Capsid Control for Organic Cocoa in Ghana

Results of participatory learning and action research

Godwin Kojo Ayenor

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Capsid Control for Organic Cocoa in Ghana

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Abstract

Cocoa is an important foreign exchange earner for Ghana. However, compared to Ivory Coast and Malaysia, two other major producing countries, yields are extremely low. The causes of low yields are many. They include low producer price offered until recently by the government, costs of labour, poor tree husbandry practices, and pest and diseases. The recent increase in producer price has rekindled farmers' interest in measures that can help them address low yields especially in pest and disease control. Cocoa Research Institute of Ghana has developed and disseminated a number of recommendations, but less than five percent of cocoa farmers have adopted those. It is believed that one of the major problems is the application of conventional research models through linear processes of technology transfer. With the view to improve research uptake and use, we adopted technographic and diagnostic studies followed by participatory technology development. Hence, we tried an interactive participatory approach focusing on alternative technology generation, development and delivery to other cocoa farmers. Capsids (*Sahlbergella singularis* and *Distantiella theobroma* (Heteroptera: Miridae) emerged as the most serious biological production constraints. Therefore, in this study we addressed the problem of capsids in cocoa. We did this within Brong-Densuso area, in the Eastern region of Ghana. With 'free' pesticides spraying by government, organic marketing arrangements between an American company and the cocoa farmers' association collapsed. Thus, we had to explore alternatives in order to sustain farmers' motivation to use the non-chemical pest management technologies. Therefore, the overall objective was to facilitate and develop, together with farmers, Integrated Pest Management methods to control capsids in an organic production system of cocoa. This objective was pursued by grounding the research in the needs and opportunities of farmers through a diagnostic process and by systematic blending of indigenous and formal knowledge. The focus was not only on technical improvements, but also on finding new social and institutional arrangements, such as more effective approach for information sharing and an alternative supply marketing chain for organic farmers.

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Synopsis

In one of my first encounters with a cocoa farmer in the study area (Brong-Densuso), this is what he said:

'Most of us in the older generation do not like the use of poison or DDT because since we started using them, our snails that we picked from the ground for meals have totally disappeared from here. Now if you want snails, you have to buy them. For the past 20 years that many of us do not use the poison again because we cannot afford them, the numerous earthworms that had almost disappeared are coming back. We can now see a lot of worm cast – an indication that our soils are getting their 'fat' back. These days many farmers support us more for the complete ban of the pesticides because the Americans have come to buy our cocoa for a better price if we do not start using the poison here again. Meanwhile, the problem is the tiny-tiny insects especially 'Akate' (capsids)'

This old farmer, who appeared to have seen it all, wanted something new; a change based on learning and experience derived from practical experiment. He did not receive formal education, but is he ecologically literate? Is he better informed in his cocoa environment than some policy-makers? Were people like him consulted before the cocoa mass spraying? Will they ever be listened to before such decisions are made? Or are some people better placed to tell him what is 'right' for cocoa in Ghana?

Chapter 1

General Introduction

G. K. Ayenor

Chapter 1

General Introduction

Cocoa production in Ghana and the impact of price increase

Cocoa (*Theobroma cacao L.)*, a second storey tree originating from the South and Central American rainforest, was introduced to the West African mainland in the latter part of the 19th century (Wood and Lass, 1985). Commercial cultivation of cocoa in Ghana started from Amelonado cocoa pods brought into the country by a migrant blacksmith-farmer returning home from the island of Fernando Po in 1879 (Anon 2000). The sudden popularity and spread of cocoa around the globe was mainly because it was used to prepare chocolate drink (Wood and Lass, 1985). However, cocoa is not only a basic component of chocolate. Industrially extracted cocoa fat is the basis for many pharmaceutical preparations and cosmetics. The most widely known of such products is cocoa butter, which is very effective in treating lip sores and other ailments due to its invigorating, diuretic and wound healing properties (Pamplona-Roger, 1998).

In the early 1920's, with an annual production of between 165,000 to 213,000 metric tonnes (MT) of cocoa beans, Ghana contributed about 40% of the world's total output (Anon, 2000). The revenues provided the basis for the country's infrastructural and economic development. Cocoa was, and still is, an important foreign exchange earner for Ghana. Cocoa is cultivated in six of the ten regions of Ghana, and about 80% of it is produced by small-scale farmers who depend on it as one of their major sources of cash income (Anon, 2000; Vos and Kraus, 2004). Small-scale farmers in Brong-Densuso in the Eastern Region, where this study was conducted, claim to obtain about 80% of their annual cash revenue from cocoa (see Chapter 2).

In 2004, cocoa once again became the main driver of agricultural growth, which in turn became the main contributor to the growth of the gross domestic product (5.8%). In the same year, the cocoa sub-sector grew by almost 30%, up from 16.4% in 2003, where other sectors recorded only modest growth (Anon, 2005). This was due to an unprecedented increase in production (Table 1), itself a direct response to the Government's decision to start paying farmers a larger percentage of the Free On Board (FOB) price (culminating in 70% in 2004), so as to stop the erosion of one of its bases of revenue.

This increase in price has had a dynamising effect on the whole cocoa industry, a fact that underlies many of the observations made throughout this dissertation.

Table 1 shows a number of important developments. In 2001 and 2002, production was lower than the projected 500,000 MT (Anon, 2000), reflecting the lack of incentive for farmers to look after their plantations and harvest the beans. In the same years, foreign exchange earned increased by about one fifth, indicating the improved international prices, possibly as a result of

Table 1. Cocoa production (MT), foreign exchange earned (US$) and nominal producer price (US$/MT) for farmers in Ghana (2001-2004).

Year	Production		Foreign exchange earned		Producer price (nominal)	
	MT	% Change	US$	% Change	US$	% Change
2001	389,800	- 2	381,000,000	20.4	269.78	7.9
2002	340,600	-12.6	463,000,000	22.4	535.41	98.5
2003	496,846	46	817,700,000	35	972.22	81.6
2004	736,911	48.3	1,071,000,000	39.2	1,000	2.9

* The nominal producer price for farmers was converted from the Ghanaian (Cedis ¢) to United States dollars (US $) with current average exchange rate of ¢9,000=$1

Sources: Bank of Ghana and Ghana Cocoa Board in (Anon, 2005).

the collapse of exports from the Ivory Coast. But cocoa production really rose fast from 2003 when farmers began to be paid a better price (and perhaps, some smuggling from the Ivory Coast), culminating in 2004 when they received about 70% of the FOB price. Between 2002 and 2004, production more than doubled. This rapid increase shows that there was a great deal of latent production that could be mobilised quickly. Further increase will have to pay attention to improving production techniques, e.g., by controlling pests and managing plantations, the subject of the present dissertation.

Societal problem: low yields in cocoa

From Table 1, it seems that Ghana's cocoa production is bouncing back. However, that impression ignores the fact that major challenges still need to be addressed in order to attain sustainable increases in production that go beyond mobilising latent resources, as has happened so far. Given the better prices paid to farmers, the motivation now seems to be there to improve the management of cocoa plantations. In that respect, there is much room for improvement. Compared to Ivory Coast and Malaysia, cocoa yields in Ghana remain very low, even in 2004 and 2005 (figure 1) (FAO Stats., 2006).

The five years national average yield of 377 kg/ha in Ghana is almost half the national average yield in Ivory Coast (744 kg/ha) (Figure 1). Scientists have equally expressed concern that the

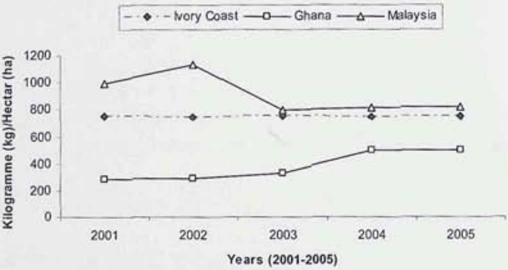

Figure 1. Cocoa yields from three major producing countries

national average of about 400 kg/ha falls so far short of the 1-5 MT/ha achieved on experimental plots (Flood *et al*, 2004; Asante and Ampofo, 1999). Ghana, once the world's leading producer of cocoa, lost her position in 1976/77 to Ivory Coast (Figure 1). Cocoa farmers involved in the Convergence of Sciences (CoS) studies also mentioned low yields as one of their major problems (Chapter 2; Dormon *et al*., 2004). The old strategy where farmers cleared virgin forest to establish new cocoa farms in order to make up for low yields is no longer feasible and has become unsustainable (Flood and Murphy, 2004). Recent development aims at encouraging the intensification of existing cocoa production, rather than at clearing rainforest (Vos and Page, 2005).

The causes of low yields are many (Abekoe *et al.*, 2002; chapter 2). They include, until recently, the low producer price offered by the government, youth migration, the increased cost of labour, an aging farmer population, aging plantations, poor tree husbandry practices, pest and diseases, etc. (Anon, 2005). The increased producer price has rekindled farmers' interest in measures that can help them address low yields.

Causes of low yields

The three major biological problems that affect cocoa productivity in Ghana are Cocoa Swollen Shoot Virus Disease (CSSVD), Black Pod fungus disease and capsid insects (Hemiptera: Miridae) (Padi *et. al.*, 2002; Chapter 2). Lesser constraints are imposed by organisms, such as termites, mealy bugs, stem borers, pod borers, pod feeders, aphids, etc. There are also problems with weeds and parasitic mistletoes (Entwistle, 1972; Padi *et al*., 2002).

CSSVD is transmitted by mealy bugs (Homoptera: Pseudococcidae). Infection by the virus include chlorotic vein streaking, leaf mosaic, stem and root swelling, as well as pod deformation (Flood *et al*., 2004). It is estimated that the virus causes 11% total crop loss in West Africa (Van der Vossen, 1999). The main method of control is by removal of infested trees and the ones in their immediate vicinity since the vectors, mealy bugs, do not migrate over long distances (Ollenu *et al*., 1989). In Ghana, a major programme to eradicate CSSVD from cocoa farms led to the destruction of 190 million trees (Flood *et al*., 2004). Black pod disease is mainly caused by two *Phytopthora* species, *P. palmivora* and *P. megakarya*. The latter is the more aggressive of the two pathogens and can cause total loss of pods, but it is limited to certain parts of the country, and therefore is not that serious a problem in the Eastern region. The more dominant species in the study area, *P. palmivora*, (see figure 2 for the map) causes less crop loss than *P. megakarya*, and is mainly controlled through agronomic practices (Opoku *et al*., 2000).

Capsids remain one of the important causes of low yields of cocoa in Ghana. About forty different species have been observed on cocoa and the common ones in Ghana are *Sahlbergella singularis* (Hagl.), *Distantiella theobroma* (Dist.), *Helopeltis* spp. (the Cocoa Mosquito) and *Bryocoropsis laticollis* (Flood *et al*., 2004). The first two species are the most important cocoa capsids in Ghana; hence, the work on capsids reported upon in this thesis largely refers to these two species.

The direct assessment of crop loss caused by capsids is complex because they are part of a disease complex (Padi *et al*, 2002); and the damage they cause can manifest itself as symptoms of physiological die-back (Entwistle, 1972). However, it is estimated that the damage caused by *S. singularis* and *D. theobroma* amounts to about 25% to 30% annual crop loss (Anon, 1951). Recent studies confirmed such losses in Ghana, and estimated that 100,000 MT of world production is lost annually as a result of capsids (Holmes and Flood, 2002). Capsids have a sporadic distribution, cryptic habitats and can be extremely damaging in small numbers, even to the extent of killing cocoa trees (Entwistle, 1972; Flood et al., 2004). Combination of these characteristics makes the control of capsids not only difficult, but also imperative. It is for this reason that I chose to focus my doctoral research on the control of capsids, with special attention to the development of Integrated Pest Management (IPM) and avoidance of the use of synthetic pesticides. Chapters 2, 3 and 4 of this thesis elaborate further on capsid damage or lesions, behaviour and impact. The two dangerous species mentioned above turned out to be the main biological problem that both farmers and scientists active in the study area identified as the major cause of low yields in cocoa (chapter 2).

Existing capsid control methods

Several measures for the control or management of capsids in cocoa are at different stages of scientific development and field implementation in Ghana. They include the use of resistant cocoa varieties, cultural control, biological control, mass trapping of capsids with sex pheromones, botanical pesticides such as neem (*Azadirachta indica*) and application of conventional or synthetic insecticides (Padi *et al*, 2002).

Upper Amazon cocoa cultivars that have low water content in their stems are unattractive to capsids (Flood *et al*., 2004). Such cocoa genotypes are resistant to cocoa capsids and some have been identified among the Amazon cultivars in Ghana. Together with exotic cultivars with similar traits, they are undergoing preliminary laboratory and field screening (Anon, 2001). However, the challenge is whether cocoa farmers will use these resistant genotypes because many of them usually replant by using their old planting materials or seeds. Vos and Lass (2002) observed that about 70% of the cocoa trees grown in Ghana are from non-selected varieties.

Cultural methods recommended by research focus on the control of capsids and other pests and diseases, such as Black Pod, mistletoes, other parasitic plants, weeds, etc. Some of the measures include manipulation of the overhead shade trees, pruning of excess branches from the cocoa trees (chupons), regular harvesting, weeding with machete, etc. (Padi *et al*., 2002). With respect to shade management, a delicate balance must be found so as to create optimum conditions that can reduce capsid attack and Black Pod disease at the same time (Flood *et al*., 2004). The main problem with the use of these cultural management practices is the labour demand on the ageing farming population (Chapter 2). Youth migration to the cities has compounded the problem because the cost of labour has escalated beyond the reach of most small-scale farmers, and share-cropping arrangements are not functioning properly (Chapter 2).

Biological control through the use of natural enemies (parasitoids) against cocoa capsids was reported in the 1940s, but is just beginning to receive research attention again (Padi *et al*., 2002). The ant *Oecophylla smaragdina* has been known to be a natural enemy of several pests in Asia, and its equivalent in Ghana is the *Oecophylla longinoda* Latr. (Hymenoptera: Formicidae) (Van Mele and CuC, 2003). Some of the concerns reported to affect the wider use of the *O. longinoda* are; the fact that the ant is a facultative predator, it is aggressive to humans and its habitat requirement with respect to shade conditions is completely different from capsids (Marchart, 1971). Therefore, it has received little scientific attention (Entwistle 1972) even though farmers insist that they can be effective (Leston, 1971; Chapter 2 and 3).

The Cocoa Research Institute of Ghana (CRIG), in collaboration with other institutions such as Natural Resources International (NRI) and CABI Bioscience, has initiated the search for other natural control options, including an uncompleted investigation on the use of mycopesticides (e.g., *Beauvaria bassiana*) (Padi *et al.*, 2002). However, because most of the *B. bassiana* isolates are exotics, there are concerns about their field application for possible failure to achieve specificity for capsids (Padi, CRIG, pers. comm.). Other on-going field research concerns the use of sex pheromone lures for mass trapping of capsids both for monitoring and for control (Padi *et al* 2001; Vos and Page, 2005).

The Organic Commodity Products, Inc. (OCP) from the United States supported CRIG to conduct research into the use of neem (*Azadirachta indica*) as an organic pesticide, so that it could purchase cocoa beans with an organic label especially from members of the Traditional Organic Farmers Association (TOFA) (Chapter 2, 3, 4. and 5). As part of this study, CRIG compared the effectiveness of 20% crude Aqueous Neem Seed Extract (ANSE) with that of 5% Neemazal (a commercial neem preparation), and of synthetic pesticides. The neem-based products resulted in 80% capsid mortality, against 95% for the synthetic pesticides (Padi *et al.*, 2002; Vos and Page 2005). The use of ANSE as a botanical pesticide could be most appropriate for small-scale cocoa farmers because it is generally cost-effective and fairly available in many rural communities in Ghana (Padi *et al.*, 2002). Dormon (2006, in press) has shown that farmers can be organised to acquire neem seeds from areas where the tree grows well and where the seeds have a high content of the active ingredient. What is more, he has also shown that farmers can locally process the seed to produce the ANSE.

Dominant control method

The application of synthetic pesticides by motorized mist-blowers is the main method for capsid control recommended by CRIG. Currently, the major insecticides being applied are Confidor 200 SL (Imidacloprid) at 150 ml/ha; Cocostar (Actellic/Talstar) at 500 ml/ha; and Carbamult 20 EC (Promecarb) at 1.4 l/ha. The insecticides are to be applied four times a year at monthly intervals in August-December, omitting November, as a prophylactic measure. However, nationwide surveys on insecticide use mainly for capsids control have reported extremely low adoption rates (between 0.4-1% and 3.5%) by farmers for this recommendation (Donkor *et al.*, 1991; Henderson *et al.*, 1994; Padi *et. al.*, 2000). The low adoption is primarily attributed to the high cost of the inputs: the mist-blower, the chemicals (especially Confidor 200 SL – Imidacloprid), and the labour employed for the application (Henderson *et al.*, 1994; Padi *et al.*, 2002).

Considering these constraints and the unavailability of affordable credit, as well as the previously low farm gate price for cocoa, most farmers decided not to spray, and just to harvest whatever they could gather with minimal crop management effort, while others totally abandoned their farms altogether. In the absence of appropriate alternative measures of control, the Government is currently financing a Cocoa Diseases and Pest Control (CODAPEC) programme, also known as the 'mass spraying' campaign. This measure was initiated because it considered the national economy so dependent on cocoa, especially given the present high international prices, that pest control could not be left to farmers who are reluctant to apply the recommended technologies.

Effects of application of synthetic pesticides through mass spraying campaigns and by farmers

The CODAPEC programme employs the services of spraying gangs but also encourages individual farmers to adopt and use synthetic pesticides by themselves. Questions have been raised about this propagation of synthetic pesticides. The relatively high level of illiteracy among cocoa farmers raises doubts about their ability to properly apply synthetic pesticides, which in turn can affect the health of farmers and their families, as well as of consumers. Some notable forms of abuse and misuse of insecticides by cocoa farmers include applying unapproved ones (e.g., pyrethroids and deltamethrin) or applying recommended ones at wrong dosages and frequencies. There have been instances of cocoa farmers stirring insecticide mixtures with their bare hands and even tasting them to see whether they were 'strong enough' to be effective. There were also instances of applications of chemicals recommended for use on cocoa on tomatoes and other vegetables in non-cocoa growing areas (Donkor *et al.*, 1991; Henderson *et al.*, 1994; Padi *et. al.*, 2000).

Underutilization of public health facilities by small-scale farmers and agricultural workers; inefficient diagnosis of pesticide poisoning, particularly in the rural health centres, coupled with lack of systematic surveillance; and underreporting in most developing countries, including Ghana, tend to under-represent the magnitude of the health hazards associated with the use/abuse of synthetic pesticides (Pretty, 2005). The Imidacloprid that is used in the mass spraying campaign to suppress cocoa capsids is highly toxic to bees (Vos and Page, 2005). Ghanaian cocoa farmers who intend to embark on combining cocoa farming with beekeeping to supplement their income will be affected, but are also likely to face lower yields in cocoa due to inadequate pollination. The negative effect of pesticides may disrupt the development of farmers' own traditional capsid management practices because the population of biological control agents such as the predatory ant, *O. longinoda*, is likely to be suppressed (Van Mele and CuC, 2003).

The effect of blanket application of synthetic pesticides on human health and the environment can rarely be accurately determined; there are always some hidden costs (Pretty, 2005). In Ghana, the importation of pesticides has increased from US$15,379,000 in 2000 to US$28,181,000 in 2004, representing an increase of 83% (FAO Stat, 2006). It is not clear which of the pesticides imports was directly used in the CODAPEC programme or what the returns to this investment in cocoa was, but the government spent about US$ 1,444,444 to implement the cocoa mass spraying programme in 2004 (Anon, 2005). It is also not clear whether the money spent includes pesticides purchased locally from manufacturing companies such as the Abuakwa formulation plant in which the Ghana Cocoa Board (COCOBOD) owns shares. However, since only one or two rounds of the four recommended calendar-based applications were actually carried out in 2004, the cost of implementing the fully recommended package is likely to be higher. What is more, the irregularity of spraying might well stimulate the development and resurgence of the resistance to pesticides of capsids that was reported at Pankese, in the Eastern Region, in 1956 (Entwistle 1972). A further issue is sustainability of capsid control when Government funding of the CODAPEC programme stops.

It seems worthwhile to explore the practical use of alternatives that are less costly in terms of money, health and the environment. Given the serious threats posed by the indiscriminate and injudicious use of pesticides by farmers and the mass spraying campaign, the demand for alternative control methods is highly salient (Padi *et al.*, 1997; Vos and Page 2005). Apart from some apprehensions of inadequacies expressed about the present 'mass spraying' arrangements, currently, CRIG is not only searching for alternative solutions to the four annual blanket applications of synthetic pesticides that it has recommended since the 1957; it also appears to be looking for ways to become more efficient in its operations (MASDAR, 2004) and has taken steps to find out how it could be more effective through strategic review and analyses of its strengths and weaknesses (Table 2).

The problems associated with pest and disease control and the low uptake of technologies from CRIG are a serious concern to the institute (Table 2). Meanwhile, the low adoption of recommended pest management practices is not only a Ghanaian problem. Similar concerns were expressed by most cocoa scientists from West and Central Africa who converged in Cotonou, Benin (November 2001), to discuss IPM initiatives (Vos and Neuenschawander, 2002).

Table 2: Strategic analysis of Cocoa Research Institute of Ghana (CRIG)

Strengths	Weaknesses
• Many good technologies developed • Under utilized assets, e.g., land bank and plantations • Excellent reputation • Strong human resource base • Low staff turnover	• New technology not taken up by farmers • No culture of commercialization • No training in commercial management • No marketing experience • Farmers not adequately involved in planning research • Financial control systems cumbersome, sometimes slow down operations.
Opportunities	**Threats**
• Most stakeholders want an increase in Ghana's cocoa production • Farmers to receive greater proportion of FOB price of cocoa. • Privatisation of input supplies to farmers leads to more supplies being available • Problems of pests and diseases need immediate attention • Become West Africa's centre for excellence for cocoa research • Donor funded research • Technical assistance available for management training	• Farmers losing interest in cocoa due to low prices, and pests and diseases • Reducing availability of funds for CRIG from COCOBOD • Other institutions or private sector companies respond to farmers concerns faster than CRIG

Source: Commercialisation of CRIG–Ghana- final report by MASDAR (2004)

Integrated Pest Management of capsids

The International Code of Conduct on the Distribution and use of Pesticides defines IPM as (Pretty, 2005):

> *IPM means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.*

Van Huis and Meerman (1997) note that IPM emerged in response to negative consequences of the chemical approach to crop protection, and ever since has seen remarkable advances. However, until some 20 years ago, IPM Research and Development (R&D) hardly addressed the issue of farmers' practice. Participatory IPM is an approach to farmer education that is

farmer-driven and has contributed to assisting farmers' understanding and practice of IPM (Ter Weel and Van der Wulp, 1999). Learning and empowering farmers through experimentation and self-discovery is central to this approach (Chapter 3 and 4). The Farmer Field School (FFS) and the Local Agricultural Research Committee (LARC) are two approaches or platforms for promoting integrated decision making and innovation for sustainable agriculture by small-scale farmers through learning and experimenting (Braun *et al.*, 2000). The emphasis on learning as a process of knowledge co-construction and interpretation by individuals interacting with their ecological and cultural environment, is replacing the earlier extension theory and assumptions about 'pouring relevant messages into empty vessels of backward farmers' (Pretty and Chambers 1994). To give IPM a more practical and realistic meaning in the context of small-scale farmers in Africa, it is crucial that the focus on methodological aspects of IPM overshadows the one on technological issues (Van Huis and Meerman, 1997).
Many of the scientists, including the Africans, who met in Cotonou realized that, if the IPM technologies they intended to develop for cocoa were to be successful, it would depend on the process of farmer education and on farmers' involvement in the research process (Neuenschwander and Vos, 2002; Baah, 2002). Holmes and Flood (2002) observed that the effectiveness of future cocoa IPM is dependant on farmers understanding of the ecology of their crop, and of the pests and diseases, and the beneficial organisms, that live in and on it. They concluded that it is far easier to tell a farmer to spray four times a season than to facilitate intensive knowledge sharing process that empowers them with IPM tools.

Ghana is a beneficiary of a pilot sub-regional cocoa IPM/FFS initiative: the Sustainable Tree Crop Project (STCP). In addition to Ghana, it involves Ivory Coast, Cameroon and Nigeria in a public-private partnership that includes farmers and encourages stakeholders to collaborate towards economic and social improvement of small-scale farmers in sustainable tree crop production (Vos and Page, 2005). It aims to train farmers with the long-term objective of institutionalising organization and participatory training of farmers into the national extension services. The STCP has assisted farmers' cooperatives, such as Kuapa Kokoo, to implement cocoa IPM/FFS and to apply fair trade standards so as to obtain additional income from alternative niche markets (Vos and Page, 2005). The STCP's strategic objective to institutionalise its pilot operations in the mainstream cocoa extension services in Ghana appears unlikely in the foreseeable future because of lack of commitment and support from key institutions (Nathaniel, CABI Bioscience, pers. comm.). This problem is compounded by the confusion about which institution has the mandate for cocoa extension.

The internationally recognised quality of Ghana's cocoa attracts premium prices, a factor that features highly in COCOBOD's strategic and managerial decisions. Ghana's reputation provides an opportunity for further value adding in the growing niche markets for fair-trade and organic cocoa products in Europe and USA (CREM, 2002; Newell and Tucker, 2004). What is more, cocoa is becoming somewhat of a health food in industrial countries, particularly because of the demonstrated benefit of a consumption of 10 g a day of pure chocolate for the heart, probably as a result of flavonoids (NRC/H'bld, Science Section, July 3, 2006: 45). However, for the potentials of fair-trade cocoa, health food, and organic cocoa to be fully realized, infrastructural investment, commitment from key institutional actors and especially the development of capacity to organise and train farmers in IPM practices and certify the products will be essential (CREM, 2002; Chapter 5).

The phasing out of hazardous pesticides and phasing in of alternative capsid control methods is one of the keys to producing cocoa for more sustainable and reliable economic development in Ghana (Pretty, 2005; Vos and Page, 2005). This may have to be supported by the following 'ingredients': an appropriate policy and institutional context; more proactive and responsive public organisations; need-based research; responsive extension; and farmers' indigenous practices for participatory IPM. Röling *et al.*, (2004) re-emphasize that for agricultural science to make real impact on the lives of small-scale farmers, innovative research efforts need to be complemented with appropriate policies and more commitment from institutions that make the use of science worthwhile.

Convergence of Sciences Project

The Convergence of Science (CoS) project has been undertaken by a group of scientists from the Université de d'Abomey-Calavi, Benin; the University of Ghana at Legon, Ghana; and Wageningen University in the Netherlands (Annex 1). The Convergence of Sciences (CoS) programme, of which this study is one of nine projects, does not presume to provide the 'ideal' framework or pathway of science by which agricultural research improves the livelihood of the small-scale farmers. It seeks to build upon the achievements of other better-known approaches, such as Farming System Research (FSR) (e.g., Collinson, 2000) and Participatory Technology Development (PTD) (Van Huis *et al.*, 2006). These approaches have emerged because the conventional on-station type of research does not allow for the development of technologies that satisfy farmers' criteria (Röling *et al.*, 2004). The CoS embraced 'convergence' among disciplines, scientists and organizations from three main perspectives based on the following assumptions (Van Huis et al., 2006):

1. Different natural and social sciences must collaborate and integrate their work because

innovations have technical, social-economic and institutional dimensions.

2. Research that is relevant to poor-resource (small-scale) farmers requires their active involvement and also the inclusion of non-academic stakeholders, especially farmers, consumers, and others (trans-disciplinarity).
3. Innovations emerge from multi-stakeholder processes and interactions at different levels; within the farmers' local context and also at the organizational level where key framework conditions are set.

Although both PTD and FSR share similar features, principles and approaches such as the use of Participatory Rural Appraisal (PRA) tools, the CoS approach differs in the following ways (Van Huis *et al.*, 2006):

a. It considers social relations and institutions as integral parts of innovation, thus going beyond the boundaries of technology to learn, influence and possibly change the conditions that affect the space for positive change, without creating unsustainable conditions;
b. Continuous diagnosis across levels and scales;
c. Continuous re-orientation and flexibility.

For instance, the CoS approach sees institutional phenomena such as land tenure arrangements, policy changes of producer prices, the introduction of cocoa mass spraying with synthetic pesticides (that affects organic marketing arrangements), as opportunities for research or even development work. Others consider such social phenomena as conditions that impede research and adoption of technological innovations (Chapter 5). Similarly, problem diagnosis is not considered a research *phase*, but a continuous process during which the need for flexibility informs and re-orientates the focus of enquiry based on clients' needs and circumstances (Chapter 2). For instance, in the course of the diagnostic study, government ordered countrywide mass spraying of all cocoa farms. Based on the CoS approach, we facilitated the process of getting all stakeholders in the study area to discuss the farmers' intention to reject the synthetic pesticide. In the end, all stakeholders agreed that cocoa farms in the area be exempted from the national CODAPEC spraying programme because the farmers in the area were interested in organic cocoa production. However, the production and sustainability of organic cocoa and space for innovative research was still dependant on other forms of policy and institutional framework conditions; and the need to adapt the plans resurfaced with respect to marketing of organic cocoa (Chapter 5).

Justification and research questions

Based on the issues raised in this study under the perspective of the CoS approach; the following are our main research issues. First, there is lack of alternative capsid control methods that work, are appropriate under cocoa farmers' own conditions, and are acceptable to them, based on their criteria. Secondly, there seems to be a lack of appropriate extension approaches and interactive processes that ensure effective development and dissemination of capsid control methods in which farmers play an active role. Thirdly, the institutional and policy framework required for the production and marketing of organic cocoa, the contours of which emerged during the course of the field research (Chapter 2 and 5), has not been established. This meant that farmers' motivation to use IPM capsid control technologies has not been optimally contextualised.

The main research questions are:

I. How can agricultural research on cocoa capsid management be made more useful to small-scale farmers within their own context?

II. What are the alternative control (IPM) methods that can be effective and compatible for sustainable cocoa production, including organic production, in Ghana?

III. What extension or interactive approaches can be effective in generating, developing and disseminating sustainable capsid management practices?

IV. What is the institutional impact on the development and implementation of research aimed at creating space for innovation to improve small-scale cocoa farmers' livelihoods?

V. In the context of cocoa research and development, what lessons can be learnt for the agricultural and economic progression of Ghana?

Objectives of the study and approach

The overall objective was to facilitate and develop, together with farmers, alternative IPM methods that are effective for the control of capsids in an organic production system of cocoa. It was pursued by grounding the research in the needs and opportunities of farmers through a long identification and diagnostic process and by systematic blending of indigenous and formal knowledge. The focus was not only on technical improvements, but also on new social and institutional arrangements, such as an alternative supply marketing chain for organic farmers.

Specific objectives were:

1. To identify cocoa production constraints together with farmers in the study area and assess the technical efficacy of alternative interventions, considering their cultural and ecological implications.
2. To assess the technical efficacy of alternative control methods that are environmentally acceptable and affordable or would rely on low external inputs, and fit better into the conditions, aspirations and context of small-scale (organic) cocoa farmers.
3. To identify and facilitate interactive social actions, using appropriate approaches to facilitate the generation, development and sharing of capsid management information

among stakeholders, including different farmers groups, for sustainable cocoa production.

4. To assess the extent to which existing government policies and institutional arrangements facilitate or hamper the production and marketing of organic cocoa, given international trade requirements.
5. To reflect on the lessons learnt in terms of the challenges and opportunities that the study provides and their implications for research and development of agriculture in Ghana.

The scope and Outline of the thesis

Working within farmers' context is relevant because it is acknowledged that locally generated technology is continuously tested, adapted and evaluated by participating farmers, thereby ensuring high degrees of acceptability, ecological appropriateness and sustainability (Bruin and Meerman, 2001). It is against this background that the present study seeks to place emphasis not only on working with farmers to develop capsid control methods that can increase cocoa yields, but also incorporating participatory steps and creating the minimum conditions that ensure sustainability. Hence, under the (CoS) programme, technographic and diagnostic studies on cocoa preceded a participatory technology development in order to ensure that the end results would become useful to all stakeholders, especially farmers.

Chapter 2:

The chapter is based on the outcome of the technographic study on cocoa. The study was suggested by Richards (2001), and was conducted by the CoS group in Ghana, which identified broad areas of socio-technical innovations in the cocoa landscape (Abekoe *et al.*, 2002). The diagnostic study on cocoa, which has its roots in the technographic study, is the main objective of this chapter. It was conducted as an in-depth analysis to ground the entire PhD research in the needs and aspirations of cocoa farmers. The technographic and diagnostic studies provided the basis for understanding the cocoa industry and set the boundaries for key stakeholders to make capsid control methods more relevant to farmers. The diagnostic study adopted the use of participatory tools with farmers and confirmed some of the results from the technographic and other previous studies that indeed, cocoa farmers' main problem was low yields.

The diagnostic study identified the major constraints in organic cocoa production at Brong-Densuso, Eastern Region of Ghana. The two capsid species (*S. singularis and D. theobroma*) were identified as the most serious technical constraint causing the low yields. As a result both farmers and scientists together with other stakeholders agreed on three alternative capsid control methods for further research. The use of sex pheromone traps, crude aqueous neem seed extract, and *O. longinoda* as a biological control agent were agreed upon during this study. The diagnostic study spelt out what issues were worth investigating from the perspectives of both scientists and small-scale farmers. It provided the basis and insight into how, with whom, and within which policy and institutional setting, we were to conduct the research with farmers and scientists.

Chapter 3

Following the results of the diagnostic study, stakeholders collectively decided to develop ecologically acceptable capsid control methods. The efficacy of the three methods was tested on capsid numbers, lesions, damage on the cocoa tree canopy and yields together with farmers. It turned out that sustainable production of organic cocoa is technically feasible with the use of IPM methods, which could be potential components of organic cocoa production in Ghana.

Chapter 4:

This chapter reports on the effectiveness of the LARC approach, not only for developing and sharing of the agro-ecological knowledge and practices between researchers and farmers, but also for its ability to reach a wider audience through community presentations. TOFA used the information it gathered from the research in its attempts to mobilize its members. The LARC approach showed that beyond its ability to enhance intensive learning and empowering of participating farmers with complex skills for better pest management, just as the FSS does, it can also transmit these skills to exposed farmers. Through the LARC approach as an educational tool, the position of TOFA farmers was re-enforced in agro ecological management of cocoa capsids. Hence, LARC was an effective alternative approach for generating and sharing key knowledge and practices for sustainable capsid control developed in chapter 3.

Chapter 5:

However, the non-availability of an organic export market remained the key motivating factor that could affect the entire process of establishing sustainable organic cocoa production. The chapter explains that most of the cocoa farmers became more interested in organic cocoa primarily because of their expectation of a price premium, given appropriate certification. The organic export company cancelled the deal with the TOFA, following government policy to adopt countrywide calendar-based mass spraying for the control of pest and diseases. As a result, we sought to create an alternative marketing channel, including capacity building programmes for farmers, and attempted to facilitate the restoration of an organic marketing channel (on a smaller scale than before). However, the lack of organizational support became a major constraint. Hence, the chapter illustrates the multidimensional nature of innovation and the key role of support and commitment from institutional actors.

Chapter 6:

This chapter revisits the need to improve the impact of agricultural research on the livelihoods of small-scale farmers, which is the key issue CoS tries to address. Based on the CoS experience in this study, it highlights the key lessons learnt, challenges and opportunities in the production of organic cocoa, and reflects on the implications for Ghana's agricultural development.

The Study area, Brong-Densuso was exempted from cocoa mass spraying to allow for field experiments on alternative capsid control methods (Figure 2).

