MAIN SUBJECT 4

ENVIRONMENTAL AND SAFETY ASPECTS OF PESTICIDE USE

TOPIC 4A

PESTICIDES AND HUMAN SAFETY

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RISK - DO THE PUBLIC, PRESS AND POLITICIANS REALLY CARE?

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ABSTRACT

The public does care about risks to health and the environment, but only when it has been aroused in a powerful and emotive way. Since Rachel Carson, the risk side of pesticides has seen far more exposure than it deserves and the benefits side has been given far less exposure than it warrants. The results have been the emergence of the popular view that all pesticides are poisons and the witch-hunt against DDT. A free press has a vital role in exposing dangers to society, and we must support its right to do so, but it should never blow up a specific incident into a general condemnation in order to satisfy its craving for sensationalism. Both public and press must realise there is another risk - the risk to both health and food supplies if pest control is reduced by their action. Continue to care - yes ..... continue to condemn - no. And finally the politicians and administrators - they must treat pesticide toxicities on technical merits rather than the need to allay unwarranted public fears or hostile press reaction.

THE PUBLIC

Every delegate will be at risk once this Conference is over. If the journey home involves a 240 mile trip by car then the chance of being killed is 250,000 to one. Flying 4000 miles will mean an increased risk - the chance of not surviving the journey is shortened to 100,000 to one. Staying here is not the answer - 42 people died in just one hotel fire earlier this year.

The point of these statistics is to illustrate that everything we do and use and eat and drink contains some element of risk. In order to enjoy a normal life we ignore the multitude of remote dangers which surround us. But not all risks are remote and some must be taken seriously - how does public opinion decide?

In my view the decision by the public to tolerate or refuse to accept a risk has nothing to do with a rational assessment of the facts nor an objective balancing of the dangers against the benefits. Apart from inborn phobias such as the fear of heights or of being underground, the public will ignore each and every risk unless the danger is brought to its attention in a powerful and emotive way. When that happens, fear is created, and if the case against the risk is put over strongly enough then the source of the danger will no longer be acceptable to the public at large.

Thus the acceptability or otherwise of a risk is based on the amount of publicity received rather than the amount of danger involved, and the non-pesticide world offers many examples. The average intake of common salt in Britain is 10 g per day and that represents 10% of the lethal dose. It has been estimated that this excessive use of salt puts one third of the population at risk from salt-induced hypertension. The public, however, blissfully ignores the problem because no pressure group nor tabloid newspaper has switched on the spotlight. On the other hand lead emission from car exhausts is an alleged risk which arouses strong feelings and is becoming unacceptable to public opinion ..... but that is because someone has turned on the spotlight.

The removal of risks from the environment as a result of the active arousal of public opinion can, of course, be a good thing. But if this arousal is based upon a deception about the dangers and a suppression of the benefits then the effect on the community can be serious or even disastrous. In 1484, Pope Innocent VIII put forward the falsehood that so-called witches put the community in danger and so had to be killed. In the ensuing years about 9 million people were put to death. Unfair, of course, but 'everybody knew' that these women were polluting the environment and public opinion once aroused in a powerful and emotive way will not tolerate a risk.

In the pesticide world we have had our own witch-hunts. In 1955, the malaria eradication programme began and DDT was its cornerstone. It has been estimated that in 15 years about 2000 million malaria cases were prevented and 15 million lives saved (USAID 1977), but by the late 1960s things had started to go wrong. There was a resurgence of the disease, and David Bull (Bull 1982a) of OXFAM recently listed the causes - overconfidence, poor detection, high pesticide prices and shortages plus the establishment of new mosquito breeding sites. All relevant, of course, but how strange that he should omit to mention the DDT witch-hunt which started in America after the publication of Silent Spring in 1962. The U.S. Environmental Defence Fund screamed "Sue the bastards" - a latter-day version of the "Kill them" call by the Salem witch-hunters. The protests that DDT was one of the safest of all pesticides and that there were no known ill-effects on man were ignored - the protesters were labelled as 'paid liars'. The result was inevitable - 'everybody knew' that DDT was dangerous and there was a ban imposed on its use in the U.S.

The Third World response was equally predictable - Why should black people use a chemical which white people banned? DDT use declined. The cause was politics, not just higher prices and shortages as claimed by OXFAM, and the incidence of malaria rose in India from 49,000 cases in 1961 to 6.5 million in 1976. The DDT witch-hunt was not the only cause, of course, but it was a factor which was too important to be now swept under the carpet. As Dr. Mellanby has pointed out, "On a world scale the effects of the American ban on DDT have been disastrous, as it has probably led to more deaths than the 1939-45 war" (Times Literary Supplement, 21 August 1981).

So public opinion on pesticides, as on other subjects, is moulded by what it is told in strong and emotive terms. Since Rachel Carson, the risk side of pesticides has seen far more exposure than it deserves and the benefits side has been given far less exposure than it warrants. Somehow or other, the balance has to be redressed if pests and weeds are not going to win in our battle against famine and disease.

As discussed later, we really cannot expect the press to redress the balance for us. It is up to industry, governments and impartial scientists to put the risks in proper perspective in the public's mind. But we shall never succeed in doing this until we learn to express the position in simple terms for ordinary people. We whine about development costs and the care that is taken and we bluster with a barrage of complex toxicological arguments on specific issues, but we do not squash the general lie that all pesticides are poisons.

