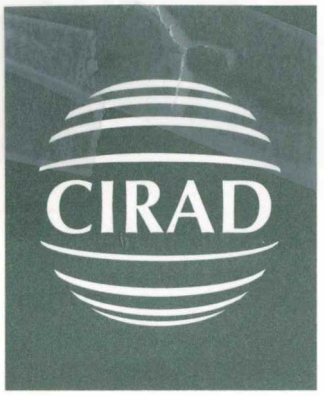
Documents de travail en économie des filières
N° 31



The diffusion and impact of cocoa research themes in Ghana and Côte d'Ivoire

E. Hanak Freud, Ph. Petithuguenin, J. Richard

Centre de coopération internationale
en recherche agronomique pour le développement

Unité de recherche économie des filières
Documents de travail en économie des filières
N° 31 - Mars 1997

The diffusion and impact of cocoa research themes in Ghana and Côte d'Ivoire

E. Hanak Freud, Ph. Petithuguenin*, J. Richard

Communication présentée au Symposium international :
12th International Cocoa Research Conference
Salavador-Bahia, Brazil, 17-23 November 1996

* Present address : Proyecto Cacao, Edificio MAG Piso 22,
Avenidas Quito y Padre Solano, Guayaquil, ECUADOR

Centre de coopération internationale
en recherche agronomique pour le développement

CONTENTS

ABSTRACT

This paper reexamines the record on the diffusion of innovations in cocoa farming and their impact on yields in these two major producing countries of West Africa. Their cocoa farming systems have a great deal of similarity in terms of social organization and agro-ecological conditions of production, and yet a quite different history of incentive structures in the post-Independence period. The received wisdom in the cocoa profession is that these systems are in general very extensive, with very limited adoption of research recommendations. Hypotheses vary as to the reasons (poorer husbandry, older trees, disproportionate incidence of cocoa swollen-shoot-virus disease) but converge on the conclusion that Ghanaian farms have even lower yields than their Ivorian counterparts.

The data base for the analysis is drawn from parallel surveys of 356 cocoa farmers across Ghana and 482 in Côte d'Ivoire in late 1994, covering agronomic and labor management practices at the plot level and socio-economic conditions of the household. The paper summarizes the survey results concerning adoption patterns for individual components of the "package" of research recommendations : seed type, planting methods, shade, application of chemical inputs, and husbandry. To provide a cumulative indicator of adoption, a simplified typology is developed measuring gradients of intensification in the establishment and maintenance phases. The socio-economic determinants of adoption, including contacts with extension services, are examined briefly. The impact on yields, based on declared area and output in two crop years, is examined via mean-variance analysis of yield levels according to the intensification typology, and via multiple regression analysis using a semi-logarithmic specification.

The results suggest that, contrary to various pessimistic hypotheses concerning agronomic practices in these cocoa systems, partial intensification is fairly widespread, even though adoption of the complete package recommended by research is virtually nil. Nor do the systems appear blocked by the rarefaction of forest reserves. Contact with extension significantly raises the probability of adoption of recommended planting techniques in both countries, but only in Ghana is it associated with a higher likelihood to use pesticides. For this latter innovation, scale and migrant status appear more important. Not all innovations register the anticipated yield gains: in particular, while anti-capsid treatments are unambiguously positive, intensive planting methods only register a favorable impact on yields in those regions of Côte d'Ivoire subject to greater environmental stress, and varietal choice does not appear to have a significant impact under farmer conditions in either country. The prevalent "no shade" method of growing cocoa under full exposure in Côte d'Ivoire significantly raises yields. Overall, the survey confirms a yield handicap of roughly 150 kg/ha in Ghana versus Côte d'Ivoire. Based on these findings, the paper concludes with some inferences concerning the sources of divergence in average yield levels between Ghana and Côte d'Ivoire, and more generally, with some questions for cocoa research and extension in the region.

***Key words**: innovation, adoption rates, typology, extension*

RESUME

Cette communication revient sur le succès de la diffusion des innovations dans l'agriculture paysanne cacaoyère et son impact sur les rendements des deux principaux producteurs de l'Afrique de l'Ouest. Les systèmes de production présentent de nombreuses similitudes en termes d'organisation sociale et de conditions agro-écologiques de production, mais l'histoire post-coloniale des structures incitatives vis-à-vis de la culture est différente.

L'idée reçue de la profession est que ces systèmes sont généralement très extensifs et l'adoption des recommandations de la recherche y est très limitée. Les hypothèses évoquées varient autant que les raisons (mauvaise gestion des exploitations, vieillesse des vergers, effets surestimés de la maladie du Swollen-Shoot au Ghana), mais toutes s'accordent pour conclure sur le fait que les rendements des plantations ghanéennes sont plus faibles que ceux de Côte d'Ivoire. Les données de l'analyse sont extraites de deux enquêtes menées parallèlement au Ghana et en Côte d'Ivoire, sur respectivement 356 et 482 planteurs, à la fin de l'année 1994. Ces données concernent les pratiques agricoles et la gestion de la force de travail au niveau de la parcelle, et les conditions socio-économiques de la conduite de l'exploitation. La communication résume les résultats concernant l'adoption des itinéraires techniques préconisés par la recherche : types de semences, modes de mise en place, ombrage, application des intrants chimiques et conduite de la plantation. Pour obtenir des indicateurs d'adoption, on a mis sur pied une typologie simple qui mesure des degrés d'intensification dans les phases d'installation et d'entretien de la plantation. L'impact sur les rendements basés sur les superficies déclarées et les productions de deux campagnes, est examiné à travers une analyse de variance des niveaux de rendements selon notre typologie de l'intensification, et à travers une analyse de régressions multiples utilisant une spécification semi-logarithmique.

