Executive Summary Report: Droplet Size Spectra for Xtendimax Tank Mixes

Andrew Hewitt, Chris O'Donnell and Ray Roberts

Study Conducted by and at The University of Queensland Gatton QLD 4343

A study was conducted in the straight through blower wind tunnel at The University of Queensland Gatton to measure the emission droplet size spectra from nozzles with tank mixes for ground spray applications in Australia. Each tank mix was prepared with herbicide and adjuvant ingredients to produce tank mix compositions supplied by Bayer. Tap water, free of particulates was used as the carrier and each ingredient was added and mixed using stirring until uniform. The dynamic surface tension (DST) was measured at surface lifetime ages of 20 and 40 ms for each tank mix using a SITA DynoTester maximum bubble pressure surface tensiometer, within 5 minutes of the tank mix then being sprayed through the test system.

Following mixing and measurement of DST, each tank mix was placed in a pressurised stainless steel canister which was shaken before each application. Tank mixes were displaced through the respective nozzle(s) at the required spray pressure using a needle flow valve. Pressure was verified at the nozzle tip using a calibrated pressure gauge. The sprays were sampled through a full vertical traverse of the spray plume in approximately 8 to 12 seconds measured by a Malvern Spraytec laser diffraction instrument with its laser at the wind tunnel centre approximately 50 cm downwind from the nozzle. The Standard Operating Procedure (SOP) included the following actions in respective automatic order: entry of the treatment details, alignment of the laser using automatic motor control for x and y positioning, background measurement, sample light diffraction measurement during the traverse of the nozzle to provide a full spray sample from the bottom edge of the plume through the centre and then the top of the plume. Data were processed using the full measurement data of the light diffraction pattern with a model independent curve fit for droplet size in size classes up to 2000 microns.

All measurements were replicated three times.

The instrument and system calibration were verified against the American Society for Agricultural and Biological Engineers (ASABE) standard S572 reference sprays for droplet size classifications.

Analysis of Results Wind Tunnel Testing UQ Gatton Under Supervision of Dr Andrew Hewitt 22nd – 24th December 2021.

Introduction

Advanced Wetting Technologies Pty Ltd (AWT) has developed a proprietary technology to dramatically enhance the performance of the application of herbicides across all types of agricultural crop spraying. This performance is critical to the effectiveness of crop spraying in terms of the efficient and appropriate absorption of chemicals into the target crops as well as the optimisation of spraying area by controlling 'drift'. Both these factors have obviously become increasingly critical in all agricultural and other spraying applications. In order to confirm the efficacy of the AWT technology, a study was conducted in the straight through blower wind tunnel at The University of Queensland Gatton under the supervision of Dr Andrew Hewitt a world authority on spray drift to measure the emission droplet size spectra from nozzles with tank mixes for ground spray applications in Australia.

Methodology

Each tank mix was prepared with herbicide and adjuvant ingredients to produce tank mix compositions supplied by Bayer and AWT. Tap water, free of particulates was used as the carrier and each ingredient was added and mixed using stirring until uniform. The dynamic surface tension (DST) was measured at surface lifetime ages of 20 and 40 ms for each tank mix using a SITA DynoTester maximum bubble pressure surface tensiometer, within 5 minutes of the tank mix then being sprayed through the test system.

Following mixing and measurement of DST, each tank mix was placed in a pressurised stainless steel canister which was shaken before each application. Tank mixes were displaced through the respective nozzle(s) at the required spray pressure using a needle flow valve. Pressure was verified at the nozzle tip using a calibrated pressure gauge. The sprays were sampled through a full vertical traverse of the spray plume in approximately 8 to 12 seconds measured by a Malvern Spraytec laser diffraction instrument with its laser at the wind tunnel centre approximately 50 cm downwind from the nozzle. The Standard Operating Procedure (SOP) included the following actions in respective automatic order: entry of the treatment details, alignment of the laser using automatic motor control for x and y positioning, background measurement, sample light diffraction measurement during the traverse of the nozzle to provide a full spray sample from the bottom edge of the plume through the centre and then the top of the plume. Data were processed using the full measurement data of the light diffraction pattern with a model independent curve fit for droplet size in size classes up to 2000 microns. All measurements were replicated three times.

