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E-mail: research.competitions@defra.gsi.gov.uk

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SID 5 Research Project Final Report

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Project identification

1. Defra Project code: PS2022
2. Project title: Additional field spray drift studies with modern application practices to inform policy on setting of buffer zones in the UK.
3. Contractor organisation(s): Food and Environment Research Agency, Sand Hutton, York, YO411LZ
4. Total Defra project costs (agreed fixed price): £ 27898
5. Project: start date .... 06 April 2009
   end date .... 31 March 2010

6. It is Defra's intention to publish this form.
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Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

During 2007 a review of spray drift data was undertaken by CRD, using examples of data from previous Fera (then CSL) field spray drift studies. This included reviewing data from wind tunnel experiments using nozzles and operating conditions for which no field data existed.

One of the outcomes of this review indicated that further data reflecting modern application practices were required to inform on-going discussions in the setting of harmonised unsprayed buffer zones (UBZ) for arable sprayers. Therefore following on from the initial project PS2015 further work was undertaken with projects PS2017 and PS2022 which have generated data for airborne and ground deposited spray drift arising from what are considered to be more representative of the range of spraying practices in tall and short crop situations. These data are intended to supplement the historical data generated with spraying practices involving forward speeds of 8 km/h and boom heights of 50cm above a short crop. As the modern practices for arable spraying involve spraying at tractor forward speeds of >10km/h and boom heights of in excess of 0.5 above the target (ground or crop), field studies were designed to generate data with the following conditions with a 24m width horizontal boom sprayer

Tractor forward speed of 12 and 16 km/h;

Boom heights of 0.5, and 0.7m above a mature crop ;

Boom heights of 0.7, and 1.1m above a short crop

Three nozzle types were used:

- Standard flat fan nozzle used for LERAP (e.g. FF 11003);
- Extended range flat fan nozzle (XR11003)
- Air Induction (A.I.) nozzle with LERAP 3-star low drift status (size 025).

These treatments used in both tall and short crop situations.

There were two further operating conditions:

- 11002 nozzle sprayed the swath 12-24m from the edge of the field to quantify the drift with a nozzle of fine spray quality when used to spray a field which had been treated using a LERAP 3-Star low drift nozzle on the 12m headland only.

- The use of a low boom (0.5m height) for the 03F110 nozzle and the use of an end nozzle (half of the spray pattern) in the tall crop were also investigated.

The protocol for the field studies followed that used in previous field studies by Fera, using multiple passes spraying a visible tracer and adjuvant tank mixture. Downwind spray drift collection for ground deposited spray drift was carried out at 2.0, 3.0, 4.0, 5.0, 6.0, 8.0, 12.0 and 20 metres downwind of the treated area. Airborne spray drift was collected up to a height of 2m at 2.0, 4.0, 8.0, 12.0 and 20 metres downwind of the treated area

During the period 2007-2010 approximately 100 datasets were generated for spray drift at distances of up to 20m downwind of the treated area. The data included both sedimenting drift deposited on the ground, suitable for aquatic environmental risk assessment (ERA) e.g. watercourses, and airborne drift suitable for terrestrial ERAs e.g. wildlife strips and hedgerows, or for bystander exposure. The results from the field spray drift studies indicated increased amounts of ground deposited and airborne drift at distances up to 20m downwind of the treated area. This was true for both tall and short crops with the range of modern operating conditions evaluated compared to the more traditional 8 km/h forward speed and 0.5m boom height.

Indications are that the boom height may be more important than forward speed across the nozzle types used in these studies. This work confirms the early findings from PS2015 reported by Byron and Hamey (2008) and Glass *et al.* (2010)

There were also other datasets published by Zande et al. (2002) indicating that for horizontal boom sprayers operating in potato or cereal crops with a boom height of 0.5m above the crop, the measured drift was greater than published data such as Rautman *et al.* (2001) and Defra funded studies carried out by Fera (CSL), e.g.project PA1728.

Project Report to Defra

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:
   - the scientific objectives as set out in the contract;
   - the extent to which the objectives set out in the contract have been met;
   - details of methods used and the results obtained, including statistical analysis (if appropriate);
   - a discussion of the results and their reliability;
   - the main implications of the findings;
   - possible future work; and
   - any action resulting from the research (e.g. IP, Knowledge Transfer).

Scientific objectives

Generate data for 3 extra nozzle configurations at 2 boom heights and forward speeds for ground deposited and airborne drift at distances up to 20m downwind of the treated area consisting of either a mature cereal crop or a short crop representative of cereals before GS 31.

Provide an evaluation of the data for use by CRD investigating the setting of unsprayed buffer zones for the UK.

Milestones

Milestones 1 and 2 have been completed, with milestone 3 consisting of this SID5. Milestone 4 is under preparation, with a number of papers being prepared for peer reviewed publication

1. Provide CRD with interim report from studies completed during Spring 2009
2. Complete field work for spray drift studies
3. Final report for airborne and drift fallout data with recommendations
4. Submission of scientific paper to refereed journal

Standard trial set-up

Field studies were performed with either a tall crop, such as mature winter wheat (0.7m height) or a short crop such as short grass (<0.15m height). A modified in-house Fera method was used to measure spray drift beyond the application area as used with the Defra funded project PA1728. The most appropriate headland or crop section was selected based on the prevailing wind direction to obtain a track as near as possible to 90 degrees to the wind direction. A spray track up to 80m long was used which was free from obstructions such as trees, hedges, buildings etc. For each replicate data set (Run), the number of sprayer passes required in each instance was determined by observing the deposition of tracer on collection media at 20m downwind. The minimum number of passes was used to obtain a visible deposit (with the aid of a small hand lens) at the 20m sampling point.

The zero point was 0.25m beyond the last nozzle, which also coincided with the edge of the cropped area. The zero point was positioned in the field by measuring the appropriate distance from the centre of the tramlines, and checking that this coincided with 0.25m from the end nozzle by stopping the sprayer as it passed along the spray track (while not spraying) during the set up procedure.

Measurements of ground deposited drift were made at 2m, 4m, 6m, 8m, 12m, 15m and 20m metres downwind of the treated area.

Airborne drift was collected at five downwind distances 2m, 4m, 8m, 12m and 20m.

Meteorological measurements

Wind speed and direction were measured at heights of 2m and 0.5m above ground level. Air temperature and relative humidity were also recorded at a height of 1m above ground level. In all cases the meteorological equipment was deployed close to the application track. The wind direction and speed were measured and recorded at 1 and 10 second intervals respectively during the whole spraying period.

The meteorological data logger hardware was set up allowing a time stamp to be recorded for the beginning and end of each pass of the sprayer. Using this time stamp the wind speed/direction data (for the actual period of application) have been isolated from the whole data set of meteorological readings for the day. This method improved the quality of data obtained by identifying extraneous data, which has no relevance to the experimental results.

Application

The application was made with a range of self propelled or tractor mounted sprayers with boom widths of 20-24m, fitted with nozzles at 0.5m spacing. The boom sections used were either the full boom or 12m of the boom depending on the treatment, and the nozzle height above the crop was set at 0.5 – 1.1 m. A range of hydraulic flat fan nozzle types were used for the study. Nozzle pressure was set based on manufacturer’s flow rate charts for the 3 bar setting.

Settings used for PS2015

Tractor forward speed of 12 and 16 km/h;
Boom heights of 0.7 and 1.1 above short crop
Boom width 24m, full boom width sprayed
3 Nozzle types – 03FF110
XR11003
ABJ025

Settings used for PS2017

Tractor forward speed of 12 and 16 km/h;
Boom heights of 0.5 and 0.7 above tall crop
Boom width 24m
3 Nozzle types - 03FF110 (outer 12m swath sprayed)
XR11003 (outer 12m swath sprayed)
02FF110 (inner 12m swath sprayed)

Settings used for PS2022

Tractor forward speed of 12 and 16 km/h;
Boom heights of 0.5 and 0.7 above tall crop
Boom width 24m
2 Nozzle types - 03FF110 plus end nozzle (outer 12m swath sprayed)
ABJ025 (outer 12m swath sprayed)

Tractor forward speed of 12 and 16 km/h;
Boom heights of 0.5m above short crop
Boom width 24m
1 Nozzle type - 03FF110

Application treatments

Nozzle	Output at 3 bar (L/min)	Crop type	Fwd speed (km/h)		Boom height above crop (m)		
			12	16	0.5	0.7	1.1
XR11003	1.18	Short	√	√		√	√
		Tall	√	√	√	√	
03FF110	1.20	Short	√	√	√	√	√
		Tall	√	√	√	√	
ABJ025	1.00	Short	√	√		√	√
		Tall	√	√	√	√	
11002	0.80	Tall	√	√	√	√	
03FF110 + end nozzle	1.20	Tall	√	√	√	√	

Sampling

Two types of sampling media were used during the trials:-

1) Ground deposited spray drift: wooden laths. Thin (~8mm) strips of softwood 1m long by 50mm wide with an upper surface covered in Whatman no.1 chromatography paper.