A survey carried out amongst U.S. college students revealed that they rated pesticides as the third most important danger in the present-day environment. In fact pesticides are not in the top 25 when measured in terms of deaths per 100,000 of the population. In Britain we had the Chairman of an OXFAM Press Conference in 1982 describing companies selling agrochemicals abroad as "Exporters of death". Well-meaning publications warn householders to take especial care when storing or using pesticides 'or other poisons'. But again what are the facts? In the Home Accident Surveillance for 1981, the 20 co-operating hospitals reported 87,900 accidents requiring attendance at an Accident or Emergency Department. Just 52 of these cases involved pesticides ..... a smaller number than accidents involving flower pots and half the number involving books and newspapers!

For far too long we have sat back and allowed the public, press, governments and even ourselves to group all pesticides together as 'poisons' or 'toxic substances'. Pesticides, like many household products and materials used on our farms, range from being quite safe to highly toxic. The solanine in potatoes and the caffeine in coffee are much more toxic than most pesticides, yet we don't refer to these foodstuffs as poisons.

A number of pesticides are truly hazardous when handled or applied without due care, and the risks involved must never be hidden from the public for either profit or political motives. Of course the public cares and it has a right to know, but it also has the right to know that the risk from pesticides in general is less than they have been led to believe. This also applies to the effect on wildlife. It is interesting that despite all our spraying we have failed to eradicate a single species of insect, weed or fungus, yet 100 million species of plants and animals are estimated to have become extinct before technology arrived!

In addition to putting the risk from pesticides in proper perspective we must also get the benefit message over much more clearly. The worn-out arguments that food would be dearer without pesticides and fruit would be maggot-ridden without their use carry little persuasion. Instead, we need to present the FAO message of Spring 1983 - the developing nations must double their food production over the next 20 years. The stark truth is that shifting surpluses to the Third World is at best only a partial answer to world famine - without adequate but at the same time responsible pest control in these countries part of the world will have to starve.

THE PRESS

We cannot expect much help from the popular press in damping down irrational fears about farm and garden chemicals, but I do not agree that the media are inherently anti-pesticide. I know that stories have bothered you in the past and there will no doubt be more to bother you in the future, but the press have pro-sensationalism rather than anti-pesticide motives. The appeal of a scare story is that it is good copy. Pressure groups provide powerful and emotive stories and the papers act as their mouthpiece. Over the years we have had campaigns against fluoridisation in water, lead in petrol, factory farming, vivisection, oil seed rape ..... and the pesticide risk story merely takes its place in the queue. It also seems that in good campaigning journalism the risk must be close at hand - the story headlined 'Grain Slump Threatens Famine in Third World' was tucked away on page 11 in the Observer (10 April 1983).

I do not wish to criticise the campaigning role of the popular press. You cannot change the situation and it has served us extremely well on many occasions - pressure groups, like pesticides, are not always dangerous. My message to the press is for them to carry on attacking pesticides when they consider it right and proper, but I should like to appeal for the following:-

1. Editors should consult impartial authorities before accepting the word of any pressure group as gospel. The statement in Silent Spring that the American robin "seems to be on the verge of extinction" should have been checked with the U.S. Audubon Society. When Rachel Carson was writing her book the population of this bird had increased 12 times during the DDT era!

OXFAM last year quite rightly pointed out that the lack of care in the handling of pesticides in the Third World was a serious problem and led to accidents. In the abstract released to the press, the alarming Sri Lankan figures were given under the heading 'Occupational and Accidental Poisoning'. The book itself makes it quite clear (Bull 1982b) that about 70% of these cases were in fact suicide attempts.

2. Editors should be conscious of the grave danger to food supplies if vital pesticides are unfairly hounded out of existence in the search for a good story. Pesticide abuse does occur in the Third World and we must work hard to reduce the problem. Isolated accidents and incidents can and will continue to occur, but such happenings should not be used to condemn all pesticides out of hand.

THE POLITICIANS

All we can ask from the popular press is a less ready acceptance of the one-sided scare stories which bombard them - the DDT witch-hunt of the 1960s was a sad episode. However, we have a right to expect our administrators to treat the situation much more seriously. Pesticides should be put above politics, but that does not always happen. The recent sad episode here was the medfly epidemic in California in 1981. Governor Jerry Brown banned aerial spraying on supposedly environmental grounds. "More on his mind, however, was the effect the spraying might have on his chances in next year's race for the Senate". (The Economist, 20 July 1981). The result was near-disaster to the citrus crop, which was only saved at the eleventh hour by the Federal Government threatening to embargo the fruit unless spraying began immediately.

This blatant use of the environmental lobby for political ends was an extreme case, but the attitude of many governments towards pesticides causes me great concern. I accept that public opinion is swayed by strong and emotive messages. I accept that the popular press must always be interested in a 'good story', even if it is sometimes trivial and damaging. But I cannot accept that responsible governments should treat all pesticides as extra-dangerous products despite the technical facts, just because these chemicals arouse strong passions amongst specific pressure groups and the public at large. I know that these are strong words but let me give you a couple of examples.

In the E.E.C. a garden pesticide which causes a slight reddening of the skin after 4 hours' exposure would be classed as an irritant. Of course there would be no irritancy risk in practice but the label would still have to bear a black cross and in the U.K. there would have to be the warning phrases "KEEP OFF SKIN. WASH OFF SPLASHES. WASH HANDS AFTER USE".

