Atomization Models for Actual Tank Mixes

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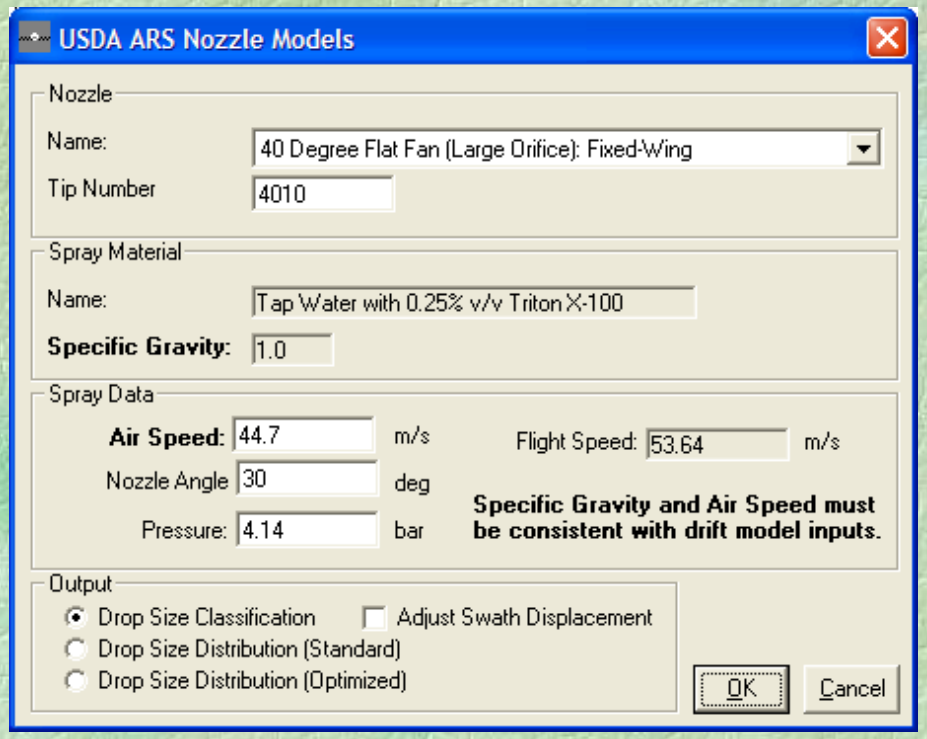
Droplet Size Data Application

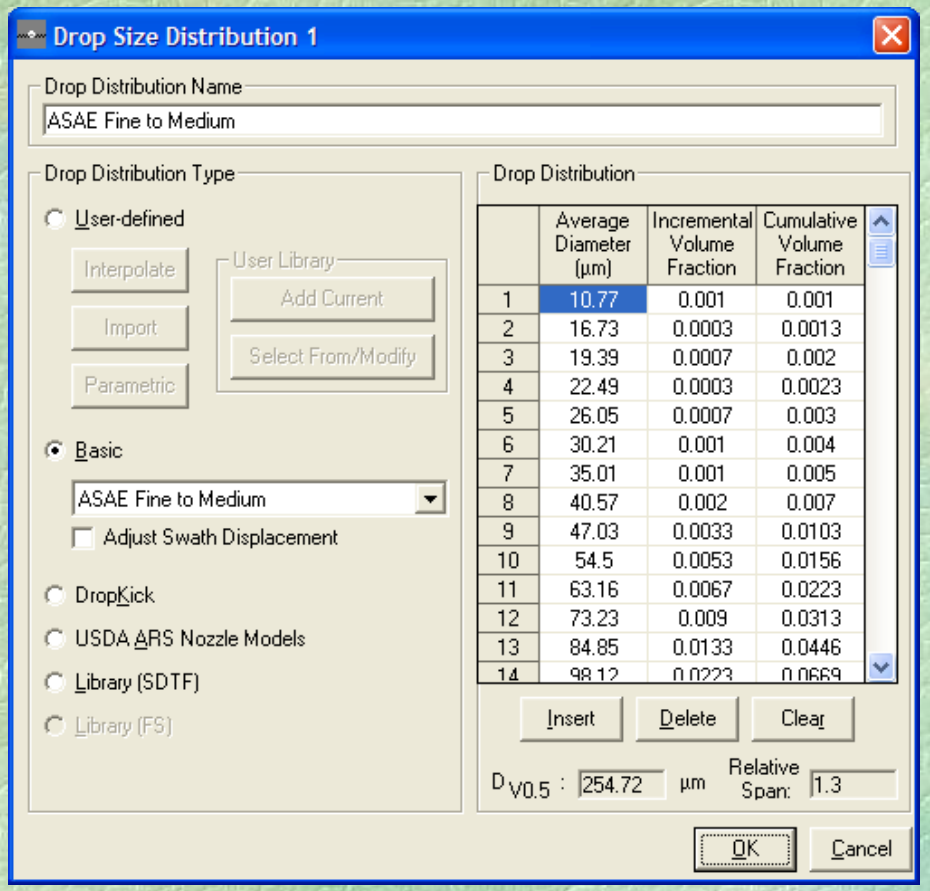
- Important for product performance and efficacy
- Primary input for drift and application modeling, e.g. using AGDISP/ AgDRIFT
- Specified on increasing number of pesticide labels

Droplet Size Models

- USDA ARS – aerial models
- SDTF – DropKick within AgDRIFT
- Jones Air – JARBA
- ASC models
- Unimiser model
- Micronair models – SERG, Cotton Research Council, Micronair

