncertain harvest has proved very risky, not only in Côte d'Ivoire, and comes close to pure speculation.

In Bringakro, farmers are encouraged by the extension service to elimi-

nate shade trees in order to intensify cocoa production. Unfortunately, many of the plantations visited, where this measure had been taken, were in very bad condition. When shade is removed, pest attacks increase. Also, the additional light stimulates the trees' metabolism. This results in faster growth and higher fruit production rates. But to allow for sustainable higher production, pesticides and additional fertiliser must be applied. If this is not done, as on most Bringakro plantations, cocoa trees tend to exhaust faster and may die within a short period [Wessel, 1985].

Secondly, ecological considerations are gaining in importance. One could imagine it beneficial to the environment to produce cash crops on as little surface as possible in an intensive way, thus preserving as many forest areas as possible. But at a closer look, this becomes less desirable and seems hardly realistic. Firstly, because it would change the structure of production. Today production is in the hands of many small- and medium-size farmers. This has resulted in a relatively wide distribution of the gain from coffee and cocoa. If production is intensified on a large scale, it would shift to the control of fewer, better educated farmers who dispose of the means to carry the risks of production and who have the know-how to manage intensified plantations. Secondly, because it would be an illusion to believe that the forest not occupied by those plantations, would not be touched and used for other purposes by the villagers who, after all, are the owners of their land (at least according to the traditional law system). Or would one imagine a kind of remuneration for fallow land as it is applied in some industrialised countries? Who would pay for this and how would it be implemented?

The claim of Hoekstra [1987] appears thus fully justified, that at least some of the world-wide research on coffee and cocoa should be reoriented to production systems that are adapted to small farmers holdings. Such production systems could be based on today's 'extensive' plantations. It would certainly be worth-while examining them more closely by taking into account *all* products they furnish, risk management and environmental considerations. In a second step, they could be optimised (instead of maximised). To do so, a close investigation of the interaction between multipurpose shade trees and cash crop should be undertaken (concurrence, phytopathological problems, allelopathic effects, benefits by leguminous trees). Such systems may prove to be more sustainable and fulfil the farmers' needs more adequately than intensified systems.

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