Now look at another domestic product. It is a stronger irritant and in tests caused caustic necrosis of the skin. Yet this non-pesticide bears no black cross nor do warnings appear to keep it off the skin. Such warnings would be impractical, because it is waterproof mascara for application around the eyes! (Guillot 1979). Obviously we have double standards here. The 'poison' assumption is always there with pesticides and so a relatively safe product would have labelling requirements in terms of irritancy which are far in excess of those required for a cosmetic.

As another example we can look at a moderately effective weed-killer which has not been launched as a commercial pesticide. The problem is that it contains 0.5% of an ingredient which has been identified as a cause of skin cancer. It is also a co-carcinogen, increasing the tumour-promoting action of other carcinogens. Furthermore it is also readily absorbed through the skin and cases of chronic poisoning as a result of skin absorption of this active ingredient have been recorded. Any government would have to look at these facts very carefully before granting clearance for sale under the present guidelines for safety. Such a product would have to bear many warnings if ever it was cleared for sale, but that need not stop you buying it. Any chemist shop will sell it to you as calamine lotion, with instructions for you to "apply liberally to the inflamed area of the skin".

Like waterproof mascara, calamine lotion with its 0.5% phenol content is an everyday product which causes no problems in practice and arouses neither public opinion nor press reaction. Their labelling is simple but certainly would not be so if sold as pesticides. We may take the view that it is right for a government to be overcautious and to have too many precautions rather than too few on relatively safe pesticides. I contend that it is not a good thing for the following two reasons:-

1. If all pesticides bear a long list of warnings then there is a danger that they will be ignored. Ray Bates as Pesticide Residue Specialist with FAO made the following point in April 1981: "Many of the requirements have been often enforced with more enthusiasm than logic, more emphasis than common sense and often with little regard to the actual hazard involved. Minimal danger should be recognized and proclaimed. Warnings should be reserved for those cases which merit them". (Bates 1981).

2. If relatively safe materials are banned due to succumbing to pressure and if they bear a long list of warnings 'to be on the safe side' then undue restrictions may be placed on them by developing countries. Ironically these Third World regimes may then turn to much more toxic materials which might not be suitable for use in their primitive conditions. Once again Ray Bates put the position quite clearly in his April 1981 speech - "Many authorities in developing countries face a dilemma when considering the use of pesticides merely because of the action of governments of industrialised countries in temperate regions to ban the use of a number of well known, safe and potentially useful pesticides. The use of valuable materials such as DDT and lindane is discouraged in some developing countries because of the action of governments in other parts of the world and because of the adverse publicity that has surrounded such materials in recent years".

I do commend this apparently over-caring attitude by the industrial nations and they must never relax their watch on pesticides, but I feel that the regulations for the relatively safer materials should be relaxed in order to highlight the dangers of the more toxic ones.

With regard to the more toxic pesticides which can be properly classed as poisons I would like to see a strengthening in the controls. As a minimum the following changes are needed:-

1. It should be illegal to sell a pesticide which does not bear precautions printed in the language of the country.

2. A system of picture warnings should be evolved. The people using pesticides in the Third World are often illiterate and both words and symbols are equally useless. I propose easily recognisable drawings or photographs of wrong practice with a bold red cross through each one. Once the system is established, it should be illegal to sell a toxic pesticide in a low-literacy country without picture warnings appearing on the label.

3. A level of toxicity should be established above which it should be illegal to sell a pesticide for home or garden use. Clear labelling is all very well, but neither small children nor pets can read.

I know that politicians and governments do care, but my final point is that this caring should never deteriorate into a mass of complex bureaucracy where everything is tarred with the same brush. It is nonsensical to have a product which is as safe as whisky being treated almost as a poison in the E.E.C. and at the same time having a poison sent to an underdeveloped country with a label which is no more comprehensible to the user than the words on a bottle of whisky.

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EXPOSURE OF OPERATORS AND BYSTANDERS TO PESTICIDES IN THE UK

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Background

The hazardous nature of a pesticide is usually classified on the basis of toxicity data derived from tests on animals. LD 50 values of <10 mg/kg usually characterize the extremely toxic group but this form of hazard classification does not consider the magnitude and nature of exposure to a chemical which may put a worker at risk when handling and applying pesticides of lower toxicity ratings. The exposure of humans in operations with pesticides must therefore be studied in the practical situation if the risks are to be defined realistically.

Methods of Studying Human Exposure to Pesticides

Several complementary procedures may be employed. Epidemiological studies are normally designed to look for untoward effects of exposure to pesticides through differences between related exposed and unexposed groups. Clinical observations supplemented by biochemical measurements may be involved or used in monitoring activities but they may only be capable of detecting gross exposure to a pesticide. The degree of correlation between a biochemical measurement and the magnitude of exposure to a pesticide is unlikely to be precise however judging from data on worker exposure to other groups of chemicals.

Such exposure studies demand considerable resources for the range of chemicals is wide and ever-changing, the use of a selected chemical may be intermittent, the locations may be widely-scattered and the conditions of use very variable. Moreover when a risk to health is indicated it may not be clear whether the safety procedures were inadequate or just not observed. Direct measurements of pesticide residues on clothing and uncovered skin, and the filters of air sampling equipment, tend to be used frequently therefore in assessments of worker exposure to pesticides because they establish the potential hazard, its magnitude under different operational conditions and the major factors influencing the hazard without making unreasonable demands on resources. Useful data are also provided on which to base performance requirements of personal protective equipment.