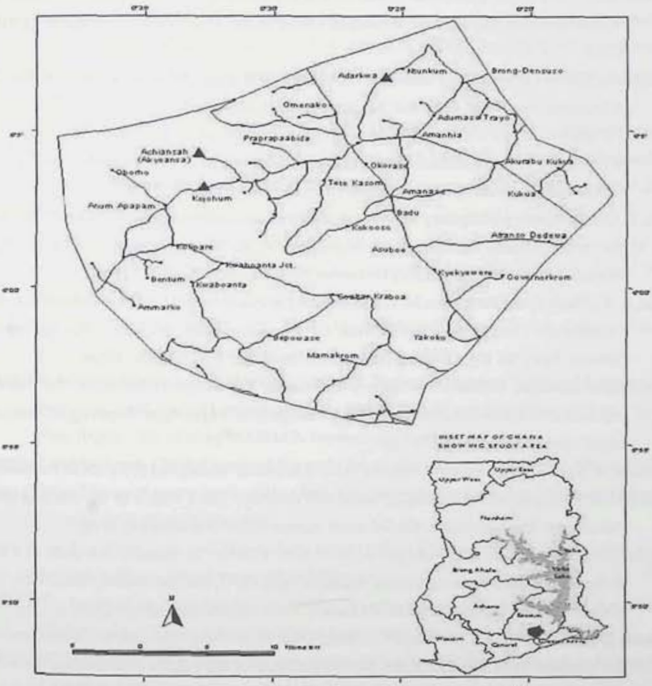

Figure 2. Map of Suhum- Kraboa Coaltar District, showing Brong-Densuso at upper right corner.

References

Abekoe, M.K., Obeng-Ofori D., and Egyir, I.S (2002) Technography of Cocoa in the Forest Zone of Ghana. Unpublished Technical Report, Convergence of Sciences Project. University of Ghana, Legon, 51 pp.

Anonymous, (1951) Capsid Research: Chemical Control. Annual Report, West African Cocoa Research Institute, April 1949- March 1950, 42–44 pp.

Anonymous, (2000) *Ghana Cocoa Board Handbook*, (8th Edition). Accra, Ghana: Jamieson's Cambridge Faxbooks Ltd.

Anonymous, (2001) Cocoa germplasm utilization and conservation: a global approach. Report of a regional technical meeting held in Abidjan, Côte d'Ivoire, 19-23 March 2001, Rome: (IPGRI) 40 pp.

Anonymous, (2005) *The state of the Ghanaian economy in 2004*. University of Ghana, Legon: Institute of Statistical Social and Economic Research (ISSER) publication.

Asante E. G. and Ampofo, S. T. (1999) Formation of village level farmers' services companies as a means of improving farmers' productivity and cocoa production in short term: Document submitted to Ministry of Food and Agriculture, Ghana (Unpublished): 25 pp.

Baah, F. (2002) Farmer participatory approaches towards cocoa implementation. Pages 27-35 In: J. Vos, and P. Neuenschwander, (Eds.) Proceedings of the West African Regional Cocoa IPM Workshop, Cotonou, Benin, 13-15 November 2001. Newbury (UK): CPL Press, .

Braun, A. R., Thiele G and Fernandez, M. (2000) Farmer Field Schools and Local Agricultural Research Committees: Complementary Platforms for Decision-making in Sustainable Agriculture. Network Paper No 105, Overseas Development Institute (ODI), London, 16 pp

Bruin, G. and Meerman, F. (2001) New ways of Developing Agricultural Technologies: The Zanzibar experience with participatory Integrated Pest Management. Wageningen: Wageningen University, Department of Entomology, 167 pp.

Collinson, M. (Ed.) (2000). History of Farming Systems Research. Wallingford (UK): CABI Publishing

CREM, (2002) Analysis of environmental, social and economic issues related to the cocoa products consumed in The Netherlands, CREM report number 02.578 (Unpublished) 33 pp.

Donkor, M. A., Henderson, C. P. and Jones, A. P. (1991) Survey to Quantify Adoption of CRIG Recommendations. Farming System Research Paper No 3, Interim Working Document. Tafo (Ghana): Cocoa Research Institute of Ghana (CRIG), (unpublished report) 29 pp.

Dormon, E. N. A., Van Huis, A., Leeuwis, C., Obeng-Ofori D. and Sakyi-Dawson, O. (2004) Causes of low productivity of cocoa in Ghana: farmers perspectives and insights from research and socio-political establishment. *NJAS – Wageningen Journal of Life Sciences 52: 237-259.*

Dormon, E. N. A., Leeuwis, C. Fiadjoe, F. Y. Sakyi-Dawson O. and Van Huis A. (2006) Creating space for innovation: the case of cocoa production in the Suhum-Kraboa-Coaltar District of Ghana. *International Journal of Agricultural Sustainability* (accepted, in press).

Entwistle, P.F. 1972. *Pests of cocoa.* London: Longmans, 779 pp.

Flood, J., Guest, D, Holmes, K.A., Keane, P., Padi, B., and Sulistyowati E., (2004) Cocoa under attack. Pages 33-53 In: J. Flood and R. Murphy. (Eds.). Cocoa Futures: A source book of some important issues facing the cocoa industry. Chinchina (Colombia): CABI- EDERACAFE.

Flood, J. and Murphy, R. (Eds). (2004) Cocoa Futures: Asource book of some important issues facing the cocoa industry. Chinchina (Colombia): CABI- EDERACAFE.

Henderson, C. P., Owusu, G. K., Jones, A. P. and Padi, B. (1994) The importance to cocoa research for understanding farmers' rationale towards pest and disease control with reference to capsid and black pod disease control in Ghana. In: Proceedings of the 11th International Cocoa Research Conference, 18–24 July 1993, Yamoussoukro, Côte d'Ivoire. Hertford (UK): Stephen Austin & Sons Ltd., 299–304 pp.

Holmes, K. A. and Flood, J. (2002) Biological control of diseases of tropical tree crops with specific reference to cocoa and coffee. Pages 17-26 In: J. Vos, and P. Neuenschwander, (Eds.) Proceedings of the West African Regional Cocoa IPM Workshop. Cotonou, Benin, 13-15 November 2001. Newbury (UK): CPL Press, .

Leston, D. (1971) Ants, Capsids and swollen shoot in Ghana: interactions and the implications for pest control In: Proceedings of the 3rd international cocoa research conference, Acrra, Ghana. 1969, 205-221 pp.

Marchart, H. (1971) Reply to Denis Leston: Ants, Capsids and swollen shoot. In: Proceedings of the 3rd cocoa International research conference, Accra, Ghana. 1969.

MASDAR, (2004) Ghana/European Union Cocoa Sector Support Programme Technical Assistance for the Re-organisations and Commercialisation of the Cocoa Research Institute of Ghana. Project Final Report. Submitted by MASDAR- International Consultants. 28 pp.

Newell, C. and Tucker, A. (2004) Cocoa and fair-trade. Pages 104-113 In: J. Flood and R. Murphy.(Eds.). Cocoa Futures: A source book of some important issues facing the cocoa industry. Chinchina (Colombia): CABI- EDERACAFE

Ollenu, L. A. A, Owusu, G. K. and Thresh, J. M. (1989) Spread of cocoa swollen shoot virus to recent plantings in Ghana. Crop protetion 8: 251-264

Opoku I. Y., Appiah A. A., and Akrofi A. Y. (2000) Pytophtora Megajkarya: a potential threat to the cocoa industry in Ghana. Ghana Journal of Agricultural Science 33, 23-248.

Padi, B. (1997) Prospects for the control of cocoa capsids-alternatives to chemical control. In: Proceedings of the First International Cocoa Pests and Diseases Seminar, 6–10 November 1995, Cocoa Research Institute of Ghana (CRIG), Akim-Tafo, Ghana, 28–36 pp.

Padi, B., Ackonor, J. B., Abitey, M.A., Owusu, E. B., Fofie, A. and Asante E. (2000) Report on the Insecticide Use and Residues in Cocoa Beans in Ghana. Internal Report submitted to the Ghana Cocoa Board. 26 pp.

Padi, B., Downham, M., Farman, D. I. and Sarfo, J. E. (2001) Evidence of sex attractants in the cocoa mirids *Distantiella theobroma* (Dist) and *Sahlbergella singularis* Hagl. (Heteroptera: Mridae) in field-trapping experiments. In: Proceedings of the 13th International Cocoa Conference, Kota Kinabalu, Saba, Malaysia, 9-14 October 2000, 395-402 pp .

Padi, B., Ackonor, J. B., and Opoku I. Y. (2002) Cocoa IPM Research and Implementation in Ghana. Pages 54-62 In: J. Vos, and P. Neuenschwander, (Eds.) Proceedings of the West African Regional Cocoa IPM Workshop, Cotonou, Benin, 13-15 November 2001. Newbury (UK): CPL Press, .

Pamplona-Rogers, G.D. (1998) *Encyclopaedia of medicinal plants: Education and health library*. Madrid, Spain: European Union. Vol. 2 795pp.

Pretty, J. N. (Ed). (2005) *The pesticide Detox: Towards a more sustainable Agriculture*. London: Earthscan 294 pp.

Pretty, J. N. and Chambers, R. (1994) Towards a learning paradigm: new professionalism and institutions for agriculture. In: Scoones, I. and Thompson, J. (eds.) *Beyond farmer First: Rural Peoples Knowledge, Agricultural Research and Extension Practice*. London: Intermediate Technology Publications,182-202 pp.

Richards, P. (2001) Technography: Notes on methods. Unpublished working paper. Wageningen University, Wageningen: Convergence of Sciences Project.

Röling, N. G., Hounkonnou, D., Offei, S. K., Tossou R. C. & Van Huis, A. (2004) Linking science and farmers' innovative capacity: diagnostic studies from Ghana and Benin. *NJAS-Wageningen Journal of life sciences* 52: 211-235.

Ter Weel P. and van der Wulp H. (1999) Participatory Integrated Pest Management: Policy and Best Practice. The Hague, Netherlands; Ministry of Foreign Affairs. 67 pp.

Van der Vossen, H. A. M. (1999) Strategies of variety improvement in cocoa with emphasis on durable resistance. Proceedings of the International Workshop on the Contribution of Diseases Resistance to Cocoa Variety Improvement, 24th – 26th November, 1996, Salvador, Bahia, INGENIC (International Group for Genetic Improvement of Cocoa): 23-31.

Van Huis, A. and Meerman, F. (1997) Can we make IPM work for resource-poor farmers in Sub- Saharan Africa? *International Journal of pest management* 43 (4), 313-320.

Van Huis, A., Röling, N.G., Jiggins, J., Leeuwis, C., Sakyi-Dawson, O., Struik, P.C. and Tossou, R.C. (2006) Research researched: Can Convergence of Agricultural Sciences support innovation by resource-poor farmers in Benin and Ghana? *International Journal of Agricultural Sustainability* (accepted in Press)

Van Mele, P. and Cuc, N. T. T. (2003) *Ants as Friends: Improving your Tree Crops with Weaver Ants*. Cali (Columbia): CABI *Bioscience*, 67 pp.

Vos, J. and Lass, T. (2002) Biscuit, Cake, Chocolate, and Sugar Confectionery (BCCCA) Cocoa research programme: Supporting the development of better ways to control pests and diseases in cocoa. Pages 11-14 In: J. Vos, and P. Neuenschwander, (Eds.) Proceedings of the West African Regional Cocoa IPM Workshop, Cotonou, Benin, 13-15 November 2001. Newbury (UK): CPL Press, .

Vos, J. and Neuenschwander, P. (Eds). (2002) Proceedings of the West African Regional Cocoa IPM Workshop. Cotonou, Benin, 13-15 November 2001. Newbury (UK): CPL Press,.

Vos, J. G. M. and Krauss U. (2004). Working with farmers. Pages 140-149 In: J. Flood and R. Murphy. (Eds.). Cocoa Futures: A source book of some important issues facing the cocoa industry. Chinchina (Colombia): CABI- EDERACAFE

Vos, J. G. M. and Page, S. L. J. (2005) Towards Safe Cocoa Pest Management in West Africa. Pages 181-192 In: J.N. Pretty (Ed.) The Pesticide Detox: Towards a More Sustainable Agriculture. *London: Earthscan*

Wood G. A. R. and Lass R. A. (1985) Cocoa: Tropical Agricultural Series (4th Edition). London and New York: Longman 620 pp.

http//www.faostat.fao.org/(Fao, 2006) [Faostat Citation-database]

Padi, Beatrice (Ex-Deputy Director of Cocoa Research Institute of Ghana and Head of Entomology Division). Personal Communication in 2003.

Nathaniel, Nick (Scientists CABI Bioscience UK) Personal Communication in 2005.

Chapter 2

Converging farmers' and scientists' perspectives on researchable constraints to organic cocoa production in Ghana: results of a diagnostic study

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Chapter 2

Converging farmers' and scientists' perspectives on researchable constraints to organic cocoa production in Ghana: results of a diagnostic study

Abstract

A diagnostic study was conducted to identify the major constraints on organic cocoa production at Brong-Densuso and surrounding communities in the Suhum-Kraboa-Coaltar District, Eastern Region, Ghana. The study followed a technographic study that highlighted cocoa as a public crop requiring broad techno-social innovations. In the technographic study, problems identified included low yields, persistent pest management constraints and a low adoption rate of technologies developed by the Cocoa Research Institute of Ghana (CRIG). The diagnostic study adopted a Participatory Learning and Action Research (PLAR) approach to set up and implement fieldwork with relevant stakeholders leading to problem identification, prioritisation, and collective design of an action plan (research agenda). Cocoa farmers within the study area are conscious of the environmental problems associated with the use of inorganic pesticides and the high cost of using them. Hence, they produce cocoa without applying any pesticides. Quite recently, however, their association with an organic marketing company led to the search for non-chemical pest and disease control measures and for ways to certify their cocoa beans as organic. A misconception as to what species of cocoa pests constitute 'capsids' was settled between farmers and scientists using a cage experiment on capsid damage. The farmers became convinced that the Cocoa Mosquito (*Helopeltis* spp.) (Hemiptera: Miridae) which they had previously considered an important pest, was a capsid specie that caused little or no damage to the beans inside the pods. After this clarification, damage caused by the Brown Capsid (*Sahlbergella singularis*; Hemiptera: Miridae) and the Black Capsid (*Distantiella theobroma*; Hemiptera: Miridae) emerged as the most serious production constraints, followed by Black Pod disease (caused by *Phytophtora palmivora)*. The malfunctioning of tenancy agreements and the mistrust between landlords, who are mainly absentee farmers, and their caretaker cocoa farmers pose a serious threat to pest management innovations, especially where pruning to control Black Pod disease and uprooting trees infected with swollen shoot are concerned. The key stakeholders involved in the study agreed on three innovative (organic) capsid control methods for further research. The use of sex pheromone traps, crude aqueous neem (*Azadirachta indica*) seed extracts, and the use of ant (*Oecophylla longinoda*) colonies as biological control agents, the latter being proposed by farmers. The paper reflects on diagnostic study as a continuous process in response to a continually changing context even beyond the end of the diagnostic research phase.

Additional keywords: participatory research, cocoa pests and diseases.

Introduction

Agricultural research agendas are often drawn up and implemented without systematic participation of and consultation with farmers. Agriculture in tropical regions usually is complex and risk-prone. It uses few external inputs and has multiple purposes (Reijntjes *et al.*, 1992). It therefore requires site-specific solutions and active involvement of farmers. Conventional agricultural research based on 'linear ways of thinking' has largely failed to provide the desired technologies and innovations that meet the needs of resource poor farmers (Richards, 1985; Chambers and Jiggins, 1987; Röling 1988; Van Huis and Meerman, 1997). Formal research institutions are becoming increasingly concerned about the very low adoption rates of the technologies they have developed. For example, surveys revealed that only 0.4% - 3.5% of the farmers adopted pest and disease control technologies developed by the Cocoa Research Institute of Ghana (CRIG) (Donkor *et al.*, 1991, Henderson *et al.*, 1994; Padi *et al.*, 2000).

This concern often translates into a misconceived question: how do we make farmers adopt our research recommendations? The low adoption may be due to the linear processes and top-down approaches used in their development and dissemination in the first place (Matteson *et al.*, 1994; Röling, 1996). Conventional practice assumes that researchers are the custodians of knowledge and the source of technical innovations, that extension is a delivery mechanism and that farmers are the 'ultimate users' (Bruin and Meerman, 2001) The ineffectiveness of conventional agricultural research, especially for highly diverse, rainfall dependent and risk-prone agriculture has led to a search for Participatory Technology Development (PTD) methods (e.g., Jiggins & De Zeeuw, 1992). Such methods are especially important in situations where farmers do not have countervailing power over agricultural politics, over research and other institutions, including donors (Röling and Jiggins, 1998).

The diagnostic study presented below fits squarely into the PTD tradition. It is an attempt to experiment with a research phase that deliberately sets out to make 'pre-analytic choices' (Giampietro, 2003) in a way that gives farmers an optimal chance to influence the outcome. A diagnostic study seeks to establish effective collaboration among stakeholders, especially farmers, but also including others such as extension workers, scientists, marketing groups, and policy makers, to identify production constraints and to design action research to overcome them. The method involves collective problem description and mobilization of local resources towards an interactive design of research to produce technologies and forms of organization 'that work and are acceptable' to farmers and hence can become part of farmers' innovation strategies (Röling, 2002).

In order to allow the reader to assess the extent to which farmers and other stakeholders were given a fair chance to affect the pre-analytic choices, it is relevant to explain the 'baggage' with which the principal researcher entered the study. At the beginning, when he joined the Convergence of Sciences (CoS) project, he intended to work on cashew. However, this was not allowed by CoS management. CoS scientists from the three participating countries (Ghana, Benin and the Netherlands) had met and decided on the crops and eco-regions that CoS was to work on, and cashew was not one of the crops selected. These decisions had been made before any farmer was consulted. Hence, his initial interest in Integrated Pest Management (IPM) in cashew shifted to IPM in cocoa. In this regard, two pre-analytic choices were made: cocoa and IPM. These choices seem not unreasonable, however.

The diagnostic study draws part of its objectives from an earlier study referred to as technographic study suggested by Richards (2001). The technographic study was to identify broad socio-technical innovation needs and key actors within an industry (at the macro-level). Cocoa had been identified as a public crop that required introduction of innovations to enhance and sustain Ghana's major cash crop industry (Abekoe *et al.*, 2002). The technographic study on cocoa highlighted some broad techno-social constraints including low yields, persistent pest management problems, collapse of farmers' organizations, weak extension support and low adoption of proposed technologies (Abekoe *et al.*, 2002). Literature reviewed suggested that low yields in cocoa are associated with capsid damage causing between 25%–30% crop losses (Anon., 1951). A more recent study indicated that the cost of capsid control by the use of synthetic pesticides is too high for resource-poor farmers, and that farmers, consumers and the general public are increasingly aware of their negative effects on human health and the environment (Padi, 1997). This threatens the sustainability of cocoa production, an important cash crop and foreign exchange earner in Ghana. The questions then are: Is there an opportunity to pursue ecologically friendly methods of capsid control? Will that lead to sustainable pest management towards organic cocoa production?

The concept of organic cocoa is fairly new in Ghana even though some aspects of organic practices have been used by cocoa farmers for decades. They practise 'organic by default' for two main reasons: some do not spray synthetic pesticides because they cannot afford to use them and others because they consider them poisonous and hazardous to human health. 'Organic by default' is simply the way the cocoa farmers produced cocoa before the introduction of inorganic fertilizers and pesticides. So the potential for producing organic cocoa exists but there is a need to organize and build the capacity of interested farmers and provide them with the necessary research and extension support to increase yield for sustainable production. Owing to the fact that organic cocoa is fairly new, the structures and networks to support its development are equally weak or non-existent. As a result, there are only two areas in Ghana where some experiments with organic cocoa production have been carried out. These areas are the Kakum forest reserve in the Central Region, and Brong-Densuso reported on in this article. The re-introduction of cocoa diseases and pest control (CODAPEC) programme (mass spraying) by the Ghanaian Government in 2001 has adversely affected the Kakum organic initiative and cocoa beans from that area can no longer be classified as organic. Hence, the only place in Ghana with the potential to produce and market organic cocoa now is Brong-Densuso. But had it not been for farmers' outcry that we witnessed and that alerted CRIG, which in turn involved other relevant institutions to intervene, the only organic cocoa production initiative left would have been effectively destroyed.

Organic cocoa farming at Brong-Densuso could be said to have started long ago because over 95% of the farmers have not sprayed their cocoa farms for about 20 years. Yet, it was not until one of the cocoa farmers travelled overseas and returned with the idea of adopting scientific organic practice in order to benefit from a mark-up that they decided to embark upon 'organic' cocoa production. Consequently, about 80% of the community farmers embraced the idea of organic farming and formed the Traditional Organic Farmers Association (TOFA). The association established links with the International Federation of Organic Agriculture Movements and became members of the movement. In 1997, TOFA established links with the Organic Commodity Products (OCP). Currently, the organic cocoa production at Brong-Densuso intends to work towards a broader understanding of the cocoa ecosystem and use its components wisely in respect of the laws of nature. Specifically, farmers want to be assisted to use natural and environmentally friendly methods to improve soil fertility and control pests and diseases, particularly capsids.

The diagnostic study was, therefore, to establish whether capsid damage in cocoa was indeed perceived as a serious production constraint by cocoa farmers, and whether it was worthwhile devoting four years of research to that problem. It was also to find out who constitute the relevant stakeholders and what are their perceived problems, views, interests and goals, as well as who would be willing to participate in a further study to address farmers-felt needs. The diagnostic study aimed to co-design with all stakeholders an action research agenda to develop IPM approaches to tackle the capsid problem.

Materials and methods

Overall approach

The diagnostic study began with an extensive literature review. For its fieldwork, the study used qualitative methods adopting Participatory Learning and Action Research (PLAR) methods described in a resource guide that draws heavily on the application of Participatory Rural Appraisal (PRA) tools and techniques (Defoer *et al.*, 2000). PLAR aims to assist farmers through learning tools to identify, infer and analyse what they perceive as problems and suggests ways that make the best use of local resources to address them. The study with farmers was conducted using the following major steps: (1) *introduction*, which primarily looked at setting up and implementing the study; (2) *participatory problem identification and prioritization*, with emphasis on making the problems and processes more practical through the use of maps and diagrams drawn by farmers; and (3) *re-examining and sorting out conceptual differences* through further dialogue and discovery learning experiments involving the farmers' Local Agricultural Research Committee (LARC), CRIG scientists, extension workers and the PhD research team. The final step, (4) *action-planning*, included the election of farmers by the community to conduct further research with other stakeholders. During the entire process, the senior author continued to reflect on the changing government policy, marketing opportunities and other contextual issues.

The study area

The Brong Densuso study area was chosen based on farmers', scientists', extension officers' and researchers' opinions after preliminary visits because of the following characteristics:

1. Brong-Densuso is the central location of an estimated 600 ha area where cocoa farmers are committed to the production of organic cocoa but are experiencing some production problems.
2. Its cocoa farmers are committed to learn, share knowledge and experience to address their production constraints.
3. The presence in the area of a cocoa farmers association and a private organic marketing company.
4. The proximity to the CRIG research station allowing easy interaction with scientists.

After preliminary interaction with the relevant stakeholders, it was realized that the area offered a unique opportunity for carrying out interactive research leading to local innovations that can be shared by all partners. The presence of an organic company, OCP from the USA, and of the traditional organic farmers association TOFA seemed to offer an ideal space for innovation and partnership between a strong market development company and relatively organized farmers with whom the research team could establish a contractual partnership.

The study area covers the township of Brong-Densuso and its surrounding communities including hamlets in cocoa farms. Brong-Densuso is a small twin town with Akwadum on the trunk road that connects Suhum, the district capital of the Suhum-Kraboa-Coaltar District, and Koforidua, the capital of the Eastern region. The Eastern Region falls within the semi-equatorial forest zone and experiences a major (March to June) and minor (September to October) rainy season. The temperature varies between 24 °C and 29 °C, and the annual rainfall between 1270 mm and 1650 mm (Abekoe *et al.*, 2002). Brong-Densuso is the central point for Brong No.1 and Brong No. 2, Obuotumpan and Nkatenkwan villages and hamlets. The estimated population for all four communities is 1881 people from various ethnic groups who are mainly farmers. The main ethnic groups include Akans, Ewes and Ga-Adangbes. The Krobos who are part of the Ga-Adangbe ethnic group constitute the majority tribe in the area. The various ethnic groups - who are migrants - have purchased cocoa lands in the study area from the Akyems (the indigenous landowners) and have now become the *de facto* owners. The present generation of cocoa farmers has either inherited the land from their parents or grandparents. Family members who have not benefited from direct inheritance, in some cases, have been given the right to use the land but cannot own it.

Farm owners (cocoa landlords) who engage the services of caretakers mainly adopt the *abusa* system, according to which the yield is shared in a 2:1 ratio: two-thirds go to the farm owner and one third goes to the caretaker. The concrete arrangement varies per situation and depends on the relationships between the two parties. In other cases, landlords and caretakers share the yield equally (the *abunu* system). This system is usually adopted for caretakers who are close family relatives or migrant farmers who had helped to establish new cocoa farms. There is still another category of farmers who have their own cocoa farms, but have arranged to take care of neighbouring farms for people referred to as 'absentee landlords'. They share the yield in different proportions. Few farmers have documented agreements to abide by; but the arrangements are mostly based on trust with family members or neighbours as witnesses.

Specific Participatory Learning and Action Research tools used

The methodological tools of PLAR are steps to guide the study aimed at participatory identification of constraints and collective planning to resolve them. The specific PLAR tools used were as follows:

The introductory community meeting

The diagnostic study started with a meeting to inform all cocoa farmers in the Brong-Densuso and surrounding farming communities about the objectives of the study and to ask for their participation in drawing up a plan of action. On the day of the meeting, the senior author had to introduce himself as a research student in the presence of an extension worker, CRIG researchers, OCP staff, a Produce Buying Company (PBC) officer and members of the TOFA. The message was to conduct research into cocoa with them, with emphasis on learning from each other. After the formalities, the meeting took the form of an open forum discussion on the general concerns in farming and life in the community. Following a brainstorming session on general farming problems, we agreed to meet each Thursday (a non-farming day) to collectively diagnose the causes of the problems the farmers had enumerated or perceived to be affecting cocoa production. At the end, 22 (15 males and 7 females) out of the 57 cocoa farmers present volunteered to participate in the diagnostic phase of the research. The 22 farmers became the consultation group that represented the community in subsequent meetings for open discussions, jointly facilitated by the researcher, the farmers and an extension worker from the Ministry of Food and Agriculture (MoFA). The number of farmers at meetings varied from time to time due to absentees.

A community territory map

In a subsequent meeting, farmers were given a flip-chart sheet to draw a map of their community showing territorial boundaries, neighbouring villages and important resources for discussion by all stakeholders. The process of drawing the map, surprisingly, went beyond the initial goal and generated discussions on land ownership and on apparent disagreements between cocoa land caretakers and landlords in relation to certain agricultural management practices.

A community organizations chart

The volunteering farmers were encouraged to list and indicate on paper the various organizations they interact with, using Venn diagrams to classify them into external or internal organizations and also indicate the extent of interaction in each case (Defoer *et al.*, 2000). The diagram was to assist the research team, farmers and community members, in identifying and visualizing the major agricultural organizations to which community members belong or interrelate with. It was also to show linkages between the organizations and their respective functions. Some information gathered from the map was triangulated with the organization diagram and vice-versa (see stakeholder analysis for details).

Farm visits with key informants

The research team accompanied three to five farmers to their fields on four different occasions to see the practical things they do, experience how they conduct their farm activities and listen to the reasons for the things they do. The farm visits were to provide opportunity to observe, learn and discuss farm management practices including how the farmers handle cocoa pest and disease problems in the field.

Identification of major pest and disease constraints

Ranking and scoring was used as a methodological tool to prioritize pest and disease problems in order to find out whether capsid damage was the major technical problem affecting cocoa production. Initial meetings held with farmers did not confirm the expectation. It was only after a disagreement between farmers and scientists as to what constituted 'a capsid' was resolved and pest and disease problems were re-prioritized, that capsids came out as the major technical constraint. Details of how the priority setting took place are presented in the section on results and discursion under the subheadings 'production constraints' and 'negotiating insect knowledge between farmers and scientists'.

Discovery learning and negotiation exercises through cage experiments

In the first round, Black Pod disease came out as the highest priority problem. The Cocoa Mosquito (*Helopeltis* spp.) (H) was second, while the other capsids *Distantiella theobroma* (DT) and *Sahlbergella singularis* (SS) ranked fourth in importance. Farmers considered the cocoa mosquito as a major pest because it leaves unsightly lesions on the skin of cocoa pods and causes clamped beans. However, clamped beans are known to be caused by the African shield bug (*Bathycoelia thalassina*) (BT). Meanwhile, according to scientists, the capsid species DT and SS cause real economic damage by attacking young shoots and small and medium pods, but this damage is less visible to farmers. To 'negotiate' this issue, the following experiment was designed with farmers.

Farmers collected the insect species H, SS and BT from their farms, including adults and nymphs. At the time of experiment DT was not available. A cage experiment was subsequently conducted under farmers' conditions using six treatments and three replications. The treatments included H adults, BT nymphs and adults, SS 2nd instar, SS 4th instar and SS adult. A treatment consisted of four insect specimens per cage. Plastic containers with a nylon-mesh lid to allow for effective ventilation were used as cages. In each cage the insects were offered cocoa pods, young cocoa shoots (both soft and hard) and fruits of *Displatsia dewevrei* (an alternative host plant for *Sahlbergella singularis*) of about the same size or surface area as the cocoa pods.

The set-up was monitored four times for 96 hours involving farmers and scientists. Data on feeding lesions of the various groups of insects were recorded. After the experiment, the pods were opened and the 'beans' (seeds) observed for possible damage (clamped beans, etc.). The number of lesions on the shoots and pods was counted and compared to identify the relative feeding preferences of the insects and the damage they caused.

Concluding community meeting

The purpose of the concluding meeting was to report on the major issues that had emerged in order to find ways to address them. It was an opportunity for the rest of the community to express their concerns and reactions. Following this exercise, community members belonging to different social groups such as farmers, opinion leaders and TOFA members, were divided into two smaller groups in a way that ensured that each subgroup represented all the categories identified. They discussed, debated and came out with their methods for pest and disease control, stating what is known and practised and what is known but not practised. The same subgroups followed the same procedure to come out with their criteria for appropriate pest management strategies. From the list of the criteria, scientists from CRIG, the extension worker and other stakeholders also made their suggestions, until all finally agreed on three methods to be tested against capsids. The senior author facilitated this process.

The agreed research agenda was appraised to assess its economic viability, with all stakeholders sharing information on the prospective benefits of organic cocoa production. The community members were asked to elect not more than seven highly committed farmers from the 22 who had volunteered from among the initial 57 at the first meeting, to represent the community in the subsequent research and learning processes to be undertaken. Although they were asked to take into account gender balance, the seven farmers elected included six males and only one female. Hereafter they will be referred to as the Local Agricultural Research Committee (LARC), which became the link between the community and the research team as described by Braun *et al*. (2000).

After the election of LARC members it became evident that the farmers had used the following election criteria, not in any order of importance:

1. Voluntary spirit as judged by the community.
2. Appreciable knowledge about cocoa.
3. Previous experience with agricultural research, development, or extension
4. Readiness to make time for communal activities.
5. General behaviour of the chosen farmers; in terms of attitude to work ('not lazy').
6. Self-help spirit and devotion to the community's goals.

7. Generally, primary school level education
8. The ability to report back to the community on what has been done within a fixed period of time.
9. Active and not shy to express themselves in public (for females in particular).
10. Patience, honesty and humility.

Other tools or methods employed

1. Extensive use of PRA tools such as ranking and scoring, seasonal calendar, semi-structured interviews, problem-tree techniques and triangulation of data from secondary sources.
2. Intensive literature search and desktop analysis of data collected in the field.
3. Sharing the outcome of the study in a seminar with key organizations such as CRIG, MoFA and CoS project members to incorporate suggestions as necessary.
4. Stakeholder analysis
5. Facilitation by the senior author of the prevention of mass spraying of the organic farms including the plots set aside for the experiment.
6. Translation into the local language of written reports from the study to community members for their comments. LARC has asked for a final copy for its records.

Results and discussion

The major Stakeholders

The major stakeholders in organic cocoa production identified during the diagnostic study are:

The Traditional Organic Farmers Association

The Traditional Organic Farmers Association (TOFA) is the umbrella association that represents the aspirations of cocoa farmers who are interested in producing cocoa for premium prices by using organic and safe methods of farming. It was established to help educate its members to achieve their collective aim of not spraying synthetic pesticides but its organization still appears to be quite weak. There are about 10 farmers who have been trained to act as a neem extract spraying gang. They work under instructions from TOFA, OCP and CRIG.

The Organic Commodity Products

Organic Commodity Products (OCP) is an American organic cocoa marketing company. Being interested in organic cocoa OCP established contact with TOFA and had an agreement with Ghana cocoa board (COCOBOD through CRIG to fund CRIG's small-scale and countrywide large-scale trials on the use of neem to control capsids, and to improve soil fertility in organic production, and finally, buy the cocoa beans for a premium price from farmers once the organic certification would be successfully completed. OCP was also paying for the cost of organic certification. In the absence of effective extension support, the company employed field staff who provided support to organic farmers.

The Ghana Cocoa Board

The Ghana Cocoa Board (COCOBOD) was established in 1947. It is governed by a board of directors appointed by the Government and is mandated to monitor and regulate the operations of the cocoa, coffee and sheanut industries. COCOBOD regulates the marketing and export of cocoa and its products but had no project to produce organic cocoa until OCP sought its permission to fund organic research and certify the beans for export. Therefore, OCP expected COCOBOD to grant exclusive rights to the company for at least five years after the organic certification of Ghanaian cocoa had been obtained so as to enable the company to obtain sufficient returns on its investment into neem research that began in 1998 and was supposed to end in 2003.

The Licensed buying companies

There are three main buying companies in the community but, as part of the agreement with OCP, plans were far advanced for OCP to purchase the organic cocoa through the COCOBOD. One of COCOBOD's subsidiaries, the Produce Buying Company (PBC), received specific instructions to separate the organic cocoa beans when certified so that OCP can export them.

The Cocoa Research Institute of Ghana

The Cocoa Research Institute of Ghana (CRIG) is a subsidiary of COCOBOD, charged with the responsibility for research on cocoa. CRIG initiated cage, laboratory and field trials with neem in 1998. The first year of a field verification trial was in 2001. With funding from OCP, CRIG also trained spraying gangs and provided them with spraying equipment and other inputs required for the application of aqueous neem seed extracts (ANSE).

The Ministry of Food and Agriculture

Traditionally it was not the Ministry of Food and Agriculture (MoFA) but the Cocoa Services Division (CSD) – also a subsidiary of COCOBOD – that was in charge of cocoa extension. Under pressure from a structural adjustment programme, MoFA has now been given this responsibility. The effect of this recent change can be seen in the field. The number of farmers per extension worker was already very large and has now been increased further while their work has been complicated by having to take on cocoa as additional crop. Meanwhile, OCP had a special arrangement with two extension workers, in addition to its own field staff, to provide extension support to the organic farmers. Individual interests of all stakeholders were in sink with their collective objective of producing organic cocoa for the export market. Although their efforts, to some extent, were already quite complementary, all of them in different ways welcomed the CoS approach of working together with farmers to identify priorities for further research.

The different categories of cocoa farmers

Within the local context, we identified four different categories of farmers with females and males in all categories, except for casual labourers who all were males. Figure 1 presents a pie chart with the percentages of the different categories in the 'farmer' population. Two major farmer groups are the landlords and the caretakers, who represent 43% and 28%, respectively. The other ones are landlords/caretakers i.e. farmers taking care of their own cocoa farms and, in addition, playing the role of caretakers for absentee landlords, and casual labourers who represent a relatively small number of people hired on a daily basis.

