High chlorpyrifos levels on vegetables in Ghana

Revelations of high levels of pesticide residues on foodstuffs has led to an outcry over the inappropriate use of pesticides on vegetables cultivated in urban and peri-urban areas of Ghana. In 2006 a survey of sixty farmers from the Volta region of Ghana revealed inappropriate pesticide application practices. Residue analysis detected the presence of chlorpyrifos, DDT, cypermethrin, and dimethoate in shallots, with levels of chlorpyrifos exceeding the Codex maximum residue level in most samples. ***Daniel A. Kotey, Winfred Seth K. Gbewonyo and Kwame Afreh-Nuamah*** *report on their findings.*

Most vegetable farmers in Ghana (87%) use synthetic chemical pesticides to control pests and diseases on vegetables[1] including a number of highly persistent organochlorine (OC) pesticides. Some of these, such as lindane, endosulfan and DDT, are either restricted or even banned in Ghana[2]. The lower cost of these older pesticides makes them attractive to poor farmers. They are readily available and lax regulations have allowed inappropriate application practices to develop, such as the mixing of two or more chemicals[3]. Concerns have been raised about potential adverse effects of pesticide residues on human and environmental health. High levels of residues are sometimes found. For example, in Akumadan, a major tomato producing area of Ghana, an estimated 4% of all pesticides used are organochlorines and pesticide residues are now found in water, soil and in human body fluids such as breast milk[4].

A threat to exports

Statutory maximum residue levels (MRLs) for pesticides in food and water have been defined in most countries and residue analysis has become a requirement to support the enforcement of legislation[5]. In Ghana, residue violations are a key concern as such violations could potentially ruin the rapidly growing fast food industry the mainstay of which is fried rice (the fresh vegetables used in fried rice undergo little processing in most cases). It also has the potential to affect the cash crop export business. For example, in 2006, a consignment of 2,000 metric tonnes of cocoa beans from Ghana was rejected by Japan as a result of the excessive levels of pesticide residues found in the beans[6]. Residue violations for chlorpyrifos have also been observed on 10 samples of tomatoes grown in the Upper East Region of Ghana[7] and on seven samples of cabbage grown in the Greater Accra Region of Ghana[8]. Although there is concern about pesticide residues on produce destined for the international market, targeted monitoring of produce for the domestic market by regulatory agencies is virtually non-existent.

Shallot cultivation

Shallots, a type of onion, are a minor crop in Ghana but a major crop in Anloga, the coastal capital of the Anlo Traditional area, about 185km east of Accra, in the extreme South Eastern corner of the country[9]. At least three shallot crops are grown each year and, compared to other vegetables, in general they have relatively few serious insect pests. However, in the Anloga area onion thrips (*Thrips tabaci* Lindeman) and the cotton leaf worm caterpillar (*Spodoptera littoralis* Boisd.) are widespread and are considered a serious constraint to shallot cultivation.

Survey

A survey was conducted in the Anlo traditional area of the Keta district of the Volta Region of Ghana. It aimed to determine the sources, types, formulations, dosages and application frequency of pesticides used on vegetables in this region. It also aimed to identify the levels of residues remaining on shallots and whether these exceeded Codex MRLs. Two vegetable cultivation zones were chosen as study sites to gather information through formal and informal interviews (questionnaire) and through field observations. The first site was located within depressions in the area while the second was located along the Keta lagoon of the Anlo Traditional area. A total of 60 farmers were surveyed, all of whom were in active production and routinely applied pesticides to their crops. The survey was conducted from August-October 2006 with

Sixty farmers from the Anlo traditional were interviewed about their use of pesticides

Photo: Daniel Kotey

extension personnel from the district directorate of the Ministry of Food and Agriculture (MofA), who provided local insight, as well as translation and interpretation of farmers' responses. Shallots were selected at random from the farms of six randomly selected farmers for residue analysis. Residues were extracted and analysed by gas chromatography[10].

Survey results

Shallots, okra, pepper, tomatoes and aubergine are cultivated alternately in the area. 91% of farmers are men educated up to basic or secondary level with an average farm size of 0.13 ha and 0.17 ha in depression and lagoon areas, respectively. Respondents had been cultivating vegetables for up to 11 years. Although they used hired labour on their farms, they generally applied pesticides themselves using hand operated CP-15 knapsack sprayers.

Pesticide choice

The chief factor informing what pesticide type to use to control pests was efficacy (77% and 69% of respondents in depression and lagoon areas, respectively) with other important factors being availability (15% of depression respondents) and level of safety (12% of lagoon respondents).

