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COTTON RESEARCH AND DEVELOPMENT CORPORATION

ADVISORY OFFICER TRAINING IN PESTICIDE APPLICATION TECHNOLOGY

DAN 75C

FINAL REPORT

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NSW Agriculture

<u>COTTON RESEARCH AND DEVELOPMENT CORPORATION</u>

FINAL REPORT

Project Number: DAN 75C

Project Title: ADVISORY OFFICER TRAINING IN PESTICIDE APPLICATION TECHNOLOGY

Field of Research: Research Training Field Code: 7.1

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SUMMARY

Funding from the CRDC and NSW Agriculture allowed two District Agronomists from major cotton producing areas to attend the International Pesticide Application Technology Residential Course at the Gatton campus of the University of Queensland.

These District Agronomists are called on to give advice on pesticide application on a routine basis and it is critical that they are well trained, and familiar with the latest technology in this important area.

The course at Gatton certainly had the desired result in enhancing the skills of the agronomists to the point that they have been able to run meetings and be involved in workshops on pesticide application with cotton growers.

This report looks at the course itself, the need for the course, the key areas covered and the most important concepts learnt.

A. INTRODUCTION

(a) The Course

The 1992 Course was the sixth time Gatton College has offered an International Pesticide Application Technology Residential Course. It covered all areas of the science with an equal division between theory and practical aspects. The latest technology was discussed and demonstrated and current legal trends in application management included both ground and aerial spray operations and all aspects involved with the effective, efficient and safe application of pesticides and related products including biocontrol materials.

Course leaders are acknowledged experts in their field. International and national in addition to staff of C-PAS, including Prof. J. Spillman and Dr. S. Parkin from the U.K. and Dr. J. Fischer from Switzerland.

(b) Aims and Objectives

The Course provides delegates with the technology to enable a wider appreciation of the physics of droplet formation, transport and deposition. It also demonstrates the practical use of this knowledge in selection of appropriate application methods for various formulations and targets. The practical sessions allowed participants to develop their own skills in using and assessing pesticide application equipment.

(c) Course Content

The Course covered each of the following areas in the depth necessary to develop a full understanding of the application of pesticides to targets.

Historical Background: The parallels between pesticide development over the past two hundred years and the delivery systems used for placing them on target.

Droplet Formation: Methods of breaking liquids into droplets and their efficiency.

Drift-distribution and Deposition of Particles: The management of drift in relation to effective target cover. Methods of minimising off-target movement and the use of buffer zones was discussed.

Safety: Safety aspects in the course included personal protection for operators, safe equipment operation, equipment decontaminating and disposal options for rinsate.

Centre Resources: Demonstrations of Image analysis, Laser diffraction analysis, fluorometry techniques were given to acquaint course delegates with current assessment. A wide range of application and safety equipment was available for delegates examination and use.

Economics and IPM: The selection and use of application techniques in the context of using integrated pest management programmes.

Future Developments: New equipment and techniques and the influence of politics in 1992 in Australia and overseas.

B. THE NEED FOR THIS COURSE

With pesticides and the cotton industry under the environmental microscope and with much public opinion being based on perceptions rather than facts it is important as public agronomists operating in cotton growing areas to have a thorough understanding of pesticide application issues.

The Centre for Pesticide Application and Safety is recognised internationally for it's expertise in this area. The course offered is also well regarded internationally.

An understanding of the technology involved in pesticide application will allow more well informed comments to questions raised locally by producers and the generally public. In our roles as Government extension agronomists we have contact with a wide section of industry and the general community.

Through this contact it would be hoped that we could transfer some of this understanding to others, thus helping to ensure the correct application and handling of pesticides and an improved profile for our industry.

C. KEY AREAS COVERED BY THE COURSE

(a) Target Orientation and Droplet Formation.

The section of the course highlighted the need for understanidng the target orientation for succesful pesticide application. The various method of droplet formation were discussed in detail looking at the advantages and disadvantages of each. the 5 main methods of breaking liquids into droplets are;

(i) Hydraulic Pressure (various nozzle types)
(ii) Centrifugal Energy (rotation discs and cages)
(iii) Airshear (twin fluid, air blast)
(iv) Aerosal Sprays
(v) Electrodynamic Methods

The physics of the process of droplet formation was also covered in great depth.

(b) Droplet Capture and Sampling Technology.

