CPAS
Electrostatic Evaluation
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The Centre for Pesticide Application and Safety

Final Report

Field Evaluation and Droplet Spectrum Analysis
For the Spectrum Electrostatic System for use in Cotton

The Centre for Pesticide Application and Safety is a national scientific research and training group that provides a wide range of research and consultancy services to industry and government in pesticide application technology

Project Manager: Bill Gordon

Centre Staff Involved

BILL GORDON BAppSci, PGDipAppSci(Ag), GDipEd, GDipRurSysMan(Ext), ADLT(Chem).	Senior Research Officer
JAMIE NICHOLLS PhD, BScAgr	Senior Research Officer
GARY DORR BEng(Agric) PGDip(App Sc)	Senior Research Assistant
SUMMER GAVAN	Research Assistant
MURRAY BYRNES	Research Assistant

The Centre for Pesticide Application and Safety
University of Queensland Gatton
Queensland 4343 Australia

Tel : (07) 5460 1293
Fax : (07) 5460 1283

Email: b.gordon@mailbox.uq.edu.au
jamie.nicholls@mailbox.uq.edu.au

CPAS Project Number: 644

Part 1: Field Evaluation of Electrostatic Nozzles Fitted to an Agricultural Aircraft.

OBJECTIVE:

To conduct a preliminary evaluation of the deposition characteristics onto mature cotton plants and the associated drift profile of an electrostatic application system fitted to an aircraft, and compare it with an application system currently used in commercial practice.

METHODOLOGY: (Overview):

This single trial was conducted to compare the same aircraft fitted with the 'spectrum' electrostatic system operating at 10 L/ha with a micronair AU5000 rotary atomisers operating at 30 L/ha (as an example of commercial practice). The evaluation was conducted on a mature cotton field (just prior to defoliation).
Deposition of a fluorescent dye was measured on leaves from various zones within the crop canopy and on artificial collectors within the field and on drift arrays located downwind from the field. Amounts of dye were quantitatively measured using fluorometric techniques and analysed using a standard one-way analysis of variance and calculations of the coefficient of variation CV.

Design: A single, unreplicated, three whole plots (intensive sampling within each).

Treatment Details:

Treatment 1: (Electrostatics ON at 10L/ha)

Helios® 500 SC fluorescent dye was applied at approximately 10 gai/ha in water using a CESSNA T188C AIRCRAFT supplied and setup by Gwydir Air Moree.

The aircraft was fitted with 80 electrostatic nozzles setup to deliver a total volume of 10 L/ha at an airspeed of approx 54 m/sec producing a VMD of 150-160 microns.

The electrostatic charge will be TURNED ON for this treatment.
Swath width: 15 m. Number of swaths: 10

Treatment 2: (Electrostatics OFF at 10L/ha)

Helios® 500 SC fluorescent dye was applied at approximately 10 gai/ha in water using a CESSNA T188C AIRCRAFT supplied and setup by Gwydir Air Moree.

The aircraft will be fitted with 80 electrostatic nozzles setup to deliver a total volume of 10 L/ha at an airspeed of approx 54 m/sec producing a VMD of 150-60 microns.

The electrostatic charge will be TURNED OFF for this treatment.
Swath width 15 m. Number of swaths: 10

Treatment 3: (Micronair at 30 L/ha)

Helios® 500 SC fluorescent dye was applied at 25 gai/ha in water using a CESSNA T188C AIRCRAFT supplied and setup by Gwydir Air Moree.

