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Insecticide use and practices among cotton farmers in northern Uganda

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Abstract

Cotton (*Gossypium hirsutum* L.) is an important cash crop in Uganda. Insecticide application practices among cotton growers in northern Uganda were examined to determine the pests targeted and the compliance of control measures with the standards recommended by the Uganda's Cotton Development Organization (CDO). A semi-structured questionnaire was administered to fifty farmers, who were randomly selected from seven sub-counties of Padyere County, Nebbi district. Insecticide use practices were not consistent with the recommendations of the CDO. For instance, over 50% of the farmers did not use protective wear during insecticide application. The concentrations of insecticides applied were lower than those recommended by the CDO. The main insecticides used were Cypercal (Cypermethrin), Karate 5EC (Lambdacyhalothrin), Ambush (Permethrin) and Polytrin Ka (Profenofos). Insecticides were mostly applied during flowering and pre-harvest stages. The main target pests were bollworms (*Helicoverpa armigera* Hubner.), aphids (*Aphis gossypii* Glover), lygus bugs (*Taylorilygus vosseleri* Pop.) and cotton stainers (*Dysdercus cingulatus* Fab.).

Key words: *Gossypium hirsutum,* organophosphates, pest management, pyrethroids

Introduction

Cotton (*Gossypium hirsutum* L.) is an important cash crop in Uganda. Lint exports contribute about US$ 86 million annually, i.e., 4% of the total export revenue and 12% of the revenue generated from traditional exports of the country (BoU, 2011), making it one of the four traditional exports of Uganda after coffee, tea and tobacco. Cotton is mainly grown by small-scale farmers, with an average farm size of 1.2 ha (PMA, 2009). It is grown mainly in the North, East and South East of Lake Kyoga, and in the Kasese area in the West (CDO, 2000). Yields vary between 200 and 450 kg/ha of seed cotton and the area under cotton cultivation is estimated at 80,000 hectares in 2009 (MAAIF, 2011). Uganda's cotton production potential rates are over one million bales (185,000 tonnes) annually (Sabune, 2005; CDO, 2008; Baffes, 2009).

Cotton is host to several insect pests that attack all growth stages (Mathews, 1989; Shaw, 2000; Pyke and Brown, 2000; Farrell and Johnson, 2005). Consequently, large quantities of acutely toxic insecticides are used in production of

cotton in order to realise higher yields. For instance, the Cotton Sub-sector Development Project (CSDP) aimed at a significant increase in insecticide use in cotton from approximately 80,000 to 300,000 liters/year by the year 2000 (Anon, 1993). In 2010, the CDO distributed 319,077 units of cypercal and polytrin. These huge volumes of insecticides often lead to severe and fatal poisonings of humans, livestock and the environment (Ferrigno *et al*., 2005). In Nebbi district for instance, beekeepers attributed low honeybee colonisation levels and colony losses to the insecticides used during cotton production (NDLG, 2010). These claims are, however, unsubstantiated.

Most of the active ingredients used in formulation of cotton insecticides are classified by the World Health Organisation (WHO) as Class II (moderately hazardous), for acute mammalian toxicity. Presently a number of broad spectrum insecticides such as Deltamethrin and Cypermethrin are used for the control of cotton pests (CDO Annual Report, 2009 – 2010). In addition, other insecticides such as Rogor (Dimethoate 40%), Polytrin Ka (Profenofos) and Cypercal (Cypermethrin) were supplied by the Cotton Development Organization (CDO) for simultaneous use by cotton farmers (CDO, 2002). An important first step towards designing sustainable pest management approaches for cotton is to understand farmers' insecticide use practices.

Therefore, the objective of this study was to determine which pests are targeted by farmers; and the dosages of different insecticides used by cotton farmers.