When a liquid is broken up by a nozzle and dispersed into the atmosphere as a spray several important factors govern the way in which the droplets are caught by a plant or insect. The most important of these is the droplets size. Othercontributing factors are the speed of the air stream carrying the droplet and the shape, texture and position of the target. The main spray collection and assesment techniques are;

(i) Fluorescent Dye Tracers.
(ii) Water Sensitive Paper.

Both of these methods are easy to use in the field.

(c) Ground Spraying Technology

This section of the course looked at mainly hydraulic boomsprays but there was discussion about air assisted, air shear and CDA equipment.

The paper in Appendix 1 Ground Application of Pesticides In Cotton by Hughes and Rickmann is a summary of the key factors discussed in the course.

(d) Adjuvants

An adjuvant was defined as any substance in a herbicide formulation or added to the spray tank to modify herbicidal activity or application. Information presented by Harry Combellack from the Keith Turner Research Institute is detailed in Appendix 2.

(e) Drift Visualisation

This section of the course was presented by Phil Koschitzke a post graduate student of the Melbourne Institute of Technology who was doing work on the effects of wind on droplets. His videos of spray nozzles in wind tunnels and the effect on drift were very useful to course participants in understanding droplet drift.

(f) Micro and Macro Meteorology

This section of the course was covered by Nicholas Woods and Professor John Spillman. The importance of a good understanding of meteorological conditions was highlighted. Conditions likely to cause concern to operators such as inversion layers, were covered in depth. Much of the discussion centred around temperature/humidity and formulation selections.

(g) Aerial Application

There are 275 aircraft registered in Australia for the application of pesticide. Approx 20% (by value) of the plant protection market is applied by air. In many aspects of aerial application Australia is a world leader, but the perceived risk to the environment as a result of aerial spraying means that operations must maintain the highest possible standards.

(h) Spraying Techniques

The session looked at the two techniques that are used,

Placement Spraying

If spraying is conducted in such a way that large droplets are produced (with a minimum number of small particles), with the aim of laying down a uniform deposit over the surface or crop or ground primarily under the influence of gravity the technique is called placement spraying. It is used primarily for the application of herbicides.

Wide Swath Spraying

Pesticide sprays are also deposited using aircraft by utilising mechanically generated turbulence present above a crop canopy to distribute small droplets about a target in a process known as wide swath spraying.

(i) Droplet Spectra Analysis

When micronair equipment is used the droplet spectra is primarily determined by airspeed and blade angle settings. However formulation type, temperature and flowrate also influence droplet production and with the large number of products now on the market, published (water) droplet size data provided by manufacturers can usually only be considered as a general guideline.

At Gatton they have the facilities to analyse the droplet spectra from different formulations under different conditions. The system they use is designed around the Malvern 2600 laser diffraction analyser.

This system is able to direct high velocity air over both hydraulic and centrifugal energy nozzles and thus simulate droplet generation in flight. Equipped with a Micronair digital tachometer, flowmeter, variable restrictor unit (VRU) and chemical management system, the apparatus is set up to examine the influence of tropical environmental parameters, nozzle settings and formulation on droplet generation. Spray from test nozzles passes through a laser beam generated by the Malvern. The resulting diffraction pattern is focused on a detector and the light intensity measured. Using the principle that large droplets subtend small angles and small droplets, large angles, the signal is sent to a computer where the volume distribution of the spray is determined in about 20 seconds.

A database of droplet size information is now being compiled so that aerial operators will be able to obtain accurate information regarding the droplet size of pesticide sprays emitted by their equipment. By way of example, Figure 5 shows the droplet spectra generated with water using a Micronair AU5000 with blade angle settings of 35 and 75 degrees. Such data sets are being compiled and analysed so that the droplet size of specific formulations can be predicted and more accurate nozzle configurations setup on agricultural aircraft. (Appendix 3 contains additional information about the Malvern 2600 including a schematic diagram and some test print outs).

(j) Spray Deposit Analysis

There are a number of methods for measuring spray deposits on crops for artificial targets. There are four basic spray deposit parameters which can be measured, volume of spray per unit area, number of droplets per unit area, size of the droplets and the percentage area covered by the deposit. The methods available to measure these parameters can be roughly divided into two broad categories, droplet stain analysis techniques and volumetric analysis techniques. Within each category there are several techniques available,

Volumetric Analysis	Droplet Stain Analysis
Fluorimetry	Counting
Colorimetry	Visual Assessment
Chemical Analysis	Droplet Sizing
Radioactive Tracers	Image Analysis

Much discussion centred around the Image Analysis technique and the Optimax V System that is used at Gatton (See Appendix 4 for details).