Supply outlets and sources of information

Most pesticides were obtained from pesticide retailers, who supplied pesticides to 94% of depression area and 85% of lagoon area respondents respectively. Extension agents and non-governmental organisations (NGOs) provided pesticides to some farmers (generally less than 10%). Information on pesticides and their use was obtained mainly from friend farmers and extension agents. For example, whilst friend farmers provided information to 35% (depression area) and 27% (lagoon area) of respondents, extension agents provided information to 35% (lagoon area) and 30% (depression area) of respondents.

Application practices

Nine different pesticide active ingredients (a.i) in four chemical classes (Table 1) were used and these were mainly in WHO toxicity classes II (moderately hazardous) and III (slightly hazardous). 71% and 58% of depression and lagoon area respondents respectively said they used more than one active ingredient per crop cycle (approximately two months). Of these farmers, over 70% stated that they applied these active ingredients in mixtures of two or more active ingredients (either of the same, or of different chemical classes).

Lack of adequate protection

Farmers generally failed to protect themselves from contamination. Standard protective clothing such as goggles or overalls was almost never worn. Instead long-sleeved shirts were worn by some respondents (18% and 25% of depression and lagoon area respondents respectively) or handkerchiefs wrapped over the mouth and nostrils, a dangerously inadequate substitute for a face mask (64% depression and 42% lagoon area respondents). 18% of depression and 33% of lagoon area respondents wore a combination of these two items during pesticide application.

Estimation of application dose

Four different containers (empty tomato tin, empty milk tin, 15ml measuring cup, lid of pesticide container) were used to estimate the amount of pesticide to use, with most farmers using the lid of the pesticide container (41% and 23% of depression and lagoon area respondents respectively). 29% and 58% of respondents in the depression and lagoon areas respectively said they relied on experience to measure the amount of pesticide to be applied (Figure 1).

Farmers could not state precise application doses to use for specific pests and crop stages and were unable to calibrate application equipment. They estimated the amount of pesticide to add from an estimation of the volume of the lid of the pesticide

Figure 1. Estimating volume of pesticide

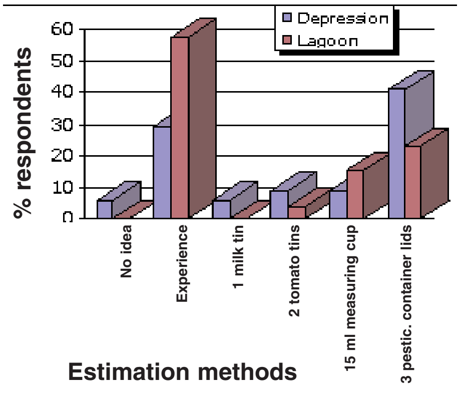

Table 1. Pesticide used and their status in Ghana

Pesticide product	Active ingredients	WHO Toxicity class	Status
Actellic	Pirimiphos-methyl (OP)	III	PCL
Cydim super	Cypermethrin+ dimethoate (PY+OP)	II+II	PCL
Cymbush	Cypermethrin (PY)	II	PCL
Cypercal	Cypermethrin (PY)	II	FRE
Dimethoate	Dimethoate (OP)	II	FRE
DDT	DDT (OC)	II	Banned
Dursban	Chlorpyrifos (OP)	II	FRE
Furadan	Carbofuran (CARB)	Ib	FRE
Gammalin 20	Lindane (OC)	II	Restricted
Karate/PAWA	Lambda-cyhalothrin (PY)	II	FRE
Pyrinex	Chlorpyrifos (OP)	II	FRE
Topsin	Thiophanate-methyl (OP)	III	PCL

FRE: Fully registered for use in Ghana (valid for maximum of three years)
PCL: Provisional clearance in Ghana (valid for maximum of one year)
OC: Organochlorine OP: Organophosphate PY: Pyrethroid CARB: Carbamate
WHO Toxicity classes: Ib - highly hazardous; II - moderately hazardous; III - slightly hazardous

container and knowing the volume of the mixing container. According to farmers, higher tank doses were used during the first pesticide treatment of the season (mostly during the seedling stage) and during heavy pest infestation. Okra was said to require the highest doses whilst shallots were said to require the least.

High levels of residues

Residues of chlorpyrifos, DDT, cypermethrin and dimethoate were detected in over 90% of samples submitted for Gas Chromatography analysis. Over 60% and 50% of samples from the depression and lagoon areas respectively had chlorpyrifos residue levels above Codex and EU MRLs of 0.05 mg/kg (Table 2). Residue levels of DDT, cypermethrin and dimethoate were lower than Codex MRLs.