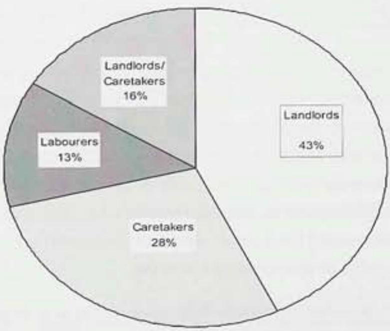

Figure 1. Estimated distribution of different categories of cocoa farmers (n = 830).

The impact of cocoa production on farmers' incomes

The population of the study area are farmers and the economy is basically an agrarian economy where about 90% of the inhabitants are cocoa farmers who also grow food crops for subsistence. However, information collected shows that they sometimes sell food crops to meet minor domestic expenses. For example, they may sell some cassava to be able to buy dried-fish for evening meals.

Wealth ranking with 10 farmers who used 100 stones to represent 100% of the people of Brong-Densuso and its surrounding communities revealed that the majority see themselves as low-income farmers but will not accept the word 'poor' (Table 1). According to them poverty is about all the negative things such as misery, deprivation, lack of education and no access to health care. As they put it, "If we continue to call ourselves poor, then there is no hope, but we have hope to overcome". A rich person or *osikani* was defined as someone who does not only possess his/her own house and a vehicle (either commercial or private, or both), but also contributes to the development of the community. For example, the only farmer score as 'rich' was a man who had provided a set of furniture for a church in the community. Community members in the self-help category (*mmodenbofo*), who constitute about 70% of the population, work hard to meet their basic needs with few available resources (land and their own labour).

Table 1. Distribution of societal (or Wealth) status as scored by farmers.

Societal status	English Translation	%
Osikani	Rich	< 1
Mmodenbofo	Self help	69
Anihafo	Lazy people	30

On the other hand, the lazy people or *Anihafo* are those who do not have any trade and are not 'real farmers' but spend most of their time 'arguing while playing draughts under a big tree'.
In another exercise, 18 farmers (males and females) were given 60 stones to score six crops they had earlier mentioned for their importance as the main source of income. The results from the scoring and ranking of the major crops grown confirmed that cocoa is their main source of income (Table 2). Farmers explained that income from cocoa enables them to build new houses or repair existing ones. At the personal level, some of them are able to save enough money from cocoa to pay the dowry needed to be able to marry a woman.

Table 2. Six most important crops ranked according to their contribution to cash income

1. Cocoa	4. Plantain
2. Cassava	5. Orange
3. Maize	6. Oil palm

To cross-check the relevance of cocoa as their major cash crop, the same 18 farmers used 120 stones, to show the distribution of their income across the year (Figure 2). The cocoa cropping calendar starts in November when the major harvest takes place, and ends in October the following year. Farmers explained that November is the month when their income is highest because it coincides with the peak cocoa harvest. The cumulative effects of acute shortage of

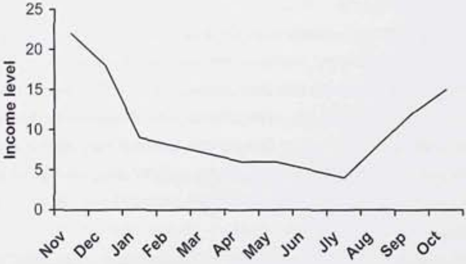

Figure 2. Monthly income levels of cocoa farmers at Brong-Densuso, Ghana

basic foodstuff such as cassava, and plantain, and unusual expenses at Christmas in December are felt in January, leaving a sharp decline of cash at hand. In January, income from cocoa is less than in the two previous months.

From Table 2 and Figure 2, it can be seen that cocoa clearly is the major source of monetary income. Farmers claim they obtain about 80% of their annual cash revenue from this crop. Consequently, they welcomed a research focus on cocoa.

Cocoa production levels

In another prioritizing exercise, farmers identified decreasing production as the core problem and cause of poverty. To triangulate farmers' claims, production data were gathered from the local officer of the PBC, a company which purchases about 80% of cocoa produced at the Brong-Densuso.

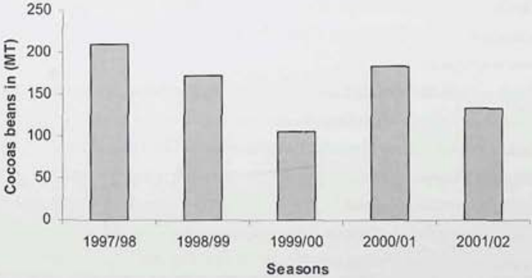

Figure 3. Amount of cocoa beans purchased from Brong-Densuso, Ghana, during five consecutive seasons.

Figure 3 shows wide fluctuations in production which was a cause for concern. What is more, for the second half of the 1990s, farmers' views on declining production levels in cocoa were to a great extent confirmed by these production data gathered. Cocoa beans purchased declined from 210 MT in 1997/1998 to 106 MT in the 1999/2000 season. However, the first years of the new millennium seem to show a slight improvement. The increase may be due to favourable cocoa prices offered by government and by an expected premium price for organic cocoa.

Production constraints

Table 3 shows how 19 farmers identified and ranked their production constraints by using 20 stones per farmer. Ten out of the 16 items in Table 3 are related to pest and disease problems. The farmers attributed their low yields to Black Pod disease caused by *Phytophthora palmivora*, which was seen as the most serious production constraint, followed by *Helopeltis* sp. (cocoa mosquito). Parasitic mistletoes, capsids, financial problems in the pre-harvest season and 'Malfunctioning of Tenancy Agreement' ranked among the highest production constraints. The relatively high score of the financial problems at pre-harvest period validates the data gathered on monthly income levels (Figure 2). Malfunctioning of tenure agreement was the fifth constraint together with the general disagreements between landlords and caretakers that affected crop management.

Table 3. Cocoa production constraints in order of importance, identified and ranked by 19 farmers in the study area (1st round). Local and scientific names in parentheses.

1.	Black pod (anonom)
2.	Cocoa Mosquito (*Helopeltis* spp.)
3.	Mistletoe (nkranpan)
4.	Capsids (akate) and financial problems
5.	Malfunction of tenure agreement
6.	Stem borers (osah)
7.	Weeds and parasitic climbing plant
8.	Destructive ants on (shade-plantain) roots
9.	Termites (nfote) and over aged trees
10.	Financial problems at pre-harvest season
11.	Swollen shoot (kokoo sasabro)
12.	Shade management (removal of unwanted chupons, overgrown branches, thinning or filling in)
13.	Destruction of cocoa by falling trees

As already indicated in the methodology section, the high ranking farmers gave to the Cocoa Mosquito provided an interesting example of scientist-farmer interaction. Farmers gave the high ranking because the cocoa mosquito is often seen in appreciable numbers and causes highly visible black lesions on the cocoa pods. For scientists, the cocoa mosquito belongs to the same insect family as the capsids. However, the damage it causes is relatively harmless, whereas, the damage caused by two other capsid species is economically very important indeed. These species, which are difficult to spot because they hide under the peduncles and pods and in crevices on stems and branches, are *D. theobroma* (DT) and *S. singularis* (SS). Although they also feed on pods, these two are more important because their feeding on tender shoots forms lesions that can become infected by fungi such as *Calonectria rigiduscula* which causes dieback disease of the cocoa tree (Entwistle, 1972).

Scientists explained these points to the farmers, which strengthened farmers' conviction that pests and diseases constitute their major problem. According to the farmers, six out of every ten pods are lost to pests and diseases.

Table 4. Cocoa pests and diseases of economic importance as ranked by 19 farmers in the study area (2^{nd} round).

Pest/disease	Local names	Pest/disease	Local names
1. Capsid	Akate	4. Termites	Nfote
2. Black Pod	Anonom	5. Mistletoes	Nkrapan
3. Swollen Shoot	Kookoo sasabro		

After sorting out the misconception on *Helopeltis* sp. damage, farmers re-ranked their production constraints (Table 4). In this second ranking exercise, capsids ranked first, followed by Black Pod. Although the assembled farmers felt that capsids should be the focus of the research, they agreed that also Black Pod disease control should be given some attention.

Negotiating insect knowledge between farmers and scientists

Joint ecological studies in cocoa plantations involving LARC farmers and scientists identified the following 'shortcomings' in the knowledge of farmers as perceived by the scientists:

1. Most of the farmers were not able to identify the capsid species *S. singularis* and *D. theobroma*, but all of them recognized the Cocoa Mosquito (*Helopeltis* spp.).
2. The farmers were not aware that capsid lesions on pods, if left untreated for long periods, become necrotic and could look like the result of Black Pod infection;
3. The farmers believed that *Helopeltis* spp. damage cocoa pods and are the cause of clamped beans ('apo-a-apo'). In reality they are caused by *B. thalassina* feeding, leaving the beans

empty and dehydrated.

On the other hand, farmers made the following observations, which were confirmed by scientists:

1. All farmers associated the visible lesions on cocoa pod with *Helopeltis* spp.
2. One farmer claimed that SS capsids feed on the cocoa tender shoots, sucking sap from the plant and that this effect is most devastating in young cocoa plants.
3. Farmers observed that the Cocoa Mosquito (*Helopeltis* sp.) physically looks like a malaria mosquito (the vector of malaria) and that this species is very different from the two capsid species that form the major pests.

CRIG scientists were impressed by the farmers' knowledge on cocoa ecology. To bridge the 'gaps' they perceived between their knowledge and that of the farmers, they made a presentation showing the species and the damage they cause. They also shared some information on the biology and behaviour of capsids. The scientists explained that *Helopeltis* lesions on cocoa pods only have serious consequences when the pods are still as small as fully grown okra (*Abelmoscus esculentus)* fruit, but that they do not lead to damage pod is mature to the beans, when pods are mature.

Although the earlier misconceptions about the role of *Helopeltis* spp. appeared to have been cleared following the explanations from CRIG scientists and the ecological studies in the plantations, it was considered appropriate to conduct a cage experiment for discovery learning to further clarify the situation. We have explained the experimental set-up in the methodology section. Here we describe some of the concrete outcomes. The cage experiment focused on allowing farmers to discover 'what eats what and causes what'?

The farmers convinced themselves that although the cocoa pods in the cage with *Helopeltis* spp. showed a lot of lesions, when the pods were opened the beans were not affected in any way. They also observed that apart from the cocoa pods, *Helopeltis* spp. did not feed on any of the other plant materials, indicating that in the absence of cocoa pods, *Helopeltis* spp. do not cause any harm to the tree. The adult of SS adult fed on all the plant materials in the cages. Farmers were shocked to learn that the five developmental stages (1st to 5th instars) as well as the adults of SS feed on both hard and soft tissues and on the productive parts of the cocoa plant, including the pods. The scientists explained that the DT capsids, which were not included in the cage experiment, also passes through five instar stages causing similar damage (as the SS) to cocoa, but prefer soft shoots to hard ones.

The adult of *S. singularis* fed on all the materials in the cages. Farmers realized that the likelihood that the species can survive in the absence of the cocoa pods makes them quite dangerous. In all treatments, however, farmers observed that although some pods and young shoots had turned black and mouldy, no damage to the beans was observed when the pods were opened. Yet, the scientists argued that the lesions on the tree and the pods, particularly on shoots, could become infested and cause die-back, which consequently may kill the cocoa tree.

Farmers concluded from their own observation and discussions that *S. singularis* causes much more damage than *Helopeltis* spp. They also observed that, although all the *B. thalassina* used in the experiment were still alive after 96 hours, no lesions were observed on any of the feeding materials. On the other hand, in all cages with *B. thalassina* drops of water occurred on the plant materials. Scientists explained that the mouthpiece of *B. thalassina* is much longer than that of the other insects and can penetrate deep into the pods to suck sap from the cocoa beans, leaving them dry and later clamped. The drops of water in the cage were the result of this feeding behaviour. It was therefore concluded that *B. thalassina* was associated with clamped beans in cocoa pods. This learning experience settled the misconception between scientist and farmers about which capsid species constitute the most important pests reducing cocoa production.

Cause-effect relationships of socio-technical constraints identified

To identify and verify the major causes of low yields and their relationships for possible areas of research intervention, a problem tree technique was used. Malfunctioning of tenure agreements leads to inadequate crop management practices that in turn lead to excessive weed growth becoming the cause of low yields. The farmers explained that high humidity and lack of proper shade management promote the incidence of Black Pod disease. For swollen shoot virus disease the only control measure is to uproot the affected tree, a measure landlords do not easily accept. On the other hand, Caretakers complain that most of the landlords do not comply with their part of the tenure agreement and neither do they visit the farm even when they live in the community, and so they do not seem to appreciate the problems of crop management. Most absentee landlords only visit their farm during harvesting to collect the proceeds but do not invest in inputs to improve the farms. Further probing confirmed that only 39% of the landlords are local residents and that about 25% of all farmers are absentees. Some landlords in turn blame caretakers for stealing cocoa beans before declaring the production.

The exercise revealed that some of the land tenure arrangements are not functioning properly, and this is partly the cause of inadequate maintenance of cocoa plantations and mistrust among some cocoa landlords and their caretakers. This mistrust may have some relation with the low adoption of technologies developed by CRIG since the category of farmers to whom information about the technologies is disseminated may not be the implementers, and if they are, they may not be the owners who make the final decisions.

However, the caretakers and the landlords have some disagreements with timber contractors collaborating with some district authorities about felling large shade trees and in this process destroying cocoa trees. This endangers the biodiversity which farmers crave to maintain for organic certification. The shade trees may belong to the cocoa farmers but the District Forestry Officers and the District Assembly, in consultation with the traditional council, give the permission to fell them.

Meanwhile, both caretakers and landlords admit that their disagreements and mutual mistrust negatively affect crop management practices including pest and disease management. The two groups also share the common view that the cocoa trees do not only constitute an important asset in family wealth (agyapadee), but they also make farmers eligible for the acquisition of government scholarships for their children. Cocoa trees can further be used as collateral to obtain loans from banks. All these benefits lead some farmers to consider the number of trees or hectares of cocoa they own as important, if not more important than the yield itself. The social value of cocoa trees is reflected in land tenure arrangements and their role in crop management practices. So capsid control is the only important production-enhancing measure for which the malfunctioning tenure arrangements provide a window of opportunity.

Farmers' pest and disease management practices

After the subgroup discussion at the concluding meeting, farmers showed the pest and disease control measures they practise and the ones they ignore (Table 5). It was noted that apart from *Oecophylla longinoda* that had been proposed as a biological control agent, all the measures mentioned - according to the farmers – were in fact CRIG recommendations. So the very limited adoption of CRIG recommendations that we mentioned earlier is obviously not caused by lack of awareness. As we can see from the second and third columns in Table 5, farmers have good reasons not to follow the recommended practices. Hence, even farmers within the reach of CRIG have adopted a management system that is very low in cost, both in terms of money and labour, but provides them with some needed cash with minimal effort. Consequently, national yields are very low and reduce Ghana's status as a cocoa exporter. There is no doubt that the very low prices paid to cocoa farmers have stimulated this strategy.

Table 5. Cocoa pest and disease management practice known to and actually practised by farmers, and reasons for the discrepancy.

Pest/disease	Control measure		Measure not practised and reasons why not
	Known to farmers	Actually practised and why	
Capsids	Spraying of synthetic insecticides Spraying neem extract	Farmers benefited from the spraying of neem in 2001 and 2002	No synthetic insecticides for over 20 years due to cost., hazards and interest in organic production for premium price
	Control by *Oecophylla* ants (predators) present on cocoa trees	Some farmers believe *Oecophylla* ants control capsids but no conscious efforts made yet	
Black Pod	Crop management practices: weeding, pruning, removal of infested pods (all meant to reduce excessive humidity and spread of disease)	Very few do management practices frequently	Management practices are not done because of labour and financial constraints, and caretaker versus landlord conflict
Swollen shoot	Cutting down or uprooting trees for use as firewood	None	Landlords do not want to cut cocoa trees Mealybugs not controlled because farmers are ignorant of their role as vectors
Mistletoes	Removal of mistletoes	Done by very few farmers	Mistletoes not removed because of labour constraints

In the past 20 years, farmers only received about 40% of the world market price. The current study is undertaken at a time when the Ghana government has realized that it is killing the 'goose that lays the golden eggs'. As a result, it has strategically increased producer prices from 56% in 1998/99 season to 68% of the Free On Board (FOB) price in the 2002/2003 cocoa season (Anon., 1999). For instance, in June 2002 the price of a bag of cocoa beans (64 kg) was increased from $ 34 (¢ 274,000) to $ 48 (¢ 387,500), which was about a 41% increase. By October the same year, it was further increased to $ 66 (¢ 531,250). Given also the proposed premium prices of 120% to 140% paid for organic cocoa, the experiments with organic cocoa start at a moment when technical innovation again makes sense. Previously, the adoption of even the most appropriate technologies would hardly have been worthwhile. We shall come back to this issue later in the paper.

Towards collective decisions about the research agenda

All stakeholders were brought together in front of a cocoa shed in a special meeting to discuss the next research phase. Apart from all categories of male and female farmers, the stakeholders included community leaders, extension workers, CRIG scientists and an OCP representative. The community leaders consisted of the Caretaker-Chief and some opinion leaders, who at the same time are advisors to the Chief. Special effort was made to include landlords, who have the last say when it comes to choose the agricultural practices on their farmlands. Unlike most places, landlords in the study area do not pay any form of royalty to any Chief because they have purchased their land from the then Chief of the Akyem-Abuakwa traditional council. This makes the position of landlords very crucial.

The high awareness of CRIG pest and disease management technologies and farmers' reasons for *not* adopting them (Table 5) makes the identification of farmer criteria for choosing or accepting pest management strategies an important task for the diagnostic study. These criteria were identified in two sub-groups that produced the following consolidated list:

1. The method should be effective against capsids and other important pests.
2. It should help increase yields.
3. It should be cost-effective.
4. Availability of simple operating equipment in processing the product (e.g. a corn-mill to grind neem seeds).
5. Availability of biological insecticides in the community (e.g. neem trees producing seeds).
6. The method should not be harmful to human life and the ecosystem (e.g. it should not destroy snails that are eaten as source of protein and that form a delicacy for some of the ethnic groups).
7. Technology should not affect the taboos or cultural beliefs within the community.
8. The waste products of pesticides should be useful (e.g. neem chaff controls some termites).
9. The technology should have other uses, such as medicinal (e.g., neem cures malaria).
10. The product should break down rapidly into harmless compounds. So food crops grown under cocoa should be safe to harvest soon after pesticide application (this is because the farmers practise mixed cropping even in the cocoa plantations).
11. The method should conform to organic certification standards.

It was observed that because farmers had worked with CRIG, OCP and TOFA on research about botanical pesticides such as neem, it became their point of reference for formulating the criteria.
Discussion among stakeholders about appropriate strategies to address capsids, taking into account the history of farming practices in the area and arguments brought forward, showed that they were interested in organic pest management. Consequently, the farmers suggested that our study would continue to investigate the use of ANSE. Since the community was engaged in on-going joint trials with CRIG and OCP, the research team initially protested that such a focus would mean a duplication of effort. Yet, the farmers, TOFA, OCP and CRIG argued that ANSE be included because the farmers were divided in their views as to whether it could effectively control capsids as alleged by the scientists.

Therefore, the PhD study in which farmers would be represented by LARC farmers was an opportunity for an independent cross-check whether ANSE really controls capsids. Another control method to be investigated – the use of a biological control agent (predatory ant *Oecophylla longinoda*) – was suggested by a female farmer and supported by the rest. Although few farmers argued that *O. longinoda* can effectively control capsids, their concern was that the ants are extremely aggressive so their use should be further investigated. Although two CRIG scientists insisted that we discard the use of *O. longinoda* because some work had been done in the 1960s without much success, the majority decided that we look into the potential of the ants. In addition, CRIG researchers proposed the use of sex pheromone traps for capsids control.

Conclusions and implications for further research

I. The diagnostic study has confirmed that pest management innovations emerging from the technographic study on cocoa deserves more research attention.
II. Specifically, capsid damage was prioritized as most serious technical production constraint followed by Black pod disease. Key actors have suggested three innovative (organic) methods to be interactively developed to manage capsid damage.
III. Farmers were initially ignorant of the fact that *S. singularis*, *D. theobroma* and *Helopeltis* spp. were all capsid species. However, they realized through self-discovery learning processes that, although *Helopeltis* spp. are easily spotted on the field causing a lot of visible lesions on cocoa pods, *S. singularis* and *D. theobroma* cause real damage to cocoa production.
IV. The study identified an interface between land tenure and pest management constraints: existing malfunctioning of tenancy agreement between landlords and caretaker cocoa farmers, as a social problem, poses a serious threat to effective pest management in cocoa.

V. The study has also provided a better understanding of the livelihood of cocoa farmers and created a platform for learning opportunities among key stakeholders towards the development of more effective pest management methods to address the production constraints identified.

VI. In Ghana there is potential for organic cocoa production. So there is a need for creating appropriate conditions such as favourable market opportunities to support interested farmers.

The diagnostic study did not end with the concluding community meeting. The policy context of the cocoa industry changed considerably from 2001 onwards, particularly, after the diagnostic study had been completed. Two contextual issues stand out: (1) the change in Government policy, and (2) events around OCP.

Since independence in 1957, the government has always managed the cocoa industry and in fact creamed it off as one of the few sources of hard currency and revenue. In the period1982-2001, under the World Bank's structural adjustment initiative, the government did not provide or subsidize agricultural inputs. The present government considers this one of the main causes of low productivity. It is against this background that its present policy of intensifying cocoa production was designed, including the re-introduction of cocoa disease and pest control programme (mass spraying). As mentioned earlier, other important new policies include raising the farmers' share of the FOB price. This price increase alone creates a completely new context for cocoa farming.

The second major contextual change was the withdrawal and collapse of OCP. One of the company's concerns, apart from financial problems, was the fact that they and COCOBOD had a fragile agreement. Whereas COCOBOD argues that OCP has been given exclusive rights for five years to buy organic cocoa from within Brong-Densuso once the local cocoa has been certified, OCP maintains that it has funded research into organic cocoa in four regions for four years with the understanding that COCOBOD would allow the company to buy cocoa from all those areas to justify their investments.

In all, it became clear after the diagnostic study that OCP had withdrawn. The official reason given was that the company has run into financial problems, which was true: the company was liquidated. The withdrawal and collapse of OCP means that the policy environment is no longer very conducive to organic cocoa and that the ideal opportunity has been lost. As described earlier, during the diagnostic study, OCP, CRIG, MoFA and ToFA had all worked in harmony in their complementary roles as stakeholders. But few months after the completion of the diagnostic study, news formally got to farmers that OCP had withdrawn from the deal they had with TOFA and CRIG. The LARC farmers deeply regretted this.

During one of the meetings one of the LARC farmers got up and said that their attitude or commitment is low this time because, as he put it, "*We still have a problem*". They listed the following:

1. "The withdrawal of OCP as the organic marketing company has demoralized farmers interested in producing organic cocoa because the promised premium prices, the input support (neem seeds and other resources), as well as extension support will not be forthcoming".
2. "We find it very difficult to come together and learn about organic pest management when government is spraying other farms free of charge. For this reason, farmers from other places as well as new entrants from neighbouring villages not yet involved in TOFA's programme would be less willing to adopt organic farming and not have adequate quantities of organic cocoa beans to attract new marketing contracts."

Similarly, for the above reason, the LARC meeting did not focus on implementing the research agenda agreed upon. Instead the farmers raised issues that questioned the basis for moving ahead with organic cocoa production. What were we to do? Should we as facilitators ignore farmers' concerns and go ahead with the implementation of the research agenda when they claimed "We still have a problem"? In response to the problem situation, our primary strategy was to identify the situations desired by farmers, set these as goals, and collectively search for ways of achieving them. The LARC farmers enumerated the following as the major ingredients for the situation they perceived as desirable:

1. Organic cocoa production and premium prices to be restored to reduce poverty.
2. Formalize protection from synthetic pesticides to ensure a safe environment and organic cocoa.
3. Indiscriminate felling of forest trees on the cocoa farms should be stopped.
4. TOFA's capacity to facilitate concerted action should be strengthened.

Finally, we called for an emergency meeting of all stakeholders who had participated in developing the action plans, which included the Chief, Assemblyman, CRIG, MoFA, COCOBOD and the rest of the community farmers, where we all agreed on both the problems and the proposed way forward. As a result, COCOBOD through CRIG assumed full responsibility to play the role of OCP, and promised the farmers to continue the certification process and to ensure that the cocoa will be purchased at a premium price. Consequently, COCOBOD through CRIG has set aside a budget to support the only organic cocoa production initiative in Ghana.

Reflections on the diagnostic study

Diagnostic studies are not so much a research phase as a continuous process

The diagnostic study did not end with the concluding community meeting, and perhaps it will continue as long as the context keeps changing – requiring regular adaptation through dialogue. These contextual changes have to be discussed among the stakeholders including LARC and the larger community before entering the next phase. The local platform established by the diagnostic study facilitates such discussions when necessary. The variability of the context seems mainly to be caused by institutional unpredictability. Farmers are keenly aware that their opportunities are determined by the context.

Farmers' perceptions are not necessarily 'indigenous'

The influence of the neem experiment on farmers' perceptions of what is desirable shows that their views are highly influenced by all kinds of sources. It is likely that farmers, upon-hearing the devastating effects of Black Pod disease in other parts of the country, and upon seeing its effects on pods, gave priority to Black Pod disease as the most crucial problem. Theoretical explanations and a discovery learning experiment *made visible* the impact of the capsids.

A realistic research agenda is not just based on eliciting farmers' views

Farmers may not have the complete knowledge. What is important is that the scientists' views have a space of entering into the process of co-producing the research agenda as well, through a negotiation process that maintains farmer ownership over that research agenda. So the purpose of the diagnostic study was not to 'test the hypothesis' that capsids are a major problem. It was to mobilize the collective intention to tackle a shared problem with stakeholders having agreed on complementary roles in designing answers to the problem.

These learning experiences buttress the view that farmers' and scientists' perspectives may be influenced by existing knowledge, which can often be biased and or limited. Hence, the need for participatory and interactive approaches to converge ideas from both scientists and farmers in addressing agricultural production constraints.

References

Abekoe, M. K., Obeng-Ofori, D., and Egyir, I. S. (2002) Technography of Cocoa in the Forest Zone of Ghana. Unpublished Technical Report, Convergence of Sciences Project. University of Ghana, Legon, 51 pp.

Anonymous, (1951) Capsid Research: Chemical Control. Annual Report, West African Cocoa Research Institute, April 1949- March 1950, 42–44 pp.

Anonymous, (1999) Ghana Cocoa Sector Development Strategy. Ministry of Finance, Accra: Unpublished Government Policy Document, 94 pp.

Braun, A. R., Thiele G. and Fernandez, M. (2000) Farmer Field Schools and Local Agricultural Research Committees: Complementary Platforms for Decision-making in Sustainable Agriculture. Network Paper No 105, Overseas Development Institute (ODI), London, 16 pp

Bruin, G. and Meerman, F. (2001) New ways of Developing Agricultural Technologies: The Zanzibar experience with participatory Integrated Pest Management. Wageningen: Wageningen University, Department of Entomology, 167 pp.

Chambers, R. and J. Jiggins, (1987) Agricultural research for resource-poor farmers. Part I. Transfer-of-technology and farming systems research. *Agricultural Administration and Extension* 27: 35–52.

Defoer, T. (2000) Moving Methodologies: Learning about Integrated Soil Fertility Management in Sub-Saharan Africa. Wageningen: Wageningen University, Published doctoral dissertation, pp 189.

Donkor, M. A., Henderson, C. P. and Jones, A. P. (1991) Survey to Quantify Adoption of CRIG Recommendations. Farming System Research Paper No 3, Interim Working Document. Tafo (Ghana): Cocoa Research Institute of Ghana (CRIG), (unpublished report) 29 pp.

Entwistle, P.F. 1972. Pests of cocoa. London: Longmans, 779 pp.

Giampietro, M. (2003) *Multi-Scale Integrated Analysis of Agroecosystems*. Boca Raton, Florida, CRC Press, 437 pp.

Henderson, C. P., Owusu, G. K., Jones, A. P. and Padi, B. (1994) The importance to cocoa research for understanding farmers' rationale towards pest and disease control with reference to capsid and black pod disease control in Ghana. In: Proceedings of the 11th International Cocoa Research Conference, 18–24 July 1993, Yamoussoukro, Côte d'Ivoire. Hertford (UK): Stephen Austin & Sons Ltd., 299–304 pp.

Jiggins, J. L. S. and De Zeeuw, H. (1992) Participatory technology development in practice: process and methods. Pages 135–162 In: C. Reijntjes, B. Haverkort and A. Waters-Bayer (Eds), *Farming for the Future. An Introduction to Low External Input Agriculture*. London: Macmillan.

Matteson, P. C., Gallagher G. D. and Kenmore, P. E. (1994) Extension of integrated pest management of planthoppers in Asian irrigated rice: Empowering the user. Pages 656–685 In: R.F. Denno and T. J. Perfect (Eds), *Ecology and Management of Planthoppers*. London: Chapman and Hall.

Padi, B. (1997) Prospects for the control of cocoa capsids-alternatives to chemical control. In: Proceedings of the First International Cocoa Pests and Diseases Seminar, 6–10 November 1995, Cocoa Research Institute of Ghana (CRIG), Akim-Tafo, Ghana, 28–36 pp.

Padi, B., Ackonor, J. B., Abitey, M.A., Owusu, E. B., Fofie, A. and Asante E. (2000) Report on the Insecticide Use and Residues in Cocoa Beans in Ghana. Internal Report submitted to the Ghana Cocoa Board. 26 pp.

Richards, P. (1985) Farmers also experiment: a neglected intellectual resource in African science. *Discovery and Innovation* 1: 19–25.

Richards, P. (2001) Technography: Notes on methods. Unpublished working paper. Wageningen University, Wageningen: Convergence of Sciences Project.

Reijntjes, C., Haverkort, B. and Waters-Bayer, A. (1992) *Farming for the Future: an Introduction to Low-External-Input and Sustainable Agriculture*. London: Macmillan, 250 pp.

Röling, N. G. (1988) Extension Science: Information Systems in Agricultural Development. Cambridge: Cambridge University Press 233 pp.

Röling, N. G., (1996) Towards an interactive agricultural science. *European Journal of Agricultural Education and Extension* 2 (4): 35–48

Röling, N. G. and J. Jiggins, (1998) The ecological knowledge system. Pages 283–311 In: N. G. Röling and M. A. E. Wagemakers (Eds) *Facilitating Sustainable Agriculture: Participatory Learning and Adaptive Management in times of Environmental Uncertainty*. Cambridge: Cambridge University Press.

Van Huis, A. and Meerman, F. (1997) Can we make IPM work for resource-poor farmers in Sub-Saharan Africa? *International Journal of pest management* 43 (4), 313-320.

Chapter 3

Facilitating the use of alternative capsids control methods towards sustainable production of organic cocoa in Ghana

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CHAPTER 3

Facilitating the use of alternative capsids control methods towards sustainable production of organic cocoa in Ghana

Abstract

Cocoa (*Theobroma cacao L.*) is an important foreign exchange earner for Ghana. However, production is constrained by a high incidence of pests and diseases. Based on farmers' needs, this study focused on the control of capsids, mainly *Sahlbergella singularis* Hagl. and *Distantiella theobroma* (Dist) (Hemiptera: Miridae). Annual crop loss caused by capsids is estimated at 25% to 30%. To control capsids, formal research recommends four times application of synthetic pesticides between August and December. However, farmers hardly adopt this recommendation, which they consider unsuitable for their conditions and context. Three alternative control methods were tested with farmers: mass trapping, using sex pheromones; applying crude aqueous neem (*Azadirachta indica*) seed extract (ANSE); and using the predatory ant *Oecophylla longinoda* Latr. (Hymenoptera: Formicidae) as a biological control agent. Studies on temporal distribution of cocoa capsids indicated that the population peaked in March; contrary to most previous reports. ANSE was effective against capsids and other cocoa insect pests and did not affect the predatory ant. When *O. longinoda* occurred in high numbers, capsid incidence was low. Shade did not influence ant or capsid abundance significantly. ANSE caused 100% mortality of capsids in cage and 79%-88% in field experiments. Sex pheromone was as effective as ANSE or ants in suppressing capsids. All the three methods were effective and compatible; hence, they can be used in an Integrated Pest Management (IPM) strategy for cocoa, including organic production in Ghana.

Key words: *Distantiella theobroma*, integrated pest management, Neem, *Oecophylla longinoda*, *Sahlbergella singularis*, sex pheromone traps, *Theobroma cacao*

Introduction

Cocoa (*Theobroma cacao L.*) has been grown in Ghana since the last half of the nineteenth century. Ghana became the world's leading producer of cocoa from 1910 to 1979, contributing to a maximum of 40% of the total supply (Anon, 2000). Ghana's cocoa attracts premium prices for its quality compared to cocoa beans from other countries. Cocoa remains an important foreign exchange earner for Ghana. However, after 1965 production consistently plummeted and became as low as 158,000 MT in 1983/84 (Anon, 2000). This decline was due to low yields caused by the high incidence of pests and diseases, poor crop husbandry because of low producers' prices and increased labour costs (Padi *et al* 2002). Cocoa production rose from 496,846 tonnes in 2002/2003 to an all time record high of 736,911 tonnes in 2003/2004, an increase of 48.3% (Anon, 2005). In spite of this increase, the national average yield of about 400 kg/ha falls short of an expected 1-5 tonnes/ha achieved on experimental plots (Asante and Ampofo, 1999). Low yields in cocoa require further attention since massive clearing of the already limited virgin forest lands for cocoa cultivation (as in the Western Region) as a measure to increase production, appears unlikely.

Presently, there are three major production limiting factors in Ghana: the Cocoa Swollen Shoot Virus (CSSV) disease, Black Pod disease and capsids (Hemiptera: Miridae). Other cocoa pests but of less importance include the stem borer *Eulophonotus Myrmeleon* Fldr. (Lepidoptera: Cossidae), termites and pod feeders *Bathycoelia thalassina* (H-S) (Heteroptera: Pentatomidae) (Padi *et al.*, 2002). CSSV disease is transmitted by mealybugs (Homoptera: Pseudococcidae). The black pod fungal disease is mainly caused by two *Phytopthora* species, *P. palmivora* and *P. megakarya.* The latter is the more aggressive of the two pathogens and can cause total loss of pods (Opoku *et al.*, 2000); the former causes less severe crop losses and can be controlled using cultural practices.

Capsids are considered to be one of the main causes for low yields of cocoa in Ghana. The main species involved are *Distantiella theobroma* Dist. (Dt) and *Sahlbergella singularis* Hagl. (Ss). Capsids can cause an annual crop loss of 25% to 30% (Anon, 1951). Both adults and immature nymphs use their needle-like mouthparts (stylets) to inject saliva into plant cells and ingest sap from stems, branches, cherelles and pods (Entwistle, 1972). As a result, the penetrated host cells die producing necrotic lesions. This usually does not affect mature pods but immature pods may wilt. Capsid feeding on shoots is usually followed by a fungus infection, often resulting in the death of terminal branches and leaves affecting the cocoa tree canopy, and ultimately causing die-back (Entwistle, 1972). In the end, yields decline, and the infested trees may eventually die.

Estimating capsid impact is complicated because they are part of a disease complex (Padi *et al.*, 2002) and are associated with physiological die-back (Entwistle, 1972).