Area of Lath (1000mm x 50mm) = 50,000 mm^2

2) Airborne spray drift: 2mm external diameter Portex fine bore polythene tubing in horizontal 0.5m lengths set at heights 0.20 to 2.00m above the ground.

Underboom ground deposit media.

The actual application rate achieved by the sprayer was measured by placing media under the boom at crop height within the application area.

Tracers

Aqueous solutions of the food colour Brilliant Blue (approximately 0.4% w/v) with an appropriate surfactant (Agral at 0.1% v/v or Tween 20 at 0.2 % v/v) were used as pesticides simulants.

Samples of the tracer solution were taken at regular intervals for each tank mix prepared to act as a reference for the quantification of media deposits.

Sprayer calibration

Nozzle calibration was carried out in the field immediately prior to the runs with the tracer solution. Outputs were checked from a minimum of 3 nozzles (one from each section of the boom). This procedure was done with a gravimetric technique as the foaming of the liquid in the collection jug prevented a rapid reading in a measuring cylinder. The nozzle output rates were set so that they matched those for the manufacturer's data for output at 3 bar pressure. Tractor forward speeds were also recorded for each sprayer pass.

Sample extraction and Analysis

Field samples were placed into plastic bags or glass bottles, sealed and labelled in the field. These samples were extracted in the laboratory using a solvent mixture of acetone and demineralised water (10% acetone:90% water). Each sample was placed in a water tight container or sealed polythene bag, with sufficient acetone:water solvent added to allow good mixing with the sample and enable an extract to be taken for analysis.

Each extract was filtered using a 0.45 µm micropore filter and peak heights (λmax=630nm) determined using a scanning spectrophotometer. The amount of dye deposited was determined using standard calibration curves.

Recovery of the tracer was determined under the typical storage conditions for transport from field to laboratory and subsequent storage in the laboratory. Method validation data indicated that there were no problems encountered with recovery or stability of the tracer.

Table 1.Spray drift fallout (ground) with nozzle 03F110 at 3 bar (1.2 L/min nozzle flow rate) with end nozzle for tall crop applications

Forward speed km/h	Boom height m		Wind Speed m/s	Ground deposit of spray drift at downwind distances (ml spray per square metre) 2m	4m	6m	8m	12m	15m	20m
12	0.5		3.04	0.95	0.35	0.11	0.080	0.024	0.004	0.006
			2.18	1.03	0.31	0.07	0.030	0.004	0.007	0.008
			2.82	0.54	0.28	0.14	0.082	0.016	0.006	0.005
		Mean	2.68	0.84	0.31	0.11	0.06	0.01	0.01	0.01
		SD		0.26	0.04	0.03	0.03	0.01	0.00	0.00
12	0.7		2.77	0.76	0.24	0.09	0.049	0.018	0.013	0.005
			2.60	1.26	0.35	0.17	0.081	0.025	0.010	0.008
			4.78	0.27	0.72	0.45	0.30	0.16	0.16	0.08
		Mean	3.38	0.76	0.43	0.24	0.14	0.07	0.06	0.03
		SD		0.50	0.25	0.19	0.13	0.08	0.08	0.04
16	0.5		1.91	0.40	0.18	0.07	0.02	0.016	0.013	0.012
			2.27	0.58	0.19	0.05	0.03	0.016	0.015	0.012
			3.27	0.34	0.45	0.19	0.11	0.040	0.035	0.012
		Mean	2.48	0.44	0.28	0.10	0.06	0.02	0.02	0.01
		SD		0.13	0.15	0.07	0.05	0.01	0.01	0.00
16	0.7		2.29	0.95	0.10	0.068	0.025	0.023	0.017	0.017
			3.42	0.84	0.26	0.13	0.10	0.068	0.037	0.014
			3.83	0.31	0.57	0.79	0.20	0.12	0.078	0.042
		Mean	3.18	0.70	0.31	0.33	0.11	0.07	0.04	0.02
		SD		0.34	0.24	0.40	0.09	0.05	0.03	0.02

Application volume rates
At 12 km/h = 120 L/ha
At 16 km/h = 90 L/ha
Wind speed measured at 2m above ground level

Table 2. Airborne spray deposits with nozzle 03F110 at 3 bar (1.2 L/min nozzle flow rate) with end nozzle for tall crop applications

Forward speed km/h	Boom height m		Wind Speed m/s	Total airborne spray drift in sampling frame (0.5m x 2m) at downwind distances (mL spray per square metre) 2m	4m	8m	12m	20m
12	0.5		2.8	0.72	0.41	0.21	0.11	0.05
			2.7	2.32	1.11	0.61	0.40	0.22
			2.6	3.49	2.12	1.43	1.07	0.77
		Mean	2.7	2.179	1.212	0.751	0.528	0.347
		SD		1.391	0.862	0.620	0.493	0.373
12	0.7		2.8	0.72	0.41	0.21	0.11	0.05
			1.9	2.32	1.11	0.61	0.40	0.22
			3.6	3.49	2.12	1.43	1.07	0.77
		Mean	2.8	2.179	1.212	0.751	0.528	0.347
		SD		1.391	0.862	0.620	0.493	0.373
16	0.5		2.8	2.10	0.86	0.58	0.24	0.11
			2.0	2.45	1.20	0.47	0.24	0.11
			3.5	2.71	1.40	0.63	0.32	0.24
		Mean	2.8	2.419	1.150	0.562	0.267	0.153
		SD		0.306	0.275	0.083	0.049	0.073
16	0.7		2.5	1.10	1.07	0.40	0.18	0.11
			3.2	1.78	0.99	0.48	0.33	0.13
			3.4	3.22	1.28	0.78	0.53	0.38
		Mean	3.0	2.031	1.112	0.550	0.343	0.206
		SD		1.083	0.151	0.201	0.176	0.149

<u>Application volume rates</u>
At 12 km/h = 120 L/ha
At 16 km/h = 90 L/ha
Wind speed measured at 2m above ground level

Table 3. Spray drift fallout (ground) with nozzle ABJ025 at 3 bar (1.00 L/min nozzle flow rate)

Forward speed km/h	Boom height m		Wind Speed m/s	Ground deposit of spray drift at downwind distances (mL spray per square metre) 2m	4m	6m	8m	12m	15m	20m
12	0.5		3.0	0.10	0.08	0.06	0.05	0.03	0.03	0.04
			2.0	0.42	0.08	0.03	0.007	0.006	0.006	0.004
			1.7	0.50	0.10	0.03	0.02	0.012	0.007	0.008
		Mean	2.2	0.34	0.09	0.04	0.02	0.02	0.02	0.02
		SD		0.21	0.01	0.02	0.02	0.01	0.02	0.02
12	0.7		2.7	0.28	0.16	0.07	0.06	0.05	0.03	0.03
			2.4	0.73	0.05	0.03	0.02	0.008	0.003	0.005
			1.8	1.35	0.29	0.10	0.06	0.03	0.013	0.006
		Mean	1.8	0.79	0.17	0.07	0.04	0.03	0.02	0.01
		SD		0.54	0.12	0.03	0.02	0.02	0.02	0.01
16	0.5		2.0	0.43	0.07	0.02	0.011	<LOQ	<LOQ	0.005
			1.9	0.49	0.08	0.02	0.02	0.012	0.006	0.004
			2.9	1.01	0.19	0.11	0.05	0.012	0.008	0.006
		Mean	2.3	0.64	0.11	0.05	0.03	0.012	0.007	0.005
		SD		0.32	0.06	0.05	0.02	0.0003	0.0016	0.0010
16	0.7		2.0	1.36	0.19	0.07	0.03	0.02	0.012	0.008
			3.1	1.15	0.32	0.12	0.06	0.04	0.03	0.02
			2.4	1.47	0.20	0.08	0.04	0.011	0.008	0.006
		Mean	2.5	1.33	0.24	0.09	0.04	0.02	0.02	0.01
		SD		0.16	0.07	0.03	0.01	0.01	0.01	0.01

