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Environmental impact of pesticide drift

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Final Report

Environmental Impact of Pesticide Drift

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C O N T E N T S

SUMMARY

1. **Effects of herbicide drift on higher plants**
The effects of herbicide drift on native vegetation have been assessed in two ways. First, established perennial dicotyledon species were grown, with and without the grass *Lolium perenne*, in microcosms. One set of microcosms has been exposed to mecoprop drift downwind of a sprayer for four years and three sets of microcosms have been exposed to drift of one of three herbicides - glyphosate, MCPA and mecoprop for three years. Data on end-of-season yield, flowering performance, seed production and seed viability are presented. Few effects were noted at the greatest distance tested (8 m), but significant effects on end-of-season yield and performance were found in the downwind 0-8 m zone. For established perennial plants a buffer zone distance of 8 m, therefore, appeared adequate. Second, establishing seedlings of 15 species were exposed to glyphosate drift downwind of a sprayer. Damage was variable, but appeared to be confined to 20 m. Buffer zones may, therefore, need to be 20 m in communities where seedling establishment is important.

2. **Effects of aerial spraying of asulam**
An experiment to estimate buffer zones required to protect SSSIs was done at Bamford Edge in Derbyshire. Bioassay plants (*Rumex acetosa*) were placed up to 240 m downwind of a bracken strip sprayed with asulam by helicopter. This study was done at a rather high wind speed, but the no-effect distance was estimated to be 161 m. Buffer zones, therefore, should be at least 160 m. A second, small scale study was done to determine whether bioassay plants would be damaged when bracken was sprayed in and around a Derbyshire clough (a small valley in the moorland). Rare ferns are often found in such cloughs and would be adversely affected by asulam. All bioassay plants showed some damage, and hence it can be inferred that rare ferns are at risk.

3. **Spray drift capture by plants**
A technique is described for measuring spray deposition on leaves using a fluorescent dye, UV photography and image analysis. A prototype spray drift regime is used to apply Tinopal to leaves under standardised conditions for comparing leaf textures (hairy, smooth), orientations (vertical, oblique, horizontal), surfaces (upper, lower), and different downwind distances and heights. Significant differences were found for % cover at 2 m and 3 m, and for mean spot size for different orientations. Greater precision in spraying coupled with more replication and quicker image analysis would be needed to obtain significant differences between other variables. This photographic technique is compared with that of rinsing dye off whole plants to measure the distribution of deposition over stems and leaves.

4. **Insecticide drift from ground crop sprayers**
Six bioassays of insecticide drift from agricultural spraying operations are described using *Pieris brassicae* larvae. Cypermethrin was used on five occasions on peas and brussels-sprouts, with triazophos on peas in the sixth case. Initial laboratory and field experiments with cypermethrin indicate that the field 'hazard index' for cypermethrin is similar to that for diflubenzuron. The mortality profiles from the six bioassays showed that significant drift effects were regularly recorded up to 13-16 m distance in light winds. These results are comparable with those obtained for diflubenzuron under

experimental conditions at Monks Wood. The commercial operating conditions were fairly uniform, but variations in downwind terrain make it difficult to produce generalized models.

5. **Insecticide drift from orchard sprayers**
Drift from air-assisted sprayers in orchards is potentially much greater than from conventional hydraulic spraying of ground crops. The effects of cypermethrin and carbaryl (used for bud thinning) were studied in one orchard. Carbaryl has a lower contact and stomach toxicity than cypermethrin but is used at a much higher rate. Bioassays of cypermethrin drifting into an adjacent field under a wind speed of 2 m s^{-1} and carbaryl drifting within the orchard with a wind speed of 3-3.5 m s^{-1} gave broadly similar results. Worst case mortality figures showed that both sprays could have major effects 30-40 m downwind and detectable effects (≤10% mortality) at 50-60 m. Under still conditions, no mortality from chlorpyrifos drift was observed beyond about 15 m.

Spray drift across an orchard was measured with water-sensitive papers, and demonstrated the effectiveness of a shelterbelt in reducing drift. The effects of shelterbelts on wind speeds in three orchards were also demonstrated but these could not readily be predicted. The results are discussed in relation to an ADAS booklet on windbreaks.

6. **Effect of hedges on spray drift**
The effects of hedges on drift deposition were measured using fluorescein dye and efficient artificial collectors. One series of trials compared deposition at 0.45, 1.0 and 2.0 m heights in front of and behind a continuous laid hedge 1.6 m high. This showed a marked shelter effect for the two lower heights immediately behind the hedge, followed by an increase again up to about 20 m. Deposition at 2.0 m height declined more slowly behind the hedge until it reached similar values to those of the lower receptors at 20 m. A second series confirmed these shelter effects by comparing deposition in the presence or absence of a hedge.

These results were supported by bioassays with a herbicide and an insecticide, and are discussed with respect to wind speed, hedge height and porosity, and toxicity of the spray.

7. **Pesticide drift from aerial spraying**
The operator returns for aerial applications in Britain are reviewed since 1987. These show a marked decline in the number of contractors (from 24 - 8), number of compounds used (from 19 - 9) and in total number of applications (from 1914 - 211). The most widely used compounds in 1991 were alphacypermethrin and pirimicarb, with deltamethrin in Scotland.