Studies in the UK by the Operator Protection Group (OPG)

Many operator exposure studies have been conducted in the UK by the OPG. These studies are providing a data-base on the relative hazards and influencing factors in different operations with pesticides. Direct measurements of exposure therefore predominate and, in general, exposure levels found chiefly by direct measurements, in operations involving the use of different forms of application equipment, rank in a similar order to those experienced in other countries. Operators of hand-held or back-mounted sprayers face the highest levels of exposure to spray particles whereas operators of tractor-based sprayers, equipped with air-conditioned cabs, experience the least contamination. Handling and mixing pesticide concentrates continues to be potentially hazardous but studies by the OPG and other workers show that with attention to the pouring characteristics of containers and the introduction of automatic transfer systems the risks may be greatly reduced. Exposure of the general public to drift of spray chemical from the target area appears generally to be minimal under UK conditions.

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✓ **4A—R2**

TAINT TESTING OF AGROCHEMICALS

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The evaluation of a chemical for taint potential at the Campden Food Preservation Research Association follows the 'Standard Procedure for Taint Tests with Agricultural Chemicals' prepared as an unpublished Working Document by the Advisory Committee on Taint of the Ministry of Agriculture, Fisheries and Food. This document recommends the standardization of all stages from field trial design to the calculation of results so that valuable comparisons can be made between tests.

Precautions are taken to ensure that food flavour is not influenced by processing or storage conditions, and before the samples are submitted to the tasting panel they are cooked using standard methods. Since the palate is more sensitive to warm food, the samples are heated before being macerated to a puree or finely chopped, ensuring that each taster takes a portion that is representative of the whole sample.

The tasting panel realize the importance of this research and take their work very seriously. All tasters for this work are volunteers, the only criteria necessary to be accepted as members of the tasting panel being an ability to detect slight flavour differences. Care to avoid the influence of external conditions on the taster's judgement is also of extreme importance, and so individual tasting booths are used, with special lighting to mask any colour differences between the samples.

The basic method of tasting should be as simple as possible and as accurate as the conditions of the test allow. For this reason, the triangle tests was suggested as the standard method for taint test work.

In the triangle test each taster is presented with three samples, two of which are treated samples and the third a control; or vice versa. Tasters are first asked whether they can detect a flavour difference, and if so, to describe this difference. They are also asked whether a taint is present or not.

A statistical analysis of the results of the test is sent to the chemical manufacturer after each test. An annual publication is produced giving the results of all the taint tests.

PROTOTYPE TESTING FOR SAFETY IN USE OF VEHICLE-MOUNTED 'ELECTRODYN'* SPRAYERS

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Background and objectives

Prototype testing and safety in use have been fundamental concepts in the development of ICI's Electrodynamic Spraying System. Vehicle-mounted prototypes have been tested in arable crops in order to evaluate performance in relation to operator, environmental and consumder safety and to indicate the scope and direction for improvement.

The prototypes (VMRD) tested were characterised by charged, small drop (50-90 um vmd), ULV application, usually 1 l/ha or less. These were compared in simultaneous operation with conventional (CONV) large drop (150-500 um vmd), high volume (90-390 l/ha) production sprayers and with a small drop (97 um vmd) low volume (6-12 l/ha) rotary atomiser (CDA).

Operator exposure

Comparative operator dermal and respiratory exposure to permethrin insecticide was analysed by GLC following application by VMRD and CONV in cotton (US).

Results and conclusions

During mixing/loading, containerisation of the VMRD formulation reduced operator exposure by 50 percent.

The airborne concentration of permethrin was generally less than 3 mg/m^3, so that respiratory exposure was unlikely with either device.

The mean dermal exposure for VMRD was 64 to 14 mg/hr, equivalent to 0.04 - 0.005 percent of ai applied. This was higher than that for CONV at 2.2 mg/hr, 0.001 percent of ai applied. Boom contamination was the major source of the increased dermal exposure during application with VMRD, especially when adjustment to nozzle/boom increased the risk of hand/arm exposure.

Modification of the design to reduce this risk is in progress.

Non-target contamination

Drift potential for non target contamination was interpreted from the analysis of cord sampling devices after simultaneous application of ai by VMRD and CONV devices in cotton (Zimbabwe), barley (UK) and soya (US).

Results and conclusions

The mean ai in the spray drifting or depositing at headland width of 11-15 metres downwind, was 2.8 and 8.1 percent of emission for VMRD and 0.4 and 1.4 percent for CONV. The small drops of VMRD were more prone to drift in winds of 1-6 m/s than the large (150-500 um vmd) drops of CONV, but charged drops of 50-90 um vmd (Johnstone et al, 1982) were rather less so than uncharged drops of 97 um vmd from CDA in winds up to 3 m/s.

The practical significance of this comparative drift will depend on the cumulative risk of unacceptable crop damage and environmental contamination. This will depend on specific ai, concentration of deposit and crop and environment susceptibility.

Work continues to predict those circumstances where application would be safe for these and other devices.

Crop residues

Selected pesticide residues have been analysed by appropriate GLC methods after residue sampling from representative crops. Comparative application was made with VMRD and CONV modes using a range of ai/ha rates, times of application and pre harvest intervals, including those recommended in practice.

The pesticide/crop range included the insecticides permethrin and cypermethrin on leafy vegetables, cotton and maize and the triazole fungicide PP450 on wheat and barley.

Results and conclusions

In each of the representative crops tested, differences in pesticide residue level between the two devices were small. Residues in general were acceptably low with both devices and within the temporary maximum residue limits of FAO/WHO where these have been established.

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4A—R4

HAZARD EVALUATION OF BIORATIONAL PESTICIDES IN THE U.S.