Les résultats suggèrent que, contrairement aux nombreuses hypothèses pessimistes émises sur les pratiques agronomiques de ces systèmes de production cacaoyers, une intensification partielle existe bel et bien, même si l'adoption complète de l'ensemble des recommandations de la recherche est quasiment nul. De même, les deux systèmes n'apparaissent pas bloqués par la raréfaction des réserves forestières. Les relations des planteurs avec les services de vulgarisation élèvent significativement, dans les deux pays, la probabilité d'adoption des techniques de mise en place recommandées, mais ce n'est qu'au Ghana qu'on peut leur associer une plus forte utilisation des pesticides. En ce qui concerne cette dernière pratique, la taille de l'exploitation et le statut de migrant de l'exploitant semblent plus importants. Toutes les innovations n'enregistrent pas les gains de productivité attendus : en particulier, si les traitements anti-capsides sont partout bénéfiques, les modes intensifs de mise en place n'apparaissent positifs que dans les zones de Côte d'Ivoire affectées par la sècheresse, et les choix variétaux ne paraissent pas avoir de signification particulière dans l'un ou l'autre des deux pays, dans les conditions d'agriculture villageoise. La prédominance en Côte d'Ivoire de la plantation sans ombrage élève significativement les rendements. Par ailleurs, les enquêtes confirment les faibles rendements de la cacaoyère ghanéenne inférieure de 150 kg à ceux de Côte d'Ivoire. A partir de ces résultats, la communication conclut sur les causes des différences de niveaux de rendements et, plus généralement, sur quelques questions à la recherche cacaoyère et sa vulgarisation dans la région.

***Mots clés** : innovation, taux d'adoption, typologie, vulgarisation*

1. INTRODUCTION

With an annual production of roughly 900,0000 t and 300,000 t respectively, Côte d'Ivoire and Ghana account for over 40% of world supply. In these two countries, cocoa production is a smallholder cash crop and the cocoa production systems are often likened to systems of hunting and gathering (*"culture de cueillette"*), on the grounds that they are barely less extensive. In fact, both casual observation and more localized studies suggest that adoption rates for the intensive package recommended by research are low, and the industry estimates yields well below the 2 to 3 t/ha obtained on experimental stations. But is this statement confirmed on a wider, national, scale ? What are the real levels of adoption ? How low are yields at smallholder level ? How much are these yields improved by the adoption of technical recommendations ?

The purpose of this communication is to contribute to answering the various questions raised above, using information from a research project examining the competitiveness of West African cocoa in comparison to new producing regions in South-East Asia (especially Indonesia). One component of this project, launched in 1993 by CIRAD in cooperation with various institutions in producing countries, focuses on cocoa production systems in Côte d'Ivoire and Ghana. The information presented will also be useful to researchers interested in comparing cocoa producing countries in general, and Côte d'Ivoire and Ghana in particular, as to their assets and perspectives in cocoa production (Ruf, 1993 ; Nyanteng, 1995).

Other components of this study, notably socio-economic factors affecting the adoption of innovations by cocoa farmers, and recent dynamics of new planting have been presented elsewhere (Hanak Freud et al, 1996).

2. MATERIALS AND METHODS

For this study, 482 cocoa farmers from 20 villages in Eastern, Centre-West and South-West regions of Côte d' Ivoire and 356 cocoa farmers from 13 villages in Eastern, Ashanti and Western regions of Ghana were surveyed in late 1994, on a parallel basis. The survey was

particularly concerned with the agronomic and labor management practices of cocoa plots and the socio-economic conditions of the household.

Data were analyzed first with a program developed by CIRAD for agro-socio-economic surveys (named LISA), and work was completed by multiple regression analyses using SPSS software.

It must be underlined at this stage that two factors in the methodology ask for prudence in the interpretation of our results :

• the survey was only carried out in known villages accessible by road ; we were therefore unlikely to interview cocoa farmers who had very recently planted in the forest, at the edge of the remaining agricultural "frontier", where villages and roads are not yet established (essentially in the western zones of both countries).

• yields per cocoa farm were not actually measured but calculated from farmer's declarations on farm surface and output.

3. SOME BACKGROUND TO THE CROSS-COUNTRY COMPARISONS

In both countries, cocoa cultivation began in the eastern regions, and expanded westward in waves of migrant farmers. Farmers today typically own several cocoa plots, and labor hiring is also frequent : over 40% of households use sharecroppers and only 1/4 of Ghanaian and 1/3 of Ivorian households surveyed use only family labor. An overwhelming majority (90%) of cocoa farmers consider cocoa as their first source of agricultural revenue, with coffee taking an important second place in eastern and central Côte d'Ivoire. Food crop sales are the only agricultural alternative in Ghana, but a higher proportion of farmers there (10% versus 3%) declare non-agricultural sources of revenue to be more important than cocoa. Ivorian farms are somewhat larger (see Table 1), and the ratio of the household labor force to farmland is somewhat lower (roughly 2 ha cultivated/active person vs. 1.5 ha in Ghana). Ghanaian heads of household are slightly older (54 years versus 47 on average).

