SESSION 10A

GLOBAL ASPECTS FOR THE SAFE USE OF CROP PROTECTION AGENTS

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Pesticides Safety Directorate, York, UK

Papers: 10A-1 to 10A-4

Pesticides in the third world – their changing role and a need for new thinking

J F Cooper, H M Dobson
Natural Resources Institute, University of Greenwich, Chatham Maritime, Kent, ME4 4TB, UK
Email: j.f.cooper@gre.ac.uk

ABSTRACT

Use of pesticides is increasing in developing countries alongside rising populations with increased lifestyle expectations. Some examples are given of unsafe pesticide use, with associated risk of poisoning and environmental pollution. To change this situation, a realistic, rather than dogmatic approach is needed. We need to understand problems in order to be able to deal with them, and to integrate unavoidable pesticide use into a pest management technology spectrum which makes more use of resistant crop varieties and increased exploitation of the beneficial effects of biodiversity. In some cases we need to change the nature of pest management research so that it does not favour pesticides to the detriment of alternatives.

THE HUMAN AND AGRICULTURAL CONTEXT

The world population is now around 6 billion, and is expected to peak at 8.5 billion in 2035 (Population Reference Bureau, 2001). Around four fifths live in the developing world where human expectations of a decent lifestyle and standard of living are rising. Arable land per person in the developing world is shrinking, from 0.38 ha in 1970 to 0.23 ha in 2000, with a projected decline to 0.15 ha per person by 2050, (FAO, 2001). Even in Africa which is suffering most from the devastating impact of an HIV/AIDS epidemic, the population is expected to increase from its current level of around 794 million to at least 1.7 billion, with upper estimates of around 2.3 billion by 2050 (United Nations 2000).

The ability of the world's farmers to produce food has increased greatly over our lifetimes. The Food and Agriculture Organisation (FAO, 2001) estimated that by 2030, global food production in the developing countries will be 70% higher than in 1995/97, with 80% of this increase coming from increased intensification. In recent years it has been good to see the dramatic success of agriculture in India, which has now become an important agricultural exporter. The changes have been possible because of technologies such as increased fertiliser usage, irrigation, better crop cultivars, mechanisation and improved pest control. Pesticides have played an important part in reducing potential losses of up to 50% from pests (Oerke *et al.*, 1994) but are the risks of this type of crop protection too high?

CONTRADICTORY VIEWPOINTS ON PESTICIDES

People's attitudes to pesticides are frequently based on personal belief or a series of subjective values, which may be ecological, psychological, political, social or even religious in nature. In relation to developing countries, these attitudes are particularly polarised in favour of, or against pesticides. Negative views are often fuelled by the perception that the agrochemical industry is out to sell their products at any cost. Even those who have access to objective data struggle to make objective decisions on pesticide risks in the context of other life risks around them.

Table 1. A selection of viewpoints on pesticides:

Anti – "Unless changes are made it may not be far from truth to say that, rather than feeding the hungry, pesticides will be poisoning the hungry to feed the well-fed" (MacManus 1988)

Pro - "Humanity in the 21st century can banish hunger, end nutritional deficits in its children, and save virtually all of the remaining wildlands in the process. But there are only two ways to do it: either murder four billion people, or use chemicals and biotechnology to maintain and increase yields on land already under farming" (Avery, 1999)

Anti – "Extensive pesticide use is a symptom of an agricultural system that is no longer about food or people, the land or the environment, but just about profits". (Van der Gaag, 2000)

Pro – Lomberg (2001) claimed that if pesticides were abolished, the lives saved would be outnumbered by a factor of around 1000 by the lives lost due to poorer diets. Secondary penalties would be massive environmental damage due to the land needs of less productive farming, and a financial cost of around 20 billion US Dollars.

Organic production for all?

Organic agriculture is perceived by some to be the antidote to pesticides. Areas are increasing and attitudes to it are changing. A distinction is important here. Many farmers in developing countries are 'organic by default' since they have no access to, or funds to buy inputs such as pesticides and fertilisers, whereas the developed world perception of organic is that it is a deliberate strategy with independent certification of produce. Until recently in the developing world, not using pesticides was considered to be old-fashioned and the message from extension agencies was that farmers should adopt the modern approach of intensifying their production with artificial inputs. Today attitudes have changed. Organic farming is now seen as the more sophisticated 'lifestyle' approach compared with the rather 'crude' tools of pesticides and fertilisers. The authors are yet to be convinced that organic production can fully replace agriculture which uses pesticides and fertilisers, but we do believe there is a need to look at some radical ways to rationalise and reduce pesticide use.

PESTICIDE USE IN THE DEVELOPING WORLD

Pesticide use has been increasing for the last 20 years. Around 2,000,000 tons of pesticide active ingredient are now applied around the world each year (World Resources Institute, 1999), with around 25% applied to one crop - namely cotton. The context of pesticide use in the developing world contrasts starkly with its context in the developed world – see Table 2. The consequences are serious in terms of human safety and production efficiency.

Table 2 – Contrasts between pesticide use in the developing world and elsewhere

Factor	*UK (and Europe)*	*Developing countries*
How they are applied	vehicle-mounted sprayers on large farms	mostly portable such as lever operated knapsack sprayers on small farms
Products in use	mainly herbicides and fungicides (newer molecules)	mainly insecticides and fungicides (old molecules)
Safety considerations	strong emphasis on safety and chronic exposure is the concern – operators are trained/certified	safety given low priority and acute poisoning is the concern – operators often untrained.
Independent advice	advice usually available	advice not available or linked to a particular company or vested interest
Legislation	usually effective	often only partly effective or non-existent
Regulation and testing of produce	Closely regulated and produce subject to residue analysis	not closely regulated and produce unlikely to be analysed, unless exported

Human poisoning

In the developing world, lack of emphasis on safety, widespread use of portable sprayers (often leaking), minimal use of protective clothing and unregulated availability and use of more toxic, older pesticides all result in much greater risks to sprayer operators.

Figure 1 shows contamination of a protective suit removed after the operator had sprayed tall cotton plants. A fluorescent dye technique (King & Dobson, 1992) shows up spray deposits as white areas. These are worrying images when it is realised that operators do not usually wear such protective suits, and deposits would normally go directly on to the clothes or skin of the sprayer operator.

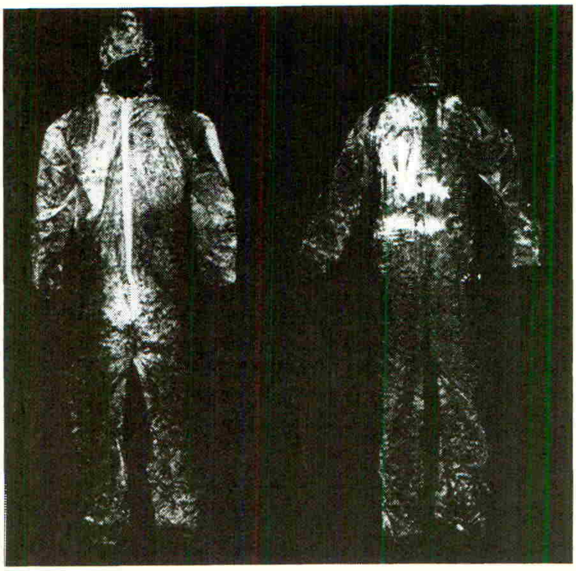

Figure 1 Contamination from pesticide (white patches) on the front and back of a protective suit, after spraying an area of tall cotton using a lever-operated knapsack sprayer.

Products in common use in developing countries tend to be relatively toxic older molecules, which are often cheaper, but hazardous for users, even as formulated products (Table 3).

Table 3. Dose and toxicity data for some products used on cotton in the Punjab. LD50 figures are acute oral toxicity on rats, which have been used to calculate lethal human doses per sprayed hectare in the last column. OP = organophosphate, OC = organochlorine

Insecticide	Type	g of active ingredient per ha	LD50 of active ingredient (mg/kg)	LD50 of formulated product (mg/kg)	Nominal number of lethal human doses per ha
metasystox	OP	187	45	180	32
monocrotophos	OP	720	15	42	123
ebdosulfan	OC	700	70	25	120
methomyl	OP	170	17	136	29
chlorpyriphos	OP	400	145	725	68
quinalphos	OP	500	71	284	85

In the early 1990s, the World Health Organisation (Jeyaratnam, 1990) estimated that 3 million people a year suffered from acute pesticide poisoning with as many as 200,000 being fatalities. Most are in the developing world, where lack of awareness of the dangers or lack of appropriate protective clothing make safe use of more toxic products almost impossible. A study in Indonesia showed that 21% of spraying operations resulted in three or more symptoms associated with pesticide poisoning (Jeyaratnam, 1990). 84% of farmers were also found to be storing chemicals in their homes, in unsafe conditions where children could reach them. According to Corson (1990) third world nations use only 10 to 25% of the world's pesticides, but suffer up to 50% of the acute poisoning and 73% to 99% of the fatalities among pesticide applicators, and six out of every 10 farmers using pesticides had suffered acute poisoning.

