

Evaluation of Spray Drift, Deposition and Droplet Size for T40 and T50 Aircraft– Executive Summary Report

For DJI

The University of Queensland, Gatton QLD, Australia
Drs Andrew Hewitt and Christopher O’Donnell, and Mr Bruce Llewellyn

September 21, 2023



EXECUTIVE SUMMARY

A field deposition and drift study and an atomisation wind tunnel droplet size measurement study were conducted at The University of Queensland, Gatton to measure the spray performance for T40 and T50 unmanned aircraft spray systems.

A soluble fluorescent tracer dye, Pyranine 10G, was added to the spray tank at a rate of 0.4 g/L in tap water.

The aircraft was flown on 8 July, 2023 at The University of Queensland Gatton campus on a bare ground nominally flat, open fetch paddock adjacent to the university wind tunnel, in 3 swaths of length ~150 m, width ~6.5 m across a paddock of low stubble and drift of a water + 0.4 g/L Pyranine 10G dye tank mix was measured at -90 degrees perpendicular to this flight direction. Applications were made at flight speed of 4 or 7 m/s and heights of 3 or 1.5 m above ground. The application volume rate was ~31 L/min through standard rotary spinning disc atomisers as fitted on the commercial aircraft. The droplet size spectra were set with target values of 300 and 500 μm based on prior DJI configuration assessments. The treated area was approximately one third of a hectare for each of the 12 treatments.

Weather data were collected from the Australian government-operated Bureau of Meteorology (BOM) weather station 040082 which is located at The University of Queensland, Gatton within 350 m directly west (i.e. upwind) of the application site. Wind speeds were also verified at the actual application site using a hand-held Kestrel anemometer.

Deposition within the intended swath and beyond the swath as swath displacement and drift were measured using both Water Sensitive Papers (WSPs) and Mylar cards placed slightly above the ground. The Mylar cards were placed within the spray swaths at 10 equally spaced 1 m separation locations (from 0 to -9 m) at the centre of the treated area, and at distances downwind of the swath of 1.5, 3, 6, 12, 25, 50 and 100 m in three lines (A,B,C). WSPs were placed within the centre of the application area. Mylar cards were placed in ZIPLOK bags in a dark freezer prior to analysis in the laboratory. Analysis involved rinsing the Mylar cards with 28 mL deionized water with 10% v/v ethanol, and reading the Pyranine concentration with a Shimadzu RF5301-PC multispectral fluorometer.

