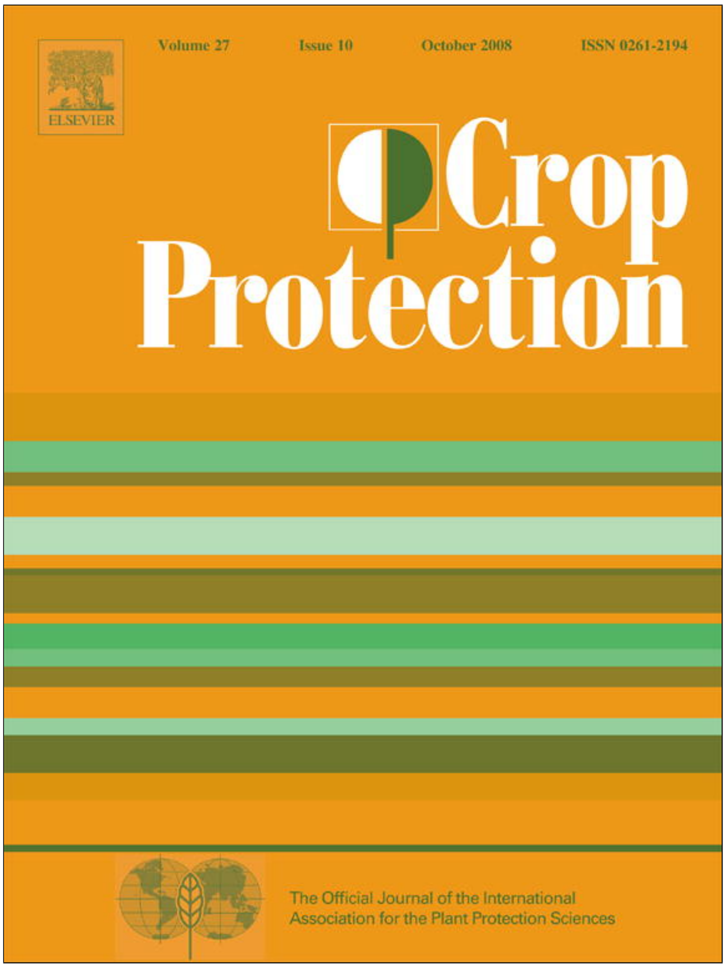
Volume 27
Issue 10
October 2008
ISSN 0261-2194
ELSEVIER
Crop Protection
The Official Journal of the International
Association for the Plant Protection Sciences

Crop Protection 27 (2008) 1327–1334

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Trends in pesticide use and drivers for safer pest management in four African countries

Stephanie Williamson[a,*], Andrew Ball[b], Jules Pretty[c]

[a] International Project Officer, Pesticide Action Network UK, Development House, 56-64 Leonard Street, London EC2A 4LT, UK
[b] Chair in Environmental Biotechnology, School of Biological Sciences, Flinders University, Sturt Road, Bedford Park, Adelaide, SA 5001, Australia
[c] Head of Department of Biological Sciences, University of Essex, Colchester CO4 3SQ, UK

ARTICLE INFO

Article history:
Received 17 December 2007
Received in revised form
23 April 2008
Accepted 27 April 2008

Keywords:
Pesticides
Smallholder farmers
Food safety
Africa
IPM
External costs

ABSTRACT

Patterns in pesticide practice were studied among smallholder farmers in Benin, Ethiopia, Ghana and Senegal, growing cotton, vegetables, pineapple, cowpea, and mixed cereals and legumes, for export and local markets. Quantitative and qualitative methods were used to examine pesticide use and handling, costs and access and health, welfare and sustainability issues. Drivers encouraging pesticides as the dominant form of pest management include food staple varieties highly susceptible to insect attack; increased pest incidence; lack of advice on alternative methods; a growing informal market in 'discount' and often unauthorised pesticides; subsidy; and poor attention to the economics of pest control. The paper contrasts the situation of food crops for African consumers with the increasing attention to food safety and pesticide restrictions in export horticulture to Europe and the growing demand for organic cotton, and discusses challenges for implementation of IPM and safer practice.

1. Introduction

Pesticide use in Africa accounts for only 2–4% of the global pesticide market of US$31 billion (Agrow, 2006). But accurate data on actual pesticide use in developing countries and trends in use at national level or for major cropping systems are rarely available (Fleischer and Waibel, 2003), while import data may not include foreign government donations, an important source of pesticides into African agriculture (Tobin, 1996). Average pesticide use per hectare in Africa is low, reported as only 1.23 kg a.i./ha, compared with 7.17 and 3.12 kg for Latin America and Asia (Repetto and Baliga, 1996). Small-scale farming systems are often viewed as low input, with low or zero use of pesticides (Nsibande and McGeoch, 1999; Abate et al., 2000; Way and van Emden, 2000; Ebenebe et al., 2001). Pesticides tend to be used most intensively on cash crops, especially cotton, cocoa, oil palm, coffee and vegetables (Matthews et al., 2003), suggesting that hazards involve mainly large scale, commercial agriculture. However many of these crops are grown by smallholders (Buffin et al., 2002; Nathaniels et al., 2003). One conclusion could be that since the volume of pesticides used in Africa is so much lower than elsewhere, the risks and impacts must also be correspondingly lower. But this would ignore hazards arising from the toxicity of the compounds used and widespread and serious shortcomings in handling practices.

African studies frequently highlight poor pesticide practice (Cauquil and Vaissayre, 1994; Partow, 1995; Sibanda et al., 2000; Ashburner and Friedrich, 2001; Matthews et al., 2003). Highly inefficient practices include using inappropriate products, incorrect dosage, timing and targeting of application, non-calibrated and poorly maintained or leaking application equipment. Inappropriate use has consequences not only for the effectiveness of the intended pest control but also for operator and consumer health, farm livestock, soil organisms, wildlife and vegetation, and contamination of soil, water and air (Conway and Pretty, 1991; Kishi, 2005; Pretty and Hine, 2005). Extremely hazardous practices include use of unauthorised or banned products, cocktail mixes of products, mixing with bare hands, splashing pesticides onto crops using brushes or twigs, lack of minimal protective clothing and even tongue-testing to assess concentration strength (Sibanda et al., 2000; Tettey, 2001; Addo et al., 2002; Dinham, 2003).