Crop protection efficiency

Because, information, advice and training are often missing, pesticide application in the developing world is often inefficient, and may sometimes be completely ineffective if the pest is resistant or the product is applied at the wrong dose. Figure 2 illustrates how observed dose varied from the recommended dose during a survey of spraying in Zimbabwe. Observations of 15 spray events on small scale horticultural plots revealed that doses varied between 10% and over 500% of that recommended on the label.

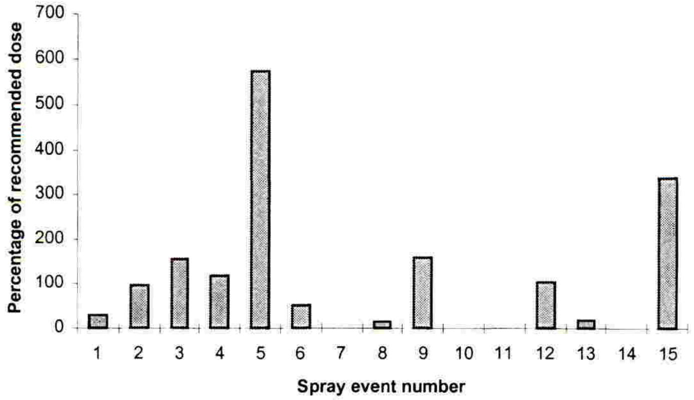

Figure 2. Pesticide dose used by farmers as a percentage of recommended dose in 15 observed spray events of smallholder vegetable farmers in Zimbabwe, (Sibanda *et al.*, 2000). There was insufficient data on the pesticide label to determine a recommended dose for events 7, 10, 11 and 14.

Overdosing increases production costs and increases the risk of residues in produce. Misuse of pyrethroids in India has led to resistance and inability to control key pests despite massive pesticide usage (Kranthi *et al*, 2002). Resistance factors (the multiple of the topical LD50 for field pest populations compared with susceptible populations) for pyrethroids were found to vary from 5 – 6,500 at 98 sites across India. Resistance was highest in sprayed areas but no field strain was fully susceptible.

With these product choices and dose variations, it is little wonder that natural enemies struggle to play an important pest regulatory role (see Fig. 3).

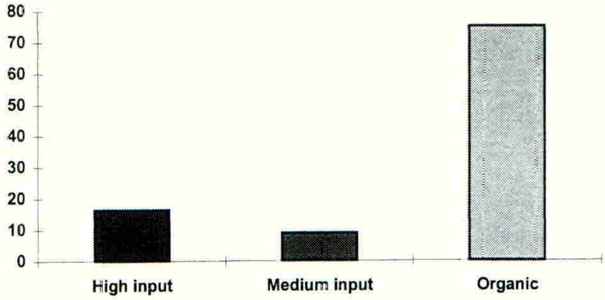

Figure 3 Relative numbers of natural enemies (mostly syrphid and coccinellid larvae and parasitoids)observed on farms with high and medium input pesticide regimes, and organic farms (Cooper, 1998).

WHAT CAN BE DONE?

Legislation

Legislation is a blunt instrument and can have undesirable effects as well as those that are intended. However I do not think that changes will take place without legislation because too many people have a stake in the status quo. Tighter restrictions need to be introduced for the older more toxic products. For example it would seem sensible to withdraw all World Health Organisation Class 1a and 1b products for use through portable equipment.

Training in safe use

Training farmers how to use pesticides properly is essential, but it is difficult to reverse bad habits and attitudes to personal safety and wearing protective clothing, even if it is available (which it is often not) and affordable. Spraying is hard work, and when temperatures are high, air needs to circulate on the skin to allow evaporative cooling. It is probably always going to be the case that protective clothing will not be used in hot climates, so there is another strong reason for only using less toxic pesticides.

IPM compatible pesticides

There is a conflict between the needs of IPM practitioners and those of the agrochemical industry. The IPM ideal is selective products which kill only the pests without harming the natural enemies, whereas pesticide manufacturers prefer multipurpose products which control a range of pests. High development costs can then be recouped by sales in a variety of markets. This commercial imperative makes it unlikely that many selective pesticides will ever be available at affordable prices. However there are some agricultural practises which favour the survival of natural enemies. These include leaving some parts of the crop unsprayed, so that natural enemies can re-colonise after pesticide treatments. Formulation can help. For example, predators are unlikely to be killed by systemic products applied as seed treatments. Early season sucking pests can be controlled in this way without harming predators. Timing can also be a way of targeting pests. Tsetse flies have been eradicated from large areas using a sequential aerosol technique (Cooper *et al.*, 1993) which is synchronised with the life cycle of the flies, while other insect numbers recover after spraying.

Research

Current research methods often favour pesticides and disadvantage alternative pest management technologies. Most scientists use a classical experimental approach to compare different pest management treatments and determine which are the most effective. These experimental trials usually involve several comparisons such as product *a* versus product *b*. Researchers cram in several replicates of the different pest control treatments alongside each other in blocks. The reason for this strategy is to try to prove statistically, with limited resources, whether product *a* is better than product *b* at controlling the pest. With sufficient replicates we can separate the variability between the treatments from the background effects such as different soil or moisture, or pest pressure variations across the field. These methods work very well for comparisons between different insecticides, herbicides and fungicides. They do not work at all well when comparing alternative pest management technologies which take an approach nearer to organic agriculture. The reason is because organic farms need to combine several approaches, rather than relying on a single potent poison. When assessing the benefits of 'percentage' treatments (those which reduce the pest problem, but not as completely as a conventional pesticide) small-plot-replicated trials are destined to favour conventional pesticides. Pest management systems which rely on biodiversity are especially ill-suited to the conventional trial design layout. Natural enemies need time and space to build up in sufficient numbers to exert a useful effect. They need to be encouraged by provision of flowers and hiding places and may even need to be introduced from nearby fields. It is futile to look for beneficial effects from natural enemies in a plot sandwiched between two pesticide plots. Repellents are unlikely to work sufficiently well alone, so a repellent treatment in a conventional statistical experiment may similarly look like a waste of time. In addition to the spatial challenges of experimental design due to small plot replicates, there is a temporal factor. The bio-diverse farm may take several seasons to reach a balanced status in which pests are kept in check. A single season experiment cannot do justice to this complex system, and will be doomed to fail in a comparison with a system based on pesticides, whose effects on the pest are more direct and immediate. However when several of these alternative methods are used in combination, bearing in mind synergistic effects as well as additive effects, they may tip the balance to keep the pest problem below the level of economic injury.

CONCLUSIONS

Problems exist with the use of pesticides, particularly in the developing world. However, they will continue to be needed for the foreseeable future and we should not bury our heads in the sand - doing away with them is not the solution to an ever-expanding population.

Training is certainly required - perhaps with new approaches to make the messages more meaningful and influential in changing habits.

Innovative research methods are also required to draw out the true potential of cultural and biological technologies and to integrate them in a complementary way with carefully chosen pesticides into effective IPM systems.

REFERENCES

Avery D (1999) The Wall Street Journal, August 12th edition.

Cooper J. (1998). Final technical report: Pest management in horticultural crops; integrating sustainable pesticide use into biocontrol-based peri-urban production systems in Kenya. DFID Crop Protection Programme reference R6616.

Cooper J F; Dobson H M (1993). Aerial Spraying for Tsetse Fly Control. A handbook of aerial spray calibration and monitoring for the Sequential Aerosol Technique. NRI publication series.

Corson W H (1990). *Global Ecology Handbook*. Beacon Press, Boston, MA.

FAO (2001). Food security and environment – a document prepared for the World Food Summit – Document AD/I/Y1 303 E/1/7.01/36000.

Jeyaratnam J (1990). *World Health Statistics Quarterly* **43**, No. 3, 139-144.

King W J; Dobson H M (1992). A photographic fluorescent tracer technique for assessing operator exposure to pesticides. *Proceedings of the Brighton Crop Protection Conference, Pests and Diseases* 889 - 894.

Kranthi K R; Jadhav D R; Kranthi S; Wanjari R R; Ali S S; Russell D A (2002). Insecticide resistance in five major insect pests of cotton in India. *Crop Protection* **21** 449-460.

Lomberg B (2001). *The Skeptical Environmentalist*. Cambridge Press, Cambridge.

MacManus S (1988). *Crisis Magazine* - Third World War Edition, Fleetway Press.

Oerke E C; Dehne H W; Schönbeck F; Weber A (1994). *Crop Production and Crop Protection - Estimated Losses In Major Food and Cash Crops*. Elsevier.

Population Reference Bureau (2001). World Population Data Sheet , http://www.prb.org.

Sibanda T; Dobson H M; Cooper J F; Manyangarirwa W; Chiimba W (2000). Pest management challenges for smallholder farmers in Zimbabwe. *Crop Protection* **19**, 807-815.

United Nations (2000). *World population prospects: the 2000 Revision*. Population division, Department of Economic and Social Affairs, New York. www.un.org/popin.