Materials and methods

Study area

This study was conducted in seven sub-counties; (Akworo, Erussi, Nyaravur, Parombo, Ndheu, Nebbi town and Kucwiny) of Padyere county, Nebbi district in North Western Uganda. The area is located at 2° 28' 32" N and 31° 6' 9" E; and at 1,082 m above sea level. The area receives 1000 - 1400 mm of rainfall per year. The rainfall is of bimodal pattern, with unpredictable amounts and patterns. Wet seasons are from March-May and August-November, while the dry seasons are in June-July and December-February. The study area belongs to the North Western savanna grassland agro ecological zone with shrubs of *Acacia* spp., legume trees, woodlands and scattered trees (Anywar *et al*., 2014).

Crops grown include the non-pollinator dependent crops such as cassava (*Manihot esculentum* L.), sweet-potato, (*Ipomoea batatus* L.), maize (*Zea mays* L.); pollinator dependent crops like beans (*Phaseolus vulgaris* L.), groundnut (*Arachis hypogea* L.), tomato (*Lycopersicon esculentum* L.), pumpkin (*Cucurbita moschata* L.), sim-sim (*Sesamum indicum* L.) and several other vegetable crops (Uganda Districts Information Handbook 2011-2012). Bee keeping is also widely practiced.

Sample selection and data collection

A total of fifty cotton farmers were randomly selected, at least seven farmers from each of the seven sub-counties. To obtain information on insecticide use practices in cotton, a semi-structured questionnaire with both open and close-ended questions, was administered to each

farmer. Consent of the farmer was obtained prior to the interview and the identity of each farmer was kept secret. The questionnaire sought information on the farmers' educational background, knowledge on insect pests of cotton, insecticides used and quantities applied, frequency of application and insecticide handling. In some cases, samples of cotton pests were collected from the fields using hand nets and hand picking following the approach of Burleigh *et al*. (1998). The pests were later identified in the laboratory at Makerere University using online identification keys of cotton pests by Boyd *et al*. (2004).

To determine the quantity of liquid insecticide applied, the farmer was asked the number of lids (lids from the insecticide containers) used per tank of water. Lid volume was verified using a graduated cylinder. The recommended dosages for each insecticide used were obtained from extension agents/site coordinators employed by CDO to educate farmers on the use of insecticides (Ambush = 250 ml/ tank mixture; Cypercal = 120 ml/tank mixture; Karate 5EC = 120 ml/tank mixture; Polytrin ka = 240 ml/tank mixture). Labels on the insecticide containers were also used to determine the recommended dosages of the various insecticides.

Data analysis

The data obtained were coded and entered into a spreadsheet in SPSS statistical package (version 16.0); then analysed using descriptive statistics, including means and percentages. Chi-square test at 5% probability level was used to determine whether farmers' profiles (age, educational levels and gender) were associated with insecticide use practices (Armstrong and Eperjesi, 2001). Additionally, it was used to determine whether farmers' use of insecticides differed significantly from the standards recommended by CDO. The frequency of citations for each pest was used to rank the pests from 1 = the most important (highest number of citations) to 9 = least important (lowest number of citations).

Results

General characteristics of respondents and insecticide use

Forty-six percent of the farmers were between 30-44 years of age, 38% were above 44 years of age and 16% were under 30 years of age (Table 1). Most (72%) of the farmers had not studied beyond primary level, 18% had secondary education, 8% did not attend any school and 2% attended tertiary education.

The majority (72%) of farmers interviewed applied insecticides. Of those who sprayed, about one-third made three applications per season, another one-third made one or two applications and the remaining one-third made four or more applications per season. The number of insecticide sprays made by the farmers in the season was not significantly associated with farmers' gender ($\chi^2 = 3.29$, d.f = 7, p = 0.857), age ($\chi^2 = 17.56$, d.f = 14, p = 0.228) or educational level ($\chi^2 = 22.14$, d.f = 21, p = 0.392).