Examples of uneconomical use of pesticides among African farmers are also well documented for cotton, legumes, pigeonpea, vegetables and cashew (Ochou et al., 1998a; Isubikalu et al., 1999; Adipala et al., 2000; Minja et al., 1996; Sibanda et al., 2000; Nathaniels et al., 2003). The sustainability of these pest control regimes is questionable, in terms of the risk of resistance development and disruption of natural control, as well as farm family welfare. Yet medium to long-term sustainability issues

* Corresponding author. Tel.: +44 207065 0916; fax: +44 207065 0907.
E-mail address: stephaniewilliamson@pan-uk.org (S. Williamson).

0261-2194/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.cropro.2008.04.006

tend to be ignored in conventional economic cost–benefit analysis of the utility of pesticide-dominant control strategies (Ajayi, 2000; Wilson and Tisdell, 2001; Pretty and Waibel, 2005).

Pesticide use trends are affected by several economic, biological or climatic factors, as emphasised in the Pesticide Policy Initiative reports, one of the few sources analysing issues in African policies and practice, published for Zimbabwe, Cote d'Ivoire, Ghana and Mali (Mudimu et al., 1995; Fleischer et al., 1998; Gerken et al., 2000; Ajayi et al., 2002). Changes in state and private sector provision and control of agricultural inputs under liberalisation exert strong influence on agrochemical use patterns, particularly for smallholders (Shepherd and Farolfi, 1999; Ajayi, 2000; Cromwell et al., 2001; Williamson, 2003; Kelly et al., 2003). Changes in global food supply chains, mostly in food safety aspects, and of stricter legislation on maximum permitted levels of pesticide residues and other food contaminants in industrialised country markets also influence practices in developing country agriculture (Dolan and Humphrey, 2000; Chan and King, 2000; Otsuki et al., 2001; Boselie and Muller, 2002).

This paper examines pesticide practice and policy issues among smallholder farmers growing crops for export and local markets in four African countries. The research assessed patterns of pesticide use and impacts on farming communities' health, income, food security and livelihoods, complemented by stakeholder assessment and analysis of the policy context governing pesticide controls, distribution and use. Aspects of pesticide provision and subsidy; health, welfare and livestock impacts are detailed elsewhere (Williamson, 2003, 2005). This paper focuses on use trends, costs and access and discusses challenges for African pesticide and pest management policy and drivers for change towards sustainability.

2. Methods

Four countries and five cropping systems were selected to cover a range of policy scenarios, drivers for and against pesticide use, market contexts and production potential zones, and a case study approach combining quantitative and qualitative research methods was used. Table 1 summarises the cropping systems and rationale for their selection, farming context and countries and villages studied.

Research was conducted in 2000–2003 with partners from agriculture ministries, universities and non-governmental organisations, with coverage of 400 male and female smallholders and 80 key informants from public and private sector organisations. Questionnaire surveys via purposive sampling were conducted with 210 smallholders in Benin and Senegal and focus group discussions with 190 smallholders in all four countries. Villages were selected with local agricultural extension offices to reflect farming communities representative of the selected cropping systems and which had not received recent training in pest or pesticide management. Participatory appraisal methods were used in group discussions, including wealth ranking and matrix scoring exercises (Pretty et al., 1995; Ellis and Ade Freeman, 2004) and individual open-ended interviews. These were complemented by group construction of partial participatory farm budgets (Galpin et al., 2000; Dorward et al., 2003). Semi-structured interviews were used with key informants and assessment of relevant policy documents and programme reports where available. Due to the purposive rather than random sampling approach and adaptation of survey tools to country contexts, quantitative data were not amenable to statistical cross-country analysis. The data collected from farmer groups was triangulated with data from government or private sector agencies.

Table 1
Cropping system selection, study sites and agricultural context of case studies

Cropping system and rationale	Study sites	Agricultural context
Cotton—promoted by West African governments and donors as livelihood strategy for savannah zones. Increasing concerns about pesticide impacts.	*Benin*—Kpako village, Banikoara district, Alibori Dept.	Low potential lowland, savannah zone, erratic rainfall, v. limited access to irrigation.
	Senegal—Diaobe, Sare Bounda, Linguewal and Nemataba villages, Kounkane district, Velingara Dept., Kolda Region.	Sorghum, millet, maize; a few vegetables and livestock.
Peri-urban vegetables—renowned for their profitability and rapid growth, but also for serious pesticide misuse.	*Benin*—Sekou village, near Cotonou, Atlantic Dept.	High potential lowland, ample rainfall in Benin; unreliable rainfall and water shortage in Senegal.
	Senegal—Sangalkam, Gorom II, Tivaouane Peul and Wayembame villages, Sangalkam Rural Community, Les Niayes district, near Dakar.	Tomato, okra, chilli, onion, leafy vegetables, cabbage, cucumber, courgette, aubergine, sweet pepper, carrot for local/national markets, plus green beans for export from Senegal.
Cowpea—in transition from subsistence status to cash crop, with increased cultivation accompanied by growing insecticide use.	*Ghana*—Sakuba, Moglaa and Voggu villages, Tolon-Kumbungu District, Northern Region.	Low–medium potential savannah lowland, very limited access to water.
		Sorghum, millet, maize, yam, cassava, cowpea, groundnut and soyabean, and livestock.
Mixed cereal and legumes—local food production system only recently moving into cash-oriented economy.	*Ethiopia*—Zenzelima, Yigoma and Fereswega villages, Bahir Dar Zuria district, Amhara Region.	Medium potential highland zone, with regular rain failures but some access to irrigation.
		Maize, tef, sorghum, millet, legumes, vegetables, *qat* (narcotic shrub), eucalyptus, beekeeping and livestock.
Pineapple—lucrative export crop for smallholders, now subject to compliance with stricter residue levels and market requirements in Europe.	*Benin*—Sekou village, Allada district, Atlantic Dept.	Medium—high potential hilly or lowland zones, regular rainfall, some access to irrigation.
	Ghana—Fotobi and Samsam villages, Eastern region.	Pineapple, maize, cassava, vegetables, other fruits, livestock.

3. Results

3.1. Pesticide use patterns

Chemical pest control was the dominant strategy in all case studies. A total of 47 different pesticide active ingredients were reported by farmers (26 insecticides; 10 herbicides; 5 fungicides; 1 acaricide; 1 nematicide; 1 fumigant; 1 rodenticide; 1 biopesticide and 1 plant growth regulator). The most commonly encountered active ingredients across the 19 study villages were the insecticides endosulfan, dimethoate, cypermethrin, chlorpyrifos, fenitrothion, malathion, profenofos and deltamethrin and the herbicide glyphosate. Whilst the range of compounds and formulated products reported in use was wide, individual farmers used two to six products per season. Insecticides dominated chemical pest management in all cropping systems, reflecting not only the serious problems of insect attack but perhaps also the availability and relative cheapness of many older generation insecticides. Fungicides were used mainly by vegetable farmers. Use of non-chemical control methods[1] for insect pests was very limited, although mechanical weeding, by hand or by ox-drawn tools, was common in most systems.