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Introduction

The U.S. Environmental Protection Agency (EPA) requires premarket testing and regulates the usage of pesticides, including microbial and biochemical agents (i.e., biorational pesticides). While evidence thus far indicates that biorationl pesticides are unlikely to pose significant hazards, it is still necessary to fully identify each biorational pesticide and to test for potential toxicity, allergenicity, infectivity and pathogenicity.

Hazard Evaluation - Current Status

Biorational pesticides are inherently different in their mode of action than most conventional chemical pesticides and therefore EPA uses a different approach to evaluate potential hazards associated with their use.

Unlike most of the conventional chemical testing, biorationals are evaluated using a sequential tier testing scheme, so that products which are judged safe, based on the initial set of tests (i.e., Tier I) may be subjected to no further testing. To ensure that the Tier I tests will identify potentially hazardous pesticides, the dose, test species, test animal age or life stage, and route of administration are all selected to pose the maximum challenge to the test organism. Therefore, a negative result provides a high degree of confidence that the pesticide is unlikely to pose an unreasonable risk. Testing in subsequent Tiers, if required, focuses on effects observed in Tier I in order to more accurately assess the likelihood such adverse affects will materialize under actual conditions of pesticide use.

Product analysis data consist of information on product identity, product purity, product assay and standardization and manufacturing process. The minimum human safety data requirements include single dose acute bioassays on mammalian test species. Oral, dermal, inhalation, ocular and injection routes of exposure are used in these tests to assess potential infectivity and toxicity. Tests to evaluate irritation, hypersensitivity and effects on cellular immune response are also minimum requirements, in addition to cell tissue culture studies for viruses. Results of these tests may dictate the need for additional human safety testing. Baseline ecological effects data include short term laboratory studies on selected avian, fish, aquatic invertebrate and plant species using the maximum challenge testing approach. Tests to evaluate environmental fate, transport and contamination of food or feed crops would normally be required only if results of Tier I tests provided evidence of potential human health or ecological hazards. These data would then be developed along with additional (Tier II or Tier III) human health or ecological effects data, as appropriate. Post-registration monitoring is necessary to confirm the identity of the microbial agents and to ensure that no chemical or biological contaminants have been inadvertantly introduced.

Although the tier testing scheme and maximum challenge approaches are unique to the biorationals, once the data are developed, the hazard evaluation process is similar to that for the conventional chemical pesticides, and the same kinds of scientific and regulatory decisions must be made. For example, the "effects" data must be judged in terms of the potential or expected "exposure," since without exposure (of humans or other nontarget species), effects alone are of no practical significance.

Genetically Engineered Microbial Pesticides

Genetically Engineered Microbial pesticides are a new group of biorationals currently under development. EPA believes that, at a minimum, the testing required to evaluate non-engineered microbials is also applicable to the engineered pesticides. Some additional concerns that arise with engineered microbes are genetic composition, stability of recombinant DNA, and the potential for genetic transfer. EPA expects to evaluate these pesticides on a case-by-case basis and to require additional information or data, as appropriate.

Summary

Biorational pesticides pose a broader scope of potential hazards since they include such a diversity of products- living, engineered, chemical- with a variety of modes of action (mating disruption, attraction, feeding disruption, pathogenesis). However, testing to date has revealed no serious adverse human health or ecological effects. As a class, the biorationals appear to be among the safest pesticides available.

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FATE AND BEHAVIOUR OF NE 79168 IN DIFFERENT CROPS

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Background and objectives

Organophosphorus insecticides having high biological activity have been applied in the agricultural practice for many years. To assure their safe application and to accept the risk - from the viewpoint of human safety - the control of the fate of new compounds and the identification of their main degradation products during agricultural usage are necessary. The decomposition of a new phosphorilated acid anilide insecticide NE 79168; (phosmetilane; 0.0-dimethyl-S [(N-(2-chlorophenyl)-butyrilamino)methyl]-ditiophosphate) was followed under glass house conditions and in field trials in various crops, such as cabbage, lucerne, pear, bean and peach. The photolysis of parent compound and its rate have been also studied with the identification of the main degradation products.

Materials and Methods

The decomposition of NE 79168 on bean plant was investigated in the glass house. The applied dose was 1000 µg a.i./leaf. For the field trials with cabbage, lucerne, pear and peach the dose rate was 40 g a.i./100 m^2. Combined column and thin layer chromatographic clean-up techniques were applied. The residue analysis was carried out by high performance liquid chromatography with u.v. detector. The minimum detectable residue was 0.05 mg/kg. Standard deviation at 0.1 mg/kg level was 2-5 %. For the structure identification of photolytic degradation products thin layer chromatography, direct mass spectrometry, gas chromatography-mass spectrometry and infrared micro-technique were applied. To confirm the structure the main degradation products were synthesized.

Results and conclusions

According to the investigations for the decomposition of parent compound on bean plant, the half-life was 4-6 days. The main degradation products were 2-chlorobutyro-anilide, 2-chloroaniline and the P=O analogue of the parent compound. The results of the field experiments were in good agreement with the glass house ones. The half-life of the parent compound was 3-5 days for lucerne, cabbage, pear and peach. The rate of decomposition was higher in lucerne than in cabbage, but this result can be explained by the dissimilarity in growth of the two crops. The decomposition of the parent compound was practically accomplished within 3 weeks. The residue level of the harvested crops at 3 weeks post-treatment was below 0.1 mg/kg.

