Farmers' knowledge and perception of cotton pests and pest control practices in Benin: results of a diagnostic study

A.A.C. Sinzogan[1,*], A. Van Huis[2], D.K. Kossou[1], J. Jiggins[3] and S. Vodouhè[1]

[1] Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, 01 BP 526 Cotonou, Benin
[2] Laboratory of Entomology, Wageningen University, Wageningen, The Netherlands
[3] Communication and Innovation Studies Group, Wageningen University, Wageningen, The Netherlands
* Corresponding author (e-mail: sinzogan2001@yahoo.fr)

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Abstract

Cotton production constraints in Benin as perceived by farmers were studied from May to July 2003. The knowledge, perceptions and practices of farmers growing cotton under different pest management regimes were analysed. The methods used were open and semi-structured interviews with groups and individuals, as well as participatory exercises (brainstorming, prioritization, and problem analysis). Pest damage, low price of produce, late payment for seed cotton, and increasing input costs were the main production constraints perceived by producers. Regardless of the pest management system practised, most of the farmers adapt the recommendations of the research institute and non-government organizations to their livelihood systems. In general, farmers had a poor understanding of the key concepts underlying alternative pest control systems. Pest damage was considered important and farmers were eager to share their knowledge, perceptions and practices in pest management. The study provides the foundation for the creation of a learning platform; actors will be invited to collaborate in participatory experimental agricultural technology development linked to the farmers' needs. In order to develop sustainable pest management strategies further interactive research is proposed, involving all stakeholders.

Additional keywords: integrated pest management, farmers' knowledge, interactive research

Introduction

Cotton is by far the world's leading textile fibre. For many developing countries that grow and process it, the crop is vital for employment, and rural and industrial development (Morris, 1990). Cotton is the largest foreign exchange earner in nine developing countries, including Benin (Morris, 1990).

In less than 20 years, cotton production in Benin has increased fourfold (Raymond & Beauval, 1995; Biaou & Ahanchédé, 1998; Anon., 2002a). From 1994 to 1996 Benin was the second ranking sub-Saharan African country in terms of production. However, the higher production was not attained by higher yields but by an increased acreage (400% from 1988 to 1998). Over the last decade the production system has degraded, experiencing more expensive inputs, delayed cotton payments, problems of injudicious use of chemicals, and increased insect resistance to pesticides, e.g. *Helicoverpa armigera* (Lepidoptera: Noctuidae) against pyrethrenoids. As a result, cotton yields dropped below 1000 kg ha^{-1} between 1997 and 2000 (Raymond & Beauval, 1995; Anon., 2002a; Ton, 2002; Anon., 2003). The Cotton Research Institute of Benin in 2002 conducted research revealing that farmers do not respect the institute's recommendations, such as the pesticide quantities to be applied. The farmers cited as reasons the onerous price of pesticides and the fact that they are not convinced that the use of the recommended pesticide against aphids would improve yields (Anon., 2002a).

Cotton production in Benin seems to be on the classical 'pesticide treadmill' in which heavy reliance on synthetic pesticides works well for several years and then in the end proves to be disastrous (Castella *et al.*, 1999). Once on the treadmill, the farmer faces spiralling pesticide input costs, increased pest problems and lower yields, which eventually make cotton production uneconomic. Indiscriminate use of pesticides often causes pest resistance and/or resurgence because they also destroy the beneficial fauna. The question is how to increase production in a sustainable manner without compromising public health and the environment, while conserving the natural enemies and avoiding the development of pest resistance? Are there ecologically based alternatives? It has been argued that a crop production system that does not rely heavily on chemical inputs but that nevertheless produces an adequate yield will ensure economic and environmental sustainability, e.g. the Integrated Pest Management (IPM) approach (Mengech *et al.*, 1995; Röling & Van De Fliert, 1998; Anon., 2000; Matteson, 2000). Several IPM technologies have been developed but they have not been widely adopted. This could be explained by several reasons among which (1) a 'non-diagnosis' of farmers' real problems, (2) a lack of fit between the proposed techniques and the local farming systems and livelihood strategies, and (3) limited availability of and access to external inputs.

Technographic studies conducted in Benin in 2002 (Kossou *et al.*, 2004) aimed at getting a general overview of the technological innovation landscape of a sociotechnical system in a country (Richards, 2001). From these studies it was concluded that innovations in pest management (pertinent research priorities) need to be based on the perspective of the cotton producers. However, technographic studies stay at a very high level of aggregation in determining fields of research priorities. Such a research priority should next be explored in relation to a specific research site. And that is where diagnostic studies are aimed at (Richards, 2001). If scientists were to work more closely with farmers to improve crop production and protection, they might come to recognize farmers' constraints and their existing technical knowledge as the basis for an effective collaboration (Morse & Buhler, 1997).