The main method recommended by the Cocoa Research Institute of Ghana (CRIG) for capsid control has been the use of synthetic pesticides. The major insecticides being used by motorized mist blower spraying machines are: Confidor 200 SL (Imidacloprid) 150ml/ha; Cocostar (Actelic/Talstar) 500ml/ha and Carbamult (Promecarb) 1.4l/ha. The insecticides are supposed to be applied as a prophylactic measure four times from August to December, omitting November. However, there are several constraints to the adoption of chemical control methods: the high cost of pesticides and labour, expensive spraying equipment and low return on investments due to low producer prices (Henderson *et al.*, 1994). Meanwhile, there are reports about abuse and misuse of insecticides by cocoa farmers including the application of unapproved insecticides (e.g. the pyrethroids Thiodan, Callaphan, Decis and Karate) (Henderson *et al* 1994; Padi *et al.*, 2000). In addition to the human and environmental health risks as well as the high costs involved, there are concerns about development and/or resurgence of capsid resistance as was first found at Pankese, in the Eastern Region in 1956 (Entwistle, 1972). These constraints motivate the search for a more affordable, effective and environmentally acceptable alternative capsid control methods that would rely on low external inputs and better fit into farmers' conditions and context.

CRIG and others have begun investigations into alternative capsid control methods such as the use of resistant/tolerant cocoa varieties, botanical pesticides, and sex pheromone traps (Padi *et al.*, 2002). We conducted a diagnostic study with farmers and scientists at Brong-Densuso in the Eastern Region of Ghana. Following this study it was agreed with the farmers to investigate three alternative methods to control capsids. These were: the use of sex pheromone traps suggested by CRIG; the use of crude Aqueous Neem (*Azadirachta indica*) Seed Extracts (ANSE), suggested by the farmers' association and CRIG; and the use of the predatory ant species *Oecophylla longinoda* Latr. (Hymenoptera: Formicidae) as a biological control agent, proposed by farmers (Chapter 2).

Materials and Methods

Experiments

The following experiments were conducted:

1. Determination of the effective dosage for neem in a cage experiment.
2. Effect of predatory ants (*O. longinoda*) on capsids.

3. Effect of shading on capsid and predatory ant incidence in cocoa.
4. Effect of different control methods on capsid population and damage: Neem; Predatory ants and Sex pheromone traps.

Study area

The study was conducted at the Brong-Densuso in the Suhum-Kraboa-Coaltar District of the Eastern Region with farmers (Chapter 1 and 2). These farmers are attempting to grow organic cocoa, reason why the study area was exempted from the government organized Cocoa Disease and Pests Control (CODAPEC) spraying programme with synthetic pesticides. Most of the farmers practise mixed farming where cocoa is sparsely intercropped with various other crops (e.g., oil palm, banana, plantain) on small parcels of land usually inherited from their parents. The cocoa farms have large overhead shade trees, most of which were wild and either left to grow during establishment or was deliberately planted to provide shading to the young cocoa trees. The field experiments were conducted on already established cocoa farms; each plot selected measured 0.25 ha and was separated from each other by at least 100 m. The field experiments were negotiated and conducted with farmers, who because of time constraints, insisted on three replicates only.

Effective neem dosage

Neem seeds were bought from Kodiabe in the Eastern Region, and were dried; weighed (150, 200, 250 and 300 g) milled and soaked in a liter of water for 24 h. Each suspension was sieved using a 0.5 mm mesh width and the filtrate was used as the neem spray. Sixty capsids (*S. singularis*) were placed in 15 cages of 0.4x0.5x1.5 m made with nylon mesh and wood. Each cage contained two cocoa seedlings of about 0.7 m tall and two pods of similar surface area as food for four capsids. The capsids were observed for 24 h and no mortality occurred before treatments were applied. Crude neem seed extracts were compared to a control treatment which was a liter of distilled water. A hand sprayer was used for the application, which released about 4 squirts of the spray to cover each of the feeding materials in the cages. Data collected were numbers of dead insects and lesions caused on the seedlings and pods in 24 h before and 6, 12, 24, 36 and 48 h after spraying.

Effect of predatory ants on capsids

The effect of the predatory ants was established comparing plots where ant nests were abundant and where they were virtually absent. In each month capsid numbers on the trunks of cocoa trees and pods within reach of about 2 m from the ground were counted as well as the number of visible ant nests about 3-4 m from the ground when looking into the canopy.

Effect of shading on incidence of cocoa capsids and presence of ant nests

The shading was mostly caused by large wild trees and two criteria were used to distinguish two shade conditions:

(i) The number of fully established over-head shaded medium to big trees had to be at least 12 per plot for the heavily shaded and less than five for the lightly shaded plots.

(ii) Open space without any cover from cocoa trees or wild over-head trees (broken canopy) was not exceeding 3 m^2 within the plot in order to qualify for a heavy shaded plot/treatment.

The data collected were monthly numbers of capsids and *O. longinoda* (ants) nests.

Effect of different control methods on cocoa capsids population and damage

The design was approximately a randomized complete block design with 3 blocks. Each block had four plots, of which one was the control (sprayed with water), and the other three being separate treatments: 1) sex pheromone traps 2) neem applications, and 3) predatory ants. The ant treatment could not be randomized. Weeding was done twice a year to ensure uniformity across all the fields. Mistletoes, infested pods caused by black pod disease chupons and dead branches were removed from all fields every three months.

Crude Aqueous Neem Seed Extract (ANSE)

Crude neem extract was sprayed with a Solo motorized mist-blower of 12.5 litres capacity at 200 g/l (20 kg/ha) based on the result of the cage experiment (Exp. No. 1). Spraying was carried out when the threshold of six capsids per 10 trees was reached (Entwistle 1972). In the last year, the mean capsid numbers was below the threshold. However, in two plots the threshold was reached and we decided spraying those. To avoid contamination with synthetic insecticides, the Solo motorized mist-blower used was exclusively for neem spraying.

Sex pheromone traps

Eight pheromone traps per plot were used. Each trap had the same standard lure recommended by CRIG and the Natural Resources Institute (Padi *et al*., 2001). The traps were suspended on branches of cocoa trees at 2 m above the ground level, 6 m apart. A ninth trap per plot with no lure was added to serve as a control. The traps caught males of both capsid species (*D. theobroma and S. singularis*) which were distinguished and recorded. The rectangular traps were constructed from Corex sheet (38 cm long with cross section 10 cm wide x 14 cm high) with Corex liner (28 cm long coated with polybutene sticker -tanglefoot) on both inner base and inner side surfaces. The traps were baited with the synthesized pheromones to lure the male capsids into the sticky medium where they died. The lures and the corex liner were replaced with new ones after every three months. The outer layer of the traps was changed annually.

Predatory ants

Areas with abundant nests of naturally occurring *O. longinoda* were identified with farmers. Their average occurrence or abundance per 50 trees/plot was rated as 1 (Low: 0 nest), 2 (Average: 1-2), 3 (High: 2-5) and 4 (Very high: >5nests). Plots of high *O. longinoda* occurrence (level 3 were selected).

Data collection and analysis of the three alternative control methods

In each plot, 50 cocoa trees were randomly selected, and tagged for monthly data collection. The data collected (July 2003 to December 2005) were number of capsids, number of fresh capsid lesions on pods and number of cocoa trees with other cocoa insects. They were Cocoa mosquito *Helopeltis spp.*, mealybugs *Planococcoides njalensis* (Laing), termites *Glyptotermes parvulus* (Sjost), aphids *Toxoptera aurantii* (B. de Fonsc.), pod borers *Conopomorpha cramerella* (Snellen) and the predatory ant, *O. longinoda*. Insects on the trees were counted up to about 2 m above the ground and ant nests that could be seen up to about 3-4 m from the ground. Pods were lifted in order to find all insects. For the neem experiment, the monthly counting served as a basis to decide whether to spray. Sampling was conducted 48 h after spraying. Pods were harvested each month within the periods from September to December in 2003, 2004 and 2005. Cocoa trees with capsid damage on canopy (foliage) were assessed each July in 2003, 2004 and 2005 using the Hammond index: nil damage 0%; mildly damaged 1-20%; moderately damaged 21- 50%; severely damaged 51-100%) (Johnson and Burge, 1971). The data were analyzed using univariate analysis of variance (Post-hoc: Tukey $P<0.05$) to test the efficacy of the three capsid control methods.

Results

Effective neem dosage

During the first 24 h before spraying in the cage, we did not observe any mortality at the different neem concentrations used. The control (sprayed with water only) did not show any mortality in the entire duration of the experiment. However, 100% mortality was achieved after 24 h with the 300 g/l treatment, after 36 h with the 250 g/l, and after 48 h with the 200 g/l treatment. Because 200 g/l achieved 100% mortality after 2 days, we chose this concentration for the field trial. After the application of neem, capsids feeding ceased on both substrates, while in the control, 215 lesions on pods and 73 on seedlings were counted.

Capsids population dynamics

The population dynamic of capsids monitored using sex pheromone traps are shown in figure 1. In two successive years March was the peak of capsid population followed by August to December. At high numbers of the capsids; *D. theobroma* and *S. singularis*, the incidence of the first one increased even up to 100% in March and April.

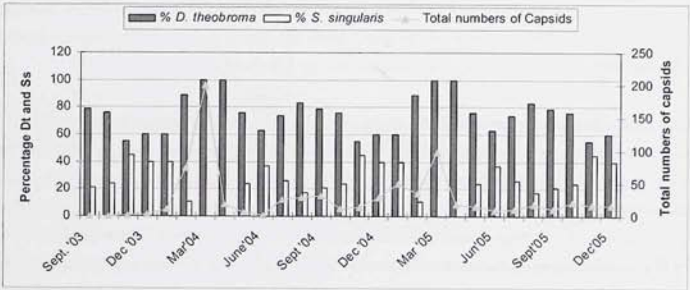

Figure 1. Numbers of capsids trapped by sex pheromones (in 24 traps) showing the relative abundance of *Distantiella theobroma* (Dt) and *Sahlbergella singularis* (Ss) in experimental cocoa plots in Ghana (September 2003-December 2005)

Effect of ant abundance on cocoa capsid

Where *O. longinoda* nests were abundant, capsids were virtually absent (Figure 2). There is a negative correlation between the two insects.

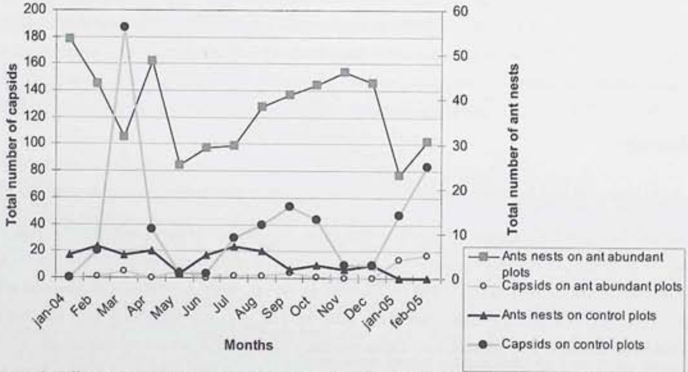

Figure 2. Effects of ant abundance on capsid incidence on 150 trees in experimental cocoa plots in Ghana.

Effect of shading on capsid and ant incidence

Capsids counts recorded in the lightly shaded areas were higher than those in the heavily shaded areas, although the pattern of incidence over time was similar (figure 3).

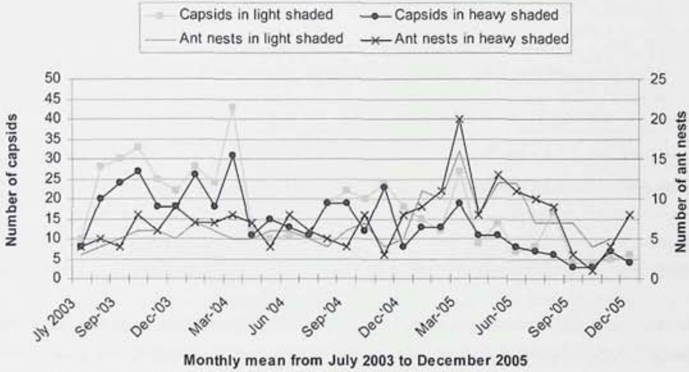

Figure 3. Effect of shade on capsid and ant nests in cocoa using 150 cocoa trees in experimental plots in Ghana.

Further analysis concentrating on the peak and low capsid occuring periods showed that capsids were more abundant in lightly shaded areas than in the heavily shaded areas, while ant nests were generally more abundant in the heavily shaded areas, although the differences were not significant except in capsid peak in March 2005 which was significant ($P< 0.10$) (Table 1)

Table 1. Capsids and nests of *O. longinoda* (ants) under light and heavy shade conditions in cocoa in Ghana.

High and low capsid incidence periods	Capsid & ant nests counted	Mean (± SD) from different shade conditions		F-value	P-Value
		Light	Heavy		
March 2004 (peak)	Capsids	0.86 ± .06	0.62 ± .30	2.48	0.26
	Ants nests	0.10 ± .04	0.16 ± .04	7.34	0.11
March 2005 (peak)	Capsids	0.57 ± .08	0.38 ± .05	9.23	0.09*
	Ants nests	0.32 ± .07	0.40 ± .01	3.31	0.21
June 2004 (low)	Capsids	0.22 ± .11	0.27 ± .05	0.33	0.63
	Ants nests	0.13 ± .01	0.16 ± .07	1.00	0.42
June 2005 (low)	Capsids	0.14 ± .03	0.16 ± .02	0.44	0.58
	Ants nests	0.24 ± .07	0.22 ± .08	0.13	0.76

* Significant ($P \leq 0.10$) difference between means

Alternative capsids control methods

The means of capsid incidence and fresh feeding lesions in the three treatments (neem, sex pheromones and ants) were all significantly lower compared to the control, both in 2004 and 2005 (Table 2).

Table 2. Effect of neem extracts, predatory ants (O. longinoda) and sex pheromone traps on capsid incidence and their feeding lesions on cocoa in Ghana (2004-2005).

Treatment	Mean (± SD) No. of capsids		Mean (± SD) No. of fresh capsid lesions	
	2004	2005	2004	2005
Neem extract	12.6 ± 0.9 b	7.6 ± 0.7 b	22.6 ± 2.2 b	17.3 ± 1.7 b
O. longinoda	6.1 ± 0.5 c	3.9 ± 0.3 c	11.3 ± 0.9 b	7.8 ± 0.6 c
Sex pheromone	7.0 ± 0.4 c	5.0 ± 0.2 c	21.7 ± 1.3 b	16.4 ± 0.4 b
Control	26.9 ± 0.3 a	21.7 ± 0.4 a	59.1 ± 15.6 a	42.8 ± 3.1 a

* Means with the same letter in the same column do not significantly differ (Post-hoc Tukey: $P \leq 0.05$)

The treatments with ants and sex pheromones reduced capsid incidence more than the neem treatment both in 2004 and 2005. With regards to capsids lesions, there was only a significant difference in 2005: ants performed better than the sex pheromone and the neem treatment. The mean difference of canopy foliage scores of treatments between July 2003 and July 2005 was significant ($P \leq 0.10$) (Table 3).

Table 3. Effect of neem extact, predatory ants (*O. longinoda*) and sex pheromone traps on cocoa canopy damage by capisds between July 2003 and July 2005 in Ghana.

Treatments	Mean (± SD) difference of canopy damage	F-Value	P-Value
Neem extract	0.27 ± .05	4.49	0.056*
O. longinoda	0.18 ± .18		
Sex pheromone	0.17 ± .26		
Control	-0.17 ± .10		

* Significant ($P \leq 0.10$) (Post-hoc Tukey) difference of means between 2003 and 2005

The ant and the sex pheromone treatment did not perform differently from the control. Only the neem treatment had better canopy cover and therefore less damage than the control.

In 2003, yields (number of pods per ha) of the neem and the ant treatments did not differ significantly from the control (Table 4).

Table 4. Effect of neem extract, predatory ants (*Oecophylla longinoda*) and sex pheromone traps on cocoa yields in Ghana in September to December of 2003, 2004 and 2005.

Treatments	Mean (± SD) cocoa yields (pods/ha)		
	2003	2004	2005
Neem extract	13,100 ± 268 a	17,676 ± 718 a	10,604 ± 140 a
O. longinoda	13,296 ± 275 a	14,052 ± 437 b c	10,364 ± 121 a
Sex pheromone	10,500 ± 714 b	16,452 ± 537 a b	10,956 ± 304 a
Control	12,880 ± 862 a	11,400 ± 1769 c	6,128 ± 861 b

* Means with the same letter in the same column do not significantly differ (Post-hoc Tukey: $P \leq 0.05$)

The yield in the sex pheromeone treatment was significantly lower than those of the control and in the other two treatments. In 2004, only the yield in the ant treatment did not differ signicantly from the control, although it was about a quarter higher. The yield in the neem treatment was highest and significantly different from the control and the ant treatment. Due to low rainfall (Table 5), yields in 2005 were generally lower. Yields in this year in the three treatments did not significantly differ from each other, but were significantly higher (>70%) than the control. Neem applications conducted twice a year from (2003-2005) reduced the number of capsids and the number of fresh capsid lesions by 80-95% in 48 h after treatment (Table 6).

Table 5. Monthly rainfall (mm) at Brong-Densuso, Eastern Region of Ghana (2003-2005)

Month	2003	2004	2005
January	15.3	11.2	0.9
February	53.3	73.8	38.7
March	45.8	92.0	140.8
April	153.9	59.8	55.4
May	129.7	132.3	173.3
June	194.0	184.9	72.8
July	109.3	51.0	23.8
August	78.0	54.4	59.9
September	49.9	261.1	106.3
October	242.5	119.5	133
November	75.7	97.8	23.3
December	21.0	82.4	18.3
Annual	1168.4	1220.2	846.5

Table 6. Effect of neem extract on capsids and their feeding lesions on pods in cocoa in Ghana (average of 50 trees).

Year	Month Sprayed	Before/After Neem Treatment						Before/After Water treatment (Control)					
		No. of capsids			No. of lesions			No. of capsids			No. of lesions		
		BT	AT	% Mort	BT	AT	% DecL	BT	AT	% Mort	BT	AT	% DecL
2003	September	38	5	87	126	19	85	39	39	0	139	247	-78
	November	32	4	88	121	23	81	27	30	-11	146	134	8
2004	March	34	7	79	122	11	91	46	48	-4	225	169	25
	October	30	2	93	138	15	89	31	35	-13	154	188	-22
2005*	January	13	2	85	132	7	95	22	35	-61	154	194	-26
	March	22	4	82	130	13	90	29	38	-31	167	205	-23

* Spot spraying on two plots in January and March of 2005

BT= 1 day before treatment

AT= 2 days after treatment

% Mort. = Percentage mortality

% DecL = Percentage decrease in lesions

In the control treatment, both the incidence of capsids and their lesions showed in most cases an increase during the three days interval.The neem treatment reduced the numbers of other (non-targeted) insects such as *Helopeltis spp*., *P. njalensis*, *B. thalassina* etc. to almost insignificant levels in 2.5 years (Table 7). Neem, however, did not affect the incidence of the predatory ant *O. longinoda*.

Table 7. Effect of neem extract on other cocoa insects (AT/BT) on average of 50 trees 24 hours before (BT) and 48 hours after treatment (AT) in cocoa in Ghana (2003-2005).

Periods	*Helopeltis sp.*		*Planococcus njalesnsis*		Termites		*Bathycoelia thalassina*		*C. Stictigrata*		*Toxoptera aurantii*		*O. longinoda*	
	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT
Sep.'03	32	0	22	13	17	9	8	5	12	3	19	7	7	6
Nov.'03	37	2	18	10	19	11	0	0	7	3	21	7	4	3
Mar.'04	39	0	19	8	24	15	3	0	5	2	11	3	9	9
Oct.'04	26	2	11	4	20	11	0	0	3	0	3	1	3	2
Jan.'05	15	5	7	3	12	8	2	0	6	0	0	0	14	11
Mar.'05	11	2	4	2	4	3	0	0	3	2	0	0	8	6

BT= 1 day before treatment

AT= 2 days after treatment

Discussion

Cage experiment on effective neem dosage

The cage experiment was used to determine the appropriate dosage of neem and its mode of action on cocoa capsids. The concentration of 200 g/l was chosen because it was effective and required less neem seeds to process than the 250 and the 300 g/l. Neem does not only kill on contact, but also inhibits capsids' feeding. In addition to neem's anti-feedant properties and lethal effect on capsids, others have even documented its ability to repel the insects (Adu-Acheampong, 1997; Padi *et al.*, 2004).

Capsids population dynamics

The numbers of capsids caught in the traps indicated the general population fluctuations during the year, although some caution is needed during a high incidence of capsids as the natural pheromone may compete with the synthetic one and so population densities could be undervalued. *D. theobroma* was more prevalent in the area than *S. singularis*, particularly during the peak periods (March and April).

March being a peak period for capsids was observed in two successive years (Figure 1) This finding contradicts previous reports on the temporal distribution of capsids in Ghana which indicated August to December as the peak periods (Entwistle, 1972; Padi and Adu-Acheampong, 2003). This was the second peak period of capsids incidence in our study. The government's sponsored mass spraying is based on the peak in August to December. Although, our study was conducted in a relatively smaller area as compared with nationwide surveys, Padi and Adu-Acheampong (2003) working in different areas of the country also found that sometimes high numbers of capsids may occur in February and March.

Distantiella theobroma was more common in our study area than *S. singularis*. This used to be the case but recent surveys by CRIG in the country suggested the contrary (e.g., Padi and Adu-Acheampong, 2003). They attributed the dominance of *D. theobroma* or *S. singularis* in an area to be associated with the prevalence of Amelonado and hybrid cocoa varieties respectively. Hence, they explained their findings by the general shift from the cultivation of Amelonado to hybrid as the reason for the common ascendancy of *S. singularis* in Ghana. However, it is unlikely that the prevalence of one of the species in a location is due to the most dominant cocoa variety in the area because the varieties on our fields are highly mixed. What is more, on two different occasions when we scouted for *D. theobroma* for cage experiments all we got were *S. singularis* and the vice-versa when we needed *S. singularis*.

Effect of *O. longinoda* on capsids

Farmers' experience that the ant *O. longinoda* is an effective predator of cocoa capsids appeared to be based on the perceptible negative correlation between occurrence of the two insects. Based on similar observations in the 1950s and the 1960s, Leston (1971) suggested the ants as a potential biological control agent to scientists. Leston's efforts to investigate this subject was met with criticism by Marchart (Marchart, 1971). This criticism was at the time when many believed chemical control was the best solution (the 'silver bullet') for effective pest management. Brew and Koranteng (1984) reported that the ant establishes its colonies only in the vicinity of good closed canopies or on available shade trees, and equally concluded that it cannot be used as a predator of capsids. Despite these findings, some farmers continue to believe that *O. longinoda* can be used as a biological control measure, insisting that their neglect by scientists is mainly to pursuade them to purchase costly synthetic pesticides. Other scientists have reported on the use of *Oecophylla smaragdina* by other farmers in cashew and citrus in Vietnam to suppress various pests (Peng *et a*l., 1999; CuC and van Paul, 2003).

Effect of shading on capsids population and *O. longinoda* nests

We could not confirm Marchart's (1971) finding that capsids are found in the lightly shaded areas and *O. longinoda* in the heavily shaded areas. He claimed that *O. longinoda* cannot be effective predator of capsids because the two insects have different habitats and ecological requirements. Entwistle (1972), however, suggested that capsids retreat from feeding sites (lightly shaded/broken canopy areas) into areas of acceptable light intensity (heavily shaded/closed canopy) for shelter and safety. According to him, capsids and ant habitats overlap. He also found that *O. longinoda* workers preyed on *D. theobroma*, however, he was uncertain whether the ants could sufficiently protect cocoa trees against *S. singularis*, which to him, was the more important of the two capsid species in West Africa (Entwistle, 1972).

The seemingly high population of capsids in lightly shaded areas could well be explained by the fact that the penetration of sun light improves visibility of the cryptic insects. Capsids tend to feed more in the night and early hours of the day and not during hot hours of the day; they also prefer to hide in dark places and in micro-habitats such as under pods where the relative humidity is higher (Entwistle, 1972). Therefore, it is possible that heavily shaded areas may actually contain more numbers of capsids than observed.

Unlike cocoa, cashew and citrus are normally not cultivated under heavily shaded trees and *O. smaradina*, which is not very different from the *O. longinoda,* is abundant enough to warrant its use as a biological control agent (Peng *et a*l., 1999; CuC and van Paul, 2003). Hence, we believe that shading is not an issue and that *O. longinoda* can effectively be used for capsid control in cocoa.

Evaluation of alternative capsids control methods

The three capsids control methods; sex pheromone trapping, employment of predatory ants and application of neem seed extract were effective in supressing capsids numbers when compared to the control. Concerning the incidence of capsids and their feeding, the ant and the sex pheromone treatments were the most effective (Table 2). The difference of these two treatments with that of neem is that they remain effective while neem only works for few weeks. It is also possible that neem mainly repels the insects under field conditions, although, it improved the cocoa canopy better than the other two treatments (Table 3).

Yields (pods/ha) obtained from all the three treatments were significantly higher than the control (Table 4). Under conditions of high and low rainfall and the control regime having been effective for 15 months (2004 and 2005), the treatments were equally effective. In 2005, the remarkable drop in cocoa yields across treatments was due to a nationwide cocoa crop failure caused by unfavourable rainfall conditions (850 mm compared to about 1200 mm in 2003 and 2004). Wood and Lass (1985) mentioned that reduced rainfall or unsuitable distribution of rainfall can greatly affect cocoa yields. But the effect of the treatments relative to the control was still very good in 2005. So from the point of view of a stable income, it might be very worthwhile to apply especially in a dry year.

The use of neem seed extract reduced the incidence of some non-targeted cocoa insect pests which are increasingly becoming important in cocoa (Table 6) (Padi *et al* , 2002). Neem does not seem to affect the predatory ant, *O. longinoda*. This indicates that neem could be a more sustainable capsid control method than the use of synthetic pesticides which tend to reduce the abundance of natural enemies.

It can be concluded that the three alternative capsids control methods were equally effective in reducing capsids incidence and their lesions on cocoa pods and in increasing yields. Therefore, all three methods can be used in an IPM strategy for sustainable production of cocoa. They can also play a role in the production of fair-trade and organic cocoa products.

References

Anonymous, (1951) Capsid Research: Chemical Control. Annual Report, West African Cocoa Research Institute, April 1949- March 1950, 42–44 pp.

Anonymous, (2000) *Ghana Cocoa Board Handbook*, (8th Edition). Accra, Ghana: Jamieson's Cambridge Faxbooks Ltd.

Anonymous, (2005) *The state of the Ghanaian economy in 2004*. University of Ghana, Legon: Institute of Statistical Social and Economic Research (ISSER) publication.

Adu-Acheampong R. (1997) Laboratory and field evaluation of neem (*Azadirachta indica, juss*) for the management of cocoa mirids (Heteroptera: miridae), Master Phil thesis submitted to the University of Ghana, 76 pp.

Asante E. G. and Ampofo, S. T. (1999) Formation of village level farmers' services companies as a means of improving farmers' productivity and cocoa production in short term: Document submitted to Ministry of Food and Agriculture, Ghana (Unpublished) 25 pp.

Brew A. H. and Koranteng, S. (1984) Biological control of capsids. Cocoa. Research Institute of Ghana. Annual Report, 1976/77 –1978/79 95pp.

Entwistle, P.F. 1972. *Pests of cocoa*. London: Longmans, 779 pp.

Henderson, C. P., Owusu, G. K., Jones, A. P. and Padi, B. (1994) The importance to cocoa research for understanding farmers' rationale towards pest and disease control with reference to capsid and black pod disease control in Ghana. In: Proceedings of the 11th International Cocoa Research Conference, 18–24 July 1993, Yamoussoukro, Côte d'Ivoire. Hertford (UK): Stephen Austin & Sons Ltd., 299–304 pp.

Johnson C. G. and Burge, G. A. (1971) Field trials of anti-capsids insecticides on farmers' cocoa in Ghana 1956-60: Effects of different insecticides compared by counting capsids, and capsid-counting compared with counting the percentage of newly damaged trees, *Ghana Journal of Agricultural Science*, 4: 33-38

Leston D (1971) Ants, Capsids and swolen shoot in Ghana: interactions and the implications for pest control In : Proceedings of the 3rd international cocoa research conference, Acrra, Ghana. 1969, 205-221 pp.

Marchart H. (1971) Reply to Denis Leston: Ants, Capsids and swollen shoot. In: Proceedings of the 3rd cocoa International research conference, Accra, Ghnana. 1969.

Opoku I. Y., Appiah A.A., and Akrofi A.Y. (2000) *Pytophtora Megajkarya*: a potential threat to the cocoa industry in Ghana. *Ghana Journal of Agrcultural Science* 33, 23-248.

Padi B., Ackonor J.B., Abitey M.A., Owusu E.B., Fofie A. and Asante E., (2000) Report onthe Insecticide Use and Residues in Cocoa Beans in Ghana. Internal Report submitted to the Ghana Cocoa Board, 26 pp.

Padi B., Downham, M. Farman D.I. & Sarfo, J.E. (2001) Evidence of sex attractants in the cocopa mirids Distantiella theobroma (Dist) and Sahlbergella singularis Hagl. (Heteroptera: Mridae) in field-trapping experiments. In: Proceedings of the 13th International Cocoa Conference, Kota Kinabalu, Saba, Malaysia, 9-14 October, 395-402 pp .

Padi, B., Ackonor, J. B., and Opoku I. Y. (2002) Cocoa IPM Research and Implementation in Ghana. Pages 54-62 In: J. Vos, and P. Neuenschwander, (Eds.) Proceedings of the West African Regional Cocoa IPM Workshop, Cotonou, Benin, 13-15 November 2001. Newbury (UK): CPL Press

Padi B., Adu-Acheampong R., Asamoah M., Aneani F., Baah F. and Tamakloe M. K. (2004) Screening of Neem Extracts for the control of Cocoa Capsids. Proceedings of 4th International Cocoa Pests and Diseases (INCOPED) Seminar, 19-21 October 2003, Accra, Ghana: 44-52. pp.

Peng R. K., Christian, K. and Gibbs, K. (1999) The effect of colony isolation of the predacious ant, Oecophylla smaragdina (F.) (Hymenoptera: Formicidae), on protection of cashew plantations from insect pests. *International journal of Pest Management*, 45: 189-194.

Wood G. A. R. and Lass R. A. (1985) *Cocoa: Tropical Agricultural Series (4th Edition)*. London and New York: Longman 620 pp.

Van Mele P. and N. T. T. Cuc (2003) *Ants as Friends: Improving your Tree Crops with Weaver Ants*. Cali (Columbia): CABI *Bioscience*, pp. 67

Chapter 4

Assessing the effectiveness of Local Agricultural Research Committee in diffusing sustainable cocoa production practices: the case of Capsid control in Ghana

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CHAPTER 4

Assessing the effectiveness of Local Agricultural Research Committee in diffusing sustainable cocoa production practices: the case of Capsid control in Ghana

Abstract

The conventional method of 'delivering' technologies recommended by researchers to farmers through extension has proved ineffective, resulting in a persistent low (0.4% - 3.5% over ten years) adoption of research-based cocoa technologies. The present study was conducted in the Eastern Region of Ghana and assessed the impact of the Local Agricultural Research Committee (LARC) approach on the diffusion of capsid management knowledge and practices, developed with the LARC, to others in the community. Capsids (*Sahlbergella singularis* and *Distantiella theobroma*) were diagnosed as the most serious production constraint. LARC members engaged in intensive interactive learning and experimentation to control them. The interactive approach developed by International Centre for Tropical Agriculture was used to link the LARC with community farmers, a majority of whom aspired to produce organic cocoa for a premium. The LARC acquired vital agro-ecological knowledge on capsid management, including skills in scouting for capsids to determine their temporal distribution and systematic experimentation with control methods, before presenting its results to the community. This article reports on a survey comparing three categories of farmers: LARC members, exposed and non-exposed community farmers, so as to assess the diffusion and impact of LARC knowledge co-production. The results show that the LARC approach significantly influenced acquisition and diffusion of knowledge and practices.

Key words: Integrated Pest Management (IPM), Interactive learning, Neem, *Oecophylla longinoda*, Organic cocoa production, Pheromone traps.

Introduction

Nearly all cocoa beans exported from West Africa are produced by small-scale farmers. Involving them in the development of sustainable cocoa production requires a new interface with research (Vos and Krauss, 2004). Ensuring active farmer engagement in research and extension requires a paradigm shift from the prevailing top-down approaches to participatory learning approaches. Cocoa farmers' views would, for example, be regarded as a necessary ingredient in research and development decision-making. Discovery learning by farmers would be the result of using interactive tools for improving farmers' decision-making capabilities. Such approaches are now considered more effective than the linear approaches that often are still applied today (e.g., Meir and Williamson, 2005).

The benefits of Integrated Pest Management (IPM)/Farmer Fields Schools (FFS) as an approach to interactive learning, in terms of introducing more sustainable farming methods and in terms of empowering farmers, are well-documented (Bruin and Meerman, 2001; Van de Fliert, 1993). The FFS approach has amply demonstrated its ability to deeply affect the professional skills and their ability to apply principles to solve new problems or to capture opportunities in diversity (e.g., Röling and Van de Fliert, 1998). Despite the fact that the FFS approach has been very successful in improving farmers' decision-making processes and enhancing their analytical skills (Braun *et al*., 2000), it has been criticised for having little impact on farmers other than the direct FFS participants (Feder *et al*., 2004). This is because experience with FFS world-wide has shown that diffusion from the members of the FFS to other farmers is limited to simple ideas, practices and issues that can be easily observed. However, the understanding of the basic principles (like the action of natural enemies) and several skills do not get transferred easily. As such, the FFS has been branded cost-ineffective. This raises the question whether there are other approaches to interactive learning that would create space for non-participating farmers to benefit. Hence, the present study assesses the influence of the LARC approach, which does focus deliberately on the link between the farmers in the experimental learning group and the rest of the community. It evaluated the diffusion of knowledge; practices and attitudes acquired for effective capsid (a pest in cocoa) management from LARC members to the rest of the farmer community, and reflects on some complementary tools for effective farmer learning.

Ashby *et al*. (2000) indicated that the LARC approach was developed as a result of concerns regarding low adoption and limited impact of formal research on resource poor farmers. They reasoned that research that did not involve farmers as active participants in the early stages had, a high risk of low adoption (Ashby, 1987). The LARC and the FFS are two approaches to interactive learning for promoting integrated decision-making and innovation for sustainable agriculture by small-scale farmers (Braun *et al*., 2000). Both the FFS and the LARC focus on identifying concrete solutions through discovery learning, and on enhancing the capacity of individuals and local groups for critical analysis and decision-making. They also stimulate local innovations and focus on principles rather than recipes or technological packages (ibid). The LARC and other interactive learning methods such as the FFS are ways of approaching agricultural research and development with the aim of fully involving farmers as partners in all or key stages of technology development and or dissemination processes, including strengthening their capacity to experiment and innovate (Van Veldhuizen *et al*. 2002). These interactive approaches are often referred to by the umbrella term Participatory Technology Development (Van Veldhuizen *et al*. 1997)

Whereas FFS often focuses on gaps in agro-ecological knowledge that are not easily observable, the LARC approach focuses on active participation of farmers in systematic evaluation of technological alternatives through research. One of the other most striking differences is the selection of the participants. With the LARC platform, the larger community selects between two to four farmers who represent it in the research effort and who report back to the entire community. FFS usually have about 20-25 participants who are normally not selected by the community and who do not deliberately report to them. At best, some neighbours and close family members learn informally some of what was experienced (Feder *et al*., 2004).

