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Drift of 10 herbicides after tractor spray application. 2. Primary drift (droplet drift)

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Abstract

In the present study the primary drift of 10 herbicides was investigated in five field experiments, and the amount deposited per surface area was quantified outside the application area using simple passive dosimeters. In addition, samples for measuring a possible background value were taken upwind of the sprayed field. Deposits of spray drift were common to all spray equipment and spray was detected up to 150 m off-target. There were deposits of 0.1–9% of the applied amount close to the sprayed field (up to 2 m). But 3 m from the spraying zone deposits were reduced to 0.02–4%. The amounts decreased exponentially when moving away from the field. The differences in drift could be described mainly by the different drop sizes, the wind velocity, the formulation and the filtering effect of vegetation on the sampling area. The tendency of the active ingredients to evaporate could also have an, although less important, influence on the drift. This is a factor, which ought to be exposed to a further study. The findings supported that it is the physical properties of the spray and the conditions of application (i.e. equipment and meteorology) that are the primary determinants of primary drift rather than the chemical property of the pure active ingredients.

Keywords: Spray drift; Passive dosimeters; Herbicide; Bromoxynil octanoate; Desmedipham; Ethofumesate; Fluroxypyr-1-methylheptylester; Ioxynil octanoate; Metamitron; Pendimethalin; Phenmedipham; Prosulfocarb

1. Introduction

When pesticides are applied to crops some of the spray may move beyond the intended area. Primary, spray or direct drift is defined as the amount of crop protection active ingredient that comes directly from the nozzles and is deflected out of the treated area by the action of air flow during the application process (Combellack, 1982; Hilbert, 1992). In this article drift is defined as spray, which unintentionally reaches areas outside the target area, either as droplets, dry particles or vapor, during or after application on the target area.

The drift may be influenced by various factors: (1) Meteorological factors: Wind speed, atmospheric stability, turbulence, temperature and humidity; (2) Application factors: Sprayer type, nozzle type, nozzle size, nozzle pressure, release height, angle at which the pesticides are spread and driving speed; (3) Formulation: Additives, density and viscosity. Generally, the drift can be reduced significantly by spraying at low wind speed, at low temperature, with low turbulence, at times of low radiation from the sun and at high relative humidity. Small droplets should be avoided and can be prevented by additives to the spray mix, which enlarge droplet size or reduce evaporation. Drift is also reduced if accompanying air is used, if drift-reducing spray equipment is used or if spraying-boom height above the field and the nozzle pressure are minimised.

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The formulation (the composition of the spray fluid) is very important in relation to the application and use of pesticides as it influences the behaviour of the drops as well as their persistence at the site of action (Combellack, 1982). The amount of pesticide not reaching the target area depends strongly on the formulation (Grover et al., 1972; Berg et al., 1999).

The size of the particles has a large impact on the off-target drift and has been found to be more important than the wind speed (Frost and Ware, 1970; Combellack, 1982; Bird et al., 1996). Likewise, losses can be reduced by the selection of application systems that produce large droplet sizes by nozzle design, reduced liquid pressure, directed nozzle discharge in addition to use of preferred products with thickening additives (Frank and Ripley, 1994). The different nozzle types include for instance the conventional flat fan nozzles and low-drift nozzles. The low-drift nozzles are flat fan nozzles with an orifice plate that restricts the flow, so reducing the effective operating pressure and thereby giving coarser drops than the ordinary flat fan nozzle (Cooper and Taylor, 1999; Jensen, 1999a; Kudsk and Mathiasen, 1999; Miller, 1999).

Buffer zones, which are unsprayed strips between the field and the neighbouring areas, have been investigated for use as protection by filtering out the pesticides. No general agreement exists among researchers on whether or not the buffer zone will offer enough protection to the surroundings, and different experiments have showed different results. Distances between 3 m and 24 m have been mentioned as appropriate for protection. A zone of 5–10 m reduces drift considerably (Harris et al., 1992; Hilbert, 1992; Koeman, 1995; Longley and Sotherton, 1997; Snoo and Wit, 1998).

Rautmann et al. (2001) used results from drift trials conducted from 1996 to 1999. Results achieved in 50 agricultural trials and 72 fruit growing trials were available for evaluation. They found that a power function was suitable as equation and that the drift in field crops could be expressed as $y = 2.7705x^{-0.9787}$; $r^2 = 0.9873$, where $y =$ ground sediment in % of the application rate and x is the distance in metres from the treated area.

In most cases the measurements of drift have been done with a fluorescent tracer added to the spray (Nordby and Skuterud, 1975; Permin, 1980; Longley and Sotherton, 1997; Longley et al., 1997) or to tap water with a non-ionic surfactant (Cooper and Taylor, 1999). There are also examples of spraying with water only (Snoo and Wit, 1998) or spraying liquid containing Lissapol Bio (Nordbo et al., 1993). In measurements of drift determined at 26 sites across Ontario measurements were done on the active ingredients themselves (Frank and Ripley, 1994). With the use of fluorescent tracer the composition of the tank mix is probably not altered significantly, but to what degree the tracer follows the water or the pesticides is an important question. When spraying is with water only, the chemical and physical properties will not be the same as the tank mix. Based on the information given in this section it was chosen to measure the drift of active ingredients in formulated products.

There are no standards or general agreement about which dosimeters to use. Taking this into account, we decided to use horizontal plates as collection surfaces, as we would like to investigate the fallout of drops but neither the lateral impact of drops nor the drift of vapor. These dosimeters are in the literature described not to be as efficient as cylindrical dosimeters (Hilbert, 1992; Kirchner et al., 1996) but the exact exposure area will be known, in contrast to vertical cylinders (Longley and Sotherton, 1997; Longley et al., 1997). The passive-dosimeters method was found to be a good and reliable method for collection of sprayed pesticides (Carlsen et al., 2005).

In the present study the applicability of simple passive dosimeters for determination of pesticide drift was demonstrated and in contrast to most other drift studies, real formulations of pesticides were used in real spraying situations taken into account the impact of adjuvants, variation in climatic conditions, vegetation height and nozzle type. The drift of 10 herbicides as formulated products was investigated during five field experiments and the amount of pesticide deposited per surface area was quantified inside and outside the application area.

2. Materials and methods

2.1. Site and application

Samples were collected during five different field experiments at Danish Institute of Agricultural Sciences, Flakkebjerg, Zealand, Denmark. Two field experiments were conducted in the autumn of 2000 and three in the spring of 2001. The spraying was done under normal conditions (see Table 1).

A number of passive dosimeters were placed (1) downwind, outside the field, in order to collect pesticides deposited beyond the field via drift, (2) inside the field to evaluate the direct exposure on the field and the evaporation and possible degradation of the pesticides (see Carlsen et al. (2005)) and (3) upwind outside the field to establish a reference value. It was attempted to fit dosimeter distances to the field so that they were logarithmic as it was anticipated that the concentration of drifted pesticide would decline exponentially away from the field. A sample from the sprayer tank was collected as well. Immediately (10–30 min) after spraying, the samples were collected, registered and stored on freeze. The preparation of the samples included extraction with methanol, manual shaking and a stay in the ultrasonic bath. Samples were analysed in LC–MS/LC-DAD by methods developed for the purpose. (For more details about preparation for the sampling, collection and storage as well as sample preparation, chemicals and LC–MS/LC-DAD methods see Carlsen et al. (2005).) By analysis of the drift the concentrations were too low to be measured directly. It was therefore decided