D. IMPORTANT CONCEPTS LEARNT

Through an appropriate mixture of theoretical and practical sessions, we tracked the life of a droplet from it's formation through it's movement to the target and it's final capture. We were constantly made aware that the ultimate aim of any application of pesticide is to most efficiently apply the pesticide to the actual target, whilst minimising any off-target drift.

Vital to ensuring efficient application is properly defining the target and carefully selecting the appropriate apparatus to achieve the desired spectrum of droplets. We compared the droplet spectra from a range of application equipment including hydraulic, air assisted, air shear and CDA equipment.

Important features of droplets are -
- Droplet Size
- Range in Droplet Size
- Droplet Lifetime

There is a compromise when selecting the most appropriate droplet size. Large droplets fall nearly vertically and can be accurately applied to a horizontal target. Vertical targets, such as most crops however, are very difficult to cover with large droplets. Smaller droplets will achieve a far more even coverage, with local air movements supplying turbulence and some horizontal air flow to ensure movement of droplets around a target. Reducing the droplet size also greatly increases the number of droplets for a given volume. Small droplets however, are more susceptible to drift and evaporation.

Application equipment producing a narrow range of droplets is generally most desirable as it provides greater prediction of the fate of the pesticide. The operation can be managed to ensure efficient capture of the known droplet size. Where a wide range of small and large droplets are produced it would be very difficult to avoid drift and also achieve thorough coverage.

Rotary atomisers and CDA equipment produce a narrower droplet spectrum than hydraulic nozzles, due to the difference in their mode of droplet formation.

Environmental conditions of temperature and relative humidity impact greatly on the survival of water based droplets. The addition of solvents however, will significantly reduce evaporation.

Characteristics of the target should also be considered when aiming to maximise droplet capture. Greatest droplet deposition is achieved with a target of low diameter or width, with a rough complex surface. This is useful information when designing a biological buffer zone for drift reduction. An open porous barrier with multiple rows of trees having long, thin and rough foliage with a height at least 1.5 times the droplet release height has been found to be most suitable.

The fate of a stream of droplets is also influenced by turbulence generated by wind and vortices around ground or aerial spray rigs. The effect of this turbulence can be predicted and measured.

Aerial operators prefer to utilise steady crosswinds to apply pesticide than use calm conditions. They utilise the turbulence to provide better penetration and coverage of target plants. It also allows management of drift to reduce off target application.

The course provided those attending with a good understanding of some complex issues relating to pesticide application.

APPENDIX 1

GROUND APPLICATION OF PESTICIDES IN COTTON

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To maximise spraying efficiency, pesticides must be applied at the minimum pesticide rate which will produce effective pest management without wastage through run-off or drift.

For this to occur, a sprayer must be capable of:

1. Producing sufficient droplets of the correct size

2. Depositing these droplets in sufficient numbers evenly over the target

3. Minimising the effect of drift.

There are many methods of assessing the efficiency of pesticide spray application. Because cotton is a well monitored crop, biological assessment quickly answers the question 'Did the spray work or not? '. By measuring droplet deposition on the target surface and combining this with a biological assessment, it is possible to quickly isolate problems into either the chemical or its application.

Whilst this section is primarily concerned with application equipment and techniques, some 'application problems' have arisen because of insufficient chemical and total spray volume rather than poor application techniques. The farmer in association with his consultant and spray contractor, needs to accurately assess the crop size and therefore determine what level of BAND WIDTH to use. The band width factor used underpins the rest of the application operation as it will ultimately determine both the volume of concentrate and total spray volume. If the band width factor is incorrect the whole operation is in jeopardy. If in doubt, a higher rather than a lower rating should be used.

SPRAY APPLICATION EQUIPMENT

At present, cotton crops are being sprayed by four different types of ground sprayers. These are :

1. Conventional boom sprayers

2. Air assisted boom sprayers

   - air blast sprayers
   - air shear sprayers

3. CDA boom sprayers.

Success has been achieved using all of these sprayers when the limitations of each is appreciated and all are correctly set-up for the conditions encountered at the time of spraying.

1. Conventional boom spraying

Most dryland cotton has been sprayed by conventional hydraulic boom sprayers.

Whilst the crop is young (150-200 mm high) good insect control has been achieved by a single nozzle directly above the row. Either a cone or a flat fan nozzle can be used. Fan angles are not critical and either a 65° cone or an 80° flat fan would suffice. Application volumes of 40-60 L/crop ha at 300-400 kPa should give good coverage.