Although the FFS and LARC have similar approaches to farmer learning, such as the styles of facilitation, motivation and the village diagnostic meetings, the purposes of diagnosis are different. The main objective for the diagnostic meeting prior to the establishment of FFS is to determine whether the location meets some given criteria and to help the facilitators adapt activities to suit local agro-ecosystems. The main aim of a diagnostic meeting with the use of the LARC platform is to define the agricultural research topic that the community entrusts to the committee (Braun *et al*., 2000). Another evolving platform is community IPM that sees FFS as a first step in the sustainable development and management of community resources. The goal of this strategy is to institutionalise IPM at the local level and consequently, it has three basic overlapping elements: learning, experimenting and organizing (Van de Fliert *et al*., 2002).

In view of the specific needs of study area, and the low adoption of pest recommendations in cocoa, the LARC approach was chosen as the main platform to test three alternative capsid control methods: Neem as a botanical (organic) pesticide (Padi *et al*., 2004), pheromone traps as a lure and kill method (Padi *et al*., 2001), and enhancing *Oecophylla longinoda* (ants) populations as natural predators (Chapter 2). During diagnostic studies conducted in the study area (Chapter 2), it appeared that cocoa farmers had erroneous ideas about which capsid species caused most damage. Therefore, we employed discovery learning tools (cage experiments traditionally used in the FFS) to help fill LARC farmers' agro-ecological knowledge gaps. To meet the aspirations of the local community to engage in organic cocoa production so as to capture premium prices, the LARC farmers were encouraged systematically to share their knowledge with the community so that the association of organic cocoa farmers could use its new understanding of the ecology and sustainable capsid control measures to convince other interested farmers and expand its membership. This aspiration was the basis for importing some communty IPM development tools into the LARC .

However, the extent to which LARC farmers passed their knowledge on to the rest of the farmers in the community was not known. Two questions were of particular interest to us. Did the use of LARC, as applied in this study, create the capacity to significantly influence knowledge, attitudes, and practices of cocoa farmers in the wider community? Based on the circumstances of the study area, can the LARC successfully integrate other learning tools to meet the holistic learning and action goals of the cocoa farming community?

To answer these questions, a survey was conducted to assess the potential of the LARC approach to generate, develop and share cocoa pest management information and practices with farmers at large. The survey was also meant to assess the potential of LARC to integrate research and extension concerns in cocoa crop management.

Context

The Cocoa Research Institute of Ghana (CRIG) develops pest management technologies, which are expected to be transferred to farmers through the Extension Service. However, a number of reports show low adoption by cocoa farmers of pest management practices recommended by CRIG (Donkor *et al.*, 1991, Henderson *et al.*, 1994, Padi *et al.*, 2000). Therefore, the Chapter 2 of this thesis (diagnostic study) made suggestions to involve farmers actively in decision-making processes about technology development and in dissemination.

The goal of the Cocoa Services Division – now ceded to the Ministry of Food and agriculture (MoFA), is to offer cocoa extension services, including crop protection advice, to farmers. The public extension service (MoFA) organizes seasonal training sessions on crop protection for its Agricultural Extension Agents (AEA), prescribing calendar-based application of conventional insecticides for the control of cocoa capsids (Gerkern *et al.*, 2001). In 2001 the Ghanaian Government introduced a 'free' Cocoa Disease and Pest Control Programme (mass spraying). In effect, cocoa capsid control in Ghana is mainly the responsibility of the central government and not of farmers. It is the Government that manages the programme to spray cocoa farms with conventional pesticides within a pre-determined peak capsid period (August to December). And it is the Government that allocates revenue from cocoa exports to this mass spraying, sometimes using pesticides produced in Ghana.

Most of the farmers in our study area had made a decision to produce organic cocoa to capture the premium prices that would be offered once the organic export chain had been set up and certification had been assured. At the inception of our research project, a diagnostic study on cocoa identified capsids damage, mainly by *Distantiella theobroma* (DT) and *Sahlbergella singularis* (SS), as the most serious constraint to cocoa production. In order not to frustrate the farmers' plans to produce organic cocoa, key stakeholders involved in the project convinced the authorities to use crude aqueous neem seed (*Azadirachta indica*) extract (ANSE) for the mass spraying in the study area. The key stakeholders were the Traditional Organic Farmers Association (TOFA) in the study area, MoFA, and CRIG. The process was facilitated by the principal author who represented the Convergence of Sciences (CoS) project, as part of his PhD research study.

In Ghana, an IPM/FFS strategy in cocoa production was primarily pursued by a Non-Governmental Organization (NGO), Conservation International, and other stakeholders including CRIG and MoFA, in the Kakum forest reserve area (Baah, 2002). By the end of 2002 the cocoa mass spraying had taken over the farms used for the IPM/FSS experiments. Currently, the Sustainable Tree Crops Programme (STCP) of the International Institute of Tropical Agriculture (IITA) also conducts Farmer Field Schools in Ghana (Vos and Page, 2005). The STCP is a sub-regional project in Ghana, Côte d'Ivoire, Nigeria and Cameroon. The control of capsids is included in its FFS curriculum. However, given the repeated concerns expressed about the low adoption of pest management technologies in cocoa, the FFS/IPM approach alone is not likely to improve the situation.

After the diagnostic study was conducted with 22 farmers, the community was asked to select seven farmers from the 22 to represent them in a research endeavour aimed at testing three alternative capsid control methods (Chapter 2). The seven became the initial LARC farmers made up of six men and one woman. In less than a year into the process, as a result of the performance of the LARC female-farmer as against the lack of commitment of two male-

LARC farmers, the community reconstituted the LARC with five men and five women. The LARC became the official research committee that linked the activities of the CoS research team and the community, most of whom were either members of the TOFA or had an interest in the association because of an anticipated premium price for organic cocoa.

The LARC farmers were organized and trained in the identification of key cocoa pests in the study area. They were also exposed to basic concepts such as *treatments*, *control*, and *replications* in research and experimental design, as well as to some information and practical skills required for field data collection. The major contributions of the LARC farmers included the design, execution and data collection for the field experiments and the invitation of the community to offer its indigenous knowledge and experience, and their values and socio-economic interests that could affect the research. They also assisted in the preliminary interpretation of what was observed based on their local experience, and were assisted to present the results of the field experiments to the rest of the community.

Materials and Methods

The study area and procedures

The study area covers cocoa farms in the township of Brong-Densuso and the surrounding farm communities. Brong-Densuso is a small town on the main road that connects Suhum, the district capital of the Suhum-Kraboa-Coaltar District, and Koforidua, the capital of the Eastern region of Ghana. A local forum for decision-making was established consisting of LARC farmers, an AEA and, depending on the activities and topic for discussion, scientists from the CRIG. These stakeholders met twice a month during the key stages of the research dealing with the three capsid control methods. After each major stage of the research process, we tried to reflect on the learning that had taken place.

Conceptual disagreements among stakeholders that emerged during the implementation of the field research were resolved through discussion and negotiation. LARC farmers learned to identify the capsids, recognised the damage they caused, and understood their life cycles through a self-discovery learning process using cage experiments that made visible processes that were unknown to them before (Table 1).

All cage experiments had three treatments and an untreated control, all replicated three times. The experiments were placed under trees close to the hamlet of one of the LARC farmers. In each case, the experiment was initiated with joint discussion on what to look for, why, how, for how long, and what specific indicators to use. The discussions also covered the results, the lessons learnt and how they could be applied in the capsid control experiments conducted on the farms. It also focussed on how to communicate the obtained experiences to other farmers. The discussions provided an opportunity for the researcher/facilitator to learn about cocoa capsids, as it was the first time he dealt with the impact of these pests on farms. This made it easier for him to play a facilitating role between stakeholders rather than being a 'typical biological research scientist' or a resource person.

Table 1. Cage experiments on cocoa capsids* conducted with LARC Farmers.

Cage experiment	Objective	Conclusion
Damage caused by capsid species	To know the nature of lesion by specific insects and their effects on cocoa	*SS and DT* most destructive
Feeding preferences of capsid species	Compare feeding preferences for certain plant parts	*Helopeltis sp.* on pods only; SS and DT on pods and leaf parts
Ant predation on capsids	To verify ant predation on capsids	*O. longinoda* preys on capsids
Effective dosage of neem	Determine effective dosage	Dosage of 20% efficacious and cost-effective

* Capsids species: *Sahlbergella singularis* (SS); *Distantiella theobroma* (DT); *Helopeltis sp.*

Experiential learning conducted with farmers focused on the identification of cocoa insect species. Concerning capsids, we studied their life cycle, their behaviour, the damage they cause, their location on the cocoa plant, and their predation by the ant, *O. longinoda*. Farmers were encouraged to observe and document interactions between the cocoa tree, capsids and ants. The information generated helped to develop the LARC farmers' skills at scouting for capsids. Together with scientists, they recorded data on the temporal distribution of the insects, which enabled them to decide on need-based spraying. Other learning experiences included weed management, sanitation measures to control black pod disease, restoration and conservation of soil fertility, etc.

In four different sessions, the LARC farmers presented the knowledge they had acquired to the community. The first presentation dealt with the identification of cocoa pests using specimens and pictures, and with their newly acquired knowledge about the ecology, biology and the behaviour of cocoa capsids. The second presentation focused on where, and when to scout for capsids. The third presentation dealt with control measures, and with their effects on capsid numbers and yields. The fourth presentation was about the advantages and disadvantages of each method. Farmers also showed results with respect to the advantages of adopting some agronomic practices including black pod management. They further shared their views and experiences in working with other stakeholders on the research project. Apart from the four co-organized community meetings, in the farmers' own meetings, the LARC farmers were asked questions about the research. During both formal and informal meetings, the village audience made suggestions regarding the experiments and other related issues (e.g. to look into marketing of organic cocoa) to the research team.

Survey on the use of the LARC approach

Different types of farmers, depending on their participation in, or exposure to, the LARC approach, were identified and interviewed using a questionaire. The three types of farmers identified were the LARC farmers themselves (direct beneficiaries), the exposed farmers (those who attended the LARC presentations) and non–exposed farmers consisting of farmers who had not participated in the study or LARC farmers' presentations and meetings.

Eight out of the ten LARC farmers who were available during the survey were interviewed. A total of 40 out of 60 farmers who participated in the LARC presentations were selected and interviewed as exposed farmers. The exposed farmers, live in four different communities within a radius of five km. However, in the sampling of the exposed farmers, the community they lived in was not used as a criterion. It was rather from a list of attendants at the LARC presentations, including males and females, that the 40 were selected from the 60 by leaving out every third farmer. Another 40 non-exoposed farmers who had not been involved were selected. In this case, living in different communities was the key criterion. Ten non-exposed farmers were selected from each of the following four communities: Ayisa-Brong No 1, Akwadum, Brong-Densuso and Brong No 2. In each community, a meeting was held to assemble 25 farmers comprising both males and females. The 10 were selected by leaving every third on the row out. During the sampling, questions were asked to verify their status as cocoa farmers and their non-involvement in any of the LARC presentations or meetings.

The questions in the questionnaire were mainly based on the LARC farmers' earlier presentations. They included questions on the conclusions from the cage experiments, on major findings from joint ecological analysis and on data collected from the experimental cocoa fields. The questionnaire was administered by three enumerators after their training, and after field pre-testing and fine-tuning the instrument. The data were analyzed with the statistical package SPSS. The preliminary findings were shared with the interviewees in a separate meeting for collective validation, criticisms, suggestions and corrections. The key variables used were *Knowledge, Attitude, Practice* and *Intentions* in order to determine whether the LARC approach and the efforts of farmers' in presenting lessons and experiences to other farmers in their community can be considered as practical approach to cocoa information and technology generation and diffusion.

Results

The survey comparing three groups of farmers with different levels of exposure to the technology development and diffusion processes allowed us to test for impact. The main subjects farmers were assesed on were their knowledge about identification, ecology, biology and behaviour of cocoa capids. Others were information and skills required for scouting for capsids, their control measures as well as the farmers' attitudes and intentions toward the control measures.

Farmers' knowledge on cocoa capsids

All cocoa farmers interviewed agreed that cocoa capsids pose a serious threat to high yields and referred to capsids as 'cocoa farmers' enemy'. However, at the beginning of the study, farmers' had poor or, at best, incomplete knowledge about cocoa capsids (Ayenor *et al.*, 2004). Many farmers in the area, including those who later became LARC farmers, could not identify the species correctly. Basic and essential knowledge about the ecology, biology and behaviour of capsids was extremely limited. In order to control their 'enemy', farmers needed to be able to identify the capsid species. As a result, efforts were made with the stakeholders (including the LARC farmers) to collectively learn how to identify capsids and understand their ecology, biology and behaviour.

Concerning the level of knowledge acquired about capsids, the LARC farmers seem to have influenced the exposed farmers (Table 2). The exposed farmers scored an average of 57% correct answers as compared to 33% for the non-exposed farmers. Although the exposed farmers were more knowledgeable on capsids ecology and behaviour than the non-exposed, the difference between them with regards to the biology was not that pronounced.

It is believed that collective sharing of problem-based information and systematic delivery of theoretical knowledge as a prelude to engaging in desired practices is critical for effective application of solutions. Information required for effective capsid monitoring and decision-making preceded the actual practice of scouting for capsids (Table 3).

Table 2. Knowledge of LARC, Exposed and Non-Exposed Farmers about cocoa capsids (% of farmers giving correct answer).

Main Topics	Questions dealing with:	Farmers			Chi-square test (P)
		LARC (n=8)	Exposed (n=40)	Non-Exposed (n=40)	
Pest Identification	*S. singularis*	88	31	8	<.05
	D. theobroma	75	38	15	<.05
	Helopeltis sp.	100	65	32	<.05
	B. thalassina	75	30	5	<.05
	Location: under pods	100	93	74	>.05 NS
Ecology	Preferred location	88	58	33	<.05
Biology	Developmental stages	88	20	15	<.05
Behaviour	Feeding by adults and nymphs	88	70	33	<.05
	Cryptic	100	90	39	<.05
	Dropping when touched	100	79	76	>.05 NS
Mean Percentage (%)		**90**	**57**	**33**	

Table 3. Knowledge of LARC, Exposed and Non-Exposed Farmers about scouting for capsids (% of farmers).

Questions	LARC (n=8)	Exposed (n=40)	Non-Exposed (n=40)	Chi-square test (P)
Reasons	100	80	42	<.05
Where on farm	100	98	63	<.05
When	100	85	61	<.05
Frequency	100	90	74	>.05 NS
How	100	33	18	<.05
Control decision based on scouting	N/A	23	8	<.05

The transfer of information on scouting by LARC to the exposed farmers seems to have been effective. There was no significant difference between categories of farmers about the knowledge of how often to scout; at least, three quarters of the farmers had correct answers. This is because the frequency of scouting is simple and logic; as often as possible, but at least, once a month. Although 33% of the exposed farmers and 18% of the non-exposed farmers know how to scout for capsids, only 23% and 8% respectively claim to practise scouting before spraying. Most of the LARC farmers had experiments mounted in their fields and the decision to scout before spraying was according to what the stakeholders in the research had collectively agreed upon. Therefore this question was not applicable to them. Farmers in all categories knew about conventional insecticides (CIs) (Table 4). All LARC Farmers were aware of the disadvantages associated with the CIs, against three quarters of the exposed and only about one quarter of the non-exposed farmers. Some of the common disadvantages mentioned include: being harmful to humans; high costs, contaminating food such as leaves of the cocoyam (*Kontomire*), a crop grown under the cocoa trees; easy means for committing suicide, etc. The use of neem (ANSE) and *O. longinoda* to control capsids are known to all LARC and exposed farmers; these percentages were 69 % and 51 % respectively for the non-exposed farmers (Table 4).

Table 4. Knowledge of LARC, Exposed and Non-Exposed Farmers on measures to control capsids (% of farmers).

Knowledge	Farmers			Chi-square test (P)
	LARC (n=8)	Exposed (n=40)	Non-Exposed (n=40)	
Conventional insecticides	100	95	97	>.05 NS
Disadvantage of conventional insecticides	100	78	27	<.05
Neem extract	100	100	69	<.05
Ant predation by O. longinoda	100	100	51	<.05
Sex pheromone traps	100	73	5	<.05

With regards to farmers' knowledge on the existence of sex pheromone traps, 73 % of the exposed farmers had either heard about it or seen it during LARC farmers' presentations in the community. However, almost none (5%) of the non-exposed farmers knew about it.

The actual control measures farmers apply on cocoa farms

No LARC farmer, but 15% of the exposed and 87% of the non-exposed farmers received the capsid spraying with conventional pesticides within a government-sponsored programme (Table 5). However, for some of the farmers within the study area who are mainly TOFA members, the Government, through the collective efforts from CoS and CRIG, agreed to spray neem for them because they rejected the synthetic pesticides.

About 60% of the LARC and the exposed farmers in principle apply or will accept the use of neem on their farms, against only 13% of the non-exposed farmers. LARC farmers were most (37%) in favour of using both neem and ants, followed by the exposed farmers (27%), while

Table 5. Capsid control measures applied by LARC, Exposed and Non-Exposed Farmers (% of farmers).

Categories of farmers	Control Measures		
	Neem	Neem & ants	Conventional Insecticides
LARC (n=8)	63	37	0
Exposed (n=40)	58	27	15
Non-Exposed (n=40)	13	0	87
Chi-square tests (P)	<.05	<.05	<.05

none of the Non-exposed farmers knew of the advantageous integration of the two methods. As the idea of controlling capsids is acceptable to all farmers interviewed (Table 6), they all have strong positive attitudes toward learning to identify capsids and the corresponding damage. However, about half of the non-exposed farmers were either not decided (39%) or had some negative reservations (10%) on the practicality of counting capsids numbers on cocoa as an appropriate action to control this pest. As compared to the LARC and the exposed farmers, the non-exposed farmers, have a different attitude towards the practice of scouting as a decision-making tool. This had mainly to do with doubts about the possibility of counting the insects, which are cryptic and can also fly into the upper storey of the cocoa canopy.

About 90% of the exposed farmers have strong positive attitudes towards the use of neem and *O. longinoda* as compared to 13% and 35% respectively, for the non-exposed farmers. LARC and exposed farmers expressed strong positive attitudes toward alternative methods, except that the exposed farmers had some concerns about the adoption of sex pheromone traps. The majority of the non-exposed farmers did not have favourable attitudes towards the use of neem; a third expressed strong positive attitudes towards the use of *O. longinoda*, while about 80% had no opinion on the use of sex pheromones.

This attitude is most likely to result from lack of information on the method, rather than from rejection. All farmers irrespective of their categories, favoured cultural control practices such as regular pruning, shade management, removal of mistletoes and infested pods and weeding (Table 6). More than 85% of the farmers in all categories wanted to learn and experiment with other stakeholders rather than taking on ready-made technologies from researchers.

Table 6. Attitudes towards capsids management practices by LARC, Exposed and Non-Exposed Farmers (% of farmers): Strong Positive Attitude (SPA); Positive Attitude (PA); No Opinion (NO); Negative Attitude (NA); Strong Negative Attitude (SNA)

Main Topics	Farmers												Chi-square test (P)
	LARC (n =8)				Exposed (n =40)				Non-Exposed (n =40)				
	SPA	PA	NO	SNA	SPA	PA	NO	SNA	SPA	PA	NO	SNA	
Controlling	100				100				100				
Identifying damage	100				98	2			85	13	2		>.05 NS
Scouting	100				80	15		5	31	20	39	10	<.05
Use of neem	75	12.5	12.5		88	5	2	5	13	8	37	42	<.05
Use of *O. longinoda*	100				90	8	2		35	10	38	17	<.05
Use of pheromone	100				30	28	40	2	2	5	80	13	<.05
Crop practices	100				100				100				
Organic production	100				87	11	2		2	5	80	13	<.05
Alternatives control	100				92	8			23	15	50	12	<.05
Joint Learning for solutions	100				97		3		85	5	10		>.05 NS

Table 7. Intentions to use alternative capsid management practices, assuming the government terminates cocoa mass spraying programme, by LARC, Exposed and Non-Exposed Farmer (% of farmers): Very likely (VL); Likely (L); Don't Know (DK); Unlikely (UL); Very Unlikely (VU).

Main activities	LARC (n =8)					Exposed (n =40)					Non-Exposed (n =40)					Chi-sq. tests (P)
	VL	L	DK	UL	VU	VL	L	DK	UL	VU	VL	L	DK	UL	VU	
Scouting	100	0	0	0	0	66	26	0	5	3	10	35	18	30	7	<.05
Neem	50	50	0	0	0	57	35	0	3	5	22	20	15	43	0	<.05
O. longinoda	63	25	0	12	0	68	24	3	3	2	25	17	10	43	5	<.05
Sex pheromone	0	25	25	38	12	5	32	30	30	3	0	16	50	32	2	>.05 NS
Crop practices	63	37	0	0	0	90	5	3	2	0	80	15	5	0	0	>.05 NS

To get some idea about the opinion of farmers on state-sponsored blanket spraying with conventional insecticides, questions were asked with the following prefix 'Given that the Ghanaian Government stopped the 'free' mass spraying, how likely is it that you will use/ adopt'.... The results of this probing exercise are presented in (Table 7).

Table 8. Primary sources of information on alternative methods of capsid control, by LARC, Exposed and Non-Exposed Farmers (% of farmers): Own family; research (CRIG); LARC Farmers; Extension; Fellow Farmers

Categories of farmers	Sources identified	Alternative capsid control methods		
		Neem	*O. longinoda*	Sex pheromones
LARC (n=8)	Own Family	0	37	0
	CRIG	25	0	25
	LARC	75	63	75
	Extension	0	0	0
	Fellow Farmer	0	0	0
Exposed (n=40)	Own Family	0	8	0
	CRIG	26	0	0
	LARC	69	88	68
	Extension	3	2	0
	Fellow Farmer	2	0	0
Non-Exposed (n=40)	Own Family	0	8	0
	CRIG	5	5	0
	LARC	30	25	5
	Extension	5	10	0
	Fellow Farmer	23	2	0

All LARC farmers, 65% exposed farmers and only 10% non-exposed farmers are very likely to scout for capsids before control, in case Government stopped the mass spraying. About half of the LARC and exposed farmers and about a quarter of the non-exposed farmers intend to use neem to control capsids. Whereas 60-70% of LARC farmers and exposed farmers are very likely to use *O. longinoda*, only 25% of the non-exposed farmers would do so. Concerning the use of sex pheromone traps, none of the farmers is likely to use them mainly because of lack of information about their availability, a situation CRIG intends to address. Most (60-90%) of the farmers in the different categories have intentions to apply crop management practices, but the differences among the categories are not significant.

Major Sources of Information of community farmers

We wanted to find out the sources of information of the exposed farmers on alternative control methods to verify the role of the LARC farmers' presentations. To establish this, we identified and compared the primary sources of information of the three categories of farmers (Table 8). Seventy percent of the exposed farmers and one third of the non-exposed farmers had heard about the use of neem for capsid control, indicating LARC as the primary source. Five out of the eight LARC Farmers learned about the use of *O. longinoda* from the other LARC farmers; the remaining three knew it already by own experience. About 90% of the exposed farmers and 25% of the non-exposed farmers traced their source of information on the use of ants to LARC farmers. Sex pheromone traps as a capsid control method is the least known (5%) among the non-exposed farmers.

LARC farmers are most likely to use information from each other, fellow farmers, CRIG and extension staff. According to the exposed farmers, CRIG is their ideal source of information followed by LARC and extension before fellow farmers (Table 9). On the other hand, the non-exposed farmers preferred extension and CRIG, ahead of LARC and fellow farmers. Many of the cocoa farmers interviewed, irrespective of their category, are not likely to use information from fellow 'average' farmer who has no special training, position or skills. CRIG as an institution

Table 9. Likelihood of use of information on capsids management from different sources, by LARC, Exposed and Non-Exposed Farmers (% of farmers).

Categories of farmers	Sources Identified	Likelihood				
		Very Likely	Likely	Don't Know	Unlikely	Very Unlikely
LARC	CRIG	75	25	0	0	0
(n=8)	LARC	75	25	0	0	0
	Extension	50	25	12	13	0
	Fellow Farmer	25	63	0	12	0
Exposed	CRIG	95	3	0	3	0
(n=40)	LARC	90	10	0	0	0
	Extension	87	10	0	3	0
	Fellow Farmer	42	32	13	13	0
Non-Exposed	CRIG	95	3	2	0	0
Farmers	LARC	53	17	7	23	0
(n=40)	Extension	95	3	2	0	0
	Fellow Farmer	49	28	5	15	3

seemed to have a good reputation among the farmers interviewed. CRIG however, normally, does not provide extension services to cocoa farmers. Between LARC and extension as the likely sources of information, there was no clear preference expressed by exposed farmers. Hence we probed further by asking the exposed farmers who have experienced both LARC and extension approaches to compare them in terms of conviction, trust, reliability, etc. (Table 10).

Table 10. Views of Exposed Farmers (n=40) when comparing the appropriateness of the LARC and the Extension approaches in diffusing knowledge on cocoa capsids management (% of farmers).

Indicators of Appropriateness	LARC Approach	Extension Approach
Convincing	64	36
Trustworthy	69	31
Practicality	80	20
Reliability	74	26
Suitability	72	28
Availability	95	5
Accessibility	95	5
Affordability	95	5
Acceptability	85	15
Overall-sustainability	85	15

The majority of the exposed farmers were convinced that the use of the LARC approach was the most appropriate for generation and 'delivery' of information and knowledge among cocoa farmers.

Adoption of calendar-based spraying

All LARC farmers, almost all exposed farmers (97%) and 68% of non-exposed farmers claim to have been advised by CRIG or MoFA to spray four times (between August and December) a year to control capsids (Table 11). This same recommendation was what farmers interested in the use of neem claimed to have been given. However, only one LARC farmer and four exposed farmers appeared to have adopted calendar-based spraying. Further probing revealed that three of the five farmers who actually applied the number of times prescribed were either part of a spraying team or had close relationships within them. The results show that irrespective of the category of farmers, the recommendation to spray four times according to the calendar is not followed. The government sprays once or twice for the farmers 'freely', and expect the farmers on their own to undertake two or three additional rounds of insecticide applications to complete the four times recommended within the peak capsids period (August to December). This recommendation has hardly changed since the 1960s.

Table 11. Percentage of LARC, Exposed and Non-Exposed Farmers being aware of calendar-based spraying, and applying it (% of farmers)

Calendar based spraying:	LARC (n=8)	Exposed (n= 40)	Non-Exposed (n=40)	Chi-square test (P)
Awareness	100	97	68	<.05
Application	12.5	10.5	0	>.05 NS

Discussion

Diffusion of knowledge and practices on capsids control

The knowledge transferred by LARC farmers to the exposed farmers was significant. LARC farmers had a great influence in enhancing the awareness of the exposed farmers on ecological and sustainable control measures.

Simple knowledge (ideas that were observable, etc.) diffused to both the exposed and non-exposed farmers, or they had already acquired such knowledge through their own experiences. For instance, farmers in each category knew *Helopeltis* sp. best. The easy identification of *Helopeltis* is because they are highly visible and farmers cannot fail to notice them due to the unsightly lesions they cause on the cocoa pods. Similarly, all farmers know about the use of conventional insecticides to control capsids (Table 4), and are equally aware of the simple message from extension as to when they should spray (Table 11).

On the other hand, complex ideas did not diffuse to the non-exposed farmers. For instance, the non-exposed farmers, significantly disagree with the other farmer categories as to whether scouting for capsids before control is realistic for effective cocoa capsid management. This shows how learning about the ecology of capsids can change farmers' (in this case the exposed farmers') attitudes towards a more positive ecological approach to pest management. The exposed farmers, as compared to the non-exposed farmers, have a better understanding of capsids and how to manage their populations; and are also aware of the disadvantages of using conventional insecticides and of the need to conserve the predatory ants. Therefore, the exposed farmers have favourable attitudes and intentions toward scouting as a decision tool, and are more likely to adopt ecologically sustainable practices involved in organic cocoa production than the non-exposed farmers.

Capsid control by mass spraying

Regardless of farmer category, very few farmers practise the recommendation to apply synthetic or botanical pesticides four times based on the calendar (Table 11). Farmers reasoned that applying the costly pesticides even once or twice was difficult. They also consider that since the government has fixed the price for cocoa at an amount they perceive to be low; it should bear the full cost of pest management, and assist them with labour costs for other crop management activities. Farmers see themselves as labourers who produce cocoa for the government. They do not see themselves as independent entrepreneurs.

This attitude is strengthened by the government taking on the responsibility for pest management through 'mass spraying' gangs who are paid per area covered. Such contracted labour may also compromise the quality of application. Taking away the responsibility of pest management through mass spraying with blanket application of synthetic pesticides has several disadvantages. First, not making farmers responsible for their own pest management is contrary to integrated pest management principles, because spraying is calendar based, and not need based. Secondly, Government does the spraying once or twice per year and the farmers are expected to continue to meet the rest of the prescribed recommendation, which they do not. Very few farmers were able to name any brand of the conventional pesticides, so they referred to them as 'DDT' or 'poison'. This indicated the possible danger of such products which often have complex instructions in a language (English) that most farmers cannot read.

It appears many farmers would rely on the control by the naturally occurring *O. longinoda*, which is a traditional pest management practice (Table 7). One of their reasons for this preference is their natural availability at no cost. They recognize that though the ants can be aggressive, working early in the morning in the cocoa farms is a way of going round the problem. For them, the benefits far outweigh the occasional painful bites. However, it is likely that the mass spraying of synthetic pesticides by the government negatively affects the abundance of the predatory ant (Van Mele & CuC, 2003). Ecological conservation of biological control agents such as a predatory ant is one of the major components of integrated pest management. Therefore, the mass spraying may disrupt the natural biological control system, which is the cornerstone of the integrated pest management approach. This, and a number of other reasons, is why the method of 'free' cocoa mass spraying needs serious reconsideration.

Farmers will be best able to make their own decisions about pest management when empowered through intensive learning approaches such as the LARC. This may well be more cost-effective in the long term, and it does not disrupt the environment. Besides, for the government, it would be beneficial to leave the farmers with the pest management decision because even in Ghana, many civil society groups are becoming increasingly concerned about the economic and environmental implications of the mass spraying campaign with synthetic pesticides. Instead, it would be better to invest in learning by farmers on integrated pest management practices (Meir & Williamson, 2004).

Comparing LARC and Extension approaches

Most farmers were concerned that extension workers are not easily available for them because they live in towns and cities and, in some cases, very far from the farms. The situation is aggravated by the problems of poor remuneration, lack of resources, and often the agents not having any means of transport. The views of the exposed farmers about the extension are symptomatic of the general dissatisfaction with their services (Table 10). Extension successfully transferred the simple message of calendar-based mass spraying across to farmers, but its application and subsequent sustainability within the context and conditions of most cocoa farmers is highly questionable (Table 11). The many disadvantages associated with the 'free' cocoa mass spraying campaign and the ineffectiveness of an extension approach (T&V) that has failed to reveal them, re-echoes the inappropriateness of the existing model of the transfer of technology in meeting the needs of ecologically responsive farmers.

Röling *et al.*, (2004) observed that co-learning in an action research context is irreplaceable with the transfer of technology by extension workers. The latter approach provides little or no space for farmers to interactively learn about pest management decision-making. It rather turns the farmers into passive recipients of handouts and fixed technical prescriptions. They become consumers of technology (Waibel, 1993). Chambers and Jiggins (1987) described the transfer of technology as a model that poorly meets the needs and priorities of small-scale farmers. Hence, the exposed farmers who have experienced both approaches, preferred the LARC approach to the existing extension approach.

Reflection on the use of LARC approach

The LARC concept was applied somewhat differently in this study as compared to Ashby *et al.* (1987). Following analysis of the conditions and context of the study area, discovery learning tools mainly used in FFS were critical to enhance a better understanding of the problem of what are capsids in the first place (Ayenor *et al.*, 2004). However, to make the whole exercise useful to the community, we paid more attention to community learning and action than FFS usually does, by systematically reporting back to the community, thus setting the basis for a community IPM, where TOFA used the information and knowledge acquired on its membership drive and advocacy activities. This adaptation of the LARC was to further enhance learning and action. The LARC experience further validates the suggestion of convergence of platforms such as

FFS, LARC and Community IPM (Braun *et al.*, 2000), also anticipated by Van de Fliert, *et al.*, (2002). They observed that the synergy and complementarities amongst these platforms, if well managed and used properly, could continue to evolve and contribute to the development and sustainability of agriculture in ways that none alone can accomplish.

Conclusions

The basis of the notable differences in knowledge, practices, attitudes and intentions about cocoa capsids management between the exposed and the non-exposed farmers can be attributed to the LARC approach and its attention to the community through series of presentations from which the exposed farmers benefited. Indeed, results indicate that LARC was the major source of information, skills and practices acquired by the exposed farmers, while the extension was responsible for the simple messages that the non-exposed farmers received. Hence, the LARC approach has not only shown its ability to diffuse information successfully to the larger community, but has equally demonstrated that it seems capable of transferring complex ideas and principles to other community farmers.

The LARC approach, as applied in this study, seems to have significantly reached and positively influenced other community farmers beyond the direct participants (LARC Farmers) to acquire complex ideas and skills required for ecologically sustainable practices. In this respect it seems more effective than the FFS approach.

The study has shown that the use of the LARC approach has effectively integrated participatory learning and action research with farmer participatory extension in cocoa production. Therefore, the LARC is a farmer educational tool that can supplement extension and enhance its effectiveness.

The use of LARC, FFS and Community IPM as complementary learning tools in this study offers some evidence for scientists to flexibly integrate these learning platforms with attention to community needs. This would open up the participatory space to embrace indirect beneficiary farmers and give more meaning to need-based research grounded in local development objectives and dynamics.

References

Ashby, J. A. (1987) The effects of different types of farmer partcipation in the management of on-farm trials. *Agricultural Administration and Extension*, 25: 235-252

Ashby J. A., Braun, A. R., Garcia, T., Guerrero, M. P., Hernandez, L. A., Quiros, C. A. & Roa J. I. (2000) *Investing in farmers as researchers: Experience with local agricultural research committees in Latin America*. Centro Internacional de Agricultura Tropical (CIAT) Cali, Colombia

Baah, F. (2002) Farmer participation approaches towards cocoa implementation. Pages 27-35 in J. Vos, and P. Neuenschwander, (Eds.) Proceedings of the West African Regional Cocoa IPM Workshop, Cotonou, Benin, 13-15 November 2001. Newbury (UK): CPL Press, .

Braun, A. R., Thiele G and Fernandez, M. (2000) Farmer Field Schools and Local Agricultural Research Committees: Complementary Platforms for Decision-making in Sustainable Agriculture. Network Paper No 105, Overseas Development Institute (ODI), London, 16 pp

Bruin, G. and Meerman, F. (2001) New ways of Developing Agricultural Technologies: The Zanzibar experience with participatory Integrated Pest Management. Wageningen: Wageningen University, Department of Entomology, 167 pp

Chambers, R. and Jiggins, J. (1987) Agricultural research for resource-poor farmers. Part I. Transfer-of-Technology and farming systems research. *Agricultural Administration and Extension* 27: 35–52

Donkor, M. A., Henderson, C. P. and Jones, A. P. (1991) Survey to Quantify Adoption of CRIG Recommendations. Farming System Research Paper No 3, Interim Working Document. Tafo (Ghana): Cocoa Research Institute of Ghana (CRIG), (unpublished report) 29 pp.

Feder, G., Murgai, R. and Quizon, J. (2004) Sending Farmers Back to School: The Impact of Farmer Field Schools in Indonesia. *Review of Agricultural Economics*, 67 (2): 423-428

Gerken, A., Suglo, J. and Braun, M. (2001) Crop Protection Policy in Ghana. Integrated Crop Protection Project and Ministry of Food & Agriculture. Pokoase, Ghana. (Unpublished Report) 185 pp.

Henderson, C. P., Owusu, G. K., Jones, A. P. and Padi, B. (1994) The importance to cocoa research for understanding farmers' rationale towards pest and disease control with reference to capsid and black pod disease control in Ghana. In: Proceedings of the 11th International Cocoa Research Conference, 18–24 July 1993, Yamoussoukro, Côte d'Ivoire. Hertford (UK): Stephen Austin & Sons Ltd., pp. 299–304.

