West Africa regional cocoa IPM workshop

November 13 – 15, 2001
Cotonou, Benin

PROCEEDINGS

Edited by Janny Vos and Peter Neuenschwander

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Sponsored by STCP and BCCCA

Sustainable Tree Crops Programme

BCCCA

Jointly organised by CABI *Bioscience* and IITA

CABI *Bioscience*
A division of CAB *International*

INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE

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[1] CABI *Bioscience*
[2] International Institute of Tropical Agriculture

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Introduction

Opening address: West Africa Regional Cocoa IPM Workshop

Peter Neuenschwander[1] *and Janny Vos*[2]

[1]*International Institute of Tropical Agriculture*
[2]*CABI Bioscience*

Dear Colleagues,

At last year's meeting of the Sustainable Tree Crops Programme (STCP), in Accra, sponsored by USAID and the Biscuit, Cake, Chocolate and Confectionery Alliance (BCCCA), it was decided that the Plant Health Management Division of IITA in Cotonou together with CABI Bioscience should hold a workshop on IPM in cocoa in Cotonou in 2001. And this is what we are now here for together.

As the director of IITAs Plant Health Management Division and head of this IITA station I would like to cordially welcome you. Janny Vos, technology transfer specialist from CABI Bioscience, co-chairs this workshop and offers her great knowledge and enthusiasm to the benefit of the STC Programme. Sampson Nyampong, a cocoa farmer himself, and my right-hand man, was responsible for much of the nitty-gritty of the organisation. The administrator, the travel office, the accountants, the kitchen, and so on, all tried to do their best for your well-being. Please bear with us when things do not work and bring problems to our attention so that we can try to solve them.

This workshop should provide scientists from the various West and Central African cocoa producing countries a platform to exchange ideas and benefit from each other and the international institutes. The rather modest funding allowed us to invite only three participants from each country, namely from Cameroon, Côte d'Ivoire, Ghana, Guinea Conakry, and Nigeria, i.e. the big cocoa producers of the region. The lucky fourth participant from Cameroon, where the STCP is housed, was specially invited by the STCP co-ordinator. Benin comes into the picture because of its central location between these large producers, the IITA station here, and its traditional hospitality, which I am sure you will enjoy. Of course, STCP and BCCCA were also invited; but I have to announce with regret that both organisations in the last minute were not able to attend. This means also that we shall miss all the chocolate that was on offer in Accra!

If the workshop took some time to organise, it is because of the two-way communication that brought about the agenda of this workshop, which allows for a tailor-made programme, but takes more time than a top down process. Thus, this is your workshop and the international institutions function only as facilitators. We note that several of the participants are housed in other ministries than their colleagues working on IPM on other crops. We hope that the workshop will give an opportunity for building bridges among IPM practitioners working on different crops.

CABI Bioscience has a long history of work and collaboration in cocoa, especially IPM and more recently in farmer participatory training and research, but where does IITA come in? Let me assure you that the co-chairing of this workshop by CABI and IITA is not just a result of Janny Vos' and my good understanding; the reasons are deeper and have to do with the crop itself. Cocoa is a rather strange cash crop in that most cocoa in Africa is produced by small holders, who grow a number of different crops. Through their national programmes, these farmers are supported by IITA with adapted varieties, IPM, soil and farm management options for cassava, maize, and legumes. For IPM, scientific identification of the organisms underpins the development of new IPM options. For this, CABI and IITA complement each other with relevant microbial and insect collections. Both also have a lot of experience in transferring knowledge as well as learning from farmers through farmer participatory techniques. We therefore conclude that this workshop brings together the best possible team to take cocoa IPM a significant step further.

Why is it that we know of more IPM success stories in the food crops maize, legume or cassava than in cocoa? In our area, these food crops, with the exception of those in peri-urban gardens, do not usually receive any insecticide treatment. By contrast, in the past, cocoa pest management often consisted of treatments on a calendar basis, which was economically feasible because of the high cash value of cocoa. With the continuous decline in the world market price of this commodity and ever louder calls for an environmentally friendly solution to pest problems in these areas with high biodiversity where cocoa is grown, new solutions have to be found. In order to stem abandonment of the culture, it has become imperative to rehabilitate cocoa groves and to find new ways to start new ones in areas where the rainforest has already been cut down, and to devise new IPM systems.

With the very recent upswing in cocoa prices, it would now be wrong to go back to the old ways. Our goal is to develop sustainable farming systems in the forest zone with cocoa as the main cash crop and farmers in the driver's seat. The solutions have to be based on what is acceptable to farmers, as we shall hear from each other during this workshop. By putting our heads together we should be able to come up with a basket of options that alleviate cocoa farmers' major pest problems. These should then be evaluated and implemented in what one could call best-bet trials using farmer participatory methods.

As the outcome from this workshop we envisage a joint regional proposal to facilitate follow-up research in cocoa IPM. DFID is represented in this workshop, and STCP and BCCCA have already expressed their interest in co-funding cocoa IPM activities in the region. The IPM problems facing us comprise a panoply of pests like cocoa mirids and diseases like swollen shoot disease, cocoa black pod, as well as mistletoe. Some management options are already employed in some areas, some are available but not widely used for various reasons, and some need to be researched anew. Among the latter, we would like to mention the looming threat of an accidental introduction of the South American witches broom disease into Africa. There are certainly many more organisms that have to be considered as either pests or their natural enemies or those profiting from the shady environment in a cocoa grove and contributing to biodiversity. But let's not forget the cocoa farmer who is at the centre of this all.

We have a dream of farmers benefiting from more profitable production of cocoa using biologically-based IPM. Besides the economic benefits we perceive this to be better for the health of the farming community. In addition, such an approach would sustain the forest environment, even providing habitat bridges between forest pockets as is the case and the further goal for the fragmented Atlantic forests of Brazil.

This is a big dream; but I think we have the human resources to take on this challenge. At the moment, cocoa production in Africa is down and prospects seem to look bleak. There is general agreement that 'business as usual' will not solve this crisis and that new approaches are needed. This workshop might as well take advantage of this window of opportunity and steer IPM towards a biologically based system for high quality cocoa production.

With this vision, I would like to declare the workshop open. *Vive la recherche scientifique, vive la collaboration internationale. Nous vous remercions!*

Keynote addresses

Sustainable Tree Crops Programme: From strategy to results

Peter Neuenschwander (IITA) on behalf of
Jose Luis Rueda
International Institute for Tropical Agriculture

Sustainable Tree Crops Programme (STCP) at a glance:

- North – South partnership: Benefits are sustainability of the cocoa supply, sustained socio-economic well-being of the smallholder farmers, increased environmental sustainability in targeted regions/countries
- Location: Côte d'Ivoire, Ghana, Nigeria, Cameroon, Guinea
- Start: 1999
- Tree crops: Focusing on cocoa, cashew, coffee
- Principle beneficiaries: Rural communities and producers

STCP goal:
Improve the economic well-being of smallholders and the environmental sustainability of their tree crop systems

STCP strategic objective:
Strengthened sustainable tree crop systems in targeted West African countries through effective support of smallholders production, processing and marketing

STCP partners:

- Private sector, donors, farmers, GOV/NARS, Universities, IARCs, NGOs
- Strategic partnership that capitalise on each partner's strengths, reflect shared goals, build on existing achievements, enhance quality of participating institutions (economic growth)

STCP components:

- Grower and business support (GBSS)
- Research and technology transfer (RT&T)
- Policy analysis (PI)
- Market information (MISD)

GBSS expected results: Farmer associations effectively provide an integrated package of services to their smallholder members

- Product identity preservation system on-going
- Marketing and management course
- Quality control lab
- Training materials for quality control of cocoa

RT&T expected results: Environmentally sustainable technologies are utilised by smallholder tree crop farmers

- Survey completed on ecological and economic characterisation of existing cocoa systems
- Potential biocontrol strains against *Phytophthora megakarya* discovered
- In vitro micro-propagation for cocoa

MISD expected results: Country and regional market information systems enhance the efficiency of the tree crop section (reduce uncertainty)

- Report on analysis of alternative approaches to improving cocoa marketing infrastructure in West Africa

Policy expected results: Policy options that increase tree crop section efficiency are identified and promoted
- Meeting with potential donors
- Social responsibility and agricultural systems in West Africa
- What are the standards to ensure systems are socially and environmentally responsible and economically efficient?

Pilot activity characteristics:
- Approach tested to promote product identity preservation
- A focus on the community (average of 100 communities per pilot activity)
- One pilot activity targeted per country
- Information systems to enhance production and marketing efficiency (supply chain management)
- Capacity built for community groups

Key elements:
- Social services
- Farmer organisations
- Quality improvement centre
- Information systems
- Technical packages
- Grower services
- Certification process
- Sustainability indicators

Conclusion: STCP is a framework for creating answers together for a sustainable cocoa supply to meet industry forecasts

Discussion:

Q: Could Cameroon explain a bit more about the mentioned activities in their country?
A (Cameroon): Yes, much of it will come out in the national presentations. Dr Rueda would have talked about labelling cocoa / certification in relation to cocoa production area (country) and quality under the grower and business support group. Because of the liberalisation and globalisation all cocoa is lumped together, which reduces cocoa quality overall. This work is done in collaboration with the chocolate industry. STCP looks for direct collaboration of producers with the industry.

Comment: A single label for all African producing countries would create more solidarity among producing countries as for rubber production in Africa.

Q: In how far are the baseline surveys being implemented?
A (Cameroon): There are surveys being done on general information for cocoa production.
A (Ghana) : Ghana has done a limited survey in the central region (with Conservation International, not under STCP)

BCCCA Cocoa research programme

Supporting the development of better ways to control pests and diseases in cocoa

Janny Vos (CABI Bioscience) on behalf of
Tony Lass
Cadbury Schweppes

The BCCCA is the trade association for UK manufacturers of biscuits, cake, chocolate and sugar confectionery. The UK industry has a long tradition of support for cocoa research and we currently fund a range of innovative projects together with key international resources, which will benefit the World Cocoa Community. Our research programme aims to achieve **sustainable** production of good quality cocoa. We understand that cocoa growers are afflicted by a whole range of pests and diseases and cost-effective and environmentally responsible ways of controlling these are urgently required. Integrated Crop Management, incorporating bio-control and rational pesticide use, brings exciting prospects for the whole cocoa chain. Reduced pesticide usage stands to benefit the growers and the environment whilst satisfying the ever increasing demands of the consumers and regulatory authorities.

Introduction

The cocoa crop is afflicted by a whole range of pests and diseases, with some estimates putting losses to be as high as 30% of global cocoa production. Improved, cost effective and environmentally responsible ways to control these are urgently required to ensure the sustainable production of good quality cocoa. Integrated Pest Management (IPM), which aims to utilise a range of control mechanisms and replace over reliance on broad-spectrum pesticides, brings exciting prospects for the whole cocoa chain. Improved planting material and plant husbandry, biocontrol and rational pesticide use can all play a role in IPM. The reduced pesticide usage achievable through the use of IPM stands to benefit the growers and the environment whilst satisfying the ever increasing demands of the consumers and regulatory authorities. All possible efforts to this end must be mobilised – substantial resources for research and extension will be needed. This workshop is a start to ensure research programmes are aligned to use the scarce resources to best effect and build on the comparative advantages of every participant.

The UK cocoa and chocolate industry has been contributing to research efforts in cocoa producing countries for over 50 years. Our cocoa research programme supports many key international resources and projects which stand to benefit cocoa growing throughout the world. We place particular emphasis on the needs of West African countries, which supply 66% of the world's cocoa production and the majority of the cocoa required by the UK industry. BCCCA has welcomed opportunities to collaborate with various research institutes and other organisations, including other industry associations, to ensure an internationally co-ordinated approach to cocoa research. We are actively involved in several international research efforts including the Sustainable Tree Crops Program, the CAOBISCO Black Pod Project and the CFC/ICCO/IPGRI project "Cocoa Germplasm Utilisation and Conservation: a Global Approach". Outlined below are some of the recent/on-going research projects and activities BCCCA, and its trust fund the Ghana Cocoa Growing Research Association (GCGRA), has supported which will contribute to the development of Integrated Pest Management (IPM) programmes for West and Central Africa.

Enhanced Breeding

Planting material with a good degree of resistance to local pests and diseases is an important component of any IPM system. It has been stated that 70% of cocoa grown comes from non-selected varieties and there is much scope for breeding new varieties, which are both high yielding and incorporate natural pest and disease resistance. Breeders need germplasm containing sufficient diversity to allow them to incorporate these characteristics. Their progress will be accelerated if they have access to information on the characteristics of the material, are confident of its identity and if they can exchange material with other genebanks via quarantine to minimise the risk of spreading pests and diseases. New technologies such as marker assisted breeding are being developed which offer great potential for rapid progress in selecting material with the desired characteristics. Efficient propagation methods, including *in vitro* techniques, and good extension networks are also urgently required to ensure that improved varieties can be bulked up and supplied to farmers efficiently.

Projects on enhanced breeding funded by BCCCA include:

International Cocoa Genebank, Trinidad – a genetically diverse collection of over 2300 cocoa clones. Associated research projects at the Cocoa Research Unit (Trinidad) to confirm identification, morphologically and genetically characterise the accessions, and analyse their genetic diversity. Research is also being conducted to develop and use disease resistance evaluation techniques for Black Pod disease (activities funded by CAOBISCO and CFC) and Witches' Broom disease (funded by ACRI/CFC). Clones identified as having breeding potential are being made available to breeders in Africa and elsewhere, following transfer to the Intermediate Cocoa Quarantine Facility (see below).

Intermediate Cocoa Quarantine Facility, The University of Reading (UK) – a collection of over 300 clones which are either undergoing or have passed a two-year virus indexing period. Associated research carried out in Ghana, funded by Ghana Cocoa Growing Research Association, is seeking to establish molecular virus detection techniques, which will improve the efficiency of the quarantine procedure.

International Cocoa Germplasm Database, The University of Reading (UK) - a computerised database of information on the origins, characteristics and present location of cocoa clones, which is made freely available to the 83 institutes, including 8 in Africa that have contributed data to the project (funded by LIFFE and administered by BCCCA).

The Genetic Basis of Resistance to *Phytophthora* Diseases – BCCCA contributed to the CAOBISCO project at CIRAD (France), CNRA (Côte d'Ivoire), IRAD (Cameroon) and CRU (Trinidad) which was successful in establishing early screening and molecular markers which can be used to accelerate progress in breeding for resistance to Black Pod disease. New progeny, pre-bred for resistance, are now being evaluated under field conditions in the producing countries.

Genetic and Physiological Basis of Incompatibility, The University of Reading (UK) – a project to understand the mechanism of this complex system and provide breeders with information on the cross-compatibility status of cocoa germplasm.

Witches' Broom Genotype x Pathotype Study, The University of Reading (UK) – output from this research could be very valuable in the selection of resistant cocoa clones to be transferred to Africa as a precautionary measure against the introduction of this devastating disease.

Elite Germplasm Selection and Multiplication in Côte d'Ivoire and Ghana, **CNRA (Côte d'Ivoire) and CRIG (Ghana)** – a project funded by GCGRA to survey for elite trees, as identified by farmers, and to use an integrated propagation technique to multiply sufficient material for distribution back to farmers. Micro-propagation and somatic embryo derived plantlets are under evaluation in the greenhouses of both CNRA and CRIG. This project forms part of the Sustainable Tree Crops Program in West Africa.

Agroforestry/Agronomy

The way that cocoa trees are grown, pruned and shaded can have an important effect on pest populations, since these all have an impact on the microclimate surrounding the trees. The selection of appropriate "companion" trees may reduce the spread of pests and diseases, as well as stabilising/enhancing soil fertility, benefiting the environment and offering alternative income sources to the farmer. Maintaining good crop hygiene, through the removal of diseased/infected material and regular harvest of pods also forms an essential part of IPM. BCCCA has contributed to the following projects:

Native Forest Trees in Agroforestry systems, University of Wales (UK) and FORIG (Ghana) – a collaborative project to study the characteristics of West African tree species which could provide shade for cocoa, the needs of farmers and develop sustainable agroforestry systems.

Cocoa Pod Borer Management Project – a collaborative project (initially co-funded with ACRI, ASKINDO and now with ACDI/VOCA/USDA) to establish agronomic practices in Indonesia which could provide effective control of cocoa pod borer and pod losses. Demonstration plots and training programmes have been established to show local farmers how to implement these techniques.

Biocontrol

There are many natural enemies of pest species, which have potential use in IPM. Beneficial insects and diseases can be fostered and augmented to maintain pests below the economic threshold and in some cases, it is possible to formulate these pathogens as biopesticides which could provide a non-chemical and sustainable method for insect control. BCCCA/GCGRA projects include:

Entomopathogenic fungi for cocoa mirid control in Ghana (CABI/CRIG) – a GCGRA project with CABI and CRIG to survey for mirid fungal pathogens and evaluate their potential for the development of mycoinsecticides. A promising isolate of *Beauvaria bassiana* has been isolated and a technique for the mass production of its spores has been established.

Training in Biocontrol techniques - A staff member from Cocoa and Coconut Research Institute, Papua New Guinea undertook a training programme at CATIE (Costa Rica) and USDA Beltsville (USA) as a step towards the establishment of a biocontrol research programme in PNG.

Acknowledgements

BCCCA would like to thank all those institutions and individuals who have worked with us in these cocoa research activities. Please contact BCCCA at michelle.end@bccca.org.uk for a brochure on our cocoa research programme and further details of individual projects.

Cocoa IPM activities in the DFID Crop Protection Programme

David Hall (NRI) on behalf of
Simon Eden-Green
Natural Resources International

Crop Protection Programme (CPP)

The CPP forms part of a Research Strategy which funds research projects in the renewable natural resources sector, which contribute to eliminating poverty and enhancing livelihoods in those developing countries targeted for assistance by DFID.

Cocoa IPM projects

1. *Development of mycopesticides and pheromones for control of cocoa mirids*

Collaboration between Cocoa Research Institute of Ghana, CABI, Natural Resources Institute (NRI). October 1998 – March 2002

- Few indigenous entomopathogenic fungi;
- Investigating effects of exotic Beauvaria bassiana;
- Female-produced pheromones demonstrated in both of two main species;
- Potential pheromones synthesised and being tested in field.

2. *Control of Phytophthora megakarya diseases of cocoa with phosphonic acid*

Collaboration between Cocoa Research Institute of Ghana, CABI, Natural Resources Institute (NRI), Reading University. February 1999 – March 2002

- Surveys establish black pod perceived as most important disease by growers;
- Phosphonate injection gives good control but phytotoxic in initial trials;
- Phytotoxicity much reduced with new trials;
- Other induced systemic resistance (ISR) agents evaluated;
- Residue problems and operator hazards studied.

The future

- Possibility of extension of existing projects if justified by results;
- The Programme is now in the sixth year of a ten-year phase and is focusing on promoting the uptake of research outputs developed in earlier phases to establish impact;
- Looking for developing countries to lead projects.

Discussion

Q: *Cameroon has tried injection of phosphonic acid on cocoa with no success. How did you assess the efficacy of the phosphonic acid treatment? Did you compare treated and untreated plots? What concentration was used?*

A (Ghana): *The concentration used was 40% at a rate of 2 * 20 ml per tree, applied in July. In Ghana the black pod season is around Sept-Oct. So it has to be injected around July. We've also found that there is no residual effect of the phosphonic acid. So if it is injected this year, it will have to be injected again next year. A comment on David's presentation: "new formulation gives no phytotoxic effect". But the phosphonic acid used in Ghana is not a new formulation as such, we don't know whether it is different from what we were using before. The previous batch caused a lot of burns around the point of injections. This year however, we found that damage was not as extensive as in the previous years. We are yet to do the final assessments in Jan-Feb.*

Q: You said that the study was conducted in Ghana where you have Phytophthora megakary *and* P. palmivora*. Did you succeed in controlling both species using phosphonic acid?*

A (Ghana): Yes, the phosphonic acid was effective for both species.