Vegetable farmers used the greatest variety of compounds (over 20 in Benin and Senegal), followed by cotton farmers, who used the majority of herbicides reported. Farmers growing mixed grains in Ethiopia and cowpea in Ghana used a limited portfolio of 5–7 insecticides, and phosphine tablets for grain preservation and one rodenticide. Pineapple growers in Benin and Ghana reported the smallest use of active ingredients: one insecticide, four herbicides, one nematicide and the plant growth regulator ethephon, applied before harvest to "de-green" fruits. In Ghana, ethephon was applied solely by pineapple traders. The limited portfolio on pineapple may reflect the narrow range of pest and disease problems affecting this crop and the influence of European markets in terms of placing restrictions on pesticide use in fresh produce. Senegalese smallholders growing green beans for export described how this crop was not as pesticide intensive as some of the crops grown for local consumers, particularly aubergine, cabbage and tomato, as pest problems only needed control after flowering stage. Green bean growers also needed to follow pest and crop management protocols provided by export companies to ensure compliance with EU regulatory and private voluntary market requirements.

3.2. *Application intensity, pest incidence and pesticide access*

Vegetable growers reported the highest application frequencies, with some Beninois farmers spraying insecticides every 3–5 days. Cotton farmers sprayed weekly or fortnightly from square formation and cowpea farmers sprayed three to six times from flowering, depending on the variety grown and cost of insecticide. Pineapple farmers in Ghana applied insecticides 3–5 times per crop cycle and 2–3 herbicide treatments at planting. In Benin, pesticide use on pineapple was more limited, with herbicides in regular use only by the better-off smallholders, who preferred to substitute these for manual weeding, even though the cost savings were minimal. Ethiopian farmers only sprayed insecticide on their high value crops of maize, tef, grasspea, vegetables and qat, averaging 2–3 applications per season, and on maize in storage.

Calendar-based spraying without consideration of pest incidence or level of attack was the norm for vegetable, cotton, cowpea and Ghanaian pineapple farmers. Cocktail mixing of products was reported by Ethiopian farmers and vegetable farmers in Benin. Detailed information on dose and application practice was not obtained although some group discussions recounted significant deviations from label recommendations. The Beninois cotton company SONAPRA recommended 5–6 insecticide applications at fortnightly intervals, yet many farmers reported spraying every 8 days. Their average regimes consisted of 8–12 treatments per season using 10.5 l/ha, rather than the 8 l/ha supplied on credit by the cotton company. In contrast, Senegalese cotton farmers said they generally followed extension advice, as confirmed by cotton company informants.

Trends in pesticide use during 1990–2000 and perceptions of access and efficacy were assessed by survey in Benin and Senegal, as summarised in Table 2. A clear trend in increased use and reliance on pesticides since the early 1990s emerged from most locations. In cotton and vegetables, pesticide use had been standard practice for several decades but farmers reported an increase in intensity, due to higher pest pressure, sometimes related to varieties of vegetables grown. In cereal and legume crops, insecticide use was directly linked to the introduction of higher-yielding varieties of cowpea in Ghana and maize in Ethiopia. These varieties are more susceptible to insect attack in the field and in storage than traditional varieties. Vegetable farmers in Benin described increases in pest incidence in recent years and control difficulties, possibly due to circulation of ineffective products, while pineapple farmers had only recently started to use pesticides against new problems, notably pineapple wilt, its mealybug vector and nematodes. As these pest problems were intermittent and patchily distributed, pesticide use had not become routine. In contrast, Ghanaian pineapple growers described how they started to use pesticides in the late 1990s, following encouragement by development agencies to use agrochemicals, particularly insecticides for mealybug control.

The most striking increase in pest incidence was reported by Ethiopian farmers. Storage treatment was reported as rare before 1995 when higher-yielding maize varieties started to be grown for the first time. Many farmers complained of the difficulty of keeping maize in store and the ineffectiveness of insecticides authorised for grain treatment. Some had developed their own "recipes", a popular one being a mix of malathion with DDT (the latter is banned globally for all agricultural purposes under the Stockholm Convention but widely available in Ethiopia's malaria control programme). Despite their use of insecticides in store, Ethiopian farmers recounted that most villagers' granaries had become severely infested with weevils since maize replaced sorghum, tef and millet as the major food cereal. A more drastic tactic for dealing with increased pest pressure is to abandon production. Ethiopian farmers cited pest-specific problems as the reason for abandoning chickpea, noug, flax, field pea and horse beans in one or more of the study villages.

Table 2
Farmer survey responses on pesticide use, access and efficacy

Topic	Interviewee responses (proportion) (%)		
Senegal	Volume increase	Volume decrease	No change in volume
Pesticide volume change			
Cotton	68	16	16
Vegetables	44	41	15
Benin	Very easy	Easy	Difficult
Access to pesticides[a]			
Cotton	3	74	23
Vegetables	20	45	35
Pineapple	5	28	67
Benin	Poor	Acceptable	High
Perceptions of pesticide efficacy			
Cotton	0	12	88
Vegetables	5	35	60
Pineapple	2	23	75

Senegal, $n = 25$ cotton farmers, $n = 50$ vegetable farmers; Benin $n = 45$ farmers per cropping system.
[a] Access included perceptions of ease of purchase.

[1] The term "non-chemical methods" is used to cover all methods that do not use synthetic, purchased pesticides. The use of botanical extracts, e.g. neem seed, with insecticidal, repellent or anti-feedant properties is included in this category.

Table 3
Sources of pesticides and unauthorised use reported by survey respondents (%)

	Senegal: Vegetables (%)	Senegal: Cotton (%)	Benin: Pineapple (%)	Benin: Vegetables (%)
Supply channel				
Informal only			54	
Formal only			40	
Both	100	100	6	100
Non-authorised use				
On food grains	8	72	100	(No food grains grown)
Non-agricultural (e.g. household pests)	43	64	No data	No data
Cotton-only products used on maize, vegetables or fruit	No data[a]	40	No data[a]	No data[a]

Benin $n = 45$ per crop, Senegal $n = 25$ in cotton, $n = 50$ in vegetables.
[a] Use of cotton products reported in group discussions but not in survey responses.