From an agro-ecological point of view, the only major difference is the disproportionate impact of the Cocoa Swollen Shoot Virus Disease (CSSVD), detected in Ghana in the late 1930s and soon afterwards in Côte d'Ivoire. In Ghana the virus caused, directly or indirectly, major losses over the following two decades, whereas its impact in Côte d'Ivoire was (and still is) insignificant. Average national yield per hectare is considered to be lower in Ghana than in Côte d'Ivoire, although hypotheses vary as to the reasons (CSSVD, poorer husbandry, older trees), consideration confirmed by our survey with national averages of 240 kg/ha in Ghana and 380 kg/ha in Côte d'Ivoire (values close to the official figures).

Table 1 : Average sizes and uses of cocoa farmers' land holdings (ha)

Country	GHANA			CÔTE D'IVOIRE		
Region / Land use :	Eastern	Ashanti	Western	East	Centre-West	South-West
Cocoa : Total	3,4	6,1	5,1	6,7	7,2	6,1
< 5 years old	0,5	0,6	1,1	1,4	0,4	1,1
≥ 5 years old	2,9	5,5	4	5,3	6,8	5
Other crops	2,1	2	1	6,5	3	2,3
Land reserves	1,9	4,4	3,5	6,6	7,4	5
Total land per household	7,4	12,5	9,6	19,8	17,6	13,4

Agricultural services have also been quite similar in nature, consisting of seed distribution, extension advice, and, at various times, incentive-oriented policies including subsidies for chemicals and equipment, and bonuses for planting or rehabilitation. The overwhelming difference in policies concerns levels of farmgate prices. For the 30 years preceding the 1994/95 season, fiscal and exchange rate policies combined to produce a situation where Ghanaian farmers received a lower real price than their neighbors. The consequences for output have been commensurate. Ghanaian production followed a downward trend from the mid 1960s to the early 1980s, while production in Côte d'Ivoire soared from less than 200.000 t in 1970 to 840.000 t in 1989 ! The past ten years have seen some improvement in Ghana's case,

following macro-economic reform. Since 1989, production in both countries seemed to stagnate, but has it increased again recently in Côte d'Ivoire.

4. COMPARISON OF ESTABLISHMENT AND MAINTENANCE PRACTICES: LEVELS OF ADOPTION OF RECOMMENDED TECHNOLOGIES

The basic "package" of recommendations concerns the establishment phase (when cocoa is generally grown in association with various food crops, especially plantain) and annual care of the adult cocoa farms, and post harvest handling, which affects bean quality. The survey did not focus on the latter techniques, since cocoa quality is high by world standards.

The principal recommendations for the establishment phase concern varieties, planting methods, and shade levels, aimed at increasing productivity and precocity. For seeds, the innovation has been to switch from the original "Amelonado" type towards varieties selected for higher yields, precocity, and better tolerance against CSSVD (in Ghana). Selected Upper Amazonian strains began to be released in Ghana in the 1950s, and hybrid varieties (generally crosses between selected Amelonado and selected Upper Amazonian clones) in both countries in the 1960s.

Table 2 shows that adoption rates of certified seed are not high, but their descendants have been widely used, with the result that only 1/4 of current area in Côte d'Ivoire is planted to Amelonado alone or as the dominant type in mixtures, and just over 14% in Ghana.

TABLE 2 : TYPES OF COCOA CULTIVARS USED (% of total cocoa area).

COUNTRY	COTE D'IVOIRE				GHANA	
REGION	East	Centre-West	South-West	National average	National average	SEED TYPES
Amelonado	21,8	27,9	22,1	25,1	14,1	Amelonado
Progenies from selected trees *	59,7	56,7	72,3	62,1	12,1	Selected Amazon
					47,9	Progenies from selected Amazon trees
					11,6	Progenies from hybrid trees
Hybrid	18,6	15,5	5,6	12,8	14,4	Hybrid

* For new plantings, Ivorian farmers use seeds coming from pods harvested on selected trees, being hybrids or Upper Amazonians, in their own farm or in their neighbors' and often as far as Ghana
NB : In all cases, the % includes plots seeded with a single variety or with that variety as a dominant in a mixture.

Planting methods for cocoa run from direct seeding, generally at densities well above recommended levels, to the considerably more labor-intensive transplanting of seedlings, either in bare earth or polybags. For both yield and precocity, research recommends the polybag system, followed by the bare earth transplants (in Ghana), followed by direct seeding at recommended spacing. Transplanting with polybags considerably reduces losses of young cocoa in harsh environments. The rates of adoption for the recommended techniques are far higher in Côte D'Ivoire, with over 1/2 of the plots at least partly transplanted, and nearly 1/4 with the polybag method. In Ghana, 3/4 were seeded directly, and only 15% transplanted with polybags. In both cases, there is some association between the use of transplantation and less favorable environments (less favorable precedent, like old coffee farm, or regions where establishment is impeded by a long dry season).

Shade relates to the density of forest trees left (or planted) in the plots to protect adult cocoa trees. Recommendations have changed over time, and differ between the two countries. In Ghana, the earlier view that cocoa thrives best under heavy shade gave way in the post-war period to a prescription of mild shade, for both yield levels and precocity. Nowadays, the Cocoa

Research Institute of Ghana (CRIG) recommends reducing overhead shade down to a maximum of 4 large trees per acre. In Côte D'Ivoire no-shade systems were developed in the early seventies by migrant farmers (especially in the Centre-West region) and were studied at the same time by the Institut de Recherche Cafe Cacao (IRCC-Côte D'Ivoire), leading to the prescription of no shade at all, *as long as cocoa is grown with fertilizers.* This difference between the two countries is reflected in the present situation of permanent shade in cocoa farms (Table 3). While "mild shade" represents the norm (over half the area) in both countries, it is an innovation in Ghana (where heavy shade still accounts for nearly 30% of total area), and the older practice in Côte D'Ivoire (where "no shade" comprises nearly 40% of total area). In Ghana, no shade situations have also increased, but more timidly, and generally in association with a non-forest precedent rather than as a result of deliberate removal of shade trees.