Application volume rates
At 12 km/h = 100 L/ha
At 16 km/h = 75 L/ha
Wind speed measured at 2m above ground level

Table 4. Airborne spray deposits with nozzle ABJ025 at 3 bar (1.00 L/min nozzle flow rate)

Forward speed km/h	Boom height m		Wind Speed m/s	Total airborne spray drift in sampling frame (0.5m x 2m) at downwind distances (mL spray per square metre) 2m	4m	8m	12m	20m
12	0.5		3.0	0.47	0.26	0.16	0.09	0.04
			2.0	0.56	0.30	0.10	0.06	0.02
			1.7	0.75	0.36	0.14	0.11	0.05
		Mean	2.2	0.59	0.31	0.14	0.09	0.03
		SD		0.14	0.05	0.03	0.03	0.01
12	0.7		2.7	0.60	0.31	0.15	0.10	0.04
			2.4	0.33	0.21	0.09	0.06	0.01
			1.8	1.36	0.54	0.26	0.19	0.05
		Mean	1.8	0.76	0.35	0.17	0.11	0.03
		SD		0.54	0.17	0.09	0.07	0.02
16	0.5		2.0	0.40	0.16	0.06	0.04	0.01
			1.9	0.63	0.23	0.11	0.05	0.03
			2.9	1.35	0.56	0.25	0.15	0.06
		Mean	2.3	0.79	0.32	0.14	0.08	0.03
		SD		0.50	0.21	0.10	0.06	0.02
16	0.7		2.0	1.00	0.41	0.22	0.17	0.06
			3.1	3.06	0.53	0.30	0.23	0.09
			2.4	1.36	0.54	0.30	0.14	0.06
		Mean	2.5	1.81	0.49	0.27	0.18	0.07
		SD		1.10	0.07	0.05	0.05	0.02

Application volume rates
At 12 km/h = 100 L/ha
At 16 km/h = 75 L/ha
Wind speed measured at 2m above ground level

Table 5. Spray drift fallout (ground) with nozzle 03F110 at 3 bar (1.2 L/min nozzle flow rate)

Forward speed km/h	Boom height m		Wind Speed m/s	Ground deposit of spray drift at downwind distances (mL spray per square metre) 2m	4m	6m	8m	12m	15m	20m
12	0.5		2.2	0.18	0.06	0.044	0.026	0.020	0.011	0.004
			3.2	0.47	0.17	0.074	0.042	0.012	0.006	0.003
			2.8	1.08	0.13	0.093	0.055	0.017	0.011	0.005
		Mean	2.7	0.58	0.12	0.070	0.041	0.016	0.009	0.004
		SD		0.46	0.06	0.025	0.014	0.004	0.003	0.001
16	0.5		2.9	0.53	0.23	0.17	0.059	0.032	0.035	0.011
			2.2	0.27	0.07	0.055	0.022	0.009	0.005	0.005
			2.0	0.96	0.14	0.061	0.039	0.021	0.013	0.008
		Mean	2.4	0.58	0.15	0.10	0.040	0.021	0.018	0.008
		SD		0.35	0.08	0.07	0.02	0.01	0.02	0.003

Table 6. Airborne spray deposits with nozzle 03F110 at 3 bar (1.2 L/min nozzle flow rate)

Forward speed km/h	Boom height m		Wind Speed m/s	Total airborne spray drift in sampling frame (0.5m x 2m) at downwind distances (mL spray per square metre) 2m	4m	8m	12m	20m
12	0.5		2.2	1.07	0.68	0.60	0.30	0.088
			3.2	1.28	0.84	0.37	0.17	0.059
			2.8	1.11	0.59	0.42	0.33	0.11
		Mean	2.7	1.15	0.70	0.46	0.27	0.09
		SD		0.11	0.13	0.12	0.08	0.03
16	0.5		2.9	1.10	0.94	0.58	0.24	0.46
			2.2	0.79	0.55	0.38	0.26	0.11
			2.0	1.09	0.67	0.41	0.27	0.13
		Mean	2.4	0.99	0.72	0.46	0.26	0.24
		SD		0.18	0.20	0.11	0.01	0.20

Application volume rates
At 12 km/h = 120 L/ha
At 16 km/h = 90 L/ha
Wind speed measured at 2m above ground level

The data have been summarised and presented below for ground deposited drift and airborne drift

Figures for ground deposited drift

Figure 1. Nozzle 03F110 with end nozzle: Ground deposited drift downwind as percentage of application rate

Figure 2. Nozzle 03F110. Ground deposited drift downwind as percentage of application rate with 0.5m boom height. Data set from 2001 included at 8 km/h for comparison.

Figure 3. Comparison of three nozzle types for ground deposited drift downwind as percentage of application rate with short crop (mean of four settings)

Figure 4. Comparison of three nozzle types for ground deposited drift downwind as percentage of application rate with tall crop (mean of four settings)

Figure 5. Comparison of boom heights and forward speed for ground deposited drift downwind as percentage of application rate with short crop (mean of all nozzles)

Figure 6. Comparison of boom heights and forward speed for ground deposited drift downwind as percentage of application rate with tall crop (mean of all nozzles)

Figure 7. Comparison of crop height across nozzles types (mean of all operating setting for boomm height and forward speed) for ground deposited drift as percentage of application rate

Figures for airborne drift expressed as mL/m^2 airborne drift up to 2m height normalised to 200 L/ha

Figure 8. Comparison of three nozzle configurations for airborne drift (mL/m^2) with short crop (mean of four settings), normalised to 200 L/ha

Figure 9. Comparison of four nozzle configurations for airborne drift (mL/m^2) with tall crop (mean of four settings), normalised to 200 L/ha

Figure 10. Comparison of height and forward speed settings for 02F110 nozzle configuration with tall crop, normalised to 200 L/ha

Figure 11. Comparison of height and forward speed settings for 03F110 nozzle configuration at 0.5 m boom height short crop, normalised to 200 L/ha