Van der Gaag N (2000). Pick your poison. *New Internationalist*, May 2000, 9-11.

World Resources Institute (1999). http://www.igc.apc.org .

The importance of product specifications to ensure availability of safe, high quality crop protection and public health products in world markets

T S Woods
E I du Pont de Nemours and Company, Stine-Haskell Research Center, Newark, Delaware 19714-0030 USA
Email: thomas.s.woods@usa.dupont.com

ABSTRACT

World farmers, public health professionals and other users have the right to expect that crop protection and public health products provided for their use are of acceptable quality, and that, when they use the products according to label instructions, the products will perform as expected, with no adverse safety or environmental consequences. For organizations involved in supply of, and in safeguarding the safety and quality of these products, an effective, universally accepted system of product specifications is a key element in ensuring that only safe, high quality products are encountered in world commerce. Such a specification system is that instituted by the Food and Agriculture Organization of the United Nations and the World Health Organization.

INTRODUCTION

Products to be used in crop protection and in public health, by their very nature as biologically active materials, require special considerations in their handling and use to ensure that users of the products and the environment to which they are applied are protected against adverse effects. These considerations include the requirement that very high quality control standards be maintained, so that safe handling and application of the products may be realized without the need for extraordinary measures. These principles relating to the importance of high quality characteristics of crop protection products have long been recognized as paramount in protecting the pesticide-using public and the environment (Anon., 1985a). This paper will discuss a globally recognized system of quality control specifications for these products that is growing in importance and implementation throughout the world, namely the scheme instituted and supported by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO). The procedures involved in the scheme are recorded in a published guidebook (Anon., 2002a) and were developed in cooperation with the global crop protection and public health product manufacturing industry and its trade associations.

HISTORY OF THE FAO/WHO SPECIFICATION PROCEDURES

Procedures for establishment of specifications for insecticides used in public health programs for insect control were first instituted by the WHO in 1953, and were codified in 1956 by means of the publication of the first edition of *Specifications for Pesticides* (Anon., 1985b). The scheme outlined in the referenced publication was devised by the WHO Expert Committee on Insecticides in order to provide a framework for setting of quality standards for these products. WHO continued its oversight to ensure the maintenance of quality of public health products and to update and augment the specification procedures in a subsequent edition of the specification guidelines in 1967. These guidelines then carried the amended title, *Specifications for Pesticides Used in Public Health,* to distinguish the products from those used in agriculture. WHO refined these guidelines in subsequent editions published in 1973, 1979, 1985, 1997 and 1999. Using the procedures detailed in the guidelines, WHO has made available on its website 30 full specifications and ten interim specifications for active ingredients/mixtures.

Meanwhile, in order to address a serious concern about the growing prevalence of sub-standard crop protection products in global commerce, in 1963, the Director General of the FAO established the Working Party on the Official Control of Pesticides (Anon., 2002a). The creation of such a body had been recommended by the FAO Conference on Pesticides in Agriculture (Anon., 1962a) and officially endorsed by the FAO Committee of Experts on Pesticides in Agriculture (Anon., 1962b) at its second session. In the charter of the Working Party, among other purposes and goals, the Director General specifically charged the group with the goal of generating specifications for agricultural pesticides, as WHO had already done for products used in public health programs. In 1975, the Working Party was renamed the Panel of Experts on Pesticide Specifications, Registration Requirements, and Application Standards. The responsibility to establish product specifications was then assumed by a subdivision of the Panel of Experts, designated Section B, which later became the FAO Group on Specifications. The Group on Specifications, which is comprised of members from official agencies of many countries, established the practice many years ago of holding informal meetings, with industry participants in attendance, in association with the annual meetings of the Collaborative International Pesticides Analytical Council (CIPAC). During these meetings, the Group on Pesticides has conducted the work of reviewing specifications that have been proposed by industry and adopting and publishing them for use by the global agricultural community.

To provide a framework in which that work can take place, the Group on Specifications has provided guidance by publishing information describing the working process in a series of Specifications Manuals, the first of which was published in 1971, and which was followed by subsequent editions in 1979, 1987, and 1995. Using the procedures detailed in these manuals, FAO has adopted and made available on its website over 220 specifications for crop protection products containing over 200 different active ingredients and mixtures.

Then in 1999, a major evolution occurred in the specification-setting process. The Group on Specifications adopted a new procedure, which, in addition to maintaining its historical emphasis on product quality as defined by physical property measurements, now was to encompass new criteria to ensure the safety of the product in use and in the environment. Details of the new requirements were set forth in a new edition of the Specification Manual (Anon., 1999), and are described in some detail in the later sections of this paper. To date, using the new procedures from the 1999 version of the manual, FAO has adopted and published fourteen specifications for eleven different active ingredients. Another major change has occurred in 2002, by which public health products, previously managed separately by WHO, are now being subjected to the same procedures for specification setting as are crop protection products, and FAO and WHO have joined together to manage the process jointly. In addition to the procedures detailed in the 2002 version of the Specification Manual (Anon., 2002a), WHO still separately oversees the efficacy requirements for public health products by means of the procedures outlined in the WHO Pesticide Evaluation Scheme (WHOPES). Details of this process and references to its implementation are provided in the current version of the Specification Manual (Anon., 2002a).

PROVISIONS OF THE CURRENT FAO/WHO SPECIFICATION PROCEDURE

Complete information describing the current FAO/WHO specification procedure is provided in the 2002 edition of the Specification Manual (Anon., 2002a); however, an encapsulated version will be discussed here. Under the procedure, manufacturers are encouraged to propose specifications to the joint FAO/WHO Group on Specifications, now renamed the Joint Meeting on Pesticide Specifications (JMPS) in order to bring the process into parallel with the corresponding Joint Meeting on Pesticide Residues (JMPR). In fact, by 2006, the JMPR and JMPS processes will essentially be conjoined. By this time, the establishment of a product specification *via* JMPS will be a prerequisite for review by the JMPR (Anon., 2002b). In submitting the specification proposal, the proposer provides detailed requirements for the physical properties and physical performance of the technical material and formulated product, as had been done since the early years of the procedure as set forth in the early manuals. Under the procedure initiated in 1999, however, the proposer must in addition provide a "minimum" data package relating to human and environmental safety, as well as information on the manufacturing process and the resultant impurity profile of the technical material. When the specification proposal and accompanying data package are received by FAO/WHO, an evaluator for review of the package is appointed from members of the FAO/WHO Panel of Experts. The evaluators, and all other participants in the closed session of JMPS, while not employees of FAO or WHO, are nonetheless bound contractually to FAO/WHO by strict obligations to ensure that no conflict of interest would ensue from their evaluation, and that all designated confidential data provided by the proposer are fully protected from disclosure (Anon., 2002a.)

It will be useful to review here the contents of the data package in some detail, since the information contained therein provides the fundamental basis on which quality and safety are to be judged and assured using the FAO/WHO specification as a benchmark. The heart of the procedure, and the portion on which product equivalence is based (*vide infra*), is comprised of the "Data requirements for technical materials (TC)." (Anon., 2002a). First, the data package contains information concerning the identity of the active ingredient, specifically, the chemical name, structure and the fundamental properties of the pure active substance, all of which information is to be publicly disclosed and published along with the final specification. This section also includes the identification of any relevant impurities, defined as those that have toxicological, ecotoxicological, product stability, or food taint significance, relative to properties of the active ingredient. Next in the package comes a series of items, which manufacturers consider highly confidential, and which provides the basis of any equivalence decisions that follow. These data, itemized below, are taken into consideration by the FAO/WHO evaluator of the data package and, during review and after acceptance of the specification, are kept strictly confidential by FAO/WHO:

- Complete manufacturing process, including all raw materials, reagents and solvents
- Complete impurity profile for all impurities present at 1 g/kg or greater
- Maximum limits for impurities present at 1 g/kg or greater
- Five batch analysis of typical manufacturing lots, supporting the impurity limits.

In addition to these confidential data, the package contains summaries of the acute, subacute, and chronic toxicological properties of the technical material, including reproductive and developmental toxicity, genotoxicity, and carcinogenicity. Likewise, summaries of the ecotoxicological profile of the technical material are provided, including toxicity to selected aquatic and terrestrial organisms. Finally, the proposer of the specification provides a letter of authorization, granting to FAO/WHO and to those acting on their behalf, access to full registration studies that are on file with a governmental authority in a country where the product is registered.

Following review by the FAO/WHO evaluator of the proposed specification and its accompanying data package, the specification proposal is reviewed by the entire FAO/WHO Panel of Experts at a Joint Meeting on Pesticide Specifications (JMPS.) The manufacturer who is proposing the specifications defends the proposal in a closed meeting with the Panel of Experts, during which the Panel may raise all matters of concern and requests for additional information for discussion. Following the review, the Panel meets in closed session to accept or reject the proposed specifications. When the specifications are accepted, FAO/WHO then publishes the specification and the accompanying evaluation on the Internet. The specifications are then available to whoever might choose to rely upon them for product quality assessments.

