HAZARDS IN USING HERBICIDES

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A. INTRODUCTION

Over the last 20 years it has become possible to produce profound changes in plants and animals by exposing them to unbelievably small doses of organic chemicals.

It is scarcely surprising therefore that the large-scale practical use of these chemicals has been beneficial to agriculture. On the other hand, it is also not surprising that their misuse has been associated with a number of recognized hazards and, on occasions, with serious economic loss.

When considering these hazards in relation to weed control programs it at once becomes apparent that, apart from measurements of toxic effects of herbicides on animals other than humans, and measurements of the breakdown of herbicides in soils, our knowledge of herbicides is based almost entirely upon qualitative field experience, usually of an incidental nature, and mostly inadequately recorded.

In the face of this gross lack of applied quantitative facts, those in charge of weed control programs have no alternative but to make decisions based primarily on field experience. It is felt therefore that this paper would be of most use to those using herbicides in the field if, instead of reviewing the quite inadequate scientific literature on this subject, it aimed at summarizing the field experience of the Victorian State Rivers and Water Supply Commission, describing the practical measures which have been taken to overcome the various types of hazard, and suggesting lines of investigation which might help to reduce hazards in the future.

This paper will therefore be inadequate as a review as it will not cover all herbicides and all the situations which arise in their application. But it is hoped that some of these inadequacies will be covered in other papers and in the discussion.

B. EXTENT AND NATURE OF SPRAY PROGRAM

The Commission uses herbicides extensively throughout 8,000 miles of irrigation supply and drainage channels. These channels serve both intensive horticultural and extensive pastoral irrigated areas. The supply channels deliver water to a very large range of crops on which spray, flood, and furrow methods of irrigation may be used; some of this water is also used for domestic purposes. The function of the drainage channels, on the other hand, is to remove excess water from the irrigated areas - this water eventually reaches river systems where it may be diluted and used again for domestic, stock, industrial, or irrigation purposes.

Under these somewhat unusual conditions, it will be appreciated that normal spray hazards are accentuated and hence rigid control of spray operations is necessary.

Over the last 8 years the practice has developed of spraying channels with herbicides, except where silt removal is also necessary and except, on the frequent occasions, where safety considerations prevent chemicals being used at all. The program is now of moderately large dimensions, the following quantities of chemicals being used during 1963/64:

	Active Ingredient	Quantity Used 1963/64
85%	acrolein (acrylaldehyde)	1,900 gallons
25%	amitrole (3-amino-1,2,4-triazole + ammonium thiocyanate)	3,800 gallons
85%	2,2-DPA (2,2-dichloropropionic acid)	20,400 lb
36%	2,4-D (2,4-dichlorophenoxyacetic acid) (butoxyethanol low-volatile ester)	1,600 gallons
80%	monuron (N-(4-chlorophenyl)-NN-dimethylurea) or diuron (N-(3,4-dichlorophenyl)-NN-dimethylurea) (alternatives)	1,500 lb
90-97%	sodium trichloroacetate	10,500 lb

The specific use made of these chemicals has been described earlier by Mr. Bill in his paper (8(a)-5).

The total expenditure on chemical weed control during 1963/64 amounted to £66,000, and it has been estimated that this produced a result which would have cost at least £503,000 to achieve by existing mechanical control measures.

The use of chemicals by the Commission is expanding, but it is expected that, unless safer techniques can be developed, it will not be possible to use chemicals in an estimated 10% of supply channels and 40% of drains. Already considerations of safety limit, and in fact virtually determine, what the chemical weed control program is to be.

C. WHAT ARE THE HAZARDS?

In executing this spray program the main hazards taken into account are:

1. hazard to spray-operators resulting from their exposure to the herbicide and, in the case of acrolein, from its explosive nature
2. hazard to plants resulting from spray drift or volatility, or from the roots of trees and vines traversing soil treated with soil sterilants
3. hazard to plants, livestock, and humans resulting from traces of herbicide reaching channel or river water, which is then later used for domestic, stock, or irrigation purposes
4. hazard to fish and wildlife

D. HOW ARE THESE HAZARDS OVERCOME?

In any large spray program there are a number of basic requirements which must be met if these hazards are to be overcome:

1. The first requirement is to establish a comprehensive set of written operating instructions. These instructions should be based on both experience and experiment, they should be given the full authority of the organization concerned, and should set out what can and cannot be done when spraying in the field. (The Commission's instructions are briefly summarized in the next section of this paper.)
2. The second requirement is to set up a system of independent inspection and training which will ensure that these operating instructions are closely followed. The Commission has five full-time inspectors engaged solely on supervision of the spray program; they operate in 12 different country centres, and closely supervise a total of 20 spray teams. Selection and training of the spray operators themselves is a most important part of the inspector's job. All ordering of weedicides is also supervised by the Senior Inspector.
3. The final requirement is to establish a system for investigation and experiment, for only in this way will improvements be made to the spray program and hazards reduced.