Biological control of pests and diseases of tropical tree crops with specific reference to cocoa and coffee

Keith Holmes and Julie Flood
CABI Bioscience

Introduction

The term "tropical tree crops" covers a wide range of crops from fruit trees to palms, and from timber producing species to beverage crops such as cocoa and coffee. Given this extremely wide remit and limited space, for the purposes of this paper we shall confine ourselves to a discussion of mainly cocoa and where relevant to coffee, crops of relevance to both the participants at the West African Regional Cocoa IPM Workshop and to the Region in the wider context.

Both the cocoa and coffee industries predict a growing demand for their products in this century and whilst there is some possibility of extending production into new areas, increased productivity is much more likely to be achieved through improvements in production in the areas currently under cultivation. However, productivity is severely reduced by numerous constraints, of which the main biological problems are pests and diseases. For cocoa, the main constraint is "Black pod" caused by various *Phytophthora* species. This group of diseases, characterised by rotting pods and associated cankers, causes an estimated 44% loss in world production (Van der Vossen, 1999). In West Africa, which produces over 60% of the world's cocoa, *P. palmivora* and particularly *P. megakarya*, have the potential to reduce production in some areas by 100%. Also in West Africa, Cocoa Swollen Shoot Virus (CSSV) causes 11% global crop loss (Van der Vossen, 1999) whilst mirids or capsids (*Sahlbergella singularis.* and *Distantiella theobroma*) affect 25-30% of the national acreage in Ghana alone and give annual losses in world production estimated at 100,000 tonnes.

Frosty pod rot (*Moniliophthora roreri*) with its abundant spore production and its destructive effect on cocoa beans and Witches' broom (*Crinipellis perniciosa)* characterised by the hypertrophic growth, presence of basidiocarps and destruction of beans, have devastated cocoa production in Latin America. Frosty pod currently causes an estimated 5% loss of the total global loss and is becoming an increasingly serious problem in Ecuador, Colombia and Central America. In parts of Peru, losses of 100% have been reported (Evans *et al*., 1998). Witches' broom causes an estimated global crop loss of 21% but in Brazil the introduction of this disease into the state of Bahia in the 1980's has resulted in a projected production of over a million tonnes of cocoa by 2000 being turned into an actual productivity of only 125,000 tonnes and Brazil becoming a net importer of cocoa.

In SE Asia and the Pacific, Vascular Streak Die-back (VSD) and Cocoa Pod Borer (CPB) are also serious constraints to cocoa production. VSD (*Oncobasidium theobromae*) causes 9% of the total global loss and can be locally very severe. In an outbreak in Sabah, East Malaysia in the mid-1980s, 100% losses were recorded in newly planted fields (Keane & Prior, 1991). Similarly, CPB (*Conopomorpha cramerella*) has caused substantial losses to the cocoa industries of Malaysia, Indonesia and the Philippines. In Sulawesi, 20% losses have been recorded frequently whilst in other areas 40-50% losses have been experienced (Matlick, 1998).

Similarly, in coffee, a number of diseases cause problems for coffee growers (Flood *et al*, 2001). For example, a severe epidemic of Coffee Berry Disease or CBD (*Colletotrichum kahawae*) in central Kenya in 1967 caused the loss of entire crops and overall losses nationally were in excess of 30%. Another serious constraint of coffee production is Coffee Leaf Rust (*Hemileia vastatrix)*. The disease has been estimated to be responsible for 10-30% loss in actual production costs in Brazil and causes losses of between $US 1-3 billion worldwide. *Fusarium* wilt caused by the fungus *Fusarium xylarioides (G. xylarioides*) has also re-emerged as a serious threat to robusta coffee causing considerable losses in Democratic Republic of Congo (DRC) and in Uganda (Flood *et al*, 2001). In Uganda, it has been estimated that nearly US$3 million has been lost since the mid-1990s due to this disease. In addition to diseases, pest problems such as coffee stem borer (West African coffee borer; *Bixadus sierricola*) and coffee berry borer (*Hyothenemus hampei*) also contribute to overall losses.

An interesting point to note is that with coffee, diseases that have tended to be regional at first have spread to many parts of the world e.g. Coffee Leaf Rust. This disease has spread rapidly throughout Africa and Asia as the coffee industries of these countries developed; it reached the New World in 1971 and now occurs in virtually all coffee-producing countries. In comparison in cocoa at the moment, many of the most important diseases such as Witches' broom and Frosty pod in Latin America and *P. megakarya* in West Africa, have a regional distribution but this may not remain as such. With faster communications and travel, trade links and the movement of mankind and commodities all over the world, there is a serious and very real risk of the introduction of cocoa diseases from one region or even one continent to another. Consequently, knowledge and understanding of biological problems in other regions is critical in order to raise awareness and to help prevent their accidental introduction.

Current management practices

From the above, it is obvious that tropical tree crops such as coffee and cocoa, face significant challenges from both pests and diseases (Flood, 1999) both indigenous to their own regions and potentially from introductions from other producing regions. Current pest and disease management relies largely on cultural and chemical methods plus inputs from breeding and use of host resistance. Specific cultural controls for specific problems remain the foundation of sustainable pest and disease management. At the same time, effective chemical control methods have been developed for many pest and disease problems, and they are presently our best approach for some. However, in some instances, the use of cultural and chemical control has proven woefully inadequate. For example, in Latin America, these methods have been incapable of even halting the progress of the two major fungal diseases, Frosty pod rot and Witches' broom, which are still in an invasive phase. Until relatively recently, the only restriction on the progress of Frosty pod rot into Brazil has been the physical barrier of the Andes (Evans, 1999). However, with its introduction into Eastern Ecuador via a cryptically infected pod (Evans, 1986), there are now no obstacles to its progress down the Amazon into Brazil.

In Ghana, control of Black pod by the use of regular phytosanitary procedures is only successful in areas where cocoa is affected by *P. palmivora.* In areas affected by *P. megakarya*, yields continued to decline despite the best effort of the farmers (Opoku *et al*., 2000). *P. megakarya* is a more aggressive pathogen, producing more spores and with a reservoir of inoculum in the soil, and large production losses can occur despite use of chemical sprays. Also of concern at present, is the fact that *P. megakarya* is still in an invasive phase and has been reported to be very close to the Ghanaian / Côte d'Ivoire border (Opoku *et al.*, 1997) and thus, threatens the largest cocoa producer (Côte d'Ivoire).

Effective Mirid control has been demonstrated through the use of four insecticide sprays during the main Mirid season. However, the indiscriminate nature of insecticides can result in the loss of natural enemies of Mirids and other pests, and hence lead to induction of secondary pest outbreaks. Similarly, the use of fungicides against CBD in Kenya has been shown to induce greater levels of disease under some circumstances. In fact, some estates where fungicides had never been used and where CBD was not serious, intermittent fungicide applications aggravated the disease. The apparent negative effects of fungicides were attributed to the removal of micro-organisms antagonistic to the pathogen. This effect was studied in more detail and elements of the micro-biota were shown to have a natural biocontrol effect on the disease. This effect is still to be developed and exploited commercially, perhaps in an integrated approach to CBD control in East Africa.

Further limitations to using pesticides include repeated applications, which are required in a season to allow for degradation by rain and sun and as the plant grows. The farmers often cannot afford repeated applications and apply them sparingly (and often ineffectively) to save money. Another major disadvantage to the use of pesticides is that in the long term, their use is not desirable or sustainable due to the impact on the environment and human health. Better application and targeting can reduce problems of cost, environmental effects and pesticide residues in the crop, but these problems will continue to discourage pesticide use.

Therefore, considering many of the problems of cultural and chemical control practices, the utilisation of alternative strategies is required for the control of pests and diseases in cocoa and coffee in the future and one of these strategies is the improvement in cocoa germplasm. Many extensive breeding programmes are under development. Strategies for cocoa improvement have been reviewed by Van der Vossen (1999). There have been some successes in coffee breeding programmes too, notably a new cultivar, Ruiru 11, resistant to both Coffee Berry Disease and Coffee Leaf Rust has been developed (Flood *et al,* 2001). There have however, also been problems. Whilst much of the resistance to Witches' broom has been attributed to the Scavina family (Bartley, 1981) when Scavina genotypes were introduced into Ecuador, they rapidly succumbed, probably due to pathogen variation (Wheeler & Mepsted, 1988). The adoption and development of new molecular methods may advance our understanding of the inheritance of resistance which should lead to more logical breeding programmes in the future as well as helping with problems of mis-labelling that has beset the industry for many years and which have hampered breeding programmes throughout the world (Wilkinson, 2001). In addition to these new technologies, classical breeding has identified local selections with some tolerance to the major cocoa diseases. Large international breeding projects such as the CFC/ICCO/IPGRI Project are helping build capacity in breeding expertise as well as allowing the exchange of resistant germplasm to take place.

Thus, breeding for resistance to pests and diseases does offer one pathway to sustainable production in the future. Biological control, in its various guises, is potentially another strategy.

Developing and future approaches to biocontrol of pests and diseases

Currently, the key challenges to West African cocoa at present are Mirids and Black pod. Both have the potential for control through the utilisation of biocontrol strategies. Future challenges to West Africa can be expected to come through the introduction of potentially devastating "aliens" from other cocoa growing regions. A number of strategies, which can be considered to come under the auspices of biological control, are presently under investigation throughout the world.

In Brazil, at Almirante Cacau in Bahia, the use of chemical elicitors of induced resistance, such as Bion (an analogue of salicylic acid), are being investigated for the control of Witches' broom. To date, results of field trials have shown that Bion does have the potential to reduce Witches' broom, although timing of application appears to be important. Similarly in Ghana, Dr Opoku's group at CRIG working in collaboration with CABI and NRI, is investigating the use of phosphonic acid and other chemical elicitors to control Black pod disease (*P. palmivora* and *P. megakarya*). In field trials, phosphonic acid has been demonstrated to reduce losses from black pod when applied as a stem injection (Opoku *et al*., 1998). Previous studies undertaken in Papua New Guinea have shown that *P. palmivora* can be controlled effectively through one application of phosphonic acid per year (Guest *et al*., 1994). These methods rely on the manipulation of the host plant's defence mechanisms. Induced resistance involves the activation of the host plant's own physical and chemical defences by a biotic or abiotic agent, such that a subsequent challenge from a pathogen results in a strong rapid response (Van Loon, 1997). A cascade of induced responses can be activated throughout the plant providing an induced systemic resistance.

Another strategy, and one, which is often given primary consideration when considering biocontrol, is the use of microbial agents. The development of biopesticides to control mirids is an obvious candidate to replace dangerous insecticides (Padi, 1997) and is currently being pursued by Dr Padi's group at CRIG in collaboration with CABI. Here, the control of mirids is being attempted through the use of locally isolated *Beauveria bassiana*. Surveys were conducted throughout Ghana. Isolates of the fungus were collected and tested against mirids using bioassay techniques developed at CRIG. Isolates abilities to sporulate profusely, growth and viability were tested as well as preliminary analysis of formulation for application in the field and mass production methods. Field testing should begin shortly.

In addition to insects, the use of natural, locally isolated, fungal biological control agents are also being investigated for the control of diseases of cocoa. These are primarily fungal mycoparasites or antagonists (fungi which directly parasitise or inhibit the target pathogen through chemical means) and endophytes (organisms with all or part of their life-cycle inside the host plant's tissues). Endophytes can potentially utilise a range of mechanisms to control or reduce disease. These include competitive exclusion, direct antagonism (mycoparasitism / antagonism) and induced resistance.

In Costa Rica, a current CABI/USDA study is investigating the use of locally isolated fungal antagonists, primarily *Clonostachys* and *Trichoderma* spp., to control Frosty pod rot. These studies have demonstrated the ability of this augmentative biocontrol to reduce the incidence of disease. In Peru however, previous CABI studies (Krauss and Soberanis, 1998) have shown a higher degree of disease control for Frosty pod rot as well as Witches' broom and Black pod. Therefore, isolates from some areas may be more effective than others. In Brazil, a similar approach is being taken for the control of Witches broom in a USDA/CABI/Mars collaborative project utilising *Trichoderma stromaticum* for inoculum reduction through colonisation of dry brooms: Basidiocarps of *C. perniciosa* are formed on dry brooms, which provide sources of inoculum. From these experiences, it is being recognised that it is not just sufficient to have an effective biocontrol agent but that the formulation and application are also critical factors as has been demonstrated with biocontrol of insects.

For example, the inappropriate use of a knapsack sprayer setting can result in a too large a droplet size (Bateman, 2000) with the result that most of the agent ends upon the ground instead of in the canopy or on the pods. Where available, optimisation of application is achieved through the use of motorised mist blowers. This aspect of the work is often overlooked by researchers and can lead to the discredit of the methodology of augmentative biocontrol when it enters the field stage. It must also be noted that though these agents may be considered more environmentally friendly than chemical applications, they suffer from a similar limitation in that they require multiple applications throughout the growing season.

It is expected that the approach using local isolates of biocontrol agents may be beneficial for the control of Black pod disease in West Africa and is an approach that needs developing in the region. A recent workshop held in Cameroon highlighted the fact that studies have been initiated in West Africa for biocontrol of *P. megakarya* and *P. palmivora.* Pierre Tondje's group at IRAD in Cameroon have been collecting and screening a wide range of micro-organisms against *P. megakarya* and Dr. Kebe of CNRA in Ivory Coast has been investigating the use of *Trichoderma.*

An alternative approach for utilising microbial biocontrol agents is the use of classical biocontrol. At present, CABI and our collaborators are investigating the use of biological control agents (primarily against *M. roreri* and to a lesser extent the control of *C. perniciosa*) using this classical biocontrol approach. These studies represent the first time that this approach has been attempted to deliberately control a plant disease although it has been successfully employed in the past to control invasive weeds and insect pests. Classical biological control within this context can be defined as the introduction of co-evolved natural enemies of the pathogen which have originated with and adapted to them over a long period of association. The approach involves returning to the centre of origin of the target pest organism to find natural enemies, in this case mycoparasites or endophytes, which have co-evolved with it.

Collections of mycoparasites have been made in the purported centre of origin of *M. roreri* in Western Ecuador (Evans, 1981) from *M. roreri* infected *Theobroma gileri,* the wild host of Frosty pod rot. (Evans, 1999). Isolates include species of *Nectria* and *Hansfordia*. Collections of mycoparasites against *C. perniciosa* were made from Amazonas, the centre of origin of Witches' broom. For endophytes, collections were also made in the centre of origin of cocoa (the Amazon basin) (Cuatrecasas, 1964; Thorold, 1975) and the strategy is based on the premise that, in natural forest ecosystems, specific endophytes have co-evolved with cocoa and its *Theobroma* and *Herrania* relatives but that these are absent or have been filtered out in exotic agro-ecosystems.

Initial results from *in-vitro* screening of the co-evolved mycoparasites of *M. roreri* suggest that these isolates are more aggressive than those isolated from cocoa plantations which have been used with some success (previously mentioned Peruvian biocontrol trials). This methodology will be further tested in forthcoming field trials in Ecuador and Costa Rica. The use of endophytes is particularly interesting and innovative as they have the potential to provide season or life-long protection against a pathogen due to the ability to persist within the host plants tissues and thus repeated applications are not required.

In preliminary assessments in Brazil, these co-evolved endophytes were shown to colonise green and dry brooms whilst the current commercially used agent (*T. stromaticum*) was only able to colonise dry brooms. This offers the potential to dramatically reduce inoculum pressure of Witches' broom. Further trials by CABI are under development. Apart from the expected increased efficacy of the co-evolved isolates, we would also expect them to be better able to persist in the cocoa environment.

This classical approach may also be applicable to the control of *P. megakarya* in West Africa. Since *P. megakarya* is restricted to West Africa (Ortiz-Garcia *et al.*, 1994) and its centre of diversity appears to be in the Nigeria/Cameroon region (Nyasse *et al.*, 1999), it was proposed that its original forest host (or hosts) will be found here. As the purported centre of origin of the disease, it would be expected that co-evolved natural enemies of *P. megakarya* would be present, offering the possibility for the use of classical biological control as a means to halt the advance of *P. megakarya.* Consequently, an initial exploratory survey was recently made in the forest of Korup National Park in Cameroon. An isolation was made from the fruit of *Irvingia* sp. (probably *I. gabonensis*) which was subsequently found to be *P. megakarya* by molecular analysis. Further studies are underway using molecular methodologies to assess the novelty of this isolate. Interestingly, the recovery of the *P. megakarya* proved difficult due to the presence of a number of aggressive antagonists. This may be the source of potential biocontrol agents for *P. megakarya* and this work is continuing.

Implementation of Biocontrol Technology

Thus, present and future research programmes developing the use of biocontrol methodologies in tropical crops especially of cocoa, appear to offer some hope of success. This is especially true when biocontrol is developed as part of a wider ICM Programme using complementary practices of cultural practices, rational pesticide use, induced host resistance and breeding. CABI scientists and their collaborators are working towards these goals through its Cocoa Programme. However, if these technologies are to be successful, then the transfer of the knowledge and best practices developed using these strategies will be the key to the final assessment of their success. This process of technology transfer is already established as part of CABIs current work in Latin America where the farmers are involved in the research process through farmer participatory trials and on-farm trials. The effectiveness of future ICM is dependent on farmers understanding more of the ecology of their crop, the pests and diseases of that crop as well as beneficial organisms that act against the pests and diseases. This is the most difficult challenge facing us today. It is far easier to tell a farmer to spray 4 times a season than to facilitate a process, which equips farmers with knowledge intensive ICM tools. However, if done properly this method can be very effective and has already been demonstrated in coffee. In Kenya, a pilot programme in coffee of season long training in ICM with hands-on experimentation, resulted in farmers having a reduction in input costs of 80%.

Conclusions

1. The major constraint to cocoa and coffee production are pests and diseases.
2. Current strategies can be effective under some circumstances but need to be improved.
3. Alternative strategies such as biocontrol have the potential to control pests and disease and should be used with a range of complementary technologies as part of an ICM approach.
4. An essential part of the development of these new strategies is to ensure farmers adopt them through an effective transfer of knowledge process that enables them to understand and adapt to these more ecological approaches.

References

Bartley, B.G. (1981). The status of Genetic Resistance in Cocoa to *Crinipellis perniciosa*. Proceedings of the Sixth International Cocoa Research Conference, 6-12th November 1977: 57-69.

Bateman, R. (2000). IPM Systems, Biocontrol News and Information, 21, 4: 96-100.

Cuatrecasas, J. (1964). Cocoa and its allies: A taxonomic revision of the genus *Theobroma*. Contributions for the United States National Herbarium 35: 379 – 614.

Evans, H.C. (1981). Pod rot of cocoa caused by *Moniliophthora (Monilia) roreri*. Phytopathological Paper 24: 1-44.

Evans, H.C. (1986). A reassessment of *Moniliophthora (Monilia) roreri*, Cocoa Growers Bulletin, 37: 34-43.

Evans, H.C. (1999). Exploration for potential biocontrol agents of cocoa diseases. *USDA-CABI-ACRI* Collaborative cocoa-coffee research meeting, ICCO, London, December 1999: 40-45.

Evans, H.C., Krauss, U., Rios, R., Zecevich, T. and Arevalo, E. (1998). Cocoa in Peru, Cocoa Growers Bulletin, 51: 7 – 22.

Flood, J. (1999). Status and Strategic Research Challenges in Cocoa and Coffee Pest Management. Proceedings of the Sustainable Tree Crop Development Forum: Strengthening Africa's Competitive Position in Global Markets, October 19-21 1999, Washington.

Flood, J., Gil, L.F. and Waller, J.M. (2001). Coffee Diseases: a Clear and Present Danger. In Coffee Futures: A Source book of some critical issues confronting the Coffee Industry (ed. P.S. Baker), CABI Commodities: 82-93.

Guest, D.I., Anderson, R.D., Foard, H.J., Phillips, D., Worboys, S. and Middleton, R.M. (1994). Long-term control of *Phytophthora* diseases of cocoa using trunk-injected phosphonate. Plant Pathology, 43: 479 – 492.

Keane, P.J. and Prior, C. (1991). Vascular Streak Die Back of cocoa. *Phytopathological Papers* 33: 39 pp.