DETERMINATION OF EQUIVALENCE UNDER THE FAO/WHO SCHEME

Once the specification has been adopted by FAO/WHO, any secondary manufacturer that wishes to claim that its products also meet FAO/WHO specifications, may submit to FAO/WHO a request for determination of equivalence under a process described in the specification manual (Anon., 2002a). This provision is extremely important because it provides a basis for formal product quality comparison and assessment, which may be applied on a global basis. To support the request for determination of equivalence, the secondary manufacturer must supply to FAO/WHO a data package covering its products, which contains many of the same pieces of information that the original specification proposer had provided. This package includes acute toxicology information, as well as a letter granting FAO/WHO access to full studies on file with a competent authority where the secondary manufacturer's product is registered. In addition, and most importantly, the secondary manufacturer must provide the critical information relating to manufacturing process and impurity profile of the technical material as produced in its plants. The FAO/WHO experts then review the data package, and on a confidential basis, make a comparison between the impurity profile and manufacturing data provided by the original proposer and those from the secondary manufacturer, in order to judge the equivalence of the second product with the first. Assuming that the impurity profiles are within the variance parameters specified in the manual (Anon., 2002a), the products may be judged to be equivalent for purposes of quality comparison. If, however, there are significant differences among the provided data, as defined in the manual, FAO/WHO may require the secondary manufacturer to supply additional data, even including subacute and chronic toxicology and ecotoxicology summaries, to support the equivalence assessment. If no serious problematic differences are noted in the comparison of the data, the FAO/WHO may declare that products covered under the new proposal are equivalent to those of the primary proposer. The secondary manufacturer may then assert that its products are in compliance with FAO/WHO specifications for commercial or other purposes.

The process for determination of equivalence represents a major upgrade to the former FAO/WHO specification process, since it provides a mechanism for "certifying" products from multiple producers under a single set of quality criteria. For the first time, therefore, there now exists a global system to establish a uniform set of quality standards for products used in agriculture and public health. The FAO/WHO specification scheme may therefore be regarded as a benchmark representing a global standard of product quality, which can be used as a tool to improve the quality and safety of crop protection and public health products in world commerce.

RECOGNITION OF FAO/WHO SPECIFICATIONS BY GOVERNMENTAL AUTHORITIES

Since the publication of the "new" FAO specification procedure in 1999 (Anon., 1999), several country regulatory authorities charged with control of crop protection and/or public health products within their respective countries have considered adoption of part or all of its principles and procedures for registration use within their countries. It has been recognized that the existence of a published FAO/WHO specification, which is supported by a confidential data package that defines a desirable quality standard, represents a global product quality benchmark that may be referenced and relied upon locally for regulatory purposes. Several countries are taking steps to integrate "FAO/WHO-like" procedures into their local regulatory framework. Examples of these are Argentina and Brazil, both of which have held national seminars on the FAO/WHO procedure in order to consider how the FAO/WHO procedures could be incorporated into their internal processes (*e.g.*, Anon., 2002c). FAO and WHO have participated in the seminars and have expressed willingness "… to explain/support governments in applying the specs standards within their registration/control schemes, in particular the equivalence determination." (G. Vaagt, FAO, personal communication). Other countries in Latin America and elsewhere are considering similar approaches.

However, even before the adoption of the 1999 procedures, the impact of FAO specifications was being felt worldwide. For example, the European Union affirmed the importance of the FAO specification process to ensure high quality of crop protection products in commerce by stating in Commission Directive 94/37/EC (Anon., 1994) that for "active substances of which inclusion in Annex I is sought, …[d]ivergences from FAO specifications must be described in detail, and justified" (Annex I, paragraph 2.iii). This recognition is also affirmed for physical, chemical, and technical properties of the finished product, with the wording that for "plant protection products for which authorization is sought, … [d]ivergences from FAO specifications must be described in detail, and justified." (Annex II, paragraph 2). The basic requirement then for crop protection products as set forth in the FAO/WHO procedures provides the standard for quality requirements for these products when they are marketed in the European Union and in other countries.

CONSIDERATIONS NECESSARY FOR UTILIZATION OF FAO/WHO SPECIFICATION PROCEDURES BY NATIONAL AUTHORITIES

While the movement toward incorporation of FAO/WHO procedures into national regulatory practice and procedures would appear to be of positive benefit, it is important to note that some trends observed in certain countries may run counter to the worthwhile goal of ensuring that crop protection and public health products in commerce are of high quality and are safe to use. It appears that some regulators believe that the mere fact of existence of a published FAO/WHO specification represents a "global registration" that may be summarily referenced for local purposes. This misconception is clearly inappropriate for two important reasons. First, the FAO/WHO procedures do not constitute a registration scheme at all, and, second, since the confidential data supporting the FAO/WHO specification are the property of the proposing company, they may not be referenced without the permission of the owner. Another misuse of published FAO/WHO specifications arises from an apparent belief by some regulators that it should not be necessary to demonstrate equivalence of products from a secondary manufacturer to those on which an FAO/WHO specification has been based – that the mere existence of a specification should suffice for granting a registration to a secondary manufacturer. Again, acting on this belief would be inappropriate, since it circumvents the important equivalence assessment step to demonstrate that the safety of the two products to users and the environment is comparable. And finally, some regulators appear not to recognize the fundamental differences between FAO/WHO specifications derived under the old system and those under the new procedure adopted in 1999. While this misconception may be understandable, the old-style specifications lack the underlying and supporting confidential data on impurities and manufacturing process. This latter point means that the older specifications cannot ever be relied upon to ascertain equivalence of products from multiple producers, because there is no basis underlying the specification for comparison of the products of the respective manufacturers.

The considerations that must be taken into account, then, for FAO/WHO specifications to be used effectively are the following (Anon., 2000):

- Published FAO/WHO specifications are completely inadequate for the assessment of equivalence of products from multiple producers.
- Full evaluation within FAO/WHO, or careful use of the FAO/WHO criteria by trained experts, is required to assess equivalence adequately.
- Secondary registrations should not be granted based only on information in published FAO/WHO specifications, whether they have been derived using either the new or the old procedures.

And in fact, considering the proprietary nature of confidential data supporting FAO/WHO specifications, countries should establish the following before adopting FAO/WHO-like procedures for internal decision-making: data protection, patent protection, competent infrastructure to evaluate data, data compensation, and procedures for monitoring the quality of pesticide products in commerce.

CONCLUSIONS

Control of the quality and associated safety of crop protection and public health products is extremely important in order to protect the public and the environment. Some of the consequences of the presence of poor quality products in commerce are the following:

- Poor quality products may be contaminated by highly toxic, unregulated impurities, with potential for resultant exposure to users.
- Poor quality products may be contaminated with other active ingredients, causing unexpected and unwanted influences on the efficacy of the product.
- Poor quality products may contain less active ingredient assay than that for which the user is paying, providing lower biological performance than expected.

- Poor quality products may exhibit unacceptable physical properties, causing difficulty in use and potential exposure to users during product application and equipment cleaning.
- Poor performance by poor quality products many damage the reputation of legitimate products, resulting in removal of valuable tools from the pest-control arsenal of the user.

The use of quality control systems, as institutionalized, for example, in the FAO/WHO procedures for setting of specifications and determination of equivalence of crop protection and public health products, clearly will facilitate the management of these products in the marketplace, with the result that agriculture and public health programs will become ever safer, more predictable enterprises. Dedicated regulators of these products and responsible manufacturing companies are in accord in their support of capable, global specification schemes, such as the one described here. Working together toward this mutually beneficial goal will ensure that companies and regulators alike will contribute to the creation of a healthier environment for global agriculture. In the final analysis, a good specification system for crop protection and public health products is the first line of defense to ensure that only high quality, safe-to-use products are available in global commerce. That outcome is critical, not only for applicators of these products and for the consuming public, but also for the global crop protection and public health product industries and those involved in the control and regulation of their products.

REFERENCES

Anon. (1962a). *Report of the FAO Conference on Pesticides in Agriculture*. FAO: Rome.

Anon. (1962b). *Report of the Meeting of the FAO Committee of Experts on Pesticides in Agriculture*. FAO: Rome.

Anon. (1985a). *Guidelines for the Registration and Control of Pesticides*. FAO: Rome.

Anon. (1985b). *Specifications for Pesticides Used in Public Health,* Sixth Edition. WHO: Geneva.

Anon. (1994). *Official Journal of the European Communities, No. L 194/65,* Commission Directive 94/37/EC. Brussels.

Anon. (1999). *Manual on the development and use of FAO specifications for plant protection products,* Fifth edition. FAO: Rome.

Anon. (2000). *The Utilization of FAO Specifications by National Authorities*. CropLife International: Brussels.

Anon. (2002a). *Manual on Development and Use of FAO and WHO Specifications for Pesticides,* First edition. FAO/WHO: Rome. (In press.)

Anon. (2002b). *Report of the Thirty-fourth Session of the Codex Committee on Pesticide Residues*. Codex Alimentarius Commission: The Hague.