TABLE 3 : LEVELS OF PERMANENT SHADE IN COCOA PLANTATIONS
(% of total cocoa acreage actually harvested).

Country	GHANA			CÔTE D'IVOIRE		
Region	Eastern	Ashanti	Western	East	Centre-West	South-West
No shade	10,7	2,5	16,9	14,9	34,1	56,6
Mild shade	57,5	59,6	58,6	75,7	43,8	40,2
Heavy shade	31,8	37,9	24,5	9,4	12,1	3,2

Fertilizer applications are rare at all shade levels in Côte d'Ivoire (where only 10% of farmers have tried fertilizers once or more) and practically nonexistent in Ghana (2% of farmers). Although part of the maintenance package for adult cocoa in full exposure, fertilizers have not been a major focus of diffusion efforts (especially in Côte d'Ivoire). Fungicide treatments against the mild strain of black pod (*Phytophthora palmivora*) are virtually absent from farmer practices too. (The survey did not cover the areas in Ghana--still marginal--where the more virulent *Phytophthora megakarya* has been making inroads for few years, and for which treatment issues are quite different).

By contrast, insecticide treatments against capsids (mirids), which defoliate cocoa trees, have been considered a central element of the package in both countries and have been fairly

widely adopted (see Table 4). In 1994, roughly half of the farmers treated against capsids, but well below the recommended 4 times per year, with most Ghanaians treating once, and most Ivorians twice. Of the non-adopters, roughly a quarter had never treated, and most of the remaining quarter had abandoned treatment in the wake of recent price events : in Ghana, the temporary removal of input subsidies in 1990, and in Côte d'Ivoire, the halving of the producer price in that year and the near doubling of input prices in early 1994 with the devaluation of the CFA franc.

TABLE 4 : CAPSID CONTROL: NUMBER OF INSECTICIDE APPLICATIONS IN 1994
(% of total cocoa area over 4 years old)

Number of insecticide applications in 1994	COTE D'IVOIRE	GHANA
No treatment	33,8	49,8
1 application	20,5	27,1
2 applications	33,1	16,7
3 applications	10,8	6,1
4 applications and over	1,8	0,3

The rest of the maintenance package consists of labor-based tasks : weeding, pruning, removal of parasitic plants, filling in gaps left by dead trees. The available indicators suggest roughly similar overall patterns, perhaps with a slight edge in Côte d'Ivoire. Two weedings per year is the norm in both countries (just over 1/2 of the surveyed plots), but a higher share of Ivorian plots fall above that value (36% versus 23% in Ghana). The majority of farmers indicate that they fill in holes with seedlings where needed. Almost all farmers indicate that they do some pruning (removing suckers, most often at the time of weeding), though few possess pruning shears (10% in Côte d'Ivoire, next to none in Ghana). A similar proportion (20%) own or borrow the specialized knives for cutting mistletoe, and roughly the same number (12-14%) indicate this as their major problem. Yet indirect evidence suggests that Ivorian farmers may do more maintenance, as they appear to spend more time in the field : owner visits of plots managed by sharecroppers are five times more frequent than in Ghana.

To go beyond these individual practices to a cumulative indicator of adoption, we constructed a simplified typology, measuring gradients of intensification (as evaluated by the adoption of high input technologies) in the establishment phase by planting method and seed type, and in the maintenance phase by the number of anti-capsid treatments. Five basic categories of conduct may be determined thus, moving from extensive modes in both phases (class 1A) to the most intensive (class 4). Using this typology, Table 5 shows the distribution of adult cocoa plots and, in parentheses, farm households, classified according to their "best" plot.

It appears that there is roughly a similar share of farmers who treat against capsids (classes 2, 3, and 4) in the two countries and a higher rate of transplanting in Côte d'Ivoire (classes 1B, 3, and 4). In Ghana, those who do transplant have a stronger tendency to associate intensive maintenance (only 1/3 of transplanted plots fall into class 1B, versus nearly 2/3 in Côte d'Ivoire). Overall, more than 1/2 of farmers in Ghana and 3/4 of those in Côte d'Ivoire show some signs of intensification in relation to the package, even if the small numbers in class 4 (itself less stringent than the full package of recommendations) suggest that the whole "package" is hardly ever adopted.

A study of the socio-economic determinants of adoption of recommended technologies, as seen through this survey, has shown that while schooling level doesn't have a marked influence, contact with extension services, migrant status and total size of farm holding are positively linked with higher levels of adoption, and that the influence of the age of the head of household was inconsistent (Hanak Freud et al, 1996).

TABLE 5 : DISTRIBUTION OF MATURE COCOA PLOTS ACCORDING TO AN INTENSIFICATION TYPOLOGY (in brackets, classification of households) .

Maintenance level	Establishment method		
	DIRECT SEEDING, uncertified seed	TRANSPLANTING	
		BARE EARTH METHOD, any seed (no amelonado in class 3)	POLYBAG METHOD, certified seed only
No treatments against capsids	***CLASS 1A:*** GHANA : 44% (43%), COTE D'IVOIRE : 23% (20%)	***CLASS 1B:*** GHANA : 7% (9%) COTE D'IVOIRE : 32% (34%)	
At least 1 insecticide application	***CLASS 2:*** GHANA : 35% (32%) COTE D'IVOIRE : 22% (21%)	***CLASS 3:*** GHANA : 10% (11%) COTE D'IVOIRE : 20% (20%)	
At least 2 insecticide applications			***CLASS 4:*** GHANA : 5% (5%), COTE D'IVOIRE : 3% (4%)

5. THE IMPACT OF ADOPTED TECHNOLOGIES ON YIELDS

The innovations constituting the "package" are all intended to raise yields, but they also imply additional costs, as is the case with chemical treatments (essentially a cash cost) or with transplanting (which adds to the labor cost). The survey permits the evaluation of cocoa yields in 1992/93 and 1993/94 (on the basis of declared area and output) and the determinants of this productivity indicator may be examined.