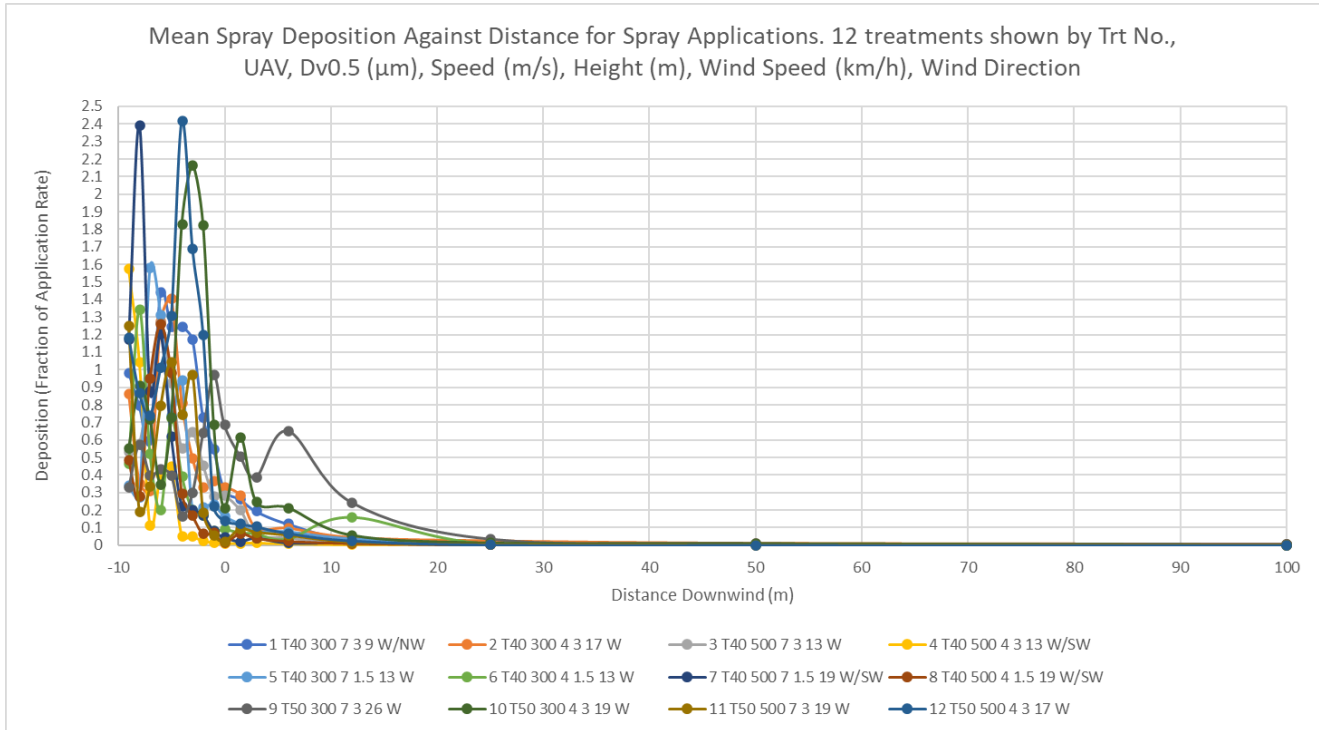
Separately, a Malvern Spraytec laser diffraction particle size analyser was used to measure the emission droplet size spectra in the University of Queensland (UQ) wind tunnel at the UQ Gatton campus, providing data for a dynamic size range of 0.5 to 2500 microns.

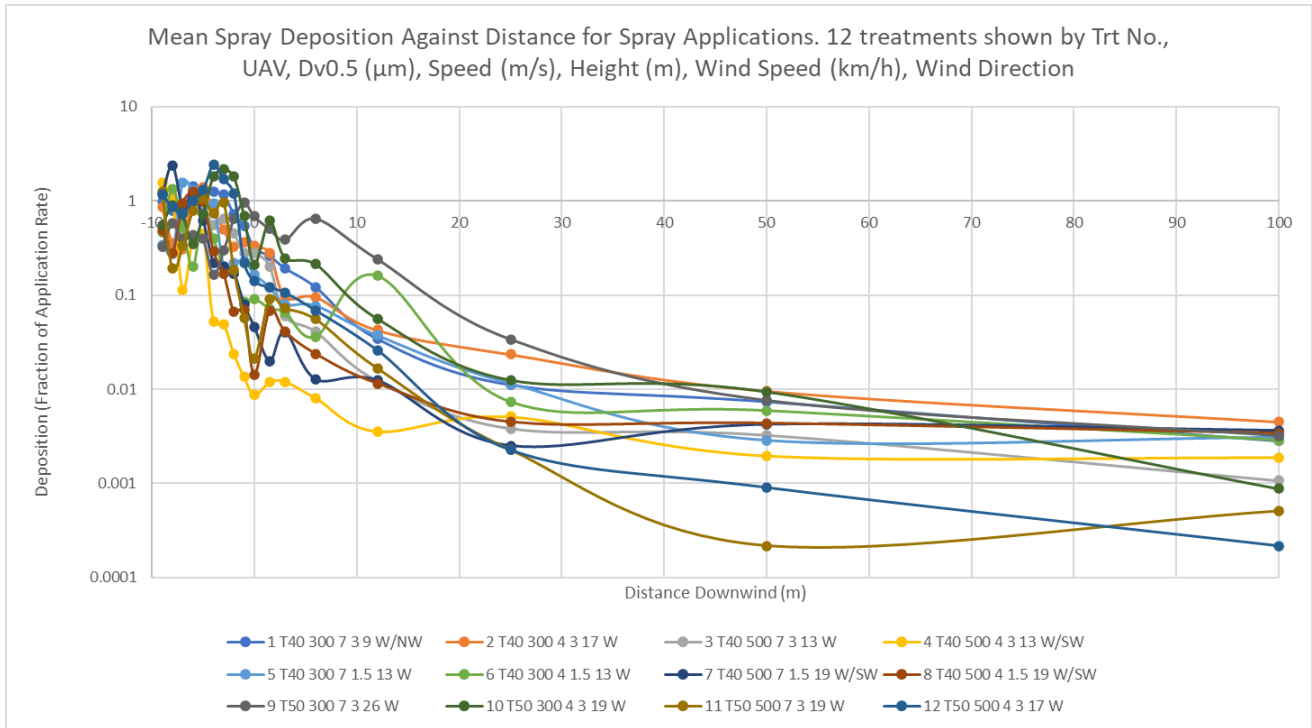
All droplet size spectra were measured by traversing the nozzle vertically down through the 1 m x 1 m working section while the laser measured the light diffraction pattern from the sprays. All measurements were replicated and mean data provided. There was excellent agreement among replicate measurements and there were no abnormalities in the data.