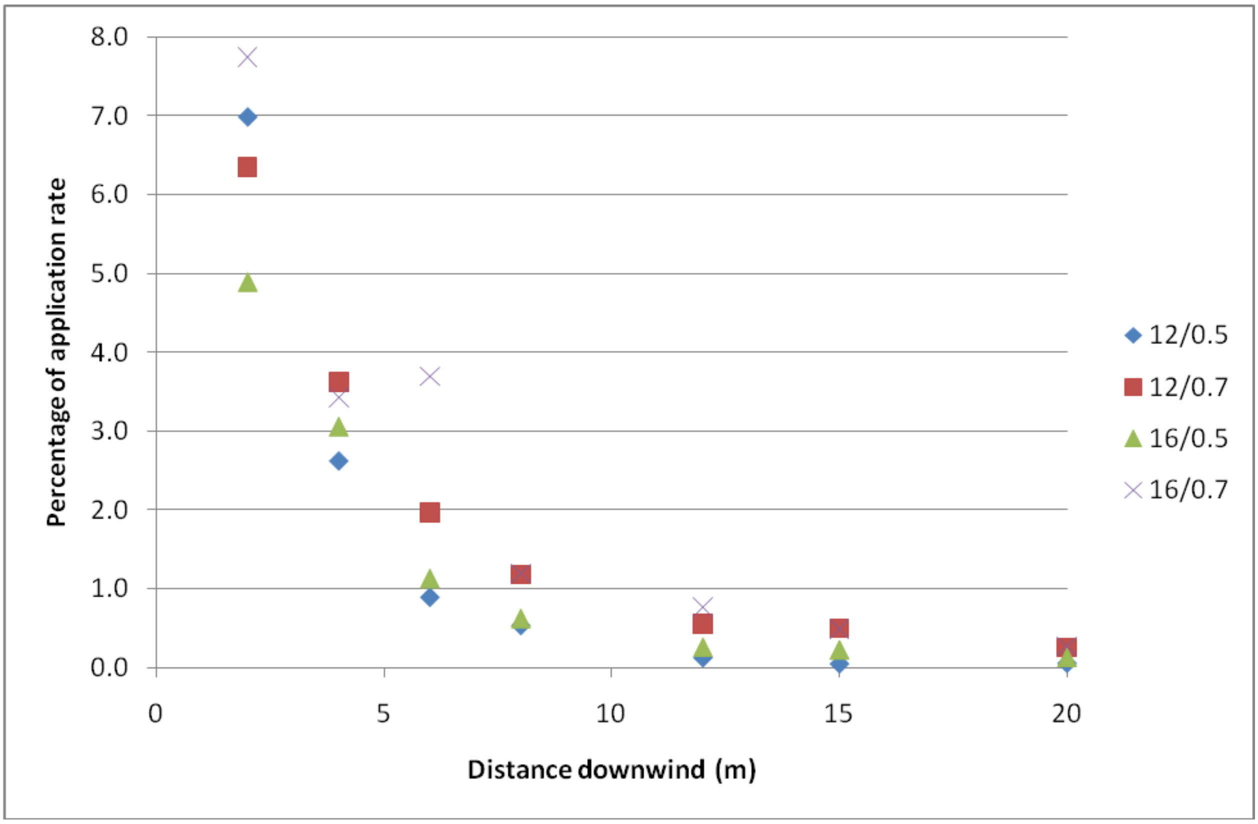

Figure 1. Nozzle 03F110 with end nozzle: Ground deposited drift downwind as percentage of application rate with tall crop

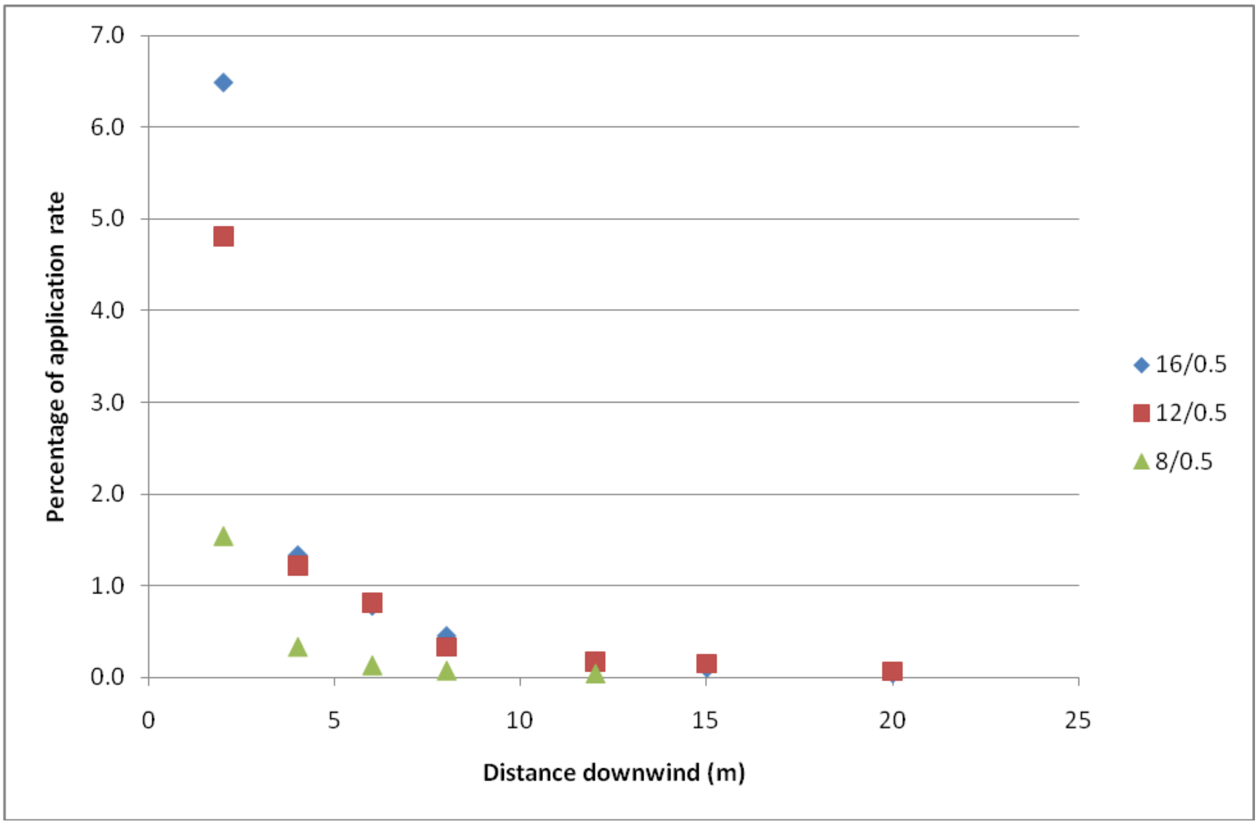

Figure 2. Nozzle 03F110. Ground deposited drift downwind as percentage of application rate with 0.5m boom height with short crop. Data set from 2001 included at 8 km/h for comparison.

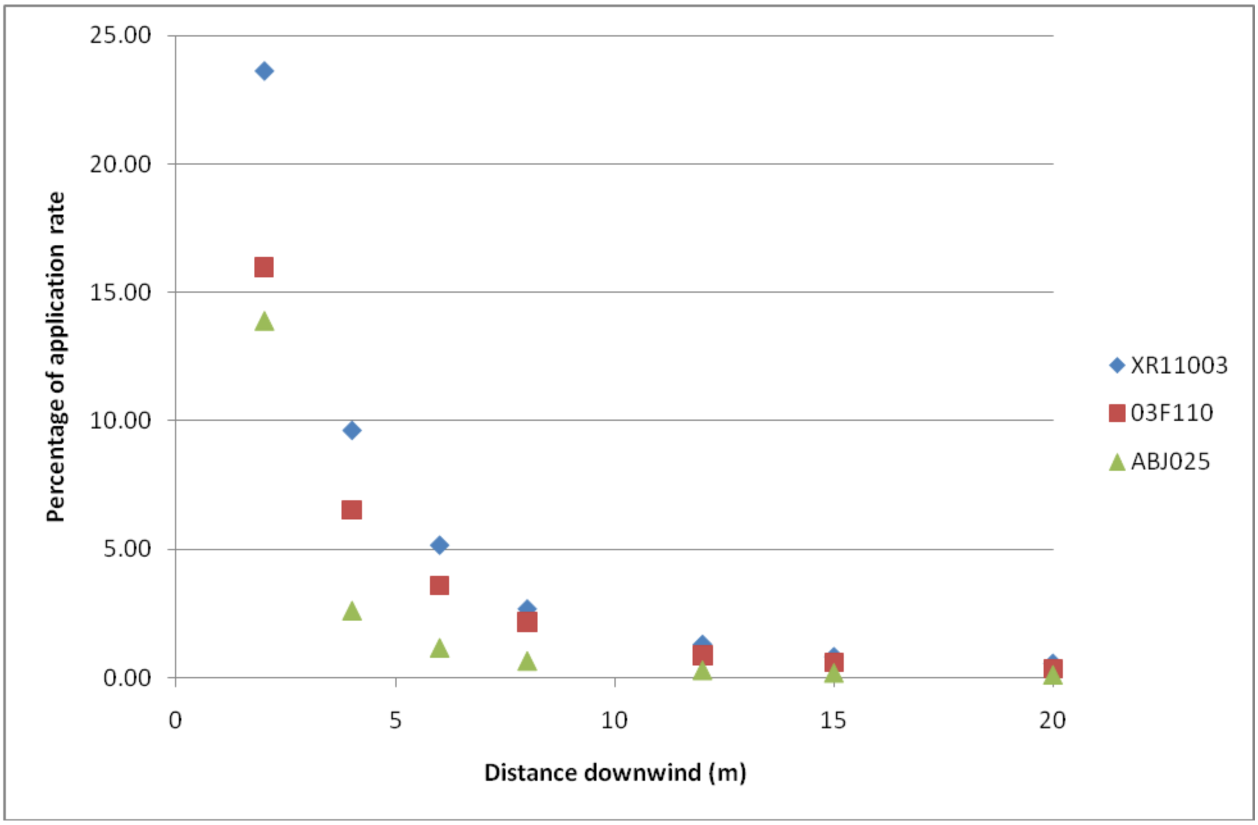

Figure 3. Comparison of three nozzle types for ground deposited drift downwind as percentage of application rate with short crop (mean of four settings)