So subsequent to the technographic studies, diagnostic studies were carried out, which addressed farmers' real problems, needs and opportunities. This in order to identify the most pertinent research priorities at each specific site. The study reported here is the first of a number of path-dependent steps (Lee, 2002), undertaken as an entry point to a longer process of collaborative research, as stated in the introductory chapter of this special issue (Röling *et al.*, 2004). The study focuses on the following issues: (1) the plant production and protection problems perceived by farmers as most important, and (2) farmers' knowledge, perceptions and practices (KPP) in pest management. At the end, the paper also points out the options towards the next step of collaborative research.

Materials and methods

Study area

Cotton in Benin is produced in six agro-ecological zones (Figure 1), which differ in environmental characteristics, population distribution and cropping patterns. Three zones were selected where most of the production is concentrated (II, III, and IV) and a low-production zone (VI) was added for comparison.

In these agro-ecological zones services to cotton farmers are actively provided by three organizations: (1) the extension service 'Centre d'Action Régionale pour le Développement Rural' (CARDER), (2) the non-government organization (NGO) 'Organisation Béninoise pour la Promotion de l'Agriculture Biologique' (OBEPAB), and (3) the project 'Projet d'Amélioration et de Diversification des Systèmes Exploitations' (PADSE) sponsored by the World Bank, and of which the cotton pest management part was implemented by the Cotton Research Institute. A number of farmer organizations are also present in these zones. In collaboration with CARDER, OBEPAB, PADSE and farmer organizations, one municipality was selected in each selected zone (Figure 1) based on the presence of service providers and the type of pest management system used in order to include all the actors and the different pest control regimes applied. The three major pest management systems are:

1. The Conventional Control System (CCS) involving calendar spraying of chemical pesticides with in total 6 applications per season at 2-week intervals starting 45 days after sowing. The first two applications are with a simple insecticide such as endosulfan and the four subsequent ones with a mixture of two active ingredients;
2. The Targeted Staggered Control System (TSCS), which is the CCS but with reduced insecticide dosages. Half the amount of pesticide is used while periodic field scouting assesses whether insect pest numbers exceed the economical threshold level, and if so a specific insecticide is used to control this pest;
3. The Organic Control System (OCS) based on the use of botanical pesticides and manual removal of bollworms.

The pest control system in use was inventoried for the villages in each municipality. A total of seven villages (Figure 1) were randomly selected. In each of the zones II, III

Figure 1. Map of the Republic of Benin, with cotton production agro-ecological zones (I–VI) and villages selected for the diagnostic study (adapted from Raymond & Beauval, 1995).

and V, two villages were selected: one with only CCS growers, and the other with CCS and either OCS or TSCS growers. In zone VI, where only conventional cotton is produced, one village was selected. The study was conducted from May to July 2003, which was the beginning of the cotton-growing season.

Methodology and tools

The methods used are based on the procedures of gathering evidence and analysing agricultural problems documented by Werner (1993), Pretty *et al.* (1995), Anon. (1997), Chambers (1997) and Mutsaers *et al.* (1997). Figure 2 shows the overall design of the data collection. Primary data gathering included group discussions (with farmers, key informants, and representatives of farmer organizations), individual interviews, and field observations. Secondary data gathering concerned the collection of general information. At the end of the village meetings (Figure 2), farmers were invited to participate in the continuation of the study. The selection of farmers for individual interviews or group discussions was based on the willingness of the farmer to participate. The total number of volunteers per village for individual interviews was limited to 20. An average of 112 male and female farmers participated in group discussions (69 CCS of which 7 females; 16 TSCS of which 2 females; 27 OCS of which 10 females), and 126 male and female farmers were interviewed individually (78 in CCS of which 7 females, 20 TSCS of which 2 females, and 28 in OCS of which 11 females). The difference between the number of participants in group discussions and individual interviews was due to the fact that some participants in individual interviews did not participate in the group discussions and vice versa.

The methods and tools used for collecting the information are listed in Table 1. Semi-structured interviews with groups, participatory exercises (brainstorming, prioritization, and problem analysis), and open discussions in a group setting were used to identify production constraints. Selected farmers were individually interviewed using open and semi-structured interviews, combined with field observations, in order to elicit their KPP in pest management. KPP issues were related to the farmers' ability to identify cotton pests and natural enemies, their knowledge of pest occurrence during the year, their pest management practices, their perceptions of the effects of pesticide use, and their application of pesticides meant for cotton but applied in other crops. In addition, farmers were interviewed about their age, education, etc., and their objectives in producing cotton. On the average each interview took one hour. Since the period of the survey coincided with the beginning of the cropping season it was not possible to cross check farmers' answers regarding the seasonal pest infestation with field observations.