The Commission has two full-time research officers engaged on research into aspects of the weed control program. As a result of this work, a continuous improvement in the safety of the program is being made.

E. OPERATING INSTRUCTIONS

The Commission's written operating instructions run to some 26 pages but the main features are as follows:

1. Only chemicals of low mammalian toxicity are used, with the exception of acrolein which is not persistent in water and which dissipates completely by evaporation within 24-48 hours of application. The oral L.D.50's to rats of the herbicides in use are as follows:

(a) amitrole)	25,000	mg/kg	
(b) ammonium thiocyanate)	484	" "	(mice)
(c) 2,2-DPA	9,330	" "	
(d) monuron	3,600	" "	
(e) diuron	3,400	" "	
(f) sodium TCA (trichloroacetic acid)	3,320	" "	
(g) 2,4-D	375	" "	
(h) acrolein	46	" "	

Only those weedicides which are relatively non-toxic are considered even for trial work, and in fact there is no weedicide in use by the Commission which is both persistent in water and also toxic to humans or stock.

2. The Weeds Inspector must always be advised before any spraying is undertaken in horticultural areas. This is because of the extra hazard in spraying close to horticultural crops.
3. 2,4-D and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) hormone sprays are not used at all in horticultural areas. Although we have shown that it is possible to apply the salt and amine forms of 2,4-D close to vines and orchards, this requires an extremely high standard of application, higher than the Commission has been able to obtain reliably in practice. To avoid mistakes the complete banning of hormone sprays in horticultural areas is therefore practised. Moreover, in pasture areas, the volatile ester forms of 2,4-D are never used and it is customary to use the low-volatile butoxyethanol ester, but even this is not sprayed within 10 chains of susceptible crops.
4. To reduce the possibility of root uptake soil sterilants are not applied within 100 ft of trees or vines.
5. Pollution of irrigation or river water which may occur following a spray program is positively controlled to limits established by the research program (see papers by W. Graham elsewhere in these proceedings (8(a)-2,4).

   Present limits include:

   (a) amitrole 0.002 parts per million
   (b) 2,2-DPA 0.004 parts per million

6. Spray drift is reduced by avoiding spraying in windy weather and by attention to droplet size. In the past, high-volume spraying only has been undertaken and drift has been well controlled. But with the increasing use of misting machines this hazard will increase in importance.
7. Channel water treated with acrolein is not released into streams for 48 hours after application, by which time the chemical has evaporated. This safeguards fish, which are extremely sensitive to traces of acrolein.

F. CONCLUSION AND FUTURE RESEARCH NEEDS

The use of potent herbicides in large amounts is gradually leading to an awareness of the hazards associated with their application. This awareness is a vital part of any systematic attempt to overcome these hazards.

Because of the human factors involved it will never be possible to avoid all instances of damage in large-scale weed spray programs, but, by attention to the practical details involved in controlling and executing the work, it should be possible to reduce damage to acceptable limits even with the herbicides presently available.

For the future, it might be said that there is a need for improved chemicals and improved equipment, which will reduce hazards in specific jobs. For example, the task of those applying herbicides to control weeds in water (and probably also to replace cultivation in some crops) would be greatly simplified if less stable chemicals were available which could be relied upon to break down after application to harmless non-toxic materials.

To the commercial 'outsider' it would appear that, in the past, much of the screening of herbicides has been directed towards developing chemicals of stability and permanence which will store and handle well.

It should be realized, however, that stability is not always a desirable quality and in many of the more sophisticated fields of herbicide use there is now a need for a wide range of less stable herbicides. In short, many herbicide users are now prepared to pay a high premium for safety and for chemicals which more closely fit their particular needs.

Industry has made remarkable progress in the development of active herbicides and, with their research programs orientated towards a reduction in hazards and towards a study of the mechanisms of de-activation, it is reasonable to expect that very great improvement in safety margins would become possible in the future.