Insecticides used

The insecticides used by cotton farmers were Cypercal (Cypermethrin), Karate 5EC (Lambdacyhalothrin), Ambush (Permethrin) and Polytrin Ka (Profenofos). Cypercal and Karate 5EC were the most commonly applied while Ambush and Polytrin were used less frequently (Table 2). The four insecticides were applied at all stages of growth

Table 1. Characteristics of respondent farmers and association with insecticide use in Uganda

Variables	Percent respondents	Association between farmer characteristics and insecticide use χ^2 value (P value)
Gender (%)		
Male	68	3.29 (P = 0.857)
Female	32	
Age		
Under 30 years	16	
30-44 years old	46	17.56 (P = 0.228)
Above 44 years old	38	
Education		
None	8	
Primary level	72	22.14 (P = 0.392)
Secondary level	18	
Tertiary level	2	

although use patterns for Cypercal and Karate 5EC were different. Cypercal was most commonly used at the flowering stage and seedling stage; while Karate 5EC was most commonly reported at the pre-harvest stage and flowering stage. The flowering stage was the most frequently sprayed by farmers; followed by pre-harvest stage and lastly the seedling stage.

The four insecticides were applied with varying frequencies. The majority of farmers (83.3%) made multiple treatments, with one or two insecticides in the season. Only 16.7% made multiple treatments with three insecticides, being alternated with each other. All the farmers who used insecticides made 3-4 treatments with Cypercal, in addition to using at least one other insecticide.

Use of insecticides versus CDO standards

Among the farmers that sprayed, the majority (80.6%) applied the first insecticide sprays at four weeks after seedling emergence. About 16.7% applied three weeks after seedling emergence; while 2.8% applied first sprays two weeks after seedling emergence. No farmer made the first sprays one week after seedling emergence. There were no significant differences between farmers' use of insecticides and CDO standards ($\chi^2 = 0.55$, d.f = 2, p = 0.760), in terms of timing of first spray, number of sprays and intervals of sprays made by the farmers (Table 3). There were significant differences in the quantities of insecticides used by farmers and the CDO rate ($\chi^2 = 47.7$, d.f = 3, p = 0.000). Farmers used

much less quantities of insecticides compared with the standards recommended by the CDO. There were, however, no significant differences in the quantities of water used with each insecticide ($\chi^2 = 0.10$, d.f = 3, p = 0.992) between farmers and the standards recommended by CDO.

Target pests at various crop stages

The four most commonly reported targets for the insecticides applied were bollworms (*Helicoverpa armigera* Hubner), followed by aphids (*Aphis gossypii* Glover), lygus bugs (*Taylorilygus vosseleri* Pop.) and cotton stainers (*Dysdercus cingulatus* Fab.) (Table 4). The majority of farmers reported bollworms as the major pest during the flowering and pre-harvest stages. Aphids and lygus bugs were the main pests during the seedling and flowering stages; while cotton stainers were reported mainly in the pre-harvest stage. Other pests cited were cotton bugs, stem borers, stink bugs and yellow termites; although these were reportedly minor pests on cotton in this region (Table 4). Pest ranking revealed that bollworms had a rank of 1, followed by aphids, lygus bugs and cotton stainers (rank 2), cotton leaf folders (rank 3), cotton bugs and stem borers (rank 4), yellow termites (rank 5), stink bugs (rank 6). The flowering stage was the most frequently cited as the stage attacked by all pests on cotton, followed by the seedling stage and lastly the pre-harvest stage (Table 4).

Spray equipment and protective clothing

Results showed that 91.7% of farmers who applied insecticides used knapsack sprayers for insecticide application. Two farmers (5.6%) used both knap sack and

Table 2. Number of farmers using different insecticides to control specific insect pests of cotton in Padyere county, Nebbi district, Uganda

Insecticides	Pest targeted by farmers	Number of farmers using the insecticides at each crop stage		
		Seedling	Flowering	Pre-harvest
Cypercal (Cypermethrin)	Bollworms, aphids, lygus	17	26	6
Polytrin ka (Profenofos)	Aphids, lygus, leaf folder	3	1	1
Karate 5EC (Lambdacyhalothrin)	Cotton stainer, bollworms	4	8	20
Ambush (Permethrin)	Bollworms, lygus, aphids	1	4	1