The instrument and system calibration were verified against the American Society for Agricultural and Biological Engineers (ASABE) standard S572 reference sprays for droplet size classifications.

Adjuvants

BS1000 is a non-ionic alcohol alkoxylate (1000g/l) produced by Nufarm in Australia. It is widely used with a number of agricultural herbicides throughout Australia particularly in broad area farming. It is an amphiphilic surfactant.

PCLL8 is a multiphase wetting composition developed by Advanced Wetting Technologies Pty Ltd. It is the subject of a pending patent worldwide. It is not an amphiphilic surfactant and is not limited by the formation of micelles. It is based on completely different technology than any existing surfactant. As a result, unlike amphiphilic surfactants, it can be used at different doses. As micelles do not form there is no Marangoni Effect (lower surface tension at the edge of the droplet compared to the bulk

of the droplet). This is what causes the production of spray fines either in the air or when the drop contacts the foliage. As there is no formation of micelles, it can also be used at different doses for faster or slower spreading and penetration and for different herbicides and weed species which is unique in surfactants.
It has been tested with Roundup and Paraquat by a team of agronomists, Outlook Ag and has been found to be more effective than BS1000 even at lower doses i.e. 50ml/100 litres of PCLL8 as opposed to 125ml/100 litres of BS1000. It is also a far better performer on difficult to kill weeds such as Flea vane, Pig weed and Milk thistle while using less Roundup. This has been verified by Outlook Ag. It also is effective with lower doses of Glyphosate at 1500ml/ha as opposed to BS1000 at 2500ml/ha.

Wind Tunnel Study

The study involved four factors listed below. The experimental design of the wind tunnel trial was as follows:

Herbicide

1 1. Roundup Ready PL
2 2. Roundup Ready PL + Xtendimax 2 (a broad leaf Dicamba type herbicide
3 3. Xtendimax 2 alone

Adjuvant

1 1. PCLL8
2 2. BS1000
3 3. LI700
4 4. No adjuvant

LI700 was fully analysed however is not the subject of this report because it has an inbuilt DRA and it has to be used at 250ml/100 litres of spray mix. Outlook Ag found it to be the least effective adjuvant with Roundup and Paraquat.

Drift Reduction Agent (DRA)

1 1. On Course FMC
2 2. Intact
3 3. Gravitate 707
4 4. No DRA

Nozzle type

1 1. AI11003
2 2. AVI Albuz
3 3. TTI60 Twin Jet

To ensure the design was fully orthogonal for Analysis of Variance, there were 144 treatments. The experimental design is in an attached file. Dynamic Surface Tension (DST) was done on all mixes (48) at both 20ms and 40ms. This data was analysed using linear regression for each nozzle type.
The data was obtained from Spraytec Software Malvern Instruments Version 4 which was used as a database, the data being transferred from Version 3 of this program. Version 3 actually runs the hardware which is a moving laser source plus an array of diodes that measures the refraction of the laser and as such calculates droplet size and distribution and records all data.
The data was checked for normality of variance, a fundamental assumption and data points with large residuals were checked for data entry error. The data was analysed using Genstat Version 7; Lawes Agricultural Trust.

There was no requirement for transformation of any of the data into natural logarithms for analysis. Where there were large residuals (substantially greater than the standard error) the data was checked. If correct the data were not excluded. The full experimental design is attached as an Appendix.
The data was analysed over the whole experiment i.e. all factors however due to the impact of nozzle type it was then reanalysed by nozzle type which enabled the regression analyses to be conducted. All of the results in this report come from the complete analyses i.e. all nozzles, DRA's, herbicides and all adjuvants. Results are presented in tabular and graphical format the latter with Least Significant Differences (LSD) bars at the 95% confidence level ($p \leq 0.05$) and p values are also displayed.
Where possible all data was obtained after the laser had tracked for 9 seconds.
Minimum size of droplets recorded was 10µm and the maximum size was 2500 µm. Particles above 2500um and in fact above 500um have a very high likelihood of rolling off foliage.
Due to the size of the experiment and number of factors, the level of interaction was set at 2 to have sufficient degrees of freedom for error, i.e., estimate of the precision of the standard error. The following analysis is with the complete data set.