Investigating the photolytic conversion of NE 79168, the main degradation products are as follows: N-hydroximethyl-2-chlorobutyroanilide; 2-chlorobutyroanilide; 2-hydroxi-butyroanilide; butyroanilide; 4-amino-5-chlorobutyrophenone; 2-amino-3-chlorobutyrophenone. During the investigated 4 week period in aqueous solution exposed to u.v. light 2-hydroxi-butyroanilide was the most persistent degradation product.

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4A—R6

BENDIOCARB SKIN CONTAMINATION WHEN MONITORING CHOLINESTERASE

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Background and objectives

Part of the World Health Organisation's vector-borne disease control evaluation programme involves health monitoring of spray operators applying novel insecticides. The observers check primarily for clinical symptoms of pesticide exposure, and in addition for organophosphate and carbamate insecticides quantitative monitoring of the nerve enzyme cholinesterase can be carried out, since the latter provides a useful correlation with clinical symptoms.

A common sampling method for cholinesterase assays in humans is one in which the finger is pricked and blood allowed to flow to the surface, where it is collected in a capillary tube. Cholinesterase activity is then determined by means of a colorimetric assay.

In studies involving the insecticide bendiocarb, the finger prick procedure has been found to produce low cholinesterase activity inconsistent with the absence of illness and observed levels of pesticide exposure. One possible explanation was that the blood samples were being contaminated with surface deposits of insecticide.

Results and conclusions

In order to confirm this hypothesis a study was undertaken in Thailand in which cholinesterase activity was compared in blood samples obtained concurrently by finger prick and venepuncture from spray operators using bendiocarb. Despite adopting rigorous cleansing procedures the finger prick blood had significantly lower cholinesterase activity, whereas the venous blood showed only slight inhibition after spraying. Contamination was confirmed by exposure of venous blood to the fingertip, since it resulted in low cholinesterase activity similar to that obtained by the finger prick technique.

It is concluded, therefore, that despite stringent cleansing procedures the finger prick sampling procedure can give rise to artefactual cholinesterase values. Consequently, the collection of samples by venepuncture is recommended.

PERCUTANEOUS ABSORPTION OF BENDIOCARB IN MAN

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Background and objectives

Bendiocarb is a carbamate insecticide which is used in mosquito control. Dermal exposure to the insecticide can occur during spraying, and thus the percutaneous absorption has been studied in male volunteers.

The [^{14}C]-labelled insecticide was applied as a 1% aqueous suspension to the forearm and the excretion of [^{14}C] in urine was used as a measure of percutaneous absorption.

Results and conclusions

Data from the study indicate that the pesticide is well absorbed if the application site is covered with an occlusive dressing, but only poorly absorbed through non-occluded skin. This implies that percutaneous absorption of bendiocarb may be toxicologically more significant when spraying is carried out under conditions where hydration of the skin is likely to occur (e.g. high humidity).

The study also showed that bendiocarb is incompletely removed by vigorous washing of the skin. The residual bendiocarb is a source of contamination of finger prick blood samples for cholinesterase assay, leading to artificially reduced values.

4A–R8

BIO-Y: A UNIQUE, PRACTICAL ONE-HOUR BIOASSAY FOR MEASURING FUNGICIDE RESIDUE

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Background and objectives

Pesticides are used routinely in agriculture with nearly all cropping systems and in non-agriculture for projects such as right-of-way spraying. However, numerous studies have reported that most pesticide applicators are not calibrated correctly. Either too much or too little pesticide was applied and the distribution in the crop canopy was uneven. Unfortunately, there is no procedure for readily obtaining a quantitative measure of sprayed material on plant surfaces, nor are there methods or models available for readily assessing the weathering and redistribution of pesticide residue. Analytical procedures are available, but they are too expensive, lengthy, and sophisticated for routine use by people not trained as laboratory technicians.

There is needed a practical, reliable, sensitive assay that can be performed routinely by Extension and Advisory personnel, agricultural consultants, crop management specialists, growers, or others. The procedure should be inexpensive, uncomplicated, quick, easily-performed, readily-understood, and designed to minimize errors. The measurements should be reliable, reproducible, and easily interpreted into practical applications with self-explanatory visual aids. BIO-Y is a one-hour bioassay that meets these criteria. A study conducted in an apple orchard to evaluate its usefulness in measuring pesticide distribution in a crop canopy is reported.

Materials and Methods

BIO-Y is a manometric technique that relates pesticide residue to CO_2 production by yeast, Saccharomyces cerevisiae. Thin, vinyl targets with 50 cm^2 of surface were placed in specified locations in the canopies of 5 semi-dwarf McIntosh apple trees spaced along a row. The row was then sprayed with a 50 WP formulation of Captan at the recommended rate and volume per acre using an orchard speed sprayer. The targets were retrieved and the residue for each location determined by bioassay and by a spectrophotometric technique included to verify the bioassay determinations. A preliminary study showed that pesticide deposition on the vinyl targets and apple leaves was similar.

Results and Conclusions

Captan densities of 1 to 10 ug/cm^2 target surface was recorded. The bioassay and spectrophotometric measurements on paired targets from each location were in close agreement (± 1 ug), indicating that the BIO-Y procedure can be used to provide quantitative measurements of pesticide distribution within a crop canopy.

BIO-Y offers several advantages over previous bioassay procedures that make it practical for widespread use: no culturing of a test organism is required, no sterilization is required, and no specialized laboratory facilities or laboratory training are required. The assay is conducted in an inexpensive temperature-controlled water bath using specialized apparatus that allows 18 targets to be processed simultaneously.