The dynamic surface tension of the tank mix was measured using a SITA Dynotester maximum bubble pressure surface tensiometer, for a surface lifetime age of 20 ms. It was 40 dyne/cm for the tank mix.

For the droplet size treatments, the sprays were classified as XXX. The droplet size data are shown below, with 3 replicate measurements per application scenario.

The spray drift deposition data for each application scenario are shown below on non-logarithmic and logarithmic scales. There was a general trend, as expected, of higher drift for the greater aircraft height, smallest droplet size and fastest aircraft speed.





The implications of these drift curves on the size of no-spray buffer zones for the same conditions will depend on the regulatory acceptable limit (RAL) for each pesticide being applied. For example, for a RAL of 0.1, the setback distance to the non-target sensitive area would be 5-20m, depending on the spray parameters, whereas for a RAL of 0.01, the setback distance to the sensitive area would be less than 10 to 40 m and for pesticide/ sensitive area scenarios with a RAL of 0.001, the distance would be less than 30 m in some scenarios but greater than 100 m for other cases.

Droplet Size Data

Average Derived Parameters

19 Sep 2023 - 13:57:37

(average scatter, weighted)
 DJI2.s mea\Exp 002 - 19 Sep 2023\Averages\DJI 300 microns 16 m_s wa 5.ps d
 Sample : DJI 300 microns 16 m_s water 8 L_min OEM6550 rpm
 Start+0 (s) :: +34 (s)

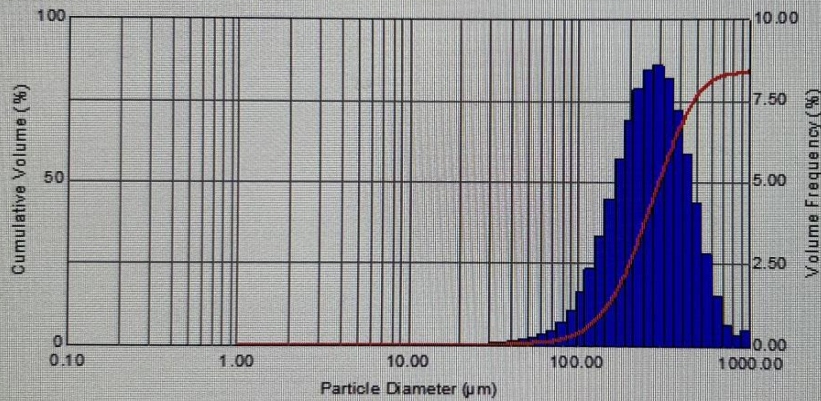
Title	Average	σ	Min	Max
Dv(10) (μm)	138.4	6.057	128.3	151.2
Dv(50) (μm)	297.4	10.88	278.7	328.9
Dv(90) (μm)	1483	270.5	636.2	1655
%V < 50 μ (%)	0.593	0.06255	0.3925	0.7133
%V < 100 μ (%)	3.817	0.5718	2.741	4.919
%V < 150 μ (%)	12.49	1.4	9.76	15.01
%V < 200 μ (%)	25.18	1.91	20.83	28.35