Summary

When pooled over all data it was found to a very high level of confidence:

- Adjuvants; BS1000 had substantially more fines than all of the others which would result in greater production of spray drift. This verifies previous work done with Outlook Ag agronomists. PCLL8 and LI700 had the least however LI700 contains soyal phospholipids as an emulsion which limits it's wetting ability, proven by Outlook Ag and also by AWT with goniometry studies.
- BS1000 also had the widest distribution of spray size in that it had the largest volume >1000um
- Nozzles; the TTI60 Twin Jet nozzle had by far the least amount of finer particles. Albuz AVI had the smallest particle sizes.
- Herbicides; when the combination of Roundup Ready PL and Xtendimax was combined this produced the greatest volume of smaller droplets which would result in potentially greater drift.
- DRA's; Intact had the least amount of fines.

Given the previous work done by Outlook Ag and the research done at Dept Applied Mathematics at ANU as well as this wind tunnel study it has been clearly proven that:

- PCLL8 performs entirely differently to amphiphilic surfactants as proven by the dose effect caused by no micelle formation. This obviates the Marangoni Effect reducing the formation of fines. This is clearly shown out by the lack of difference between solutions without adjuvants to those with PCLL8.
- The dose effect also results in different rates of wetting.
- Surface tension alone is a poor predictor of wetting performance.
- This means that with PCLL8 there is no requirement for the use of DRA's
- The fundamental principle of DRA's is to maintain droplet integrity. This is done by coating the outside of the droplet with an immiscible liquid. This however inhibits the fundamental action of the adjuvant i.e. spreading and penetration and as a result the spray mix. They are also an additional cost, and usually result in higher spray mix volumes.

Trt No	Herbicide	Adjuvant	Drift reduction agent	Nozzle
1	Roundup Ready PL	No adjuvant	No DRA	AI11003
2	Xtendimax 2	No adjuvant	No DRA	AI11003
3	Roundup Ready PL + Xtendimax 2	No adjuvant	No DRA	AI11003
4	Roundup Ready PL	PCLL8	No DRA	AI11003
5	Xtendimax 2	PCLL8	No DRA	AI11003
6	Roundup Ready PL + Xtendimax 2	PCLL8	No DRA	AI11003
7	Roundup Ready PL	LI700	No DRA	AI11003
8	Xtendimax 2	LI700	No DRA	AI11003
9	Roundup Ready PL + Xtendimax 2	Li700	No DRA	AI11003
10	Roundup Ready PL	BS1000	No DRA	AI11003
11	Xtendimax 2	BS1000	No DRA	AI11003
12	Roundup Ready PL + Xtendimax 2	BS1000	No DRA	AI11003
13	Roundup Ready PL	No adjuvant	On Coarse FMC	AI11003
14	Xtendimax 2	No adjuvant	On Coarse FMC	AI11003
15	Roundup Ready PL + Xtendimax 2	No adjuvant	On Coarse FMC	AI11003
16	Roundup Ready PL	PCLL8	On Coarse FMC	AI11003
17	Xtendimax 2	PCLL8	On Coarse FMC	AI11003
18	Roundup Ready PL + Xtendimax 2	PCLL8	On Coarse FMC	AI11003
19	Roundup Ready PL	LI700	On Coarse FMC	AI11003
20	Xtendimax 2	LI700	On Coarse FMC	AI11003
21	Roundup Ready PL + Xtendimax 2	Li700	On Coarse FMC	AI11003
22	Roundup Ready PL	BS1000	On Coarse FMC	AI11003
23	Xtendimax 2	BS1000	On Coarse FMC	AI11003
24	Roundup Ready PL + Xtendimax 2	BS1000	On Coarse FMC	AI11003
25	Roundup Ready PL	No adjuvant	Intact Bayer	AI11003
26	Xtendimax 2	No adjuvant	Intact Bayer	AI11003
27	Roundup Ready PL + Xtendimax 2	No adjuvant	Intact Bayer	AI11003
28	Roundup Ready PL	PCLL8	Intact Bayer	AI11003
29	Xtendimax 2	PCLL8	Intact Bayer	AI11003
30	Roundup Ready PL + Xtendimax 2	PCLL8	Intact Bayer	AI11003
31	Roundup Ready PL	LI700	Intact Bayer	AI11003