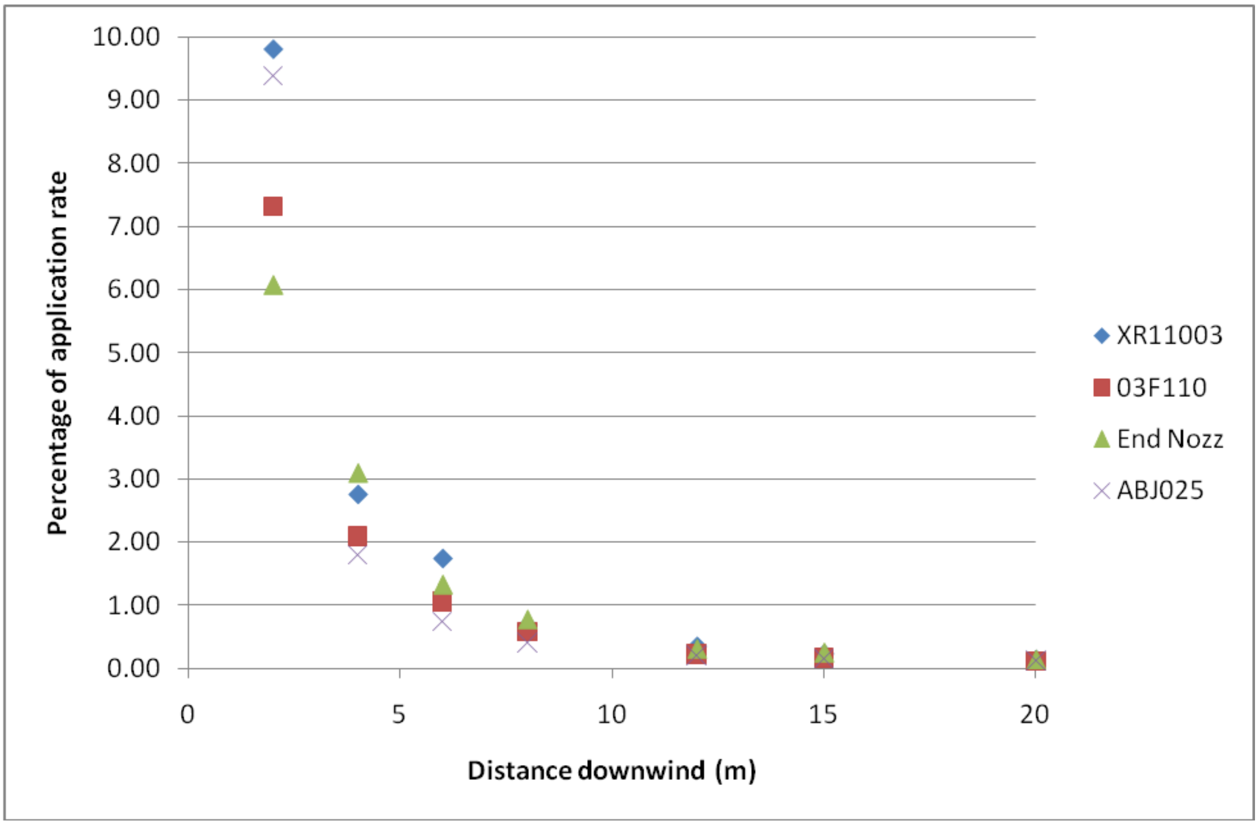

Figure 4. Comparison of three nozzle types for ground deposited drift downwind as percentage of application rate with tall crop (mean of four settings)

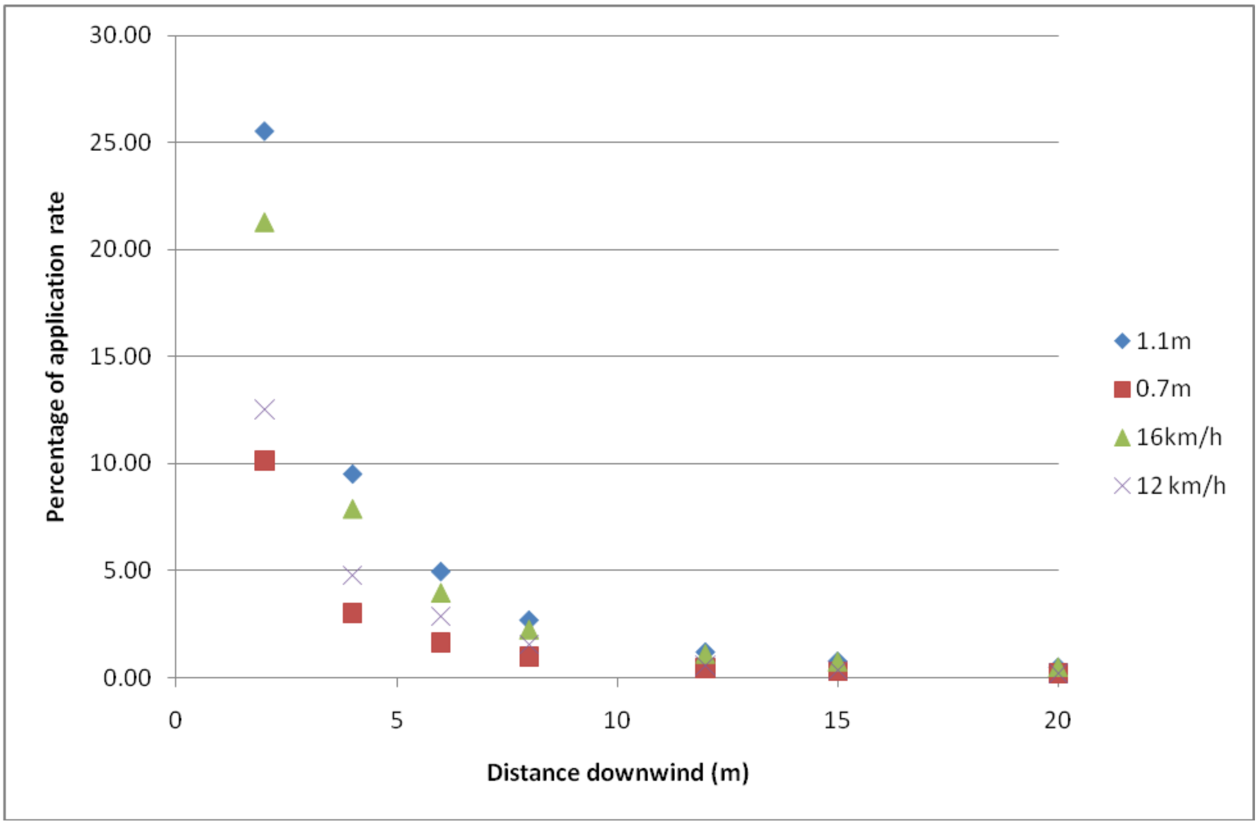

Figure 5. Comparison of boom heights and forward speed for ground deposited drift downwind as percentage of application rate with short crop (mean of all nozzles)