33 Records Averaged

Average Particle Size Distribution

19 Sep 2023 - 13:57:37

(average scatter, weighted)
 DJI2.s mea\Exp 002 - 19 Sep 2023\Averages\DJI 300 microns 16 m_s wa 5.ps d
 Sample : DJI 300 microns 16 m_s water 8 L_min OEM6550 rpm
 Start+0 (s) :: +34 (s)



Size (μm)	% V <	% V	Size (μm)	% V <	% V	Size (μm)	% V <	% V
1.14	0.00	0.00	15.46	0.00	0.00	209.85	27.85	6.90
1.30	0.00	0.00	17.62	0.00	0.00	239.08	35.72	7.87
1.48	0.00	0.00	20.07	0.00	0.00	272.38	44.19	8.47
1.68	0.00	0.00	22.86	0.01	0.01	310.32	52.78	8.59
1.92	0.00	0.00	26.05	0.03	0.02	353.54	60.98	8.17
2.19	0.00	0.00	29.68	0.08	0.05	402.79	68.20	7.24
2.49	0.00	0.00	33.81	0.15	0.07	458.89	74.10	5.90
2.84	0.00	0.00	38.52	0.26	0.11	522.80	78.44	4.34
3.23	0.00	0.00	43.89	0.41	0.15	595.62	81.24	2.80
3.68	0.00	0.00	50.00	0.59	0.19	678.58	82.75	1.51
4.20	0.00	0.00	56.96	0.84	0.24	773.10	83.40	0.65
4.78	0.00	0.00	64.90	1.16	0.33	880.78	83.72	0.32
5.45	0.00	0.00	73.94	1.62	0.46	1003.46	84.24	0.52
6.21	0.00	0.00	84.23	2.32	0.69	1143.22	85.37	1.13
7.07	0.00	0.00	95.97	3.38	1.06	1302.46	87.32	1.94
8.08	0.00	0.00	109.33	4.99	1.61	1483.87	90.00	2.69
9.18	0.00	0.00	124.56	7.36	2.38	1690.55	93.13	3.12
10.46	0.00	0.00	141.91	10.72	3.35	1926.01	96.19	3.06
11.91	0.00	0.00	161.88	15.22	4.50	2194.28	98.64	2.45
13.57	0.00	0.00	184.20	20.94	5.73	2499.90	100.00	1.36

Average Derived Parameters

19 Sep 2023 - 13:55:39

(average scatter, weighted)
 DJI2\smes\Exp 002 - 19 Sep 2023\Averages\DJI 500 microns 16 m_s wa 1.ps d
 Sample : DJI 500 microns 16 m_s water 8 L_min OEM3150 rpm
 Start+0 (s) :: +27 (s)