Many Models Included in AGDISP/ AgDRIFT



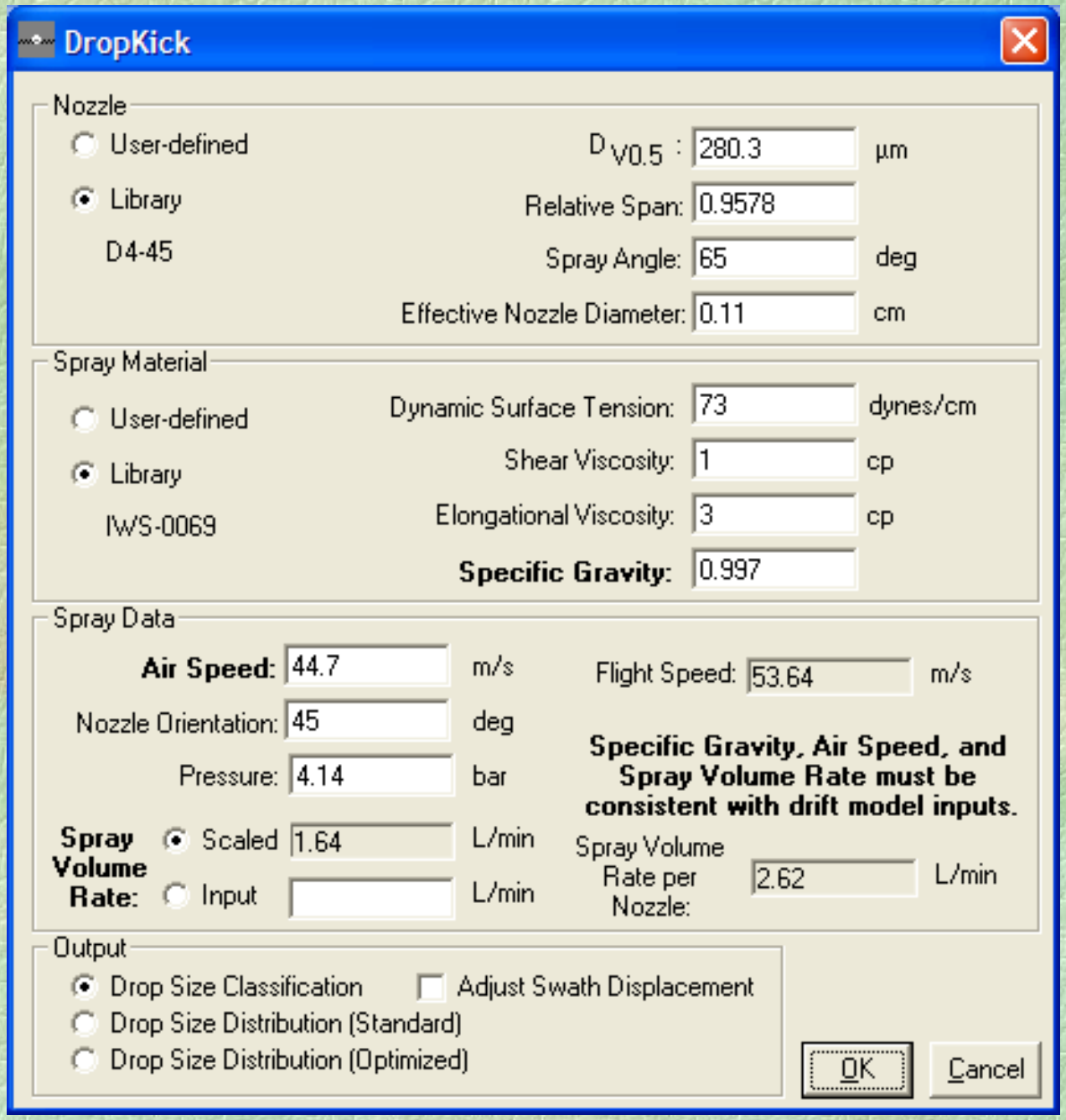


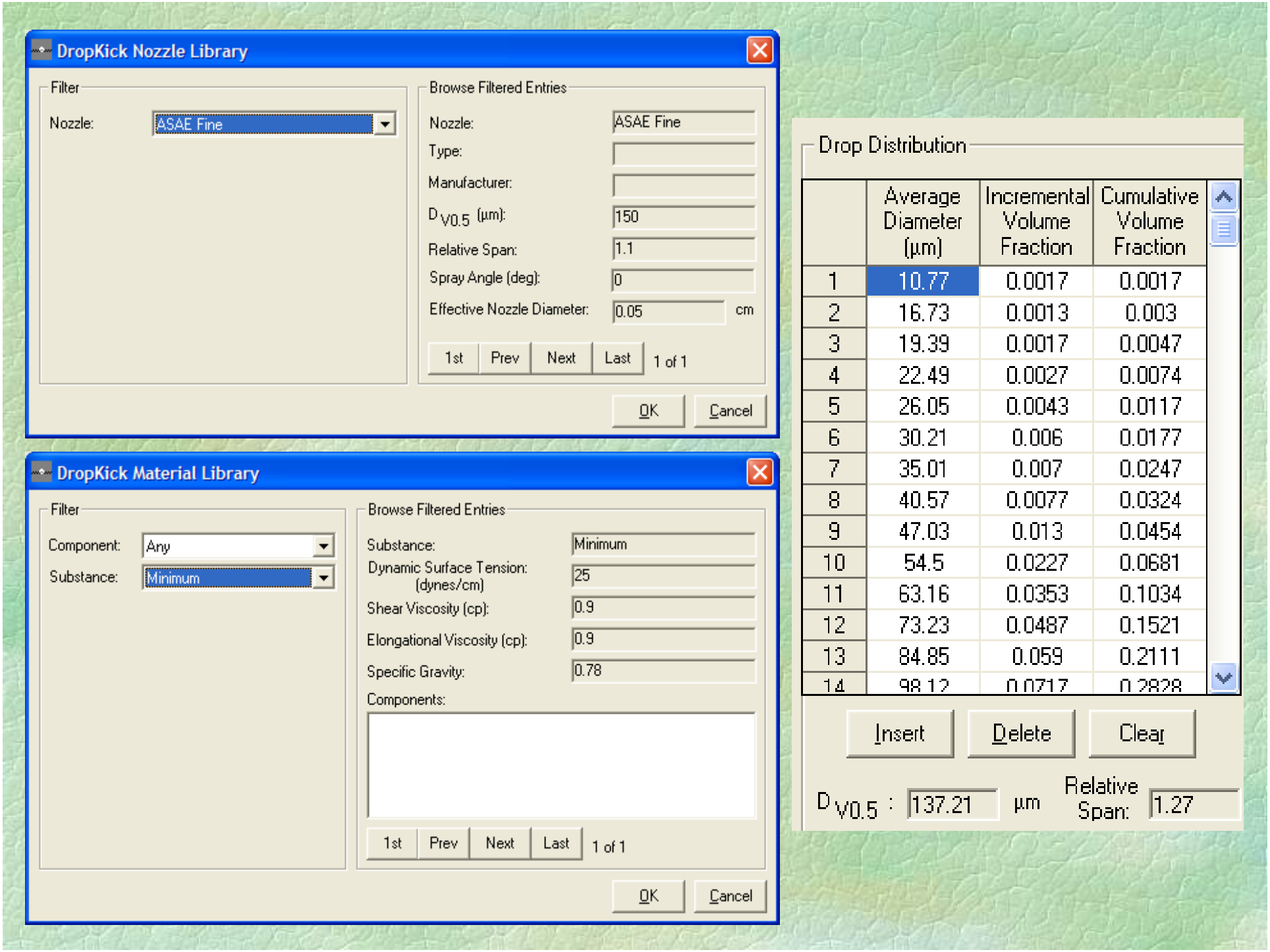
USDA Models

- Models for specific nozzle types in aerial applications with water+surfactant for PMS data
- **http://apmru.usda.gov** Downloads
- Additional models being developed for all major nozzle types
- Also included in AgDRIFT and AGDISP

DropKick

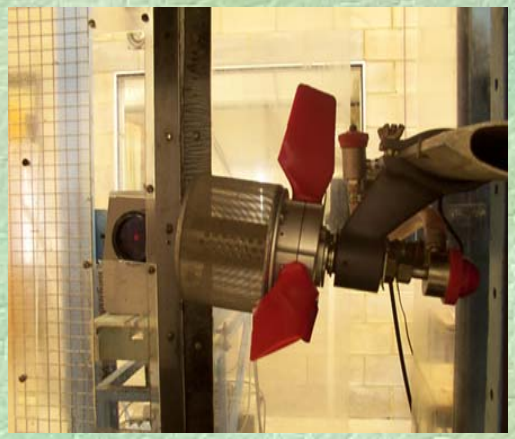
- Included in AgDRIFT (but not AGDISP)
- Covers wide range of hydraulic nozzles and tank mixes, but needs complete validation still and comparison with other models
- Provides estimate only, for approximate “ballpark” idea of droplet size spectrum