Meir, C. and Williamson, S. (2005) Farmer Decision-making for Ecological Pest Management. Pages 83-96 in J.N. Pretty (Ed.) The Pesticide Detox: Towards a More Sustainable Agriculture. London: Earthscan

Padi, B., Ackonor, J.B., Abitey, M.A., Owusu, E. B., Fofie, A. & Asante E. (2000) Report on the Insecticide Use and Residues in Cocoa Beans in Ghana. Internal Report submitted to the Ghana Cocoa Board. 26 pp.

Padi, B., Downham, M., Farman, D.I. & Sarfo, J.E. (2001) Evidence of sex attractants in the cocoa mirids *Distantiella theobroma* (Dist) and *Sahlbergella singularis* Hagl. (Heteroptera: Mridae) in field-trapping experiments. In: Proceedings of the 13th International Cocoa Conference, 9-14 October 2000, Kota Kinabalu, Saba, Malaysia, 395-402 pp.

Padi, B., Adu-Acheampong R., Asamoah, M. Aneani, F., Baah F. and M. K. Tamakloe (2004) Screening of Neem Extracts for the control of cocoa capsids. Fourth International Cocoa Pest and Diseases (INCOPED) Seminar, 19-21 October 2003, Accra, Ghana44-52 pp.

Röling, N. G., Hounkonnou, D., Offei, S. K., Tossou R. C. & Van Huis, A. (2004) Linking science and farmers' innovative capacity: diagnostic studies from Ghana and Benin. *NJAS-Wageningen Journal of life sciences* 52: 211-235.

Röling, N. G. and Van de Fliert, E. (1998) Introducing integrated pest management in rice in Indonesia: a pioneering attempt to facilitate large-scale change. Pages 153-171 in: N. G. Röling & M. A. E. Wagemakers (Eds.) *Facilitating Sustainable Agriculture: Participatory learning and adaptive management in times of uncertainty.* Cambridge: Cambridge University Press 318 pp.

Waibel, H., (1993) Government intervention in crop protection in developing countries. Pages 76-93 in D. J. Chadwick and J. Marsh (Eds.) Crop protection and sustainable Agriculture (Ciba Foundation Symposium 177) Chichester: Wiley.

Van de Fliert, E. (1993) Integrated Pest Management: Farmer Fields Schools Generate Sustainable Practices. Wageningen (The Netherlands): Wageningen University, Published Doctoral Dissertation, 304 pp.

Van de Fliert, E, R. Dilts, and J., Pontius (2002) Farmer Research Teams, Farmers Field Schools and Community IPM: different platforms for different research and learning objectives. Pages 121-146 in C. Leeuwis and R. Pyburn (Eds.) Wheel-barrows Full of Frogs. Assen: Van Gorcum, The Netherlands.

Van Mele, P. and Cuc, N. T. T. (2003). *Ants as Friends: Improving your Tree Crops with Weaver Ants*. Cali (Columbia): CABI *Bioscience*, pp. 67

Van Veldhuizen, L., A. Waters-Bayer and H. De Zeeuw (1997) Developing technology with farmers. A trainer's guide for participatory learning. London: Zed Books LtD.

Van Veldhuizen, L., A. Waters-Bayer, Killough S., Espineli M. & Gonsalves J. (2002). Institutionalising farmer participatory research: Lessons from a comparative study. Pages 375 – 387 in C. Leeuwis and R. Pyburn (Eds.) Wheel-barrows Full of Frogs. Assen: Van Gorcum, The Netherlands.

Vos, J. G. M. & Krauss U. (2004) Working with farmers. Pages 140-149 in: J. Flood and R. Murphy. (Eds.). Cocoa Futures: A source book of some important issues facing the cocoa industry. Chinchina (Colombia): CABI- EDERACAFE

Vos, J. G. M. and Page, S. L. J. (2005) Towards Safe Cocoa Pest Management in West Africa. Pages 181-192 in: J.N. Pretty (Ed.) The Pesticide Detox: Towards a More Sustainable Agriculture. London: Earthscan

Chapter 5

Lessons from attempts to establish an organic cocoa enterprise at Brong-Densuso

G. K. Ayenor

Chapter 5

Lessons from attempts to establish an organic cocoa enterprise at Brong-Densuso

Introduction

In order to introduce this chapter, we must recall some of the information provided in Chapter 2 on organic cocoa production at Brong-Densuso, our study area. With roughly 600 ha of cocoa plantations, Brong-Densuso is the only area in Ghana where organic cocoa is produced. All other cocoa areas are regularly mass sprayed with synthetic pesticides as part of the cocoa production intensification programme of the Government. At Brong-Densuso, the last time individual farmers sprayed their cocoa was at least 20 years ago. Until 2002, because farmers received low cocoa prices they could not afford the expensive pesticide applications. Therefore, cocoa production in the study area was 'organic by default'. When one of the farmers from the area, Mr Samson Anobah, went to Copenhagen in the 1980s for a workshop on sustainable agriculture, he became aware of the premium prices paid for organic cocoa in industrial countries. He realised that cocoa farmers in Ghana were 'sitting on gold', given that the price paid by the Government to farmers at the time was no more than 40% Free on Board (FOB).

Inspired by Mr Anobah about 80% of the active farming population at Brong-Densuso and other smaller villages, representing about 500 cocoa farmers, decided to organise themselves into an organisation called the Traditional Organic Farmers' Association (TOFA). It became member of the International Federation of Organic Agriculture Movements (IFOAM). In 1997, well before the increase of the proportion of FOB price paid to farmers (to about 70% by 2004), TOFA established links with the Organic Commodity Products (OCP) Company of an American entrepreneur, who sought to establish an organic cocoa supply chain in Ghana for its outlets overseas. One of the key issues was to develop organic means to control cocoa capsids. Under an agreement with Ghana Cocoa Board (COCOBOD), OCP took the initiative for, and invested in, research by CRIG into the effectiveness of Aqueous Neem Seed Extract (ANSE) spraying for capsid control in small-scale countrywide trials. It also invested in research on soil fertility maintenance in organic cocoa. It would purchase cocoa beans at the premium price once certification could be arranged. It established contacts with ECOCERT International, the French office of the certification body, and paid for the first round of certification (see the

ECOCERT report, 2002). The idea was that cocoa farmers would organise for a self-controlled group certification process, as described by Pyburn (2004), ultimately monitored by ECOCERT International. OCP employed field staff to provide advisory services to organic cocoa farmers. To obtain satisfactory returns to its investment, OCP sought exclusive rights from COCOBOD for at least five years (from 2002-2007) for the marketing of organic cocoa from many cocoa growing areas in Ghana.

The introduction of 'free' mass spraying with synthetic pesticides in 2001, together with the price increase to 70% FOB, changed the situation completely. Alerted by the TOFA farmers, the present author was able to convince the authorities to prevent mass spraying with synthetic pesticides at Brong-Densuso and the surrounding villages. About 10 farmers from the area were trained to act as an ANSE spraying gang under instruction from TOFA, CRIG and OCP, with supplies and sprayers provided by CRIG.

These were the circumstances which we had identified (and created to some extent) during the diagnostic study in 2003/2004 and which seemed to make Brong-Densuso a very promising place for carrying out research on alternative methods for capsid control. As we have seen in Chapter 2, these favourable circumstances changed very rapidly as a result of the withdrawal of OCP. The Company argued that it had funded research on organic cocoa production in four regions for four years under the understanding that COCOBOD would allow buying the organic produce from those areas in order to justify its investment. COCOBOD insisted the agreement only held for the Brong-Densuso area. Given that in Ghana only the Brong-Densuso area is officially exempt from mass spraying with synthetic pesticides at the moment, it is understandable that OCP pulled out. After all, from the 600 ha, at best only about 300 MT of organic cocoa can be expected annually, which is too small an amount for OCP to engage in.

It is against this backdrop that the present chapter must be understood. It reports on the efforts by the author to pick up the pieces with the TOFA farmers and other stakeholders. On the one hand, his commitment to the farmers in the Local Agricultural Research Committee (LARC, see Chapter 3 and 4) that he had established left the author no option but to help them explore alternatives. On the other hand, the collapse of OCP threatened the motivation of TOFA farmers to engage in the author's study. With 'free' pesticide spraying by Government and the greatly improved prices, it was not very rewarding for some of them to engage in time-consuming alternative methods of capsid control. Luckily, the majority was driven by other motivations, such as negative side effects of pesticide use on health (including suicide attempts), soil fertility and biodiversity (e.g., disappearance of edible snails).

The follow-up efforts of the author to engage farmers, CRIG, MOFA extension workers and Licensed Buying Companies (LBCs), and other stakeholders in an effort to establish an organic cocoa supply chain was an attempt to achieve space for change. The CoS project considers innovation not only to be of a technical or agronomic nature, but also emphasises the institutional context and the extent to which the framework conditions established at higher scale levels impinge on opportunities for farmers (Röling *et al*., 2004; Hounkonnou *et al*., 2006; Van Huis *et al*., 2006). This is in line with understanding innovation as a 'novel working whole' that includes hardware, software, and orgware (Leeuwis and van den Ban, 2004: 141).

The purpose of this chapter is, therefore, to report on the experience with facilitating a multi-stakeholder process towards establishing an organic cocoa supply chain from the point of view of learning about: (1) institutional constraints to creating viable business opportunities for cocoa farmers; and (2) the process of deliberately establishing a marketing supply chain through a multi-stakeholder process (as advocated by Jiggins, 2005, when she suggested Experiential Learning Forums for building the cotton 'filière' in Benin). This purpose seems highly relevant given the many long-term plans to establish an organic cocoa export capability for Ghana (e.g., CREM, 2002; Vos and Page 2005).
The chapter starts off with a description of the international and national contexts for organic cocoa production. It then describes: (1) the experience with setting up a supply chain through a multi-stakeholder process; and (2) concretely, the experiences with engaging institutional actors at higher scale levels. It ends by drawing conclusions and relevant lessons from the experience, focusing especially on institutional factors and actors that determine business opportunities in Ghana. As such, this chapter fits squarely into the CoS approach to creating space for change (Leeuwis and van den Ban, 2004; Van Huis *et al*., 2006).

Policy and institutional context

General context

As in Nigeria, cocoa became Ghana's major export industry as a consequence of farmer-led innovation. When the outbreak of swollen shoot disease in 1936-1938 threatened the industry the (then Colonial) Government stepped in, and initiated cocoa research and a government-controlled marketing board (Anon., 2000). That Board also sought to stabilise farmers' incomes by building up reserves in times of good world market prices and by supporting farmers' incomes when world market prices were low. After independence, this system changed into one for raising revenue from cocoa, to a point where farmers lost interest in growing the crop (Röling *et al*., 2004). Under international pressure and the need to resuscitate farmers' interest, the Ghana

Government agreed to gradually increase farmers' share of the FOB price from 56% in 1998/9 to 70% in 2005 (Chapter 2). As a result Ghanaian cocoa production, after years of decline, increased dramatically in 2004. In 2003, Ghana produced 497,000 MT of cocoa beans. In 2004 the figure was 736,911 MT (FAOSTAT, 2005). Though some argue that the increase was due to the mass spraying programme, or a combination of the spraying and the price increase, we believe that the price increase was most critical. There is a strong relation between price and yields; thus yields increase when producer prices become favourable to farmers (MOFA, 2000). The above is summarised in Box 1.

Box 1. Historical overview of cocoa industry in Ghana

1815	Dutch missionaries are the first to plant cocoa in the coastal areas- but are not successful.
1857	Basel missionaries plant cocoa at Aburi- but are not successful either.
1879	Tetteh Quarshie, a Ghanaian blacksmith/farmer returns from abroad and plants cocoa at Mampong Akwapim, from where he sells pod/seeds to other farmers. From this beginning, the crop spreads to all suitable cocoa planting areas, making it the largest export industry.
1920's	The drive and ingenuity which farmers and the people of Gold Coast displayed in setting up the cocoa industry is described by A.W. Knapp, saying that cocoa farmers have shown the whole world that after all, 'the indolent natives' were capable of building their own economy.
1936	A farmer called Opanin Sabeng from Nankese in the Eastern region is the first to report the outbreak of Cocoa Swollen Shoot Virus Disease.
1938	Experts confirm the farmers' observations and as a result, a cocoa research station is set up at Tafo in the Eastern Region (it was to become the present-day CRIG).
1937	As a result of low prices paid to farmers by the Association of West African Merchants, farmers collectively decide to withhold cocoa beans from the market. During this period, a farmer called Kwame Ayew buys cocoa beans from fellow farmers and goes to Liverpool to sell them himself.
1940	As a result of the farmers' strike, a body called the West African Produce Control Board is set up by the British Government to see to the purchasing of cocoa from its colonies in West Africa.
1947	This body becomes the Cocoa Marketing Board (CMB), and is later further transformed into what is presently known as the Ghana Cocoa Board (COCOBOD). It becomes a tool for raising revenue from cocoa farmers.
1975-8	High cocoa prices on the international market are not passed on to farmers. Farmers loose interest in cocoa and in some years uproot cocoa trees for firewood and to create space for food crops. Others abandon farming altogether.
2004	Under international pressure, Ghana Government decides to pay farmers about 70% of Free on Board price. Ghana's cocoa production is the highest ever (736,911 MT)

Sources: Knapp (1920); Anon (2000); Lass (2004 a); CREM, (2002).

The increase in the prices paid to farmers represents a real opportunity that farmers jump at; evidenced by the rapid rise in production and their willingness to apply available technologies to overcome production constraints (see also Dormon, in prep.). The eagerness of farmers to collaborate in the participatory experimental research reported in this dissertation is also a clear indication of this.

The increased proportion of the FOB price paid to farmers in Ghana is partly made possible by the high cocoa prices on the international market. The cocoa industry in Ghana is embedded in international marketing trends and policies. Demand for cocoa worldwide is estimated to increase annually by 3% for the next decade, based on an expected increase in chocolate consumption in emerging economies such as China, India and Russia (Lass, 2004b). Most of Ghana's cocoa is exported to Europe and the United States (Lass, 2004a). For instance, The Netherlands alone imports about 20% of its cocoa supply from Ghana, and that accounts for about 24% of Ghana's production (CREM, 2002). Eating chocolate is becoming a health fad in Europe and the USA as a result of some international research findings (Lass, 2004a). The markets for speciality cocoa increase rapidly. London cafés now offer a variety of hot chocolate drinks that mimic the variety in teas, coffees (e.g., Starbucks), and beers.

The Ghana Government has resisted international pressure to liberalise export trading so that export marketing of cocoa beans remains centrally controlled by the Ghana Cocoa Board (COCOBOD), with some exceptions, as we shall see below when we discuss Kuapa Kokoo. Internal marketing is partly liberalized and allows private sector participation through Licensed Buying Companies (LBCs). Ghana cites quality assurance as the reason for its cautious liberalization programme and it appears to have been vindicated (Newell and Tucker, 2004). Liberalisation of cocoa export marketing in Nigeria seems to have led to a drastic reduction of quality.

As described in some other chapters in this thesis, the Ghana Government has decided to stimulate cocoa production among others by making available 'free' (but paid from cocoa revenues) mass spraying with synthetic pesticides by using spraying gangs. The idea is to reduce losses from capsid damage under the assumption that individual farmers will not engage in effective control. COCOBOD is a major shareholder in a pesticide manufacturing business in Ghana (Abuakwa formulation plant) (Anon, 2000). This mass spraying seriously affects Ghana's chances of benefiting from the rapid development of niche markets for organic cocoa in industrial countries. . Increasingly, consumers in the developed world are interested in 'total quality', i.e. not only in the physical quality or the safety of the food (including pesticide revenues), but also in the impact of its production on the environment and social welfare. More recently, ethical questions have become increasingly important, such as 'Did the cocoa growers meet their cost of production, including labour?' or 'How was the cocoa traded that is used for chocolate'? 'How did the production of cocoa affect biodiversity?' In addition, consumers are becoming concerned with the use and/or abuse of child labour (www.icco.org/anrep0304english.pdf). Cocoa certified as organic or fair-trade attracts substantial price premiums in the ruling London or New York market prices (Lass, 2004b).

A requirement for accessing the organic or fair trade international markets is certification by a recognised international body. Certification labels are essential for verification and control to maintain a given quality standard for a product. They serve the interests of both producers and consumers because they secure producers' livelihoods, and confirm to the consumers that they are contributing to a fair deal for otherwise under-privileged farmers, while getting a healthier product for their money (Newell and Tucker, 2004).

The certification procedure is very expensive. For small-scale farmers in developing countries, these costs are prohibitive. That is why major certification organisations, such as IFOAM and ECOCERT International foster group certification with reliance on self-control mechanisms by local producer groups, overseen by a local official agency (Pyburn, 2004). Hence, a key aspect of group certification schemes are the internal control and monitoring systems based on the certification criteria or established standards.

Organic and Fair Trade Cocoa in Ghana

There has been a great deal of interest in the possibility of growing organic cocoa in Ghana. Recent studies conducted in Ghana by the Dutch's Consultancy and Research in Environmental Management (CREM), and another by Amsterdam research institute for Global Issues and Development Studies (AGIDS) funded by The Netherlands Foundation for the Advancement of Tropical Research (WOTRO) have highlighted the potential and benefits of organic cocoa in Ghana (CREM, 2002; Norde and Van Duursen, 2003). Similarly, in Britain, CABI has paid great deal of attention to IPM in cocoa, and to a certain extent to organic cocoa production in Ghana (Vos and Page, 2005). However, at the moment, there is no organic cocoa from Ghanaian origin on the world market. This represents a business opportunity that calls for exploitation; especially given the widely recognised good quality and superior taste of Ghanaian cocoa (it is used by manufacturers in industrial countries to improve blends).

In Ghana, Kuapa Kokoo (KK), originally a farmers' union, now operates as a LBC registered under a group-certified fair-trade label. The Third World Information Network (TWIN) based in UK is the fair trade organization. TWIN has two main complementary components: TWIN trading (UK) - an alternative trading company, and TWIN Ltd, a registered charity involved in producer support programmes with overseas partners (Newell and Tucker, 2004). Twin Trading and KK together with The Body Shop and supported by Christian Aid and Comic Relief founded a company The Day Chocolate, of which KK owns one third of the shares. The company has two brands namely, Divine fair trade milk chocolate and Dubble fair-trade chocolate, which are in supermarkets all over Europe (www.kuapakokoogh.com/pages/page.php?contentid). TWIN Ltd supported KK in its establishment as a farmer-owned LBC, and continues to assist it, with other partners such as Max Havelaar Foundation, Department for International Development, and SNV (a Dutch Development non-governmental organization) (Newell and Tucker, 2004). With various forms of support from these organizations, KK has more than 900 primary societies with about 40,000 members (Newell and Tucker, 2004). Some of the benefits KK members are receiving from their fairly traded cocoa include better prices than the ones offered by the government and social premiums which are paid into a trust fund for the infrastructural development of beneficiary communities (e.g. provision of schools, potable water, etc.). Meanwhile, the highest volume of cocoa KK has been allowed to export directly was 950 MT, representing 2.9 % of 33,000 MT it purchased in the 2000/1 season (www.kuapakokoogh.com/pages/page.php). It is only over this volume that KK can pay producers premium prices.

With the changing trends in consumer preferences in favour of organic and fair-trade products, the long-term prospects of KK go beyond the fair prices at the farm gate. In industrial countries, the value of chocolate often lies in the brand name and KK has its own since 1999 (Newell and Tucker, 2004). But in practice, KK still has to rely on the conventional marketing chain controlled by the COCOBOD to supply its business partners abroad. KK has met the preconditions for independent export marketing set by the Ghana Government, and applied to obtain a provisional license to export up to 30% fair trade cocoa directly, but this proposal still waits for approval. Meanwhile the fair-trade principles can not be fully enforced due to the existing state monopoly in the external trading of cocoa (Norde and Van Duursen, 2003).
COCOBOD still fixes the cocoa price for all cocoa farmers, including KK members. The premiums paid to KK farmers are obtained from the small proportion (e.g., 2.9% in 2001) exported directly as fair trade, and not from the whole volume of cocoa purchased by the KK. Nonetheless, KK has become the source of inspiration for other farmers' unions in Ghana, including TOFA.

The initial notion behind the effort reported in this chapter was that the key institutions shared the common concern of assisting the TOFA farmers to achieve sustainable cocoa production to improve their incomes. Based on the idea that 'innovation is the emergent property of the interaction among crucial stakeholders in the innovation process' (Engel, 1995), it was considered necessary to strengthen the linkages among the organizations that could play important roles in the development of organic cocoa from Brong-Densuso and create new partnerships and networks that would address all aspects of the organic marketing chain. This included LBCs, COCOBOD (and CRIG), an international certification body, an importer from overseas, and perhaps most importantly, TOFA, if it could organize for credible internal control of its organic (and fair trade) production practices. We shall describe and analyse what happened in the sections below.

Methodological approaches, tools, methods and procedures

The stakeholders to be involved in organic cocoa production required a Multi-Stakeholder Process (MSP) approach to planning and implementation. The MSP approach allows a variety of actors at different levels to act together, and embraces inclusiveness in learning and sharing to achieve negotiated goals (www.iac.wur.nl/msp). The design adopted was a four-phase multi-stakeholder planning process, which allowed us to employ various steps, methods and tools appropriate to the objectives of the actors involved and the conditions in the study area. Below are the key steps and the respective tools and methods used in each phase of the decision making process that was followed.

Plan of Action

Phase 1: Setting up

a. Community review meeting on the problem situation to verify goals and problems, and to assist in formulating its objectives and challenges.
b. Follow-up meeting with key cocoa sector institutional stakeholders to discuss farmers' objectives and ways of how to assist them in reaching those.
c. Identify a new cocoa exporter willing to support the development of a sustainable partnership with the producers.

Steps used for setting up:	Approach, Tools & Methods
• Scope and mandate (organic marketing) • Stakeholder analysis • Situational analysis • Internal steering committee	• Brainstorming • Visioning • *Strength, Weakness, Opportunity &* Threat (SWOT) analysis • Group discussion/short presentations

Phase 2: Strategic Planning

Based on farmers' needs and the exporter's concerns, facilitate multi-stakeholders' action planning for sustainable organic cocoa production, certification and marketing.

Steps used for strategic planning:	Approach, Tools & Methods
• Presentation of farmers' visions, objectives and challenges • Presentation of exporter's (EcoTrade) concerns • Building on stakeholders' reactions • Identifying service gaps • Inventory of stakeholders' contributions • Harmonizing stakeholders' contributions with farmers' service needs in one plan.	• Short presentations • Open forum • Strength, Weakness, Opportunity & Threat analysis • Quiet individual reflection • Group discussions/ short presentations • *Logical Framework Approach*

Phase 3: Implementing and managing

Facilitate the implementation of the agreed multi-stakeholder plan, including empowerment of the farmers to demand services and training based on their felt needs.

Steps used for implementing and managing:	Approach, Tools & Methods
• Mobilization of stakeholders and resources • Facilitation and coordination • Monitoring and evaluation with the local steering committee members • Participatory actions and adaptation • Capacity building for farmers	• Group discussion/short presentations • *Quarterly inter-institutional meeting to* asses progress • Visit to institutions and observation • Hands on training • Adult education approaches • Logical Framework Approach

Phase 4: Learning and adaptation

Progress tracking and performance review, analysis and adjustment

Steps used for learning and adjusting	Approach, Tools &Methods
• Facilitation and coordination • Monitoring and evaluation with local steering committee • Participatory actions and adaptation • Reflections, review of plans • Flexibility (plan, structure and style facilitation) • *Capacity building for farmers*	• Group discussion/short presentations • Quarterly inter-institutional meeting to asses progress • Visit to institutions and observation • Peer review and consultation • Informal discussions with stakeholders Hands-on training • Adult education approaches • Logical Framework Approach

Data collection

The data collection began when problems with marketing and certification of organic cocoa raised serious concerns as to whether it was still useful for farmers and stakeholders to engage in the field research. The methods and tools used for data collection included active listening, observation and documentation, interviews, informal meetings, inter-institutional meetings and literature review. Other opportunities for understanding the process were presented through communication through the internet with the exporter, visits to major organizations, as well as a visit by the prospective exporting company (EcoTrade) to Ghana.

Results

Farmers' vision, objectives and challenges

After the withdrawal of OCP, farmers' commitment to the participatory field research on capsid control was very low. What they wanted was a restoration of the conditions that would justify organic production, especially the creation of access to a market that would offer them a premium price. This demanded finding an exporter and the completion of the certification process. In a meeting to verify their aspirations, they expressed their visions, challenges and objectives (Table 1).

To be able to produce organic cocoa remained a crucial issue for the TOFA members. In a meeting at Brong-Densuso, they indicated that if they wanted to achieve their goals, commitment to meetings and time management needed to improve. They acknowledged that training and attitudinal change could make the difference.

Table 1. Visions, challenges and goals of organic cocoa farmers at Brong-Densuso, Eastern Region of Ghana.

Visions	Challenges	Goals
Develop organic farming in all TOFA member communities	How to sustain farmers' commitment to organic production	Applying good crop management practices and getting rewarded
Improve livelihoods by using an IPM (and if possible an organic) approach	To ensure transparency and trust Achieve dynamic attitude towards collective action	Strengthen TOFA's organizational skills through training Information sharing at community meetings
Have healthy & prosperous people	Awareness creation about dangers of pesticides	Healthy food under cocoa plantation, free from pesticides
Improve farmers' commitment	Goal awareness - regular attendance to meetings Effective time management	Continuous education and setting up fines for lateness/ absenteeism and incentives for punctuality, etc.
Develop their communities to become model places/towns	Organic marketing opportunities Empowerment of all organic farmers	Become organic cocoa producers in Ghana.
Become self sustaining farmers	To view cocoa production as business, and not as a way of life	To further develop TOFA to meet its organic production needs.

Efforts to obtain a prospective marketing partner also yielded some positive results. EcoTrade, a specialty brokerage company in Miami, USA, showed interest. It supplies fine flavour and certified fair trade cocoa as well as organic cocoa. EcoTrade is a member of the Organic Trade Association, the Cocoa Merchant's Association of America, Transfair USA, and the Rainforest Alliance. Internationally, its major clients included Ben & Jerry's, Scharffenberger chocolate, Guittard chocolate, etc. To ensure that it became a fully fledged stakeholder, EcoTrade was incorporated into the collective planning process (Table 2).

Table 2. EcoTrade's general interests, concerns and questions with respect to organic cocoa from Ghana.

General Interests	Concerns and questions
There is no Ghanaian organic cocoa in the market (business opportunity)	Whether to purchase through Produce Buying Company (PBC) or Kuapa Kokoo?
EcoTrade could buy any volume TOFA could mobilize from a minimum of 150 MT and pay a premium (20-40%), depending on quality	Obtain beans as samples from the TOFA farms for quality tests including pesticide residue assessment to ensure organic status
Needed: highly uniform quality beans with good fermentation	Can the PBC and TOFA separate the organic beans from others and keep them until collection?
Maintain uniform quality	Additional information on the area; biodiversity, TOFA membership, number of villages involved, etc. Information on fermentation and drying practices

What made EcoTrade more than an ordinary business partner was that it followed the new trend of highlighting the origin of cocoa. EcoTrade was one of the few whose emphasis had shifted from commodity extraction to sustainable development of new relationships, based on fair-trade principles between consumers and growers. EcoTrade was an ideal prospective partner for TOFA because it could absorb the low volumes (a minimum of 150 MT) that TOFA was capable of supplying. Meanwhile, the company had concerns which needed to be addressed.

For the farmers to meet the quality demands and other expectations of the exporter, they needed some assistance from service providers and other institutional support. Prior to EcoTrade's involvement, OCP had facilitated the first round inspection for group certification by ECOCERT International. The latter had made some recommendations with respect to the improvements that were required. In addition, based on the facilitator's experience in working with farmers groups, a participatory needs assessment was conducted in line with the farmers' objectives (Table 3, compiled in stakeholder meetings). The stakeholders accepted the challenge in the presence of the farmers to assist by verbally committing their respective organizations' support.

Table 3. Synthesis of ECOCERT's recommendations for service and assistance to TOFA as compiled by stakeholders

Areas Identified	Issues and actions that needed attention
Production and protection of cocoa ecology	Good husbandry practices (timely weeding, good shade management, etc.)
	Diseases & pest control
	Increased yields without upsetting the ecological balance (no synthetic pesticides)
Post-harvest handling	Provision of uniform quality beans
	Good fermentation practice (5-6 days in plantain leaves, etc.)
	Proper sun drying (6-7 days, occasional rubbing and picking of debris, etc.)
	Effective storage in between and after drying (not close to kerosene, etc.)
Certification	Implementation of recommendations based on internal control systems in place from first round of inspection of TOFA farms
	Coding and documentation of organic farms
	TOFA to conduct own internal inspection and report
	Multi-stakeholders' inspection based on the internal control system
	Inspection by the licensing team (International Experts)
Marketing	Maintain communication and contact with EcoTrade
	EcoTrade directly to communicate with COCOBOD through CRIG
	Request for 5 kg of dried cocoa beans as sample for testing
	Negotiation of premium
	Drafting and signing of Memorandum of understanding between EcoTrade and COCOBOD on behalf of TOFA
Capacity Building (TOFA)	Training of TOFA in farmers' group development, management and sustainability of the association.
	Leadership and facilitation skills for management of TOFA
	Record-keeping training (documentation and reporting, filing, receipt and payment voucher writing, basic profit and loss accounting and analysis, etc.)
	Social communication and conflict (effective communication and practical skills for conflict management)

Policy Gap	Establish channels of communication among stakeholders at different levels
	Create enabling organic marketing conditions and channels for TOFA
	Acknowledge of the organic cocoa production efforts as pilot case study
	Encourage policy-makers and institutional players to include project in their main activities
Facilitation:	Coordination of sequence of activities and resolution of practical problems for effective implementation
	Mobilization of people and resources for implementation
	Facilitating collective monitoring and evaluation with the local project steering committee
	Organization of meetings and progress report sharing

Hence, the contributions of these organisations and some recommendations from the ECOCERT report were harmonized into a collective plan to establish sustainable organic cocoa production (Table 3).

However, apart from some of the training aspect of the plan, none of the major activities were carried out. This could be attributed to lack of commitment from MoFA, CRIG/COCOBOD and weak leadership of TOFA. The lack of institutional support and lack of transparency within TOFA, as well as ineffective leadership of the association led to a situation in which most of the farmers became disillusioned. The role of the key stakeholders (organizations) and lack of transparency in TOFA is discussed below.

MoFA

Under the collectively developed action plan, MoFA was given the responsibility of organizing the training of the farmers.

The MoFA's Agricultural Extension Agent (AEA) was either absent or arrived late, often blaming lack of transport. To solve this problem, the CoS project provided him with a transport allowance. However, no reports on any activities conducted with the farmers were received, despite several requests. He also did not follow the action plan. As a farmer put it 'we only see him sometimes when CoS organizes a meeting'.

He was quite comfortable with giving technical messages to the farmers; however his facilitating skills in organizing the farmers were far from what was expected. He also caused a serious mistrust between him and the farming community. One example will be given. He asked some leaders and members of TOFA and other farmers to follow him to the District office because there was a Farmer Based Organization's (FBO) development fund that they could access to support whatever businesses they were interested or involved in . They joined him to the District office, only to learn what was already explained to them during an earlier meeting which the extension worker did not attend. To qualify for the fund the farmers needed to show evidence of a viable group with active membership, a bank savings book, constitution or by-laws, minutes of meetings, a proposal for what the fund was to be invested in, etc. The extension worker's role was to assist the farmers to develop the proposal and submit it. As a result, the farmers became very angry and even demanded their transport fare from him. Some even advocated his removal, so we had to intervene and settle the issue. Afterwards the MoFA's District Director tried to correct the situation. The lack of effectiveness of MoFA's extension staff seriously affected TOFA's organization for certification.

CRIG/COCOBOD

CRIG represented COCOBOD, and insisted that we would not deal with the Board directly. It was officially mandated to take up the certification responsibilities in addition to its original role in supporting the research into alternative capsids control methods (Chapter 3). The Deputy Director of CRIG, who retired in 2003, had shown much support and interest in the certification process. However, after she left, CRIG hardly attended the quarterly inter-institutional meetings organized to discuss the progress of certification and marketing. Initially, CRIG asked for the full report of ECOCERT's first round of inspection. We copied it from OCP; made it available to CRIG and added a full report of the multi-stakeholder meeting. However, there was no follow-up. The CRIG officer assigned to the project was very knowledgeable about the certification process since he had been part of the effort from its inception even when OCP was involved. He blamed the lack of follow-up on his overloaded difficult schedule with too many things competing for his attention, and was later taken off this duty. But he was not replaced.

A letter was written (through CoS Ghana) asking CRIG to assign a new officer to this dossier. A person was nominated but he hardly dedicated any time to the organic cocoa project.

EcoTrade wanted to know why there was a delay in the certification process and its prospective clients in the US equally wondered whether the organic cocoa was ever going to be delivered. The President of EcoTrade came to Ghana. We went to meet the Deputy Director of CRIG and were given a warm reception. EcoTrade's President left with a great deal of hope, but his electronic mails and calls to CRIG were not answered after we tried to link CRIG and EcoTrade to communicate directly. We advised the President of EcoTrade to contact COCOBOD directly.

He travelled from Miami to Washington to meet the Chairman of COCOBOD. Eventually, EcoTrade gave up. Further visits that we made to CRIG seemed to indicate that CRIG/ COCOBOD did not have much confidence in the future of organic cocoa. Some of the questions from CRIG/COCOBOD were: *Do you really think organic cocoa production would ever work in Ghana? Do you think the beans can pay for the cost of certification? What if other farmers also become interested in organic cocoa production?*
The final conclusion we drew was that COOCBOD is very concerned about the effectiveness of alternative capsid control methods. It also fears that, where Ghana already receives a premium price for the high quality of its cocoa, trading the beans as organic is not likely to add anything substantial to what is already earned.

TOFA

In the absence of the TOFA Chairman, the association experienced serious problems of leadership, and it worsened by the lack of support from the key stakeholders to assist in the re-organization process. In this situation, some members accused a number of TOFA's leaders of corruption and favouritism.

TOFA leadership received several training sessions and, as part of the capacity building process, we asked them to deal with the key stakeholders, including CRIG. One issue was how to take full control of the CRIG sponsored ANSE spraying. Thanks to their training, TOFA leaders became empowered to handle the entire budget for the spraying and to deal directly with CRIG. Their newly offered responsibilities included collection and management of the spraying inputs, and the money used to pay for the services of the 10 sprayers in the organic gang. They also had to decide which part of the demarcated areas (apart from the experimental plots and its surroundings- Chapter 3) were to be sprayed with ANSE or required application of organic manure.
Perhaps the TOFA leadership became 'overly empowered' because the ordinary members began to complain seriously about the way favouritism and other corrupt practices had become common in TOFA's management of the spraying programme. Their criteria for spraying one particular place and not the other were questioned. We addressed these issues in several meetings but the complaints continued. The leadership accepted some of the grievances from the members but reasoned that the application was selective because some of the farmers were not weeding their farms and did not provide the gangs with water for spraying. Both were conditions agreed upon as a pre-requisite to qualify for the ANSE application. However, it turned out that the conditions for deciding who should benefit had been seriously abused because family members and relatives of some TOFA leaders, and even some of the gang sprayers, did not meet the

qualification criteria but had their farms sprayed nevertheless.
As a consequence, TOFA lost control over organizing the farmers. Although the attendance at meetings was a challenge the leadership recognised early (Table 1), it only declined. The ordinary farmers clamoured for changes in the TOFA executive leadership but that could not be done until the association had a constitution that stipulates tenure of office, electoral procedures, etc. The executives had been leaders since the inception of TOFA, over 15 years ago. Several attempts to involve the District Officer of the Department of Cooperatives in handling the situation failed. Meanwhile, the founder and chairman of TOFA had left the village to farm elsewhere, which made re-organization difficult. He was contacted and agreed to resign and become a-life-patron of TOFA, but due to the lack of institutional support to progress with the certification, and the alleged corrupt practices experienced within TOFA, farmers' commitment in the process of re-organization was extremely low.