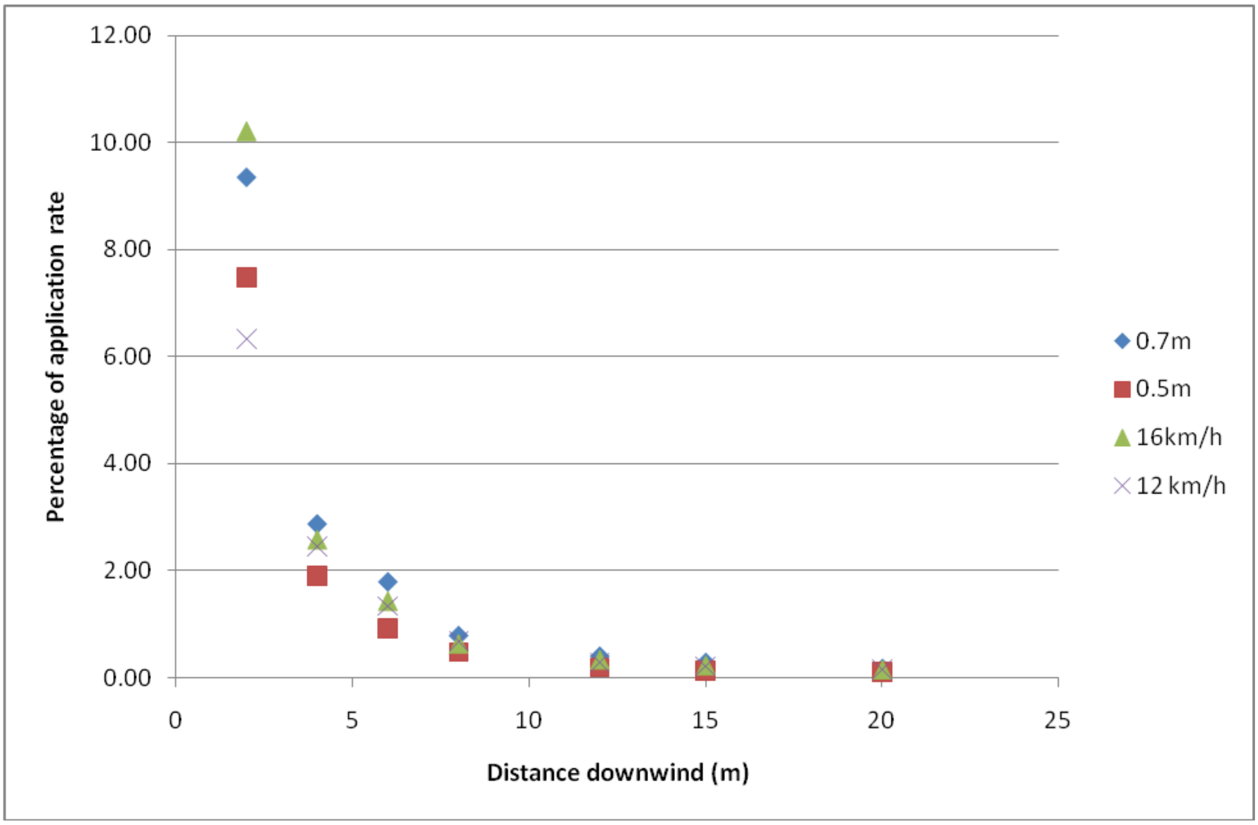

Figure 6. Comparison of boom heights and forward speed for ground deposited drift downwind as percentage of application rate with tall crop (mean of all nozzles)

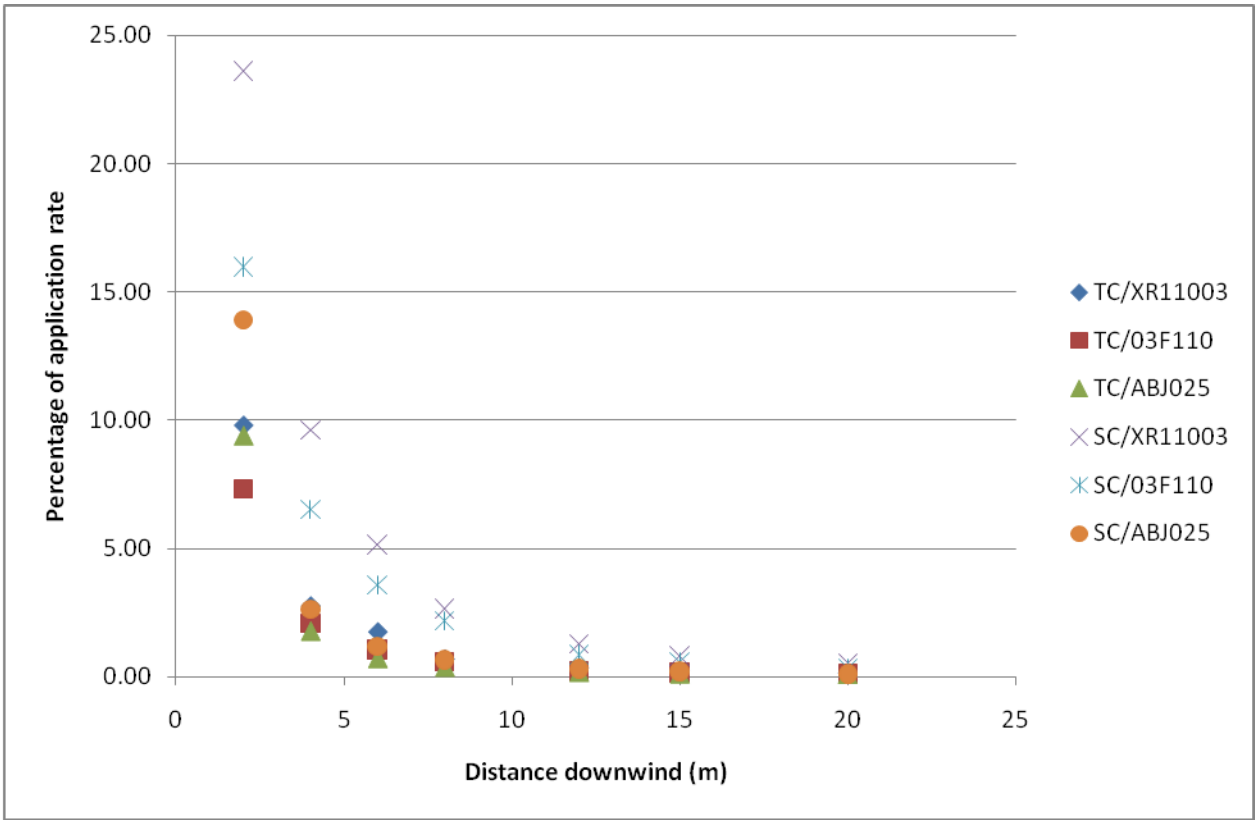

Figure 7. Comparison of crop height across nozzles types (mean of all operating setting for boomm height and forward speed) for ground deposited drift as percentage of application rate