Results

Farming systems

Agriculture in all four selected zones used to be based on shifting cultivation. However, this practice is no longer used, due to the unavailability of idle land (increase of the active population with regard to land). Farmers now cultivate the same piece of land more or less continuously.

Smallholdings on which a small range of crops is grown represent the dominant farm type. The survey revealed that cotton production units average 5 ha with a maxi-

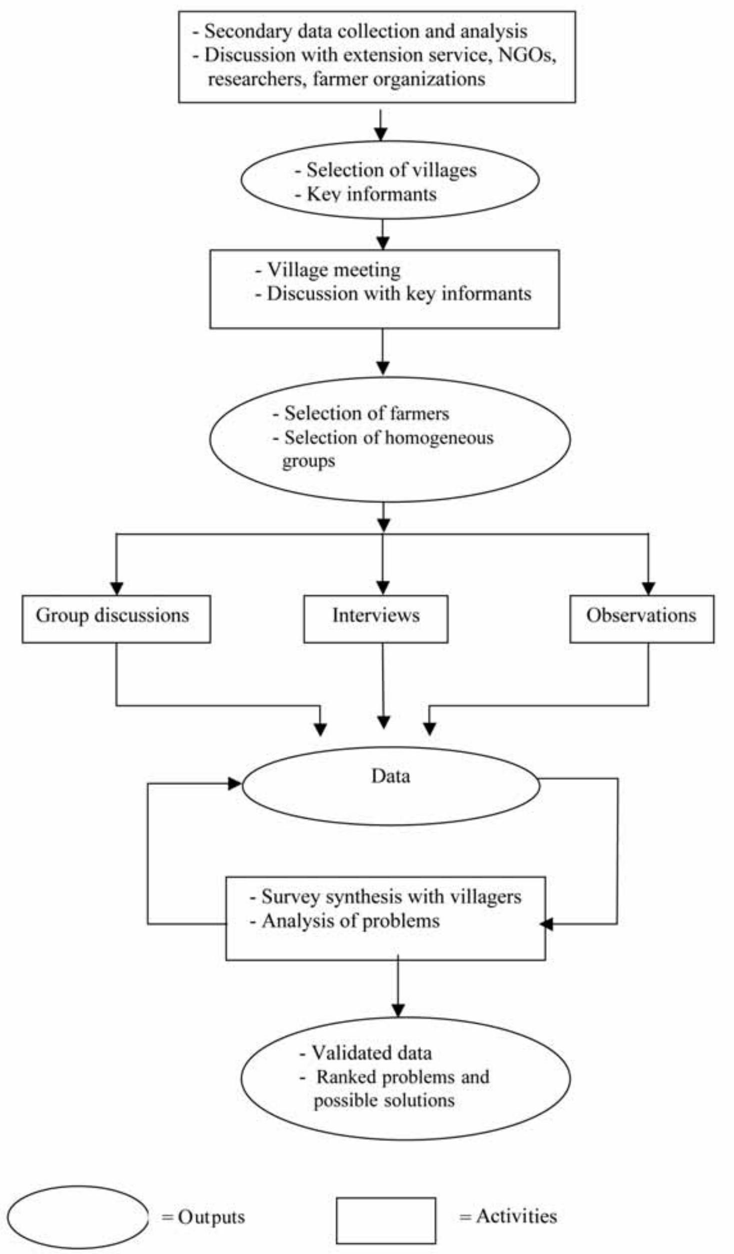

Figure 2. Master plan for data collection.

Table 1. Objectives and methods for the collection of data on cotton production and pest management in different villages in Benin.

