Quantification of Spray Drift from Aerial Applications of Pesticide

D.M. Caldwell[1], and T.M. Wolf[2]

[1]Department of Plant Science, University of Saskatchewan, #51 Campus Dr., Saskatoon, SK, S7N 5A8
[2]Agriculture and Agri-Food Canada, 107 Science Place, Saskatoon, SK, S7N 0X2

Key Words: Spray Drift, Aerial Application

Abstract

As pesticides become more biologically active and their use becomes more widespread the impacts of spray drift become a topic of considerable interest. The drifting of sprays is a complex process; factors influencing it include meteorological conditions, application parameters, and the nature of the target. Advances in aerial application technology and in our ability to measure drift, coupled with the adoption of new technologies for regulating pesticide application spurs a desire for a greater understanding of the pesticide application process. Experiments were conducted to quantify and profile drift from aerial applications of pesticide. The effects of atomizer type, spray quality and ground cover were examined. The materials and methods essential to conduct such a project were reviewed in detail.

Introduction

Pesticide spray drift is defined as plant protection product carried out of the target area through the air during the application process, or shortly thereafter (ISO Draft Proposal, 2003). The applied chemicals move down wind of the treated area where they can have a detrimental effect on sensitive plants, wildlife and humans.

The drifting of sprays is a complex process. Factors influencing drift include meteorological conditions, application parameters, and the nature of the target or other interceptors (Teske, 2002).

The protection of the environment is a fundamental value of all Canadians. It is important to keep our air and water free from pollutants. A renewed interest in protecting the environment from pollutants coupled with advances in aerial application technology and in our ability to measure drift spurs a desire for a greater understanding of the pesticide application process. The most recent efforts to quantify drift from agricultural aerial applications of pesticide in Canada were 25 years ago (Maybank, *et al*. 1978). Modern applications are made from aircraft with different aerodynamic characteristics and with different atomization technology. The chemicals applied today are more target specific, and less toxic to non-target organisms than the ones applied a quarter century ago. In addition we have adopted new technologies for regulating pesticide application which have yet to be validated. The above noted reasons necessitate further study in the area of spray drift.

The primary objective for this project was to generate empirical data to quantify spray drift deposits from fixed wing aerial applications of pesticide. Attempts were also made to profile the spray cloud as it moved down wind of the application area. The data generated from this experiment may also prove useful in illustrating the effects of specific application parameters on the amount of spray deposited downwind. The results of this experiment will be evaluated against the output of the mechanistic models currently used for decision making in the regulatory process.

Materials and Methods

The treatments in this experiment were designed to examine the effects of several application parameters. The specific issues of interest in this project include the effects of spray quality, atomization, and ground cover. Application scenarios include Fine vs. Medium spray qualities, deflection vs. rotary atomizers, and application to bare ground vs. to a mature crop canopy.
The two spray quality treatments were generated using the same CP 09 nozzle with a deflection setting of 0^{o} for the Medium spray quality and a deflection setting of 30^{o} for the Fine spray quality. The two different atomization treatments included the CP 09 flooding-deflection type nozzle, and the ACS rotary-cage type nozzle. The two ground covers in the experiment were a barley crop in the late stages of anthesis (standing approximately 0.9 m tall) and the bare ground treatment was a field of peas that had been harvested, leaving very little residue on the surface. Each treatment in the experiment was replicated three times. This project was designed as a fractional factorial experiment, whereby the effect of one particular treatment can only be examined with respect to that application parameter. It was not logistically feasible to design a factorial experiment with enough treatments where one application parameter could be evaluated as influenced by another. All treatments were made with an Air Tractor AT502, applying a tank mix of Rotamine-WT tracer dye, Ag-surf surfactant and an optical brightener.

Table 1. Application scenarios evaluated.