In the end, some farmers felt that the only way to re-organize TOFA was to ask EcoTrade to buy the uncertified cocoa and pay the premium. After long negotiations, the company agreed to further negotiate the idea with some Organic Associations in USA, which under some special circumstances, could give EcoTrade such special permission and label our produce as 'organic cocoa beans in transition'. However, this also required that CRIG and COCOBOD allowed chemical residue and other laboratory testing using 3-5 kg of beans from the area. We facilitated the collection of a representative sample and paid for it to be delivered to CRIG as requested by EcoTrade. However, EcoTrade never received the parcel. It is not clear who finally kept the beans: the farmers or CRIG.

Presently, TOFA leadership is organizing the ANSE spraying and the members do not actively participate in meetings because nothing would change in the near future. Openly standing up against the TOFA leadership could cost them the input services TOFA provides. Meanwhile, the TOFA members are not denouncing their interests in the organic cocoa. The majority still do not like the synthetic pesticides. The general posture is that perhaps one day the much-anticipated premium for organic cocoa will become a reality, but for now, most are extremely sceptical.

Conclusion

The experience in the small area (600 ha) of Brong-Densuso with organising a pilot organic cocoa production effort provides sobering lessons for those involved in the current international enthusiasm for developing a supply chain for organic cocoa from Ghana. By way of conclusion, a few of these sobering lessons are enumerated below.

Technically, there seems to be no impediment to organic cocoa production. Our own research has shown that the main pest in cocoa, the various species of Capsids, can be controlled without the use of synthetic pesticides. The fact that COCOBOD is not convinced is to be expected. Disbelief in the possibility of pest and disease control by IPM is a normal gut reaction among conventional government staff, as has been experienced in many Farmer Field School projects. Often this disbelief is fuelled by active lobbying by the pesticide industry (e.g., Sherwood, 2006). In this case, COCOBOD is part of the pesticide industry. Solving other technical problems such as Black pod disease control also seems possible through organic methods, e.g., the time-honoured collection and destruction of infected pods (see also Dormon, in prep.).

Economically, the conclusion is less straightforward. In the nineties, when farmers received maximally 40% of FOB and world market prices were low, the premium price paid for organic cocoa in markets in industrial countries seemed to be very attractive for farmers. This is the origin of the TOFA farmers' organisation. Now the situation is completely different. The world market price is high and the farmers receive up to 70% of FOB. It is uncertain whether the 30 – 40% higher premiums for organic produce are a sufficient incentive for engaging in the required self-control for certification and other organisational efforts. We come back to this point below, when we discuss farmers' institutional issues.

The problems that most seriously determined the outcome of our efforts to establish a pilot project in organic cocoa seem especially *institutional*. MOFA's Extension Service turned out to be incapable of organising self-control for certification. It seemed to be a matter of sheer incompetence and lack of organisational capacity. The situation with respect to COCOBOD/ CRIG seems to be more complex.

COCOBOD funds CRIG and this can influence the policy of the research institute (CREM 2002; MASDAR, 2004), and raises questions about its objectivity. The institute supported research for alternative capsids control methods and promised the farmers support to arrange the certification. However, later CRIG showed less commitment towards the certification process, and seemed to have closed its doors to prospective exporters. It began to question the viability of the organic project, instead of testing it with the key stakeholders.

Another concern is the way CRIG welcomed OCP to fund its programme on the use of neem as an effective means of controlling capsids (Chapter 2; Vos and Page, 2005). However, CRIG switched to support the CODAPEC spraying programme when the new government and COCOBOD took the decision to apply synthetic pesticides in all cocoa growing areas in Ghana.

With respect to COCOBOD as the key stakeholder for building a capacity for organic cocoa production in Ghana, the lessons are the following:

- It seems that COCOBOD (and even CRIG scientists) doubt whether capsid damage can be prevented using alternative control methods.
- COCOBOD seems worried about the implication of a possible organic cocoa project at Brong-Densuso, in the event that TOFA obtains market access and other cocoa farmers begin to become interested.
- The implications of the success of organic cocoa in Ghana are not known but the Board anticipates some possible 'consequences' with respect to, for example, the mass spraying programme and the sales of synthetic pesticides.
- The Board is uncertain about the growing market opportunities for organic cocoa. COCOBOD is very proud of the very good reputation of Ghana's cocoa and the high prices it receives for it. Its caution with respect to liberalising cocoa exports from Ghana seems to have paid off in this respect. The exploration of the potential of organic cocoa in Ghana by foreign funded studies such as CREM (2002) might not be sufficiently credible.

Opening up direct exports of organic cocoa from Ghana, for example through an effective partnership between EcoTrade and TOFA, could leave COCOBOD with a reduced role. I
The farmers, especially some of TOFA's executive members, have noted that building a sustainable farmer organization to partner other stakeholders for organic cocoa marketing is complex and requires more than reaping immediate benefits. Given the current high price that farmers receive, in the present state of a loosely organized TOFA, at least some of the most influential executive members (Vice-Chairman and the Secretary/Financial Secretary) appear content with receiving their monthly allowance for supervising and managing the ANSE spraying programme.

The ordinary members of TOFA have to wait and see. Said some: '*If we openly say we are not members of TOFA then our farms would not be sprayed with the ANSE for free. And since we do not want the poison (synthetic pesticides), we just keep quiet and look on. But, we have no time to attend TOFA's meetings*'. Apparently, these farmers have lost trust in their leadership and have decided not to invest their precious time and resources in TOFA's activities. Lack of trust was identified by Ana Laven during her field work in Ghana as a serious problem affecting cocoa farmers in their attempts to form groups (Norde and Van Duursen, 2003), and could affect mobilization of new energies for group action aimed at achieving developmental goals.

So where does this summing up of lessons leave the prospects for organic cocoa in Ghana? Kuapa Kookoo is a living testimony as to what organized cocoa farmers in Ghana can do with market opportunities (Newell and Tucker, 2004). Building alternative institutions is not impossible. But it requires a great deal more effort than our pilot project could give it.

(i) Any attempt to build a supply chain for organic cocoa from Ghana should pay a great deal of attention to the central role of COCOBOD and it's to some extent legitimate, and certainly understandable, doubts about organic cocoa. It is not farmers who need to be convinced, but COCOBOD. Strong guarantees from a commercial partner in the industrialized world might be required.

(ii) A second major issue is the building of a strong farmers' organization that can manage self-control for certification and other tasks. The incentives for farmers to engage in such efforts, given the gains that can be made, need to be carefully studied.

References

Anonymous, (2000) Ghana Cocoa Board Handbook (8th Edition). Ghana Cocoa Board, Accra, 62pp.

Bedergue, J. A. S. (2001) Cooperating to compete: Associative peasant business firms in Chile. Wageningen: Agricultural University, Doctoral Thesis 276 pp

Chema, S., Gilbert, E. and Roseboom, J. (2003) A Review of Key Issues and Recent Experiences in Reforming Agriculture Research in Africa. The Hague: ISNAR, Research Report 24 pp.

CREM, (2002) Analysis of environmental, social and economic issues related to cocoa products consumed in the Netherlands. Field research in Ghana. CREM report number: 02.578, Commissioned by VROM Amsterdam, The Netherlands

Donkor, M. A., Henderson, C. P. and Jones, A. P. (1991) Survey to Quantify Adoption of CRIG Recommendations. Farming System Research Paper No 3, Interim Working Document. Tafo (Ghana): Cocoa Research Institute of Ghana, (unpublished report) 29 pp.

ECOCERT International (2002) Inspection report: Farming, collection, processing handling, and exportation of cocoa for Organic Commodity Project. Commissioned by Organic Commodity Product. Inc. USA (Internal Report) Code: 1086GH0200r1e 30pp.

Engel, P. (1995) Facilitating innovation: An action-oriented approach and participatory methodology to improve innovative social practice in agriculture. Wageningen: Agricultural University, published doctoral dissertation. Will be published commercially by the Royal Tropical Institute in Amsterdam, 1997.

Henderson, C. P., Owusu, G. K., Jones, A. P. and Padi, B. (1994) The importance to cocoa research for understanding farmers' rationale towards pest and disease control with reference to capsid and black pod disease control in Ghana. In: Proceedings of the 11th International Cocoa Research Conference, 18–24 July 1993, Yamoussoukro, Côte d'Ivoire. *Hertford (UK): Stephen Austin & Sons Ltd., pp. 299–304.*

Hounkonnou, D., (2001) Listening to the cradle: building from local dynamics for African Renaissance: case studies from Benin and Ghana. PhD thesis, Wageningen University Wageningen, 263pp.

Hounkonnou, D., D.W. Kossou, T.W. Kuyper, C. Leeuwis, P. Richards, N. Röling, O., Sakyi-Dawson and A. Van Huis (2006) Convergence of Sciences: the management of agricultural research for small-scale farmers in Benin and Ghana. *NJAS. - Wageningen Journal of Life Sciences* 53 3-4: 243-267.

Jiggins, J. (2005) The Concept of Experiential Learning Forums (ELF).Appendix to Convergence of Sciences Report (2005) Experiential Learning Forums as a Tool for Capacity Building among Stakeholders in Cotton Chains in West Africa. Wageningen: Wageningen University, North-South Centre. Report INREF Workshop March 10-11.

Knapp, A.W. (1920) Cocoa and chocolate: their history from plantation to consumer. London: *Chapman and Hall Ltd.*

Lass, T. (2004a) Balancing cocoa production and consumption. Pages 8-15 in J. Flood and R. Murphy.(Eds.). Cocoa Futures: A source book of some important issues facing the cocoa industry. Chinchina (Colombia): CABI- EDERACAFE,

Lass, T. (2004b) Opportunities and threats to cocoa consumption. Pages 25-32 in J. Flood and R. Murphy.(Eds.). Cocoa Futures: A source book of some important issues facing the cocoa industry. Chinchina (Colombia): CABI- EDERACAFE,

Leeuwis, C. *with contributions from Van Den Ban A. (2004)* Communication for rural innovation: Rethinking agricultural extension (Third Edition) Oxford UK: Blackwell Science.

MASDAR, (2004) Ghana/European Union Cocoa Sector Support Programme Technical Assistance for the Re-organisations and Commercialisation of the Cocoa Research Institute of Ghana. Project Final Report. Submitted by MASDAR International Consultants. 28pp.

MOFA, (2000) Directorate of Agricultural Extension Services: The Impact of Extension Delivery (Draft Internal Report)

MOFA, (2005) Reforms within Ministry of Food and Agriculture. Report, Ministry of Food and

Agriculture, Accra (Unpublished Report) 7pp.

Newell, C. and Tucker, A. (2004) Cocoa and fair-trade. Pages 104-113 in J. Flood and R. Murphy.(Eds.). Cocoa Futures: A source book of some important issues facing the cocoa industry. Chinchina (Colombia): CABI- EDERACAFE,

Norde, D. J. and Van Duursen, J.A. (2003) Identifying and assesing convergences of interest for stakeholders in the cocoa chain, in order to attain increased farm income and wider sustainability. European Postgraduate Course in Environmental Management (EPCEM) Report 80 pp.

Padi, B., Ackonnor, J.B., Abitey, M.A., Owusu, E. B., Fofie, A. and Asante E. (2000) Report on the insecticide use and residues in cocoa beans in Ghana. Internal report submitted to the Ghana Cocoa Board. 26 pp.

Pyburn, R. (2004) SASA Final Report on Internal Control Systems and Management systems: Public Summary 7pp.

Robbins, P., (2003) *Stolen fruit: the tropical commodities disaster*. London: Zed Book and Technical Centre for Agricultural Rural Cooperation (CTA).

Röling, N. G., Hounkonnou, D., Offei, S. K., Tossou R. C. & Van Huis, A. (2004) Linking science and farmers' innovative capacity: diagnostic studies from Ghana and Benin. *NJAS-Wageningen Journal of life sciences* 52: 211-235.

Röling, N. G. and Woodhill, J. (2001) From Paradigm to Practice: Foundation, Principles and Elements for Dialogue on Water, Food and Environment. Background Document for National and Basin Dialogue Design Workshop. Bonn, The Netherlands.34pp.

Röling, N. and Jiggins, J. (1998) The ecological knowledge system. In: Röling, N. and M. A. E. Wagemakers (eds.) Facilitating sustainable agriculture. Cambridge: University Press, Cambridge, UK. 283-311pp.

Van Huis, A. Jiggins, J., Kossou D., Leeuwis, C., Röling, N., Sakyi-Dawson, O., Struik, P., and Tossou, R., (2006) Can Convergence of Sciences support innovation by resource-poor farmers in Benin and Ghana? International Journal of Agriculture Sustainability. (Accepted in press)

Vos, J. G. M. and Page, S. L. J. (2005) Towards Safe Cocoa Pest Management in West Africa. Pages 181-192 In: J.N. Pretty (Ed.) *The Pesticide Detox: Towards a More Sustainable Agriculture*. London: Earthscan

www.icco.org/anrep0304english.pdf

www.kuapakokoogh.com/pages/page.php

http://portals.iac.wur.nl/msp/?Methodologies

http://www.fairtrade.net/sites/impact/facts.html

http//www.faostat.fao.org/[Faostat Citation-database 2006]

Chapter 6

Conclusions and implications

G. K. Ayenor

Chapter 6

Conclusions and implications

As in other countries in Africa, the idea of using agriculture science as a vehicle for sustained growth and development to overcome rural poverty in Ghana has so far not yielded the expected results. Formal agricultural research agencies have partly been blamed for this lack of significant impact, especially given the diversity of the tropical regions of Sub-Saharan Africa. The International Service for National Agriculture Research (ISNAR) observed that improvements in agriculture production and productivity in Sub-Saharan Africa have persistently lagged behind those in the rest of the World (Chema *et al.*, 2003). Some of their reasons for this conclusion are: (1) poor performance or lack of impact of agricultural research; (2) insufficient investment in agricultural research; (3) extremely diverse production system; (4) slow diffusion of the technology developed; (5) weak integration of farmers in markets. The Convergence of Sciences (CoS) Programme (see annex 1) takes off from the premise that the impact of agricultural science on the livelihoods of resource poor farmers in West Africa has been sub-optimal.

This dissertation reports on one of the two CoS studies that has focused on cocoa, a sector that has been dynamised in recent years by the decision of the Ghana Government to increase the percentage of the FOB price paid to farmers from around 40% to currently about 70%. In addition, world cocoa prices have been very good. For the time being, cocoa represents one of the few windows of opportunity for small-scale farmers in West Africa. The climate for innovation is therefore good.

The current Research and Development (R & D) system underpinning the cocoa industry in Ghana is organized according to a classical top-down model. The role of farmers as potential key stakeholders in the cocoa sector including in research, has practically been reduced to passive recipients of technologies and service support that Government and some key organizations in the cocoa sector assume they need.

The purpose of this concluding chapter is to pull together the main conclusions and recommendations from a study that sought to follow a totally different approach - in that it involved small-scale farmers in the formulation of the purpose and objectives, the choice of the research topics, the implementation of the research, and the dissemination, in an attempt to create the framework conditions for scaling up the impact of the research.

In the following sections, we shall recall the main research problems and questions raised in the general introduction, and provide answers to them based on the research reported in this dissertation. We shall then use criteria and crosscutting factors developed by the CoS group, to assess the effectiveness of the research pathway that has been followed in the present study. Finally, we shall reflect on how the adoption and/or adaptation of the CoS approach can be used to advance agricultural research, education and development in order to improve research on cocoa, and possibly address some of the goals in Ghana's Poverty Reduction Strategy Paper.

Main research problems, questions and answers

We formulated a number of research problems for this study in terms of the absence of vital knowledge. This concerned the following issues:

1. Alternative capsid control methods that work and are appropriate under farmers' conditions and that are acceptable to them, based on their criteria.
2. Appropriate extension approaches and interactive processes to ensure effective development and dissemination of capsid control methods in which farmers play an active role.
3. Institutional and policy frameworks required for the production and marketing of organic cocoa.

The last issue emerged during the course of the field research. It turned out that farmers' motivation to use Integrated Pest Management (IPM) - capsid control technologies depended on how the policy and institutional constraints (e.g., alternative marketing chain for organic cocoa) could be addressed. In all, the research reported in this thesis sought to create space for the active participation of farmers in R&D based on the CoS perspective.
The following are the main research questions that the study addressed. For each question, we provide the answers that are suggested by the empirical studies we carried out.

1. *How can agricultural research on cocoa capsid management be made more useful to small-scale farmers within their own context?*

Our research focused on understanding the needs and aspirations of farmers within their own context and used this knowledge together with them to address the main research problems as listed above. Based on the recommendations of the technographic study, the diagnostic study on cocoa identified farmers' production constraints (low yields caused by capsids) and together with scientists agreed on effective and acceptable alternative capsid control methods. The diagnostic study also provided understanding of the agro-ecology, economic situation, socio-cultural setting, and local institutions and identified opportunities (chapter 2). In addition, it showed how all the understanding gained from the diagnostic study could constantly and flexibly be harnessed to meet the small-scale farmers' aspirations of obtaining additional income from producing organic cocoa. Hence, we focused on working with small-scale farmers and some cocoa scientists so as to ensure that agricultural research on cocoa capsids created the space for them not only to become active participants in setting the research agenda that is based on their felt needs but also in the implementation of the agenda (democratisation of science).

2. *What are the alternative control (IPM) methods that can be effective and compatible for sustainable cocoa production, including organic production, in Ghana?*

The alternative capsids control methods that can be effective and compatible for sustainable production of organic cocoa are the following methods tested with farmers:

1) The use of the predatory ant, *Oecophylla longinoda* as a biological control agent

2) The application of crude Aqueous Neem (*Azadirachta indica*) Seed Extract (ANSE)

3) Mass trapping using sex pheromone traps

It was concluded after two and half years of field experimentation with farmers that all three methods were equally effective in reducing capsids (*Sahlbergella singularis* and *Distantiella theobroma*) incidence, resulting in increased cocoa yields. The methods were also compatible because no method was observed to exert any negative influence on the other (e.g. ANSE did not affect *O. longinoda*); therefore they can be used as IPM strategy for the control of capsids (Chapter 3).

3. *What extension or interactive approaches can be effective in generating, developing and disseminating sustainable capsid management practices?*

The use of the Local Agricultural Research Committee (LARC) adopted as an interactive approach for learning, developing and sharing of sustainable capsid management information and skills with the farmer-research group (LARC) was effective. The extent of this effectiveness was shown by how the LARC farmers in turn, successfully transmitted their knowledge and sustainable practices on capsid management to other cocoa farmers ('exposed farmers'), including complex skills that are usually not easily passed on to others (Chapter 4).

4. *What is the institutional impact on the development and implementation of research aimed at creating space for innovation to improve small-scale cocoa farmers' livelihoods?*

Existing policy frameworks and institutional settings are key elements in determining whether research aiming to cause a positive social change would be successful or not. These elements exert an influence from the conceptualisation of the research ideas through the implementation. This is well before the stage in which their impact would become noticeable, i.e. the up-scaling and out-scaling of the results. It is partly for these reasons that the CoS project conducted the technographic and diagnostic studies involving key sector stakeholders so as to create space for the various institutional actors to collaborate effectively to address any challenge that might emerge in the course of the research (in this case, the organic marketing issue). However, from the experience of this study, the institutional actors have not been entirely supportive in all respects. Effective collaboration seems to depend more on individual representatives from the organizations or institutions, than on systems put in place based on core values derived from the goals of the organizations. Nonetheless, in this study, the institutional impact has been acknowledged as one key factor. For instance, Government policy to embark on nationwide application of synthetic pesticides almost killed farmers' interests and enthusiasm in this study. Similarly, it proved to be difficult to gain the support from COCOBOD and its subsidiaries, as well as the field officer from MoFA and the District Co-operative Office of the study area, for setting up an export marketing channel for organic cocoa (Chapter 5).

5. *What are the overall lessons learned from our work for the research and development in cocoa in Ghana?*

We mention two key issues:

1. The top-down manner in which research is organized is probably the reason for the low adoption of its recommended technologies. Because we involved farmers actively in the entire research process, we addressed their felt needs and opportunities. A higher rate of adoption for jointly developed technologies is likely. Our conviction is based on the responses from the survey conducted to assess the impact of the LARC approach on different cocoa farmer populations in the study area (Chapter 4).
2. Concerning the cocoa extension, the practical integration of research and development goals in the field is weak, and so are the support services and training that would assist farmers to be better organized. Attention should be paid to the involvement of farmers in research because developing research agendas and co-researching with farmers probably leads to higher uptake of the developed technologies.

Criteria to assess processes of enquiry into sustainable cocoa production

The positivists/reductionists usually uphold conventional scientific criteria, such as internal validity, external validity, reliability, objectivity, and replicability. This could be at the expense of what works and would be acceptable within the local context. Experiences have shown that what usually becomes workable and acceptable are not only innovations that address technical issues but rather all-round innovations that also include new social arrangements and institutions. It is believed that this would enhance the impact of agricultural research. In this study, we used three types of technologies to control capsids: one on the shelf (neem), an indigenous one (predatory ants), and one suggested by research (pheromones). Each technology may be constrained by institutional factors: neem by its availability, predatory ants by the mass spraying programme (killing the ants), and the pheromones by their availability and delivery system. The CoS approach is particular about alleviating the institutional constraints in order to create space for change.

To estimate the effectiveness of the new *pathway* of science followed in this study, we used the CoS group's criteria to assess the usefulness of the research to small-scale farmers:

1. The extent to which relevant opportunities for research contribution are collectively identified at the macro level.
2. Extent to which research is grounded in the needs, conditions and demands of farmers.
3. Extent to which research develops technologies and innovations that work under farmers' conditions.
4. Extent to which research develops technologies or innovations that is acceptable.
5. Extent to which research develops technology or innovation approaches that can be scaled up.
6. The crosscutting factors are the following:
    - Learning processes with stakeholders.
    - The application of natural and social science methods to address complex issues.
    - Democratisation of science (decentralisation, participation and transparency).
    - Globalisation (Farmers do not live in isolation - global and world markets trends affect them).

We shall now consider these points one by one in order to assess the quality of the work reported in this thesis from a developmental perspective.

1. *Extent to which relevant opportunities for research contribution are collectively identified at the macro level*

Identifying existing opportunities for research at the macro level facilitates the process of identifying innovation needs and that include issues concerning policy, institutional reforms, market interest and their relevant actors. Global, international and regional issues that shape research needs were not dealt with as explicitly as one would expect. However, we tried in vain to organize certification of organic cocoa for farmers. Another issue was to convince the government to allow the spraying of ANSE instead of the synthetic pesticides which would compromise the intended certification.

2. *Extent to which research is grounded in the needs, conditions and demands of farmers*

In contrast to the conventional linear processes, our proposed interactive and participatory learning processes, inherently mandates that research be grounded in the priorities, needs and demands within farmers' conditions. A sense of ownership and the internalization of the research process are the conditions for achieving this criterion, which implicitly embraces active participation, and therefore enhanced acceptability and sustainability. The question is to what extent the study has taken these values and issues into consideration. The diagnostic study and the flexible and continuous collective approach to resolving practical research related problems that emerged (e.g., marketing of organic cocoa) is indicative of how the research embraced the needs and demands of the cocoa farmers.

3. *Extent to which research develops technologies and or innovations that work under farmers conditions*

The core reason for this criterion is to ensure that research activities make the desired impact. Therefore, designing systems that work should as much as possible consider farmers' conditions and their local dynamics, so that the technology or innovations that emerge practically address farmers' problems. For example, the capsid control methods include the farmers' own traditional method. The methods were effective in managing cocoa capsids and farmers' response as to their use has been encouraging.

4. *Extent to which research develops technologies or innovations that are acceptable*

'What works is not necessarily 'acceptable'. Technology might meet its intended purpose of pest control on farmers' fields but for many reasons, it may not be acceptable. Some of these reasons might not be only economic, but could more often be religious, cultural, organizational, or social. The diagnostic study followed by the participatory field experiment with farmers and their desire to share the outcomes with the wider community suggest that the capsid management technologies and the way they were developed together with them were not only effective , but also acceptable to them.

5. *Extent to which research develops technology or innovation approaches that can be scaled up*

Local conditions and contexts are crucial to ensure that a design works and becomes acceptable. However, if the atmosphere or the socio-cultural fabrics that determine the success of research are so specific to one situation, it is unlikely to reap the maximum benefit from research. Up-scaling, as a criterion tries to look for substantial ingredients that allow for widespread applicability of research findings to make them more cost effective. This raises the question to what extent efforts have been made in the current study to create space or conditions for scaling up or institutionalising the results. We used several modalities for this purpose, such as forums (including the use of quarterly inter-institutional meetings), and visits to key institutes to share ideas. However, this aspect would require additional effort to ensure that the lessons learnt by some actors are shared and become internalized in the respective organizations.

6. *Cross-cutting factors*

Social and participatory learning with relevant stakeholders was a central element in our study. Interdisciplinary methods and approaches were equally important tools in dealing with technical and social questions the study raised. Democratic values in science were expressed in the way we tried to enhance accountability, transparency and efficiency among stakeholders. For instance, farmers' ideas about *O. longinoda* were investigated as well as scientists' suggestion concerning the use of sex pheromones.

Globalization has come to be with us. The study acknowledged the global agricultural policies and their influence on vulnerable local farmers. On the other hand, pressure to liberalise cocoa prices and give farmers a larger share has been a key factor in determining the context, which has framed this study.

Even more than before, the current high price of cocoa on the world market means that the cocoa industry is the mainstay of the Ghanaian economy. The innovative research with farmers who contribute to the development of the crop is crucial in enhancing the competitive advantage of the nation, especially with regards to maintaining the high quality of cocoa beans for which Ghana is known internationally. Cocoa beans that become damaged by diseases and pests or contaminated with undesirable chemical residues would compromise the quality, and this would negatively affect foreign exchange earnings. Research with farmers as conducted in this study, which could eventually lead to a reduction of the use and abuse of synthetic pesticides for controlling capsids, seems very appropriate in this international context for capturing the diversity of opportunities that the world market provides.

Our study suggests some issues that the CRIG, the Ghana Cocoa Board (COCOBOD), and government could address:

Cocoa Research and extension

The strategic review of CRIG in 2004 revealed that the institute is concerned about the fact that the technologies it develops are not taken up by farmers. This study indicated that diagnostic studies involving stakeholders in the identification of researchable issues that address the needs and opportunities of farmers will increase the likelihood of improving the impact of research.

This means that research institutes should no longer consider themselves just as 'expert' institutes, but also as 'learning' institutes in which other societal stakeholders, including farmers, will be involved in the Research and Development (R&D) process. This recognition would recognise farmers' organisations as viable and active partners empowered to demand an effective contribution from research.

Agricultural training and education

Research institutes tend to pay more attention to the natural or biological sciences than to the social sciences. Therefore the social and institutional parts of innovations that constrain the adoption of technologies are often not addressed. This means that R&D institutes have to pay more attention to the natural and social science interface (interdisciplinarity), as well as to the involvement of societal stakeholders (transdisciplinarity). This probably requires new skills of researchers and research managers, which can be honed by engaging in participatory inter- and trans-disciplinary projects.

Development

The cocoa sector policy reforms have been reluctant to accept private sector participation in cocoa export trading. Apart from input supply and internal marketing of cocoa by the Licence Buying Companies (LBCs), not much has been done about cocoa export by private companies. This is understandable, given COCOBOD's concern to maintain the excellent quality for which Ghana cocoa is internationally renowned. However, it appears from our experience with farmers and international exporters who are keen to exploit promising niches for organic cocoa marketing, that the policy creates serious constraints on flexibility. Coupled to the mass spraying of cocoa plantations with synthetic pesticides, this reduced flexibility can only do Ghana harm in the long run, especially now that consumers in importing countries are becoming increasing aware of health risks, and environmental impacts of pesticides. Kuapa Kokoo is an example of what a farmers' organization can contribute to the economy and development in Ghana. The experience of Kuapa Kokoo attests to the need to involve farmers and the private sector in development and poverty reduction strategies in the cocoa sector. What Kuapa Kokoo has achieved with respect to fair trade cocoa can also be achieved with organic cocoa.

Reference

Chema, S., Gilbert, E. and Roseboom, J. (2003) A Review of Key Issues and Recent Experiences in Reforming Agriculture Research in Africa. The Hague: ISNAR, Research Report 24 pp.

Summary

Summary

In Ghana cocoa is an important source of foreign exchange for the country. In 2004, the cocoa sub-sector alone contributed over US $1 billion (39.2%) to the total foreign exchange earnings of the country, and 74% of the agricultural foreign earnings during the period. Cocoa is cultivated in six of the ten regions of Ghana, and well over 80% of it is produced by small-scale farmers who depend on the crop as one of their main sources of cash income. However, until recently, cocoa production had declined due to low yields. Compared to Ivory Coast and Malaysia, which together with Ghana are the three major producing countries, yields in Ghana are extremely low. Even in 2004 when Ghana recorded an unprecedented high production of 736,911 MT, the average national yield per hectare was still twice lower than that in the other two major producing countries. The causes of low yields are many and they include, until recently, the low producer price offered by the government, youth migration, increased costs of labour, an aging farmer population, aging plantations, poor tree husbandry practices, pest and diseases.

The increased producer price has rekindled farmers' interest in measures that can help them address low yields. When farmers received better prices in 2003, cocoa production increased with 46% compared to 2002, and in 2004, when farmers received about 70% of the Free on Board (FOB) price, with 48% compared to 2003,. Between 2002 and 2004, production more than doubled. This rapid increase shows that there was a great deal of latent production capacity that could be realized quickly. Further increases will have to pay attention to improving production techniques, e.g., by controlling pests and diseases, and improving crop management practices, the subject of the present dissertation.

The present dissertation focuses on Capsids, one of the key pests in cocoa. It is estimated that the damage caused by the two main capsids (Hemiptera: Miridae) species *Sahlbergella singularis* (Hagl.) and *Distantiella theobroma* (Dist.) amounts to about 25% to 30% annual crop loss. Capsids have a sporadic distribution, cryptic habitats and can be extremely damaging in small numbers, even to the extent of killing cocoa trees. Combination of these characteristics makes the control of capsids not only difficult, but also imperative. The main methods available for Capsid control that are propagated to small farmers rely on the use of synthetic pesticides, which farmers cannot afford. This is the reason why the Ghana Government has decided to invest cocoa revenues in the mass spraying of Ghana's cocoa farms with synthetic pesticides using spraying gangs with motor sprayers.

Alternative capsid control methods that are effective at the small-scale farmer level are not available. Regular spraying of expensive pesticides with a motorised back-pack sprayer is simply beyond most farmers' reach, given their small cocoa plots, complex tenure arrangements, and their shortage of cash due to expenses such as school fees. Most cocoa farms have been neglected for 20 years, with farmers opportunistically harvesting some cocoa if they needed cash, without giving attention to the pest management recommendations produced by researchers. The Government sponsored mass spraying of cocoa farms does imply environmental and health costs. Hence, farmers need effective and sustainable capsid control methods which they can access and afford to use.
A diagnostic study revealed that there was a real opportunity for farmers to market organic cocoa for premium prices. To make this possible, the control of capsids by control methods other than using synthetic pesticides was necessary. Integrated Pest Management (IPM) methods are developed by the Cocoa Research Institute of Ghana (CRIG) and similar organizations. The diagnostic study also revealed that the low adoption of pest management recommendations (<4%) by formal research was probably due to lack of attention to farmers' needs and opportunities, and therefore due to lack of active participation by farmers in Research and Development (R&D).

The Convergence of Sciences (CoS) project (see appendix 1) holds the view that the contribution of agricultural science to poverty alleviation is suboptimal. To enhance the impact of science, the programme encourages convergence of ideas and efforts between natural and social sciences and between societal stakeholders, including farmers, and scientists. This study conducted experiments with farmers following technographic and diagnostic studies. This resulted in identifying a number of problems that were widely agreed to address the needs and opportunities of cocoa farmers.

The following priority constraints were considered in our research:

1. The lack of alternative capsid control methods that work, are appropriate under cocoa farmers' own conditions, and are acceptable to them, based on their criteria.
2. The lack of appropriate extension approaches and interactive processes that ensure effective development and dissemination of capsid control methods in which farmers play an active role.
3. The lack of an institutional and policy framework required for the production and marketing of organic cocoa, the contours of which emerged during the course of the field research (Chapter 2 and 5). This meant that farmers' motivation to use IPM capsid control technologies has not been optimally contextualised.

Therefore, the overall objective was to facilitate and develop, together with farmers, IPM methods to control capsids in an organic production system of cocoa. This objective was pursued by grounding the research in the needs and opportunities of farmers through a long identification and diagnostic process and by systematic blending of indigenous and formal knowledge. The focus was not only on technical improvements, but also on new social and institutional arrangements, such as an alternative supply marketing chain for organic farmers. The following chapters indicate the key outcomes of the research.

Chapter 2

The diagnostic study adopted a Participatory Learning and Action Research (PLAR) approach to set up and implement fieldwork with relevant stakeholders leading to problem identification, prioritisation, and collective design of an action plan (research agenda). Cocoa farmers within the study area are conscious of the environmental problems associated with the use of synthetic pesticides and the high cost of using them. Hence, they produce cocoa without applying any pesticides ('organic by default'). However, their association with an organic marketing company led to the search for non-chemical pest and disease control measures and for ways to certify their cocoa beans as organic so that they can obtain higher profit margins through the price premiums paid for organic cocoa.

A misconception as to what species of cocoa pests constitute 'capsids' was settled between farmers and scientists using a cage experiment on capsid damage. The farmers became convinced that the Cocoa Mosquito (*Helopeltis* spp.) (Hemiptera: Miridae) that they had previously considered an important pest, was a capsid species that caused little or no damage to the beans inside the pods. After this clarification, damage caused by the two capsids *S. singularis* and *D. theobroma* emerged as the most serious production constraints. The key stakeholders involved in the study agreed on three innovative (organic) capsid control methods for further research. They are: 1) the use of sex pheromone traps (proposed by research); 2) applying crude aqueous neem (*Azadirachta indica*) seed extract (ANSE); and 3) the use of colonies of the predatory ant species *Oecophylla longinoda* biological control agent (proposed by farmers). The chapter reflects on diagnostic study as a continuous process in response to a continually changing context even beyond the end of the diagnostic research phase.

Chapter 3

The diagnostic studies confirmed capsids to be a serious constraint. To control the capsids, formal research recommends four applications of synthetic pesticides between August and December, omitting November. However, farmers hardly adopt this recommendation because they consider it not appropriate for their conditions and context. Based on farmers' needs, this study focused on testing with farmers the three alternative control methods (Chapter 2) for the control of populations of the two main capsid species. In over two cocoa seasons some systematic observations were conducted using research designs negotiated with an elected group of experimental farmers to principally determine the efficacy of the three alternative methods for capsids control. Data collected on numbers of capsids and their fresh lesions on pods, damage on cocoa canopy and the resultant yields were analysed using statistical tools. Studies on temporal distribution of cocoa capsids indicated that the population peaked in March, contrary to most previous reports. ANSE was effective against capsids and other cocoa insect pests and did not affect the predatory ants. When *O. longinoda* occurred in high numbers, capsid incidence was low. Shade did not influence ant or capsid abundance significantly. All the three methods were effective and compatible; hence, they can be used in an Integrated Pest Management (IPM) strategy for cocoa, and in an organic production system.

However, are farmers likely to use these methods especially beyond the few who worked with scientists? What extension approach could integrate technology generation, development and delivery to other farmers in an interactive learning manner?