Anon. (2002c). *I Seminário Nacional de Capacitação sobre Equivalência de Agrotóxicos*. Government of Brazil: Brasilia.

Implementation of FAO Guidelines on Minimum Requirements for Pesticide Application Equipment: a case study in Cameroon

G Matthews
IPARC, Imperial College, Silwood Park, Ascot SL57PY, UK email g.matthews@ic.ac.uk

T Wiles
T L Wiles and Associates, Chichester, PO19 6LE, UK

H Dobson
Natural Resources Institute, University of Greenwich, Chatham Maritime, Kent, ME4 4TB, UK

T Friedrich
FAO, Via delle Terme di Caracalla, Rome, 00100 Italy

ABSTRACT

To reduce hazards for operators and the environment, FAO has published minimum requirements for pesticide application equipment as part of a series of guidelines to improve the safety and efficiency of pesticide use. In response to a request from the African Union through the Inter-African Phytosanitary Council, FAO has implemented a pilot project to facilitate the adoption of these standards in Africa for manually-carried equipment. The pilot project is based in Cameroon, as it has a wide range of agro-ecological areas and crops representative of the whole continent. An initial survey of users showed that lever-operated knapsack sprayers are the most widely used type of equipment, except in the drier areas where CDA rotary atomiser sprayers are used, especially on cotton. A training manual and courses appropriate to Africa are being developed as part of the project, and these will improve awareness of sprayer design and correct procedures in using the equipment. The project also includes a system for the certification of the proficiency of sprayer operators and with improving the availability of spare parts for sprayers in farming areas.

There have been numerous reports of adverse effects of pesticides on the health of farm workers in tropical countries (Lum *et al*., 1993; Aguilar *et al*., 1993; Mwanthi & Kimani, 1993; Harris, 2000), where minimal regulation has resulted in highly toxic pesticides being used without adequate protective clothing or training. While efforts are needed to get users to apply pesticides with lower mammalian toxicity, the low cost of older, generic pesticides has led to their extensive use in many countries. Industry has provided training courses on safe use and conducted a seven-year research programme assessing pesticide use in three countries, India, Mexico and Zimbabwe to assess the impact of communication campaigns (Atkin & Leisinger, 2000). However, in their surveys, little attention was given to the equipment used and the role it can play in improved operator safety.

It is essential to minimise exposure of the spray operators to the pesticides being applied. In some areas of the world with mechanised farming, this is achieved through closed transfer systems, low level induction hoppers and other engineering developments, but little has been done to help the small-scale tropical farmer, who uses manually carried equipment (Mamat *et al.*, 1993). For these users protective clothing is often too expensive and/or impractical to wear in the typically high ambient temperatures they experience.

Recognising the problems associated with manually-carried equipment, not only on small-scale farms but also on plantations, the Food and Agriculture Organisation – Agricultural Engineering Branch (FAO-AGSE) has worked since 1995 on the formulation of guidelines to improve the safety and efficiency of the most commonly used types of spray equipment. These were published as part of a general series of guidelines (Anon, 1998), which was revised in 2001 and is available on the internet (FAO, 1998).

Concerned about the need for improved safety and efficiency of pesticide use throughout Africa, the Inter-African Phytosanitary Council (IAPSC) of the African Union (AU) requested assistance from FAO to establish a programme to implement the FAO guidelines, including minimum standards for spray application equipment (Ashburner & Friedrich, 2001).

A pilot project for Pesticide Safety and Spray Application Equipment has been initiated in Cameroon, in close collaboration with the Ministry of Agriculture, to improve rural worker and family health, environmental protection and crop production efficiency. Cameroon was selected as the location for the project as climatic conditions vary widely, from dry desert areas in the north to equatorial rain forest in the south, thus representing the range of agroecological zones found throughout Africa.

The project covers the most commonly used operator-carried sprayers in Africa as included in the FAO guidelines: lever-operated knapsack (LK), motorised knapsack, compression sprayer, motorised mist blower, rotary atomiser (for herbicides, insecticides and fungicides), hot (thermal) and cold foggers.

The introduction of proficiency schemes for the certification of those who operate the above sprayers also forms part of the pilot project.

MINIMUM REQUIREMENTS FOR SPRAY EQUIPMENT

Health problems associated with pesticide application are usually blamed on the pesticides without considering how they are applied. Concern about the design of a lever-operated sprayer was raised by Mamat *et al.* (1993), among others, listing specific features which increase the risk of direct physical harm as well as the health hazards due to exposure to the sprays. These included sharp edges on the sprayer tank, narrow straps of unsuitable material, tank weight, size of filler opening, leakages, and the design of the spray lance. According to Castanada (1993), the left hand used to hold the container measuring out a pesticide was most heavily contaminated during the preparation of a spray but the right hand holding the trigger valve on the lance was then most exposed to the pesticide during spraying operations. Labourers on large plantations have been estimated to spend over 1400 hours per year spraying herbicides such as paraquat (Whitaker, 1989).

An important objective of the guidelines on minimum requirements is to assist FAO and other agencies to ensure that sprayers purchased are safe to users and to the environment as well as being efficient and durable in operation. Price will always play an important part in purchase decisions on equipment but even the cheapest sprayer models should meet minimum standards of safety and durability.

The FAO minimum requirements take into account sprayers that are already on the market, many of which already meet the requirements. The prime objective therefore is that member countries can adopt them immediately, to begin to eliminate substandard and unsafe sprayers from national markets and ultimately from the international scene.

The guidelines on minimum requirements are presented separate volumes. Volume one covers the principal types of portable (operator-carried) sprayers, including rotary atomizers, while volume two deals with vehicle-mounted and trailed (tractor) sprayers, and volume three with foggers.

To overcome the deficiencies in sprayer design, the guidelines published by FAO (Anon., 1998, and revision 2001) provide minimum standards to enable manufacturers and users to recognise what is required to reduce health and safety problems. The entire series comprises so far 10 guidelines, including policy guidelines on the introduction of registration, certification or testing schemes and good practice. Besides the Guidelines on Minimum Requirements for Agricultural Pesticide Application Equipment, there are volumes on more detailed Standards for Agricultural Pesticide Application Equipment and Related Test Procedures to be used as basis for more demanding national standards and legislation. The volumes on minimum requirements are arranged in a modular system (Table 1), as certain features such as lance assemblies, tanks and lids or engines are common to several different types of sprayer. Although primarily concerned with manually carried equipment, larger tractor operated equipment is also included in the guideline series.

Table1: Modules used in the Guidelines.

1. General requirements
2. Tank strainer and lid
3. Lance assembly
4. Straps and padding
5. Power sources
6. Nozzles

For LK sprayers, the key area of concern relates to leakages. Leakage on the hand at the trigger valve is common and many of the less expensive sprayers have poorly-fitted lids or spray leaking from the tank where the pump is located. Spillage over the tank while spraying can saturate the clothing or directly wet the skin.

New designs of sprayers now have a valve to prevent liquid escaping from the air vent and a larger tank opening for easier filling. A large deep-set filter in the opening also allows more rapid filling without splashing. Where pesticide is available in water-soluble sachets, these can be placed in the deep-set filter and the tank then filled with water. A distinct mark within the filter, which is visible to the person pouring the water into the tank, is used to indicate the maximum filling of the tank.

The other major area of concern is that operators invariably walk into the spray cloud, but this problem can be considerably reduced through improved lance designs. Earlier studies have shown that operator exposure can be reduced by mounting nozzles behind the operator (Tunstall & Matthews, 1965), but such equipment has not been adopted. However similar studies with equipment fitted with rotary atomisers has demonstrated that operator exposure can be reduced by spraying downwind away from the operator (Thornhill *et al.*, 1996), or by holding the nozzle behind the operator (Thornhill & Matthews, 1995).

Thermal foggers were introduced into cocoa plantations (Bruneau de Mire, 1966), primarily for insect control over large areas. In Cameroon the government purchased large numbers of these machines and subsequently sold them to growers who use them with little instruction and inadequate protection. Thermal foggers present specific concerns in relation to inhalation and fire hazards and minimum requirements for this equipment are also included in the FAO guidelines.

THE BASELINE SURVEY IN CAMEROON

Mbiapo and Youovop (1993) carried out a survey of pesticide use in Cameroon, but little mention of application methods was made other than that, in addition to sprays, thermal foggers and mists were used without adequate protection. Therefore, to initiate the project in Cameroon, a baseline survey was carried out to determine the types and condition of sprayers used in the different zones of the country on the various crops. At the same time it was important to build up a profile of those who mix and apply pesticides.

Interview teams visited three zones, each with three distinct areas and completed 741 survey forms in September 2001. Sixty-five per cent of these related to farmers who applied pesticides, although sprayer operators and managers on larger farms, plantations or co-operatives also participated in the survey. Seventy-six per cent of the responses related to farms of less than 5 hectares. Nkot *et al.*, (2002) reported that the lever-operated knapsack sprayers predominated in most of the country irrespective of the crop, although rotary atomiser sprayers were extensively used on cotton in the semi-arid areas in the north. (Table 2). Both insecticides and herbicides were being applied with rotary atomisers where water was not readily available. Thermal foggers were reported as being used by groups of small farmers in cocoa as well as on large plantations.