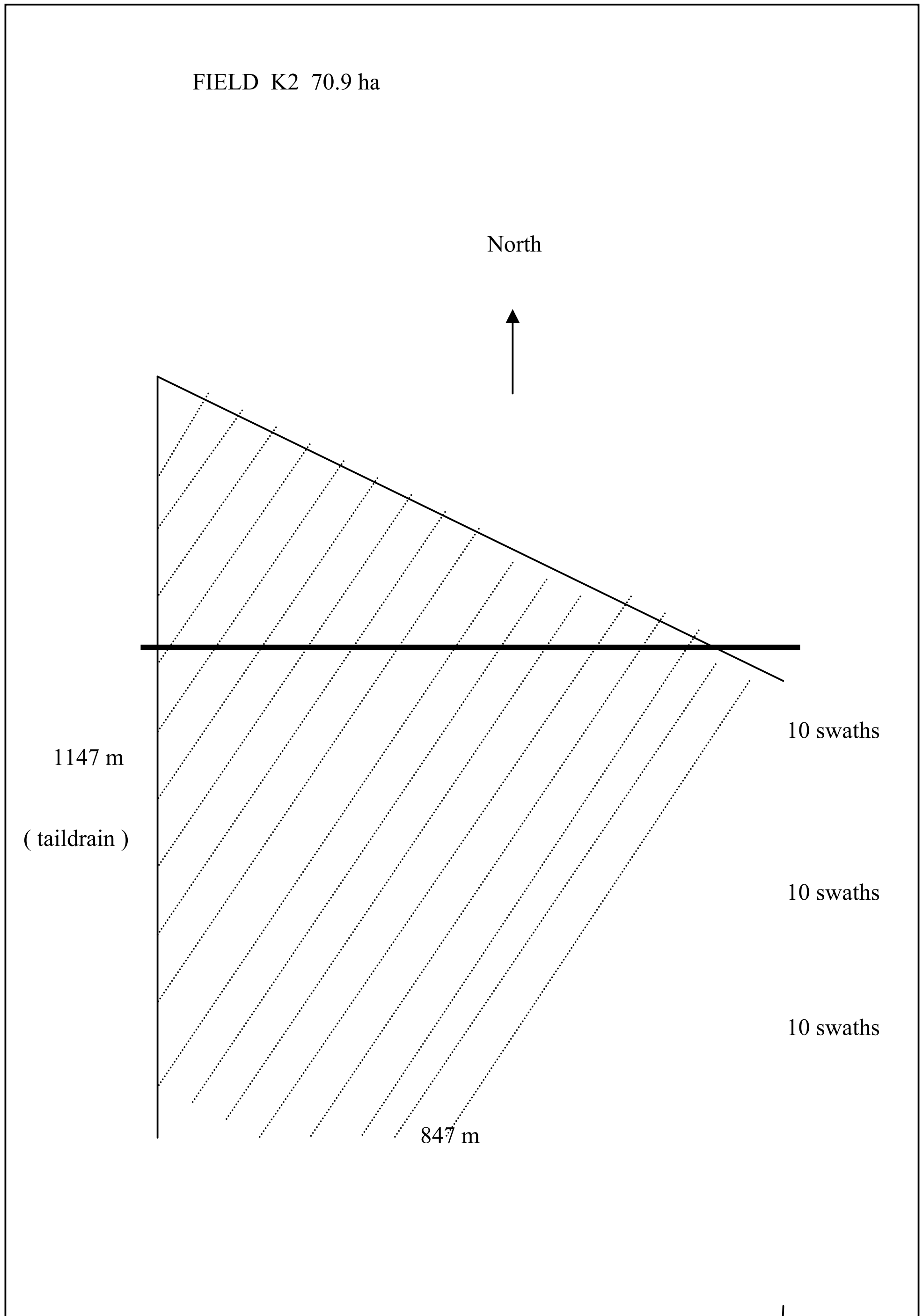
The aircraft will be fitted with 8 micronair AU5000 rotary atomisers setup to deliver a total volume of 20 L/ha at an airspeed of approx 54 m/sec producing a VMD of 150-160 microns.

Location / Cooperator: Moree, Property CAROALE/KERN

The Electrostatic On Treatment in use during the trial

The aircraft fitted with the 80 spectrum electrostatic nozzles prior to the trial

Overall Trial Layout



Trt 2 electrostatics off
10 L/ha

SAMPLING METHOD

Deposition onto leaves.

For each of the three treatments leaves were collected from ten locations within centre two swaths of each treatment (two rows of five sampling positions).

5m 5m 5m 5m
X X X X X

X X X X X
5m 5m 5m 5m

At each location of the ten locations, leaves were collected from each of the 3 positions on the cotton plants, those being:

> The Upper (leaves from the top 4 nodes),
> The Mid (leaves from the outer part of canopy adjacent to first fruit retention) and
> The Inner (Inner part of plant adjacent to the mid).