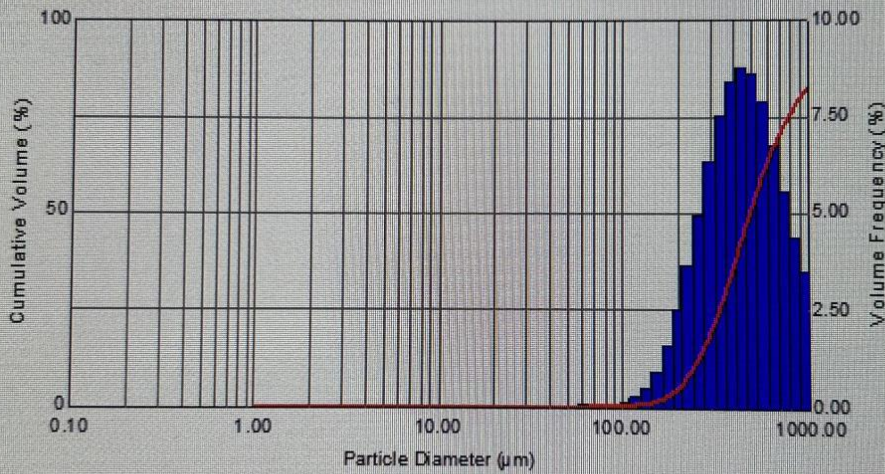
Title	Average	σ	Min	Max
Dv(10) (μm)	238.9	73.44	220.5	389.4
Dv(50) (μm)	486.7	437.1	421	1369
Dv(90) (μm)	1384	602.4	721.8	2048
%V < 50 μ (%)	0.08702	0.02599	0.04033	0.124
%V < 100 μ (%)	0.5069	0.2034	0.1488	0.6834
%V < 150 μ (%)	1.706	0.7693	0.3456	2.596
%V < 200 μ (%)	5.334	2.265	1.329	7.251

27 Records Averaged

Average Particle Size Distribution

19 Sep 2023 - 13:55:39

(average scatter, weighted)
 DJI2\smes\Exp 002 - 19 Sep 2023\Averages\DJI 500 microns 16 m_s wa 1.ps d
 Sample : DJI 500 microns 16 m_s water 8 L_min OEM3150 rpm
 Start+0 (s) :: +27 (s)



Size (μm)	% V <	% V	Size (μm)	% V <	% V	Size (μm)	% V <	% V
1.14	0.00	0.00	15.46	0.00	0.00	209.85	6.37	2.49
1.30	0.00	0.00	17.62	0.00	0.00	239.08	10.02	3.64
1.48	0.00	0.00	20.07	0.00	0.00	272.38	14.98	4.97
1.68	0.00	0.00	22.86	0.00	0.00	310.32	21.31	6.33
1.92	0.00	0.00	26.05	0.00	0.00	353.54	28.85	7.54
2.19	0.00	0.00	29.88	0.00	0.00	402.79	37.27	8.42
2.49	0.00	0.00	33.81	0.00	0.00	458.89	46.06	8.79
2.84	0.00	0.00	38.52	0.01	0.01	522.80	54.66	8.60
3.23	0.00	0.00	43.89	0.04	0.03	595.62	62.54	7.88
3.68	0.00	0.00	50.00	0.09	0.04	678.58	69.31	6.78
4.20	0.00	0.00	56.96	0.15	0.06	773.10	74.85	5.53
4.78	0.00	0.00	64.90	0.22	0.07	880.78	79.24	4.39
5.45	0.00	0.00	73.94	0.30	0.08	1003.46	82.77	3.53
6.21	0.00	0.00	84.23	0.38	0.08	1143.22	85.80	3.04
7.07	0.00	0.00	95.97	0.47	0.09	1302.46	88.67	2.87
8.06	0.00	0.00	109.33	0.61	0.14	1483.87	91.53	2.87
9.18	0.00	0.00	124.56	0.87	0.26	1690.55	94.36	2.83
10.46	0.00	0.00	141.91	1.37	0.50	1926.01	96.93	2.57
11.91	0.00	0.00	161.68	2.30	0.93	2194.28	98.91	1.98
13.57	0.00	0.00	184.20	3.88	1.58	2499.90	100.00	1.09

The Test Record