Table 2: Proportion (%) of different operator-carried sprayers in different crop zones

Zone	LK	RA(IF)	RA(H)	MB	HF	CF	CS	D
1	91.4			2.96	4.05	0.4		
2	77.9	2.2	2.4	4.8	1.5	1.1	10.0	
3	3.6	83.2	13.2					0.2

Zone 1: Savannah Zone 2: Forest Zone 3: Semi-arid (north)

Abbreviations for different sprayers referred to in the guidelines are:-

- LK lever-operated knapsack,
- CS compression sprayer,
- MB motorised knapsack mistblower
- RA IF rotary atomiser insecticide / fungicide
- RA H rotary atomiser herbicide
- HF hot (thermal) fogger
- CF cold fogger
- D duster

The data confirmed that many of the sprayers did leak. Information on different locations on lever-operated knapsack sprayers where leaks occurred (Table 3) showed that the operator was exposed to spray liquid mostly from the top of the tank either through the lid or where the pump moved at the top of the tank. The trigger valve and connections on the hose were also common sources of leakage.

Users complained that they were unable to maintain their equipment due to a lack of spare parts, including replacements for worn nozzles. The average age of the sprayers was assessed at 6.9 years, with the newest generally found on plantations.

Table 3: Proportion of leaks (%) at different positions on the LK sprayer.

Position	*%*	*Comment*
Between pump and hose	24.9	(various positions between pump and trigger valve)
At trigger valve	23.2	
At bottom of tank	17.0	(probably due to wear of pump affecting screws holding the pump to the bottom of the tank)
Top of piston	14.8	(where piston moves through the top of the tank)
Through lid	9.0	(through ventilation hole in lid without a valve)
Between lid and top of tank	8.8	(lid not fitting the body/top of tank)
At nozzle	2.0	

The extent of the leakages is of great concern in that 85% of the small-scale farmers reported that they did not use protective clothing. The reasons for this were primarily the lack of availability and high cost. Of major environmental concern was the finding that many of the sprayers were washed after use in the nearest river or stream.

As a follow up to this survey, an additional survey will collect more detailed information concerning the sprayers and spraying and their effect on the health of those applying the pesticides.

TRAINING COURSES

The Pilot project will develop a training course together with a trainers' manual specifically designed for trainers who train operators of portable spray equipment in Africa. Training will be provided for selected trainers from each of the main zones in Cameroon, so that they can organise courses in their own localities and then for trainers selected by IAPSC from different AU member countries. In addition to technical information on spray equipment and its correct usage, the courses cover skills of planning, managing and participatory delivery of national training courses.

TRAINING MANUAL

Several organisations, including agrochemical companies have already produced manuals for training in the safe and effective use of pesticides. However, most of these have not been designed specifically to address aspects of equipment design and safety.

The new FAO/AU Trainers' Manual sets out to emphasise the importance of engineering design to minimise operator exposure to pesticides. It is divided into three main sections. The first provides an introductory text in which concepts of sustainable agriculture and integrated pest management (IPM) are described. As part of IPM, pesticides are recognized as a valuable tool, but only to be used as a last resort after all other control tactics have been tried. The second section deals with the individual types of equipment, stressing certain features or mode of use, while the third section deals with training techniques.

In order that the information is in a readily accessible format for widespread use, the training manual is well illustrated and provides clear, simple text that can be easily used and translated into vernacular languages. It is well illustrated with line drawings, which can be copied for projection as overhead projector transparencies.

The manual includes changes in application technique to improve efficiency. These include the use of a control flow valve to maintain constant pressure and output of nozzles on manually pumped sprayers, as this has assisted in reducing operator exposure in trials in India (Shaw *et al.*, 2000). Selection of nozzles is seldom considered on small-scale farms, yet there are specific problems of applying some pesticides very selectively, for example herbicides along intra-rows without drift, or fungicides to cocoa pods, and guidance is given on nozzle choice.

OPERATOR PROFICIENCY CERTIFICATION

Another of the aims of the pilot project is to develop for introduction into Cameroon a practical system for the certification of those who apply pesticides. The scheme is to cover all the commonly used sprayer types in the country and operators are certified as competent on individual sprayer types (i.e. not for sprayers in general). The aim is to develop a quality-assured, harmonised scheme backed by legislation to ensure that operators meet FAO-based standards set by a certification authority and drawn up in consultation with the regulatory authority and the industry. A key feature is that the certification body is independent of any training authority.

THE FUTURE

Despite new developments in genetically modified crops and the desire of many people to reduce or eliminate pesticide usage in agriculture, there is no doubt that if the ever increasing global human population is to be fed and clothed, then pesticides will continue to play an important role in IPM for cost-effective crop production.

Fortunately, the trend in registration requirements in many countries is ensuring that the most hazardous pesticides will no longer be available in the future. Nevertheless, it is essential that, wherever pesticides are used, the risk to the operator be kept to an absolute minimum.

Improvements in engineering design and manufacturing technology need to be emphasised to benefit the small-scale farmer. Modern manufacturing techniques can produce more reliable and robust equipment, without necessarily increasing costs. In some cases new designs may increase the cost of manufacture, but this must always be balanced against the reduced negative effects on human health from exposure to pesticides, which are often ignored

The pilot project is by definition a starting point. It aims to develop, validate and implement in Cameroon the experience of FAO AGSE over the last several years in order to develop down to earth policies and practical programmes to take improved pesticide safety and efficiency to other parts of Africa in a structured and consistent manner. The programme focuses on application equipment and involves the integration of several components and approaches, some of which have been covered briefly in this paper.

REFERENCES

Aguilar G C; Medina H; Chinchilla J; Veneros N; Aguilar M; Carranza F (1993). Pesticide poisoning among agricultural workers in Bolivia. In : Forget G, Goodman T and de Villiers A (Eds.) *Impact of pesticide use on health in developing countries*. IDRC Ottawa. 76 – 84.

Anon. (1998). *Agricultural pesticide sprayers* Vol 1 FAO guidelines on equipment quality control and use and FAO minimum standards. Vol. 2 FAO Technical standards: sprayer specifications and test procedures. FAO Rome. [revised 2001].

Ashburner J; Friedrich T (2001). Improving handling of pesticides application equipment for the safety of applicators. *Pesticide Management in West Africa*. No. 2 9- 11.

Atkin J; Leisinger K L (2000). *Safe and effective use of crop protection products in developing countries.* CABI Wallingford.

Bruneau de Mire P (1966). Comparaison entre deux modes de traitement anti-mirides du cacaoyer: La thermonebulisatio etl'atomisation. *Conference International Recherche Agronomic Cacao,* Abidjan, 154 – 159.

Castaneda C P (1993). Field exposure during application of organophosphates using knapsack sprayers in the Philippines. . In Forget G., Goodman, T. and de Villiers A. (Eds.) *Impact of pesticide use on health in developing countries*. IDRC Ottawa 62 – 69.

FAO (1998). http://www.fao.org/ag/AGS/agse/activity.htm#PesticideApplication.

Harris J (2000). *Chemical pesticide markets, health risks and residues*. CABI Wallingford.

Lum K Y; Mamat M J; Cheah U B; Castaneda C P; Rola A C; Sinhaseni P (1993). Pesticide research for public health and safety in Malaysia, the Philippines and Thailand. In : *Impact of pesticide use on health in developing countries*, eds G Forget, T Goodman. and A de Villiers, pp 31-48. IDRC Ottawa..

Mamat M J; Anas A N; Sarif Hashim S H (1993). Safer pesticide application equipment for small-scale farmers in developing Asian countries. In : *Impact of pesticide use on health in developing countries*, eds G Forget, T Goodman. and A de Villiers, pp 178-185. IDRC Ottawa.

Mbiapo F D; Youovop G (1993). Pesticide use in agriculture, public health and animal husbandry in Cameroon. In : *Impact of pesticide use on health in developing countries*, eds G Forget, T Goodman and A de Villiers, pp114-117. IDRC Ottawa.

Mwanthi M A; Kiomani V N (1993). Agrochemicals : a potential health hazard among Kenya's small scale farmers. In : *Impact of pesticide use on health in developing countries*. eds G Forget, T Goodman and A de Villiers, pp 106-113. IDRC Ottawa.

Nkot B ; Nkodo J ; Ayuk C ; Mpouma R ; Nzodjo P ; Kouenkeu T (2002). A survey of sprayer use in Cameroon . *International Pest Control.*

Shaw A ; Nomula R ; Patel B (2000). Protective clothing and application controls for pesticide applicators in India : A field study. *Performance of protective clothing : Issues and priorities for the 21st Century : Seventh Volume ASTM STP 1386 West Conshohocken PA.*

Thornhill E W; Matthews G A (1995). Potential operator exposure to herbicides : A comparison between knapsack and CDA hand sprayers. *Brighton Crop Protection Conference* 507 – 512.