Krauss, U. and Soberanis, W. (1998). A case study on the effect of biological disease control on the rehabilitation of abandoned cocoa farms under two shading regimes and two application times in Tingo Maria, Peru. In: Multi-Strata Agroforestry Systems with Perennial Crops (ed. F. Jimenez and J. Beer): 116-119.

Matlick, B.K. (1998). Machete Techniology: What small cocoa farmers need! Shade-grown Cacao Workshop, 30/3-2/4 1998, Smithsonian Migratory Bird Centre, Panama: http://natzoo.si.edu/smbc/Research/Cacao/cacao.htm

Nyasse, S., Grivet, L., Risterucci, A.M., Blaha, G., Berry, D., Lanaud, C. and Despreaux, D. (1999). Diversity of *Phytophthora megakarya* in Central and West Africa revealed by isozyme and RAPD markers. Mycological Research, 103 (10): 1225 – 1234.

Opoku, I.Y., Akrofi, A.Y. and Appiah, A.A. (1997). The spread of *Phytophthora megakarya* on cocoa in Ghana. Proceedings of the 1st International Cocoa Pests and Diseases Seminar, 6-10 November, Accra, Ghana: 98-107.

Opoku, I.Y., Akrofi, A.Y., Appiah, A.A. and Leuterbacher, M.C. (1998). Trunk injection of Potassium Phosphonate for the control of black pod disease of cocoa. Tropical Science 38, 3: 179 – 185.

Opoku, I.Y., Appiah, A.A. and Akrofi, A.Y. (2000). *Phytophthora megakarya*: a potential threat to the cocoa industry in Ghana. Ghana Journal of Agricultural Science 33: 135-142.

Ortiz-Garcia, C.F., Herail, C., and Blaha, G. (1994). *Utilisation des isozymes entant que marquers pour l'identification specifique des Phytophthora responsables de la pourriture brune des cabosses dans les pays producteurs de cocoa*. In: Proceedings of the XIth International Cocoa Research Conference, Yamoussoukro, Ivory Coast: 135 – 143.

Padi, B. (1997). Prospects for the control of cocoa capsids- alternative to chemical control. Proceedings of the 1st International Cocoa Pests and Diseases Seminar. 6-10 November, Accra, Ghana: 23-36.

Thorold, C.A. (1975). Diseases of Cocoa. Clarendon Press, Oxford, UK: 423 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 Disease Resistance to Cocoa Variety Improvement, 24th-26th November, 1996, Salvador, Bahia, INGENIC (International Group for Genetic Improvement of Cocoa): 23-31.

Van Loon, L.C. (1997). Induced resistance in plants and the role of pathogenesis-related proteins, European Journal of Plant Pathology, 103: 753-765.

Wilkinson, M.J. (2001). The Application and Constraints of New Technologies in Plant Breeding. Proceedings of the International Workshop on New Technologies and Cocoa Breeding 16-17th

October 2000, Kota Kinabalu, INGENIC (International Group for Genetic Improvement of Cocoa): 12-24.
Wheeler, B.E.J. and Mepsted, R.C. (1988). Pathogenic variability amongst isolates of *C. perniciosa* from cocoa. Plant Pathology, 37: 475-488.

Discussion

Q: What about risk analysis with regard to biological control work world-wide?

A: In cocoa there have not been any specific risk assessments yet. We know that Trichoderma *and* Chlomostachys *are environmentally safe based on toxicology tests. Introduction of bio-agents goes through national quarantine assessments. However, the chocolate industry manufacturers have advised that they would not accept biocontrol agents of certain genera that produce toxins, such as* Penicillium *and* Aspergillus.

Farmer participatory approaches towards cocoa IPM implementation

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Abstract

Since the transfer of technology model of technology dissemination was largely discarded as being top-down in the early 1970s, efforts have been made to develop models of technology development and dissemination that would involve the intended beneficiaries of these processes. The results have been many models or approaches with accompanying methods of information gathering and sharing with farmers. This paper briefly reviews three of the widely used approaches and discusses how they could be useful in the efforts to incorporate Integrated Pest Management/Farmer Field School strategy in cocoa production in Ghana.

Introduction

The concept of participation

Participation in the context of research and extension activities appears to have different meanings depending on the context in which it is used. There appear to be general agreement however that participation conveys the idea that the intended clients of agricultural research and extension (R & E) have some influence over decisions about the focus and content of R & E (Farrington, 1988). ILEIA (1989) described participation as a process of purposeful and creative interaction between local communities and outside facilitators, in order to understand the main characteristics and dynamics of the particular agro-ecological options. Oakley (1987) described participation as a process developed in relation to perceptions and ideological paradigms. The different conceptions of participation include:

- Collaboration, in which rural people take part in projects in which decisions have already been taken.
- Community development, in which rural communities play an active role in developing a specific goal-oriented project for which they have some responsibility for management.
- Organisation, in which people are encountered to develop local organisation to improve their involvement in decision-making.
- Empowerment, in which the aim is to develop rural people's ability to be self-reliant and independent.

Oakley's perceptions of participation are not radically different from the classification of modes of participation by Biggs (1989):

- Contract - scientists contract farmers to provide land and/or services;
- Consultative - scientists consult farmers about their problems and develop solutions;
- Collaborative - scientists and farmers collaborate as partners in the research process;
- Collegial - scientists strengthen the independent informal research and development systems in rural areas.

Different organisations or institutions often interpret and implement participatory approaches according to their underlying objectives. Whilst most public sector research and extension institutions have adopted participatory approaches to enhance efficiency in the development of adoptable and suitable technologies, for most NGOs, the underlying objective of participation is social, economic and political empowerment of the disadvantaged and marginalised.

A brief review of some participatory approaches

Farming Systems Research (FSR)

The shortcomings of the transfer of technology approach prompted economists at the International Agricultural Research Centres (especially CIMMYT and IRRI) to put forward proposals to make research more appropriate and problem-oriented. These became known as farming systems research (Wiggins, 1995).

As an approach, FSR had a strong philosophical basis: research conducted in close collaboration or partnership with the farmer can provide better understanding of the farmer's circumstances. This is to ensure that the new technology will be appropriate to farm conditions and farmer needs.

Some FSR 'trade marks' (Wiggins, 1995) include:

- Formation of multi-disciplinary teams incorporating natural and social scientists.
- Classification of farming systems and the establishment of recommendation domains.
- Diagnosis of the farming system. This involves the identification of critical bottlenecks and potential opportunities. Case studies, formal household surveys, RRAs are a regular feature.

Design, implementation and evaluation of research. Some basic and adaptive research may be done on-station, but testing and trials are done on-farm with farmers. Results of such trials are assessed using both scientific methods (agronomic and economic analysis) and consultation with farmers.

- Recommendations. These are passed on to the extension service.
- Evaluation of results with farmer.

FSR Evaluation

The FSR methodology has been criticised for being extractive, top-down with scientists in command in a softer guise (from the old 'transfer of technology model), and not cost-effective (Chambers 1980, 1986, 1989; Jiggins, 1981).

It is contended that on-farm trials, a major feature of FSR for instance tend to be highly structured and focus on the testing and validation of packaged technology. The farmers' involvement in these trials is often reduced to the provision of land or labour with researchers dominating the design, conduct and evaluation processes. Despite these criticisms, FSR has contributed immensely in the development and field testing of on-farm research methods and ideas (Okali *et al.*, 1994; Tripp, 1989).

Farmer participatory research (FPR)

At its simplest, FPR refers to the involvement of farmers in a process of agricultural research. Largely, practitioners themselves determine the nature or level of farmer involvement whether these practitioners are associated with development agencies or research institutions (Okali *et al.*, 1994). FPR developed around the idea that a greater degree of farmer involvement in agricultural research would make the research process more effective in the developing world.

In some cases, FSR describes projects designed simply to carry out research in close collaboration with farmers, or some activities including extension and institutions. Methods used in FPR are not radically different from those described under FSR: informal surveys (rural appraisals, diagnostic surveys or case studies) are regularly employed. Farmers and researchers may conduct joint trials (Sumberg and Okali, 1988) and there is often an adaptation of standard techniques for greater farmer participation. Farmers may even evaluate researcher-designed trials (Biggs, 1984).

FPR Evaluation

The literature provides clear evidence of extensive farmer involvement in activities to identify problems, opportunities and possible solutions (e.g. Biggs, 1984; Richards, 1986; Chaves, 1987; Ashby *et al*., 1987). The extent of farmer involvement in these activities depends on the institutional orientation. For instance, Ashby (1986) reports of the IFDC/CIAT project to investigate the agricultural potential of Colombian rock phosphate materials, which contained substantial farmer participation in decision-making. The account of Norman *et al*. (1988) of the Agricultural Technology Improvement Project (ATIP) in Botswana in which farmers played a strong role in establishing research priorities and in trying out and evaluating technologies is another example. Other successful farmer involvement in technology development include the diffused light technology for potato storage in Peru (Rhoades, 1989).

But does FPR constitute a new direction for agricultural research, or does it replace FSR? The consensus is that FPR does not constitute a new direction for agricultural research (Tripp, 1989), nor does it replace FSR (Farrington and Martin, 1988). FPR is to be seen as a complement to client-oriented ('problem-focused' research and development).

The Farmer First and Last (FFL) Model

This model is based on the philosophy that successful agricultural research and development must begin and end with the farmer (Rhoades and Booth, 1982). In practice, this means obtaining information about, and achieving an understanding of the farmer's perception of the problem and finally, to accept the farmer's evaluation of the solution. There should be a systematic process of scientists learning from, and understanding resource, poor families, their resources, needs and problems. Other key features of the model include (Chambers and Ghildyal, 1985):

- rapid and cost-effective appraisal
- Holistic farming systems analysis including the farm household and its needs.
- learning from farmers
- interdisciplinary with genuine dialogue
- a consultancy and referral role for scientists and experiments studies

These features are laudable, but as Garforth and Hayford (1995) asked, is it possible to develop and institutionalise within research (and extension) service methods, approaches that allow farmer-clients to dominate the research process? This question is valid given that the relationship between local people and 'outside' researchers and facilitators can be problematic.

FFL Evaluation

The model has been criticised for being too 'farmer-centric'. It is suggested that scientists and scientific methods do have a more important role to play than the model suggests (Farrington and Martin, 1988). Bentley (1990) is of the view that most FFL cases are "one-off" examples of farmer participation in research which fail to indicate how the process can be sustained and replicated for other groups of farmers and diverse farming systems, within existing research and extension constraints.

Research-Extension-Farmer Linkage

As the use of participatory approaches bring researchers and farmers closer, extension's traditional role of simply transferring technology to farmers has to change. Extension is expected to help farmers identify constraints and opportunities on their farms, and improve farmers' access to information and other support they need to solve problems and take advantage of opportunities. This necessitates changes in the training and attitudes of extension agents.

Participatory research requires researchers to obtain feed back from farmers in developed technologies (Biggs and Farmington, 1991). The evidence is that scientists rarely seek feedback.

Integrated Pest Management

Integrated Pest Management has been defined as a dynamic, integrated approach involving a number of control techniques to manage pest populations in an ecologically sound fashion (Urguhart, 1999). IPM requires constant and thorough monitoring of the population levels of relevant pests. The choice of the path of action is dependent on the information collected - in other words; a feed back loop is an essential part of the system.

IPM was a concept proposed to promote the use of biological control, good agronomic practices, and other means before investing in chemical practices to control pests.

IPM activities probably commenced in Ghana in the 1980s with the implementation of a biological control program with IITA for the control of cassava and mango mealybugs and green mites. In 1992, the Government of Ghana adopted IPM as a pest control strategy.

Farmer Field Schools (FFS)

The FFS training methodology is said to have originated from the FAO Intercountry Programme in Asia where it has been used to train over one million rice farmers (Afreh-Nuamah, 1999). Under a National Poverty Reduction Programme (NPRP) and with funding from UNDP and FAO, the IPM/FFS training programme took off in 1995 initially with Rice Farmers at Dawhenya Irrigation Project. The programme aims at training 1,700 rice farmers from five districts using the IPM/FFS strategy (Afreh-Nuamah, 1999). At a recent review workshop in Accra (1999), participants were satisfied with progress being made. A Deputy Minister of Agriculture announced that the Ministry of Food and Agriculture (MOFA) has decided to fully incorporate the FFS training methodology into its extension delivery system.

IPM in Ghanaian cocoa

The use of a multiplicity of approaches to tackle the main pests of cocoa and coffee in Ghana has a long history. Scientists at the Cocoa Research Institute of Ghana (CRIG) have been employing chemical, biological and cultural methods to control cocoa and coffee pests. Many of these studies involve farmers on their farms.

The successes achieved by the National IPM programme in rice, plantain and vegetables prompted CRIG, MOFA and a Non-Governmental Organisation (NGO), Conservation International, to commence incorporation of IPM/FFS strategies in cocoa production. A pilot programme began in the Kakum Forest reserve in the Central Region. Researchers from CRIG carried out a baseline survey in four communities surrounding the forest reserve. The results were discussed with all the stakeholders in a workshop at CRIG. Preliminary materials for a curriculum to train Trainers of Trainers was put together. Further discussions led to the identification of issues to be demonstrated or validated in trials in all the communities. Demonstration/Validation trials have now been set up in all the four communities.

Discussion: Participatory approaches and IPM implementation

How relevant are participatory approaches in the efforts to incorporate IPM/FFS strategy in Ghana's national crop production programmes? The underlying principle in all the participatory approaches is that research done in close partnership with farmers is likely to produce much more appropriate and better-adapted technology because it allows local knowledge and the normal experimental capacity of farmers to influence and guide the research process.

IPM implementation requires constant interaction between researchers and farmers to decide on paths of action for ecologically sound control strategies. The use of participatory methods by researchers and extensionists in their interaction with farmers would help strengthen the linkages between them and ensure the full involvement of farmers in all the phases of IPM implementation.

A working partnership between researchers and farmers is critical in the development of technologies, which will improve the lot of resource-poor farmers in developing countries. Work conducted by either (farmer or researcher) to the exclusion of the other will be less efficient in defining the options for research, conducting trials and evaluating results. Knowledge and skills in participatory methods can assist IPM practitioners in building the needed professional attitudes, behaviours and relationships with farmers to ensure that farmers are empowered not only to make their own crop management decisions but also to confidently evaluate the appropriateness of new technologies being introduced to their farming environment.

Conclusions

Participatory approaches are useful in our efforts to build new partnerships with our farmers. The adoption success or otherwise is influenced by the institutional setting or environment, and the orientation and attitudes of researchers. Many models or approaches have been developed, each trying to make the involvement of farmers in the research and development process more meaningful. The important issue is the extent to which the intended beneficiaries of research or development are involved in every phase of the process.

IPM / FFS has proved successful in Asia in rice fields. It is doing well in rice, plantain, vegetables and vegetable fields in Ghana. Its application to cocoa cultivation has started well and with support from all fronts, it should succeed.

Acknowledgement

I am grateful to the organisers of the workshop for the invitation to present this paper. I thank Mr. E.G. Asante (Acting Head, Social Science and Statistics Unit, CRIG) for reviewing the paper. This paper is published by the kind permission of the Agricultural Executive of Cocoa Research Institute of Ghana.

References

Afreh-Nuamah, K. (1999). Integrated crop and pest management activities in Ghana: Prospects and constraints. Paper presented at the National Review Workshop on IPM in Ghana, Accra, 16-17 December, 1999.

Ashby, J.A. (1986). Methodology for the participation of small farmers in the design of on-farm trials. Agricultural Administration 22: 1-19.

Ashby, J., Quinos, C.A. and Rivera, Y.M. (1987). Farmers participation in on-farm varietal trials. Workshop on "Farmers and Agricultural research: complimentary methods", IDS, University of Sussex, 26-31, July 1987.

Bentley, F. (1990). Facts, Fantasies and Failures of farmer participation. Ceiba 31, 2.

Biggs, S.D. (1984). Agricultural Research: A review of social science analysis. Discussion paper 115, School of Development Studies, University of East Anglia, Norwich.

Biggs, S.O. (1989). Resource-poor farmers in research: a synthesis of experiences from nine national agricultural research systems. OFCOR comparative study, Paper No. 3, ISNAR: The Hague.

Biggs, S.D. and Farrington, J. (1991). Agricultural Research and the Rural Poor A review of social science analysis. IDRC, Ottawa, Canada.

Chambers, R. (1980). The small farmer is professional. *Ceres* 13 (2): 20-23.

Chambers, R. (1986). Normal professionalism, new paradigms and development. IDS Discussion paper No. 227, IDS, University of Sussex, Brighton.

Chambers, R. (1989). Reversals, institutions and change. In: Chambers, R., Pacey, A. and Trupp, L. (eds) Farmer first: Farmer innovation and agricultural research. Intermediate Technology, London.

Chambers, R. and Ghildyal, B.P. (1985). Agricultural research for resource-poor farmers. The farmer first and last model, Agric. Admin, 20: 1-30.

Chaves, L.E.E. (1987). On-farm research: some experiences on farmers. Participation in Columbia, Workshop on farmers and agricultural research: complimentary methods, IDS, University of Sussex, 26-31.

Farrrington, J. (1988). Organisational roles in farmer participatory research and Extension: Lessons from the last decade. Natural Resource perspective, ODI, London, # 27.

Farrington, J and Martin, A. (1988). Farmer participation in agricultural research: a review of concepts and practices. ODI, Agricultural Administration Unit Occasional paper 9

Garforth, C. and Hayford, N. (1995). Issues in Agricultural Extension. Experiences of Agriculture and National Resource Management Programmes, through the 1980s and 1990s, AERDD, University of Reading.
ILEIA (1989). Operational approaches for participative technology development in sustainable agriculture. Proceedings of a workshop, ILEIA, Leusden.
Jiggins, J. (1981). Farming systems Research: New name for old habits or the key to increasing farm productivity? An exploration with reference to sub-Saharan Africa. Ford Foundation, Kenya: 16 pp.
Norman, D., Baker, D., Heinrich, G., Worman, F. (1988). Technology development and farmer groups: Experiences from Botswana. Experimental Agriculture 24(3): 321-331.
Oakley, P. (1987). State or process, means or end? The concept of participation in Rural development. Ideas, RRDC Bulletin March 1987: 3-9.
Okali, C., Sumberg, J. and Farrington, J. (1994). Farmer Participatory Research. Intermediate publications, London.
Rhoades, R.E. and Booth, R.H. (1982). Farmer-Back-To Farmer: A model for generating acceptable agricultural technology. Agric. Admin. 11: 127-137.
Rhoades, R. (1989). The role of farmers in the creation of agricultural technology. In: Chambers, R.; Pacey, A. and Tripp, L.A. (Eds). Farmer first, farmer innovation and agricultural research, Intermediate technology Publications.
Richards, P. (1986). What's wrong with Farming Systems Research? Paper for the conference of the development studies association, University of East Anglia, 15-16 September 1986.
Sumberg, J. and Okali, C. (1988). Farmers, on-farm research and the development of new technology. Experimental Agriculture 24(3): 333-342.
Tripp, R. (1989). Farmer participation in Agricultural research: new directions or old problem? Discussion paper 256, IDS, University of Sussex.
Urguhart, P. (1999). IPM and the citrus industry in South Africa' Gatekeeper Series No. 86. IIED, London.
Wiggins, S. (1995). Farming Systems Research and Farmer Participatory Research. A discussion paper presented to AERDD students, Reading University, October 1995.

Discussion

Q.: When using farmer participatory approaches, do we allow farmers to use their indigenous practices? When we want to do chemical efficacy testing, how do we work with farmers?

A.: Working with farmers is not easy. Sometimes there are institutional restrictions and insufficient funds. The FFS as we have it in Ghana is not meant to replace the existing extension structure. It's merely another strategy to complement existing extension approaches. With respect to the use of chemicals, IPM does not exclude the use of chemicals as long as it is used rationally.

Q.: The tendency is to present the FFS as an ideal approach. What are in fact the weak areas? In Ivory Coast, we have other models that are not as participatory but where farmers and researchers work well together.