Implications

High pesticide application costs can drive farmers to source inferior pesticides from unapproved sources in a bid to reduce costs. Private (and unregistered) pesticide retailers are widely acknowledged as sources of cheap pesticides (pesticides from registered retailers are relatively more expensive than those from unregistered sources). The overwhelming number of farmers that sourced pesticides from private retailers (over 85%) is indicative of this trend. The buying of pesticides in small quantities is sometimes attributable to high pesticide application costs.

Due to the close proximity between agricultural fields and waterways such as the Keta lagoon, the continued use of DDT and Gammalin 20 (lindane) to control pests in the Keta-Anloga area poses health hazards to residents and consumers of food products grown in this area. Both of these pesticides are highly persistent and bioaccumulate. Residues of DDT, for instance, have been detected in wells and soil sediments on farms in the Anlo Traditional area[11]. It is therefore possible that the natural processes of leaching and run-off, particularly in the rainy season, could facilitate the transfer of these organochlorine pesticides from agricultural fields to drinking water wells in households as well as into the Keta lagoon which is a fishing ground. Farmers who mentioned DDT and Gammalin 20 as some of the pesticides they applied cited Nigeria as the source of their supply. The Ghana Environmental Protection Agency estimates that 20% of

Table 2. Chlorpyrifos levels in shallots

Sample (Depression)	Residue levels on shallot bulb (mg/kg)	Sample (Lagoon)	Residue levels on shallot bulb (mg/kg)
V	0.1962, 0.0118, 0.1009	D	0.3054, 0.1575, 0.0051
G	0.1290, 0.0244, 0.2266	K	0.0051, 0.0004, 0.0822
J	0.3329, 0.0137	P	0.0827, 0.0441

Letters D, G, J, K, P and V are the initials of farmers from whom samples were collected
Each extract was made from 25 grammes of shallots.

Sowing shallot 'mother bulbs'
Photo: Daniel Kotey

pesticide imports are unauthorized, and occur via cross-border trade[12].

The application of mixtures of two or more pesticides was a common occurrence in both areas, confirming previous findings from Ghana[13]. This may be fuelled by perception that pesticide mixtures will be more powerful and effective than individual products which is not always the case[14]. When unregistered mixes of chemicals are used their effects cannot be predicted. Chemicals that act similarly (e.g. cholinesterase-inhibiting pesticides) can demonstrate additive toxicity even if, individually, they are below levels considered dangerous[15]. Application of pesticide mixtures can also result in the simultaneous development of resistance[16].

Although residues of all four selected pesticides analysed were detected in more than 90% of samples, levels of chlorpyrifos were highest. Chlorpyrifos residue levels for depression and lagoon areas were significantly different. One possible explanation could be the application of higher pesticide doses in the depression area[17]. Whilst residue levels of all the other pesticides detected in samples were lower than Codex MRLs, more than 50% of samples in both areas had chlorpyrifos levels above Codex MRLs. Two factors may account for the relatively higher levels of chlorpyrifos residues in samples. Chlorpyrifos was the most extensively used pesticide and so residues may have accumulated from continuous use. It is also possible that shallots were harvested within two weeks of chlorpyrifos application (most respondents sprayed their crops every two weeks). Chlorpyrifos does not degrade easily and can persist on plant surfaces for periods of up to 14 days[18]. In addition, chlorpyrifos residues can persist in soils for over a year depending on soil type and climatic conditions[19].

Conclusions

The detection of chlorpyrifos levels above Codex MRLs in samples has several health implications. Chlorpyrifos is moderately toxic to humans[20] and is reported to damage the developing nervous system, specifically targeting the immature brain[21]. Exposure to chlorpyrifos has also been reported to cause adverse effects on brain cell development and cholinergic biomarkers[22]. Secondly, chlorpyrifos is suspected to be neuroteratogen, and recent findings suggest that it has a shifting cellular target, initially impairing the development of neurons and subsequently affecting the glia, which develop much later and support nerve function[23].

Although chlorpyrifos residue levels on most of the samples analysed exceeded Codex MRLs, an estimation of daily intake of these residues revealed that the amount of chlorpyrifos residues that would be ingested by eating a kilogramme of shallots per day was generally well within FAO/WHO Acceptable Daily Intake (ADI) limits. The study however, highlights the fact that in spite of concerted efforts by both Government and NGOs to reduce reliance on pesticides as a primary pest management tool, its use, particularly amongst vegetable farmers still remains high and alarming. The key to solving this and the attendant problem of pesticide residues in food and food items is the coupling of farmer education with the prosecution of persons promoting the illicit trade and use of cheap, unregistered pesticide products, as stipulated by Ghana's Pesticide Control and Management Act (Act 528, 1996).

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Harvested shallots being 'cured' on a field used for pepper cultivation Photo: Daniel Kotey

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