Trt	Atomizer	Spray Quality	Target
1	CP 09 0^{o}	Medium	Mature Cereal
2	CP 09 30^{o}	Fine	Mature Cereal
3	ACS Rotary	Fine	Mature Cereal
4	CP 09 30^{o}	Fine	Bare Ground

The northern third of a field measuring approximately 600m by 1600m was used as the experimental site. The flight path was marked off perpendicular to the wind direction on the windward side on the field. Three parallel sampling lines were marked perpendicular to the flight path. Sampling stations for drift measurement were placed at 12.5m, 25m, 50m, 100m, 200m and

400m on each of the sampling lines. The off-swath samples were placed at these stations. Stations were also placed directly on the flight path and upwind of the application area, the on-swath samples and check samples were placed at these respective stations.

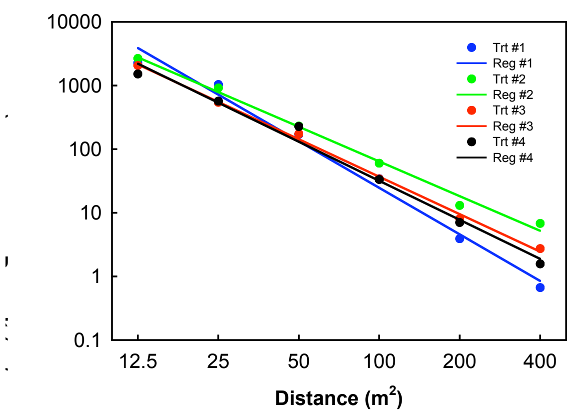
Samplers utilized in this experiment simulated both vertical and horizontally oriented targets. The horizontal samplers were 15-cm diameter petri dishes placed at each sampling stations. The vertical samplers were plastic drinking straws 0.6cm in diameter and 12cm long. These were also placed at each sampling station. Plastic strings sampled the spray cloud with height. The strings were suspended by helium blimps elevated to a height of 30m. The strings were 2mm in diameter and processed in 1m sections. Blimps were placed at the 25m, 100m and 400m stations. Rotorod towers actively sampled the spray cloud at a rate of 120L per minute. The towers sampled the air at 1m, 2m, 3m, and 4m. A pair of rotorod towers was placed at the 25m, 100m and 400m stations.

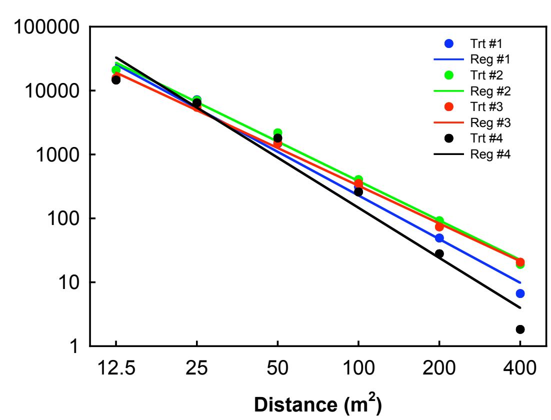
In order to account for the photolytic break down of the tracer dye in ultra violet light, several samples were sprayed with dye prior to the experiment and stored in the dark. These were placed upwind of the treatment area in direct sunlight during the course on the spray application. Once the pesticide application had been made the samplers were collected in a sanitary manner and placed into dark storage. In order to prevent contamination of the samples, care was taken to ensure off-swath samples were not handled near or stored with the on-swath samples. Samples were processed by washing in ethanol. The wash was collected and its dye concentration was determined on a fluorescence spectrophotometer. The fluorescence spectrophotometer measured the fluorescence intensity of the wash solution and the concentration of dye in the solution was determined by comparison to standard solutions. Dye concentrations from the fluorescence spectrophotometer were expressed as parts per billion.

The wash concentrations from the fluorescence spectrophotometer were then converted to µg of the dye deposited per unit area. These conversions were made based on the concentration of the dye in the spray tank solution, surface area of the sampling device, volume of ethanol used to wash the sampling device, photolytic multipliers, and the conversion of ppb to µg or % of the actual amount applied.