3.3. *Pesticide sourcing, costs and affordability*

Availability and affordability of pesticides was a major concern for many farmers. Group discussions and surveys revealed widespread sourcing from unauthorised dealers, selling products of dubious quality and origin in small volumes to meet the reduced purchasing power of smallholders. Farmers identified five separate supply channels:

(i) authorised retail outlets of agricultural supply companies,
(ii) via government extension services (Ethiopia and Senegal only),
(iii) small-scale informal traders operating via local shops,
(iv) itinerant peddlers visiting villages and weekly markets, and
(v) bulk supplies from general markets in larger towns.

The last three channels frequently repackaged products, the contents of which rarely corresponds to the label. In Ethiopia, informal traders decanted insecticides into empty penicillin vials or scraps of plastic, without labelling. All farmers were aware of the quality problems in non-authorised channels but felt the advantages of speed, accessibility and small cash outlay outweighed the substantial risks of being sold fraudulent or adulterated products. Pineapple farmers in Ghana were the sole group to purchase only through authorised channels. Table 3 details supply channels used by farmers in Senegal and Benin and use of insecticides for non-authorised purposes.

Pesticide cost increases, particularly since market liberalisation in the mid-1990s and devaluation of the francophone CFA currency, were a common complaint and farmers indicated that their relative costs, as a proportion of production expenditure, had risen sharply in recent years. National cotton statistics from Benin confirm this, with average pesticide treatment costs rising 80% between the 2000 and 2001 seasons, while income per hectare remained static. Senegalese cotton farmers reported pesticide costs of over US$50/ha, compared with US$20–25/ha for maize and a mere US$2/ha on groundnut. The state cotton company figures show a steady increase in average pesticide costs charged to farmers supplied under quota.

Partial participatory budgets (PPBs) constructed with focus groups provided more detailed estimates of pesticide costs at farm level. Budgets were developed to reflect practice by average smallholders in the village in an average season at 2001 prices (Table 4). Weed control was only included under pesticides in those cropping systems where herbicides were generally used (pineapple and cotton). Labour costs were only included where these were for hired labour, since farmers considered their own family labour as "free".

Pesticide treatment costs included the price of chemicals, hire of spray equipment, battery costs for ULV sprayers, labour costs where workers were employed to carry out water haulage and/or spraying, and travel expenses in some cases. Pesticide costs ranged from US$23–220/ha according to crop and country and from US$21–39 per farm for Ethiopian farmers of different wealth ranks. These figures are hard to compare across widely ranging circumstances and different farm budgeting calculations. Rough estimates of production costs also varied widely, with some of the highest relative proportions incurred by farmers growing food staples, rather than high value cash crops. Ghanaian pineapple revealed the highest gross margins across all crops, confirming farmer and key informant opinions about the economic returns for this crop.

Some caution should be exercised in interpreting the results of PPBs, as none of the farmers had written records of input and output values, although many had excellent recall of specific purchase costs. This caveat would also hold for cost and income estimates generated by individual questionnaire. Ghanaian pineapple farmers, for example, found it hard to estimate actual income; therefore gross margin calculations were sketchy. Nevertheless, stakeholders from the pineapple export industry confirmed farmers' estimates of around US$2100–2300 production costs per ha under smallholder practice.

3.4. *Health impacts*

A clear picture of regular and sometimes serious health effects emerged from the research arising from exposure to hazardous pesticides and risky handling and storage. Farmers growing food staples in Ethiopia and Ghana reported the most serious consequences, namely frequent ill health episodes and cases of hospitalisation following application and fatalities through accidental exposure or misuse. Cotton farmers also reported frequent acute symptoms, linked particularly to use of endosulfan. Endosulfan was associated with more severe poisoning episodes among cowpea farmers, along with products containing chlorpyrifos, profenofos, lambda-cyhalothrin and cypermethrin. Vegetable and pineapple farmer groups, however, noted only occasional, mild effects, despite the frequent application of a considerable number of neurotoxic organophosphates, including World Health Organisation Class 1a and 1b compounds, in vegetables. Table 5 provides survey data on hazard awareness and hazardous practice among farmers in Senegal and Benin.

This demonstrates that while farmers were not ignorant of pesticide hazards, they continued to carry out hazardous practices in the field and at home. Negligible use of protective clothing, pesticide storage in bedrooms, granaries and kitchens and use of empty insecticide containers to store food or drink was common. Topical application of field insecticides to treat lice, fleas, open wounds was reported in Ethiopia, with tragic examples of four fatalities in two villages from people using malathion, sometimes

Table 4
Partial participatory budget summaries from Senegal, Ghana and Ethiopia

Country/crop	Pesticide costs (US$ equivalent per ha)	Proportion of production costs (%)	Gross margins (US$ equivalent per ha)
Senegal	Pesticide purchase cost	Of total crude production costs	Gross margins
Cotton			
Diaobe village	58	22	352
Sare Bounda village	65	31	286
Vegetables			
Cucumber	99	40	2496
Tomato	23	45	485
Green beans (export)	54	4	1533
Ghana Pineapple (*export*)	Pesticide treatment costs[a]	Of production (and purchased input) costs	Gross margins in average year
Fotobi (men)	220	14 (19)	3260
Samsam (women)	185	13 (16)	5216
Cowpea	Pesticide treatment costs[b]		
Voggu village	187	32	4
Moglaa village	65	61	16
Ethiopia	Pesticide treatment costs per farm[c]	Of total production cash outlay per farm	Net cash income per household
Yigoma village			
Rich farmers	39	22	694
Medium farmers	32	26	497
Poor farmers	22	15	275
Zenzelima village			
Rich farmers	21	12	265
Medium farmers	38	39	176
Poor farmers	39	55	99

All data converted and rounded up to US$ equivalents per ha (per farm in Ethiopia) from local currency exchange rates in 2001.
[a] Including labour costs for water haulage and spraying.
[b] Including labour costs and spray equipment hire.
[c] Including purchase, day trip expenses to purchase point, hire of spray equipment.

mixed with DDT, applied to the hair to kill lice or to the skin to try and cure wounds. Regular and costly poisonings of farm animals were reported by cotton and food staple farmers through grazing on contaminated foliage, eating baits for vermin or skin application of crop insecticides for tick control.

Quantitative ill health incidence was not attempted, though direct health costs associated with insecticide application were estimated via questionnaire and focus groups with 30 cowpea and cotton farmers in five villages in Ghana in 2003. Table 6 summarises the data obtained. Affected farmers identified products containing endosulfan, chlorpyifos and lambda-cyhalothrin as associated with regular ill health episodes and estimated that 33–60% of villagers were adversely affected each season.