The occurrence of stable meteorological conditions favouring drift was examined for 10 year data from Wyton, Cambridgeshire. Between April and September Pasquill categories E - G only occurred after 2000 or 2100 (British Summer Time).

A field bioassay of aerial spraying with deltamethrin is described. This took place after 2000 in early August in the Cambridgeshire Fens under stable or near stable conditions. *Pieris brassicae* larvae and

air-breathing aquatic insects *Notonecta glauca* and *Sigara dorsalis* were exposed at distances up to 250 m. Wholly submerged invertebrates *Asellus aquaticus*, *Gammarus pulex* and *Centroptilum pennulatum* were exposed to water from contaminated targets brought back to the laboratory. Mortality for *P. brassicae* declined from 100% at 4 m to about 20% at 200-250 m, so no 'safe distance' could be estimated. 'No effect' distances for aquatic fauna ranged from less than 60 m for *N. glauca* to about 230 m for the two crustaceans, *A. aquaticus* and *G. pulex*. Mortality in the more distant targets, placed at crop height in wheat, were greater than the predicted levels. In natural populations, mortality would almost certainly be less than predictions derived from these experiments.

8. **Insecticides in freshwater**

Nymphs of air-breathing Hemiptera, *Notonecta* sp and *Corixa* sp were exposed to ground based cypermethrin spray drift at distances up to 15 m. Mortality was relatively high in *Corixa* for up to 10 m with *Notonecta* proving to be much more resistant. The 96 hour LD_{50} for *Corixa* was estimated to be about 8 m with an absolute safe distance of 28 m. In natural populations mortality would almost certainly be less than predictions derived from this type of experiment.

Concentrations of pesticide residues were estimated in a range of water and sediment samples. Residues in water, as expected, were generally low but those in sediments, especially of DDT, lindane and dieldrin give some cause for concern. However, exposure of nymphs of the mayfly *Ephemera danica* to contaminated sediments for up to four months produced to mortality.

Residues of pesticides were also analysed in five species of fish and five invertebrates. Dieldrin was detected in every case and DDE and lindane were present in all of the fish samples. Concentrations of these pesticides were closely correlated with the proportion of lipid in the bodies of the fish. Other pesticides occurred more sporadically. Of the pyrethroids, only permethrin and fenvalerate were detected in animal tissues. Cypermethrin and deltamethrin, although commonly present in sediments were not present in the animal tissues. The half life for dieldrin in sediment collected from a field drain was estimated under controlled laboratory conditions as about 73 days.

9. **Vapour drift of pesticides**

A review was carried out of published values of the saturated vapour pressures of pesticides currently used in the UK. Also, a study was made of pesticide evaporation by taking simultaneous measurements of evaporation and uptake of formulated [2-^{14}C] 2,4-D butyl, applied as 10 µl droplets, from the leaves of 3-week-old barley plants, using an air-flow system. Uptake was generally about 2.5 times more rapid. Temperature affected evaporation strongly whereas uptake was largely unaffected. Evaporation from glass slides and leaf surfaces were very similar if surface temperature was taken into account. Evaporation from leaves increased in darkness and in conditions of high boundary layer conductance caused by rapid air circulation. Most of the herbicide in the plant (95%) remained in the leaf to which it was applied, but it affected physiological processes within the plant because transpiration and CO_2 exchange were reduced by about 8 and 18%, respectively, of the initial rates. Comparison with published values of herbicide uptake suggested that 2,4-D butyl is relatively rapidly

taken up by barley leaves, and that at 27°C, about 30% of the 2,4-D butyl sprayed onto barley leaves would evaporate.

It was concluded that many pesticides in use in the UK are slightly volatile, and that in spite of the drawbacks, the saturated vapour pressure remains the only simple means to predict the potential of a pesticide to evaporate. The fact that vapour damage is not more frequently reported is probably because it is difficult to attribute such damage to pesticides with certainty and because no large-scale search has been made.

BACKGROUND AND ORGANISATION

ITE carried out a three year study, from April 1987 to March 1990, for the Nature Conservancy Council and Department of Environment on 'Pesticide Drift and Impact' (Contract HF3/03/22 and PECD 7/2/50). The final report contained seven sections covering the effects of herbicide drift on higher plants, lichens and ferns, and the effects of insecticide drift on terrestrial and freshwater invertebrates. Work on the dose response of plants and drift modelling was done by AFRC, Long Ashton Research Station, under a subcontract. Freshwater aspects were done by IFE.

Following this report, ITE was commissioned by DOE and NCC to undertake a further two year study to continue some lines of work already started, and to examine certain new aspects of pesticide drift and pollution. These are listed below under nine headings and form the basis of the present report. Section 9 on vapour drift of pesticides has again been subcontracted to AFRC. The approach to this work was mutually agreed in September 1990, and the subcontract started in October 1990. Section 8 on freshwater aspects has likewise been delegated to IFE and is divided between the Eastern Rivers Group at Monks Wood and the River Laboratory at Wareham.

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