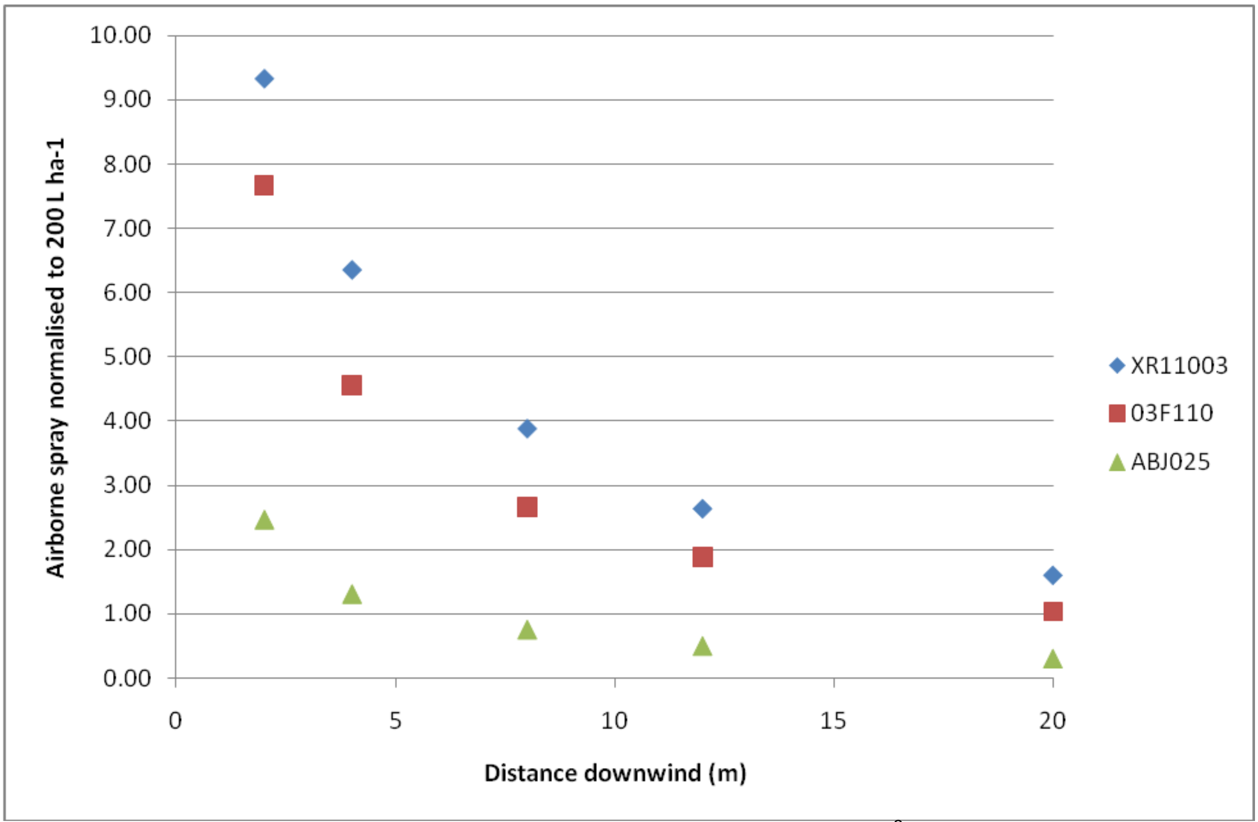

Figure 8. Comparison of three nozzle configurations for airborne drift (mL/m^2) with short crop (mean of four settings), normalised to 200 L/ha

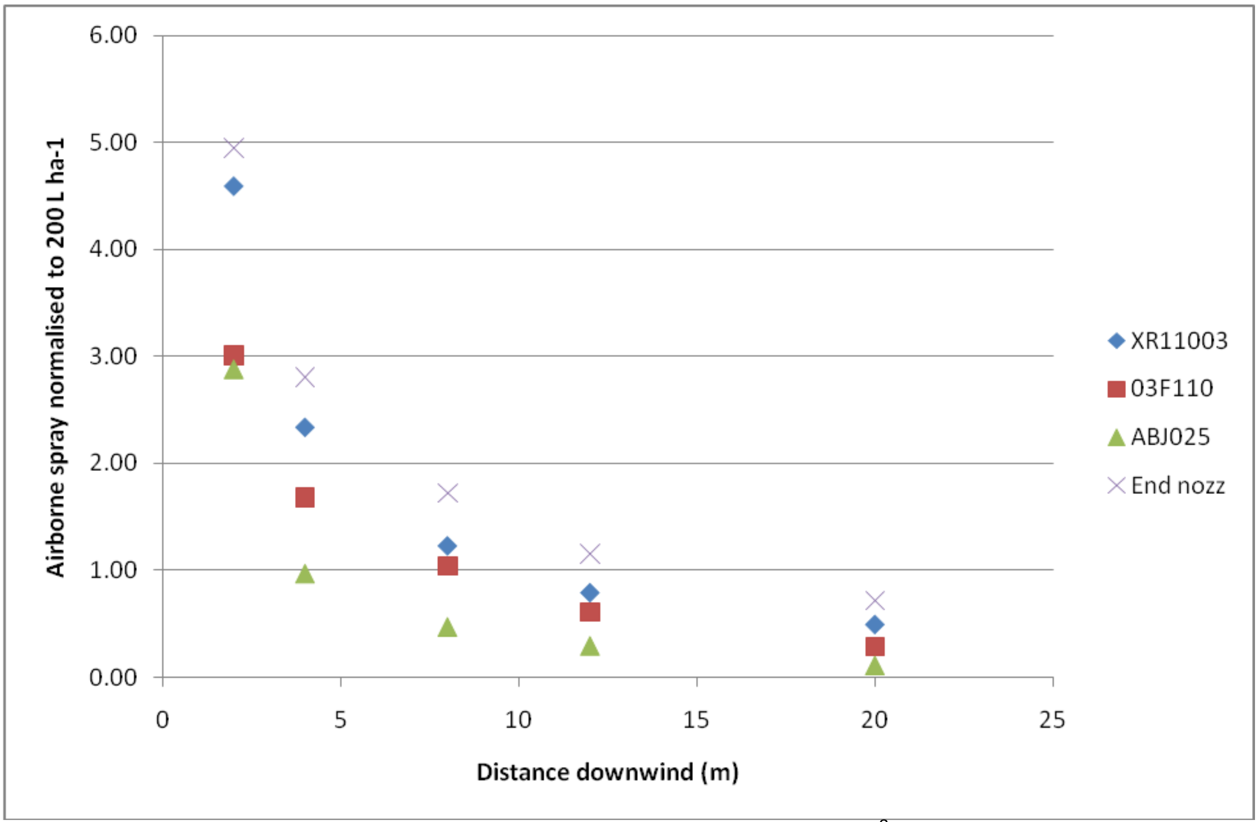

Figure 9. Comparison of four nozzle configurations for airborne drift (mL/m^2) with tall crop (mean of four settings), normalised to 200 L/ha

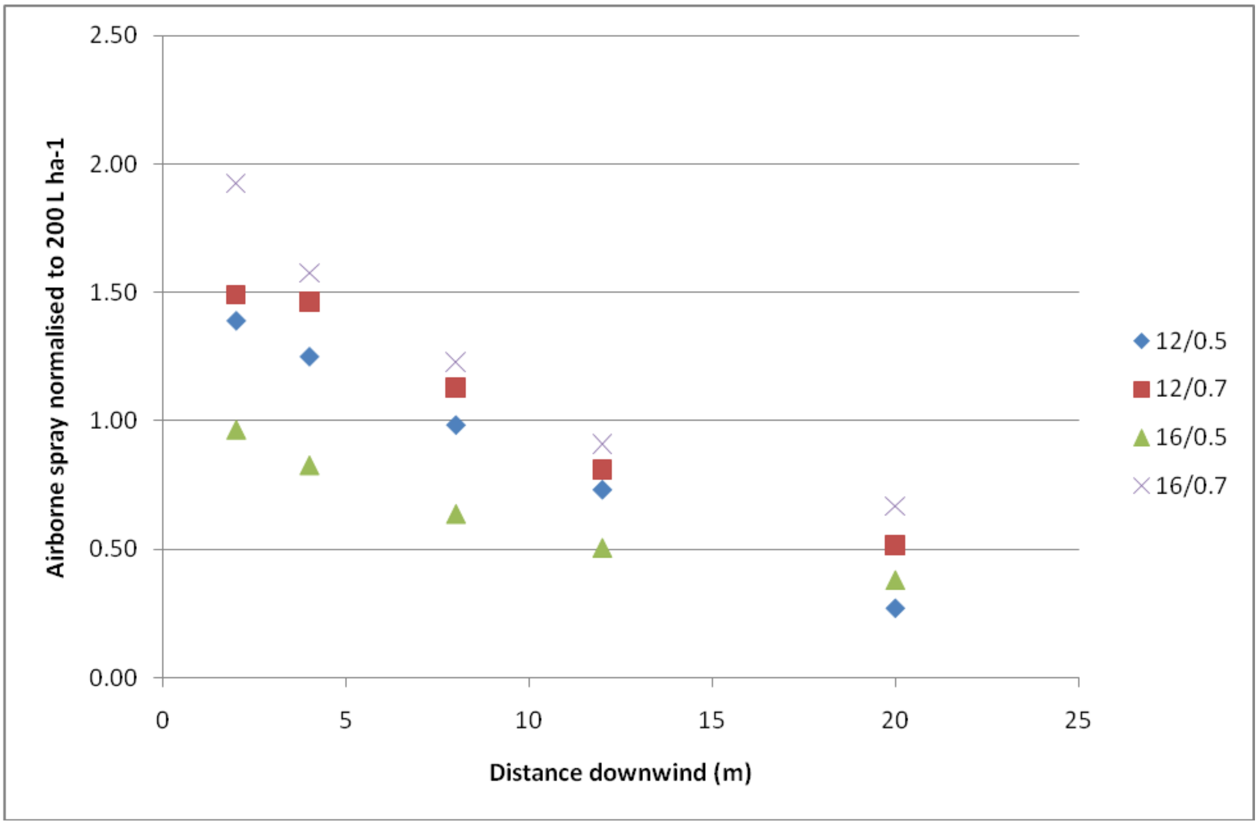

Figure 10. Comparison of height and forward speed settings for 02F110 nozzle configuration with tall crop, normalised to 200 L/ha