As the crop grows (above 200 mm), a standard dropper (380 mm) should be added between the rows. Either a cone or flat fan nozzle can be fitted on the dropper and above the row. Spray pressures should be increased to 450-500 kpa and consideration given to increasing the fan angle (110° for a flat fan). Water volumes should be increased (60 -80 l/ha), especially if ambient temperatures are starting to increase.

Once the crop reaches 500 mm, where cone nozzles are being used, then a second cone nozzle will need to be added to the dropper . If flat fans are used, one 110 ° nozzle per dropper will do the job so long as the rows have not closed up too much. If the inter-row space has decreased, consider using a 150° flat fan on the dropper. The advantage that flat fans offer is that three nozzles will do the same job as five cones. Spray pressures need to be increased to at least 500 kPa and spray volumes increased to 60-100 l/ha. By this time, ground conditions will probably limit speeds to 13-14 km/hr so it may not require larger nozzles to be used. If spraying conditions are getting tougher- large bushes, high ambient temperatures and lower humidity- then water volumes may need to be increased. Volumes of 100 l/ha, plus, are quite acceptable later in the season.

Defoliation volumes of 100-200 l/ha may be required to get an effective coverage especially on the lower leaves. Fitting a larger nozzle on the bottom of the dropper may also help.

Table 7. A summary of recommendations for conventional boom-sprayers

CROP SIZE (mm)	NOZZLES		WATER RATES (l/ha)	SPRAY PRESSURE (kPa)	DROPPERS
	Flat Fan	Cone Nozzle			
0 - 200	1 @ 8001	1 @ TX6	40 - 60	300 - 400	
200 - 500	3 @ 11001	3 @ TX4	60 - 80	400 - 500	1
500 +	3 @ 11001 or 15001	5 @ TX4	60 - 100	500 +	1 - flat *1+1 - cone
Defoliation	3 @ 11002 or 15002	5 @ TX8	100 - 200	500 +	1 - flat *1+1 - cone

- * 1+1 is a dropper arrangement that will carry two nozzles.
- This table is a guide only. Volumes and configurations will need to be modified to meet individual requirements.

2. Air assisted booms

Air assisted booms can be classified into air blast sprayers and mister sprayers.

Air blast sprayers are designed to transport droplets produced by hydraulic or controlled droplet application nozzles in an air stream to the target. Air blast sprayers differ from misters in that the mister uses the air stream to produce as well as transport the droplets. The Hardi Mini-Variant, Hardi Twin System and the Degania Sleeve Boom are all air blast sprayers. The Silvan Turbomiser is a mister because the droplets are produced by wind shear in the air stream.

The key to air blast and mister spraying is the air stream- its volume, velocity, placement and direction. The aim is to displace the air volume within the target plant and replace it with chemical-laden air from the sprayer. As the plant size and foliage density increase then the volume of air may need to increase and the ground speed decrease. Better penetration occurs where turbulent air streams are used.

Air blast sprayers

Air blast sprayers are basically of two types . One system uses individual ducting to carry the air supply to outlets mounted on the boom arms (Hardi Mini-Variant). This system allows a range of configurations to be used, depending on the crop layout. The major disadvantage is the limited boom width on commercially available machines. (10 outlets). The second system uses an air-bag and a specially designed outlet along the whole length of the boom (Hardi Twin System). Boom widths are available in 12-18m sections. A hybrid of these two systems has been produced that uses the air-bag to transport the air to individually-mounted outlets along the boom. Like the Hardi Twin System this allows much wider boom widths (20 m) to be used but still concentrates the air and spray through a 100 mm outlet directly above the row.

Nozzles for air blast sprayers:

The nozzle is the most important component on any sprayer.

Flat fans and cone nozzles are both effective if the correct spray volumes and pressures are used. Water volumes of 40 L/crop hectare, applied at pressures of 400 -500 kPa are required. If cone nozzles are being used make sure pressures are at least 500 kPa. Where individual outlets are used, they should be set directly above and angled back along the row at 45°. One outlet is required for each row. To avoid spray deflection of the ground when spraying small plants, reduce the fan speed or decrease the outlet angle (30°).

Outlet modifications are available both for splitting the liquid flow between two nozzles per outlet and also in the shape of the outlets. Field tests have occasionally favoured a more oblong or oval shape outlet but the results were not always repeatable.

Nozzles which have proved to be effective and comparative in performance are Hardi S4 110-12, Spraying systems 110-02, 110-3 flat fans and the TX-8 cone nozzle. Air speeds at the outlet need to be at least 120-160 km/hr with a fan capable of producing at least 1100 m^3 of air/outlet/hour.

