

## Benefits and costs of pesticide use

Many people in the world are hungry. The food shortage is reported daily in the media, and by national as well as international organizations. To solve the problem, many factors must be taken into consideration, such as improving agricultural yields per unit area; providing better protection of crops and livestock from attack by pests; increasing the amount of land available for agricultural production; improving the existing marketing systems; and increasing the cash money available to people for purchasing food. An effective and lasting solution of the world-wide food shortage requires a determined effort by all countries and organizations. Especially for developing countries, it is a matter of high priority to increase food production through effective use of agricultural chemicals.

Recently, the International Atomic Energy Agency and the Food and Agriculture Organization of the United Nations (FAO) jointly sponsored an international symposium\* which dealt with isotope techniques to solve problems related to agrochemicals, in particular pesticides. The tone of the meeting was set by scientific papers which evaluated the benefits and the costs of pesticides.

### Pesticides are needed

*Agrochemicals in India – impact on agriculture:* Pesticide use in developing countries must continue to expand in order to maintain agricultural productivity and to permit farmers to reap the benefits of related agricultural investments. The keynote address at the symposium documented the fact that the increased use of agrochemicals – primarily fertilizer and pesticides such as insecticides, herbicides, and fungicides – was largely responsible for the great increase in food production in India in the last decade. Indeed, the food production per hectare has doubled since 1950, an increase which correlates well with the rate of pesticide use. In tropical countries such as India, when agricultural crops are grown without protection, yields are always reduced and are frequently non-existent, due to losses sustained from pests (insects, weeds, and diseases). Modern agricultural methods including the

use of high-yielding plant varieties, more intensive cultivation, greater use of fertilizer, and intensified irrigation practices require increased use of pesticides. The appropriate use of pesticides thus results in increased yields and simultaneously protects the farmer's financial investment in good-quality seed, fertilizer, etc.

*Economics of pest control with emphasis on developing countries:* The average cost of developing a new pesticide is about US \$25 000 000. This means that new pesticides are more expensive than ones developed years ago. Most pesticides are manufactured in developed countries and thus developing countries must have convertible currency to purchase these materials. As a result, developing countries frequently select the older, better known, and cheaper pesticides such as DDT and BHC which have been partially restricted in developed countries. The appropriate use of pesticides pays great dividends in developing countries, and, in examples reported at the symposium, benefits exceeded costs by a ratio of more than 20 to 1. Sound economic policy demands also that farmers be trained in the safe and effective use of pesticides (for example, through an extension service).

### Tracing the fate of pesticides

*Problems caused by pesticides with particular impact on the agricultural environment:* Some of the environmental problems of concern in agriculture in both developing and advanced countries include pesticide movement, persistence, and uptake by plants; pest resistance to pesticides; the ability of micro-organisms in soil rapidly to metabolize certain pesticides because of repeated applications; and exposure of the user and consumer to pesticides, their residues, or their by-products. These topics were discussed with examples. Before a pesticide can be registered for use in the United States, for instance, each of these topics must be researched. These data are considered essential by US officials even though research costs are very high. In spite of restraints including increased costs of pesticide development and environmental problems associated with pesticides, both the total amount of pesticides used and the total agricultural production have increased in the United States during the past several years.

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\* FAO/IAEA International symposium on agrochemicals: fate in food and the environment using isotope techniques, held in FAO Headquarters in Rome, Italy, 7 to 11 June 1982.

The international symposium dealt with benefits and problems of pesticides for a very simple reason. Excessive concern regarding problems with pesticides has sometimes overshadowed both the very great value that pesticides already provide and the enormous potential value pesticides offer for increasing agricultural production in developing countries. However, pesticides must be carefully evaluated for their potential to cause illness and to pollute the environment. For such studies, isotopes can be used to trace the fate of pesticides in food and the environment. These potential problems can then be compared with the benefits which the pesticides provide. This type of analysis should be conducted and evaluated by each country, at least with regard to human health, food production, and food consumption within its borders. The problem of pesticide residues associated with export and import of agricultural commodities is of course very different, and must be dealt with at the international level. Many people cannot understand why pesticides such as DDT continue to be used in many developing countries. In most cases it is because officials within those developing countries have conducted risk-benefit analyses and have concluded that local benefits derived from the use of DDT exceed the risks to the public.

*Rationale in the design of pesticide metabolism studies using radioisotopes:* This paper detailed the types of studies that can be conducted with radioisotopes; some of the problems associated with interpreting the data of these studies; and the design and execution of radioisotope-aided pesticide metabolism studies — a subject of paramount importance. For any scientist who has not had a great deal of experience in designing and conducting studies utilizing radiolabelled pesticides, this kind of information is essential.