Objectives	Activities	Methods/tools	Information collected	Target respondents
Selection of villages Selection of key informants	Collecting secondary data Discussions with extension service, local leaders, missionaries, NGO's Observations	Maps Reports (government, NGOs, development project) Publications Personal communication	Physical and socio-economic conditions Village social structure Demography Cotton production strategies	Scientists NGO agents Extensionists Local leaders
Production constraints Pest problems Solutions for constraints or problems	Village meetings Open and semi-structured interviews Group discussions (brain-storming and prioritization exercises) Verbal information	Check lists Papers for brainstorming and prioritization exercises	Constraints by subject area subdivided into specific problems Pest problems Possible solutions for each problem	Individual farmers Farmer groups Women organizations
Farmers' knowledge, perceptions and practices with respect to pests Social aspects of pesticide use	Open and semi-structured interviews Observations (cross-check farmers' answers) Verbal information	Check lists Pest books Existing pest strategies handbooks	Seasonal calendar of production and pest infestation Identification of cotton pests and natural enemies Pest management practices Pesticides used Timing and frequency of pesticide applications Advantages and disadvantages of pesticides as perceived by farmers Use of pesticides outside cotton (medicine, poison, other crops etc.)	Individual farmers Farmer groups Farmer organizations Women organizations
Input (pesticides) supply system	Open and semi-structured interview Observations Group discussion	Check lists	Pesticides used Pesticide provider sources Role of farmer organizations	Individual farmers Farmer groups Farmer organizations NGO agents Local dealers

mum of 14 ha for CCS and TSCS, and from a minimum of 0.5 ha to a maximum of 4 ha for OCS. The percentage cultivated area planted to cotton decreases along a gradient from north to south. In the CCS and TSCS, cotton is grown as a monoculture in rotation with other crops. Organic cotton is grown in two- or three-year rotations with cereals and legumes and as an intercrop with a variety of other crops, including maize.

In the area where cotton is intensively cultivated (Kpèdè, Koutakroukou, Gounin), some farmers use animal traction to plough their fields. In the south of zone III, tractors are used because, according to the farmers interviewed, conditions are unfavourable for cattle keeping. In the south (Sètto, Mangassa, and Damèwogon), tillage is done manually using hoes. The labour used in the four zones is both domestic and hired. Women and children mostly do the time-consuming operations such as weeding, harvesting, and fetching water for mixing chemicals, while men handle the cotton inputs, mix the chemicals and wash out the containers. Women complained that they have to do these operations in their husbands' fields before they are allowed to cultivate their own plots. As a result they indicated that they are always late in carrying out the necessary operations in their own fields, leading to low yields.

The cotton variety H279-1 is sown throughout the study area and provided free of charge by the cotton regulatory body 'Association Interprofessionnelle du Coton'. In the CCS and TSCS, cotton seed is treated with fungicide before it is made available to the farmers. In the OCS, the use of pesticide-treated seed is prohibited. The Organic Cotton Project (OBEPAB) tries to supply the farmers with seeds from crops not treated with chemical pesticides and does not treat the seed. Farmers are organized in producer groups called 'groupement villageois' that take care of cotton seed purchases and issues such as seed and input distribution.

In the study area, cotton is the main source of cash income. In the most important production zones (II, III), everything is linked to cotton; farmers pay for everything with money that 'grows on cotton' (their clothing, building their homes). One farmer said, "We depend on cotton not just to live but also to survive".

Farmers' perceptions and analysis of production constraints

In the study area, low yield was identified as the main problem. The main priority of farmers is to look for ways to increase the yield. Farmers mentioned technical, institutional and socio-economic production constraints. Technical problems relate to pest damage, low soil fertility, and weed problems, whereas institutional and socio-economic problems relate to delays in payments for seed cotton, low price of produce, expensive inputs, lack of technical assistance, and lack of labour. Farmers prioritized these constraints differently in each pest control system (Table 2).

Each of these constraints was analysed with the farmers in group exercises using participatory constraint analysis. It followed from the participatory constraint analysis that institutional and socio-economic constraints lie at the root of the technical constraints (Figures 3 and 4). Only one technical reason was given, *viz*. the inefficiency of pesticides (Figure 5) as a cause of pest problems; all the other reasons given were socio-economic.

Table 2. Cotton production constraints as perceived by farmers in 9 villages of Benin, by pest control system. Responses expressed as product of number of farmers × their ranking; the lower the score the more important the constraint. Empty cells indicate 'no constraint'.

Production constraint	Villages								
	Conventional control system						Organic control system		Targeted staggered control sysem
	Kpèdè (n = 18)	Koutakroukou (n = 7)	Maréborou (n = 14)	Sètto centre (n = 8)	Mangassa (n = 8)	Damè-wogon (n = 14)	Koutakroukou (n = 9)	Mangassa (n = 18)	Gounin (n = 16)
Delay in seed cotton payment	48	9	14	24	9				32
Low price of produce	52	30	39		16	52			46
High price of inputs	70	18	48			46			
Late sowing	73						21		
Pests	75	25	28	22	23	17		21	28
Corrupt cotton quality controllers		27		26					
Low soil fertility						25	14	42	
Lack of labour							16		54
Low yields of new varieties			29						
Weeds				8					
Lack of credit								55	
Lack of rain								62	