Thornhill E W ; Matthews G A ; Clayton J C (1996). Potential operator exposure to insecticides : A comparison between knapsack and CDA spinning disc sprayers. *Brighton Crop Protection Conference* 1175 – 1180.

Tunstall J P ; Matthews G A (1965). Contamination hazards in using knapsack sprayers. *Empire Cotton Growing Review* **42**, 193-196.

Whitaker M J (1989). The handling and use of paraquat by Malaysian rubber and oil palm smallholders. *Journal of Plant Protection in the Tropics* **6,** 231 – 249.

Safe and effective use of crop protection products in developing countries

J Frei
The Syngenta Foundation for Sustainable Agriculture, 4002 Basel, Switzerland

ABSTRACT

This paper summarises the work of a seven-year-long research programme that looked at the best way to reduce pesticide use among low-income farmers in developing countries while improving the effectiveness with which they used the products and the safety of their practices. The research was undertaken as part of a Risk Fund set up by Novartis in 1988 to support its business activities in the Third World; the study was sponsored by the Novartis Foundation for Sustainable Development.

The project draws attention to the fact that if farmers were to take a series of relatively simple steps, they could reduce their exposure to pesticide-related health risks. At present, many if not most farmers give low priority to "safety", and many have not adopted the necessary precautions to reduce health risks. Some procedures may well be made more acceptable to low-income farmers—for example, by developing and subsidizing the sale of both cheap and comfortable clothing that can provide adequate dermal protection. In the main, though, it appears that there are few if any easy ways to promote change among large numbers of poor smallholders.

There will have to be a continued reliance on sustained efforts such as some of those incorporated in this project. Any pesticide manufacturer that cannot guarantee the safe handling and use of its high toxicity products should withdraw those products from the market. At the same time, since in all likelihood pesticides will continue to be the technology of choice for crop protection in the years ahead, there is a continued need to get farmers to adopt the most important risk-reducing procedures.

BACKGROUND

The ability of the world's farmers to produce food has improved dramatically over the past four decades. Yields of maize, rice and wheat nearly doubled between 1960 and 1994 and similar progress was made in other crops. Achievements such as these were due largely to technological progress in the form of improved varieties, irrigation, fertilisers, use of crop protection agents and a range of technologies that aided farmer's management of crops and resources. This increased output can be demonstrated by using the output achieved in India over 20 years. From an average yield of 0.95 tonnes per hectare of grain in 1961-63 the yield had increased to 1.98 tonnes of grain per hectare in 1991-93. The key components for this Green Revolution were the use of modern seed varieties, fertilisers, irrigation, mechanisation and insect and weed control. Benefits were seen by both the rich and the poor landowners. In addition the increased food production has led to general decreased food costs and improved food security.

The use of crop protection products in rural areas of the developing countries beset by poverty has been a highly controversial topic for many years. Criticism of the use of pesticides in the developing world was summarised by Conway (1997) saying that "Pesticides not only cause or aggravate pest problems,..... they contaminate the environment and may have serious consequences for human health". However there are proponents of the use of pesticides who estimate pest-induced production losses. From analysis Oerke *et al.* (1994) found that pathogens, animal pests and weeds can cut the potential production of nearly all food crops by half.

The opponents of chemical crop protection raise the following main criticisms against the products and their manufacturers:

a) Due to the prevailing conditions in developing countries (illiteracy, ignorance of side effects etc.), the safe and proper use of chemical crop protection agents cannot be guaranteed. This can lead to the possibility of pesticide residues in the harvested produce.

b) The inappropriate use of these products can be downright counterproductive, above all for small holder farmers: the costs to the environment and health outweigh the benefits. The indiscriminate use of pesticides harm useful organisms more than it does the pests, and thus exacerbates the pest plague while making the farmer dependent on chemical weapons.

c) In the face of stagnation of pesticides in developed countries, the pesticide industry is expanding in developing countries with more and more aggressive marketing methods while cutting back on applications guidance.

As result of these criticisms, broad sectors of the public hold a general sceptical or even adversarial attitude toward chemical crop protection and the manufacturers. Pressure groups in particular have placed their stamp on media coverage and on the information databases of parliamentary investigating committees and on social science institutions.

There are many issues which make it difficult to form a sound judgement on the benefits or otherwise on the use of pesticides. There are around 800 active ingredients of pesticides, each with different characteristics and spectrum of activities. Some are over 50 years old, are now considered too dangerous and non-selective and are used at rates of kilos per hectare. Most have been banned by regulatory authorities in industrial countries yet are produced and sold at very low prices in many developing countries. Most modern products on the other hand are highly selective with low toxicity to humans and other non-target organisms. They are often applied in quantities of a few grams per hectare but are mostly considerably more expensive than older products.

Although many experts are convinced that important aspects of chemical crop protection can be scientifically demonstrated, data are lacking on whether the safety problems associated with their use are in fact due to lack of knowledge, "bad" habits (despite knowing better), or lack of access to protective devices. Health statistics have been used to attempt to understand the effects of pesticides on humans. However most statistics do not differentiate between occupational health problems and the intentional misuse for suicide and murder. There is strong evidence of widespread use of pesticides for such crimes. For example in a report of 400 cases of poisoning from pesticides in a five year period, the great majority were found to be attempted suicides using organophosphates and none of the incidents were connected with the person's occupation.

RATIONALE FOR THE PROJECT

In today's public debate and discussion responsibility for harming personal health and environment as well as for the resulting economic losses through the use of crop protection products are almost exclusively attributed and shifted to the manufacturers.
As a consequence critics urge either to reduce drastically or even to prohibit distribution and sale of crop protection products to small holder farmers in developing countries.

Against this background a manufacturer has basically seen only the following alternatives:

a) Carry on trading as normal with a closed eye to the critics with the consequence that in the long-term a hostile social environment may develop as well as an increasing regulatory framework which will reduce the market potential or

b) A commitment which goes beyond conventional marketing, sales and information practices and which is well-understood and used by the manufacturer to secure long-term business success.

The assessment of the risks versus the benefits of pesticides use is complex and difficult to quantify. Crop protection products undoubtedly contribute towards the increased production of affordable food in developing countries. However the evaluation of the damage they cause to humans, natural enemies and the environment is necessary and demands the rational collection of facts and figures. Therefore in January 1991 the former CIBA-GEIGY Foundation approved a Risk-Fund Project in order to bring forward an innovative approach along the lines of the second alternative mentioned above with the following objectives:

a) To produce evidence that a crop protection products manufacturer can have constructive interest in the perception of the problems of small holder farmers in developing countries without any ideological hidden agenda and on scientifically sound and workable solutions for those problems. It goes without saying that the participation of external consultants and critics are part of an element for enhancing credibility.

b) To shape constructive dialogue and contribute to the debate on safety and effectiveness of crop protection products through a self-imposed empirical research study.

OBJECTIVES

The Risk Fund Project was launched to answer the following questions:

a) What factors hinder the safe and effective use of crop protection products in developing countries?

b) What sort of groundwork must or can the manufacturer, in collaboration with other institutions and organizations (agricultural extension services, for example), undertake to eliminate these factors?
c) In a given socio-cultural context, what communication methods are best suited to furthering rational and safe use of crop protection products?

RESEARCH GOALS

To obtain a broad database covering various socio-cultural and economic factors that shape Knowledge, Attitudes and Practices, a so-called KAP-Study was mounted with questionnaires established containing ten key messages on safety and seven on effectiveness. These questionnaires served as parameters in the surveys carried out during the project and having been tracked throughout the different phases. Its main objectives were:

a) To acquire insight into knowledge, attitudes, and practices of the target groups as these relate to crop protection and the use of crop protection products;

b) To gauge the significance of knowledge and attitudes for the rational and effective use of crop protection agents;

c) To establish indicators that can be used to measure future changes in KAP; and

d) To analyse differences and similarities in the three geographically and socio-culturally dissimilar study sites, with a view to determining whether standardized modes of intervention for increasing the safe and effective use of crop protection products are possible.

HYPOTHESES OF THE PROJECT

Hypotheses were established that through communication and training specific aspects of safety and effectiveness could improve farming practice. These were measured and tracked throughout the project. These hypotheses were based on four facts.

1: Reduction in dermal contamination leads to reduction of possible health problems.
2: Proper handling and use limits negative impact on the environment.
3: Effective handling and use improves economic situation of farmers.
4: Farmers value economics more than safety.

DESIGN OF THE PROJECT AND ORGANISATION

In order to collect as broad an experience as possible the study was carried out in three developing countries with totally different socio-cultural environments and structures, although with similar economic and technological standards. The countries were India, Mexico and Zimbabwe.

In each country an "intervention region" was selected as the site of an information, education and communication program. For comparative purposes in all three counties, a control region, or a no-intervention zone was also designated and where possible located far enough away to preclude any influence from the above program.

The project areas in the three countries were as follows:

The Coimbatore district in India was chosen. The intervention programme was tested in the Udumalpet block. The control area was defined as the rest of the district.