A simple way of looking at the cumulative impact of intensification is by comparing average yields of adult cocoa according to the typology developed above (Table 6). For Ghana, where the absence of regional differences permits the presentation of only national averages, there

is a clear effect of treatments under extensive planting (gain of over 60 kg moving from class 1A to 2), but an apparent drop when moving to more intensive planting (class 1A to 1B), subsequently recouped under the combined package (classes 3 and 4). In Côte d'Ivoire, there is a large yield gain with capsid treatment under extensive planting in all three regions (+ 100 to 150 kg/ha), and an increase of 60-70 kg/ha with intensive planting in the two drier regions (East and especially Centre-West), where this practice is quite frequent. There is, however, a fall in yield with intensive planting in the South-West, and, apart from a small number of farms in the East, hardly any additional yield gains when passing from class 2 to the most intensive classes. National and regional average yields are generally higher in Côte d'Ivoire at every level of intensity, the exception being the most extensive level in the Centre-West, a small fraction (8%) of the total Ivorian cocoa area.

TABLE 6 : AVERAGE YIELDS (KG/HA) OF ADULT COCOA FARMS ACCORDING TO THE INTENSIFICATION TYPOLOGY (in brackets, average values based on less than 10 individual data)

Country	COTE D'IVOIRE				GHANA
Region	East	Centre-W	South-W	National average	National average
Class 1A	377	164	361	332	219
Class 1B	402	223	389	349	169
Class 2	(546)	320	496	494	274
Class 3	(675)	318	509	435	353
Class 4		(344)	(678)	468	368

NB : Average of 1993 and 1994 yields ; all farms over 4 years old , except farms without production - sign of no harvest

Multiple regression analysis, using a semi-logarithmic specification, was used to examine this difference in yields between Côte d'Ivoire and Ghana for a similar level of intensification. This can also reveal the role of other potential sources of yield variation. Results from this analysis are summarized in Table 7 (more details in Annex).

The significant positive effects of anti-capsid treatments and of reducing permanent shade are clearly confirmed in both countries. Similarly, the influence of age on yield follows a

quadratic curve (the regression is non significative in the case of Côte d'Ivoire for lack of very old plots), as expected. It is of some interest to note that cocoa seems to remain in its "prime" (but at low levels) under smallholder conditions for quite a long time, even though this result could be partly due to the common practice in both countries of replacing dead or missing trees.

TABLE 7 : MULTIPLE REGRESSION ANALYSIS OF FACTORS AFFECTING COCOA YIELD: SUMMARY OF RESULTS.

	GHANA	COTE D'IVOIRE
Establishment practices :		
- Precedent	No effect of old cocoa, negative effect of weeded fallow ***/*	No effect of old cocoa, possible negative effect of weeded fallow */-, and of old coffee -/*
- Planting method	Negative effect of bare earth transplant **/***, possible positive effect of polybags -/*	Positive effect of bare earth **/**, possible positive effect of polybag transplants */-
- Shade	Negative effect of heavy shade ***/***, positive effect of no shade -/**	Negative effect of heavy shade **/***
- Seed type	Possible negative effect of amelonado -/**	No effect
- Food crop associated	n.a.	Negative effect of rice association ***/***
Maintenance practices :		
- Anti-capsid treatments	Positive effect ***/***	Positive effect **/***
- Weeding	Possible negative effect **/-	Possible positive effect -/**
Age of trees	Quadratic yield curve **/***	No clear yield curve
Agro-climatic zone	Possible negative effect in Western Region **/-	Negative effect in Centre-West Region ***/***
Management system	Positive effect of sharecropping **/**	Positive effect of sharecropping ***/***

Key : " -" coefficient insignificantly different from zero, "*" significant at 90%, "**" significant at 95%, "***" significant at 99%, in two-tailed test ; "/" separates estimates for 1992/93 and 1993/94 seasons.

The influence of some other factors is more inconsistent. Transplanting techniques register a significantly positive impact in Côte d'Ivoire, but in Ghana there is no significant difference between the polybag method and direct seeding, and an apparent negative effect of bare earth transplants. Ghanaian farmers may be using these techniques mainly on relatively degraded soils (for which transplanting only partly compensates). Similar results were obtained in the mid 1980s in the Centre-West region of Côte d'Ivoire (Ruf, 1988) : in plots between 5 and 15 years old, average yields were higher following direct seeding compared to plots established using polybags. This result could be explained by the incidence of weeds and pests : the very high density obtained with direct seedling limits weed growth during establishment (especially in the case of non-forest precedent) and produces a continuous canopy earlier, which helps control capsids.