Mister type sprayer

The major difference between the air blast and the mister type sprayer is the way droplets are formed. The mister forces fluid through a metering disc and then relies on a high velocity air stream to break the fluid into fine droplets.

For this reason the Silvan Turbomiser requires a much higher air velocity than the Hardi Mini-Variant. Air velocities must be at least 300-350 km/hr and preferably higher at the venturi outlet.

3. Controlled droplet application spraying

The term CDA refers to a type of spraying which produces uniform droplet sizes and is therefore not limited to any specific type of spray equipment. The most commonly available CDA equipment uses centrifugal energy rather than hydraulic energy to produce droplets.

The most common boom mounted CDA applicator in cotton is the Micromaster. This unit forms droplets by means of a spinning disc. A fan provides an air-blast which directs droplets into the crop, aiding penetration and deposition. Cowlings are fitted around the heads to give better air flow characteristics. Most units are driven by hydraulic motors.

Spray application rates are determined by variable orifice plates and ground speed. A spray volume of 20 L/crop ha for water and 10 L/ha for oil based sprays would be a good starting point. One head is required per row and this should be slightly offset, angled back along the row (40°) and positioned approximately 20 cm above the crop.

Boom width

The systems that use individual ducting from the fan to the outlet will have their width determined by the number of outlets from the fan and the planting configuration of the crop.

The Hardi Mini-Variant and the Silvan Turbomiser P45 have 10 outlets but only eight of these can be used in a skip row situation. On single skip, the boom has the potential to be extended to cover 12 m and on a double skip cover 16 m.

The Silvan Turbomiser P55 has 14 outlets, but only 12 of these could be used on a skip row configuration. Potentially, this boom could be extended to cover 18 m of single skip and 24 m of double skip. In either situation one outlet is required per row.

Before purchasing or modifying boom widths, consider the planter width. Ideally the planter and the boom will be the same width, and this will then nullify any problems associated with guess rows. If the boom and the planter are different widths, great care will be required to get accurate guess rows and straight planted rows. If there is only one outlet over each row, a discrepancy of 20 cm at planting is enough to cause application problems. Whilst the problem is not quite as bad for a conventional boom with droppers, problems have still been encountered. The Hardi Twin system is probably least affected by planting inaccuracies.

Outlets should be set 20-30 cm above the crop.

Row spacing

For the sake of contractors and conventional boom owners, increments of 1m should be used for rows and skips. Planted rows should be 1m apart, single skip rows 2m apart and double skip rows 3m apart.

CONCLUSION

Much has been written and spoken about having the number and size of droplets that will be most effectively deposited on the target. In reality, all spray applicators produce a range of droplet sizes and all applicators produce more than enough droplets if sufficient spray volume is applied.

Summarising the 1991 field studies, where droplet numbers, size, dispersion within the crop and application volumes were recorded, the following conclusions can be drawn:

1. Flat fans and cone nozzles produce similar droplet sizes (100-140 microns) at operating pressures around 500 kPa.

2. Flat fans and cone nozzles produce similar numbers of droplets and deposit them in a similar fashion through the crop for the same application volume. As the crop matures five cone nozzles will be required to give the same coverage as three flat fan nozzles.

3. The total application volume for air assisted booms does not need to be as great as for conventional booms if they are well set-up. Where conventional booms need to apply 60 L/ha, air-assist boom sprayers would do a similar job at 40 L/ha. Comparable volumes for a CDA sprayer would be 20 L/ha for water and 10 L/ha for oil.

4. Air-assist booms deposit more droplets on the lower leaves and the underside of the leaves than conventional booms.

5. Greater skill and care is required when setting up a CDA boom sprayer (Micromaster) than other row crop sprayers.

6. One outlet per row is required for all row crop sprayers. (Silvan Turbomiser, Hardi Mini-Variant, Micromaster).

7. Spray pressures need to be set at 500 kPa (5 bar), especially for cone nozzles.

ADJUVANT: ANY SUBSTANCE IN A HERBICIDE FORMULATION OR ADDED TO THE SPRAY TANK TO MODIFY HERBICIDAL ACTIVITY OR APPLICATION

ADJUVANTS

SPRAY MODIFIERS ACTIVATORS UTILITY MODIFIERS

SPRAY MODIFIER ADJUVANTS:

- Spreader
- Spreader stickers
- Stickers
- Film formers
- Spray thickeners
- Foaming agents

Spreaders

- Added to spray to cause spray droplets to adhere and spread on foliage.
- Materials include nonionic surfactants typically nonylphenols which have ten moles of ethylene oxide appended.
- Many have minor effect on activity.