32	Xtendimax 2	LI700	Intact Bayer	AI11003
33	Roundup Ready PL + Xtendimax 2	Li700	Intact Bayer	AI11003
34	Roundup Ready PL	BS1000	Intact Bayer	AI11003
35	Xtendimax 2	BS1000	Intact Bayer	AI11003
36	Roundup Ready PL + Xtendimax 2	BS1000	Intact Bayer	AI11003
37	Roundup Ready PL	No adjuvant	Gravitate 707	AI11003
38	Xtendimax 2	No adjuvant	Gravitate 707	AI11003
39	Roundup Ready PL + Xtendimax 2	No adjuvant	Gravitate 707	AI11003
40	Roundup Ready PL	PCLL8	Gravitate 707	AI11003
41	Xtendimax 2	PCLL8	Gravitate 707	AI11003
42	Roundup Ready PL + Xtendimax 2	PCLL8	Gravitate 707	AI11003
43	Roundup Ready PL	LI700	Gravitate 707	AI11003
44	Xtendimax 2	LI700	Gravitate 707	AI11003
45	Roundup Ready PL + Xtendimax 2	Li700	Gravitate 707	AI11003
46	Roundup Ready PL	BS1000	Gravitate 707	AI11003
47	Xtendimax 2	BS1000	Gravitate 707	AI11003
48	Roundup Ready PL + Xtendimax 2	BS1000	Gravitate 707	AI11003
49	Roundup Ready PL	No adjuvant	No DRA	TTI60 Twin Jet
50	Xtendimax 2	No adjuvant	No DRA	TTI60 Twin Jet
51	Roundup Ready PL + Xtendimax 2	No adjuvant	No DRA	TTI60 Twin Jet
52	Roundup Ready PL	PCLL8	No DRA	TTI60 Twin Jet
53	Xtendimax 2	PCLL8	No DRA	TTI60 Twin Jet
54	Roundup Ready PL + Xtendimax 2	PCLL8	No DRA	TTI60 Twin Jet
55	Roundup Ready PL	LI700	No DRA	TTI60 Twin Jet
56	Xtendimax 2	LI700	No DRA	TTI60 Twin Jet
57	Roundup Ready PL + Xtendimax 2	Li700	No DRA	TTI60 Twin Jet
58	Roundup Ready PL	BS1000	No DRA	TTI60 Twin Jet
59	Xtendimax 2	BS1000	No DRA	TTI60 Twin Jet
60	Roundup Ready PL + Xtendimax 2	BS1000	No DRA	TTI60 Twin Jet
61	Roundup Ready PL	No adjuvant	On Coarse FMC	TTI60 Twin Jet
62	Xtendimax 2	No adjuvant	On Coarse FMC	TTI60 Twin Jet
63	Roundup Ready PL + Xtendimax 2	No adjuvant	On Coarse FMC	TTI60 Twin Jet
64	Roundup Ready PL	PCLL8	On Coarse FMC	TTI60 Twin Jet
65	Xtendimax 2	PCLL8	On Coarse FMC	TTI60 Twin Jet