Table 5
Information on hazard awareness and practice from survey respondents

Health hazard	Country/crop	
	Proportion of respondents[a] (%)	
Hazard awareness	Benin/pineapple	Benin/vegetables
Effect of pesticides on your health?		
Negligible	19	28
Noticeable	65	43
Considerable	16	30
Heard of or witnessed human poisonings?	Senegal/cotton	Senegal/vegetables
Yes	24	20
No	76	80
Use of protective clothing	Senegal/cotton	Senegal/vegetables
No use	56	86
Use some form	44	14
Own some form	28	11
Storage of pesticides	Benin/cotton	Benin/pineapple
In bedroom	60	93
In kitchen	11	0
In separate store	13	5
Under granary	8	0
In field	8	2
Re-use of empty insecticide containers	Benin/cotton	Benin/pineapple
Transport water	45	16
Store/transport broth	20	0
Store/transport milk	35	0
Store kerosene	75	81
Store seed	40	35
Sold	15	9
Destroyed	10	12

[a] Benin $n = 45$ per crop, Senegal $n = 25$ in cotton, $n = 50$ in vegetables.

4. Discussion

4.1. Issues for pesticide and pest management policy

Some common themes emerged from the 19 villages studied. Our findings highlighted the considerable use of pesticides in lower value food staples among 'subsistence' smallholders, and not only in higher value cash crops such as vegetables and cotton. Unlike the situation for synthetic fertiliser in recent years (Cromwell et al., 2001; Crawford et al., 2003; Kelly et al., 2003), most smallholders had tended to increase their use of pesticides. There may be several reasons for this trend, including: widespread availability of 'discount' priced pesticides sold in small unit volumes in the flourishing, informal sector; promotion of higher-yielding varieties of cereals and legumes, which are much more susceptible to insect attack; continued government provision or subsidy in some cases, distorting market prices; farmer perceptions of potential risk and yield loss; and lack of readily available pest management solutions other than pesticide reliance.

In Ethiopian cereals, cowpea in Ghana and vegetables in Benin and Senegal, pest incidence and/or status had risen, triggering increased insecticide application. Farmer complaints of the inability to control pests effectively indicate flaws in pest management strategies or decision-making for these crops. For

Table 6
Farmer health costs estimated by cowpea and cotton farmers in Ghana

Average no. days off sick after spraying cotton ($n = 26$)	Cost in terms of average daily farm labour rate	Average no. days off sick after spraying cowpea ($n = 19$)	Cost in terms of average daily farm labour rate	Preventative treatment costs ($n = 13$)	Medical treatment costs ($n = 30$)
21.7	34.59	15.1	17.76	0.92	53.12

Costs in US$ equivalent. Daily labour rates equivalent in 2003 to 1.12–2.24US$.

some, this led to major indebtedness where expenditure on inputs could not be recouped, most notably in Ethiopia, where prices for cereal and legumes crashed by up to 40% during 2000–2001. This left many farmers averaging debts of US$35–117 incurred on inputs provided on credit by government schemes. While individual farmers' attitudes to risk in relation to pest control and pesticide use play an important role in their decision-making, national policy and programmes are also influential. It was clear from discussions with farmers and key informants that energetic promotion of higher-yielding varieties of cowpea in Ghana and maize in Ethiopia had failed to address their increased susceptibility, particularly to weevils in storage, in comparison with local varieties. These varieties had not been accompanied by information on their higher pest susceptibility or associated control costs, or training in appropriate pest management methods. Government crop protection staff in Ethiopia expressed strongly that pest management needs had been ignored in the race to boost food staple yields and their efforts were hampered by a lack of resources and policy commitment.

Issues of inequity in pesticide access emerged from group discussions. Poorer cotton families reported selling agrochemical inputs obtained on credit from the cotton company in order to buy food during the 'lean' season. These were sometimes sold at a fraction of the price that would be deducted from their cotton revenues, resulting in income reductions, in addition to yield reductions from loss of the inputs (Williamson, 2003). Non-transparent and unequal distribution of cotton inputs by village officials was a cause for complaint in Senegal and Benin. Other studies have highlighted how state or company facilitation of pesticides on credit or via subsidy schemes can be highly problematic and divisive (de Groot, 1995; Gerken et al., 2000; Ajayi, 2000). In Ghana, most women were unable to grow higher-yielding cowpea varieties because they could not afford the insecticides required. These varieties were promoted in the name of food security and poverty reduction, yet scant attention was paid to providing safe and robust pest management advice or training, which would enable poorer farmers to benefit from their adoption. Ghanaian women growing export pineapple were also struggling to afford inputs and some had abandoned pineapple for cheaper but less profitable crops.

Costly and potentially non-sustainable use of insecticides was an issue for concern, in cotton and food staples in particular, with the proportion of production costs spent on pesticide application exceeding 30% in almost half the budgets estimated. Proportions over 10% are considered indicative of problematic pest control tactics, while over 25% is considered unsustainable in other developing countries (Ashburner and Friedrich, 2001; Blackie and Gibbon, 2003). Cowpea farmers were spraying more frequently than IPM programmes have found necessary (Adipala et al., 2000; Isubikalu et al., 1999), increasing their production costs and undermining income gains that could be realised from higher-yielding varieties. Highly hazardous products and practice raised further sustainability concern, not only of serious human health impacts in farming communities but also frequently observed mortality of non-target organisms by farmers and disruption of beneficial species such as bees, termites, earthworms and vertebrate predators, linked to endosulfan in particular. Further health impacts of the shift to endosulfan reliance in West African cotton continue to be documented (PAN UK, 2006; EJF, 2007) although others applaud its introduction, focusing only on its role in bollworm control (Martin et al., 2005).

4.2. Drivers for change

In food staples, IPM training in Farmer Field Schools was carried out in parts of the regions studied, with notable support from the Amhara Regional Bureau of Agriculture in Ethiopia and the Savannah Agricultural Research Institute in Ghana. But these projects reached only a very small proportion of smallholders and many key informants were unaware of their existence. Despite successful results and farmer demand for training, these programmes had not been mainstreamed at national policy level. Effective and affordable methods for controlling pests without synthetic pesticides were available too, but poorly disseminated in comparison to the investment and promotion of insecticides. Over half of stakeholders in Ghana, including the Ministry of Food and Agriculture, predicted an increase in pesticide use by smallholders under the government's agricultural sector investment programme for poverty reduction and food security, unless substantial effort is put into IPM implementation. Yet many informants viewed IPM in the context of addressing environmental problems in industrialised agriculture in rich countries and did not appreciate its applicability to African situations.