BIO-Y is adaptable for (a) calibrating sprayers, (b) monitoring pesticide deposition in the canopy of a wide range of orchard, row, and field crops, (c) monitoring pesticide contamination of non-target objects, (d) monitoring exposure of applicator and field workers to pesticides, and (e) providing residue data contributing to the decision-making process for selecting the rate and timing of pesticides in crop management programs.

PESTICIDE EXPOSURE AND MODELING IN THE UNITED STATES

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The United States Environmental Protection Agency (U.S. EPA) is charged with ensuring the safe use of pesticides as authorized under the Federal Insecticide, Fungicide, and Rodenticide Act. This task requires the determination of the amount of pesticide exposure to humans, animals, and plants which are not to be intentionally treated or otherwise exposed. Exposure to pesticides (e.g., oral, dermal, inhalation) can occur during all phases of pesticide usage:

(1) before application (mixers and loaders),

(2) during application (applicators, field workers, and off-target humans and other organisms due to spray drift),

(3) after application (farm workers re-entering the fields or runoff from the fields, possibly affecting fish and other aquatic life and water used for human consumption), and

(4) from leaching into ground water (water used for irrigation and human consumption).

To quantify exposure, an estimated environmental concentration must be determined from the fate of the chemical, transport in the environment, and use conditions of the pesticide.

To determine the fate and transport of pesticides in the environment, chemical and physical information about the pesticide must be known, as well as various environmental and meteorological parameters. Information about the pesticide includes: solubility, sorption to soil, persistence in the environment, and type of pesticide formulation (granular, emulsifiable concentrate, wettable powder, etc.). The environmental and meteorological data are normally gathered or generated for actual or hypothetical use and impact sites. Pesticide use sites include agricultural fields, grasslands, or surface water bodies from which pesticides are transported by way of wind, rain, sediment runoff, water flow, or leaching. Pesticide impact sites include terrestrial environments, ponds, lakes, streams, and ground water aquifers.

The pesticide information used for all types of modeling is similar. However, the environmental and meteorological information required depends on the type of modeling being conducted.

(1) Runoff evaluations depend on information on crops, agricultural practices, storm events, and evapo-transporation for predicting pesticide losses from fields.

(2) Water quality evaluations depend on water flow, size of water body, and physical and chemical characteristics of the water and region in which the water body is found.

(3) Leaching evaluations are based on recharge rates and on soil characteristics.

(4) Spray drift evaluations use two basic types of models, ballistic and diffusion, to quantify pesticide movement from application equipment, e.g., aircraft, mistblowers, and ground-hydraulic rigs. Wind speed and droplet distribution are the primary factors for aerial drift determination.

Several models are available for each type of exposure assessment to predict the quantity of pesticides on the ground, in surface waters, in ground waters, and in the air. The primary models regularly used by the U.S. EPA include a runoff model, Simulator for Water Resources in Rural Basins (SWRRB), a water quality model, Exposure Analysis Modeling System (EXAMS), and a leaching model, Pesticide Analytical Solution (PESTANS). No specific aerial drift models are presently being used by the Agency.

Exposure, expressed as a function of time, is determined from estimated environmental concentrations and the phase or means of exposure. The exposure data, along with human, animal, and plant toxicological data for pesticides, are used to determine whether a potential risk is likely to exist with the intended use of a pesticide.

STUDIES ON RESIDUES OF OXAMYL AND ITS METABOLITE IN PARSLEY AND CELERIAC CROPS

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Background and objectives

Oxamyl is the approved common name for methyl N',N'-dimethyl-N-[(methylcarbamoyl) oxy]-1-thiooxamimidate. It is toxic to insects and nematodes, both by direct contact and ingestion and rapidly metabolises in plant or mammalian systems to compounds of lower toxicity. One of the major metabolites is methyl N',N'-dimethyl-N-hydroxy-1-thiooxamimidate, hereafter called oxamyl oxime. We undertook to determine the residues of oxamyl and oxamyl oxime in leaves and roots of parsley and celeriac crops, grown in soil treated for the control of nematodes.

Materials and Methods

In field experiments, oxamyl was applied as a 10% granular formulation at seed planting time at the rate of 8 kg per hectare. For residue analysis, samples of each crop were taken several times during the growing season. The samples were washed briefly with water to remove adhering soil, mixed and reduced by quartering. Roots and tops were separated for individual analysis. A simplified method has been developed for the separation and determination of oxamyl and oxamyl oxime. This method is based on the extraction of both compounds from the plant material and their separation by liquid chromatography on aluminium oxide. Both separated compounds are then determined by gas-liquid chromatography using on column reaction with trimethylphenyl-ammonium hydroxide. The derivative so formed was detected by a flame photometric detector operated in the sulphur mode.

Results and conclusions

Minimum detectable residues were about 0.008 mg kg^{-1} for oxamyl and oxamyl oxime. Recoveries averaged 97% for oxamyl and 93% for oxamyl oxime when leaves or roots of parsley and celeriac were fortified at the levels of 0.1 - 0.5 mg kg^{-1}. Residues of oxamyl and oxamyl oxime in parsley and celeriac, 49 days after oxamyl application, were found in leaves at the level of 0.02 mg kg^{-1}, but no detectable quantities of either compound were found in roots. Final residues in leaves and roots at harvest time were below the limit of detection. The results obtained allow us to conclude that the rapid disappearance of the oxamyl residue in parsley and celeriac crops brings about a low risk to consumers.