*Insecticides are stated by their trade names followed by the active ingredients in brackets

Table 3. Comparison of insecticide dosages applied by farmers with standards recommended by the Cotton Development Organisation (CDO)

				Volume of insecticides (ml/tank mixture) used				Volume of water (l) used with each insecticide			
	A	B	C	D	E	F	G	D	E	F	G
Farmers' rate	4	3.6	3	86.4	212.5	115.4	106	14.5	12.5	14.2	15
CDO rate	5	6	2	120	240	120	250	15	15	15	15
	$\chi^2_2 = 0.55$ (p = 0.760)			$\chi^2_3 = 47.7$ (p = 0.000)				$\chi^2_3 = 0.10$ (p = 0.992)			

· Volume of insecticides by farmers is an average value; tank capacity is 15l

A = Timing of first sprays in weeks after seedling emergence; B = Number of sprays; C = Intervals of sprays in weeks; D = Cypercal; E = Polytrin ka; F = Karate 5EC; G = Ambush

hand-held sprayers; while one farmer (2.8%) used hand-held sprayer only (Table 5).

With regard to the use of protective clothing during insecticide application, protective masks and boots were worn by 2.8% and 16.7% of the farmers, respectively; during field applications of insecticides. Only 5.6% of the farmers used full protective wear (masks, rubber boots and rubber gloves) and 19.4% used at least two items of protective wear (masks and rubber boots). Most (55.6%) of the farmers did not use any protective clothing (Table 6).

Discussion

Insecticides were used by the majority (72%) of cotton farmers, but it was also evident that farmers' frequency of insecticide application did not follow the guidelines recommended by CDO. For instance, some farmers made one spray per season and others two, three, and even 15 sprays per season; while the guideline was six sprays per season. Contrary the beliefs of the communities in the sub-counties surveyed, cotton farmers did not use excessive quantities of insecticides, and were actually using doses that were lower than those recommended by the CDO. Reasons for this were unclear, but could be ignorance of the farmer about the recommendations, poor calibration methods or attempts by the farmers to use little amounts of the product as a cost saving measure. Such practices could facilitate the development of insecticide resistance within the targeted pests as has been reported for bollworm in many cotton-growing areas (Mu *et al.*, 1995; Wu *et al.*, 1997; Rui *et al.*, 1999). Many of the farmers in the sub-counties surveyed stated that the pests did not respond well

Table 4. Frequency of mention of cotton pests at various crop stages by farmers in Uganda

Targets	Number of mentions of pests at each crop stage by farmers		
	Seedling	Flowering	Pre-harvest
Aphids	19	7	0
Lygus bugs	13	11	2
Bollworms	3	28	15
Stainer	0	4	22
Stink bugs	1	1	0
Cotton bugs	5	4	0
Stem borers	4	3	2
Yellow termites	0	2	2
Cotton leaf folders	6	5	2

Aphids (*Aphis gossypii* Glover); Lygus bugs (*Taylorilygus vosseleri* Pop.); Bollworms (American bollworm, *Helicoverpa armigera* Hubner, Spiny bollworm, *Earias insulana* Boisd and *E. biplaga*, Red bollworm, *Diparopsis castanea* Roths); Stainers (Red cotton bug, *Dysdercus cingulatus* Fab., Dusky cotton bug, *Oxycarenus hyalipennis* Costa); Stink bugs (Green and Brown stink bugs); Cotton bugs (Clouded and Tarnished cotton bugs); Stem borers and Yellow termites

Table 5. Number of farmers by age group using different spray equipment

Age group	Equipment				
	Ks	Hs	Ks and Hs	N/A	Total
Under 30	6	0	0	2	8
30-44	11	0	1	10	22
45 and above	16	1	1	2	20
Total	33	1	2	14	50

Ks = Knapsack sprayer; Hs = Hand sprayer; N/A = Not applicable

Table 6. Number of farmers by age group using different protective clothing

Age group	Protective clothing						
	M	Rb	M & Rb	M, Rb & G	None	N/A	Total
Under 30	0	0	1	1	4	2	8
30-44	0	3	3	0	6	10	22
45 and above	1	3	3	1	10	2	20
Total	1	6	7	2	20	14	50

M = Masks; Rb = Rubber boots; G = Rubber gloves; None = Did not use any protective clothing

to insecticide treatments and this was the reason for multiple insecticide treatments.