In Mexico the communication campaign was undertaken in the southern state of Chiapas bordering on Guatemala. The Villaflores region was chosen as test, and the Cintalapa region for the control area.

In Zimbabwe the project was carried out in the communal lands of Sanyati in the Kadoma disrict.

Heading the project was an international Steering Committee consisting of staff from Basel Crop Protection Division, the Novartis Foundation for Sustainable Development, and representatives of the Agricultural divisions of the three participating Novartis Group Companies, together with independent outside experts and a critical free-lance journalist. The Indian Market Research Bureau (IMRB) was responsible for the studies and their evaluation.

The target farmer groups chosen were small-scale cotton growers in India and Zimbabwe and maize growers in Mexico. Four distinct project phases were established, Phase one, from 1991-1993, - production and evaluation of the baseline KAP; Phase two, from 1994-1997, - tailor-made interventions such as the use of film, video and pest scouting booklets in India, radio programs, children's drawing booklets and cartoon-stories in Mexico, folk theatre plays, demos and insect pest calculators in Zimbabwe just to mention a few of the selected items, and evaluation of end-line KAP; Phase three, from 1997-1998, - cessation of any intervention and follow-up of persistence of impact; Phase four, from 1998-1999, - with evaluation of results, calculation of net change with interpretation, conclusion and writing-up for publication. The results of the study were presented to FAO at Rome end of 1999.

SUMMARY OF RESULTS

Baseline KAP

Knowledge of safety aspects, - as expected farmers knew little about health risks and few if any measures and precautions to reduce them.
Safety attitudes, - farmers didn't admit health risks and/or perceive them as inevitable.
Safety and effective pest control, - farmers perceived these issues as contradictory concepts. Examples supporting the last issue are as follows: in India farmers perceive health risks as an occupational hazard (fatalistic attitude); in Mexico farmers do not admit physical vulnerability (machismo); in Zimbabwe farmers state that in their fight for survival they expect to suffer at least some wounds.
In practice pesticide users made few efforts to prevent health risks, with the exception of those who have suffered intoxication symptoms, they try to reduce their own risks by improving their safety gear or by avoiding spraying personally by hiring spray operatives (as is the case in India).

Knowledge, although low, exceeded practices, but it did not really translate into practical action. Knowledge on effectiveness of pesticides varied greatly between countries and farmers.
The attitudes confirmed that pesticides are perceived as a necessity. In practice great variation and experience levels were observed.

Endline KAP

The results of the endline KAP evaluation were compared to the baseline analyses conducted at the beginning of the project. A further follow-up survey was done a year later in order to assess long-term impact. Results were then categorized into two groups according to their persistence or continuation of adoption, viz. continued vs. discontinued changes of desired traits.

Relating back to the hypotheses established at the start of the project some specific changes in farmer's attitudes and practices were tracked and found to be as follows:

Hypothesis 1 – that through communication and training we will reduce dermal contamination leading to reduction of possible health problems. This was done by improving practice in:

skin protection;
preparation of spray solution;
washing of body and work clothes;
spraying and application; and
maintenance of spraying equipment.

In Mexico personal safety has been improved persistently by using shirts, boots and footwear, in the washing of work clothes and hands in sprayer cleaning and in utilizing measuring devices. The project had a favourable impact on comparatively simple, cheap safety practices such as washing hands before eating in the field during a break in the spraying operation. More cumbersome practices did not change for long or were even used less than at the beginning of the project.
In India the practice of having a full body wash after spraying rose significantly and was sustained as was the washing of work clothes. Use of gloves for mixing pesticides however showed a small improvement following the beginning of the project but dropped after the end of the intervention. Significant improvements were registered in the maintenance of sprayers. Precautions taken before breaks for food and drinking persisted. However the use of long sleeved shirts and full trousers dropped after intervention but still registered positive change.
In Zimbabwe personal hygiene measures were already at a high level when the project started, although the project had a further positive impact. Another significant increase was reported in the regular washing of work clothes. Overall the project had a positive impact on reported attitudes regarding personal hygiene and skin protection.

Hypothesis 2 – that through communication and training we will improve practice in proper handling and use of pesticides which will limit the negative impact on the environment. This was done by improving practice in:

optimisation of pesticide used and of spray parameters;
storage of crop protection products; and
disposal of empty containers.

This area showed favourable changes in Mexico. Persisting changes included the storage of pesticides out of children's reach, not repacking the pesticide container, and the improvement in the disposal of empty containers.
In India there was already a high level of safety in the storage of pesticides which continued throughout the project. Safe disposal of containers showed no improvement in either area studied and in fact worsened. The program ensured that good practices more or less continued.
Correct disposal of empty pesticide containers improved in Zimbabwe. However the introduction of a cotton pest calculator aimed at improving the use of the optimum quantity of pesticides needed a more comprehensive introductory programme and showed no correct use of the calculator; this tool would require a more comprehensive introduction and training to become a success.

Hypothesis 3 – that through communication and training we will improve effective handling and use of pesticides to improve the economic situation of farmers. This was done by improving practice in:

- identification of pests and beneficial insects;
- selection of suitable product;
- determination of correct dosage;
- usage of suitable equipment;
- correct timing of application; and
- correct application techniques.

In Mexico knowledge of beneficial insects improved and in focus group discussions more rational attitudes towards pesticides were detected. In India there was an improvement in all the practices although only the practice of determining the correct dosage continued more or less at an improved level throughout the project period. Knowledge of beneficial insects, although dropping later in the project, nevertheless remained at a higher level than at the baseline. In Zimbabwe knowledge of beneficials remained at a moderate level.

Hypothesis 4 - improvement of farmers' economics will facilitate their adoption of messages on safety.

In Mexico it seemed as if demonstrations of more productive crop protection techniques made by the project staff raised the farmers' level of interest and thus increased the level of trust, which in turn facilitated communication. More rational attitudes towards pesticides affected farmers' perception of both effectiveness and safety issues.
In India there was widespread appreciation among farmers that Novartis had put considerable effort into the improvement of their health by teaching them how to enhance their safety as well as improve crop yields through the effective use of pesticides.
In Zimbabwe drought in 1995/96, which meant the loss of food as well as cash crops, had a very negative impact on the farmers' economic situation. This external pressure manifested itself clearly that under such difficult conditions the farmer gives priority in the spending of his funds first for basic needs before investing in safer pesticide use.

Overall, the interventions did have a positive impact. A fundamental lesson learned was that messages must be practical, basic and ready-to-use. Suggesting the use of impractical or expensive items or habits can dilute the overall message about safety precautions. A highly technical and expensive approach is not needed to improve safety.

RECOMMENDATIONS

The following recommendations to manufacturers and other stakeholders of crop protection are brought to your attention:

a) An on-going, multi-stakeholder approach is needed. Single manufacturers with isolated endeavours can have only a very limited effect. In order to achieve a real difference, actions from all stakeholders and concerted efforts of regulatory authorities, extension units with the ministry of agriculture, trade channels, NGOs, farmers' organisations etc., together with pesticide industry and its associations have to be pooled together.
b) Research-based companies vs. generics oriented industry. In this connection we need to address and reconcile the differing views between the two conflicting sides. This point needs serious discussions between industries, regulatory bodies and industry associations. All efforts should be taken to get all parties on board, encourage them to participate and join the multi-stake holder group's endeavours.
c) Incorporate social marketing into commercial marketing. Social marketing was described by Kotler and Zaltman (1971) as the use of marketing principles and techniques to advance a social cause. It is suitable to achieve required changes in attitude, but it needs to be done on a sustained basis, as farmers tend to fall back into undesirable attitudes and habits. It has to be part and parcel of commercial marketing.
d) Product and portfolio changes may also be envisaged if safe use of products of toxicity class 1A+1B cannot be guaranteed. Industry should not create a technological apartheid system by depriving small farmers of developing countries from latest innovations and technologies. Manufacturers and marketing companies should be innovative in branding, packaging and pricing.
e) Developing countries should give highest priority to an agricultural policy which provides motivation, security and stability to risk-averse small-holder farmers. However external support is needed to support these governments.
f) Product stewardship efforts are not sufficient. Stewardship efforts have to be much intensified and to be more directed to the needs of resource-poor farmers. In many instances manufacturers as well as trade channels do not play a sufficiently determined and active role in training and communication. They hardly have any presence which is directed to that farmers' segment. Some companies have had commendable activities in the past, but have given them up due to economic constraints. This situation needs a re-orientation and to be drastically improved if industry wants to be credible.

REFERENCES

Atkin J; Leisinger K M (2000). *Safe and effective use of crop protection products in developing countries.* CABI Publishing, Wallinford.

Conway G (1997). *The doubly green revolution. Food for all in the 21st century.* Penguin Books: Harmondsworth.

Kotler P; Zaltman G (1971). Social marketing: an approach to planned social change. *Journal of Marketing* **35**, 3-12.

Oerke E-C; Dehne H-W; Schoenbeck F; Weber A (1994). *Crop production and crop protection: Estimated losses in major food and cash crops.* Elsevier, Amsterdam.