A.: We see FFS as an evolving approach. FAO and UNDP fund vegetable, rice and plantain, while an NGO (Conservation International) fund cocoa IPM / FFS. There are cost implications to spreading the approach to all production areas, therefore it should not be seen as a replacement of existing extension.

Q.: I can't see the difference between conventional transfer of technology and FFS. Experience has proved that farmers have evolved methods of managing their own problems, which FFS is not taking into consideration.

A.: I think all countries have moved a long way from the classical TOT, which is a linear model of Research – Extension – Farmers. There is certainly the recognition that farmers have a lot of knowledge to offer. The essence is in the decision-making, farmers are involved at every stage – this is different from the traditional TOT.

Comment: There is a difference between farmer participatory training and farmer participatory research, although the two often go hand-in-hand.

Cocoa IPM research and implementation: country presentations

Benin

The state of cocoa cultivation in Benin

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Before 1960, cocoa cultivation in Dahomey (now Benin) was carried out by few farmers who had previously been employed in cocoa plantations of Nigeria, Ghana and Côte d'Ivoire. The plant material was introduced without scientific support and the 48 ha of cocoa crops planted annually produced about 10 tonnes average for exportation.

After 1960, and subsequent to global improvements in cocoa prices, the 70's and 80's saw the cocoa market flourish. The Republic of Benin was exporting more cocoa than it could produce, deriving contraband from neighbouring countries to cover its shortfalls. Cocoa became the second export product after cotton :

1969	5.577,39 T	1973	19.107,24 T	1977	1.326,295 T	1981	
1970	9.012,445 T	1974	3.248,835 T	1978	1.407,765 T	1982	404,4 T
1971	19.163,04 T	1975	1.559,87 T	1979	4.188,519 T	1983	3.151,135 T
1972	8.274,465 T	1976	908,44 T	1980	6.039,605 T	1984	4.400 T

These statistical data clearly show the important role played by cocoa in the establishment of the Gross Domestic Product and in the significant improvement of the producers standards of living. Certainly, Benin is not a major producer of cocoa but nonetheless is capable of rational exploitation of its natural potential.

Ecological Aspects

Temperature ranges of 28-31°C, humidity spectrums of 80-85% and ground forests can be found. A cocoa tree requires 1500 to 2500 mm of water per year, with a dry season lasting no longer than 3 months. However, the wettest region of the Southeast rarely receives more than 1200mm of rain per year, with a dry period extending beyond 3 months. This demonstrates that cocoa culture is not possible over the whole of Benin, but rather restricted to those zones possessing a particularly humid microclimate, for instance forest galleries, wooded lowlands and lake edges. The industrial cultivation of cocoa will only be commercially viable once research initiatives identify hybrid varieties tolerant to drought, insect pests (e.g. mirids) and diseases such as black pod.

Research Assets

The higher structure of the cocoa development organisation is the cocoa-coffee research unit created in 1977 within the National Institute of Agricultural Research in Benin (INRAB). Its mission is to promote the rational establishment of new plantations based on results in agronomic research. Its key assets are outlined below:

- 10 Beninese managers have received training in Côte d'Ivoire (1980) and Ghana (1985-1986).

- Soil surveys were carried out, covering more than 900 ha of cocoa soils in south Benin in the equatorial zone and nearly 5000 ha of coffee/cocoa soils in Northwest Benin in the gallery forests of the tropical zone (Bassila).
- Select varieties were introduced from Côte d'Ivoire and Ghana, leading to the establishment of good hybrid Upper Amazonian, Criollo, Trinitario cocoa collections which have performed very well and have provided good yields in stations (1500 to 2000) kg/ha.
- 7,5 ha of biclonal nursery fields and composite varieties have been established.
- With the help of extension services, 386 ha of cocoa plantations were established between 1986 and 1989 at the village scale. These plantations became commercial in 1989. However, the disorganisation of marketing channels, the lack of financial support for cocoa research and the drop in world prices have discouraged producers from establishing new plantations. As for the research element, it maintains its assets in anticipation of an eventual relaunch of cocoa cultivation.

In conclusion, we consider Benin to be of marginal importance to the cocoa industry. The few, rare soils capable of sustaining production are exploited in parallel with the fluctuations in world prices. With regards to research, funding is being sought to acquire the technological capabilities for an eventual restart. To overcome problems of global market fluctuations, we suggest local processing of cocoa products and promotion of domestic consumption. Imported cocoa end-products such as chocolate, chocolate powders (Nescao, Milo, Buenvita) and spreads are sold in all the Beninese markets. If we look at Ethiopia, half of its total coffee output is consumed locally so that Ethiopia does not suffer adverse effects from world price fluctuations. Cocoa in Benin does hold a great deal of hope for future generations.

Discussion

Q: Are there any IPM activities on-going on cocoa in Benin?
A: Not yet.

Q: What are the specific problems on cocoa in Benin?
A: In the South, the problem is the density of the population and the lack of land for cocoa production. In the North there are no such problems. Over there the major problems are (1) Mirids, and (2) Black pod. The farmers do not have the means to use recommended pesticides, such as Endosulfan, Undene or Sumithion.

Cameroon

Integrated management of cocoa mirids in Cameroon

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Cultivation Zones

Cocoa trees are cultivated in the forested zones of Central, South, South-west, Coastal and in part of the Southeast province of Cameroon.

Major Pests

Two species of mirids (Heteroptera: Miridae), *Sahlbergella singularis* Haglund and *Distantiella theobroma* Distant, are by far the most damaging pests of cocoa. Occasional damage accounts for 30-40% of pod losses. However, when mirids affect the foliage, gradual wilting occurs and eventually, tree death.

Control means and methods

Up until now, control has essentially been chemical. A range of chemical products based on e.g. Endosulfan and Diazinon allows the population to be maintained at an acceptable level. Cultural methods such as chupon removal, shade management, and elimination of alternative host-plants (*Sterculiaceae* and *Bombacacea*) allows the incidence of attacks to be reduced. In the case of biological control, a number of predators such as *Oecophylla* sp., *Tetramorium* sp. and *Wasmania* sp. play a biocontrol role in reducing large populations. Genetic control through breeding of resistant varieties is being implemented. The variety SNK413 proved unattractive, whereas the Catongo varieties were much more vulnerable to mirids attack.

Integrated control of cocoa mirids

Pests	Range	Chemical control	Cultural control	Genetic control	Biological control
MIRIDS: *Sahlbergella singularis* *Distantiella theobroma*	Whole cultivation zone. Severe attacks in the Central, South, savanna and degraded forest zones	Endosulfan Diazinon Thiamethorxam	Chupon removal Canopy maintenance Shade management Elimination of alternative hosts	Selection of cultivars Ex. SNK413 Catongo very sensitive	*Oecophylla* sp. *Tetramorium* sp. *Wasmania* sp.

Integrated management of cocoa *Phytophthora* pod rot disease in Cameroon

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Introduction

Cocoa is one of the most important cash crops grown by farmers in Central and West Africa. In Cameroon, 400,000 households produce cocoa in smallholdings, while in Ghana, between 500,000 to 600,000 farmers are employed in the cocoa sector. In Côte d'Ivoire, the world largest producing country, the numbers employed are even larger (Losch *et al*., 1990; Duguma *et al*., 1998; Gockowski *et al*., 1998). The production of Central and West Africa represent more than 59.9% of the world production (Padi and Owusu, 1998). In all these countries, controlling the spread of *Phytophthora megakarya* is among the most important agronomic and economic priorities, because average losses are estimated at over 50% of potential production when left untreated (Lass, 1997). This particular species is responsible for heavy yield losses and can cause the deterioration of cocoa quality. The origin of *P. megakarya* seems to be Central Africa (Congo Basin) where cocoa has only been introduced in 19th Century from the Americas (Assoumou, 1977). *P. megakarya* is not yet present in South American cocoa producing countries, but is present in Cameroon (Nyasse, 1992), Ghana (Opoku, 1997), Nigeria (Brasier and Griffin, 1979), Togo, Sao Tome and Gabon (Zentmeyer, 1988). According to Opoku (1997), this species is slowly spreading towards Côte d'Ivoire, the world's largest cocoa producer.

The climate in the cocoa growing zone of Cameroon is characterised by high relative humidity. The first typical site is Yaounde (3^0 50'N 11^0 50'E) within the Central province. Total average rainfall per year is more than 1600 mm, with 3 dry months (rainfall < 100mm) per year. The second typical site is Kumba in South West Cameroon where total annual rainfall per year is commonly above 2300 mm with no break in the wet season.

In this paper, some control measures for cocoa *Phytophthora* pod rot in Cameroon will be reviewed. The accumulated knowledge base of their use by farmers will be considered. The necessity of their use in an Integrated Approach for the control of *Phytophthora* pod rot of cocoa will be highlighted.

I - Cultural practices

Cultural control forms an important part for *Phytophthora* pod rot management in Cameroon. This method is based on the reduction of relative humidity and the quantity of primary inoculum in cocoa farms. The attempt for achieving this objective in Cameroon cocoa farming is pursued by regular weeding, cocoa pruning, sanitation, and shade management.

Regular weeding
This cultural method is practiced by cocoa farmers at the beginning and during the wet season and is essential for facilitating air circulation within the cocoa farm (air circulation reduces cocoa pods' wetness), and reducing the air humidity. The situation of high humidity and pod wetness are key elements for rapid *Phytophthora* pod rot spread.

Pruning of cocoa trees
In the Central Province of Cameroon, pruning is practiced during the dry season (January – February). This cultural practice is useful for facilitating air circulation in the cocoa farm, reducing relative humidity, enhancing flowering and fruit setting and thus increasing potential production of cocoa trees (Tondje *et al*., 1993). In Cameroon, 20% reduction in disease incidence was observed when pruning was practiced (Bidzanga, pers. comm)

Shade management in cocoa farms
Cocoa farms are established under shade in land occupied by forest, in the Central and Southern provinces of Cameroon. Shade management is critical for sustainable cocoa farming in this cocoa-growing zone of Cameroon characterized by acid soils with low fertility. The aim of shade management in cocoa farms is to reduce the relative humidity and contribute to reduction of the spread of *Phytophthora* pod rot.

Sanitation

Sanitation, the removal of infected cocoa pods, has been recommended (Asare-Nyako, 1969; Muller, 1974; Djiekpor *et al*., 1981). The following conditions can hamper effective sanitation of *Phytophthora* pod rot (Gregory and Maddison, 1981; Wood and Lass, 1989):

- The presence of several and not fully known primary infection sources.
- Difficulty to remove diseased pods on too tall cocoa trees within cocoa farms: Diseased pods from higher parts of cocoa trees can contribute to continuous dispersal of inoculum.

In Cameroon, only 25% reduction of disease incidence was observed when this cultural control method was regularly and exclusively practiced in the whole cocoa campaign (Tondje *et al*., 1993).

Cultural practices are environmentally friendly but time consuming. Many farmers can just make a partial application of this control method in Cameroon. In addition, the contribution of cultural practices for an economical reduction of black pod disease in cocoa farms can only be positive if combined with other control methods.

II - Breeding for resistant varieties

Breeding for resistant varieties is a valuable tool for an effective implementation of the IPDM strategy. A first evaluation of Cameroon cocoa cultivars for resistance to *Phytophthora* pod rot was made by Blaha and Lotode (1976). Different levels of tolerance to this disease were observed within the Cameroon collection of cultivars. Now, IRAD is involved with the CFC/ICCO/IPGRI project (Eskes, 1999) to screen cocoa germplasm for resistance to *P. megakarya* pod rot. Promising hybrids with good resistance potentials are being found, but are yet to become available to cocoa farmers.

III - Botanical control

The cost of black pod disease control was entirely sponsored by the Cameroon government until 1993. The devaluation of the CFA Franc during the same period increased the absolute prices of cocoa but doubled the cost of imported chemical fungicides. From 1993 many cocoa farmers developed techniques based on indigenous knowledge and practices involving the use of natural plants with the aim of reducing the cost of disease control. Farmers mix this botanical with potential fungicidal effects with very low quantities of chemical fungicides. Some of these are: “Banga” (*Canabis sativa*), “Essingan” (*Guirbourtia tesmanii*), “Elon” (*Erythrophleum ivorense*) etc. IRAD has started a research program with farmers to scientifically evaluate the fungicidal effect of these products for improving their efficacy.

IV - Chemical control

Copper- based fungicides with and without metalaxil are used. Research is being conducted at IRAD for the reduction of the frequency of application of fungicides. The frequency of fungicide application has now dropped from 12 to 4 and research efforts are still on the way. Collaboration with CABI Bioscience is expected for an optimization of fungicide use through an improvement of spraying methods.

V - Microbial biological control

In the context of a holistic approach to black pod disease in cocoa ecosystems, the use of beneficial microorganisms with good potential to suppress or minimise the incidence of *Phytophthora megakarya* is being investigated in Cameroon by IRAD. Very promising results are observed. However, the implementation of this control strategy can only be effective in an integrated disease management strategy including minimal use of fungicides and choice of fungicides with low effects on the environment in general and beneficial microorganisms specifically.

Conclusion

The sustainable management of cocoa black pod disease can only be achieved by an integration of all the components in the basket of technologies to achieve control of the disease with low environmental effects.

Farmer training on sustainable management of natural resources needs to be done for a better implementation of integrated management of cocoa black pod disease in Cameroon.

References

Assare Nyako, A. (1969). The black pod disease of cocoa, a review of the situation in Ghana. Proc. 3rd int. Cocoa research Conf., Accra, Ghana: 370-374.

Assoumou, J. (1977). *L'économie du cocoa Paris*. J.P. Delarge: 351 pp.

Blaha, G. and Lotode, R. (1976). A selection criterion of main importance for the cocoa tree in Cameroon: The resistance to black pod disease (*Phytophthora palmivora*) *café-cacao-thé* (Paris) vol. 20(2): 97-116.

Brasier, C.M. and Griffin, M.J. (1979). Taxonomy of *Phytophthora palmivora* on cocoa. Transactions of the British Mycological Society 72(1): 111-143.

Djiekpor, E.K, Goka, K., Lucas, P., and Partiot, M. (1981). *La pourriture brune des cabosses du cocoayer due a Phytophthora au Togo evaluation et strategies de lutte Café- Cocoa- The* 25, 4: 263-268.

Duguma B, Gockowski, J. and Bakala, J. (1998). Small holder cocoa (*Theobroma cocoa* L) cultivation in agroforestry systems of West and Central Africa: Challenges and opportunities. Proceedings of the 1st sustainable cocoa workshop 1998, Panama.

Eskes, B. (1999). International cocoa breeding and selection initiatives. Proceeding of USDA-CABI-ACRI Collaborative cocoa – coffee Research Meeting, London: 81 – 89.

Gockowski, J., Nkamleu, G.B. and Wendt, J. (1998). Implications of resource use intensification for the environment and sustainable technology systems in the central African rainforest. Invited paper at the American Agricultural Economics Association International Development - Conference on Agricultural Intensification, Economic Growth and the Environment. Salt Lake City Utah, July 30-31, 1998.

Gregory, P.H. and Maddison, A.C. (eds.) (1981). Epidemiology of *Phytophthora* on cocoa in Nigeria. Commonwealth Agric. Bureaux Surrey, England: 177-178.

Lass, R.A. (1997). Disease. In: Cocoa (eds. Wood, G.A.R. and Lass, R.A.), Tropical agricultural series, 4th edition. Longman scientific and Techn. and John Wiley and Sons Inc London, England: 265-365.

Losch, B., Fusillier, J.L. and Dupraz, P. (1990). *Strategies des productions en zone cafeiers et cocoayere du Cameroun: Quelle adaptation a la crise?* CIRAD- DSA Montpellier.

Muller, R. A. (1974). Effect of prophylactic measures on the dissemination of *Phytophthora* palmivora of cocoa. In P.H. Gregory (ed.): *Phytophthora* disease of cocoa Longman: London: 169-178.

Nyasse, S. (1992). *Structure d'une population de Phytophthora sp. des cacoyères Camerounaises atteintes de pourriture brune.* Memoire (DRU), ENSAT, INPT: 48 pp.

Opoku, I. Y. (1997). *Phytophthora megakarya* in Ghana. Incoped newsletter n0 1: 4-5.

Padi, B. and Owusu, G.K. (1998). Towards an integrated pest management for sustainable cocoa production in Ghana. Proceedings of the 1st sustainable cocoa workshop March, 29 to April, 3rd, 1998, Panama.

Tondje P. R., Berry D., Bakala, J., Ebandan, S. (1993). *Intérêt de diverses pratiques culturales dans la lutte contre la pourriture brune des cabosses due à Phytophthora sp. au Cameroun*. 11e Confer. Intern. sur la Recherche Cocoayère. Yamoussoukro - Côte-d'Ivoire, 18 - 24 Juillet 1993: 175 - 183.

Wood, G.A.R., and Lass, R.A. (1989). Cocoa. Tropical agricultural series, 4th edition, Longman scientific and Techn. and John Wiley and Sons Inc London, England: 265-365.

Zentmeyer (1988). Taxonomic relation ships and distribution of species of *Phytophthora* causing black pod of cocoa. X intern, cocoa research conf. Santo Domingo, Dominican Republic: 391-395.

Côte d'Ivoire

Cocoa IPM research and implementation in Côte d'Ivoire

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Abstract

Cocoa mirids and black pod rot due to *Phytophthora* spp. are among the most important pests of cocoa in Côte d'Ivoire. Cocoa mirids alone can cause an average of 20-50% crop loss. Black pod disease contributes to about 10-25% crop loss. The main control method for cocoa mirids has been the use of insecticides, applied four times in the year according to an established spray calendar. This method faces many problems including high cost of chemicals and application equipment, environmental concerns and residues problems. Thus, the adoption rate by farmers has been low.

Black pod rot is primarily controlled with cultural practices; however, this method has some limited efficacy, especially with the recent introduction in the country of *P. megakarya*, which is a most aggressive pathogen.

All these problems have made it necessary to look for new cost-effective and environmentally friendly methods, which can be combined in an integrated pest management approach. This paper gives an overview of the conventional control methods for cocoa mirids and black pod disease and describes some non-chemical alternative methods under investigation in Côte d'Ivoire.

Introduction

In Côte d'Ivoire, cocoa represents one of the most important cash crops. Every year, Côte d'Ivoire provides about 43% of the world cocoa and is currently the leading producing country in the world (Anon, 1999). Cocoa is mainly produced by smallholder farmers having between 0.5 to 4 hectares. In Côte d'Ivoire, cocoa cultivation is affected by many constraints, but the two major ones seem to be the cocoa mirids and the cocoa black pod rot due to *Phytophthora* spp.. Other important pests include Thrips, psyllids, borers, pentatomids, chrysomilids, curculionids and many foliage feeders (Braudeau, 1969; Lavabre, 1961, 1970; Entwistle, 1972; Hill and Waller, 1988).

Four species of cocoa mirids (*Sahlbergella singularis* Haglund, *Distantiella theobromae* Distant, *Bryocoropsis laticollis* Schum. and *Helopeltis bergrothi* Reut.) are represented in Côte d'Ivoire. The biology and ecology of these insects have been extensively studied (Taylor, 1954; Williams, 1953; Kay, 1961; Gibbs and Pickett, 1966; Braudeau, 1969; Kumar and Ansari, 1974; Lavabre, 1977). Mirids may feed on every part of the plant (shoots, branches, cherelles, pods etc.). Both adult and immature stages cause damage. Damage is caused by the punctures made on vegetative parts or fruiting structures during feeding. Continuous severe mirid attacks to a cocoa farm may lead to dieback of fan and twigs giving a burning appearance to the area attacked (blast), dieback of cherelles, destruction of flower cushions, partial or total degradation of the farm and important yield loss (20 to 50 %).