At each of the ten locations, artificial collectors were also used to sample deposition and assess the CV both above and within the canopy.

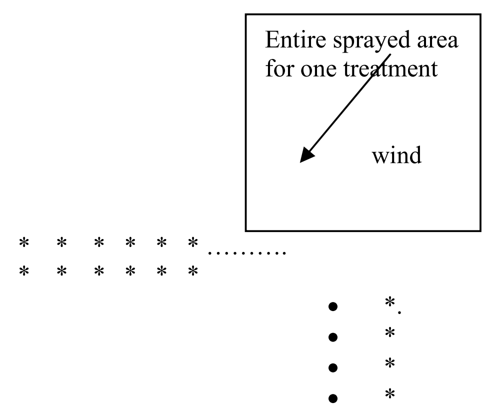
Artificial Targets

Flat plate collectors at each of the ten sampling locations per treatment. Plates were place just above the top of the canopy and within the canopy at the height of first fruit retention. Chromatography paper was placed on each flat plate to collect the fluorescent dye.

Drift Arrays

Two parallel rows of artificial targets were used for collecting drift samples, (flat plates on 1.2 m fibreglass posts fitted with chromatography paper held by rubber bands). The artificial collectors were placed downwind (to the north and west) of the treated area.

The two parallel rows of targets were placed 10m apart at following distances from the edge of the field for each treatment at 0m, 50m, 100m, 150m, and 200m.



ANALYSIS OF SAMPLES:

Deposition onto Leaves:

Quantitative:

Fluorometric analysis of deposition on leaves was determined by extracting the helios dye from 100 leaves per treatment from each sampling zone using an appropriate solvent (ethyl digol). The amount of dye in each sample was determined using a Sequoila-Turner 450 fluorometer, concentrations obtained were then related to the surface area of each sample.

Deposits on Artificial targets, conducted at CPAS laboratories - Gatton.

Fluorometric analysis of deposition on artificial targets (papers) was determined by extracting the helios dye from leaves using an appropriate solvent (isopropanol). Measurements of the amount of dye in each sample were be determined using a Sequoila-Turner 450 fluorometer, and were related to the surface area of each sample.

METEOROLOGICAL MEASUREMENTS

Stability was measured using a sonic anemometer. The full C-PAS data logged Environdata Meteorological Station was used to continuously record wind speed (at 2m, wind direction, temperature (at 2m, relative humidity, solar radiation and rainfall).

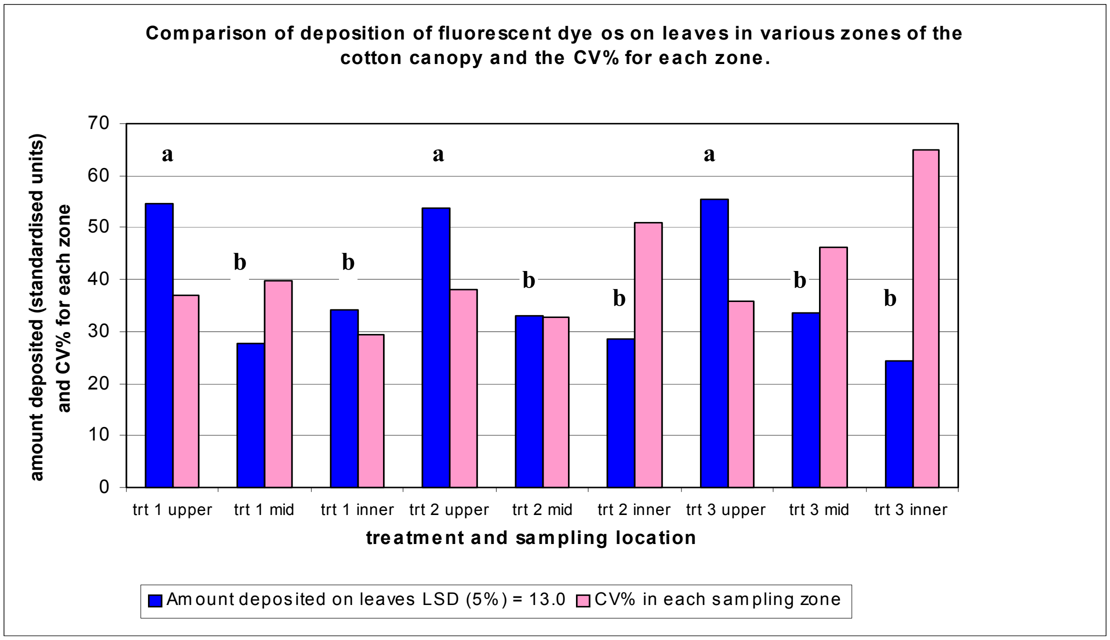
RESULTS and DISCUSSION:

Deposition onto Leaves:

The figure below shows the deposition onto cotton leaves sampled from 10 locations across the middle two swaths of each treatment in standardised units for each of the zones sampled (dark bars) and the coefficient of variation of that deposition within each zone (light bars).

Treatment 1 = electrostatics on, treatment 2 = electrostatics off and treatment 3 = micronair.

Note the LSD (5.0%) for comparing deposition in each zone is 13.00. The dark bars with the same letter or combination of letters above them are not significantly different from one another.



Deposition on leaves

Statisitical analysis (one anova) yielded the following results:

No significant difference between treatments in the deposition of fluorescent dye onto leaves in the upper part of the canopy.

Deposition onto leaves in the upper part of the canopy was significantly higher than deposition onto leaves in the mid and inner parts of the canopy for all treatments.

There were no significant differences between treatments in the deposition onto on the leaves in the mid and inner parts of the canopy.

Coefficient of Variation (CV) of deposition onto leaves

Treatment one (electrostatics on) had the lowest CV for deposition onto leaves in mid and inner zones, and a similar CV in the upper part of the canopy to treatment 3 (the micronair).

Treatment one (electrostatics on) produced the lowest range of CV's for all zones (29.4-39.8), treatment 2 (electrostatics off) and treatment 3 (micronair) were (32.6-51.0) and (35.9-65.1) respectively.

The results from this experiment tend to indicate that the electrostatics on treatment at 10 L/ha was capable of producing an equivalent deposition onto leaves as the micronair at 30 L/ha, but with a more even distribution of deposit onto leaves in the mid and inner parts of the cotton canopy.