DropKick
Nozzle
User-defined
Library
D4-45
$D_{V0.5}$: 280.3 µm
Relative Span: 0.9578
Spray Angle: 65 deg
Effective Nozzle Diameter: 0.11 cm
Spray Material
User-defined
Library
IWS-0069
Dynamic Surface Tension: 73 dynes/cm
Shear Viscosity: 1 cp
Elongational Viscosity: 3 cp
Specific Gravity: 0.997
Spray Data
Air Speed: 44.7 m/s
Flight Speed: 53.64 m/s
Nozzle Orientation: 45 deg
Pressure: 4.14 bar
Specific Gravity, Air Speed, and Spray Volume Rate must be consistent with drift model inputs.
Spray Volume Rate:
Scaled 1.64 L/min
Input L/min
Spray Volume Rate per Nozzle: 2.62 L/min
Output
Drop Size Classification
Adjust Swath Displacement
Drop Size Distribution (Standard)
Drop Size Distribution (Optimized)
OK
Cancel


DropKick Nozzle Library
Filter
Nozzle:
ASAE Fine
Browse Filtered Entries
Nozzle:
ASAE Fine
Type:
Manufacturer:
D V0.5 (µm):
150
Relative Span:
1.1
Spray Angle (deg):
0
Effective Nozzle Diameter:
0.05
cm
1st
Prev
Next
Last
1 of 1
OK
Cancel
DropKick Material Library
Filter
Component:
Any
Substance:
Minimum
Browse Filtered Entries
Substance:
Minimum
Dynamic Surface Tension: (dynes/cm)
25
Shear Viscosity (cp):
0.9
Elongational Viscosity (cp):
0.9
Specific Gravity:
0.78
Components:
1st
Prev
Next
Last
1 of 1
OK
Cancel
Drop Distribution
Average Diameter (µm)
Incremental Volume Fraction
Cumulative Volume Fraction
1 10.77 0.0017 0.0017
2 16.73 0.0013 0.003
3 19.39 0.0017 0.0047
4 22.49 0.0027 0.0074
5 26.05 0.0043 0.0117
6 30.21 0.006 0.0177
7 35.01 0.007 0.0247
8 40.57 0.0077 0.0324
9 47.03 0.013 0.0454
10 54.5 0.0227 0.0681
11 63.16 0.0353 0.1034
12 73.23 0.0487 0.1521
13 84.85 0.059 0.2111
14 98.12 0.0717 0.2828
Insert
Delete
Clear
D V0.5 : 137.21 µm
Relative Span: 1.27

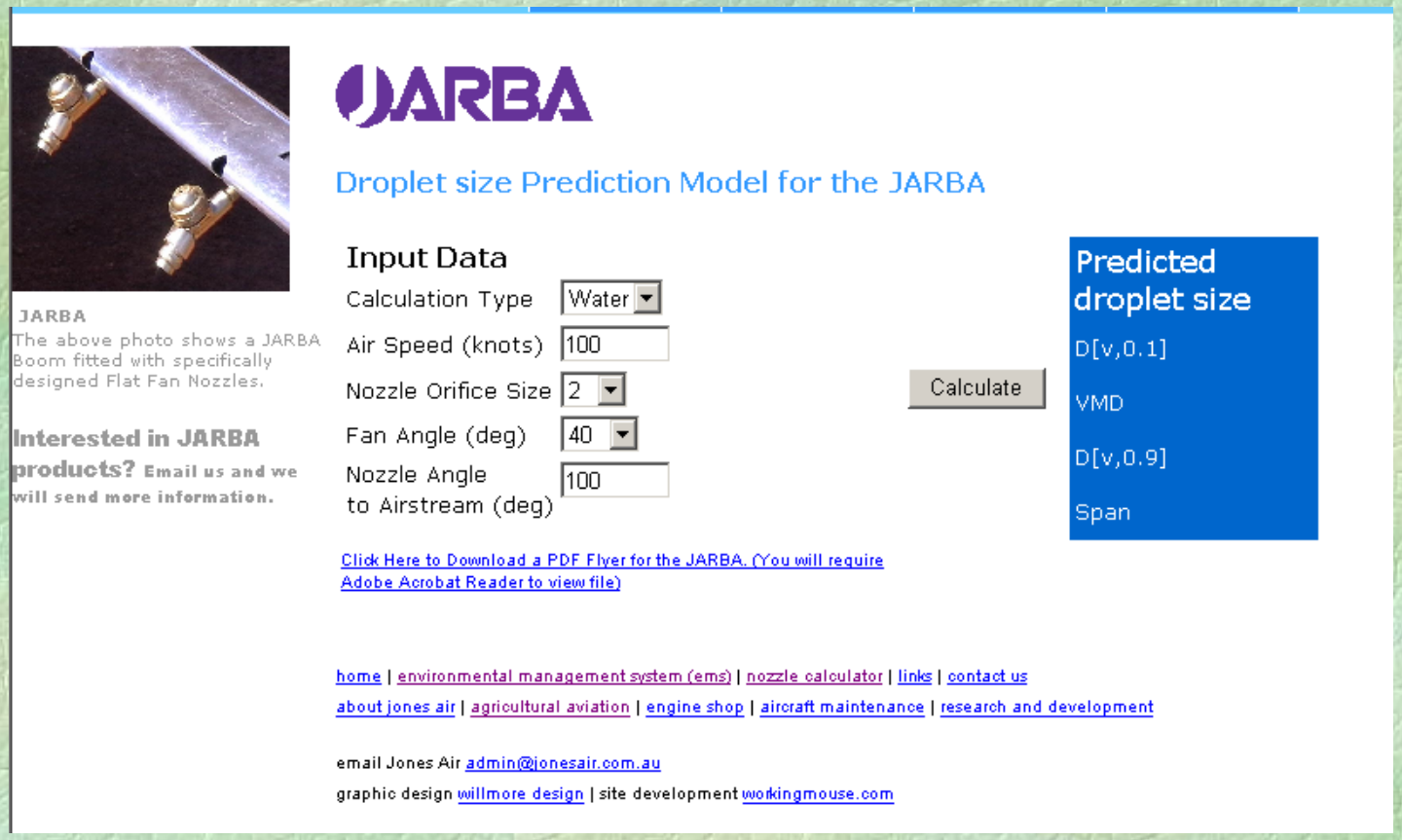
UQ Atomization Models

- Wind tunnel data being used to develop range of atomization models compatible with other droplet size data from SDTF etc (Malvern, same wind tunnel)
- Extensive rotary atomizer and active tank mix/ adjuvant modeling



JARBA Rotating Boom

- http://www.jonesair.com.au/Nozzlecalc
- Only system currently offering means to control droplet size in-flight to insure meeting label requirements as conditions change



Unimiser Rotary Screen Atomizer

Cotton Research & Development

UNISPRAY PTY LTD.