Concerning the influence of the precedent land use, cocoa planted on weeded fallows seemed to be at some disadvantage, whereas there is no evidence of a negative yield effect for planting on old cocoa or coffee farms in either country. It must be noted that these last two types of situation can provide a precedent for cocoa not so different from secondary forest, since old cocoa farms, especially in Ghana, are under heavy shade and since old coffee farms have often been abandoned to let trees regrow. Results could prove different when Ivorian or Ghanaian cocoa farmers try to replant "No shade" senescent cocoa plots (Petithuguenin, 1995). The results for the effect of the number of weedings per year are puzzling : a positive impact on yields is recorded in 1994 in Côte d'Ivoire, but the effect is negative in 1993 in Ghana ! The discordance may derive from the imprecise nature of this proxy for upkeep quality, in which neither the variability in weed pressure across fields nor the intensity of the labor input per passage are assessed.

In Côte d'Ivoire, yields are lower when young cocoa was planted in association with rice, as compared to association with yams or maize. The question raised here is whether this result is only due to the better complementarity in the work calender between yams and cacao than between rice and cacao (Ruf, 1988), or whether there are other factors at work.

But the most surprising result of this multiple regression analysis is certainly the nearly total absence of effect of seed type on yields, although influence on precocity is significant (e.g,

for Côte d'Ivoire, the mean age of the cocoa farm at first harvest is 4,4 years in the case of Amelonado, 3,8 for progenies of selected trees, and 3,5 for certified hybrids, differences being significant at 5%). Only in Ghana and in 1994 is there a significative negative impact of Amelonado cocoa on yields. Could it be that the cultivars selected on research stations only express their productive potential when the full "package" is applied ? Or that the Amelonado is well adapted to fairly extensive systems ?

Finally, and apart from the agronomical factors presented above, we note the strong positive association of higher yields with the sharecropping system in Côte d'Ivoire, where the effect is highly significant in both years. Plots thus managed have an estimated average yield bonus of at least 40% over owner-operated plots. In Ghana, where the effect is less significant, the estimated gain is about 25%. As De Fina (1995) has shown, Ivorian sharecroppers select superior plots when negotiating their contracts, but it is also possible that these plots subsequently generate higher yields because of better overall maintenance. For the owner, the average estimated yield gain actually covers the labor costs of the sharecropper, who earns 1/3 of the output under the standard contract.

6. CONCLUSION

Among other results, this study helps to explain why national average yield is lower in Ghana as compared to Côte d'Ivoire. Less than a consequence of older plantations (the quadratic curve for age shows that mean yields remain fairly stable for many years in the case of smallholders), it is due mainly to higher level of permanent shade and less intensive maintenance, and in particular lower levels of chemical control against capsids. This result is of special interest to researchers and extension services in Ghana.

Another result which will surely interest agronomists and researchers (and especially plant breeders), even though it might cause some disappointment, is the lack of effect of selected cultivars on average yields. Further work on the survey data is underway to analyze this result more accurately.

ACKNOWLEDGMENTS

For collaboration in the design and execution of the surveys, we thank Drs. Gyekye, Seini and Nyanteng (University of Ghana), Mark Oswald (French Ministry of Cooperation), and Eric Léonard (ORSTOM), and for research assistance, Mélanie Resquiers-Desjardins (CIRAD). The usual disclaimers apply.

REFERENCES

De Fina C. 1995. Le contrat de travail dans un univers complexe. Doctoral thesis, Ecole nationale supérieure agronomique de Montpellier, France.

Hanak Freud E., Petithuguenin P., Richard J. 1996. Innovation in West African smallholder cocoa: some conventional and nonconventional measures of success. International Symposium on Food Security and Innovations : Success and Lessons Learned ; 11-13 March 96 ; University of Hohenheim, Stuttgart, Germany.

Nyanteng VK. 1995. The prospects of the Ghana cocoa industry in the 21st century. in: Cocoa cycles. The Economics of Cocoa Supply. Eds Ruf/Siswoputranto, pp 179-207.

Petithuguenin P. 1996. Cacaoculture et évolution du milieu, une contribution à la réflexion sur la reproductibilité de ces systèmes de culture. Actes du séminaire Fertilité du milieu et stratégies paysannes sous les tropiques humides. 13-17 November 1995, Montpellier, France. Diffusion CIRAD-SAR. pp 340-349.

Ruf F. 1993. La Côte d'Ivoire va-t-elle céder la place de premier producteur mondial de cacao à l' Indonésie ? Café Cacao Thé, vol.XXXVI, n°3, juil-sept 1993.

Ruf F. 1988. Stratification sociale en économie de plantation ivoirienne. Thèse de Docteur 3° cycle (Doctoral thesis), Université de Paris X, 1393 p.

ANNEX

TABLE A 1 : MEAN SAMPLE VALUES FOR VARIABLES USED IN THE COCOA YIELD REGRESSIONS, 1992/93 AND 1993/94 CROP YEARS.