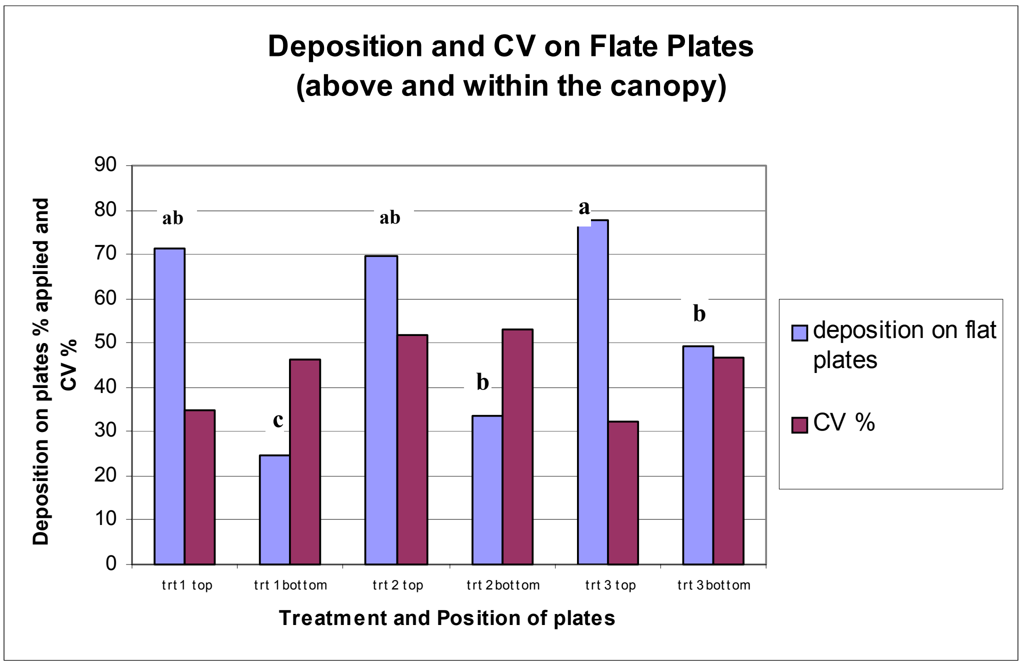
DEPOSITION ONTO ARTIFICIAL COLLECTORS

Flat Plates

The figure below shows the deposition onto flat plate collectors (expressed as a percentage of rate applied) for each of the 10 zones sampled across the middle two swaths of each treatment (lighter shaded bars) and the coefficient of variation of that deposition within each zone (darker bars).

Treatment 1 = electrostatics on, treatment 2 = electrostatics off and treatment 3 = micronair.

Note the LSD (5%) for comparing deposition in each zone is 16.55. The lighter shaded bars with the same letter or combination of letters above them are not significantly different from one another.



Deposition onto Flat Plates.

The above graph shows no significant different difference in percentage of the rate applied arriving at the top plates (artificial collectors placed just above the height of the cotton canopy).

These results reflect those obtained for deposition on leaves, where no significant difference was detected between the levels of deposition onto leaves sampled in the upper part of the cotton canopy.

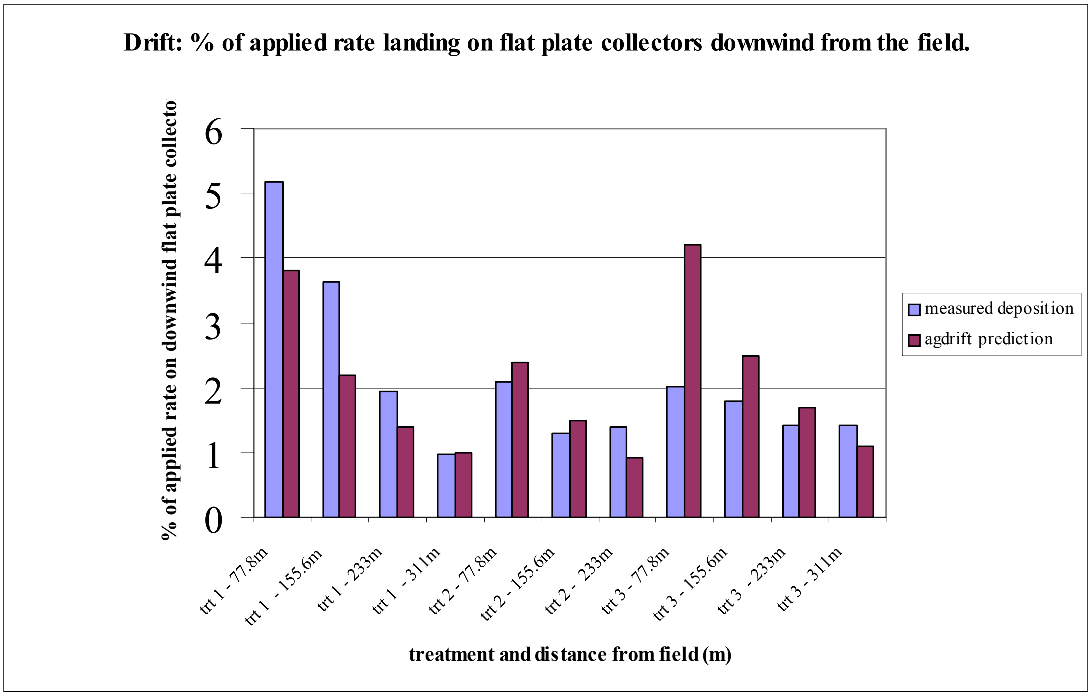
Deposition onto plates placed at the bottom of the canopy were significantly lower for treatment1 (electrostatics on) suggesting less spray was passing through the canopy, hence more was being captured by leaves.