Droplet Size Prediction Model for the UNIMISER Nozzle

Results Based on Water

Input data	
Air Speed (knots)	75
Flowrate (L/min/nozzle)	10
Wet Nozzle Rotational Speed (rpm)	4800

Predicted droplet size	
D[v,0.1]	158
VMD	240
D[v,0.9]	350
Span	0.80
Spray Quality	Medium

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ASC Rotary Drum Atomizers

Droplet Size Prediction Model for the ASC A-10 Nozzle

CURTIS DYNA-FOG Ltd
Innovators of Spraying and Fogging Technology Since 1947

Input data	
Formulation	Water
Air Speed (knots)	120
Flowrate (L/min/nozzle)	8
Blade setting	4
Dry Nozzle Rotational Speed (rpm)	5022

Predicted droplet size	
D[v,0.1]	54
VMD	140
D[v,0.9]	234
Span	1.28
Spray Quality	Fine

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2,4-D Droplet Size Calculator for AAAA's: Methods

- Measure droplet size in wind tunnel for hundreds of combinations of application and tank mix parameters
- Nozzles: flat fan size 4010, 4015, 4020, 4030
  CP with 0, 5 and 30º deflectors
- Angles of 0 and 20º back from airstream
- Spray pressures between 2 and 4bar
- Simulated aircraft speeds of 100, 120, 140knots
- Water and two 2,4-D formulations at different rates
- Two "drift control/ deposition aid" adjuvants

Droplet Size Measurement

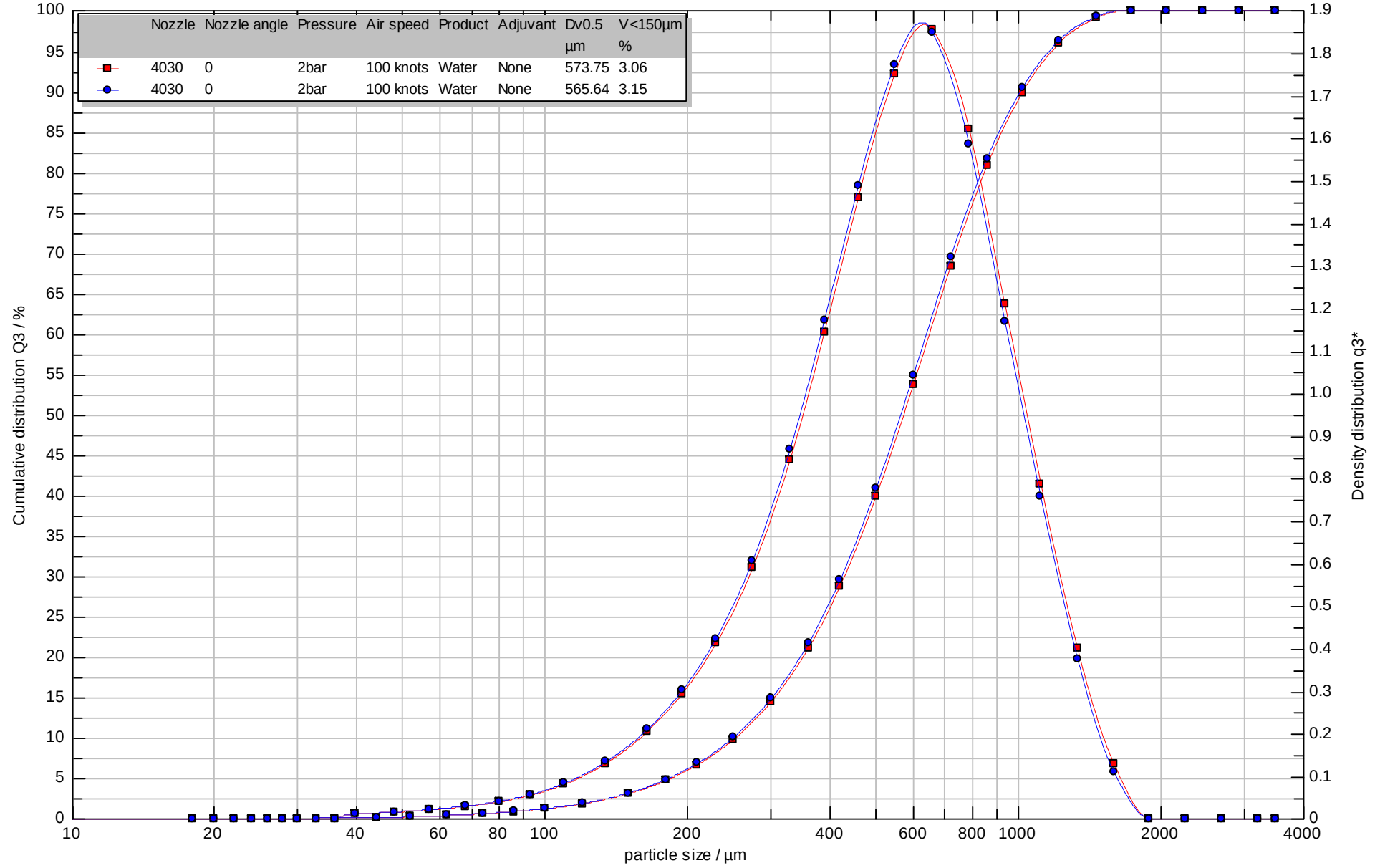
- Sympatec HELOS Vario droplet sizer measuring 0.5 to 3500µm
- Vertical traverse of spray relative to laser for representative cross-section average sampling
- Replicate measurements