With regard to cocoa black pod, three species cause damage in Côte d'Ivoire. *Phytophthora palmivora* represents 94% of the pathogen population, *P. affine citrophthora 5%*, and *P. megakarya* 1%. *P. palmivora* is the predominant species, however, *P. megakarya* seems to be spreading very fast in the western region of the country. *Phytophthora* spp. cause damage to the fruits, the leaves, the trunk and branches. Yield losses are estimated to be 10 to 15 % in the Northern production area and 25 to 30% in the Southern production area. The effect of *Phytophthora* spp. on the trunk and branches results in the destruction of flower cushion and weakening of the trees.

This paper gives an overview of the conventional methods for the control of cocoa mirids and black pod disease, as well as an indication of the IPM research programs on mirids and *Phytophthora*, and proposes some research activities within the framework of the STCP.

Conventional methods for the control cocoa mirids

Two methods are used to control cocoa mirids in Côte d'Ivoire. The main method is chemical control (Marchart, 1971; Nguyen-Ban, 1971; Decazy, 1979a; Coulibaly *et al.* 1996). The application of the insecticides is based on the population dynamic of the mirids (Lavabre *et al*. 1962, 1963; N'Guessan and Coulibaly 2000). A calendar spray schedule recommends 4 applications in the year in relation with two swarming periods of the insects. The other method is cultural control based on the frequent removal of chupons and regular weeding of the field to eliminate reservoirs for many insects, including mirids.

There are major constraints to the use of chemical control. The high cost of the chemicals and application equipment make it difficult for the farmer to adopt the method. In addition there are some problems related to quality and safety. The concerns related to residues and contamination of the environment with some of the insecticides used constitute a major obstacle to the continued use of the method. As a result, research has been oriented towards the search for new methods of control.

Conventional methods for the control of black pod disease

In Côte d'Ivoire, cocoa has been widely cultivated without overhead shade. In addition the more aggressive species of *Phytophthora*, the causal agent of black pod disease, is of recent introduction. The prevalent Phytophthora species together, combined with the harvesting period coinciding with the dry season, contribute to yield losses between 15 and 25%. Fungicide application, although effective, is not profitable for the farmers. Consequently the main control method has been cultural practices based on elimination of harvest residues and weekly harvesting as well as the elimination of infected pods.

Towards an IPM approach to mirid control

The objective is to combine the available control methods with other potential methods in an integrated management approach. The potential control methods under investigation are:

Development and use of resistant/tolerant cocoa varieties
This work is being partly carried out within the framework of the CFC/ICCO/IPGRI project. The CFC/ICCO/IPGRI project is an international project executed in many producing countries including Cameroon, Côte d'Ivoire, Ghana and Nigeria in Africa and other countries in South America and Asia. The current work is based on the screening of cocoa genotypes to identify sources of resistance/tolerance to the cocoa mirids. Preliminary results indicated that some genotypes have potential for antixenosis and/or antibiosis to *Sahlbergella singularis* (Kouassi, 2001).

Development of improved cultural methods
The purpose is to develop a cultural method based on the management of overhead shade. In previous studies (Williams, 1953; Decazy, 1979b; Smith, 1979; Campbell, 1984), it has been stated that overhead shade may affect the level of mirid attack on the cocoa plant. Our work started within the framework of the ACRI project (a project financed by the American Cocoa Research Institute) and has been assessing the impact of the overhead shade on the seasonal variations of mirids populations. The ultimate objective is to determine the appropriate level of shade, which can contribute to reduce damage by mirids.

Identification of effective botanical insecticides
In order to find a non-chemical alternative control method, a study has been conducted to assess the efficacy of neem extract on cocoa mirids. A neem spray mixture (1.5 kg of pound seed in 10 liters of water) gave an efficacy of 74% on the cocoa mirids in the field against 99% for the control [Basudine 600

EW (Diazinon)] (Bekon, personal communication). Within the same experiment, neem oil gave an efficacy of 23%. The results showed that not only the neem extract has insecticidal effect, but also act as a repellent. These results indicate that the neem extract is a potential botanical insecticide for the control of cocoa mirids.

Towards an IPM approach to the control of black pod disease

The objective is similar to that of cocoa mirids. The potential non-chemical alternative methods being investigated are cultural control, host plant resistance and biological control.

Development of improved cultural methods
Several studies have shown that in a cocoa ecosystem, overhead shade can contribute to the improvement of the lifetime of the trees and soil fertility (Ahenkorah and Akrofi, 1968, 1969; Ahenkorah *et al*, 1974; Lass and Wood, 1985). However, overhead shade may contribute to increased attacks by some diseases such as black pot rot and swollen shoot disease (Smith, 1979; Besse, 1972). The purpose is to develop a cultural method based on the management of overhead shade in order to determine the appropriate level of shade which can contribute to reduced damage by mirids and also minimize infestation by black pod disease. The work started within the framework of the ACRI project and has been assessing the impact of the overhead shade on crop loss due to black pod disease. Preliminary results indicated that black pod disease incidence was higher in cocoa farms with overhead shade than in farms without shade. In addition, disease incidence seemed to increase with the intensity of shade.

Development of resistant/tolerant cocoa varieties
Within the framework of the CFC/ICCO/IPGRI project, a number of cocoa genotypes are being screened for resistance/tolerance to *Phytophthora palmivora*. First results seem promising.

Development of biological control methods
This work started with the ACRI project and will need to be carried on within the framework of the STCP. A first survey has been conducted in some cocoa farms to search for potential antagonists to *Phytophthora* spp such as fungi and bacteria. The survey gave about 66% of fungal isolates including *Trichoderma* spp., *Botrytis* spp., *Penicillium* spp., *Fusarium* spp. and *Pestalotia* spp., 12% of bacteria strains and 34% yeasts.

Some laboratory experiments have been conducted using isolates of *Trichoderma* spp. and bacterial strains to assess their antagonistic effects on *Phytophthora* spp. In a first experiment, the survival of *Phytophthora palmivora* was evaluated in competition with 6 isolates of *Trichoderma*. Results showed that, except for one isolate, the 5 others reduced the survival of *P. palmivora* (Fig. 1). Two of the *Trichoderma* isolates T1 and T5 completely suppressed *P. palmivora* at 5 days after exposure.

In a second experiment, the antagonistic effect of the *Trichoderma* isolates was assessed on the growth of *P. palmivora* isolates in Petridishes. Results indicated that the 6 isolates of *Trichoderma* inhibited the growth of *P. palmivora* from the third day of exposure (Fig. 2).

Another experiment was conducted to assess the effect of bacterial strains on the cocoa leaf susceptibility to *P. palmivora* using a leaf disc test. Results indicated that some bacteria reduced the growth of *P. palmivora*, yielding low rating scores as compared with the growth of *P. palmivora* alone (Fig. 3).

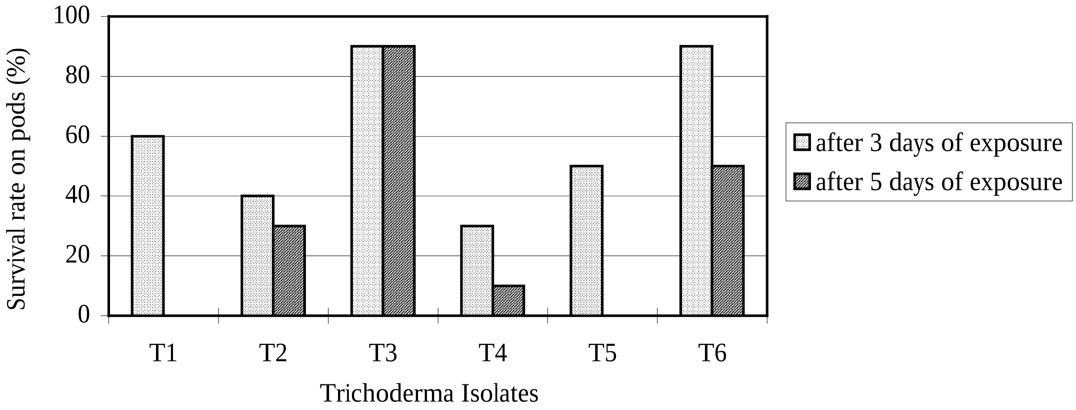

Fig. 1 Survival of *Phytophthora palmivora* isolates in competition with different isolates of *Trichoderma*

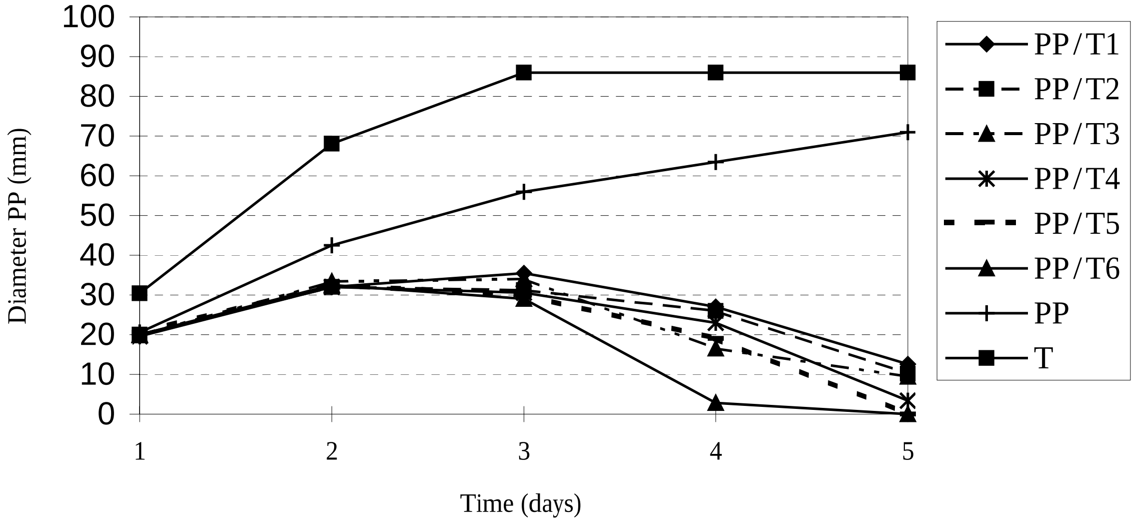

Fig. 2 Growth of *Phytophthora palmivora* (PP) isolates in competition with different isolates of *Trichoderma*

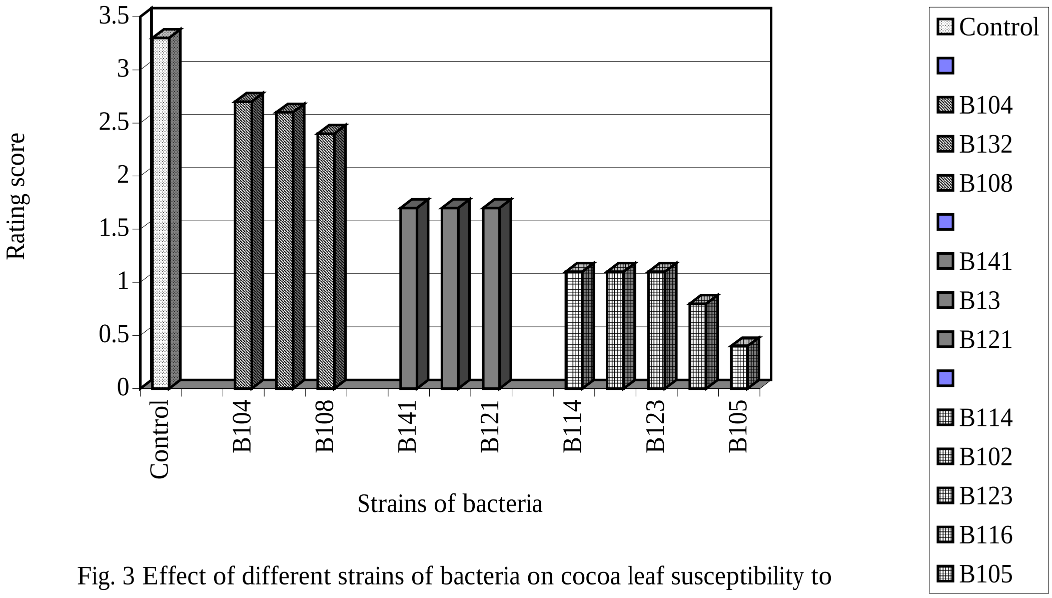

Fig. 3 Effect of different strains of bacteria on cocoa leaf susceptibility to *Phytophthora palmivora*

Proposed research activities within the framework of the STCP

For cocoa mirid

- Evaluate available biopesticides for efficacy against cocoa mirids
- Train entomologists from CNRA on insect pathology
- Identify effective natural enemies for cocoa mirids
- Continue the study on identification of resistant/tolerant cocoa genotypes
- Continue the IPM program started with the ACRI project
- Transfer of IPM technology

For black pod disease

- Continue the biological control program
- Continue the study on the identification of host resistant/tolerant cocoa genotypes
- Continue the IPM program started with the ACRI project
- Transfer of IPM technology

Conclusion

Chemical control seems to be the most effective control method for cocoa mirids. However, there is a possibility of developing a cost-effective non-chemical alternative control method, which can be combined with rational use of insecticides. With regard to black pod disease, an integrated management approach seems somewhat promising.

Bearing in mind that one of the most important aspects of crop protection is technology transfer to farmer level, there is a need to convince the farmers of the values of the new approaches and persuade him/her to adopt these.

References

Ahenkorah, Y. and Akrofi, G.S. (1968). Amazon cocoa (T. cocoa L.), shade and manurial experiment, K2O1 at Cocoa Research Institute of Ghana. I. First five years. Agronomy Journal 60: 591-594.

Ahenkorah, Y. and Akrofi, G.S. (1969). Recent results on fertilizer experiment on shade cocoa (T. cocoa L.) in Ghana. Proc., 3rd Intern. Cocoa Res. Conf., Accra: 23-29.

Ahenkorah, Y., Akrofi, G.S. and Adri, A.K. (1974). The end of the first cocoa shade and manurial experiment, at Cocoa Research Institute. Journal of Horticultural Science 49: 43-51.

Anon, 1999. *Le professionnel Agricole. Revue mensuelle des Organisations Professionnelles Agricoles en Côte d'Ivoire (ANOPACI):* 11-12.

Besse, J. (1972). *Comparaison de deux méthodes d'établissement de cocoayères. Café Cocoa Thé* 14(4): 317-320.

Braudeau, J. (1969). *Le cocoayer. Techniques Agricoles et Productions Tropicales.* Ed. Maisonneuve and Larose, Paris: 2 - 3.

Campbell, C.A.M. (1984). The influence of overhead shade and fertilizer on the homoptera of mature Upper Amazon cocoa trees in Ghana. Bull. Entomol. Res. 74: 163-174.

Coulibaly, N., N'Guessan, F. K., Decazy, B., Madus, D., Aïdara, S. and Coulibaly, A. (1996). *Efficacité du Fumivap : une nouvelle technique d'application des produits chimiques dans la lutte contre les mirides du cocoayer en Côte d'Ivoire. Actes de la 12ème conférence internationale sur la recherche cocoayère*. Salvador, Bahia, Brazil: 39-44.

Decazy, B. (1979a). *La lutte contre les mirides du cocoayer au Cameroun : nouvelles données sur les insecticides thermonebulisables. Café, Cocoa, Thé (Paris)*, vol. XXIII, No 3: 187-192.

Decazy, B. (1979b). *Ombrage et traitements anti-mirides sur les cocoayers: leur influence sur la production.* Proceedings of the 7th International Cocoa Research Conference. Douala, Cameroon: 443-446.

Entwistle, P. F. (1972). Pests of cocoa. Longman Group Limited, London: 779 pp.

Gibbs, D.G. and Pickett, A.D. (1966). Feeding by *Distantiella theobromae* (Dist.) (*Heteroptera: Miridae*) on cocoa: the effects of water stress in the plant. Bull. Entomol. Res. 57: 159 -169.

Hill, D. S. and Waller, J.M. (1988). Pests and diseases of tropical crops Volume 2. Intermediate Tropical Agriculture Series. Longman Group (FE) LTD, Hong Kong: 432 pp.

Kay, D. (1961). Die-back of cocoa. West African Cocoa Research Institute Technical Bulletin, No. 8: 20 pp.

Kouassi, L. N. (2001). *Evaluation de 16 clones de cocoayers pour la résistance aux mirides : cas de sahlbergella singularis. Mémoire de stage pour l'obtention du DEA de défense des cultures. Institut National Polytechnique Houphouet Boigny/ Ecole Supérieure d'Agronomie; Yamoussoukro:* 40 pp.

Kumar, R. and Ansari, A. K. (1974). Biology, immature stages and rearing of cocoa-mirids (*Miridae : Heteroptera*). Zool. J. Linn. Soc. 54 (1): 1-29.

Lass, R.A. and Wood, G.A.R. (1985). Present constraints and priorities for research. World Bank Technical Paper No. 39: 1-28.

Lavabre, E. M. (1961). *Protection des cultures de caféiers, cocoayers et autres plantes pérennes tropicales. IFCC, Imprimerie Jouve, Paris:* 268 pp.

Lavabre, E. M. (1970). *Insectes nuisibles des cultures tropicales.* Tech. Agri. Et prod. Ed. G.P. Maisonneuve and Larose, Paris: 199 - 229.

Lavabre, E. M. (1977). *Les mirides du cocoayer.* G-P. Maisonneuve and Larosse. Paris: 366 pp.

Lavabre, E.M., Decelle, J. and Debord, J. (1962). *Recherches sur les variations de populations de mirides (Mirides) en Côte d'Ivoire. Café Cocoa Thé* 6(4): 287-295.

Lavabre, E.M., Decelle, J. and Debord, J. (1963). *Etude de l'évolution régionale et saisonnière des populations de mirides (Mirides) en Côte d'Ivoire. Café Cocoa Thé* 7 (3): 267-289.

Marchart, H. (1971). *Efficacité des insecticides dans la lutte contre les mirides du cocoayer au Ghana. Bulletin Phytosanitaire de la FAO, Rome.* 19 (5): 97-109.

N'Guessan, K. F. and Coulibaly, N. (2000). *Dynamique des populations de mirides et de quelques autres déprédateurs du cocoayer dans la région Ouest de la Côte d'Ivoire. Actes de la treizième conférence internationale sur la recherche cocoayère*. Kota Kinabalu, Sabah, Malaysia (in press).

Nguyen-Ban, J. (1971). *Progrès récents dans la lutte chimique contre les mirides du cocoayer. Café, Cocoa, Thé* 15(2): 129-134.

Smith, E.S.C. (1979). The interrelationships between shade types and cocoa pest and disease problems in Papua New Guinea. Proceedings of the 7th International Cocoa Research Conference, Douala, Cameroon: 37-43.

Taylor, D. J. (1954). A summary of the results of mirid research in the Gold Coast. WACRI Technical Bulletin, No. 1: 20 pp.

Williams, G. (1953). Field observation on the cocoa mirids *Sahlbergella singularis* and *Distantiella theobromae* in the Gold coast. Part 1. Bull. Entomol. Res. 44: 101-119.

Discussion

Q: In Guinea Conakry, hybrids are being introduced from Côte d'Ivoire. What techniques are being used in Côte d'Ivoire to the farmers' benefits.

A: Rehabilitation is practised by total cocoa replanting together with plantain and other temporary shade trees for cocoa. If the soil is adversely affected, the soil fertility is restored through Acacia *incorporation.*

Comment: So far, no tests have been done on antagonism of Fusarium.

Q: Has Côte d'Ivoire already started with farmer field schools (as presented in Accra)?

A: We have already started with farmer participatory training. Research is being carried out with full involvement of farmers. Farmers are able to identify and count the mirids. Also for black pod, they are able to identify this disease.

Ghana

Cocoa IPM research and implementation in Ghana

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Introduction

Commercial cocoa cultivation in Ghana started in 1879 with the introduction of pods from Trinidad by a goldsmith, Tetteh Quarshie, who established the first cocoa farm at Manpong- Akwapim in the Eastern Region. Since then, cocoa has remained the most important commercial agricultural commodity for Ghana and Ghana's cocoa is well known for its superior quality that earns it a premium on the international market. A survey conducted in 1998 showed that the total acreage under cocoa cultivation in Ghana was 2,988,393 acres of which 12% was of Amelonado cocoa and 46%, 13% and 29% were of Amazon, hybrid and mixed cocoa types, respectively (Anon, 1998). However, despite the economic importance of cocoa and farmers' sustained interest in production (Owusu, 2000), yield continues to be low. Current production level averages 400,000 metric tonnes per annum with a mean of 400 kg/ha as against a potential of 1-5 tonnes/ha achieved on experimental plots (Asante and Ampofo, 1999). The main causes of the low yield are the ravages caused by pests and diseases and poor soil fertility caused by prolonged cultivation on farmlands.