CV of Deposition onto Flat Plates

The CV of deposition onto flat flates placed just above the canopy was reduced by having the electrostatic system turned on at 10 L/ha, and was similar to that of the micronair treatment at 30 L/ha.

DRIFT

The percentage of the applied rate leaving field was measured on flat plates at distances up to 311m from the edge of the treated areas. The results of measurements are illustrated in the figure below, along with agdrift® predictions for the droplet sizes used.



Note: The results obtained are from a single trial under a small range of environmental conditions, using a fluorescent dye technique (sensitive to parts per million) which has detection limits. Winds speeds during spraying for each treatment were light (average 0.7 m/sec) but reasonably consistent.

Within this single trial it be seen that treatment one (electrostatics on) shows higher levels of deposition close to the edge of the treated area with a rapid reduction in the amount of dye recovered from flat plate collectors as distance increased. The rate of decrease is similar to that predicted by Agdrift for this treatment.

Treatment 2 (electrostatics off) did not follow the agdrift predictions as closely, and did not show the same rate of decrease in deposition with distance from the field.

Treatment 3 (micronair) produced lower than predicted amounts of deposition close to the treated area, however the rate of decrease with distance from the edge of the field was less than predicted by Agdrift.

In this experiment both the predicted (agdrift) and actual depositions at 311m from the edge of the field were less for treatment 1 (electrostatics on) than those measured for treatment 3 (micornair).

Conclusions

Deposition onto leaves within the cotton canopy

Results obtained in this experiment, under the environmental conditions experienced, indicate that treatment 1 (electrostatics on at 10 L/ha) delivered equivalent levels of deposition (significant at 0.05 level) onto leaves within various zones sampled as treatment 3 (micronair at 30 L/ha) .

The CV of deposition in each zone of the canopy tends to indicate that treatment 1 (electrostatics on) produced less variation of deposit within the canopy (ie. a more even deposit across the two swaths sampled).

Deposition onto artificial collectors

Results obtained in this experiment indicate that there was no significant difference in the amount of fluorescent dye was arriving at the top of the canopy between any of the treatments. Treatment one (electrostatics on at 10 L/ha) was able to deliver the same quantity of dye to the crop as treatment3, the micronair at 30 L/ha.

However significantly less dye was recovered from flat plates at the bottom of the canopy in treatment one (electrostatics on) than for other treatments. This may indicate that when the electrostatically charged droplets were applied much of the material was captured by foliage.

Drift.

The results in this experiment, while not conclusive, do show some very interesting trends. The results obtained indicate that Treatment 1 (electrostatics on) produced a rapid reduction in the amount of material leaving the field with distance from the treated area.

Treatment 1 (electrostatics on) produced lower deposits at 311m downwind than Treatment 3 (micronair).

General Conclusion

Results obtained in this experiment indicate that the electrostatics system does warrant further investigation, particularly considering that in this experiment the electrostatic system was able to deliver equivalent levels of deposition, with lower CV's and similar or less drift at application rates of 10 L/ha when compared with the micronair au5000 at 30 L/ha.

The ability of the electrostatic system to demonstrate equivalent deposition at 10 L/ha in this trial indicates that in using such a system there may be potential cost savings to growers through reduced costs of application, increased productivity and improved timeliness of application. The ability of the system to deliver equivalent deposition with similar or lower CV's and levels of drift should be investigated further.

Recommendations.

Further investigations into the potential of the electrostatics system should be undertaken in the following areas:

- The ability of the system to provide similar reductions in the amount of spray leaving treated fields at different growth stages of the crop.
- The ability of the system to provide similar reductions in the amount of spray leaving treated fields under different environmental conditions.
- The downwind movement of spray material travelling over fallow after leaving the treated area (in this experiment spray had to travel over canopy before reaching the flat plate collectors).

Part 2: Droplet Spectrum Analysis

Nomenclature

Definitions of technical terms used in this report are listed in Table 1.