	Côte d'Ivoire			Ghana	
	1992/93	1993/94		1992/93	1993/94
Sample size	603	674		397	412
1.natural log. of yield	5.642	5.643		5.118	5.077
2. Agro-climatic zone					
Base case: Centre-west	0.221	0.252	Eastern	0.292	0.289
South-West	0.423	0.412	E.Ashanti	0.156	0.155
East	0.315	0.291	N.Ashanti	0.134	0.129
Gagnoa	0.041	0.045	Western	0.418	0.427
3.Establishment practices					
- Precedent					
Base case: forest	0.803	0.803	forest	0.698	0.704
weeded fallow	0.053	0.056	w. fallow	0.171	0.160
old cocoa	0.015	0.016	old cocoa	0.116	0.119
old coffee	0.129	0.125	burnt cocoa	0.015	0.017
- Planting method					
Base case:direct seedling	0.477	0.452		0.774	0.766
nursery w. polybags	0.216	0.224		0.108	0.109
bare root nursery	0.144	0.165		0.035	0.036
mixed (at stake + nursery)	0.163	0.159		0.083	0.087
- Shade					
Base case: mild shade	0.536	0.534		0.551	0.541
heavy shade	0.093	0.098		0.363	0.367
no shade	0.371	0.368		0.086	0.092
-Seed type					
Base case:Progenies of			Progenies of		
selected trees	0.613	0.611	selected amazon	0.654	0.650
Amelonado	0.216	0.218	Amelonado	0.139	0.143
hybrid	0.128	0.122	hybrid	0.106	0.107
mixed seed types	0.043	0.049	hybrid progenies	0.101	0.100
			Selected Amazon	0.091	0.097
-Food crop associated					
Base case:yam	0.600	0.608			
maize	0.186	0.177			
rice	0.214	0.215			
4. Maintenance practices					
- Anti-capsid treatments (#)	1.058	1.018		0.804	0.791
	(1.087)	(1.097)		(0.930)	(0.923)
- Weeding (#)	2.307	2.277		1.982	1.981
	(0.711)	(0.697)		(0.754)	(0.751)
5. Age of trees					
- age in years	16.630	17.472		19.441	19.850
	(8.865)	(8.842)		(12.868)	(12.913)
- age squared	355.015	383.329		543.108	560.345
	(367.67)	(366.680)		(661.49)	(681.166)
6. Management system					
Base case : owner mgmt	0.534	0.542		0.620	0.631
Sharecropper mgmt	0.466	0.458		0.380	0.369

Note : Standard deviations in brackets for the quanitative variables.

TABLE A 2 : SUMMARY OF REGRESSION RESULTS ON COCOA YIELD EQUATIONS, 1992/93 AND 1993/94 CROP YEARS.
(Dependant variable is the natural logarithm of yield expressed in kg/ha)

	Côte d'Ivoire			Ghana	
	1992/93	1993/94		1992/93	1993/94
Error diagnostics					
- Adjusted R^2	0.22	0.31		0.19	0.13
- Standard error	0.82	0.76		0.92	0.94
- Sample size	603	674		397	412
Parameter estimates[1]					
1. Base yield (constant)[2]	4.40***	4.61***		5.08***	4.77***
	(0.22)	(0.20)		(0.25)	(0.26)
2. Agro-climatic zone (base in RCI : Centre-West ; in Ghana : Eastern region)					
South-West	0.52 ***	0.60 ***	E. Ashanti	-0.30 *	-0.07
	(0.10)	(0.09)		(0.15)	(0.15)
East	0.26 **	0.14	N. Ashanti	-0.026	-0.08
	(0.12)	(0.11)		(0.17)	(0.17)
Gagnoa	0.14	-0.25	Western	-0.26 **	0.01
	(0.52)	(0.19)		(0.12)	(0.12)
3. Establishment practices					
- Precedent (base : primary or secondary forest)					
Weeded fallow	-0.29 *	-0.20	W. fallow	-0.38 ***	-0.22 *
	(0.15)	(0.13)		(0.13)	(0.14)
Old cocoa	0.04	0.01	Old cocoa	-0.24	-0.20
	(0.28)	(0.23)		(0.16)	(0.16)
Old coffee	-0.02	-0.09 *	burnt cocoa	-0.95 **	-0.42
	(0.06)	(0.05)		(0.41)	(0.38)
- Planting method (base : direct seedling)					
Nursery w/polybags	0.20 *	0.06		0.27	0.41 *
	(0.11)	(0.09)		(0.24)	(0.23)
Bare root nursery	0.35 **	0.22 **		-0.75 **	-0.51 **
	(0.11)	(0.09)		(0.26)	(0.25)
Mixed (at stake + nursery)	-0.11	-0.16 *			
	(0.10)	(0.07)			
- Shade (base : mild shade)					
Heavy shade	-0.31 **	-0.44 ***		-0.31 ***	-0.28 ***
	(0.13)	(0.11)		(0.10)	(0.10)
No shade	0.11	0.05		0.43 **	0.16
	(0.08)	(0.07)		(0.19)	(0.18)
- Seed type (base : in RCI, progenies from selected trees ; in Ghana, progenies from selected Amazon trees)					
Amelonado	-0.08	-0.03	Amelonado	-0.21	-0.38 **
	(0.10)	(0.09)		(0.15)	(0.15)
Hybrid	0.01	0.09	Hybrid	-0.25	-0.23
	(0.11)	(0.10)		(0.22)	(0.21)
Mixed seed types	-0.44 **	-0.54 ***	hybrid prog.	-0.09	-0.01
	(0.18)	(0.15)		(0.16)	(0.16)
			Selected Amazon	0.25	-0.05
				(0.22)	(0.21)
- Food crop associated during establishment (base : yam)					
Maize	0.05	0.0008			
	(0.10)	(0.09)			
Rice	-0.45 ***	-0.34 ***			
	(0.11)	(0.10)			

TABLE A 2 (continued)

	Côte d'Ivoire		Ghana	
	1992/93	1993/94	1992/93	1993/94
4. Maintenance practices				
- Anti-capsid treatment(#)	0.07 *	0.12 ***	0.21 ***	0.23 ***
	(0.04)	(0.04)	(0.05)	(0.05)
- Weeding (#)	0.08	0.14 ***	-0.14 **	-0.07
	(0.06)	(0.05)	(0.07)	(0.07)
5. Age of trees				
- age in years	0.05 ***	0.02 *	0.049 **	0.044 ***
	(0.01)	(0.01)	(0.013)	(0.014)
- age squared	-0.00073 **	- 0.00021	-0.00091 ***	-0.00083 ***
	(0.0003)	(0.0003)	(0.00025)	(0.00025)
- age at peak yield			53 years	53 years
6. Management system (base : owner management)				
Sharecropper mgmt	0.37 ***	0.33 ***	0.28 **	0.23 **
	(0.08)	(0.07)	(0.11)	(0.11)

Notes :

(1) standard errors in brackets : "***" indicates significantly different from zero in a two-tailed T test at the 99 % level, "**" at the 95% level, "*" at the 90 % level. See table A 1 for descriptive statistics on the sample variables.