Modeling

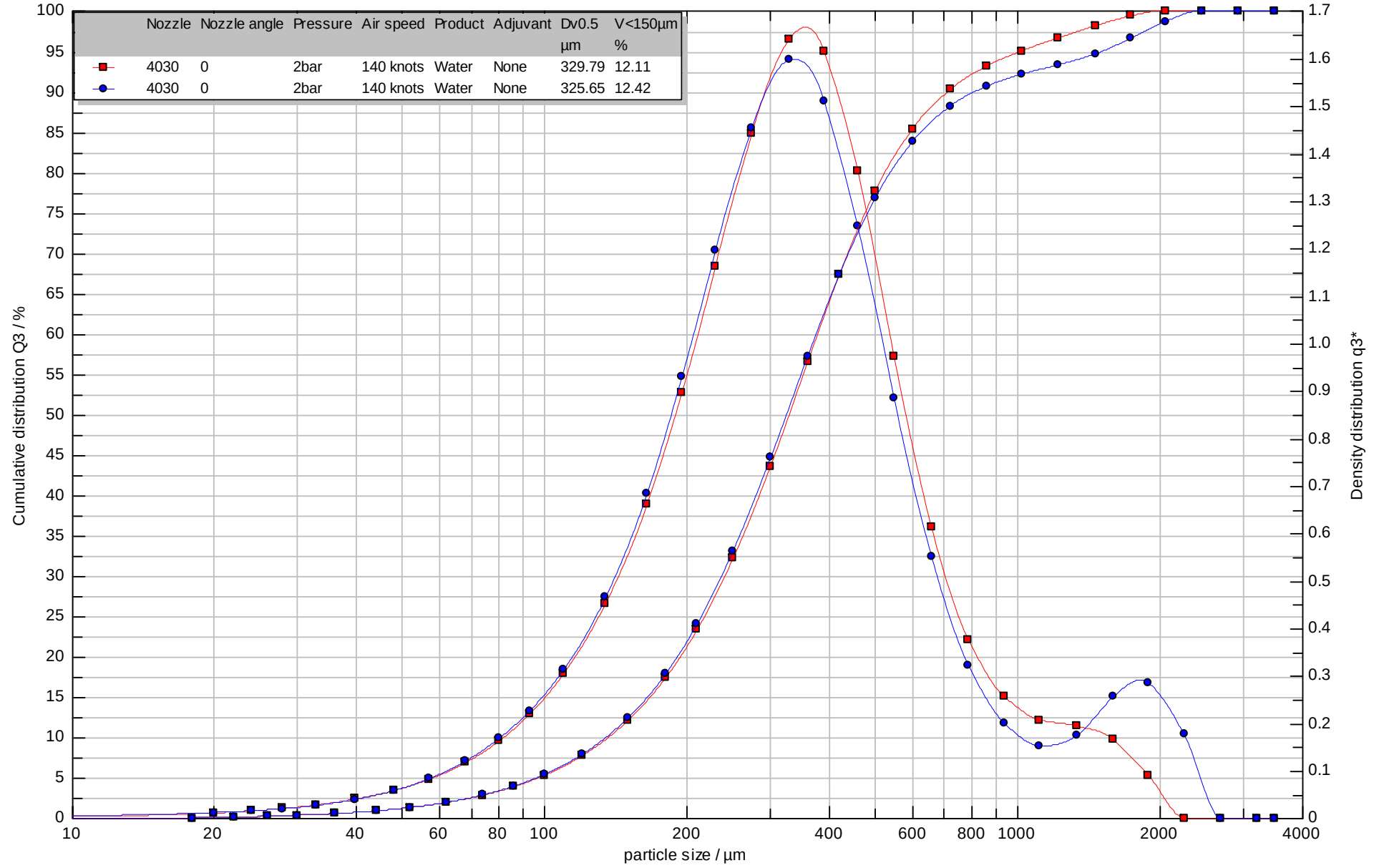
- Multiple linear regression analysis of dependent variables (droplet size parameters $D_{v0.1}$, $D_{v0.5}$, $D_{v0.9}$ and Fines %Vol<150µm) against independent variables speed, angle, pressure, orifice size etc for each tank mix for droplet size predictions
- Genstat® version 7 software

Results

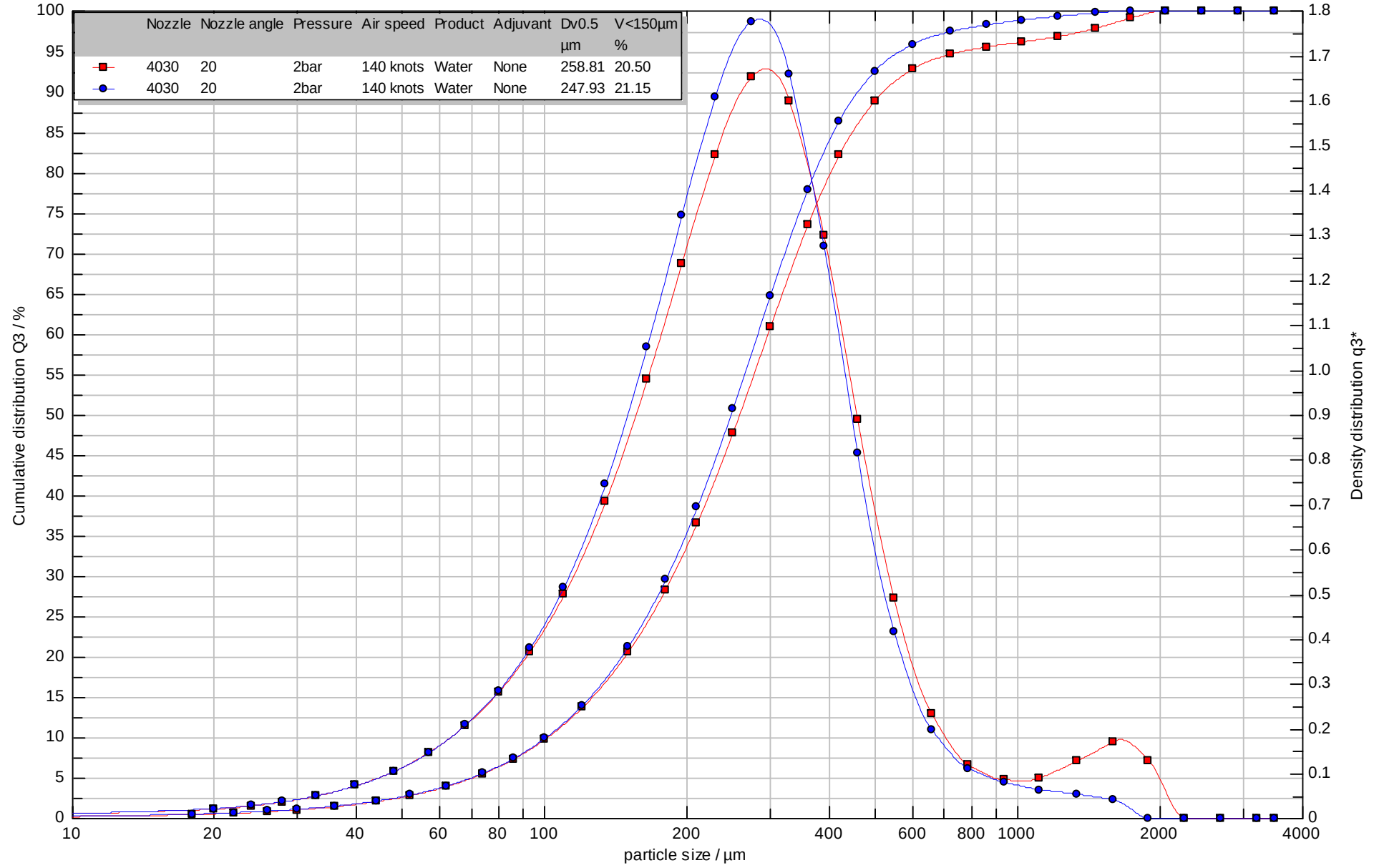
- Good agreement between replicate measurements
- Sprays became coarser with larger orifice size, slower aircraft speed, narrower nozzle angle and (for narrow angle nozzles) higher pressure
- Sprays coarser for higher rates of water – i.e. with greater dilution
- Polymeric adjuvants increased the $D_{v0.5}$ values but also increased the fines
- With this measurement system, “Coarse” is generally anything with “fines” below ~9% (actual value to be confirmed…it can vary depending on measurement system, e.g. range might be 6-12%)


Nozzle | Nozzle angle | Pressure | Air speed | Product | Adjuvant | Dv0.5 µm | V<150µm %
4030 | 0 | 2bar | 100 knots | Water | None | 573.75 | 3.06
4030 | 0 | 2bar | 100 knots | Water | None | 565.64 | 3.15
Cumulative distribution Q3 / %
Density distribution q3*
particle size / µm
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
10
20
40
60
80
100
200
400
600
800
1000
2000
4000