Table 1 Nomenclature

Term	Description
VMD or D[v,0.5]	Volume Median Diameter (VMD) 50% of the volume of the spray consists of droplets smaller than this size
D[v,0.9]	90% of the volume of the spray consists of droplets smaller than this size
D[v,0.1]	10% of the volume of the spray consists of droplets smaller than this size
SPAN	(D[v,0.9]- D[v,0.1]) / D[v,0.5], a measure of the width of the distribution

Methodology

A wind tunnel facility located at the University of Queensland, Gatton was used for the experimental program. The facility comprises an open circuit wind tunnel, a transparent working section, a Malvern 2600 laser diffraction analyser and an exhaust air scrubber extraction system. A 400mm by 400mm contraction section was used to accelerate the air up to operational speeds of 72 m/s (140 knots). The rotary nozzles were mounted on a streamline boom. Two gantries were used to independently position the laser-diffraction particle-size analyser and the nozzle system. This allowed the emitted spray plume to be traversed through the laser beam. Droplet size was measured from a traverse of the bottom half of the spray plume emitted by the rotary nozzles. The test facility was fitted with transducers to monitor fan speed, air temperature, humidity, air velocity, spray liquid temperature, pressure and flow rate. A plan of the facility is shown in Figure 1.

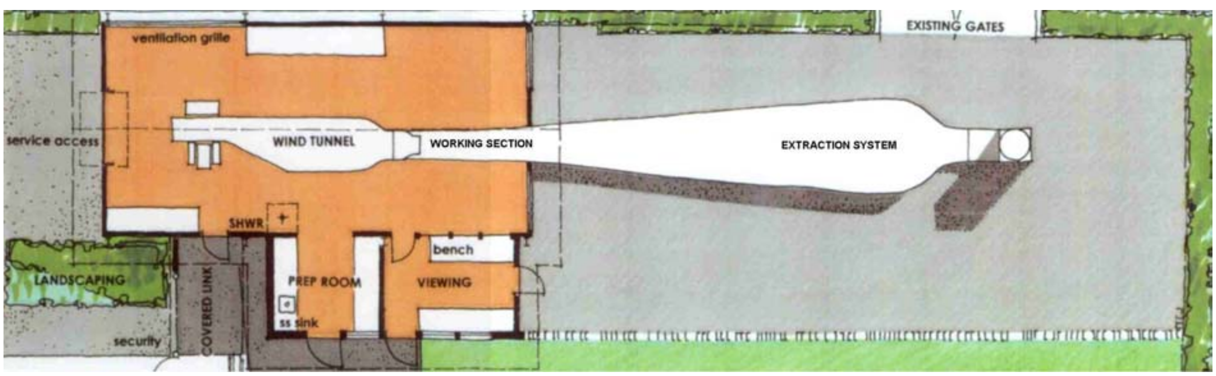


Figure 1 Plan view of the facility

The particle sizing system uses a laser-diffraction device (Malvern 2600, Malvern Instruments, UK) which is an internationally recognised industry standard for droplet and particle characterisation. It has a range of lenses and accessories for characterising sprays, powders and liquid emulsions. The 800 mm focal length lens was selected which is able to measure a particle size range from 4 µm to 1504 µm.

In use, the sample is illuminated by a visible-wavelength He/Ne laser. The particles or droplets scatter some of the light at angles which are characteristic of their size, forming a series of annular diffraction rings. The scattered light is collected by a Fourier optical system and focused on a radial diode array detector. The signal from each detector is amplified and digitised and the complete light energy pattern is analysed by a computer to derive the size distribution.

Wind tunnel (fan, settling chamber and working section)

Working section (with Malvern 2600)

Two spectrum nozzles (black and white) were tested with two formulations (water and 10% Biopest) at two airspeeds (54 and 62m/s) and two pressures (340 and 480 kPa) to give a total of 16 treatments. All treatments were replicated twice.

Results and Discussion

The Volume Median Diameter for each treatment (average of 2 replicates) is shown in Figure 2. Figure 3 shows the percentage of the total volume of the spray that is less than 141µm.

