HAZARDS ASSOCIATED WITH THE USE OF HERBICIDES DRIFT AND VOLATILITY

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Any operation that involved discharge of herbicides into or through the atmosphere carried some risk of drift to susceptible plants outside the target area.

Two kinds of drift can be distinguished:

(i) drift of liquid droplets or solid particles immediately after discharge into the air,

(ii) drift of vapours from volatile chemicals after they have come to rest on the target plants.

FACTORS INVOLVED IN DRIFT DAMAGE

These may be considered under three headings:

1. those not controllable by the operator
2. those not directly controllable but which allow some freedom of choice to the operator
3. those directly controllable by the operator.

These three categories may be further subdivided as follows:

1. Not Controllable
   - relative position of target and susceptible crops
   - topography
   - nature of non-target crops
2. Choosable but not directly Controllable
   - atmospheric conditions
   - stage of growth of non-target crops
3. Directly Controllable
   - nature and formulation of the herbicide
   - solvent or carrier
   - height and direction of discharge
   - size of droplets or particles.

The relative importance of these factors depends to some extent on whether we are concerned with drift of vapours from volatile herbicides or with direct drift of droplets or particles immediately after discharge from the spraying apparatus.

DIRECT DRIFT

The most important influences on direct drift are the size and pattern of the droplets or dust particles produced by the distribution apparatus, the height of discharge, distance of the susceptible crop from the target area and atmospheric conditions at the time of application.

Obviously, the smaller the droplets or particles, the greater is the risk that they will become airborne and carried to areas remote from the target. Droplet size is a function of nozzle aperture and design, pump pressure or air velocity at the nozzle, impact angle and speed of the slipstream relative to the speed and direction of emergence of the droplet (in the case of aircraft) and the viscosity and flow characteristics of the spraying mixture.

Nearly all types of spraying equipment produce a mixture of droplets of different sizes, generally ranging from about 50 to 300 microns in diameter. Initial drift contains nearly all the small droplets discharged by the spraying apparatus and the greater the proportion of smaller droplets, the greater is the risk of drift. In addition, the greater the distance the droplets have to travel before impinging on the target, the greater is the probability of drift. With aircraft, risk of drift increases with flying height and with ground spraying equipment, risk increases with the distance between the nozzle and the target.

In experiments with a Tiger Moth aircraft, Courshee (1961) found that the only droplets that drifted were those smaller than 200 microns in diameter when the aircraft was flown about a yard above a grassy field. At greater heights, droplets as large as 300 microns could be carried sideways across the wing into the wing-tip vortices where they would be thrown upward and could contribute to the risk of drift.

In practice, it is difficult to achieve a spray pattern in which all droplets exceed 200 microns without at the same time including droplets so coarse that they become ineffective as herbicides. Lack of uniformity in the spray pattern is one of the major problems in herbicide application, particularly at low volumes. It is difficult to produce droplets small enough to give adequate coverage without at the same time including in the pattern droplets so small that they can drift away from the target area. The lower the volume used, the greater the likelihood of drift.

Droplet size is also influenced by the solvent or carrier used in the spraying mixture. Herbicides dissolved in oil usually break up into finer droplets than those mixed with water. Applied from aircraft, oil-based sprays sink more slowly and drift more readily than those formulated in water.

It is obvious that the greater the velocity of the wind, the further the droplets or particles will travel. Less obvious is the influence of temperature, lapse rate and relative humidity on drift. High surface temperatures and high lapse rates promote turbulence and convectional movement in the lower layers of the atmosphere, increasing the chances of drift and decreasing the predictability of movement. High temperatures and low relative humidities increase the rate of evaporation of water-based materials, reducing the size of the droplets and increasing the risk of drift.

There can be a serious risk of drift in spraying under absolutely calm conditions, particularly in the morning when surface temperatures are rising and the lapse rate in the lower layers of the atmosphere is steadily increasing. These conditions are particularly hazardous with volatile herbicides but they can also produce unpredictable drift of liquid droplets.

VOLATILITY

Volatility of herbicides can be a major factor contributing to damage by drift. Even if the spray is applied under conditions when no direct drift occurs during the actual spraying operation, conditions may later be favourable to evaporation of the spray residue from the target plants, causing toxic vapours to be released into the atmosphere. These vapours can then be carried with convective or advective currents to susceptible plants, often a very great distance from the original target area.
I am led to believe that there is evidence to show that 2,4-D damage to tomatoes and other susceptible crops has occurred in Western Australia and South Australia many miles away from areas where volatile ester formulations of this herbicide have been used for treating broad-leaf weeds in cereal crops.

Conditions favouring the drift of volatile herbicides are those that bring about evaporation of the active material from the surface of the target plants and at the same time permit them to be carried upward into the advective air circulation. High temperatures during the day, leading to steep lapse rates in the lower layers of the atmosphere, are common contributing factors to this kind of damage, particularly if accompanied by a strong inversion of temperature within a few hundred metres of the ground.

With this kind of drift it is virtually impossible to predict where the vapour will again make contact with the ground or the likely consequences of using these materials under conditions where they can evaporate after application to the target.

CROPS AND CHEMICALS INVOLVED

Damage from drift has been recorded in all states on a wide range of crops and with several different kinds of herbicides.

Most cases of damage have been due to drift of droplets or vapour of 2,4-D or 2,4,5-T, but other materials such as paraquat and picloram have also been involved. Cases of damage have been reported in cotton, vines, deciduous fruits, citrus fruits, pineapples, bananas, pawpaws, linseed, lucerne, cucurbits, and vegetables, particularly beans, peas, tomatoes, and lettuce. Both aerial operations and ground spraying have been involved.

In some of the cases that have been investigated, lack of reasonable precautions in applying the spray was obviously the cause of the damage. One notable feature is the very small amount of damage relative to the enormous amounts of herbicides applied every year in Australia.

CONTROL

All States have agreed upon a uniform type of Act to control aerial application of agricultural chemicals. The necessary legislation has been enacted or is in the process of being enacted in several states, but only one, (Victoria) has such an Act in operation. The Queensland Act includes commercial ground spraying of herbicides as well as aerial application of a range of agricultural chemicals. These Acts set minimum standards of competence for operators of spray equipment and require the owners of spray equipment to take out insurance policies sufficient to indemnify them against legitimate claims for damages to crops and livestock by parties not directly involved in the spraying operations.

It is hoped that standards of spraying will be improved by the education of operators necessary to enable them to qualify in examinations and that owners of equipment will exercise the greatest care in order to meet their obligations to their insurers.

One urgent need that is already obvious is for more precise and accurate techniques for determining the nature of alleged herbicide damage and the amounts of herbicide residues in affected crops.