These predictions and perceptions signal a major challenge for agricultural policy and programmes in African countries in achieving safe and sustainable pest management, health of farming families and local food safety. Our findings reinforce experiences elsewhere that IPM is widely accepted in theory but putting it into practice at policy and programme levels is much harder (Ramirez and Mumford, 1995; Fleischer and Waibel, 2003; Herren et al., 2005). Despite their awareness of hazards to health and of the poor quality of products sold in informal channels, many farmers in this study continued highly risky and sometimes uneconomic practices, reflecting an inability to access appropriate pest management strategies rather than a lack of knowledge per se. Economic hardship and disempowerment act as serious constraints to changing hazardous behaviour among farm workers (Arcury and Quandt, 1998; London, 2003) and would seem to apply to the smallholders in this study too. Without fundamental change in crop protection policy towards sustainability goals, these constraints are unlikely to diminish for the majority of smallholders beyond pilot projects.

Together with deforestation, soil erosion and declining soil fertility (Ton, 2001; Clay, 2004), there is a clear need for ecologically centred pest management strategies in West African cotton systems (Williamson et al., 2005). With a six-fold increase in certified global organic cotton fibre since 2001 and growing demand from major clothing retailers, organic strategies are under serious consideration among formerly sceptical West African cotton companies and governments (Organic Exchange, 2007; D. Sanfilippo, personal communication).

In contrast to food staple crops and cotton, the export pineapple in Ghana and export vegetable cases in Senegal revealed lower levels of pesticide application frequency and a much smaller number of products applied. There was substantially better control over product use and pesticide handling, mainly as a result of interventions or requirements of companies exporting the produce. While widely held perceptions equate export crops with high pesticide use (Dinham, 1993; Thrupp et al., 1995; Buckland, 2004), the findings in this study suggest that the influence of food safety concerns in European retail markets could play a role in shifting smallholder production in export chains towards safer practice and reduced reliance on the most hazardous products. Ghana pineapple systems were the only case in which farmers did not use any WHO Class 1a or 1b products. However, practice was certainly not without occupational health risks, for example, common practice included prophylactic applications of chlorpyrifos drenches, without adequate protective clothing, which poses serious risks as those working in pineapple suffer continual open cuts from the spiny foliage, increasing the likelihood of insecticide absorption. Nor was it clear whether increased vigilance and stricter protocols determining pesticide practice in export horticulture cropping, with their focus mainly on residue compliance, would result in the adoption of alternative pest management strategies.

Exclusion of smallholders from export chains due to stricter EU legal and market requirements on pesticides has been identified as a major impact from the growing influence of European markets on African agriculture (Chan, 2000; Dolan and Humphrey, 2000; Boselie and Muller, 2002; Gibbon, 2003). A different question is whether donor or company initiatives to support smallholder participation in African export horticulture could positively influence practice in crops for local markets. Recent research shows continued use of highly hazardous compounds in vegetables grown for local markets in Senegal and Ghana and a lack of any drivers for safer pest management, either from traders, retailers or consumers (Kuiseu, 2006; Amoah et al., 2006). Nevertheless, there are indications that some export horticulture compliance programmes involving smallholders may produce concrete health and environmental benefits for local consumers and rural communities when trained farmers transfer practice onto other crops (Graffham, 2006; Nyambo and Nyagah, 2006).

5. Conclusions

This study identified several drivers encouraging pesticides as the dominant form of pest management, ranging from increased pest incidence, varietal susceptibility, ineffectiveness of pesticides, lack of advice on alternative methods, pesticide subsidy and donations, to competitive pressures on farmers and lack of attention to the economics of pest control. Other analyses in Africa have drawn attention to fiscal distortions favouring pesticides, the role of the cotton sector in excessive insecticide promotion and lack of knowledge on alternatives (Gerken et al., 2000; Silvie et al., 2001; Affognon, 2005). The growing informal market in poor quality but cheap pesticides (FAO/WHO, 2001; Macha et al., 2001) constitutes another major obstacle to reducing pesticide dependency, while African stakeholder perceptions on the costs and benefits of pesticides and the feasibility of IPM represent further challenges.

These findings underline major welfare and sustainability problems in pesticide practice in smallholder production of food for local markets and in cotton, which escapes export market food safety scrutiny. Farm family and African consumer health have received in the past less attention than the need to protect European consumer health and corporate reputations in export horticulture supply chains, despite the more immediate and acute risks. Pesticide debates and trends in European markets are clearly influencing pesticide practice in African export horticulture but it remains to be seen whether these, or other factors, will influence smallholders to safer and more sustainable pest management in the future.

Crawford et al. (2003).

Acknowledgements

This paper is based on research carried out by Pesticide Action Network UK, with PAN Africa (Senegal), Organisation Beninoise pour la Promotion de l'Agriculture Biologique (OBEPAB), Safe Environment Association (Ethiopia) and Community Action Programme for Sustainable Agriculture and Rural Development, (CAPSARD, Ghana) and research collaborator Seth Gogoe. This work was kindly funded by EuropeAid of the European Commission, the UK Department for International Development and the Rowan Trust. The views expressed are those of the authors alone.

References

Abate, T., van Huis, A., Ampofo, J.K.O., 2000. Pest management strategies in traditional agriculture: an African perspective. Annu. Rev. Entomol. 45, 631–659.

Addo, S., Birkinshaw, L.A., Hodges, R.J., 2002. Ten years after the arrival of Larger Grain Borer: farmers' responses and adoption of IPM strategies. Int. J. Pest Manage. 48 (4), 315–325.

Adipala, E., Nampala, P., Karungi, J., Isubikalu, P., 2000. A review on options for management of cowpea pests: experiences from Uganda. Integr. Pest Manage. Rev. 5, 185–196.

Affognon, H., 2005. Crop Protection Policy in Benin—Factors Influencing Pesticide Use. Pesticide Policy Project Publication Series no. 11. GTZ/University of Hannover, Germany.

Agrow, 2006. World agchem market steady. AGROW 497, 9 June 2006, p. 17.

Ajayi, O.O.C., 2000. Pesticide Use Practices, Productivity and Farmers' Health: The Case of Cotton–Rice Systems in Côte d'Ivoire, West Africa. Pesticide Policy Project Special Issue Series no. 3. GTZ/University of Hannover, Germany.

Ajayi, O., Camara, M., Fleischer, G., Haidara, F., Sow, M., Traoré, A., van der Valk, H., 2002. Socio-Economic Assessment of Pesticide Use in Mali. Pesticide Policy Project Special Issue no. 6. GTZ/University of Hannover, Germany.