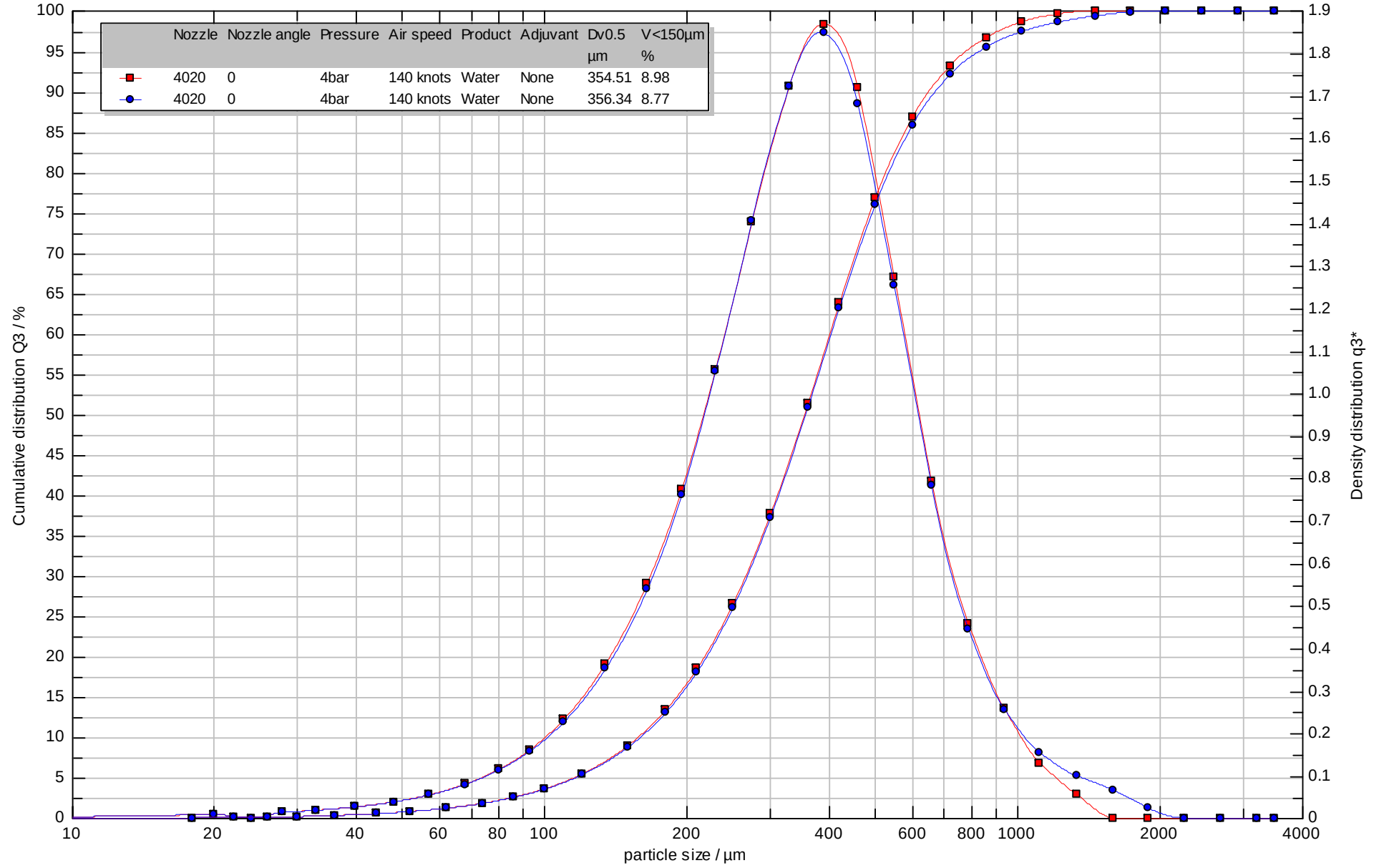
Effect of Aircraft Speed (100-140kn): 3% to 12% Fines



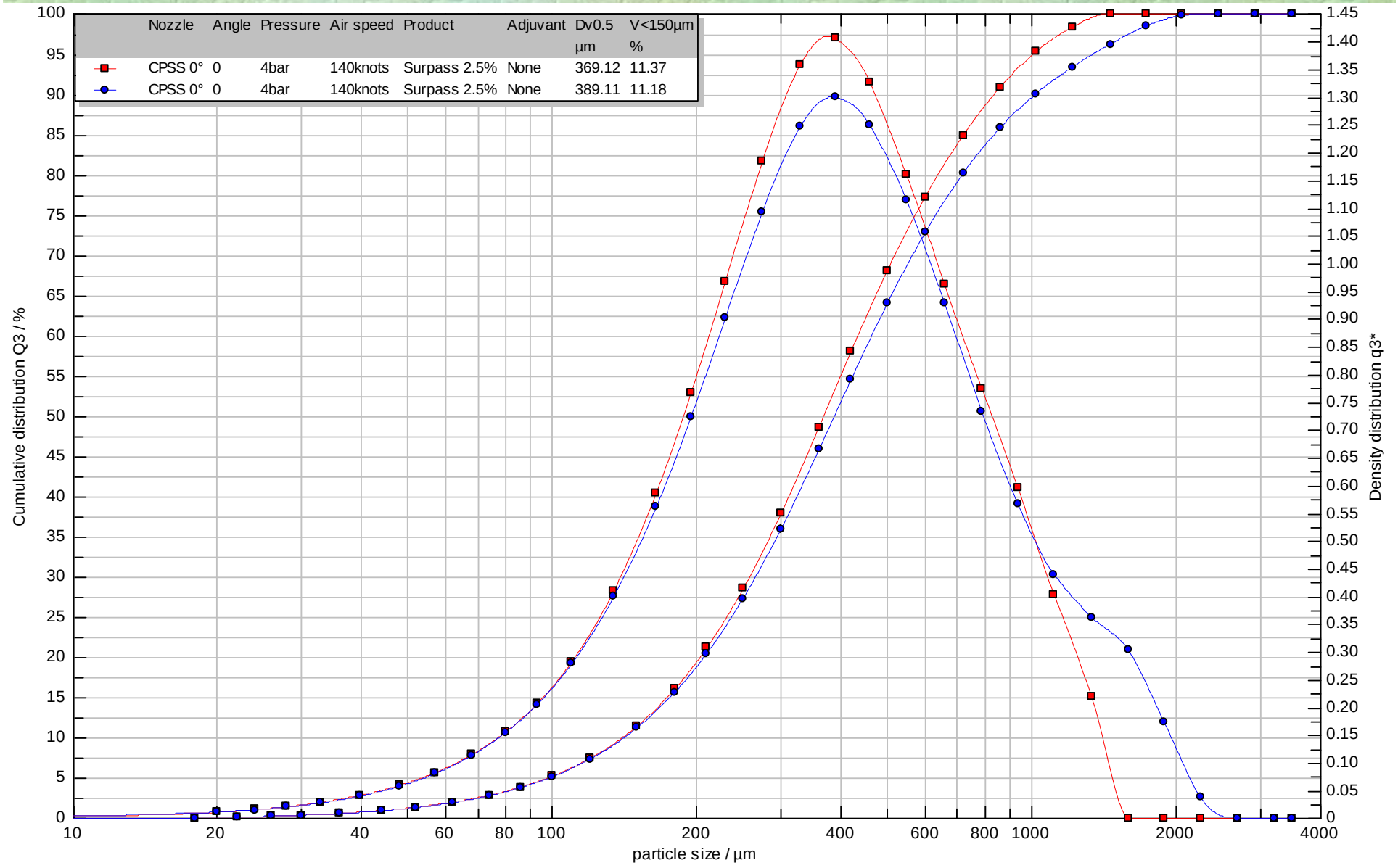
Effect of Nozzle Angle (0 to 20°): 12% to 21% Fines