Preliminary Results

Statistical analysis has not yet been conducted on the data at the time of publication but graphs of the data reveal some preliminary results of the experiment (Figure 1). The data for deposition on





the targets at ground level was linear once plotted on a log-log scale. While definitive statements regarding treatment differences cannot be made yet, the results do seem to illustrate some of the expected trends for spray drift. For example, the deposition down wind on the first treatment (the Medium spray quality) seems to be less than the deposition for the second treatment (the Fine spray quality). Another expected trend illustrated in the data is the greater deposition of drifting spray on the vertically oriented compared to horizontally oriented targets. The graph for deposition on the drinking straw samplers show greater deposition per unit surface area than on the petri dishes by about one order of magnitude. This demonstrates the superior ability of this sampler to collect airborne drift deposits.

The data collected from the string and rotorod samplers will be more challenging to analyze and interpret than the deposition data. Specific attributes of the data set will have to be identified in order to allow for statistical analysis. The graphical images of these data sets help demonstrate the typical processes which occur as the spray cloud moves downwind. At short distances downwind of the application the spray cloud tended to be heavily concentrated near the ground level (Figure 2). As the cloud moved further down wind some of its particles were deposited onto the ground, and some of the cloud was dispersed to higher elevations. The result was a spray cloud that was increasing in size and decreasing concentration as it moved down wind. Future work on this project will involve detailed analysis of the meteorological conditions measured during the applications. A comprehensive statistical analysis of drift deposits on each type of sampler will also be conducted. Finally an empirical model will be developed which can compared to the output of computer models currently used in the regulatory process.

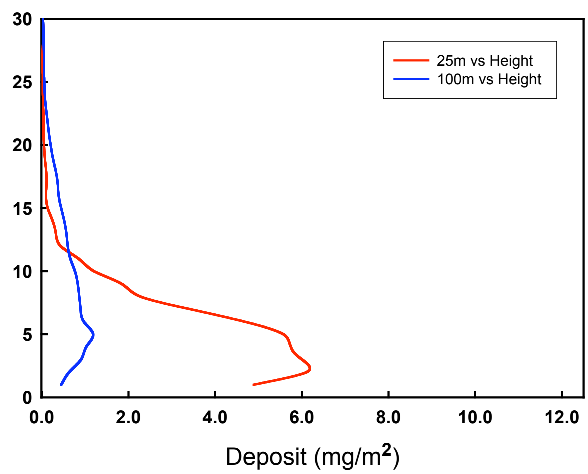


Figure 2. String deposit with elevation for the CP 09 30° treatment

Conclusions

This project has generated a valuable data set that has great potential to increase our understanding of pesticide drift. Its analysis can shed new light on an area of study that has not been looked at in some time. The results of this project can help not only to mitigate the damages caused by spray drift but also provide a level of confidence with the mechanistic models currently used in the regulatory system.

Acknowledgements:

We would like to extend our thanks to Brian Caldwell, Skye Ketilson, Lorelei Gress and Dave Cote for their technical support. We thank Ted Kuchnicki, Derek Francois, JD Whall for their assistance in conducting the trials. We would also like to thank Blair Mutcher and the staff from

Lonesome View for their assistance with the applications. Thanks also to Guy Lafond for accommodating us at the Indian Head research farm and to the Qu'Appelle Valley Plowshares Initiative for donating land for the trial.

Literature Cited

ISO Draft Proposal. 2003. Equipment for crop protection - Methods for the field measurement of spray drift.

Maybank, J., Yoshida, K., and Grover, R. 1978. Spray drift from aerial pesticide applications. APCA Journal 28(10):1009-1014

Teske, M.E., Bird, S.L., Esterly, D.M., Curbishley, T.B., Ray, S.L., and Perry, S.G. 2002. AgDRIFT: a model for estimating near-field spray drift from aerial applications. Environmental Toxicology and Chemistry. 21(3):659-671.