66	Roundup Ready PL + Xtendimax 2	PCLL8	On Coarse FMC	TTI60 Twin Jet
67	Roundup Ready PL	LI700	On Coarse FMC	TTI60 Twin Jet
68	Xtendimax 2	LI700	On Coarse FMC	TTI60 Twin Jet
69	Roundup Ready PL + Xtendimax 2	Li700	On Coarse FMC	TTI60 Twin Jet
70	Roundup Ready PL	BS1000	On Coarse FMC	TTI60 Twin Jet
71	Xtendimax 2	BS1000	On Coarse FMC	TTI60 Twin Jet
72	Roundup Ready PL + Xtendimax 2	BS1000	On Coarse FMC	TTI60 Twin Jet
73	Roundup Ready PL	No adjuvant	Intact Bayer	TTI60 Twin Jet
74	Xtendimax 2	No adjuvant	Intact Bayer	TTI60 Twin Jet
75	Roundup Ready PL + Xtendimax 2	No adjuvant	Intact Bayer	TTI60 Twin Jet
76	Roundup Ready PL	PCLL8	Intact Bayer	TTI60 Twin Jet
77	Xtendimax 2	PCLL8	Intact Bayer	TTI60 Twin Jet
78	Roundup Ready PL + Xtendimax 2	PCLL8	Intact Bayer	TTI60 Twin Jet
79	Roundup Ready PL	LI700	Intact Bayer	TTI60 Twin Jet
80	Xtendimax 2	LI700	Intact Bayer	TTI60 Twin Jet
81	Roundup Ready PL + Xtendimax 2	Li700	Intact Bayer	TTI60 Twin Jet
82	Roundup Ready PL	BS1000	Intact Bayer	TTI60 Twin Jet
83	Xtendimax 2	BS1000	Intact Bayer	TTI60 Twin Jet
84	Roundup Ready PL + Xtendimax 2	BS1000	Intact Bayer	TTI60 Twin Jet
85	Roundup Ready PL	No adjuvant	Gravitate 707	TTI60 Twin Jet
86	Xtendimax 2	No adjuvant	Gravitate 707	TTI60 Twin Jet
87	Roundup Ready PL + Xtendimax 2	No adjuvant	Gravitate 707	TTI60 Twin Jet
88	Roundup Ready PL	PCLL8	Gravitate 707	TTI60 Twin Jet
89	Xtendimax 2	PCLL8	Gravitate 707	TTI60 Twin Jet
90	Roundup Ready PL + Xtendimax 2	PCLL8	Gravitate 707	TTI60 Twin Jet
91	Roundup Ready PL	LI700	Gravitate 707	TTI60 Twin Jet
92	Xtendimax 2	LI700	Gravitate 707	TTI60 Twin Jet
93	Roundup Ready PL + Xtendimax 2	Li700	Gravitate 707	TTI60 Twin Jet
94	Roundup Ready PL	BS1000	Gravitate 707	TTI60 Twin Jet
95	Xtendimax 2	BS1000	Gravitate 707	TTI60 Twin Jet
96	Roundup Ready PL + Xtendimax 2	BS1000	Gravitate 707	TTI60 Twin Jet
97	Roundup Ready PL	No adjuvant	No DRA	Albuz AVI
98	Xtendimax 2	No adjuvant	No DRA	Albuz AVI
99	Roundup Ready PL + Xtendimax 2	No adjuvant	No DRA	Albuz AVI