In 1938, the West African Cocoa Research Institute (WACRI) was established at Tafo in the Eastern Region of Ghana to find a solution to the then prevalent problem, the cocoa swollen shoot disease (CSSVD) transmitted solely by mealybugs (Homoptera: Pseudococcidae). WACRI became known as the Cocoa Research Institute of Ghana (CRIG) in 1962 when the other member countries, Nigeria, Sierra Leone, Côte d'Ivoire, Cameroon established research institutions in their respective countries to address local problems. Since then, other problems, mainly caused by pests and diseases, have emerged in Ghana and CRIG continues to develop and conduct research activities aimed at controlling them. Prevalent among the economically important pests are the cocoa mirids, mainly *Distantiella theobroma* (Dist) and *Sahlbergella singularis* (Hagl.), and more recently, the stem borer *Eulophonotus Myrmeleon* Fldr. (Lepidoptera: Cossidae), termites and the pod feeders *Bathycoelia thalassina* (H-S) (Heteroptera: Pentatomidae) and *Pseudotheraptus devastans* (Dist.) (Heteroptera: Coreidae). Another serious problem on cocoa in Ghana is the black pod disease caused by the more virulent *Phytophthora* species, *P. megakarya*, which can cause crop losses as high as 80 - 100% on farms left unattended, compared to 4-20% for the previously prevalent species, *P. palmivora*.

Attempts to estimate losses due to mirids are always complicated by the inadequacy of records and the complexity of losses from other causes such as fungal and virus diseases and physiological dieback (Entwistle, 1965; 1972). Nevertheless, annual crop losses caused by cocoa mirids and CSSVD together is estimated at 25-30%. Mirid damage alone, if left unattended on a farm for three years, can reduce yield by as much as 75% (Anon, 1951; Stapeley & Hammond, 1959). Recent studies indicate that about 25-30% of the national cocoa acreage is badly damaged by mirids (Owusu-Manu, unpublished data).

Since 1957, the main method for mirid control on cocoa in Ghana has been chemical control with the organochlorine insecticide Gammalin 20 (Lindane), later to be alternated every two years with the carbamate Unden 20 (Propoxur) between the northern and southern sectors of the cocoa producing area. The insecticides are applied as foliar sprays four times in the year at monthly intervals from August to December, omitting November, using recommended motorised mistblower spraying machines. CSSVD, on the other hand, is controlled by the eradication of infested trees and their contacts whilst black pod disease is controlled by the spraying of fungicides, mainly copper-based, starting at the on-set of the rainy season. This method is integrated with cultural methods involving the early and regular removal of infected pods to reduce the spread of inoculum. Despite these efforts, mirid damage, CSSVD and black pod disease are still prevalent in Ghana due to logistic problems in implementation. Farmers' low adoption rates of recommended control measures are mainly caused by the high cost of inputs (Padi *et al.*, 2000a). Other environmentally friendly pest control measures recently recommended by CRIG are presented in Table 1. There is currently a recommendation to reduce the frequency of application of recommended conventional mirid pesticides from four to two applications a year on mature cocoa having good (closed) canopy (Table 1). Cultural practices such as the manipulation of overhead shade levels, the cocoa tree canopy, and the pruning of cocoa trees, are also recommended for the control of cocoa mirids and black pod disease. The manipulation of overhead shade to reduce the incidence of cocoa mirids is, however, considered a delicate strategy since it demands a careful balance between shade increase for mirid control and shade reduction to increase yield and reduce the incidence of black pod disease. These efforts are supported by the use of Potassium (Murate of Potash) and Phosphate (Triple superphosphate) fertilisers, following soil analysis, to replenish soil fertility as necessary.

TABLE 1: Recommended IPM methods

PROJECT	REMARKS
1. Reduced frequency of insecticide application	The frequency of application of insecticides reduced from four to two times in the year on mature cocoa having good canopy.
2. Use of conventional insecticides having low mammalian toxicity	One Nitroguanidine insecticide and a cocktail of Actellic and the pyrethroid Talstar recommended for cocoa mirid control in Ghana. Large-scale trials on similar products in progress.
3. The use of cultural methods • Manipulation of overhead shade, cocoa canopy and pruning of cocoa trees to control insect pests, mistletoe and black pod. • Frequent removal of infected pods for black pod control. • Eradication of CSSVD infected trees and their contacts.	• Need for a delicate balance between shade increases for mirid control and shade reduction for yield increases and reduction of incidence of black pod disease. • Effective for the control of *P. palmivora* but inadequate for control of *P. megakarya.* • CSSVD still widespread due to logistic constraints in the implementation of the eradication method.

Padi *et al.* (2000b) discussed recent efforts made by CRIG towards the development of IPM strategies for the control of pests and diseases. The present paper highlights progress and achievements realised since then.

IPM methods being developed and recent achievements

The IPM oriented methods currently being developed by CRIG and recent achievements realised are presented in Table 2.

TABLE 2: On-going cocoa IPM research and achievements in Ghana

PROJECT	TIME	COLLABORATORS	FUNDING	REMARKS
IPM in the Ghana Cocoa Industry	1998 – 2001		ACRI/DFID/ Ghana Government	
i. The use of sex pheromones for mirid control	Initiated in 1998	Natural Resources Institute, UK	DFID/Ghana Government	Pheromones for *Dt* and *Ss* identified and synthesised; laboratory tests on synthetic compounds initiated.

ii. The use of mycopesticides for mirid control	Initiated in 1998	CABI Bioscience	Ghana Government	A local *Beauveria bassiana* isolate being tested, together with four exotic isolates against both *Dt* and *Ss*. Similar studies on mealybugs initiated.
Biological control projects i. Biological control using natural enemies (parasitoids and predators) for mirid and mealybug control	 Initiated in the late 1940s and revisited in the late 1980s to date	 None	 Ghana Government	 Over 40 hymenopterous parasitoids and 20 predators of mealybugs, including two arachnids, recorded. Several parasitoids of mirids recorded.
ii. Biological control of mealybug vectors of cocoa swollen shoot virus (CSSV) using the coccinellid predator *Cryptolaemus montrouzieri* Muls. And pathogenic fungi	2002-2005	University of Florence, Italy	EU-STABEX	Positive laboratory results. Small-scale researcher-managed field trials in progress but results not promising.
iii. Biological control of black pod using parasitic fungi	2000-2003	CABI Bioscience	EU-STABEX	Laboratory evaluation in progress; no fungi amenable for biological control identified yet.
Screening of botanical pesticides for the control of cocoa mirids	1998-2005	Ministry of Food and Agriculture (MoFA) extension staff, Ghana	OCP Inc. of U.S.A. / Ghana Government	Neem Azal and crude aqueous neem seed extract (ANSE) found to be effective in small-scale field trials. Large-scale trials in progress.
Population dynamics of mirids	2000-2002	None	EU / Ghana government	Preliminary results show changes in temporal distribution of mirids.
Development of rearing methods for mirids	1998-2001	None	ACRI / Ghana Government	Appreciable numbers of *S. singularis* made available. Need to improve rearing methods.
Cocoa germplasm utilisation and conservation; a global approach	1998-2003	Sub-regional	CFC / ICCO / IP GRI	
i. Screening for CSSVD resistance	1998-2003	None	CFC / ICCO / IP GRI	Crosses with NA & IMC populations identified as the best sources of resistance in laboratory screening experiments. This and other results require confirmation (Anon, 2001).
ii. Screening for black pod resistance	1998-2003	Ghana, Cameroon, Côte d'Ivoire, Nigeria.	CFC / ICCO / IP GRI	Different clones identified to be highly resistant to black pod disease in various countries.
iii. Screening for resistance / tolerance to	1998-2003	Ghana, Cameroon, Côte d'Ivoire	CFC / ICCO / IP GRI	Different clones found to be promising materials in lab.

mirids				Preference and "cage sleeve" field tests in various countries.
Cocoa stem borer studies i. A study on the biology and ecology of cocoa stem borers in Ghana	2000-2003	None	Ghana Government	Only *Eulophonotus myrmeleon* (Fldr.) recorded on cocoa in the present study although other species have previously been recorded. Basic information on biology, larval and egg predation and temporal distribution collected.
ii. Development of an IPM strategy for stem borer control on cocoa by the use of Gastoxine (Phosphine) insecticide paste and non-chemical methods (including destruction of infested branches)	1998-2002	None	Ghana government & Chemico (Gh.) Ltd.	100% kill of larvae of *E. myrmeleon* in all cases with Gastoxin. Gastoxin paste is safe to handle and does not contaminate environment since it is squeezed into the borer hole and sealed off.

Integrated Pest Management methods

Insecticides currently being screened for cocoa mirid control include Nitroguanidine compounds and botanical pesticides that are environmentally friendlier and less toxic to humans (Table 2). Other environmentally friendly methods being developed include the use of synthetic analogues of sex pheromones of cocoa mirids, the use of biological control agents (parasitoids, predators and pathogens), and the use of cocoa genotypes resistant/tolerant to CSSVD, black pod disease and mirids (Table 2).

The ultimate aim is to combine those methods that prove to be effective and are compatible within the context of an IPM strategy. The non-chemical methods will, as necessary, be combined with minimal use of insecticides, with a bias towards the relatively less toxic and less persistent chemicals. There are also plans to test the above-mentioned methods on the newly emerged important cocoa pests such as termites, *B. thalassina*, *P. devastans* and *E. myrmeleon* and, indeed, some botanical pesticides have been tested against termites and *B. thalassina.* Also, small-scale trials on the use of parasitic nematodes for the control of *E. myrmeleon* have been initiated in the first week of November 2001.

Since the effectiveness of the appropriate control methods will depend on correct timing, a study on the temporal distribution of mirids and other cocoa pests in Ghana began in March 2001. Findings from these studies will permit a review of the recommended timing and frequency of insecticide application previously based on the temporal distribution of mirids on Amelonado cocoa which is now being phased out and is being replaced by the more vigorous and high yielding cocoa hybrids. Moreover, to ensure the availability of adequate numbers of experimental mirids for the various experiments, insectary methods for rearing the two important mirid species in West Africa, *D. theobroma* and *S. singularis,* are being developed.

Achievements

Two botanical pesticides, Neem Azal and crude aqueous neem seed extracts (ANSE) have proved effective against the two important mirid species, *D. theobroma* and *S. singularis* in laboratory tests and in small-scale field trials (Padi & Adu-Acheampong 2000). The two are currently being tested in large-scale on-farm trials located throughout the cocoa growing regions of Ghana. In the pheromone/mycopesticide project, the chemical components of the sex pheromones of *D. theobroma* and *S. singularis* have been identified and their analogues synthesised by the Natural Resources Institute (NRI), UK. The synthetic analogues (lures) are currently undergoing laboratory and field screening at CRIG, Ghana, for their effectiveness in attracting males of the species. The fruit of *Desplatsia dewevrei* (Tiliales: Tiliaceae), an alternative host plant of *S. singularis,* has been identified as suitable material for rearing *S. singularis* (Padi *et al.,* 1997). The use of this method is, however, limited by the fact that suitable fruits are available only between the months of November and May. Moreover, the fruits have proved unsuitable for rearing *D. theobroma*, the second important mirid species in West Africa. Under the pheromone/mycopesticide project, five isolates of *Beauvaria bassiana,* including one Ghanaian isolate, are being screened in the laboratory against cocoa mirids at CRIG, in collaboration with CABI scientists. Collaboration with a scientist from Cameroon, though planned, has not yet materialised. For CSSVD and black pod disease, potentially resistant/tolerant genotypes have been identified in insectary screening experiments and casual field observations but these are yet to be confirmed in well designed field experiments. Similarly, experiments on the use of the mild strains protection technique for CSSVD control has proved to be promising but is yet to be completed whilst the use of biological control agents (fungi and pathogens) for the control of black pod disease have only just started.

In laboratory and cage experiments on the use of *Cryptolaemus montrouzieri* Mulz. -a predatory beetle of Australian origin- for the control of mealybug vectors of CSSVD, the beetle proved effective against both *Planococcoides njalensis* (Laing) and *Planococcus citri* (Risso). Results from field trials, however, have not been encouraging due to ant antagonism against the beetles. Investigations to find solutions to this problem are in progress.

Sub-regional collaboration

It is hereby suggested that the project on the screening of botanical pesticides for cocoa mirid control presently being conducted in Ghana be replicated in the other African countries participating in the Sustainable Tree Crops Programme. In Ghana, extracts of locally available plants such as the neem tree, *Jatropha curcas, Clausena anisata* and *Datura metel* as well as commercial formulations including neem based Niemolgator, Neemix and Neem Azal are undergoing laboratory and field screening. The collection and screening of plant extracts in each country would enhance the possibility of finding suitable plants having the desired insecticidal properties. Similarly, the search for, and the screening of, pathogenic fungi should also be done in each country. This would be a better approach than the present one involving scientists from the different countries travelling to Ghana to search for pathogens available in Ghana only. Monies from scarce project funds being spent on travels by scientist from other countries could be more profitably spent on individual national surveys. The search for and evaluation of other potential bio-control agents for mirid and black pod disease could also be replicated in the various countries where these problems exist.

For mealybug control in Ghana, there is now the need to focus attention on the rearing, evaluation and use of locally identified natural enemies since these are already adapted to the local environment. There is also the need to put in place the necessary quarantine measures to prevent the spread of CSSVD from Ghana into neighbouring countries and from spreading within each country. Since the virus can survive in the vector for only a short period, the target should be to avoid the transfer of infested cocoa seedlings both within and between countries.

Already, all the important cocoa producing countries in the West African sub-region are involved in the CFC/ICCO/IPGRI funded global project on the cocoa germplasm utilisation and conservation. This project aimed, among others, at screening for cocoa genotypes resistant/tolerant to pests and diseases, each country is screening locally available genotypes as well as other international genotypes. This is in the right direction. Results so far generated show that Ghana, Côte d'Ivoire and Cameroon have each identified different genotypes that show some resistance/tolerance to mirid attack (Anon, 2001). Different genotypes (Table 2) have also been identified as showing resistance to CSSVD and black pod disease in laboratory screening experiments in the various countries.

Profitability issues

The ultimate goal for developing and applying the IPM methods highlighted in the present paper is to provide safer pests and diseases control methods that would help generate satisfactory income for the peasant cocoa farmer in Africa. Every effort should be made to ensure that this happens since there is always the possibility of cocoa farmers shifting to the cultivation of other commercial crops that they consider more profitable. On the other hand, it is necessary that all stakeholders in the cocoa chain from the farmer level to the manufacturer of cocoa products make enough profit to survive. Thus, the companies that produce farm inputs such as insecticides, herbicides, fungicides, mycopesticides and sex pheromones, also need to make adequate profits for their survival. However, in pricing their products, they need to take into account the level of profit the farmer is likely to make by using the products. This would be the only way to ensure a sustainable cocoa production in Africa.

Acknowledgement

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References

Anon (1951). Capsid research: Chemical control. Annual Rep. West African Cocoa Research Institute 1944-50: 44-42.

Anon (1998). Final report on Cocoa Tree Stock Project. Project GCP/INT/632/COA. Report Submitted to the Ghana Cocoa Board and ICCO: 107 pp.

Anon (2001). Cocoa Germplasm Utilisation and Conservation: a global approach - Report on the Regional Technical Meeting held in Abidjan, Côte d'Ivoire, 19-23 March 2001, Compiled by the International Plant Genetic Resources Institute (IPGRI): 40 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 the Ministry of Agriculture, Ghana: 25 pp.

Entwistle, P.F. (1965). Entomology. Report of the Cocoa Research Institute of Nigeria 1963-64: 66-72.

Entwistle, P.F. (1972). Pests of cocoa. London Group Limited: 779 pp.

Owusu, G.K. (2000). Sustaining cocoa production in Ghana. Paper presented at the 10th meeting of the Advisory Group on the World Cocoa Economy, Santo Domingo, Dominican Republic, 10-14 April 2000, International Cocoa Organisation, London.

Padi, B. and Adu-Acheampong, R. (2000). Botanical pesticides for the control of cocoa mirids (Heteroptera: Miridae). Proc. 13th International Cocoa Research Conference, Kota Kinabalu, Sabah, Malaysia, 9-14 October 2000 (in press): 11 pp.

Padi, B., Owusu, G.K. and Kumah, N.K. (1997). A record of *Desplatsia dewevrei* (De Wild & Th. Dur) (*Tiliales: Tiliaceae*) as an alternative and potential breeding host plant for the cocoa mirid *Sahlbergella singularis* Hagl. Proc. 12th Int. Cocoa Research Conf., November 1996, Salvador, Brazil: 31-37.

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

Padi, B., Dudley Farman and Sarfo, J.E. (2000b). Evidence of sex attractants in the cocoa mirids *Distantiella theobroma* (Dist.) and *Sahlbergella singularis* Hagl. (*Heteroptera: Miridae*) in field-trapping experiments. Proc. 13th International Cocoa Research Conference, Kota Kinabalu, Sabah, Malaysia, 9-14 October 2000 (in press): 6 pp.

Padi, B., Ackonor, J.B., Opoku, I.Y., Hall, D., Farman, D., Downham, M., Oduor, G., Lowor, S., Owusu-Manu, E., Adu-Ampomah, Y., Sarfo, J.E., Adu-Acheampong, R., Reich, I. and Adusei, E.O. (2000c). Recent advances in the development of an integrated pest management strategy for the control of cocoa mirids and mealybug vectors of the cocoa swollen shoot virus disease (CSSVD) in Ghana. INCOPED 3rd International seminar on cocoa pests and diseases, Kota Kinabalu, Sabah, Malaysia, 16-17 October 2000: 114-122.

Stapeley, J.H. and Hammond, P.S. (1959). Large-scale trials with insecticides against capsids on cocoa in Ghana. Emp. Journal of Experimental Agriculture 27: 343-353.

Guinea Conakry

Integrated Pest Management on Cocoa in Guinea Conakry

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The Republic of Guinea

Situated on the West African coast, the Republic of Guinea can be subdivided into four natural regions: maritime, middle, high and forested Guinea. Each of these distinguishes itself both climatically and vegetatively, displaying regional variations. The population is estimated at 7 million inhabitants. About 70% of the population works in agriculture, the country's main source of income, and generates approximately 20% of the GDP (Doc. PMT 1999-2002/IRAG).

The forested (arboreal) region of Guinea

Situated in the South of the country, this region extends over 20% of the national territory. With a surface area of around 14,5 million hectares (60% of the national territory), the forest plays a socio-economic front role and is integral to a number of production systems. The sub-equatorial climate is characterised by average temperatures of 24°C, a long rainy season of 7 to 8 months and rainfall varying between 1800 and 3000 mm. The average altitude varies between 500 to 800 m. Generally, its soils possess very good agronomic characteristics (iron-and humus-rich). Amongst others, the major crops in this zone are:

- Food (subsistence) crops : Rice, cassava, groundnut, banana, cowpea
- Cash crops: Coffee, cola, cocoa, oil palm, rubber

The role of cocoa cultivation

The role of cocoa cultivation is important in the production systems of Guinea. Its exploitation is traditional and cultivation can be both as a single crop or in association with others such as coffee, banana or avocado. Yields vary between 250 and 350 kg per hectare (RS/CRAS/94). Despite its poor production, Guinean cocoa contributes to an increase in income for farmers on the one hand and to improvement in export revenues on the other.