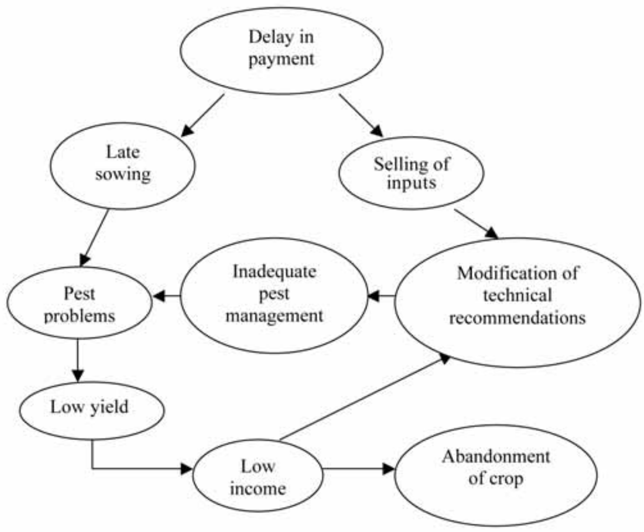

Figure 3. Analysis with farmers of the constraint 'Delay in payment'.

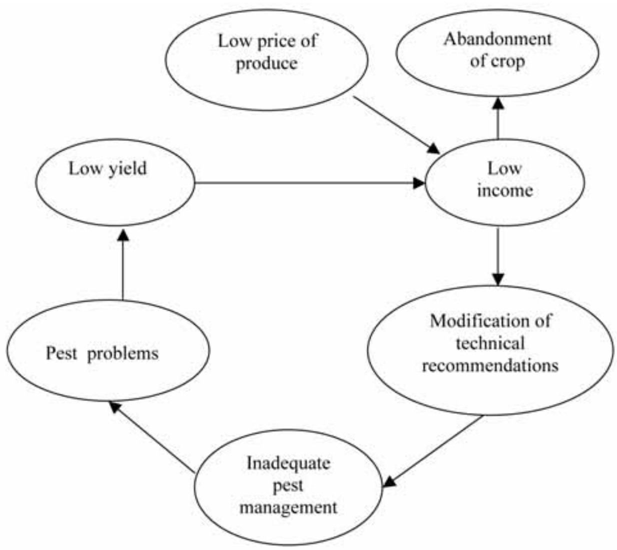

Figure 4. Analysis with farmers of the constraint 'Low price of produce'.

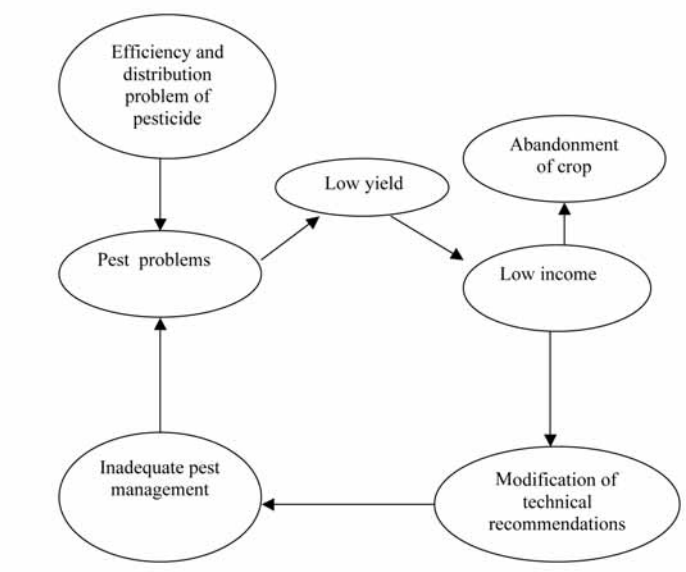

Figure 5. Analysis with farmers of the constraint 'Pest problems'.

Farmers' knowledge, perceptions and practices

Farmers' profile, experience and objectives

The age of the cotton producers interviewed was between 20 and 70 years. Slightly more than 95% of the producers were younger than 45 years in the CCS and TSCS, whereas in the OCS most growers were older than 45. Almost all the growers using TSCS and OCS had previously used the conventional method. The main reasons given for changing their pest management system included: receiving crop payments earlier, pesticide poisoning problems, and larger profits gained by using cheaper inputs like botanical pesticides.

Most of the farmers interviewed were illiterate. They had not attended any extension courses on pest management, except in two villages (Mangassa and Damèwogon) where some NGOs, like OBEPAB, or a project like the IPM cowpea project (dealing with farmers' field schools to facilitate the introduction of IPM in the cowpea cropping system in Ouémé valley, Benin) had facilitated extension courses in previous years.