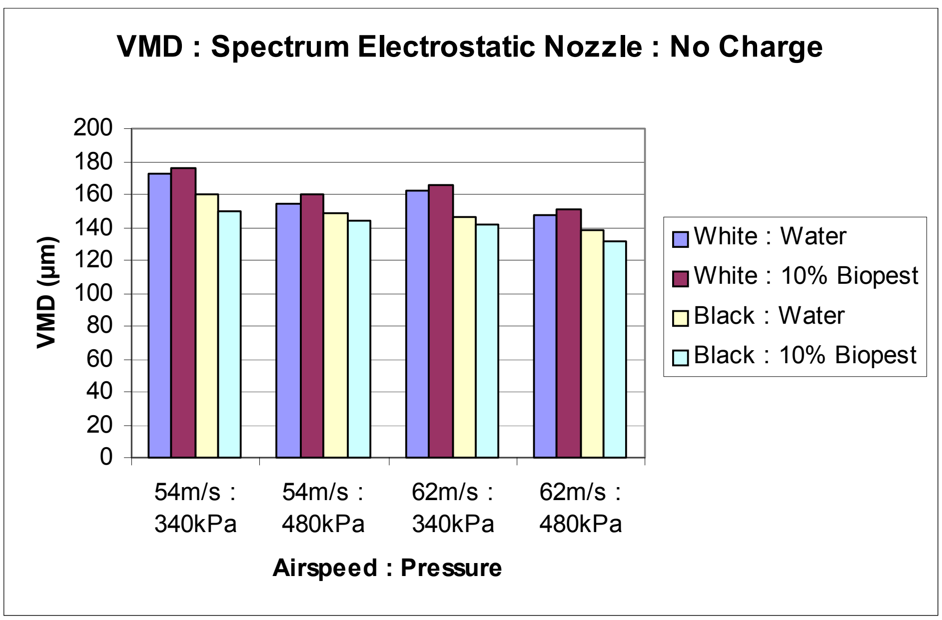


Figure 2 The Volume Median Diameter produced by a spectrum electrostatic nozzle with no charge

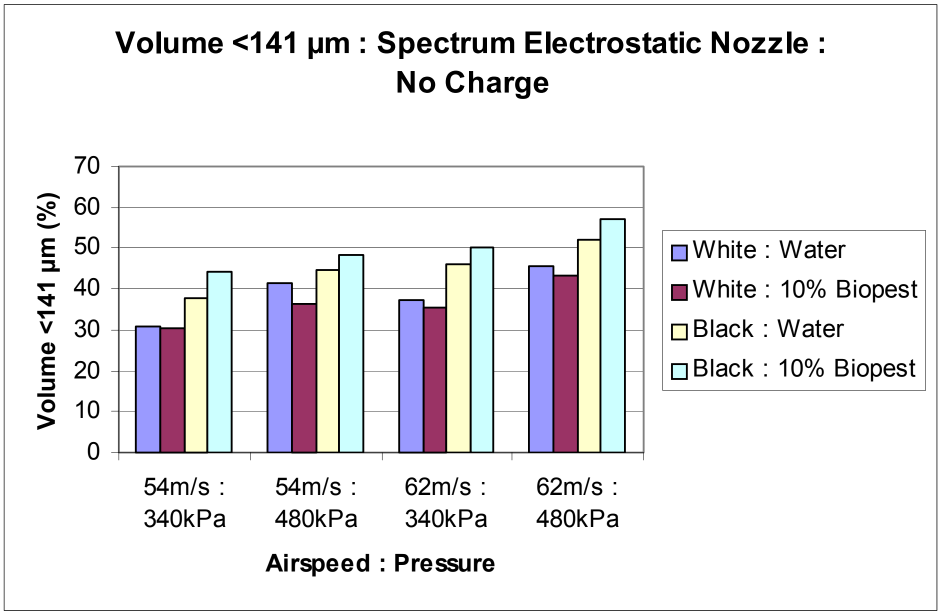


Figure 3 **The volume of spray less than 141µm produced by a spectrum electrostatic nozzle with no charge**

The black nozzle tended to produce a smaller droplet size (VMD) than the white nozzle. Increasing airspeed and increasing pressure reduced the droplet size for both the black and white nozzles. There was little difference in droplet size between water and a 10% Biopest mix.