Between 1995 and 2001, a total of 15214 T were exported as outlined in the table below :

Years or Periods	Quantity (T)
1995	905
1996	2.962
1997	4.301
1998	3.232
1999	1.997
2000	951
01/01 to 30/09/2001	866

Source : Plant protection Division, annual reports 1995-30/09/2201

Constraints to cocoa cultivation

The agro-ecological conditions in the arboreal regions are well suited to cocoa cultivation, however the growth of export cultivations in Guinea has long been impeded by a number of constraints:

- Lack of improved plant material
- Inappropriate cultural techniques
- Pest problems (mirids, pod and trunk larvae, coleopterans, lepidopterans, thrips, rodents, and ants (œcophile), which make maintenance and harvesting difficult
- Black pod Rot
- Chromoleana odorata or Vukpala (in Guinean)
- Post harvest techniques: fermentation and drying

Current status of Integrated Pest Management in cocoa cultivation

During field visits by partners and members of the cocoa and coffee industries, above mentioned constraints were identified as the most important concerns to farmers. At present, there is no integrated management program for cocoa cultivation in Guinea.

Currently used alternative farmer practices are:
- Collection and burning of infected pods
- Trapping for rodents and capture of insects, notably the variegated grasshopper (*Zonocerus variegatus*)

Prospects with respect to relaunch of cocoa cultivation

Research level

The primary challenge in the agricultural development of arboreal Guinea includes the promotion of cash crops, which are the main source of income for the majority of the population. Research studies are in their infancy in Guinea. They hinge primarily on the introduction of plant material, the incorporation of collections and wooded parks.

Recent initiatives to promote cocoa based on the agricultural development stakes have given rise to the following action plan:

Short term, 1 to 2 years:
- Characterisation of exploitable cocoa types
- Initiation of rehabilitation of old plantations
- Continuation of plant introduction
- Establishment of selective clonal breeding and hybridisation
- Characterisation of the black pod causal agent (*Phytophthora* sp) and control methods
- Identification of cocoa pests

Mid term, 2 to 5 years :
- Improvements in traditional systems of cocoa cultivation and post-harvest techniques
- Improving soil fertility for cocoa cultivation

Extension level

Strengthening capacity for:
- Extension service and training on plantation management and post-harvest techniques
- Plant Protection Technicians on plant protection

Conclusion

Through technology transfer, experienced countries such as Côte d'Ivoire, Ghana and Cameroon, can support the cocoa cultivation revival in Guinea. This could be achieved through transfer of plant material, rehabilitation of old plantations, integrated pest management, post-harvest technologies for farmers and producer organisation. We would like to thank each workshop participant for all that he/she can contribute to the promotion of cocoa in Guinea; we extend our sincere congratulations to the STCP program for its constant lobbying on behalf of the cocoa, coffee and cashew smallholders.

References

IRAG (1999-2002). Orientations stratégiques et plan à moyen terme de la recherche agronomique Guinéenne.
Guilavogui, B. *et al.* (1994). Zonage de la Guinée forestière.
Division protection des végétaux: apports d'activités 1995 au 30/09/2001
DNA/LNPV S (2000). Rapport de mission en Guinée forestière.
Zoumanigui *et al.* (2001). Carte de zonage agro-écologique de la Guinée forestière.
Hamadou, Y. *et al.* (2001). Rapport synthèse étude sur les systèmes d'exploitation sylvo-agricole en Guinée.

Discussion

Q: What is the extent of crop production in the area?
A: Pure crop production is 8.000 to 10.000 ha in the forest zone. In the year 2000, improved clones were introduced from Côte d'Ivoire. All research is being done with the farmers.

Q: Are there any indigenous practices that help to control pests on cocoa?
A: So far cocoa production was done without biocontrol or chemical control – 100% ecological. Now that hybrids are being introduced the farmers start using fertilisers.

Nigeria

Cocoa IPM research and implementation in Nigeria

O.L. Idowu, K.T.M. Ojelade and P.O. Adebola
Cocoa Research Institute Nigeria

Introduction

For almost two decades (1970-1990) research efforts on pests and diseases of cocoa were concentrated on bioecology and control of cocoa mirids, black pod disease and cocoa swollen shoot virus disease. By late 80' it had become obvious that most of the recommendations extended to cocoa farmers on the control of these insect pests and diseases have become inadequate and unsustainable. This was because mirids have developed resistance to all Lindane based insecticides that are widely used by farmers. These insecticides together with the copper based fungicides recommended for the control of black pod disease also became expensive and less affordable. Hence, the need to identify alternative but sustainable techniques for the management of these pests and diseases. In view of the above scenario, concerted research efforts were made between 1992 – 2001 to identify and evaluate various control techniques (cultural, biological and chemical) which could be harnessed for integrated management of these most important pest and disease in Nigeria.

The following research projects were therefore conducted:

1. Development and evaluation of farmer – oriented mirid monitoring and damage assessment method

This consists mainly of the search for damage symptoms, and harmonise to monitor mirid populations as well as determine damage levels during the season:

- Fresh lesions on chupons and fan branches
- Fresh lesions on pods and cherelles
- Pockets of dried/wilted fan branches/chupons
- Fresh cankers on trunks/branches
- Formation of stagheads
- Canopy blast in very bad situations
- Pole/dying trees in very bad situations
- Nymphal and adult mirids especially at pod/stem interface and underneath pod peduncle

2. Field comparison of method (1) above with conventional insecticide knock-down method

The farmers' method involved the direct count of mirids through damage symptoms while the conventional method involved the knock-down of mirids using insecticides. The farmers' method, though less sensitive for mirid population assessment, yet is simple, less costly and easily adoptable.

3. Determination of Damage Threshold for Essential Insecticide Application

- Farmer walks through length and breadth of farm (TRANSECT), stopping at intervals to take and record his observation on infestation and mirid numbers per tree.
- 100 to 200 pod-bearing trees are selected per ha per farm and the presence or absence of mirids and fresh damage symptoms are noted and scored.
- Scoring is done by using 100 or 200 pebbles kept in a small bowl/can as counters; one counter is dropped in the litter for every uninfested tree found whereas one counter is kept in the pocket for every infested tree until all the counters in the bowl are exhausted.
- The number of counters kept in the pocket gives a sensitive measure of damage (% damage).

- The decision is then made as follows:

< 5% damage	do not spray
> 5-25% damage	spot-spray
> 25% damage	blanket spray

- If a high proportion (70 – 75%) of the infested pods are already mature and ripened, farmers are advised not to spray. Similarly, spraying is also avoided if harvest is due 9-13 days ahead or if 85-90% of main crop for the year is already harvested.
- This method is applicable to the main cropping and main mirid seasons (September- December)

4. Identification and evaluation of inputs for cultural control methods

The following cultural practices were used either singly or in combination as and when necessary to minimise invasion and build-up of mirids, black pod disease and herbacious/parasitic weeds in small holder cocoa farms.

- Use of plantain as shade crop for newly established cocoa farms;
- Clean weeding and regular destruction of basal chupons;
- Hand crushing of nymphal and adult mirids found on pod-stalks and pods/stem interface;
- Removal of aerial chupons with fresh mirid lesions;
- Removal of damaged/infested/moribound cherelles;
- Intercropping of young cocoa with broad-leaved cocoyam, maize and cassava;
- Timely harvesting of healthy and infested mature/ripened pods;
- Preservation of known predators of mirids such as *Oecophylla* spp. and spiders by avoiding spraying their nest/tents;
- Watching out for the first appearance of black pod at the beginning of the early rains to commence early preventive fungicide application;
- Routine destruction of mirid infected pods and cherelles and spot spraying infected trees and adjacent healthy trees;
- Construction of drainage to get rid of excess water and to reduce high humidity in water-logged areas of the farm;
- Pruning overgrown shade and fan branches to reduce high humidity inside farm;
- Cutting mistletoes before the onset of the early rains and during the August break;
- Cutting twinning plants and epiphytes routinely;
- Filling gaps created by dead stands, by replacing dead trees with vigorous seedlings under old cocoa or suitable shade crops such as plantain.

5. Identification of pest/disease tolerant/resistant materials or black pod escapers among germplasm

Some promising materials have been identified for their tolerance or resistance to black pod. These selected parents have been crossed in different combinations to produce progenies, which are being evaluated for natural incidence of black pod. Some black pod escapers that produce the bulk of their crop during the dry season when conditions of the environment are least conducive to the growth and attack of black pod fungus (*Phytophthora palmivora*) have also been identified. These materials will be further utilised in our breeding programmes.

6. Organisation of farmer field schools on Cocoa IPM

- Principles of Cocoa IPM
- Identification of mirid nymphs, adults, feeding/resting sites and predators
- Identification of damage symptoms such as lesions on cherelles, pods, stems etc., mirid induced wilting and cankers, canopy blast, formation of stag-headedness condition and pole trees
- Identification of early symptoms of *Phytophthora* black pod on pods
- Early identification and timely removal of mistletoes
- Determination of damage threshold for essential spraying
- Chemical control and safety of farmers

The above were treated in classroom lectures and through field trips/practicals

7. Field comparison of IPM package with conventional routine spraying using on-farm trial approach

This study consisted of farmer participatory on-farm trials supervised by scientist over two consecutive seasons. This gave the farmer the opportunity to compare the IPM package with the conventional routine method and to evaluate its adoptability. Participating farmers have gone through farmer field schools on cocoa IPM.

8. Areas for further research

These include the following:

- Search for known natural enemies of cocoa mirids and exploitation of cocoa habitats which favour the natural enemies;
- Development of cocoa agro-forestry systems for mirid and black pod management i.e. Using suitable forestry shade plants which do not host cocoa pests;
- Intensify the search for pest/disease/drought tolerant cocoa materials for the sub-region;
- Identification of local botanicals for mirid and black pod management;
- Development of shorter cocoa trees through breeding and appropriate agronomic practices to facilitate pest and disease management.

Discussion

Q: *What is the level of adoption by farmers?*
A : *We are developing IPM packages. We have not yet come to large-scale extension.*

Q: *There is a problem with the threshold for mirid treatment, protect the trees and loose the pods or protect the pods and loose the trees?*
A: *Our experience so far is that the number of applications is reduced from 4 to 2 applications. There has not been a need to apply further insecticide spraying.*

Q: *Cassava is prone to be depressive when associated with cocoa.*
A: *This is only done in young cocoa plantations.*

Regional workshop sessions on cocoa IPM research

Workshop process

Workshop step 1

Plenary pest problem prioritisation exercise (highest priority = lowest score):

Pest problems	RB	CAM	CI	GH	G C	NG	Score	Priority
Mirids	2	2	1	2	2	1	10	***2***
Black pod	1	1	2	1	1	2	8	***1***
Swollen shoot	7	7	8	3	7	7	39	*7*
Mistletoe	5	4	4	6	5	3	27	*4*
Termites	3	6	5	5	4	5	28	*5*
Stem borer	4	3	3	4	3	6	23	***3***
Weeds	6	5	6	7	6	4	34	*6*
Potential new problems (frosty pod, witches broom)	8	8	7	8	8	8	47	*8*

Workshop step 2

Working in regional groups (each group had one representative of each participating country), each group focusing on one prioritised pest problem, answering the following guide questions:

1. What is the current situation with regard to the problem and available IPM options / options in development?
2. Who are the experts working on the problem in each country?
3. Do you have ideas for mutually beneficial regional collaboration to alleviate the problem?

Workshop step 3

Presentation and discussion of regional working groups on prioritised pest problems

1. Black pod
2. Mirids
3. Stem borer

Workshop step 4

Discussion of regional follow-up cocoa IPM research in plenary session, as part of a regional cocoa IPM initiative

Black pod regional workshop results

Presented by Pierre Roger Tondje (Cameroon)

1. Current situation

Country	RB	CAM	CI	GH	G C	NG
% Losses	-	50 - 80	30	60 - 100	40 - 70	30 - 100
Solutions	-	Chemical Cultural	Cultural Chemical	Chemical Cultural	Cultural	Chemical Cultural
Research and development	Genetic	Genetic Biological Botanical	Genetic Biological Botanical	Genetic Biological Botanical Elicitors	Genetic	Genetic Biological Botanical

2. Cocoa black pod experts in the region

Benin: G. Bah Bocco
Cameroon: S. Nyasse, P. Tondje, Bidzanga, Ndoumbe
Côte d'Ivoire: I. Kebe, Mathias Tahi
Ghana: I.Y. Opoku, A.Y. Akrofi
Guinea Conakry: A. Fofana, H. Balde, Diane Youssouf
Nigeria: Kourouma, P.O. Adebola, K. Badaru, P. Aikpoidodion, S. Agbeniyi

3. Ideas for a collaborative research programme

- Genetic (collection, evaluation, exchange)
- Biological
- Botanical
- Elicitors
- Rational use of chemicals
- Improved cultural control
- Collaboration on quarantine measures to avoid the introduction of external diseases in the region (in collaboration with extension services)

Discussion

Comment: Mr. Tondje indicated that the Biological Control Workshop (Yaounde, Cameroon, 25th June-29th June 2001) helped to establish a biological and botanical control working group, within the framework of the collaborative research working group on Integrated Management of Black Pod Diseases, which will be set up at the end of this workshop.

Q : Which control strategy for black pod is most promising in the region?

A : It was highlighted that there are good prospects in the International Project CFC/ICCO/IPGRI where new varieties of cocoa are produced, introduced and subsequently evaluated for resistance against Phytophthora megakarya. *Good candidate varieties will be disseminated to other countries, who will in turn participate in follow-up collaborative research.*

Mirid regional workshop results

presented by N'guessan K. Francois (Côte d'Ivoire)

1. Current situation

Yield losses from 10 to 40 %.

Major problems:

- Identification and monitoring for effective control / difficulties in establishing damage thresholds
- Rearing techniques inadequate to support further research
- Lack of manpower and knowledge in some countries
- Problems with chemical control: high costs, non-adoption by farmers, use of unrecommended pesticides

Solutions / solutions in development:

- Most countries have solutions on mirid identification and monitoring; Adapt reported Nigerian method to develop threshold for spray; Further research on rearing techniques are required;
- No solution for lack of rearing techniques – reported Ghana technique not sufficient to have mirid supply all year long;
- Make training available in countries where needed, to upgrade knowledge;
- Focus on cultural control: use of resistant plant material, use of biological agents, use of pheromones, use of botanicals, use of less toxic insecticides.

2. Cocoa mirid experts in the region

Benin:	Obehounou, J. Sagbohan, Arobokoen
Cameroon:	J.M. Mpe, R. Babin
Côte d'Ivoire:	K.F. N'Guessan
Ghana:	B. Padi, Ackonor, Safo, Achampong, Asante, Bah
Guinea Conakry:	Seny Kallabane, Lancine Traore, Ibrahima Fofana
Nigeria:	Idowu, Ojelade, Adebola, Adadeji

3. Ideas for a collaborative research programme

Methods of collaboration: Networking, exchange visits, training, joint projects

Ideas for collaborative follow-up:

- Determination of damage thresholds
- Identification, preparation and evaluation of botanicals
- Techniques for rearing mirids
- Preparation and evaluation of pheromones
- Identify, produce and evaluate mycoinsecticides
- Identification and evaluation of cultural control practices / organic cocoa production
- Evaluation of available pest tolerant / resistant cocoa types for mirid management
- Periodic evaluation of efficacy of recommended insecticides regarding possible development of resistance

Discussion

Comment: Dr. N'guessan proposed that Côte d'Ivoire should adopt techniques used in Nigeria to determine intervention thresholds, as these currently adopt a calendar treatment approach. These thresholds are known in certain countries but do not always share the same thresholds; for instance, in Nigeria a threshold of 1000 mirids par hectare is used, whereas in Côte d'Ivoire and Cameroon it is 0,7 mirid per tree.

Comment: Countries are encouraged to find plant species that can be used for mirid rearing.

Stem borer regional workshop results

presented by Beatrice Padi (Ghana)

1. Current situation

Country	Importance	Solutions
Benin	- (but is important on cashew and very important on coffee)	Mechanical Biological and ecological studies on cashew None for cocoa
Cameroon	+	Cultural (weeding, pruning, cutting of trees)
Côte d'Ivoire	+ (in East of country)	Cultural (cutting of trees) Studies on biology and ecology in progress Chemicals to be tested (Actara, Confidor, neem)
Ghana	++	Chemical (Gastoxin paste = Aluminium phosphine) Biological (nematodes) Farmers' practices (mechanical, kerosine) Studies on biology and ecology Trials on chemical, biological and farmers' practices (kerosine)
Guinea Conakry	+	Farmers' practices (cutting of trees) Tobacco powder Gas oil
Nigeria	+ (localised)	No solution available

2. Cocoa stem borer experts in the region

Benin: Lanani Chakirou, David Arodokoum, Galbert Gbehounou
Cameroon: Jean Michel Mpe, Regis Babin
Ivory Coast: Bekon, Bguesson, Kouame Joseph
Ghana: Beatrice Padi, Richard Adu-Acheampong
Guinea Conakry: Mohamed Camara, Sekou Souare, Djibril Cisse
Nigeria: Idowu, Ojelade

3. Ideas for a collaborative research programme

- Collection and survey: identification of species (regional) – in collaboration with IITA, British Museum
- Search of international literature (e.g. Entwistle 'Pests of cocoa')
- National studies on biology and ecology
- Available IPM options to be tested as appropriate at regional level (chemical, biological, etc)
- Sub-regional workshop after implementation of above studies

Discussion

Comment: Despite the fact that moths/butterflies are short lived, they must be eliminated (including larvae) to interrupt the reproductive cycle. It was also suggested that integrated management should take the use of pheromones into account.

Comment: Despite control work on stem borers in Ghana being well underway, it was felt that it was important to study the biology of the insect. Such studies have already been initiated in Ghana, which will help develop adequate control methods, but current Ghanaians emergency measures (chemical) will only give temporary control.

Q : Is anything was known on the natural enemies of these borers ?
A : Two ant species are known, one preys on larvae, the other on eggs. Research studies are concentrated however on parasitoids.

Comment: When mentioning farmers' methods of control one should investigate their efficacy.

Comment: As this workshop is focused on integrated management, one must look beyond the use of synthetic product only as their impact on non-target organisms can be rather severe and undesirable.

National workshop sessions on cocoa IPM implementation

Workshop process

Workshop step 1

Working in national groups, each group focusing on efficient transfer of technologies, answering the following guide questions:

1. The current situation with regard to cocoa IPM extension (not only by national extension, also by researchers, NGOs, etc);
2. Who are the experts in the area of cocoa technology transfer in each country;
3. Ideas on how the current methodology could be improved to reach more farmers or to improve impact.

Workshop step 2

Presentation and discussion of national working groups results

Workshop step 3

Plenary discussion on regional follow-up cocoa IPM implementation, and inclusion of accepted ideas in a regional draft proposal on cocoa IPM.

Workshop step 4

Inventory of on-going regional / national cocoa IPM research and implementation activities, continue discussion on regional cocoa IPM initiative, and discussion of strategy for taking the regional proposal forward.

Nigeria working group

Cocoa IPM implementation in Nigeria:

1. Many cultural practices and a few biological control measures effective for the control of cocoa mirids and black pod disease have been determined.
2. Damage thresholds for essential spraying against cocoa mirid have been determined.

Nos 1 & 2 above have been combined to achieve effective management of cocoa mirid with minimum number of insecticide application per season in pilot project areas. Extension workers and farmers have been trained at pilot scale levels in three of the major cocoa producing belts in Nigeria.

Experts on cocoa technology transfer in Nigeria:

- O.L. Idowu – Entomologist CRIN
- K.T.M. Ojelade – Entomologist CRIN
- P.O. Adebola – Breeder / Genetics CRIN
- R.A. Adedeji – Pathologist CRIN
- E.A. Adejemi – Farming system / agronomist CRIN
- A.A. Ajibade – Syngenta Nigeria PLC
- P.A. Ayeni – Syngenta Nigeria PLC

Organisation of FFS for cocoa farmers (training components):

- Principles of cocoa IPM
- Identification of mirid nymphs, adults, feeding / resting sites and predators
- Identification of damage symptoms: lesions on pods/cherelles, stems, etc.
- Mirid induced wilting and cankers
- Canopy blast
- Pole trees
- Early symptoms of *Phytophthora* black pod on pods
- Identification of mistletoes
- Determination of damage thresholds for essential spraying
- Chemical control and safety of farmers

Improvement of current methodologies:

- Establishment of IPM demo-farms in strategic areas
- Locating FFS in strategic areas
- Sensitisation through regular radio and television programmes
- Making agro-chemical companies / cocoa stakeholders more IPM responsive
- Mass production of hand bills and posters for distribution to farmers
- Periodical evaluation of adoption levels of IPM
- Periodical impact assessment studies (every 5 years)

Guinea Conakry working group

Cocoa IPM research in Guinea Conakry is in development.