The farmers' main objective in growing cotton was to earn cash income, as it was almost the only crop able to provide it.

Farmers' perception of pest infestation and natural enemies

The majority of farmers used descriptive rather than specific names when naming a pest. However, the organic cotton growers in Mangassa gave each insect a specific name because they had attended an extension course dealing with the recognition of cotton pests. In general, the same term was used for various insects. A commonly

used term was *koko* or *wanvu* meaning worm or caterpillar, and *yeru kanounou* or *nouvinouvi*, meaning insect in the languages Baatonou and Fon, respectively.
A specific name was given to the cotton stainer, *Dysdercus* sp. (Heteroptera: Pyrrhocoridae) in various local languages. Among well-known insects were the leaf-roller, *Sylepta derogata* (Lepidoptera: Pyralidae) and the cotton stainer. Farmers (except the farmers in Mangassa) had difficulties in distinguishing the different bollworms and only were able to describe its damage (young bolls drop, mature boll damage, etc.). They acknowledged in all of the four zones that the bollworms were already present before the period when they were supposed to make the first pesticide application, and that the bollworms peaked in the period when they were supposed to give the third pesticide application.

About 75% of farmers, irrespective of the pest management system practised, were able to relate a pest to the phenology of the plant. They perceived the reproductive stage as the most infested and bollworms as the most damaging pest (Table 3). Organic farmers identified the cotton stainer as the most frequently observed insect whereas farmers in the CCS and TSCS recognized bollworms as the most frequently observed (Table 3).

Table 3. The most frequent and the most dangerous cotton insect pests and the most vulnerable plant stage as perceived by cotton farmers in five villages in Benin, by pest control system. Responses expressed as percentages of number of farmers (n) interviewed.

	Pest control system					Average
	Conventional			Organic	Targeted staggered	
	Kpédè (n = 20)	Koutakroukou (n = 12)	Damè-wogon (n = 18)	Mangassa (n = 18)	Gounin (n = 20)	
Most frequent pest						
Leaf roller/hopper	30	33	33	15	10	24
Bollworm	65	59	61	31	80	60
Cotton stainer	5	8	6	54	10	16
Most dangerous pest						
Leaf roller/hopper	20	17	0	11	20	14
Bollworm	80	75	100	72	70	79
Cotton stainer	0	8	0	17	10	7
Most vulnerable stage						
Vegetative	5	8	22	11	15	12
Flowering	90	75	73	78	80	79
Ripening	5	16	5	11	5	9

Only a few farmers from Mangassa and Damè-wogon had any knowledge about natural enemies. When asked how they had acquired this knowledge, the answer was that they had learned it through extension courses.

Farmers' knowledge and perceptions of pest control methods

Farmers using chemical pesticides differed in their opinion of the efficiency of pesticides (Table 4). More than 40% of the CCS farmers were of the opinion that endosulfan controlled the whole pest complex when it was first introduced but that it did not do so at the time of the interviews, whereas more than 50% thought that it still did. These perceptions were similar among the TSCS farmers (Table 4). Farmers in both systems indicated that the insecticides (different in the two systems) used for the third and following applications were not effective (Table 4). Farmers using chemical pesticides (in CCS and TSCS) affirmed that they would only accept a protection programme that aimed to reduce the number of treatments if it ensured an equal or higher yield. The organic farmers thought that by using botanical pesticides they only 'put the insect into a dream' and were obliged to remove the insect manually. "This action is not possible over a big area", said one farmer.

Table 4. The efficacy of the first six chemical pesticide[1] applications in cotton, as perceived by farmers using the conventional and the targeted staggered pest control system. Responses expressed as percentage of number of farmers (n) interviewed.

Efficacy	Pest control system					
	Conventional (n = 78)			Targeted staggered (n = 20)		
	Applications: 1 & 2	3 & 4	5 & 6	Applications: 1 & 2	3 & 4	5 & 6
Moderate	43	6	4	30	5	5
High	52	0	0	65	0	0
Low	0	90	95	0	90	90
No opinion	5	4	1	5	5	5

[1] Endosulfan is used for applications 1 & 2 in both systems; other pesticides are used for the remaining applications.