Amoah, P., Drechsel, P., Abaidoo, R., Ntow, W.J., 2006. Pesticide and pathogen contamination of vegetables in Ghana's urban markets. Arch. Env. Contam. Toxicol. 50, 1–6.

Arcury, T.A., Quandt, S.A., 1998. Occupational and environmental health risks in farm labor. Human Org. 57 (3), 331–334.

Ashburner, J., Friedrich, T., 2001. Improving Handling of Pesticides Application Equipment for the Safety of Applicators. Pesticide Management in West Africa Newsletter no. 2. FAO/Economic Community of West African States, Accra, Ghana, pp. 9–11.

Blackie, M., Gibbon, D., (2003). Enhancing impact. Strategies for the promotion of research technologies to smallholders in eastern and southern Africa. Report to the DFID Crop Protection Programme, Natural Resources International, Aylesford, UK.

Boselie, D., Muller, E., 2002. Review of the Impacts of Changes in EU Pesticides Legislation (Directive 2000/42/EG) on Fresh Food Exports from Developing Countries. Case Study: The Horticultural Export Sector in Ghana. Wageningen University and Research Centre report to the Dutch Ministry of Foreign Affairs.

Buckland, J., 2004. Ploughing up the Farm. Neoliberalism, Modern Technology and the State of the World's Farmers. Fernwood Publishing, Winnipeg and Zed Press, London.

Buffin, D., Williamson, S., Dinham, B., 2002. Dying for a bit of chocolate. The Ecologist 32 (2), 48–50.

Cauquil, J., Vaissayre, M., 1994. IPM in cotton in sub-Saharan French-speaking Africa. In: IPM Implementation Workshop for East/Central/Southern Africa, Workshop Proceedings, Harare, Zimbabwe, 1993. IPM Working Group, Natural Resources Institute, Chatham, pp. 72–81.

Chan, M.-K., 2000. EU pesticide legislation—friend or foe of developing countries? Pesticides News 50, 12–15.

Chan, M-K., King, B., (2000). Review of the implications of changes in EU pesticide legislation on the production and export of fruits and vegetables from developing country suppliers. NRI Report no. 2525, Natural Resources Institute, Chatham, UK.

Clay, J., 2004. World Agriculture and the Environment. A Commodity-by-Commodity Guide to Impacts and Practices. World Wildlife Fund. Island Press, Washington, DC.

Conway, G.R., Pretty, J.N., 1991. Unwelcome Harvest: Agriculture and Pollution. Earthscan, London.