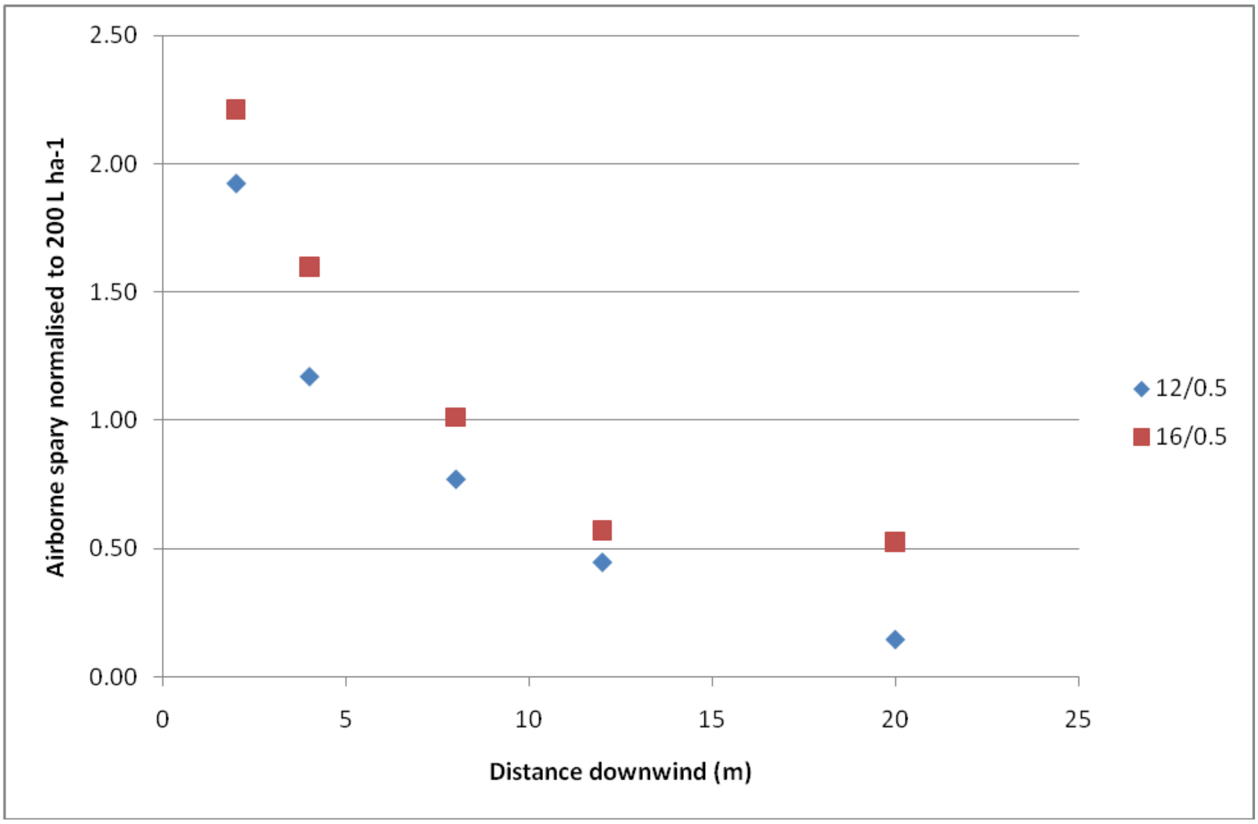

Figure 11. Comparison of height and forward speed settings for 03F110 nozzle configuration at 0.5 m boom height short crop, normalised to 200 L/ha

Conclusions

The generation of over 100 datasets for drift in field studies during the period 2007-2010 has added important information which can be used in ERAs as well as bystander and resident exposure assessments. This has shown the importance of measuring airborne and ground deposited drift at the same time allowing a more accurate indication of spray losses from the field or application area to be determined.

To allow comparison of the individual nozzle types and forward speeds, the data have been presented as a percentage of the application rate for the ground deposited drift. For the airborne spray drift data, the volume of spray drift airborne in a window of 2m height by 0.5 width has been presented, with all values normalised to 200 L/ha

The results from the field spray drift studies indicate increased amounts of ground deposited and airborne drift at distances up to 20m downwind of the treated area for both tall and short crops with the extended range of operating conditions evaluated compared to the more traditional 8 km/h forward speed and 0.5m boom height. This work confirms the early findings from PS2015 reported by Byron and Hamey (2008) and Glass *et al.* (2010)

Indications are that the boom height may be more important than forward speed across the nozzle types used in these studies

The influence of the crop height is an interesting factor, as shown by Figure 7, where there were greater levels of ground deposited spray drift with a short crop than with a tall crop across the nozzle operating conditions evaluated. It should be born in mind that the boom heights for the short crop were 0.7m and 1.1.m, with boom heights of 0.5m and 0.7m for the short crop (all boom heights are recorded as the height above the crop)

There were also other datasets published by Zande et al. (2002) showing that for boom sprayers operating in potato or cereal crops with the boom height of 0.5m above the crop, the measured drift was greater than published data such as Rautman *et al.* (2001) and Defra funded studies carried out by Fera (previously CSL).

Care must be taken with comparing datasets reported here from these recent Fera studies, as there were only three replicate sets for each nozzle and operating setting. The field studies were planned to be carried out in with wind speeds of 2 to 4 ms^{-1}, although some datasets fell outside this range. Studies were also carried out in a range of environmental conditions, although this was considered close to farming practice, with shorter crops in autumn and early spring, and taller crops in late spring and summer.

Where the data may appear to show an unexpected trend, then reference to wind speed in the tables of data should be made. For example the boom setting with the half fan end nozzle tends to show greater levels of drift than the standard boom with either XR11003 or the 03F110 nozzles. The mean datasets for the end nozzle setting has been skewed by a small number of datasets with a relatively high wind speed.

The main conclusions from this work are

Spray drift increases with increasing forward speed of the sprayer

Spray drift increases with increasing boom height

The crop canopy plays an important role not only in the setting of the boom height but also the filtering effect of the spray leaving the nozzle, both by direct contact with the canopy beneath the nozzle and the filtering of the spray plume carried by the wind.

Modern sprayers tend to operate with b boom height greater than 0.5m above the crop to avoid damage to the boom. Due to forward speeds of up to 16 km/h over uneven ground and subsequent effects on boom movement a higher boom width can be used to avoid damage of the boom by grounding or contact with the crop. Grounding of the boom was observed during the studies with the operating conditions of 0.5m boom height above a short crop.

There is evidence to show that, under modern operating conditions and with certain active substances, buffer zones greater than 5 metres adjacent to water may be required to provide the level of protection assumed in the current EU risk assessment approach (based on data from Rautmann et al, 2001).

Recent Defra and EFSA funded farm surveys should be used to identify key operating conditions which could be evaluated in greater detail in field studies with more replication over a range of wind speeds and crop conditions to determine the size of buffer zones required for specific crop types. Designing a field study with a crop (or several crops) grown specifically for this purpose would allow a greater window (more spray days), greater replication of operating conditions and reduce some of the variables which contributed to the high Standard Deviation values in the datasets reported in this study.

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Rautmann D, Streloke M, Winkler R. 2001. New drift values in the authorisation procedure for plant protection products. *Mitteilungen aus der Biologischen Bundesanstalt für Land-und Forstwirtschaft. [Federal Biological Research Centre for Agriculture and Forestry]* 383 Berlin. 133 – 141.

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References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

Comparative field drift data from applications to tall and short crops with modern operating conditions. Glass C R,Mathers J J, Harrington P,Miller PCH, Lane A, O'sullivan C, Ferreira M C. *Aspects of Applied Biology* ***99****, 2010. International Advances in Pesticide Application*

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