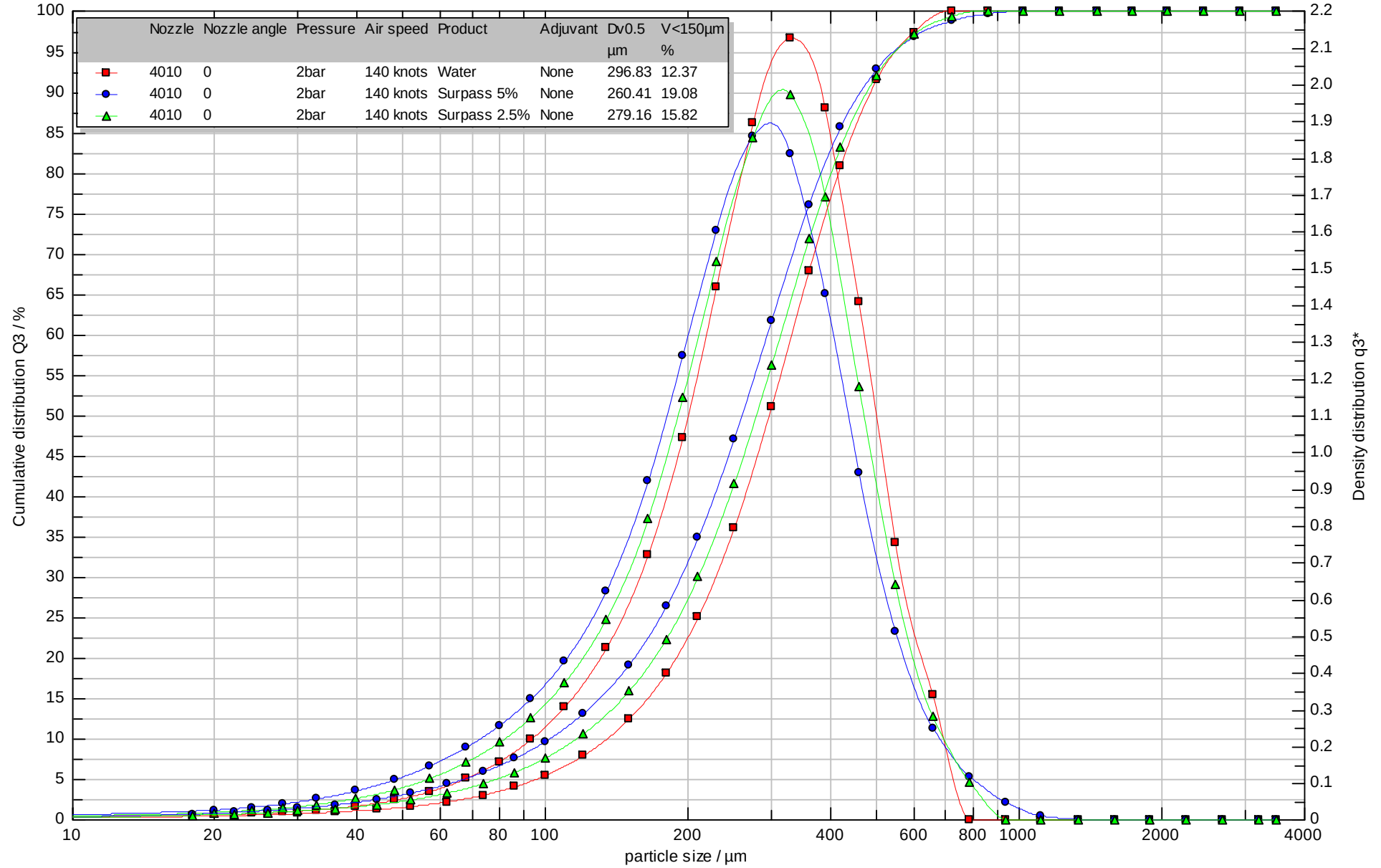
Effect of Spray Pressure (2 to 4bar): 12% to 9% Fines