Institutions and experts involved:

- Plant protection services: Dr. Traoré Lanciné, A. Fofana.
- Institute of Agricultural Research: Dr. S. Beavogui, Z. Guilavogui, H. Kourouma
- SNPRV (extension services): Mr. Keita, F. Diallo, J. Maoro

Methodology: Reinforce research collaboration with plant protection services and farmers organisations.

Further needs:

Research level	**Plant Protection level**	**Extension services level**
Characterisation of existing research work Initiation of capacities towards rehabilitation of old plantation and post-harvest techniques Follow-up on introduction of improved cocoa varieties Initiation of breeding research Research on use of inputs	Sensitisation of farmers on IPM practices Quarantine Identification of black pod and mirid agents Biological control techniques for cocoa pests	Training on rehabilitation and post-harvest techniques Training on use of inputs

Ghana working group

Ministry of Food and Agriculture:
- Modified Training and Visit approach
- CRIG – radio stations / on-farm training, training videos for television
- NGOs – Conservation International
- Chemical companies

Experts:
- Ministry of Food and Agriculture: 1. Mr Korang Amoako, 2. Mr Franklin Donkor (MOFA extension services)
- CRIG: F. Baah, E.G. Asante, F. Aneani, M Asamoah and all heads of scientific divisions
- NGOs: Mr Gyampah, Okyame Ampadu (Conservation International)
- Chemical companies: Mr Odei Tete, Mr Kwame Cyamfi

Methods:
- Participatory Rural Appraisal
- Research – Extension – Farmer
- Farmer – to – Farmer
- Research – Farmer
- Mass media
- FFS

Improvements:
- R – E – F: need feedback mechanisms
- Research – Farmer: more demo farms, more on-farm studies, open days
- Farmer – to - Farmer: more motivation to farmers
- Mass Media: Should be made more efficient, more frequent farmer education, more local languages to be used, more avenues for feedback

Further needs:
- Establish a technology transfer unit in all the research institutes, where they exist, they should be strengthened (e.g. CRIG)
- Farmer Field School programme: train more master trainers, more researchers to be trained in participatory methods

Ideas for collaboration:
- Exchange of experiences (effective networking)
- Joint training of more researchers

Côte d'Ivoire working group

1. Integrated management = cultural methods + chemical methods (as breeding and biological control is still in the experimental phase)

Historical background:
1993: Lack of research / farmer contacts
Extension service by SATMACI
Adoption < 10%

1994 – 2001: ANADER
Participatory approach (CTR, DP, SARS, AMRT)
→ improved collaboration in fields of research / extension workers/ farmers
Improved adoption (about 15%)

ACRI Project:
- Reinforce collaboration between researchers / extension workers / farmers
- IPM farmer training
Diseases and pests diagnostics
Damage identification
Knowledge of swarming periods
Knowledge of products and doses
Decision making implications

→ Professionalism of the farmer

2. Experts

ANADER (3000 agents)
CNRA (20 / 2500 agents)
Projects (Prostab, Producao, BAD)

3. Improvement of methodology

Farmer training (farmer field school) in IPM
Autonomous projects on IPM technology transfer
Strengthen collaborative links with other countries (exchange of experiences)

4. Ideas for collaboration

Networking (exchange of experiences)
Inter-country visits
Seminars
Joint Projects

Cameroon working group

Current extension methods:
There is a national extension service, financed by the World Bank. Extension conducts surveys to identify farmers' problems. Researchers work with farmers and set-up trials with farmers in the farmers' fields, where farmers do observations and also evaluate results. The Ministry of Agriculture is in charge of extension and is involved in the research with farmers. When results are available, the research outputs are transferred to extension or used by demonstration units. If experiments should be done on a large scale, farmers work with NGOs after undergoing training.

IPM component	Activities	Current state	Experts	Observation
Cultural methods	▪ Weeding ▪ Pruning ▪ Sanitation ▪ Suppression of attacked trees by insects	Ongoing but low rate of adoption	▪ IRAD ▪ Ministry of Agriculture ▪ National agricultural Research extension program (PNVRA) ▪ NGOs ▪ Parastatals ▪ Co-operatives and farmer organisations	Low labour and capital
Genetic improvement	▪ Introduction of new varieties ▪ Hand pollination ▪ Grafting ▪ On-farm selection of promising genotypes	Yet to be transferred	▪ IRAD ▪ Ministry of Agriculture ▪ National agricultural Research extension program (PNVRA) ▪ NGOs ▪ Parastatals ▪ Co-operatives and farmer organisations	Farmer and extension staff training needed
Biocontrol	1. Utilise biocontrol agents for black pod 2. Utilise parasitoids and predators 3. Utilise mycopesticides	Yet to be transferred	▪ IRAD ▪ Ministry of Agriculture ▪ National agricultural Research extension program (PNVRA) ▪ NGOs ▪ Parastatals ▪ Co-operatives and farmer organisations	1. Research on going 2. Research on going 3. Research needed for biocontrol of mirids and stem borers
Botanical	-	Already practised by farmers	Farmer organisations	Need more surveys and evaluation
Chemical	▪ Reduction of quantity of chemicals ▪ Choice of less polluting chemicals ▪ Assessment of economical	Yet to be transferred	▪ IRAD ▪ Ministry of Agriculture ▪ National agricultural Research extension program (PNVRA) ▪ NGOs	Need for more research

	threshold levels		▪ Parastatals ▪ Co-operatives and farmer organisations	

Ideas for follow-up:

- Open days
- Improve mass media

Ideas for collaboration:

- Networking
- Workshops
- Newsletters
- Regional project with many countries to benefit from each others experiences and address common constraints

Benin working group

State of cocoa IPM in Benin:
There is no concept of IPM at the farmer level of cocoa cultivation in Benin. IPM is restricted to research stations, where cultural methods are combined with appropriate phytosanitary treatments as well as introduction of pest resistant varieties. At the level of the still existing village plantations, one notes that the farmers do selective pod removal before pruning, phytosanitary treatment using non-recommended products and sanitation through elimination and burial of infected pods.

Experts:
Bah Bocco Gouse'yo
Akpo Louis (support personnel)
All the agronomic engineers at the National Institute of Agricultural Research in Benin
CARDERS who have extension services

Improvement of current methodology:
In order to improve the current system, one needs farmer field schools allowing farmers to manage their own plantations. They will undertake a managerial training on diagnostics and problem solving in their own plantations. Researchers and extension workers will work at their side to help educate them, whilst relaying information on any new technologies and facilitating information exchange through organised visits.

A step towards collaboration in cocoa IPM:
Aside from the forested galleries, lake edges and wooded lowlands (6000 ha approx.), Benin only plays a marginal role in cocoa cultivation. A close and active collaboration should be planned for and encouraged between Benin and big producer countries if the cocoa industry is to be re-launched to the status it formerly held in the 1980's, as second export product after cotton and ahead of oilpalm. A cocoa networking system would be essential.

Proposal for regional follow-up cocoa IPM research

Title

A regional IPM initiative for sustainable cocoa production in West & Central Africa

Description

Goal:

Sustainable improvement in the livelihoods of smallholder cocoa producers in West and Central Africa

Purpose:

Sustainable and cost-effective reduction in cocoa yield losses due to pests, while maintaining good cocoa quality

Outputs:

A. Sustainable and cost-effective management of black pod available
B. Sustainable and cost-effective management of mirids available
C. Sustainable and cost-effective management of stem borer available
D. Quarantine to prevent introduction of exotic pests (incl. diseases) strengthened
E. Best-bet IPM options validated with farmers

Activities:

A1. Selection and breeding of black pod resistant varieties
A2. Identification and exploitation of biological control agents
A3. Identification and exploitation of botanical pesticides
A4. Rational use of fungicides
A5. Screening of chemical elicitors
A6. Improve cultural management methods
B1. Develop efficient mirid rearing methods
B2. Selection and breeding of mirid resistant varieties
B3. Identification and exploitation of biological control agents
B4. Identification and exploitation of botanical pesticides
B5. Identification and exploitation of pheromones
B6. Improve cultural management methods
B7. Determination of economic threshold levels
B8. Rational use of insecticides
C1. Survey, collection and identification of stem borer and natural enemy species
C2. Study biology and ecology of stem borer
C3. Identification and exploitation of biological control agents
C4. Identification and exploitation of botanical pesticides
C5. Validate available management options
D1. Provide training and information to strengthen quarantine
E1. Surveying cocoa production areas for farmers' problems and management practices
E2. Curriculum development for farmer training in cocoa IPM

Summary of on-going and potential regional cocoa IPM research and implementation

Plenary inventory of on-going regional / national cocoa IPM research and implementation activities that contribute to the proposed regional cocoa IPM initiative

Proposed activities	Current regional projects	Current national projects (external funding)	Current national projects (national funding)
A1. Selection and breeding of black pod resistant varieties	Germplasm utilisation and conservation: a global approach (CFC/ICCO/IPGRI/Stabex), Ghana, Nigeria, Cameroon, Côte d'Ivoire		
A2. Identification and exploitation of biological control agents		Biological control of black pod disease in Central and West Africa (IRAD/MARS/STCP), Cameroon; Development of resistant varieties and search for biocontrol agents (STABEX), Ghana; Sustainable cocoa production: identification & exploitation of antagonists (ACRI), Côte d'Ivoire	
A3. Identification and exploitation of botanical pesticides			
A4. Rational use of fungicides		Emphasis on component research of Coffee-Cacao (FAC-Research), Cameroon	
A5. Screening of chemical elicitors		Use of phosphonic acid for control of *P. megakarya* (DFID), Ghana	
A6. Improve cultural management methods			Identification and evaluation of cultural methods (CRIN), Nigeria
B1. Develop efficient mirid rearing methods			Development of rearing methods for cocoa mirids (CRIG), Ghana
B2. Selection and breeding of mirid resistant varieties	Germplasm utilisation and conservation: a global approach (CFC/ICCO/IPGRI), Côte d'Ivoire, Cameroon, Ghana		
B3. Identification and exploitation of biological control agents		Development of mycoinsecticides and pheromones for cocoa mirids (DFID), Ghana	Identification and monitoring of indigenous natural enemies (CRIN), Nigeria; Identification and monitoring of indigenous natural enemies (CRIG), Ghana
B4. Identification and exploitation of botanical pesticides		Screening of botanical pesticides for the control of cocoa mirids (OCP Inc, USA), Ghana	

B5. Identification and exploitation of pheromones		Development of mycoinsecticides and pheromones for cocoa mirids (DFID / ACRI), Ghana	
B6. Improve cultural management methods			Identification and evaluation of cultural techniques (CRIN), Nigeria
B7. Determination of economic threshold levels			Determination of damage thresholds for mirids (CRIN), Nigeria
B8. Rational use of insecticides			
C1. Survey, collection and identification of stem borer and natural enemy species			Survey of peasant cocoa farms for stemborers and stemborer damage (CRIN), Nigeria
C2. Study biology and ecology of stem borer			Studies on the biology and ecology of cocoa stem borers (CRIG), Ghana
C3. Identification and exploitation of biological control agents			
C4. Identification and exploitation of botanical pesticides			
C5. Validate available management options			
D1. Provide training and information to strengthen quarantine			
E1. Surveying cocoa production areas for farmers' problems and management practices		Ecological cocoa production around Kakum national park (CI), Ghana	
E2. Curriculum development for farmer training in cocoa IPM		Ecological cocoa production around Kakum national park (CI), Ghana	

Discussion of follow-up on the regional proposal

1. *Potential for specific new regional activities*

Proposed activities which are not currently being addressed	Lead agencies to prepare national / regional project proposals
A3. Identification and exploitation of botanical pesticides	IRAD, Cameroon with CNRA, Côte d'Ivoire and CRIG, Ghana
B8. Rational use of insecticides	CRIN, Nigeria with CABI and CNRA, Côte d'Ivoire and IRAD, Cameroon, and CRIG, Ghana
C3. Identification and exploitation of biological control agents	CRIG, Ghana with Nigeria, Cameroon, Côte d'Ivoire with IITA
C4. Identification and exploitation of botanical pesticides	CNRA, Côte d'Ivoire with IRAD, Cameroon
C5. Validate available management options	CRIG, Ghana
D1. Provide training and information to strengthen quarantine	CABI with IITA, Benin, Cameroon, Côte d'Ivoire, Ghana, Guinea Conakry, Nigeria and in collaboration with Inter-African Phytosanitary Council

2. *Potential for taking the overall regional IPM initiative forward*

The workshop endorsed CABI and IITA as the international agencies to proceed with the fine-tuning and submission of the proposed regional IPM initiative for sustainable cocoa production in West & Central Africa, in consultation with potential donors and continued communication with the participating countries in the region.

Cocoa statistics (1996 – 2001)

Cocoa production figures per country over the past 5 years (source: FAOSTAT Database, http://apps.fao.org/)

Country	Cocoa beans	1996	1997	1998	1999	2000	2001
Benin	Area harvested (Ha)	-	-	-	-	-	-
	Yield (Hg/Ha)	-	-	-	-	-	-
	Production (Mt)	-	-	200	100	100	100
Cameroon	Area harvested (Ha)	360,000	360,000	360,000	370,000	370,000	370,000
	Yield (Hg/Ha)	3,492	3,522	3,472	3,108	3,243	3,108
	Production (Mt)	125,726	126,807	125,000	115,000	120,000	115,000
Côte d'Ivoire	Area harvested (Ha)	2,150,000	2,000,000	2,000,000	2,000,000	2,220,000	2,220,000
	Yield (Hg/Ha)	5,835	5,597	5,601	5,765	5,856	5,856
	Production (Mt)	1,254,480	1,119,108	1,120,260	1,153,000	1,300,000	1,150,000
Ghana	Area harvested (Ha)	1,050,000	1,074,970	1,364,530	1,300,000	1,500,000	1,350,000
	Yield (Hg/Ha)	3,838	3,000	3,000	3,059	2,911	3,037
	Production (Mt)	403,000	322,490	409,360	397,700	436,700	410,000
Guinea	Area harvested (Ha)	9,500	13,000	19,000	12,000	8,000	8,000
	Yield (Hg/Ha)	4,737	4,846	4,737	4,250	4,375	4,375
	Production (Mt)	4,500	6,300	9,000	5,100	3,500	3,500
Nigeria	Area harvested (Ha)	739,000	739,000	743,000	744,500	966,000	966,000
	Yield (Hg/Ha)	4,371	4,303	4,980	3,022	3,499	3,499
	Production (Mt)	323,000	318,000	370,000	225,000	338,000	338,000

- = No record available

Workshop programme

Day 1, Tuesday 13 November 2001

9:00 – 9:45h	1. Welcome and opening *Welcome and opening by Peter Neuenschwander* *Workshop announcements by Janny Vos*
9:45 – 10:15h	2. Introduction of workshop participants *Self-introduction of all participants, indicating name, country, institution, discipline, cocoa experiences*
10:15 – 10:45h	Group picture and Coffee break
10:45 – 12:00h	3. Keynote addresses *3-A. Peter Neuenschwander, on behalf of STCP: 'Context of cocoa IPM within STCP'* *3-B. BCCCA* *3-C. DFID Crop Protection Programme* *3-D. Keith Holmes (CABI): 'Biological control in tree crops in the tropics'*
12:00 – 13:00h	Lunch break
13:00 - 13:30h	Set-up posters and exhibitions
13:30 – 15:00h	4. Cocoa IPM research and implementation presentations per participating country *4-A. Benin (Institut National de la Recherche Agronomique Benin)* *4-B. Cameroon (Institut de la Recherche Agronomique et Developpement)* *4-C. Côte d'Ivoire (Centre National de la Recherche Agronomique)*
15:00-15:30h	Tea break
15:30 – 17:00h	Continue session 4 *4-D. Ghana (Cocoa Research Institute Ghana)* *4-E. Guinea Conakry (DPDRE)* *4-F. Nigeria (Cocoa Research Institute Nigeria)*

Day 2, Wednesday 14 November 2001

9:00 – 9:15h	Summary of Day 1 activities; Introduction programme Day 2
9:15 – 11:00h	5. Regional working group sessions on cocoa IPM research (working coffee break half-way through)
11:00 – 12:00h	Tour of IITA laboratories and museum
12:00 – 13:00h	Lunch break
13:00 – 15:00h	6. Regional presentations of working groups *Working group presentations with brief discussions*

15:00 – 15:30h	Tea break
15:30 – 17:00h	7. Discussion towards joint follow-up cocoa IPM research
17:00 – 18:30h	Cocktail at IITA

Day 3, Thursday 16 November 2001

9:00 – 9:15h Summary of Day 2 activities; Introduction programme Day 3

9:15 – 10:00h	8. Keynote address *Francis Baah (CRIG): 'Farmer participatory approaches towards cocoa IPM implementation'*
10:00 – 12:00h	9. National working group sessions on cocoa IPM implementation (working coffee half-way through)
12:00 – 13:00h	Lunch break
13:00 – 15:00h	10. Country-wise presentations on IPM implementation *10-A. Nigeria (Cocoa Research Institute Nigeria)* *10-B. Guinea Conakry (DPDRE)* *10-C. Ghana (Cocoa Research Institute Ghana)* *10-D. Côte d'Ivoire (Centre National de la Recherche Agronomique)* *10-E. Cameroon (Institut de la Recherche Agronomique et Developpement)* *10-F. Benin (Institut National de la Recherche Agronomique Benin)*
15:00 – 15:30h	Tea break
15:30 – 16:30h	11. Discussion towards joint follow-up cocoa IPM implementation
16:30 – 17:00h	12. Closing of the workshop *Workshop summary by Janny Vos* *Workshop impression by representative of participants*

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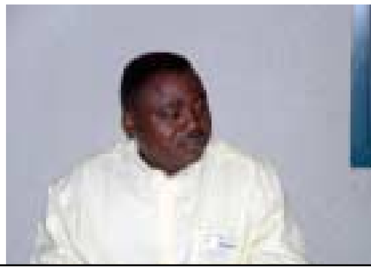

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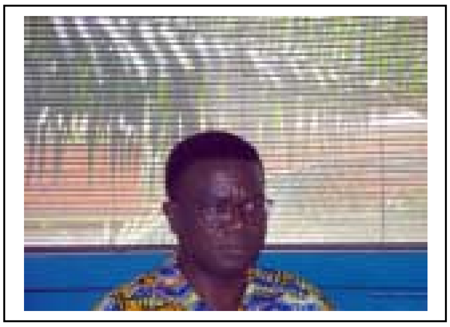

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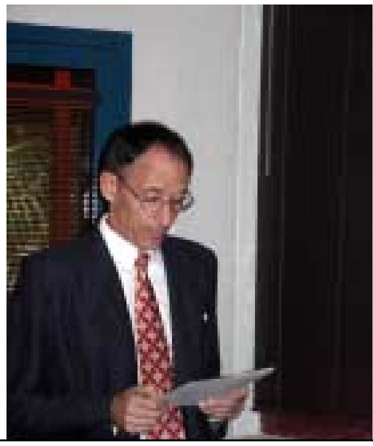

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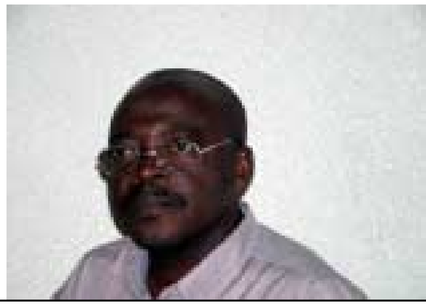

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