Farmers' practices in pest management

There was a wide range in the number of insecticide applications. Nearly 70% of the CCS and OCS farmers did not respect the number of pesticide applications recommended by research (including botanical ones), which was six for the CCS and seven for the OCS (Table 5). In the STCS, almost all farmers interviewed respected the basic programme of spraying, which consisted of six applications of reduced insecticide dosage (half a litre of pesticide instead of one; using simple insecticides instead of binary mixtures). However, there were many who had not carried out the obligatory periodic field scouting to reinforce the basic programme. Many conventional farmers used less than the recommended 8 litres of insecticide per ha. Some of them used only endosulfan for all their applications although it was only recommended for the first two. Some combined half the dose of the recommended pesticides with some local botanical insecticides (caïlcédrat – *Kaya senegalensis*) and indicated that the mixture controlled the cotton pests. They also started applications later than the recommended 6 weeks after plant emergence and did not follow exactly the interval of 15 days between subsequent applications. It was very difficult to compare organic farmers' practice with what they had learned. The flexibility of the organic control system allowed adding some ingredients to the basic recipe of 2 kg of neem (*Azadirachta indica*) seed based spray per ha. However, all of them admitted that they had difficulties in applying the quantity recommended and to respect the application time.

A number of farmers confessed that they used cotton pesticides for other purposes such as protecting maize in storage or cowpea in the field, and for controlling termites. Furthermore, they used cotton pesticide containers for water storage.

Table 5. Pesticide application regime used by cotton farmers. Responses expressed as percentage of number of farmers (n) interviewed.

Frequency of application	Pest control system		
	Conventional (n = 78)	Organic (n = 26)	Targeted staggered (n = 20)
Less than recommended	67	65	20
Same as recommended	20	23	70
Higher than recommended	5	3	5
Farmer does not know	8	9	5

Discussion

Farmers were very clear about the constraints limiting their production. Low yield was identified as the main problem facing cotton producers, which is reflected in the official figures of yields lower than 1000 kg ha^{-1}. One reason underlying the causes of low yield is probably the recent policy change in the cotton industry. The leading role of the government has been transferred to new organizations and the private sector, and inputs are no longer subsidized. As a result, the input cost has increased. In addition, the producer price of seed cotton is linked to the price on the world market, which is unstable, with a slight decreasing trend over the last five years (Anon., 2002b). In response to the high price of inputs and the low price of produce, some farmers modify the input recommendations, while others abandoned cotton production altogether. Modification of input recommendations could lead to an inadequate pest management regime and thus contributing to the perpetuation of low yields. The development of an appropriate 'production chain and an appropriate research and development system' are needed to cope with this situation. The World Bank, a major contributor to the agricultural sector and sector policy in Benin, argues, however, that such an approach would cost too much and it has been reluctant to invest in the development of a more effective pest management regime (Röling & Richards, 2002).

In the light of cotton growers' knowledge and perceptions of pest problems, there are several obstacles to improving cotton pest management in Benin. The farmers in this survey were modifying the research institute's and NGOs' recommendations. Thus it appears that "Technology usually changes as knowledge products change through the knowledge system, and that farmers 'reinvent' technologies before incorporating them in their production system" (Schoubroeck, 1999). The Transfer of Technology (ToT) model is not conducive to adoption of more effective pest management regimes. In the ToT model, adoption is supposed to happen through a linear flow of information (Schoubroeck, 1999) and in this way lacks flexibility (Hounkonnou, 2001). It appears that the conventional process of innovation development itself needs to be questioned. Leeuwis & Van Den Ban (2004) suggested Kolb's (1984) model of 'experiential learning' for organizing the communication of complex innovations. A well-documented example of the experiential learning approach to IPM, the Farmers Field School, draws heavily on Kolb's learning theory (Van De Fliert, 1993).

Another constraint on improving pest management is the lack of knowledge among farmers of insect biology and ecology. For instance, farmers' lack of knowledge of the life cycle of bollworms, and of predators of bollworms, indicates the inappropriateness of using bollworm scouting as a tool for control decisions, as proposed by the TSCS. Another consideration is that it seems that relatively few farmers have ideas about beneficial insects; farmers more commonly regard these insects also as pests and would be inclined to apply insecticides when they are spotted. All the farmers relying on the CCS and TSCS used endosulfan. The perceived high effectiveness of this insecticide, although by no means general, presumably induced some farmers to adopt this insecticide for all applications (instead of using it only for the first two applications as recommended). It may be concluded that appropriate rural education based on discovery learning, could help farmers to acquire basic skills and understanding in terms of differentiating the insects found in their cotton crop, and developing confidence in the effectiveness of integrated pest management strategies.

The results show that farmers' technical problems are grounded in a range of socio-economic problems and that current recommendations do not fit in well with these conditions. This finding gives rise to an 'open door' that technical recommendations need to fit the real context – or that socio-economic interventions need to complement technical research and development. The results further suggest that because the cash return is the strongest motivating factor in cropping and livelihood strategies, 'effective' pest management must be a 'cost-effective' option. The discussions held with farmers and service providers indicate willingness for collaborative investigation, designing and testing of the selected options.