A review of the fate of recently introduced persistent pesticides reported the extensive use of radiolabelled pesticides during recent years. As an example, in 1979 and 1980 the Joint FAO/WHO meeting of experts on pesticide residues examined 47 separate studies involving isotope-labelled permethrin. It was affirmed at the symposium that the high level of sensitivity and the relative simplicity and speed of isotopic methods make them the methods of choice — and sometimes the only practical approach — in undertaking critical studies of persistent pesticides.

*The fate of fertilizer nitrogen in soil-plant systems with emphasis on the tropics:* Isotopes are not only used to study pesticides but also to study fertilizers. Recently the use of  $^{15}\text{N}$ , a stable isotope, has made possible studies on the efficacy and potential pollution problems of fertilizer nitrogen. A number of studies have aimed at determining the fate of fertilizer nitrogen. It was noted at the symposium that losses by leaching are not a problem at normal

rates of fertilizer use. This conclusion — obtained through studies with isotope-labelled nitrogen fertilizer — should greatly alleviate fears concerning nitrate pollution from fertilizers.

The symposium also included a comprehensive review on bound pesticide residues in soil, plants, and food. Bound residues are defined as non-extractable residues, and are most commonly associated with pesticide residues in soil that cannot be extracted. The question asked by scientists is whether these bound residues remain in a toxic form, or whether the pesticides have been degraded so that the residues are non-toxic remnants. Studies on bound residues are conducted with radiolabelled pesticides since this is the only way to determine whether a pesticide is bound. In most cases, bound residues have not proven to be associated with any toxic chemical. However, the problem remains and, because all of the information on bound residues available today relates to a few model compounds, further information on other substance classes is urgently needed.

Radiolabelled pesticides have not been used extensively in developing or studying controlled-release formulations, but this is likely to change as more scientists begin to develop and evaluate this very promising area of pesticide research.

Radiolabelled pesticides have potential for use in the study of controlled-release formulations of agrochemicals. Controlled-release formulations are designed in such a way that the release of the pesticide from the formulation can be predicted and, by changing the formulation, varied. This means that the pesticide can be more precisely regulated, resulting in less pesticide use and less potential residue in the food crops. A diverse array of controlled-release formulations already exists. For example, considerable success has been achieved in the development of controlled-release formulations for aquatic herbicides. Formulations of molluscicides for use in irrigation ditches also show great promise.

The control of African trypanosomiasis in domestic animals is accomplished either by controlling the vector (tsetse fly) or by treating animals with trypanocide drugs. These drugs have been available for many years and thus were developed long before extensive toxicological and environmental studies became a prerequisite for the registered use of such drugs. Recently, however, the World Health Organization and the FAO have strongly recommended the investigation of the toxicology and pharmacology of these trypanocide drugs in domestic animals. A report at the symposium reviewed the data available from studies to determine the fate of radiolabelled trypanocide drugs in animals. The need to continue and expand these studies was emphasized as a means to improve existing drugs, design new drugs, and answer questions regarding the problem of trypanosome resistance to

these drugs. The use of radiolabelled drugs is a powerful tool in this type of study.

On the last day of the symposium a panel discussion was held to consider research needs for effective and safe pesticides in developing countries. Listed are some of the comments made during the panel:

- Developing countries need a simple and reliable apparatus to conduct research with radiolabelled pesticides.
- There is a temptation for research workers in developing countries to conduct fundamental research on pesticide mode of action, metabolism, interaction, environmental fate, etc. What is really needed, however, is adaptive research to seek ways of utilizing existing pesticides effectively, efficiently, and safely under local conditions.
- One of the most serious problems in developing countries is lack of maintenance for electronic equipment; more emphasis should be placed on training electronic technicians.
- Much of the existing information and data on pesticides relates to the needs and conditions of advanced countries. Therefore, in considering future research it is very important to take into account the different needs and conditions which prevail in developing countries.

- Radiolabelled metabolism studies have been conducted in advanced countries on nearly every pesticide used in developing countries. Therefore, the real need in developing countries is to confirm the fate of these pesticides under local conditions and in local crops – without additional expense or elaborate equipment. This goal can be met through use of radiolabelled pesticides.

- The proper use of pesticides in developing countries can be achieved only when farmers are trained in the safe use of these chemicals.

- Since the climatic conditions in the tropics are quite different from those typical in the temperate zone, the fate of pesticides used in the tropics will also be very different. This difference creates a need for studies on the fate of pesticides – in food and in the environment – under tropical conditions.

In many countries, further benefits are possible from a careful and rational use of agrochemicals, including pesticides. Optimal use requires, however, a careful evaluation of both the benefits and the costs of agrochemicals under local conditions of use. As was concluded at the symposium, the appropriate use of isotope techniques can be extremely valuable in solving specific pesticide problems in developing countries. This should lead to improved food production in many areas of the world where the food shortage is most severe.