Crawford, E., Kelly, V., Jayne, T.S., Howard, J., 2003. Input use and market development in sub-Saharan Africa: an overview. Food Policy 28, 277–292.
Cromwell, E., Kambewa, P., Mwanza, R., Chirwa, R., 2001. Impact Assessment using Participatory Approaches: 'Starter Pack' and Sustainable Agriculture in Malawi. AgREN Network Paper no. 112. Overseas Development Institute, London.
De Groot, A.BA., 1995. The functioning and sustainability of village crop protection brigades in Niger. Int. J. Pest Manage. 41 (4), 243–248.
Dinham, B., 1993. The Pesticide Hazard: A Global Health and Environmental Audit. Zed Books, London.
Dinham, B., 2003. Growing vegetables in developing countries for local urban populations and export markets: problems confronting small-scale producers. Pest Manage. Sci. 59, 575–582.
Dolan, C., Humphrey, J., 2000. Governance and trade in fresh vegetables: the impact of UK supermarkets on the African horticulture industry. J. Dev. Stud. 37 (2), 147–176.
Dorward, P., Galpin, M., Shepherd, D., 2003. Participatory farm management methods for assessing the suitability of potential innovations. A case study on green manuring options for tomato producers in Ghana. Agric. Syst. 75 (1), 97–117.
Ebenebe, A.A., van den Berg, J., van der Linde, T.C., 2001. Farm management practices and farmers' perceptions of stalkborers of maize and sorghum in Lesotho. Int. J. Pest Manage. 47 (1), 41–48.
Ellis, F., Ade Freeman, H., 2004. Rural livelihoods and poverty reduction strategies in four African countries. J. Dev. Stud. 40 (4), 1–30.
EJF, 2007. The Deadly Chemicals in Cotton. Environmental Justice Foundation and Pesticide Action Network UK, London.
FAO/WHO, 2001. Amount of Poor-Quality Pesticides Sold in Developing Countries Alarmingly High. Food and Agricultural Organisation of the United Nations and World Health Organisation, Rome Press Release 1 February 2001.
Fleischer, G., Waibel, H., 2003. Pesticide policy and integrated pest management. In: Maredia, K.M., Dakouo, D., Mota-Sanchez, D. (Eds.), Integrated Pest Management in the Global Arena. CABI Publishing, Wallingford.
Fleischer, G., Andoli, V., Coulibaly, M., Randolph, T., 1998. Analyse socio-economique de la filière des pesticides en Côte d'Ivoire. Pesticide Policy Project Publication Series no. 6/F. GTZ/University of Hannover, Germany.
Galpin, M., Dorward, P., Shepherd, D., 2000. Participatory Farm Management Methods for Agricultural Research and Extension: A Training Manual. Agricultural Extension & Rural Development Department, University of Reading, UK.
Gerken, A., Suglo, J.-V., Braun, M., 2000. Crop Protection Policy in Ghana. An Economic Analysis of Current Practice and Factors Influencing Pesticide Use. Draft Study on Behalf of the Plant Protection and Regulatory Services Directorate, Ministry of Food and Agriculture with the Integrated Crop Protection Project PPRSD/GTZ and the Pesticide Policy project. University of Hannover/GTZ, Accra.
Gibbon, P., 2003. Value-chain governance, public regulation and entry barriers in the global fresh fruit and vegetable chain into the EU. Dev. Policy Rev. 21 (6), 615–625.
Graffham, A., 2006. European standards affect African growers. Pestic. News 71, 14.
Herren, H., Schulthess, F., Knapp, M., 2005. Towards zero-pesticide use in tropical agro-ecosystems. In: Pretty, J. (Ed.), The Pesticide Detox. Towards a More Sustainable Agriculture. Earthscan, London, pp. 135–146.
Isubikalu, P., Erbaugh, J.M., Semana, A.R., Adipala, E., 1999. Influence of farmer production goals on cowpea pest management in eastern Uganda: implications for developing IPM programmes. Afric. Crop Sci. J. 7 (4), 539–548.
Kelly, V., Adesina, A.A., Gordon, A., 2003. Expanding access to agricultural inputs in Africa: a review of recent market development experience. Food Policy 28, 379–404.
Kishi, M., 2005. The health impacts of pesticides: what do we now know? In: Pretty, J. (Ed.), The Pesticide Detox. Towards a More Sustainable Agriculture. Earthscan, London, pp. 23–38.
Kuiseu, J., 2006. Challenges for safer smallholder horticulture in Senegal. Pestic. News 71, 12–13.
London, L., 2003. Human rights, environmental justice and the health of farm workers in South Africa. Int. J. Occup. Environ. Health 9, 59–68.
Macha, M., Rwazo, A., Mkalanga, H., 2001. Retail sales of pesticides in Tanzania: occupational human health and safety considerations. Afric. Newslett. Occup. Health Saf. 11 (2), 40–42.
Martin, T., Ochou, G.O., Djihinto, A., Traore, D., Togola, M., Vassal, J.-M., Vaissayre, M., Fournier, D., 2005. Controlling an insecticide-resistant bollworm in West Africa. Agric. Ecosyst. Environ. 107 (4), 409–411.
Matthews, G., Wiles, T., Baleguel, P., 2003. A survey of pesticide application in Cameroon. Crop Prot. 22, 707–714.
Minja, E.M., Shanower, T.G., Songa, J.M., Ong'aro, J.M., 1996. Pigeonpea farmers in southern and eastern Africa: do they spray their crop? Int. Chickpea Pigeonpea Newslett. 3, 98–199.
Mudimu, G.D., Chigume, S., Chikanda, M., 1995. Pesticide Use and Policies in Zimbabwe. Pesticide Policy Project Publication Series no. 2. GTZ/University of Hannover, Germany.
Nathaniels, N.Q.R., Sijaona, M.E.R., Shoo, J.A.E., Katinila, N., 2003. IPM for control of cashew powdery mildew in Tanzania. I: Farmers' crop protection practices, perceptions and sources of information. Int. J. Pest Manage. 49 (1), 25–36.
Nsibande, M.L., McGeoch, M.A., 1999. Sweet potato, Ipomoea batatas (l), cropping practices and perceived production constraints in Swaziland: implications for pest management. Int. J. Pest Manage. 45 (1), 29–33.
Nyambo, B., Nyagah, R., 2006. Sustaining Kenyan smallholders in fresh produce markets. Pestic. News 71, 10–11.
Ochou, G.O., Matthews, G.A., Mumford, J.D., 1998. Comparison of different strategies for cotton insect pest management in Africa. Crop Prot. 17 (9), 735–741.
Organic Exchange, 2007. Organic cotton market report. Organic Exchange, Berkeley, CA 〈http://www.organicexchange.org/Documents/market_high_fall07.pdf〉.
Otsuki, T., Wilson, J.S., Sewadeh, M., 2001. Saving two in a billion: quantifying the trade effect of European food safety standards on African exports. Food Policy 26, 495–514.
PAN UK, 2006. Living with Poison. Problems of Endosulfan in West African Cotton Growing Systems. Pesticide Action Network UK, London.
Partow, H., 1995. Pesticide Use and Management in Kenya. Research Memoir no. 92. Institut Universitaire d'Etudes du Développement, Geneva.
Pretty, J., Hine, R., 2005. Pesticide use and the environment. In: Pretty, J. (Ed.), The Pesticide Detox. Towards a More Sustainable Agriculture. Earthscan, London, pp. 1–22.
Pretty, J., Guijt, I., Thompson, J., Scoones, I., 1995. Participatory Learning & Action. A Trainer's Guide. Participatory Methodology Series, Sustainable Agriculture Programme, International Institute for Environment and Development, London.
Pretty, J., Waibel, H., 2005. Paying the price: the full cost of pesticides. In: Pretty, J. (Ed.), The Pesticide Detox. Towards a More Sustainable Agriculture. Earthscan, London, pp. 39–54.
Ramirez, O.A., Mumford, J.D., 1995. The role of public policy in implementing IPM. Crop Prot. 14 (7), 565–572.
Repetto, R., Baliga, S.S., 1996. Pesticides and The Immune System: The Public Health Risks. World Resources Institute, Washington, DC.
Shepherd, A.W., Farolfi, S., 1999. Export Crop Liberalisation in Africa. A Review. Agricultural Services Bulletin 135. Food & Agriculture Organisation, Rome.
Sibanda, T., Dobson, H.M., Cooper, J.F., Manyangarirwa, W., Chiimba, W., 2000. Pest management challenges for smallholder vegetable farmers in Zimbabwe. Crop Prot. 19, 807–815.
Silvie, P., Deguine, J.P., Nibouche, S., Michel, B., Vaissayre, M., 2001. Potential of threshold-based interventions for cotton pest control by small farmers in West Africa. Crop Prot. 20, 297–301.
Tettey, V., 2001. Assessment of the use of pesticides by cabbage growers in the Ga District of Ghana. Unpublished B.Sc. Thesis. Department of Home Science, University of Ghana, Legon.
Thrupp, L.A., Bergeron, G., Waters, W.F., 1995. Bittersweet Harvests for Global Supermarkets; Challenges in Latin America's Agricultural Export Boom. World Resources Institute, Washington, DC.
Tobin, R., 1996. Pest management, the environment and Japanese foreign assistance. Food Policy 21 (2), 211–228.
Ton, P., 2001. Cotton Production and Rural Livelihoods in West Africa. Occasional Papers no. 219. ENDA, Dakar, Senegal.
Way, M.J., van Emden, H.F., 2000. Integrated pest management in practice—pathways towards successful application. Crop Prot. 19, 81–103.
Williamson, S., 2003. Pesticide Provision in Liberalised Africa: Out of Control? Agricultural Research & Extension Network Paper no. 126. Overseas Development Institute, London.
Williamson, S., 2005. Breaking the barriers to IPM in Africa: evidence from Benin, Ethiopia, Ghana and Senegal. In: Pretty, J. (Ed.), The Pesticide Detox. Towards a More Sustainable Agriculture. Earthscan, London, pp. 165–180.
Williamson, S., Ferrigno, S., Vodouhe, S.D., 2005. Needs-based decision-making for cotton problems in Africa: a response to Hillocks. Int. J. Pest Manage. 51 (4), 219–224.
Wilson, C., Tisdell, C., 2001. Why farmers continue to use pesticides despite environmental, health and sustainability costs. Ecol. Econ. 39, 446–449.