Chapter 4

The conventional method of 'delivering' technologies recommended by researchers to farmers through extension has proved ineffective, resulting in a low (<4%) adoption rate of research-based cocoa technologies. We assessed the impact of the Local Agricultural Research Committee (LARC) approach (a methodology developed by the International Centre for Tropical Agriculture, CIAT) on the diffusion of capsid management knowledge and practices to other farmers in the study area.

The LARC members themselves engaged in intensive interactive learning and experimentation to control the capsids. They acquired vital agro-ecological knowledge on capsid management, including skills in scouting for capsids to determine their temporal distribution and systematic experimentation with control methods. The LARC approach means that the members report back to the community, farmers of whom the majority aspire to produce organic cocoa for a premium. Chapter 4 reports on a survey comparing three categories of farmers: 1) LARC members; 2) farmers who received the feedback by LARC; and 3) farmers who were not exposed to LARC's experience. It appeared that LARC approach significantly influenced the acquisition and diffusion of the IPM knowledge and practices among those who were exposed.

However, is it enough to achieve impact by interactively developing alternative capsid control methods with farmers and let them share the experiences with others? What framework conditions are necessary for the adoption of capsid management technologies? What are the institutional constraints in developing a niche market for organic cocoa?

Chapter 5

In Ghana, Brong-Densuso is the only area where organic cocoa is produced from about 600 ha exempted from 'mass spraying' by the government's sponsored Cocoa Disease and Pest Control Programme (CODAPEC)). For over twenty years before the decision in 2001 to regularly spray all cocoa producing areas with synthetic pesticides, no farmer at Brong-Densuso could afford the high cost of the synthetic pesticide against the backdrop of the low prices paid to them by the government. They were 'organic by default' until they formed the Traditional Organic Farmers Association (TOFA). TOFA established links with the Organic Commodity Products (OCP) Company of an American entrepreneur, who sought to establish an organic cocoa supply chain in Ghana for his outlets overseas.

One of the key issues was to develop organic means to control cocoa capsids (Chapter 2 and 3). Under an agreement with the Ghana Cocoa Board (COCOBOD) and the Cocoa Research Institute of Ghana (CRIG), OCP took the initiative for, and invested in, research by CRIG into the effectiveness of Aqueous Neem Seed Extract (ANSE) spraying for capsids control in small-scale countrywide trials. The idea was that cocoa farmers would organise for a self-controlled group certification process and would be ultimately monitored by ECOCERT International.

The introduction of 'free' mass spraying with synthetic pesticides in 2001, together with the price increase to 70% FOB, changed the situation. Given that in Ghana only the Brong-Densuso area is officially exempted from mass spraying and the highest volumes from that area could at best be about 300 MT, it is understandable that OCP pulled out. The present chapter reports on the efforts to pick up the pieces with the TOFA members and other stakeholders. This was done through facilitating a multi-stakeholder process to explore alternative organic marketing arrangements.

The chapter describes the international and national contexts for organic cocoa production, the experience with setting up a supply chain through a multi-stakeholder process, and concretely, the experiences with engaging institutional actors at higher scale level.

It ends by drawing conclusions from the experience, focusing especially on institutional constraints that determine business opportunities (space for change).

Chapter 6

This concluding chapter reflects on the entire PhD study through the convergence of science perspective based on the major findings from each chapter and how they aggregate and fit into wider agricultural research and development goals of Ghana. Formal agriculture science as a vehicle for sustained growth and development to overcome rural poverty in cocoa producing regions in Ghana has had limited impact. Some have reasoned that the lack of impact is due to the following: (1) poor performance or lack of impact of agricultural research; (2) insufficient investment in agricultural research; (3) extremely diverse production systems; (4) slow diffusion of the technology developed; (5) weak integration of farmers in markets.

The cocoa sector has been re-energized in recent years by the decision of the Ghana Government to increase the percentage of the FOB price paid to farmers from around 40% a few years ago to about 70% in 2005. This condition has created the appropriate atmosphere and 'windows of opportunity' for most small-scale cocoa farmers in Ghana. It also creates an opportunity for agricultural research. A key handicap in applying science to agricultural development is its self-imposed conventional top-down approach to Research and Development (R & D). This dissertation has, together with the other eight doctoral studies under the CoS Programme, attempted to develop and test an alternative and more effective pathway of science that becomes especially relevant now that increased cocoa prices have created space for change. The concluding chapter pulls together the main conclusions and recommendations from the entire study.

Samenvatting

Samenvatting

Voor Ghana is cacao een belangrijke bron van inkomsten van vreemde valuta. In 2004 droeg de cacao sector meer dan één miljard US $ bij (39%) aan de totale deviezenopbrengst (74% van die verkregen uit export van landbouwproducten). In zes van de tien provincies in Ghana wordt cacao geteeld. Meer dan 80% van de cacao wordt geproduceerd door kleine boeren en voor hen vormt dit gewas de belangrijkste bron van inkomsten. Echter, tot voor kort, daalde de cacao productie door lage opbrengsten. Vergeleken met landen als Ivoorkust en Maleisië, die samen met Ghana behoren tot de drie belangrijkste cacao producenten, zijn de opbrengsten in Ghana extreem laag. Zelfs in 2004, toen Ghana een ongeëvenaarde hoge productie registreerde van 736.911.000 kg, was de gemiddelde opbrengst in Ghana nog twee keer zo laag als die van de andere twee landen. Er zijn vele oorzaken te noemen voor de lage opbrengsten. Dit zijn voornamelijk: de lage prijs die de regering tot voor kort de producenten bood, jongeren die het platteland verlaten, hoge arbeidskosten, de hoge leeftijd van de boeren, verouderende plantages, landbouwkundige praktijken die te wensen overlaten en het voorkomen van ziekten en plagen.

De hogere prijs die de regering nu betaalt voor de cacao heeft de interesse van de boeren om maatregelen te nemen om de opbrengsten te verhogen, doen toenemen. Met de hogere prijzen die de boeren in 2003 kregen, steeg de cacao productie met 46 % ten opzichte van 2002, en met 48% in 2004 ten opzichte van 2003 toen de boeren ca. 70% ontvingen van de 'Free on Board' (FOB) prijs. Van 2002 tot 2004 is de productie meer dan verdubbeld. Deze snelle groei laat zien dat er latent een behoorlijke productie capaciteit voor handen was die direct aangesproken kon worden. Bij verdere groei zal aandacht geschonken moeten worden aan het verbeteren van productie technieken, bijvoorbeeld door bestrijding van ziekten en plagen en verbeteren van agronomische maatregelen. Dit is het onderwerp van dit proefschrift.

Dit proefschrift richt zich op capsiden (Hemiptera: Miridae), belangrijkste plagen in cacao. De schade veroorzaakt door twee capside soorten *Sahlbergella singularis* Hagl. (de Bruine Capside) en *Distantiella theobroma* (Dist) (de Zwarte Capside) kan leiden tot 25-30% opbrengstverlies. Capsiden komen in lage aantallen verspreid in het gewas voor, zijn moeilijk te vinden en lage aantallen kunnen nog zeer schadelijk zijn, zodanig zelfs dat cacaobomen eraan dood kunnen gaan. De combinatie van deze factoren maakt de bestrijding van capsiden niet alleen moeilijk maar ook noodzakelijk. De belangrijkste bestrijdingsmethoden aanbevolen van overheidswegen voor bestrijding van de capsiden is het gebruik van synthetische pesticiden. Echter de boeren kunnen de kosten hiervoor niet opbrengen. Daarom heeft de overheid besloten met de opbrengsten uit de cacao, de bespuitingen van alle cacao bomen in Ghana centraal te organiseren. Synthetische pesticiden worden door speciale teams met gemotoriseerde apparatuur verspoten.

Voor de kleine boer zijn alternatieve bestrijdingsmethodes, effectief in de bestrijding van capsiden, voorhanden. Het regelmatig behandelen van de bomen met dure pesticiden, gebruik makend van op de rug gedragen gemotoriseerde spuitapparatuur, ligt simpelweg buiten het bereik van de meeste boeren. Dit gezien de omvang van de bedrijven, de ingewikkelde pachtverhoudingen en het ontbreken van contant geld als gevolg van allerlei noodzakelijke uitgaven zoals het betalen van schoolgeld. De meeste cacao bedrijven zijn de laatste 20 jaar verwaarloosd en boeren oogsten heel opportunistisch een beetje cacao zodra ze contant geld nodig hebben zonder acht te slaan op aanbevelingen gedaan door onderzoekers voor plaagbestrijding. De door de regering georganiseerde massale bespuitingen van alle cacao bedrijven in Ghana brengen ook milieu en gezondheidskosten met zich mee. Om die reden hebben boeren effectieve en duurzame methoden van bestrijding nodig, die eenvoudig beschikbaar zijn en die ze zich kunnen permitteren.

Een diagnostische studie bracht aan het licht dat er een goede mogelijkheid lag voor boeren om organisch geteelde cacao te vermarkten tegen bonus prijzen. Om dit mogelijk te maken was het nodig de capsiden te bestrijden anders dan door het gebruik van synthetische pesticiden. Geïntegreerde bestrijdingsmethoden zijn door het Onderzoeksinstituut voor Cocoa in Ghana (Cocoa Research Institute of Ghana - CRIG) en vergelijkbare instituten ontwikkeld. Uit onze diagnostische studie bleek echter dat de aanbevelingen door het formeel onderzoek gedaan door minder dan vier procent door de boeren werden overgenomen. Dit is waarschijnlijk te wijten aan het gebrek van het formele onderzoek aan aandacht voor de behoeften en mogelijkheden van boeren. Boeren namen niet actief deel aan het proces van 'Onderzoek voor Ontwikkeling'.

Het 'Convergence of Sciences' (CoS) project (zie bijlage) is van mening dat de bijdrage van landbouwkundige wetenschap aan armoedebestrijding onder de maat is. Om het effect van wetenschappelijk onderzoek te verhogen, moedigt het programma de convergentie aan tussen de natuur- en de sociale wetenschappen en tussen alle maatschappelijke belanghebbenden, vooral boeren en wetenschappers. Wij voerden experimenten uit samen met boeren na het uitvoeren van technografische en diagnostische studies. Dit bracht een aantal problemen aan het licht waar men het over eens was dat zij direct de behoeften en mogelijkheden van de cacao boeren betroffen.

In ons onderzoek hebben we rekening gehouden met de volgende knelpunten:

1. Het gebrek aan alternatieve bestrijdingsmethoden voor capsiden die werken onder, en

passen binnen, de omstandigheden van de boer en tevens voldoen aan de criteria van de boeren zelf.

2. Het gebrek aan geschikte manieren van voorlichting en interactieve processen die een effectieve ontwikkeling en verspreiding van bestrijdingsmethodes waarborgen waarbij boeren een actieve rol vervullen.
3. Het gebrek aan een institutioneel en politiek raamwerk nodig voor de productie en marketing van organisch geteelde cacao, waarvan de contouren duidelijk werden tijdens het verloop van het veld onderzoek (hoofdstuk 2 en 5). Dat hield in dat de motivatie van de boeren om geïntegreerde bestrijdingsmethoden tegen capsiden te gebruiken niet voldoende in de juiste context was geplaatst.

Daarom was het hoofddoel om, samen met boeren, geïntegreerde bestrijdingsmethoden tegen capsiden te vergemakkelijken en te ontwikkelen voor het ontwerpen van een organisch productie systeem van cacao. Dit doel werd nagestreefd door te werken vanuit de behoeften en mogelijkheden van boeren door middel van een uitgebreid identificatie- en diagnostisch proces en door systematisch de inheemse en formele kennis met elkaar in contact te brengen. De focus lag niet alleen op het tot stand brengen van technische verbeteringen, maar ook op maken van nieuwe sociale en institutionele verbanden, zoals het opzetten van een alternatieve marketing keten voor organische boeren.
De volgende hoofdstukken geven de belangrijkste bevindingen van het onderzoek weer.

Hoofdstuk 2
De diagnostische studie gebruikte de "Participatory Learning and Action Research" (gezamenlijke leren en actie onderzoek) benadering om het veldwerk op te zetten en uit te voeren. Dit werd gedaan met de relevante belanghebbenden om problemen te identificeren, prioriteiten te stellen en om een plan van aanpak (onderzoeksagenda) op te zetten. Cacao boeren die deelnamen aan deze studie waren zich bewust van de hoge kosten van synthetische pesticiden en van de milieuproblemen die het gebruik ervan met zich meebrengt. Om die reden produceren zij cacao zonder pesticiden te gebruiken en produceerden dus eigenlijk al organische cacao. Echter, hun contacten met een buitenlands bedrijf voor organische marketing leidde er toe te gaan zoeken naar plaag- en ziektebestrijdingsmaatregelen zonder chemische pesticiden te gebruiken. Op deze manier zouden ze hun cacaobonen kunnen waarmerken als organisch daarbij een hogere winstmarge verkrijgend. Er worden namelijk hogere premies betaald worden voor organisch geteelde cacao.

Er was een misvatting over welke 'capsiden' nu werkelijk van belang waren. Daarom werd door wetenschappers en boeren besloten tot een kooi experiment om te zien wat voor soort schade elke soort toebrengt. De boeren werden er van overtuigd dat de Cacao Mug (*Helopeltis* spp.), die zij voorheen als een belangrijke plaag beschouwden, een capside soort is die weinig tot geen beschadiging toebrengt aan de bonen in de peulen. Na deze opheldering bleek dat de capsiden S. *singularis* en *D. theobroma*, de meest serieuze bedreiging voor de productie vormen. De belangrijkste belanghebbenden betrokken bij het onderzoek besloten drie bestrijdingsmethoden tegen deze capsiden te gaan onderzoeken, nl.:

1) het gebruik van sex feromoon vallen (voorgesteld door de onderzoekers);
2) het toepassen van een ruw water extract van zaden van de neemboom, *Azadirachta indica*;
3) Het gebruik van kolonies van een mier *Oecophylla longinoda*, predator van capsiden, als biologische bestrijder (voorgesteld door de boeren).

Het hoofdstuk reflecteert op de diagnostische studie als een doorlopend proces omdat de context zich voortdurend wijzigt. Deze studie is dus een proces dat doorloopt ook na het beëindigen van de diagnostische onderzoeksfase.

Hoofdstuk 3

Uit de diagnostische studies bleek dat capsiden een serieus probleem voor de cacaoproductie vormen. Om deze insecten te bestrijden is de officiële aanbeveling van het formele onderzoek: vier bespuitingen met synthetische pesticiden tussen augustus en december, met uitzondering van de maand november. Het blijkt echter dat boeren deze aanbeveling nauwelijks opvolgen, omdat ze deze niet geschikt voor hen vinden. Dit onderzoek heeft de behoeften van de boeren als uitgangspunt genomen en zich gericht op het evalueren, samen met de boeren, van de drie alternatieve bestrijdingsmethoden (hoofdstuk 2) in de bestrijding van populaties van de twee belangrijke capside soorten. Gedurende twee groeiseizoenen werden een aantal systematische observaties uitgevoerd van experimenten die werden opgesteld in samenspraak met een gekozen groep van experimentele boeren om de effectiviteit van de drie alternatieve methodes voor de bestrijding van de capsiden te testen. Gegevens werden verzameld over de grootte van de capsiden populaties, het aantal verse beschadigingen op de peulen, de intensiteit van de schade aan het bladerdak van de cacao bomen en de grootte van de opbrengst. De resultaten werden geanalyseerd gebruik makend van statistische methoden.

Onderzoek naar het voorkomen van de cacao capsiden liet zien dat de populatie in maart op zijn hoogst was, in tegenstelling tot eerdere bevindingen. De bespuiting met het neemextract was effectief in de bestrijding van capsiden en andere insectenplagen in cacao en had geen effect op de predator mieren. Bij hoge populaties van de mier *O. longinoda* kwamen de capsiden nauwelijks voor. Schaduw had geen significant effect op de hoogte van de mieren of de capsiden populaties. Alle drie methodes waren effectief en vergelijkbaar en kunnen daarom worden gebruikt in een geïntegreerde bestrijdingsstrategie voor cacao, en ook in een organisch productie systeem.

Echter de vraag is of andere boeren, die niet met wetenschappers hebben samengewerkt, bereid zijn deze methodes te gebruiken. Welke voorlichtingsbenadering is in staat om het genereren, het ontwikkelen en het leveren van de technologie aan andere boeren te integreren op een interactieve manier van leren?

Hoofdstuk 4

De conventionele methode van het aanleveren van door onderzoekers ontwikkelde technologie door voorlichting is ineffectief gebleken, resulterend in een laag percentage van acceptatie (<4%) van deze technologieën. Wij evalueerden de invloed van Lokale Landbouwkundige Onderzoeks Comités (Local Agricultural Research Committees - LARC), een benadering ontwikkeld door het CIAT, voor wat betreft de verspreiding van de kennis over capsiden en de bestrijding ervan naar andere boeren in het onderzoeksgebied.

De LARC deelnemers zelf waren betrokken bij het intensief interactief leren en experimenteren om de capsiden te bestrijden. Zij vergaarden agro-ecologische kennis van vitaal belang voor capsiden bestrijding, met inbegrip van vaardigheden om capsiden te vinden, om hun voorkomen gedurende het jaar te bepalen en om systematisch te experimenteren met bestrijdingsmethoden. De LARC benadering houdt in dat de leden van de groep hun bevindingen terugrapporteren naar de gemeenschap van boeren waarvan de meerderheid organische cacao wil telen om in aanmerking te komen voor extra premies. In hoofdstuk 4 wordt verslag gedaan van een enquête waarbij drie categorieën boeren worden vergeleken: 1. LARC leden zelf; 2. boeren die feedback kregen van het LARC; 3. boeren die niet waren blootgesteld aan de LARC ervaring. Het bleek dat de LARC benadering significant van invloed was op het verkrijgen en de verspreiding van de geïntegreerde bestrijdingskennis en ervaring bij degenen die ermee in aanraking werden gebracht.

Echter, is het voldoende om resultaat te boeken bij boeren door interactief alternatieve bestrijdingsmethodes tegen capsiden te ontwikkelen en hen te laten delen in de ervaringen van anderen? Welke structurele voorwaarden zijn noodzakelijk zodat andere boeren de bestrijdingsmethoden tegen capsiden accepteren?. En wat zijn de institutionele knelpunten om een niche markt te ontwikkelen voor organisch geteelde cacao?

Hoofdstuk 5

In Ghana is Brong-Densuso het enige gebied waar organische cacao wordt geteeld op ca. 600 ha uitgezonderd van de massale bespuiting door het, door de regering gesponsorde, "Cocoa Disease and Pest Control Programme" (CODAPEC). Al meer dan twintig jaar lang, nog voordat het besluit werd genomen in 2001 om regelmatig alle cacao producerende gebieden te bespuiten met synthetische pesticiden, kon geen enkele boer in Brong-Densuso zich de dure synthetische pesticiden permitteren in relatie tot de dalende, lage prijzen die de regering hen voor de cacao betaalde. Zij teelden eigenlijk al 'organisch' tot zij zich organiseerden in de TOFA (Traditional Organic Farmers Association). TOFA bracht contacten tot stand met de OCP (Organic Commodity Products Company), een Amerikaanse ondernemer, die in Ghana op zoek was naar een aanvoerketen van organische cacao voor zijn vestigingen over zee.

Een van de belangrijkste thema's voor het onderzoek was het ontwikkelen van organische methoden om cacao capsiden te bestrijden (hoofdstuk 2 en 3). Met als basis een overeenkomst met de "Ghana Cocoa Board" (COCOBOD) en het onderzoeksinstituut CRIG, nam OCP het initiatief en investeerde in een onderzoek uitgevoerd door CRIG naar de effectiviteit van bespuitingen met het waterextract van neemzaden tegen capsiden op kleine proefvelden verspreid over Ghana. De bedoeling was dat de boeren zelf de certificatie van organische cacao zouden organiseren en uiteindelijk zou worden gecontroleerd door ECOCERT International.

De introductie van massale bespuitingen met synthetische pesticiden in 2001, samen met een prijstoename van 70% FOB, bracht verandering in de bestaande situatie. Gegeven het feit, dat in Ghana alleen het Brong-Densuso gebied officieel is uitgezonderd van deze massale bespuitingen en de opbrengsten in dat gebied op zijn hoogst ongeveer 300.000 kg bedragen, maakt het begrijpelijk dat OCP zich terug trok. In dit hoofdstuk wordt verslag gedaan van de pogingen om de situatie te redden met behulp van de TOFA leden en andere belanghebbenden. Dit werd gedaan door een bemiddelingsproces te starten met alle belanghebbenden om te onderzoeken of het mogelijk was alternatieve organische marketing oplossingen te vinden.

In het hoofdstuk wordt de internationale en nationale context voor organische cacao productie beschreven, de ervaring opgedaan met het opzetten van een aanvoerketen door middel van een procedure waarbij alle belanghebbenden betrokken waren. Ook wordt verslag gedaan met pogingen om institutionele actoren van hogere schaalniveaus erbij te betrekken. Het hoofdstuk wordt beëindigd met het trekken van conclusies uit de opgedane ervaringen, met daarin speciale aandacht voor de institutionele knelpunten die de commerciële kansen bepalen (ruimte voor verandering).

Hoofdstuk 6

In dit afrondende hoofdstuk wordt teruggekeken op de totale PhD studie vanuit het perspectief van 'convergentie van wetenschap' gebaseerd op de belangrijkste uitkomsten in ieder hoofdstuk en hoe deze uitkomsten bijdragen en passen in de landbouwkundige onderzoek- en ontwikkelingsdoelen van Ghana. De formele landbouwkundige wetenschap als middel om duurzame groei en ontwikkeling te bewerkstelligen bij het overwinnen van armoede in de cacao producerende gebieden in Ghana heeft maar een beperkt resultaat gehad. Sommigen beweren dat dit komt omdat: 1. het landbouwkundig onderzoek slecht wordt uitgevoerd; 2. er onvoldoende investeringen zijn in landbouwkundig onderzoek; 3. de diversiteit in productiesystemen te groot is; 4. de ontwikkelde technologie zich te langzaam verspreid; en 5. de boeren niet genoeg geïntegreerd zijn in het marktgebeuren.

De cacao sector heeft een impuls gekregen in de afgelopen jaren door het besluit van de Ghanese overheid om het percentage van de FOB prijs die betaald wordt aan de boeren te verhogen van ca. 40% een paar jaar geleden naar ca. 70% in 2005. Deze situatie creëerde voor de kleine cacao boeren in Ghana een kansrijk klimaat. Voor landbouwkundig onderzoek wordt daarmee ook een kans geschapen. Een belangrijke handicap in het toepassen van wetenschap op landbouwkundige ontwikkeling is de door hen zelf opgelegde conventionele 'top-down' benadering met betrekking tot 'onderzoek voor ontwikkeling'. Deze dissertatie heeft, samen met de andere acht doctoraal studies in het CoS programma, getracht een alternatieve en meer effectieve wetenschappelijke weg te ontwikkelen en te testen. Dit is nu relevanter geworden met de stijging van de cacao prijzen en de daarmee ontstane ruimte voor verandering. In het afrondende hoofdstuk worden de belangrijkste conclusies en aanbevelingen samengebracht.

Annex 1

THE CONVERGENCE OF SCIENCES PROGRAMME[1]

Background

This thesis is the outcome of a project within the programme "*Convergence of Sciences: inclusive technology innovation processes for better integrated crop and soil management*" (CoS). This programme takes off from the observation that West African farmers derive sub-optimal benefit from formal agricultural science. One important reason for the limited contribution of science to poverty alleviation is the conventional, often tacit, linear perspective on the role of science in innovation, i.e. that scientists first discover or reveal objectively true knowledge, applied scientists transform it into the best technical means to increase productivity and resource efficiency, extension then delivers these technical means to the 'ultimate users', and farmers adopt and diffuse the 'innovations'.

In order to find more efficient and effective models for agricultural technology development the CoS programme analysed participatory innovation processes. Efficient and effective are defined in terms of the inclusion of stakeholders in the research project, and of situating the research in the context of the needs and the opportunities of farmers. In this way stakeholders become the owners of the research process. Innovation is considered the emergent property of an interaction among different stakeholders in agricultural development. Depending on the situation, stakeholders might be village women engaged in a local experiment, but they might also comprise stakeholders such as researchers, farmers, (agri)-businessmen and local government agents.

To make science more beneficial for the rural poor, the CoS programme believes that convergence is needed in three dimensions: between natural and social scientists, between societal stakeholders (including farmers), and between institutions. Assumptions made by CoS are that for research to make an impact in sub-Saharan Africa: most farmers have very small windows of opportunities, farmers are innovative, indigenous knowledge is important, there is a high pressure on natural resources, the market for selling surplus is limited, farmers have little political clout, government preys on farmers for revenue, and institutional and policy support is lacking. To allow '*ex-ante* impact assessment' and ensure that agricultural research is designed to suit the opportunities, conditions and preferences of resource-poor farmers, CoS pioneered

[1] Hounkonnou, D., D.K. Kossou, T.W. Kuyper, C. Leeuwis, P. Richards, N.G. Röling, O.Sakyi-Dawson, and A. van Huis, 2006. Convergence of sciences: the management of agricultural research for small-scale farmers in Benin and Ghana. *Wageningen Journal of Life Sciences (NJAS)*, 53(3/4): 343-367.

a new context-method-outcome configuration[2] using methods of technography and diagnostic studies.

Technographic and diagnostic studies

The technographic studies explored the innovation landscape for six major crops. They were carried out by mixed teams of Beninese and Ghanaian PhD supervisors. The studies looked at the technological histories, markets, institutions, framework conditions, configurations of stakeholders, and other background factors. The main objective of these studies was to try and grasp the context for innovation in the countries in question, including appreciation of limiting as well as enabling factors.

The diagnostic studies were carried out by PhD students from Benin and Ghana. They focused in on groups of farmers in chosen localities, in response to the innovation opportunities defined during the technographic studies. The diagnostic studies tried to identify the type of agricultural research - targeting mechanisms - that would be needed to ensure that outcomes would be grounded in the opportunities and needs of these farmers. Firstly, that not only meant that research needed to be technically sound, but also that its outcomes would work in the context of the small farmers, taking into account issues such as the market, input provision, and transport availability. Secondly, the outcomes also needed to be appropriate in the context of local farming systems determined by issues such as land tenure, labour availability, and gender. Thirdly, farmers also need to be potentially interested in the outcomes taking into account their perceived opportunities, livelihood strategies, cultural inclinations, etc.

The diagnostic studies led to the CoS researchers facilitating communities of practice of farmers, researchers, scientists from national research institutes, local administrators and local chiefs. The research was designed and conducted with farmer members of the local research groups. Their active involvement led to experiments being added, adapted or revised. It also made the researchers aware of the context in which the research was conducted. A full account of the diagnostic studies can be found in a special issue of NJAS[3].

Experimental work with farmers

After completing the diagnostic studies, the PhD students engaged in experiments with farmers on integrated pest and weed management, soil fertility, and crop genetic diversity, in

[2] See R. Pawson and N. Tilley, 1997. *Realistic evaluation*. London: Sage Publications.

[3] Struik, P.C., and J.F. Wienk (Eds.), 2005. Diagnostic studies: a research phase in the Convergence of Sciences programme. *Wageningen Journal of Life Sciences (NJAS)*, 52 (3/4): 209-448.

each case also taking into account the institutional constraints to livelihoods. They focused on both experimental content and the design of agricultural research for development relevance. Experiments were designed and conducted together with groups of farmers, and involving all stakeholders relevant for the study. The aim was to focus on actual mechanisms of material transformation – control of pests, enhancement of soil fertility, buffering of seed systems – of direct relevance to poverty alleviation among poor or excluded farming groups. The ninth PhD student carried out comparative 'research on research' in order to formulate an interactive framework for agricultural science.

Project organization

All students were supervised by both natural and social scientists from the Netherlands and their home countries. In each country, the national coordinator was assisted by a working group from the various institutions that implemented the programme. A project steering committee of directors of the most relevant research and development organizations advised the programme. The CoS programme had a Scientific Coordination Committee of three persons, including the international coordinator from Wageningen University.

CoS had two main donors: the Interdisciplinary Research and Education Fund (INREF) of the Wageningen University in the Netherlands and the Directorate General for International Cooperation (DGIS), Ministry of Foreign Affairs of the Netherlands. Other sponsors were the FAO Global IPM Facility (FAO/GIF), the Netherlands Organization for Scientific Research (NWO), the Wageningen Graduate School Production Ecology and Resource Conservation (PE&RC), the Technical Centre for Agricultural and Rural Cooperation (CTA or ACP-EU), and the Netherlands organization for international cooperation in higher education (NUFFIC). The total funds available to the project were about € 2.2 million.

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All of you other friends and relations whose names I cannot list here- please remember that your contribution and support are appropriately acknowledged because I remember you in my heart. Once again thanks to everyone who contributed to this study.

Curriculum Vitae

Godwin K. Ayenor was born on April 15th, 1968 at Wenchi in the Brong-Ahafo region of Ghana. He attended Presby. Secondary School, Odumase Krobo, Eastern Region for only a year before obtaining a Cuban government's scholarship in 1983. In Cuba he completed his secondary education and continued there through to his MSc in Agronomy in the University of Agricultural and Animal Sciences, Havana in 1994. After working briefly with the Ministry of Food and Agriculture on seed certification under the Plant Protection and Regulatory Services Division, he worked as Field Research/Education Link Officer with the then Overseas Development Agency of UK on farming systems research, development and training project in Ghana. He also facilitated and co-ordinated a participatory technology development field trials that basically looked at varietals selection of tomatoes and other vegetables under the Integrated Food Crop Systems Project funded by ODA/Natural Resources International (NRI) in B/A Region, Ghana. From 1997- 2001, he worked with TechnoServe Ghana Inc.(USAID funded programme) as food security Project Officer and Micro-enterprise Business Advisor providing technical assistance, market linkages and group development support to small and medium scale enterprises. In 2001/2 he got a scholarship to pursue his PhD study in Wageningen University, the Netherlands under the Convergence of Sciences Project where he worked on facilitating interdisciplinary research on cocoa. He integrated biological and social sciences with attention to farmer participation and empowerment in technology development and dissemination. He also facilitated multi-stakeholder processes towards creating organic cocoa production, certification and marketing. His strength and interest is in development projects aimed at capacity building and facilitating natural resource management through socially and ecologically acceptable practices towards wealth creation and poverty reduction.

PE&RC PhD Education Statement Form

With the educational activities listed below the PhD candidate has complied with the educational requirements set by the C.T. de Wit Graduate School for Production Ecology and Resource Conservation (PE&RC) which comprises of a minimum total of 22 credits (= 32 ECTS = 22 weeks of activities)

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- Integrated pest management and participatory learning and action research as well as contemporary literature on communication and innovation science from a multi-disciplinary perspectives (2002)

Writing of Project Proposal (5 credits)

- Capsid control for organic cocoa in Ghana: results of participatory learning and action research (2002)

Post-Graduate Courses (3 credits)

- Training in multi-stakeholder processes, International Agricultural Centre, Wageningen (2004)

Deficiency, Refresh, Brush-up and General Courses (20 credits)

- Scientific Writing (2002)
- Presentations in annual inter-country meetings of convergence of science project (2002-2005)
- Integrated pest and vector management (2002)
- Agricultural knowledge and information systems (2002)
- Participatory approaches and upscaling (2002)

PhD Discussion Groups (5 credits)

- Plant insect interaction group (2002)
- Crop science in University of Ghana (2002-2005)
- Communication & innovation (2006)
- Extension department in University of Ghana (2002-2005)

PE&RC Annual Meetings, Seminars and Introduction Days (2 credits)

- Seminar on diagnostic studies on cocoa pest. Cocoa Research Institute of Ghana (2003)
- Seminar on three alternative methods of capsids control. University of Ghana (2003)

International Symposia, Workshops and Conferences (3 credits)

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Abstract
Cocoa is an important foreign exchange earner for Ghana. However, compared to Ivory Coast and Malaysia, two other major producing countries, yields are extremely low. The causes of low yields are many. They include low producer price offered until recently by the government, costs of labour, poor tree husbandry practices, and pest and diseases. The recent increase in producer price has rekindled farmers' interest in measures that can help them address low yields especially in pest and disease control. Cocoa Research Institute of Ghana has developed and disseminated a number of recommendations, but less than five percent of cocoa farmers have adopted those. It is believed that one of the major problems is the application of conventional research models through linear processes of technology transfer. With the view to improve research uptake and use, we adopted technographic and diagnostic studies followed by participatory technology development. Hence, we tried an interactive participatory approach focusing on alternative technology generation, development and delivery to other cocoa farmers. Capsids (Sahlbergella singularis and Distantiella theobroma (Heteroptera: Miridae) emerged as the most serious biological production constraints. Therefore, in this study we addressed the problem of capsids in cocoa. We did this within Brong-Densuso area, in the Eastern region of Ghana. With 'free' pesticides spraying by government, organic marketing arrangements between an American company and the cocoa farmers' association collapsed. Thus, we had to explore alternatives in order to sustain farmers' motivation to use the non-chemical pest management technologies. Therefore, the overall objective was to facilitate and develop, together with farmers, Integrated Pest Management methods to control capsids in an organic production system of cocoa. This objective was pursued by grounding the research in the needs and opportunities of farmers through a diagnostic process and by systematic blending of indigenous and formal knowledge. The focus was not only on technical improvements, but also on finding new social and institutional arrangements, such as more effective approach for information sharing and an alternative supply marketing chain for organic farmers.

Résumé
Le Cacao est l'une des principales sources de devise pour le Ghana. Cependant, le rendement moyen enregistré au Ghana reste relativement faible comparé a ceux obtenus en Cote-d'Ivoire et en Malaysie. Les causes de ce faible rendement sont multiple et comprennent: le faible prix au producteurs offert par le gouvernement jusqu'à récemment, le coût de la main d'?uvre, mauvaises pratiques en pépinière, et le problème des ravageurs et maladies. La récente augmentation du prix aux producteurs a ravivé l'intérêt des producteurs à certaines mesures notamment le contrôle des ravageurs et maladies qui leurs permettront d'améliorer le rendement. L'Institut de Recherche sur le Cacao du Ghana a développé et vulgarisé un certain nombre de recommandations pour la production du cacao, mais moins de cinq pour cent des producteurs ont adopté ces recommandations. Il est à croire que les approches conventionnelles de recherche axée sur le 'Top Down' constituent l'un des problèmes majeurs. Dans vision d'une amélioration des acquis de recherche nous avons adopté des études technographique et diagnostique suivi par le développement participatif de technologie. Ainsi, nous avons essayé une approche participative interactive orientée vers une génération de technologies alternatives. Les contraintes majeures de productions sont les insectes ravageurs Sahlbergella singularis et Distantiella theobroma (Heteroptera: Miridae), par conséquent les activités ont été centrées autours de ce groupe de ravageurs. L'étude a été conduite dans la zone de Brong-Densuso, région Est du Ghana. Avec l'application massive et gratuite de pesticides organisés par le gouvernement, l'accord de marché de cacao organique conclut entre une compagnie américaine et les producteurs a échoué. Nous devons donc, explorer les méthodes alternatives en vue de soutenir les motivations des producteurs dans utilisation des technologies de lutte alternatives à l'application des pesticides synthétiques. L'objectif général de cette étude était de développer en collaboration avec les producteurs les méthodes de lutte intégrée contre le groupe de ravageurs précités dans le système de production cacao organique. Cet objectif a été atteint en associant la recherche aux besoins et opportunités des producteurs a travers une approche systématique d'intégration de connaissances formelles et endogènes. Le but n'était pas seulement les amélioration techniques mais aussi l'identification de nouvel arrangement institutionnel et social, telqu' une approche plus effective de communication et d'approvisionnement en intrant pour les producteurs de cacao organique.

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