Simultaneous use of different insecticides in cotton has been recommended by the National Agricultural Research Organization (NARO) as a strategy to address pest resistance to insecticides used in cotton production (Namulonge Research Station Annual Report, 1991). Farmers also reported reducing the volume of water used to mix the insecticide if they used a lower quantity of insecticide than the recommended dose. This practice explained the variable volumes of water used in the spray tanks that were reported. Therefore, the poor colonisation of beehives is unlikely to be due to the prevailing insecticide use practices in the sub-counties because the cotton growers are not using insecticides excessively. We hypothesize that poor colonisation rates may be a consequence of pests and/or diseases in the beehives.

The farmers that did not use insecticides stated this was because they could not afford the insecticides and/or the spray equipment. Instead as a pest management measure, they relied on keeping fields weed free and predatory ants. It was not possible to assess the effectiveness of this approach.

Farmers were knowledgeable about cotton pests and the plant's growth stage, which is most sensitive to pest attack. Bollworms were cited as the most important pests and the flowering stage as one where most of the insecticides were used possibly because the flowering stage was most vulnerable to pest attack. Similarly, the pre-harvest stage was also sprayed by many farmers because of bollworms and cotton strainers. Damage during the flowering and pre-harvest stage affects the targeted product, thus causing tremendous lint yield loss and consequently financial losses. Similar bollworm problems have been reported by cotton farmers in other districts of Uganda (Sekamatte, 1994), and in other countries (Kabissa and Nyambo, 1989; Ismael *et al*., 2002; Deguine *et al*., 2008). The multitude of pests reported underscores the need for a holistic pest management strategy in cotton if production volumes and incomes are to be increased.

It was also evident that many farmers did not take safety precautions during insecticide application. For instance, some used only boots, others only gloves and the majority did not use any protective clothing. Several factors that influenced use of the recommended protective wear were advanced but poverty, lack of access to information, and hot weather came out strongly as the most important. Such unsafe practices provide the risk of exposure to the dangerous chemicals. The poor insecticide practices among the farmers highlight institutional weaknesses in ensuring insecticide users are properly or continuously trained as well as a failure in enforcement of the agrochemicals regulations of Uganda provided for in Uganda's statutory instrument (29-1) on 'Control of Agrochemicals (Regulation and Control) Regulations'. In many cotton growing areas, such unsafe practices have also been reported (Rucker, 1994; Ajayi and Akinnifesi, 2007). Studies have also shown negative attitudes generally towards special protective clothing among farmers (Rucker *et al*., 1988; Gomes *et al*., 1999).

The low level of formal education among the majority of farmers presents an impediment to reading and understanding the insecticide labels, and technical and safety information presented with the insecticides. Farmers who cannot read the labels for themselves probably

have to rely wholly on information passed on by peers, sales people or extension agents. It is evident that training on good insecticide handling practices is required and should be in a format that can be understood by persons with limited literacy skills.

Conclusion

Overall, farmers' use of insecticides for spraying against cotton pests in Uganda is still below the minimum standards recommended by CDO. Under-dosage, wrong mixtures, failure to read and interpret labels, unsafe spray methods are still common practices among cotton farmers in northern Uganda. The poor insecticide handling practices by cotton farmers requires the intervention of the CDO and government departments concerned with the proper use of insecticides to pay special attention to training cotton farmers on good handling practices for insecticides. Such training would promote more effective use and safer handling of such products. It would also provide farmers with a more objective basis for decisions about insecticide use in cotton.

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