PATTERN OF DISTRIBUTION OF ETHYLENE BISDITHIOCARBAMATE RESIDUES IN CERTAIN CEREALS, VEGETABLES, OILSEED AND FRUITS IN THE SEMI-ARID TROPICS

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Background and objectives

The dithiocarbamate fungicides Dithane-M45 (a 75% wettable powder formulation of mancozeb) and Dithane Z-78 (a 75% wettable powder formulation of zineb) are widely marketed in India for use on a wide range of crops. Field experiments were conducted in Hyderabad (17^{o}N), which is located in the semi-arid tropics, to determine residues of ethylene bisdithiocarbamates (EBDC) in wheat, rice, sorghum, eggplant, tomatoes, potatoes, chillies, groundnuts and grapes, over two crop seasons. Meteorological conditions were monitored during the growing season.

Materials and Methods

The fungicides were applied at the recommended concentration of 0.25% for all spray schedules. Residues were determined by the photometric determination of carbon disulphide following acid hydrolysis of the dithiocarbamate residues. Recovery levels were normally in the range 70 - 90% depending on the crop/fungicide combination.

Results

Among the cereals, wheat grain had the lowest concentration of maneb (1.33 mg/kg) and zineb (0.38 mg/kg), while sorghum grain contained the highest residues (10.45 mg/kg and 10.79 mg/kg zineb). Residues in cereal straws followed a similar pattern being lowest in wheat (8.22 mg/kg maneb/5.75 mg/kg zineb) and highest in sorghum straw (246.8 mg/kg maneb/234.6 mg/kg zineb). Among the vegetables, tomato fruit contained the lowest residues (0.25 mg/kg maneb/0.5 mg/kg zineb) whilst chilli fruit contained the highest (2.18 mg/kg maneb/2.04 mg/kg zineb). Grapes also contained high levels of the two compounds (7.24 mg/kg maneb/8.84 mg/kg zineb). EBDC residues were not detected in pea seeds, potato tubers, polished rice or groundnut kernels.

Washing of the edible parts of vegetables, fruits and cereal grains indicated that the amount of residue removed varied with the crop. Thus it was possible to remove between 72 and 80% of EBDC residues from rice grain whereas wheat grain had the highest tenacity to retain the residues in spite of washing. Maneb had the greater tenacity to remain on cereal grains even after washing. It was possible to remove all EBDC residues from vegetables except in the case of chilli fruits.

A multiple regression analysis has been undertaken for the relationship between the pattern and extent of EBDC residues and temperature, humidity, hours of sunshine, wind velocity and rainfall.

4A—R12

ASSESSMENT OF CARCINOGENIC RISKS OF PESTICIDES

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Evidence of carcinogenicity in animal experiments is a warning signal, the intensity of which is related to the nature of the data. Such data are used to answer two questions: (1) how likely is the pesticide to be a human carcinogen? (2) if it is a carcinogen, how much cancer might it produce in practice?

Qualitative assessment (1) is always subjective. Differences in experimental design and procedure need to be taken into account. Positive results in animal experiments should be reinforced by studies of the metabolism and pharmacokinetics of the substance and by a battery of mutagenic tests. Diagnostic criteria need to be established and necropsy and histopathological procedures standardized. Criteria for statistical evaluation of data must be laid down with particular attention to the incidence of spontaneous tumours in controls. Statistical analysis should be applied only to data on tumours of the same cell type at the same site. A pesticide should be judged carcinogenic <u>only</u> if a statistically significant increase in tumour incidence at one site can be demonstrated in at least one species of test animal. If this is so, then the pesticide must be presumed to present potential carcinogenic risks to persons exposed to it. This is, however, a speculative assumption.

Quantitative assessment (2) necessitates extrapolation from data obtained from small numbers of test animals given large, often near lethal, doses throughout their lifetimes to possible effects of very small, infrequent doses on possibly very large populations of humans. Such extrapolation implies that there is no "no-effect" dose for carcinogens as there is for other types of toxicants. This is currently a matter of controversy but there are a number of plausible mechanisms of carcinogenesis for which it is true. Extrapolation depends on a functional relationship between risk and exposure. The most useful model is the multi-stage model which gives a good fit with most sets of data and conforms with current biological models of the incidence and development of cancer.

$$A(D) = 1 - \exp -(k_1D + k_2D^2 + \text{----}\ k_rD^r)$$

where A(D) is the probability that a dose D will produce a cancerous response in a single animal (as distinct from a spontaneous tumour), k_1, k_2, --k_r are positive numbers and there are experimental results available for r+1 different values of D. A chi-square test is applied to determine whether the fit of the experimental data to the model is acceptable. At low doses the equation reduces to $A(D) = k_1D$, that is, a linear relationship.

The model should be used only to calculate "virtually safe doses", not to try to assess absolute values of risks. A VSD is the dose for which the risk of an individual developing cancer as a result of the test substance is, with 95% confidence, less than a specified figure R. It is calculated as:

$$VSD = R/k_1^* \quad \text{where } k_1^* \text{ is the 95\% upper confidence limit of } k_1$$

as calculated from experimental data. This calculation gives the VSD for the test animal in terms of total lifetime dose/kg bodyweight. It can be assumed that the animal VSD also gives the VSD for humans in terms of total lifetime dose/kg bodyweight but this is purely speculative. Whether the risk is the same for the VSD given as one single isolated dose as for the VSD evenly spread over a lifetime is not known.

Carcinogenic assessment should be internationally harmonized along these lines. The acceptable value of R is a matter of subjective decision but it is suggested that $R = 10^{-6}$ provides a more than adequate safety margin.