(2)The base yield is that obtained for the combined conditions of the base case (direct seeding, forest precedent, mild shade, etc) with the quantitative variables set to zero.

Déjà parus

1. Benz H., Mendez Del Villar P. Le marché international du riz. Facteurs d'instabilité et politiques des exportateurs. Avril 1993.

2. Freud C., Hanak Freud E. Les cafés robusta africains : peuvent-ils encore être compétitifs. Août 1993. Article à paraître.

3. Gouyon A., Supriono A. De la forêt à hévéas aux usines d'Akron : une production paysanne pour un marché industriel. Avril 1993.

4. Leplaideur A. Innovations récentes dans les réseaux commerciaux et de transformation du riz à Madagascar. Résultat d'une enquête 1991 dans la filière sur Antananarivo, Antsirabé, lac Alaotra. 21 p. Septembre 1933.

5. Moustier P. Etat d'avancement du programme Filmar, phase III (CIRAD-CA/Agricongo). Octobre 1993.

6. Fusillier J.-L. La filière maïs au Cameroun. Quelles perspectives de développement de la production de maïs ? Contribution à l'étude FAC-CAPP/USAID. Octobre 1993.

7. David O., Moustier P. Systèmes maraîchers approvisionnant Bissau. Résultats des enquêtes (15 décembre 1992 au 15 juillet 1993). Octobre 1993.

8. Fok A.C.M. Le développement du coton au Mali par analyse des contradictions. Les acteurs et les crises de 1895 à 1993. Novembre 1993.

9. Cousinie P. Dynamique des systèmes de production en zone cotonnière au Togo de 1985 à 1992. Novembre 1993.

10. Observatoire des marchés internationaux. Fiches produits. Décembre 1993.

11. Naire D.L. Enquête manioc/Pool-Congo. Formes de production et modes de mise en marché des « produits manioc » dans le pays rural de Mindouli. Janvier 1994.

12. Naire D.L. Contexte d'urbanisation et démographie rurale dans le Pool congolais : les villages-centres du district de Mindouli. Janvier 1994.

13. Balde A., Leplaideur A., Puio L., Tounkara O. Les filières du riz en Guinée forestière. Résultats intermédiaires. Novembre 1993.

14. Hanak Freud E., Freud C. Methodological issues in the analysis of the competitivity of cocoa sub-sectors. Paper presented at the Workshop of the International Conference on Cococa Economy, October 19-22, 1993, Bali, Indonesia. October 1993.

15. De Crozals A. La place des Etats-Unis dans le marché mondial du coton-fibre. Décembre 1993.

16. Fusillier J.-L. La diffusion de la culture du maïs en Afrique de l'Ouest. Communications présentées au séminaire CIRAD-UNB-FAO de Cotonou (Bénin) sur la production et la valorisation du maïs en Afrique de l'Ouest. Avril 1994.

17. Observatoire des marchés internationaux. Fiches produits n° 2. Mise à jour juillet 1994.

18. Mendez Del Villar P. Les marchés mondiaux du riz. Structures et fonctionnement. Observatoire des marchés internationaux. Août 1994.

19. Daviron B. « Le pire n'est jamais certain » éléments sur la dynamique des marchés internationaux des produits agricoles tropicaux. Août 1994.

20. L'unité de recherche Economie des filières. Novembre 1994.

21. Observatoire des marchés internationaux. Fiches produits. Région Afrique de l'Ouest et du Centre. Février 1995.

22. Observatoire des marchés internationaux. Fiches produits n° 3. Mise à jour juillet 1995.

23. Liste des publications 1992-1993-1994. Unité de recherche économie des filières CIRAD. Décembre 1995.

24. Voituriez T. L'huile de palme et son marché : un essai de modélisation. Décembre 1995.

25. Benz H., Fusillier J.-L., Hassane S., Liagre L., Mendez Del Villar P., Sourisseau J.-M. Les premiers effets de la dévaluation sur les filières riz irrigué au Sahel (Sénégal, Mali, Niger). Synthèse. Décembre 1995.

26. Hanak Freud E., Petithuguenin P., Richard J. Innovation in West African smallholder cocoa: some conventional and nonconventional measures of success. Janvier 1996.

27. David O. Les effets de la dévaluation du franc CFA sur les systèmes de production de l'oignon au Niger. Février 1996.

28. Observatoire des marchés internationaux. Fiches produits n° 4. Mise à jour juillet 1996.

29. E. Hanak Freud, C. Freud. Devaluation and liberalization as tools for enhancing competitiveness? Some insights from the recent West African experience in cocoa marketing. Novembre 1996.

30. C. Escande. La gestion de la qualité du caoutchouc naturel aux Philippines. Novembre 1996.

Centre
de coopération
internationale
en recherche
agronomique
pour le
développement

**Unité de
recherche
économie
des filières**

2477,
avenue du Val
de Montferrand
BP 5035
34032 Montpellier
Cedex 1
France
téléphone :
67 61 58 00
télécopie :
67 61 56 42
télex :
480573 F