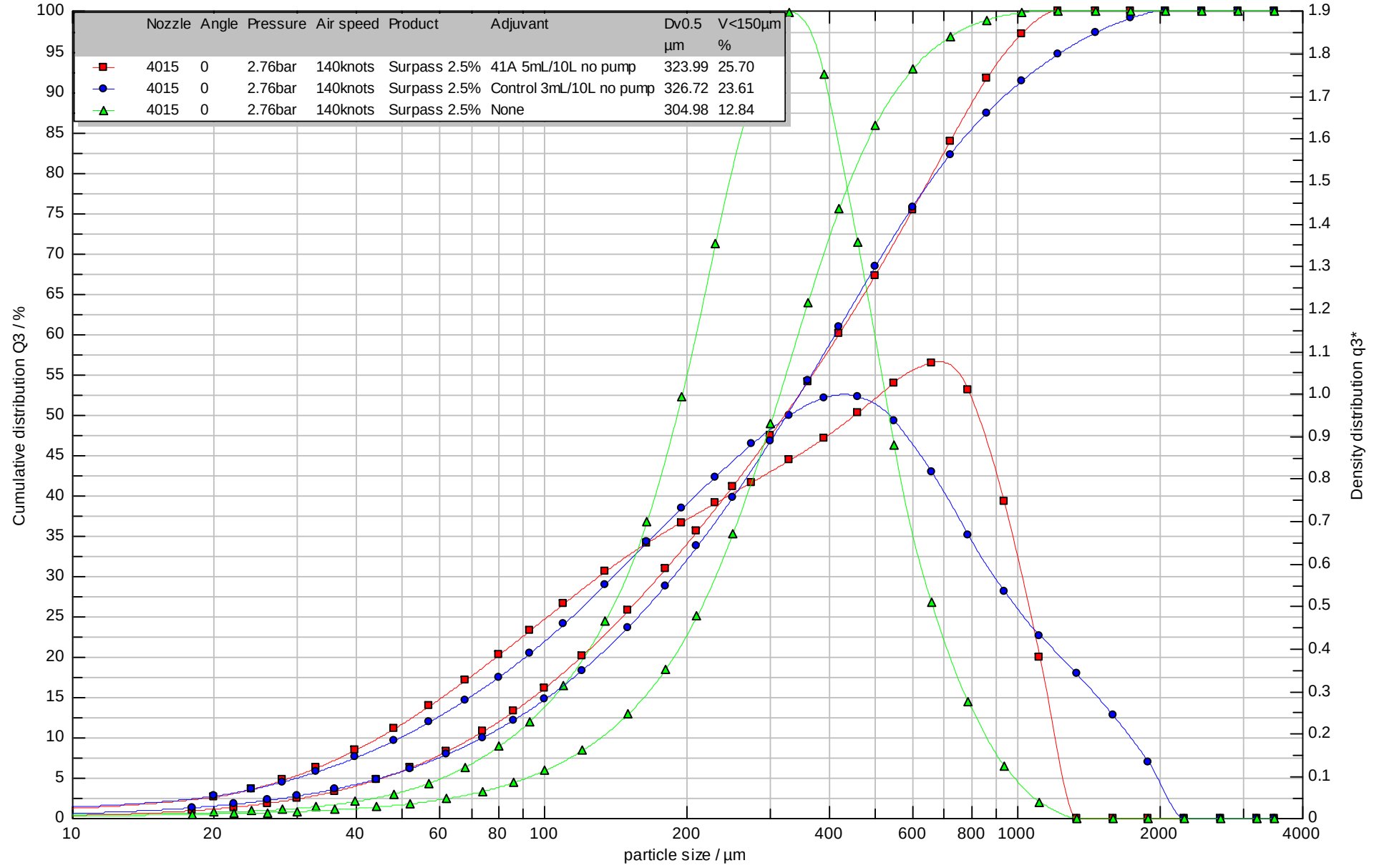
Solid Stream Nozzle



Effect of Tank Mix Rate



Effect of Polymer Increasing Fines



Example of Droplet Size Calculator

Nozzle Calculator for 2,4-D

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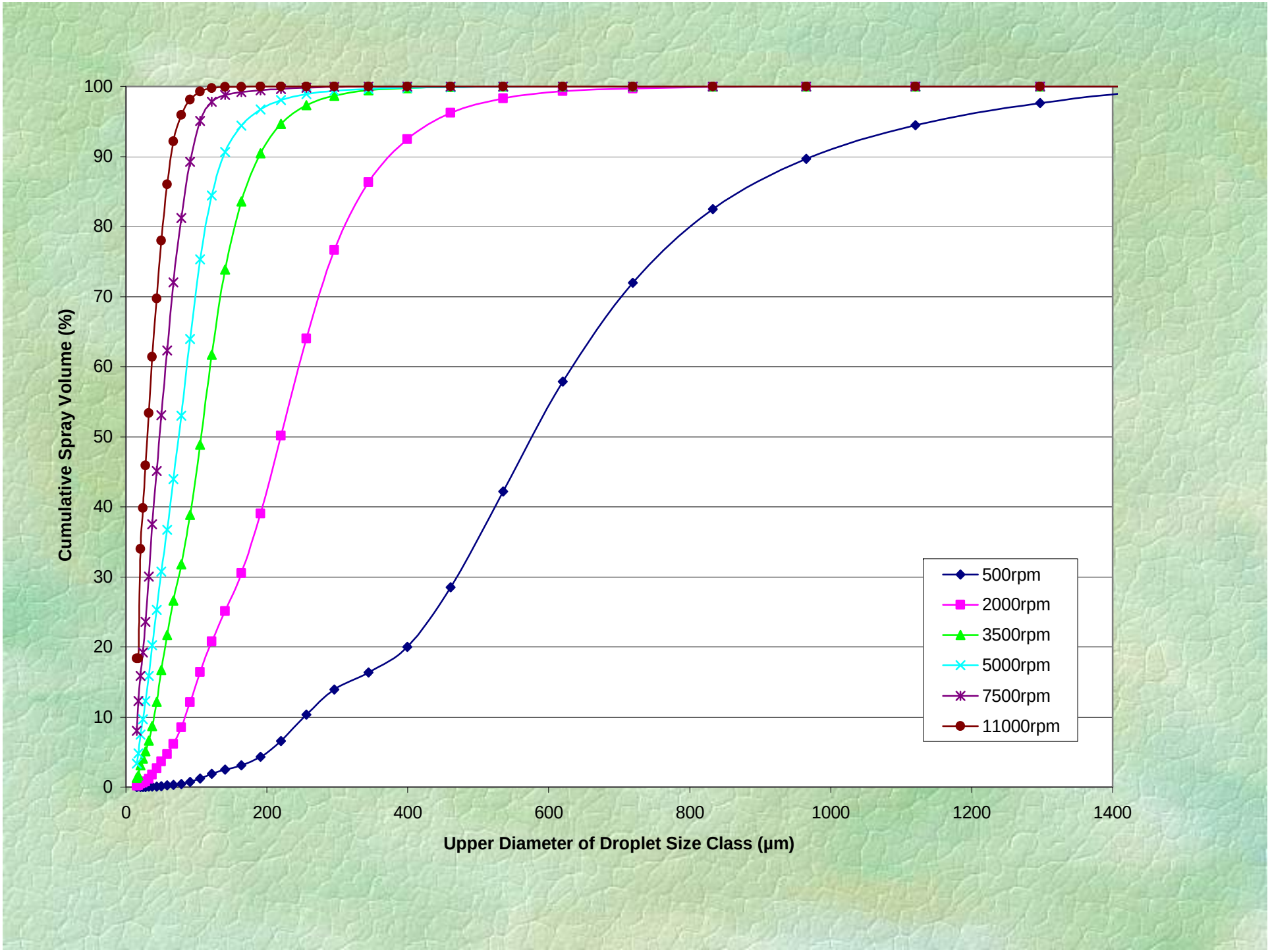
Input data	
Air Speed (knots)	120
Product	Water
Nozzle Type	40° Flat Fan
Orifice Size	10
Pressure (bar)	4
Nozzle Angle	0

Predicted droplet size			
D[v,0.1]	192		Coarse
VMD	425		Coarse
D[v,0.9]	737		Coarse
Fines (<150µm)	7.4	%	
Spray Quality			Coarse

Recommendations

- Up to 120-130knots, can obtain Coarse sprays with all nozzles tested under most conditions (except do not use 20º angle or 30º deflector)
- Use higher pressure with narrow angle nozzles (e.g. 4bar coarser than 2bar)
- Avoid use of polymer adjuvants
- Use more dilute sprays where possible (e.g. 2.5% rather than 5% rate of 2,4-D)
- At highest aircraft speeds (140kn), there are fewer options and some additional ones might be worth testing (e.g. multiple orifice solid stream or different nozzles, higher pressures, alternative adjuvant chemistries, reverse venturi chamber)

- Observe all normal good application practices to avoid drift – droplet size is not the only approach to drift management


Cumulative Spray Volume (%)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
Upper Diameter of Droplet Size Class (µm)
500rpm
2000rpm
3500rpm
5000rpm
7500rpm
11000rpm

Micronair AU5000

MICRONAIR

AU5000 ATOMISER
Droplet Size Prediction Model

Calculate flow per atomiser?	Yes	
Application rate	20	L/ha
Number of atomisers	12	
Track spacing	20	metres
Calculated flow per atomiser	5.1	L/min
Formulation	Water	
Air speed	50	Knots
Is RPM transducer fitted?	No	
Blade angle	55	degrees
Blade type	EX2021/2 Long	
Atomiser rotational speed (spraying)	2,248	RPM

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PREDICTED DROPLET SIZE (µm)

D[v,0.1]	85
VMD	257
D[v,0.9]	481
Rel. Span	1.54

Click on yellow cells to select options

Enter data in grey cells

Conclusions

- Many droplet size models available, and many under development
- Example presented of models for Micronair rotary cage atomisers with wide range of application and tank mix conditions
- Need to standardize outputs for input to AGDISP and other models
- Consider range of tank mixes covered by future models