Options towards the next steps of collaborative research

Farmers in the Gounin and Mangassa villages considered pest problems to be the primary cause of low cotton yields. Farmers in these villages are enthusiastic about interacting with scientists concerning the development of their KPP in pest management. This eagerness could be seen as a prerequisite for the development of a participatory technology development programme (Anon., 2000). Therefore, the two villages (Mangassa and Gounin) have been chosen as the location of future studies. In Mangassa there are two groups of growers dealing with contrasting production systems (conventional and organic), a situation that offers the prospect of being able to draw interesting comparisons. The Gounin growers deal only with the targeted staggered control system.

It was agreed with farmers that 'bollworm management' be taken as the entry point. Farmers considered the bollworm as the most dangerous or risky pest with regard to yield loss. However, they did not make a distinction among bollworms and merely described the damage caused. The fall or drop of the young bolls could be due to *Helicoverpa armigera*, which is most frequent in zone II, or *Diparopsis watersi* (Lepidoptera: Noctuidae) most frequent in zone V. Also, the deficient farmers' control practices documented in the study could increase bollworm populations at the local level. As the next stage in the process of the collaborative research, farmers in the two villages will be asked to participate in an in-depth diagnostic study. They will be asked to identify more exactly the pest species causing the bollworm damage they described. The aim is to learn also more about the 'gap' between research findings and farmers' practices, an important step in the IPM development process (Van Mele, 2000), and about the factors that influence farmers' KPP. For instance, why do the TSCS farmers just follow the basic spraying programme, and do not undertake the obligatory and vital periodic field scouting to reinforce the basic programme?

The challenge is not just to develop pest management strategies that are more productive, effective and safe than the current systems, but also how to bring the different actors who have different perspectives and experiences of pest management strategies, to work together in an integrated way. The choice of a methodology will be important, as its actors need to bring forth a jointly agreed strategy for pest management. The principle of experiential learning developed by Kolb (1984) can be used as a general guideline of the processes involved. At the end of the in-depth diagnostic study, the volunteer farmers selected will be establishing a local 'learning group'. The research agenda for the subsequent phases of experimentation will be 'negotiated' with the 'learning group' in collaboration with the local extension agent and the local representative of cotton research.

The biggest challenge for those promoting more sustainable cotton pest management strategies is to find an arrangement by which scientists and farmers can interact to develop a control system that works and will be accepted by farmers. Instead of using only flipcharts, field days, and visits (Anon., 2000), a sensible involvement of farmers in research activities for adaptive/innovative purposes will form the basis of the research process. Alternative control methods identified during the diagnostic study will be tried out in collaborative experiments. That is, the experiments will be jointly planned, monitored and evaluated (Van Veldhuizen, 1995).

Farmers complained that the conventional pest management strategy does not work, and that pest scouting is too complicated and too time-consuming. Is this caused by the information delivery system or are the strategies not sound? The effectiveness and acceptability of the existing pest management systems will be assessed, together with the learning group.

In the specific context of socio-economic problems that lie at the root of technical problems (pests) it was agreed with the farmers of all seven villages that some of their constraints, such as delayed seed cotton payment, low producer price, and the difficulty of obtaining inputs (related to distribution and price), also would be investigated. In particular, the new roles of actors in the cotton production and processing chain and post-liberalization of the cotton production system will be looked at.

Conclusions

This study reports the results of a participatory diagnosis of current cotton production constraints and opportunities, and has provided insight into farmers' capabilities and needs. The farmers described a complex situation in which a range of biotic and abiotic factors constrained their cotton-based livelihoods. Cotton farmers in Benin in many respects were similar to most traditional small-scale farmers in sub-Saharan Africa. Most were illiterate. They had limited comprehension of the key variables governing safe, effective and sustainable pest management. In this context, it is a challenge to develop pest control strategies such as IPM or organic control systems that offer reliable alternatives to chemical-based strategies. Clearly, a need identified is the lack of basic knowledge and skills and a possible way to respond to this need is facilitating discovery learning.

The diagnostic study allowed the conventional research process itself to come into question. Clearly, an approach is needed that does not pre-define the variables to investigate or the solutions that could be proposed. The encounter described between farmers and researchers provides the basis for the establishment of a 'learning platform' on which actors collaborate in participatory, experiment-based agricultural technology development, linked to the farmers' needs and the dynamics of local pest ecologies.

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