100	Roundup Ready PL	PCLL8	No DRA	Albuz AVI
101	Xtendimax 2	PCLL8	No DRA	Albuz AVI
102	Roundup Ready PL + Xtendimax 2	PCLL8	No DRA	Albuz AVI
103	Roundup Ready PL	LI700	No DRA	Albuz AVI
104	Xtendimax 2	LI700	No DRA	Albuz AVI
105	Roundup Ready PL + Xtendimax 2	Li700	No DRA	Albuz AVI
106	Roundup Ready PL	BS1000	No DRA	Albuz AVI
107	Xtendimax 2	BS1000	No DRA	Albuz AVI
108	Roundup Ready PL + Xtendimax 2	BS1000	No DRA	Albuz AVI
109	Roundup Ready PL	No adjuvant	On Coarse FMC	Albuz AVI
110	Xtendimax 2	No adjuvant	On Coarse FMC	Albuz AVI
111	Roundup Ready PL + Xtendimax 2	No adjuvant	On Coarse FMC	Albuz AVI
112	Roundup Ready PL	PCLL8	On Coarse FMC	Albuz AVI
113	Xtendimax 2	PCLL8	On Coarse FMC	Albuz AVI
114	Roundup Ready PL + Xtendimax 2	PCLL8	On Coarse FMC	Albuz AVI
115	Roundup Ready PL	LI700	On Coarse FMC	Albuz AVI
116	Xtendimax 2	LI700	On Coarse FMC	Albuz AVI
117	Roundup Ready PL + Xtendimax 2	Li700	On Coarse FMC	Albuz AVI
118	Roundup Ready PL	BS1000	On Coarse FMC	Albuz AVI
119	Xtendimax 2	BS1000	On Coarse FMC	Albuz AVI
120	Roundup Ready PL + Xtendimax 2	BS1000	On Coarse FMC	Albuz AVI
121	Roundup Ready PL	No adjuvant	Intact Bayer	Albuz AVI
122	Xtendimax 2	No adjuvant	Intact Bayer	Albuz AVI
123	Roundup Ready PL + Xtendimax 2	No adjuvant	Intact Bayer	Albuz AVI
124	Roundup Ready PL	PCLL8	Intact Bayer	Albuz AVI
125	Xtendimax 2	PCLL8	Intact Bayer	Albuz AVI
126	Roundup Ready PL + Xtendimax 2	PCLL8	Intact Bayer	Albuz AVI
127	Roundup Ready PL	LI700	Intact Bayer	Albuz AVI
128	Xtendimax 2	LI700	Intact Bayer	Albuz AVI
129	Roundup Ready PL + Xtendimax 2	Li700	Intact Bayer	Albuz AVI
130	Roundup Ready PL	BS1000	Intact Bayer	Albuz AVI
131	Xtendimax 2	BS1000	Intact Bayer	Albuz AVI
132	Roundup Ready PL + Xtendimax 2	BS1000	Intact Bayer	Albuz AVI
133	Roundup Ready PL	No adjuvant	Gravitate 707	Albuz AVI

134	Xtendimax 2	No adjuvant	Gravitate 707	Albuz AVI
135	Roundup Ready PL + Xtendimax 2	No adjuvant	Gravitate 707	Albuz AVI
136	Roundup Ready PL	PCLL8	Gravitate 707	Albuz AVI
137	Xtendimax 2	PCLL8	Gravitate 707	Albuz AVI
138	Roundup Ready PL + Xtendimax 2	PCLL8	Gravitate 707	Albuz AVI
139	Roundup Ready PL	LI700	Gravitate 707	Albuz AVI
140	Xtendimax 2	LI700	Gravitate 707	Albuz AVI
141	Roundup Ready PL + Xtendimax 2	Li700	Gravitate 707	Albuz AVI
142	Roundup Ready PL	BS1000	Gravitate 707	Albuz AVI
143	Xtendimax 2	BS1000	Gravitate 707	Albuz AVI
144	Roundup Ready PL + Xtendimax 2	BS1000	Gravitate 707	Albuz AVI
	Product	Rate		
	Roundup Ready PL	1.9 L/ha		
	XtendiMax 2	1.17 L/ha		
	Gravitate 707	500ml/100L	0.5	
	Intact	500ml/100L	0.5	
	On Coarse	250ml/100L	0.25	
	PCLL8	50ml/100L	0.05	
	BS1000	125ml/100L	0.125	
	Li700	250ml/100L	0.25	

The emission droplet size data for each treatment are summarised in the following tables where Dv10, 50 and 90 are the respective droplet diameters at which 10, 50 and 90% of the spray volume is contained in smaller droplets and the spray percentage volume in droplets smaller than 50, 100, 150 and 200 microns are listed in subsequent rows. Average values are weighted based on the proportional spray volume values at each part of the spray traverse.