Spreader Stickers

- Added to spray to cause spray droplets to adhere and spread to aid in retention during wet conditions.
- Spreaders generally nonylphenols.
- Stickers frequently, fatty acids, polymerized fatty acids, or synthetic polymer latex.
- Little effect on biological activity.

Stickers

- Function to reduce "wash off".
- Materials include film forming vegetable gels: emulsifiable mineral oils, emulsifiable resins, vegetable oils, waxes and water-soluble polymers.
- Can improve herbicide performance.

Spray Thickeners

- Used to reduce spray drift.
- Tend to be water soluble or swellable hydrophilic polymers.
- Little effect on biological activity.

Foaming Agents

- Used to reduce drift.
- Usually surfactants which produce persistent foam.
- Little effect on biological activity.

ACTIVATOR ADJUVANTS:

- Surfactants
- Wetting agents
- Penetrants
- Oils

Surfactant: Any substance that improves the emulsifying, dispersing, spreading, wetting or other properties of a liquid by modifying its surface characteristics.

Surfactants

- Facilitate wetting, spreading, dispersing, solubilizing & emulsifying besides other surface modifying properties to enhance herbicidal action.
- Sometimes improves herbicidal performance.
- Facilitate herbicidal effectiveness by
    - Lowering surface tension
    - Improving coverage
    - Removing air films between spray and leaf surface
    - Reducing interfacial tension between polar and apolar regions of the leaf cuticle.
    - Inducing stomatal entry
    - Increasing the permeability of the leaf cuticle or plasmamembranes
    - Facilitating cell wall penetration of herbicides at the wall-cytoplasm interface
    - Acting as co-solvents
    - Reacting or complex directly, to allow better penetration of electrically charged cuticles and membranes
    - Acting as humectant thus preventing herbicides drying on plant surfaces.

Classes of Surfactants

Anionic - Sometimes used for herbicides
Cationic - Little used for herbicides
Nonionic - Most commonly used for herbicides
Amphoteric - Seldom used for herbicides

Anionic: The hydrophobic portion of the molecule carries a residual negative charge.

Cationic: The hydrophobic portion of the molecule carries a residual positive charge.

Nonionic: There is no residual electric charge.

Amphoteric: Both positive and negative centres to be found in the molecule.

Surfactants have two essential portions;

One relatively non polar and water insoluble thus water repelled = **Lipophilic**
One polar and fairly soluble in water thus water attractive = **Hydrophilic**

Hydrophilic/Lipophilic Balance

- Used to characterise the balance or relative effect of the lipophilic/hydrophilic portions on the overall physical and chemical properties of surface active agents.

Surface Properties of Surfactants

- **Surface Tension** - related to an excess of energy localised in the surface.
- **Wetting** - describes the ability of a drop to spread or wet a solid substrate. The lowering of surface tension increases wetting.
- **Contact Angle** - the angle that a drop of liquid makes with a solid. The lower the contact angle the lower the surface tension the more readily wet is the surface.

Wetting Agent: Any substance that serves to reduce the interfacial tensions and causes the spray solutions or suspensions to make better contact with treated surfaces.

Penetrants

- Added to increase the rate of penetration through the lipid layer.
- Most enhance hydration and solubilisation of cuticle.
- Some have significant effect on herbicidal activity.

Phytobland Oils

- Base oil, highly refined paraffinic, free of impurities including unsolfonated residues to provide optimum weed control with least crop injury.
- Usually sold with 1 to 2% surfactant.
- Sometimes provides increased herbicidal activity.

Oil-Surfactant Concentrates Syn. Crop Concentrate

- Mixture of phytobland or vegetable oil (approx 80 to 95%) and surfactant (approx 5 to 20%).
- Frequently provide increased herbicidal activity.

UTILITY MODIFIERS:

- Emulsifiers
- Dispersants
- Stabilizing agents
- Buffering agents
- Coupling agents
- Co-solvents
- Compatibility agents
- Antifoam agents

Detergents

- Include both soaps and Surfactants.
- Often contain 6-8 additives, eg. optical brighteners, sequesterents (usually phosphates).
- Usually only 10-70% surfactant.
- Can reduce herbicidal activity.

MALVERN 2600

Laser Diffraction Droplet and Particle Size Analyser

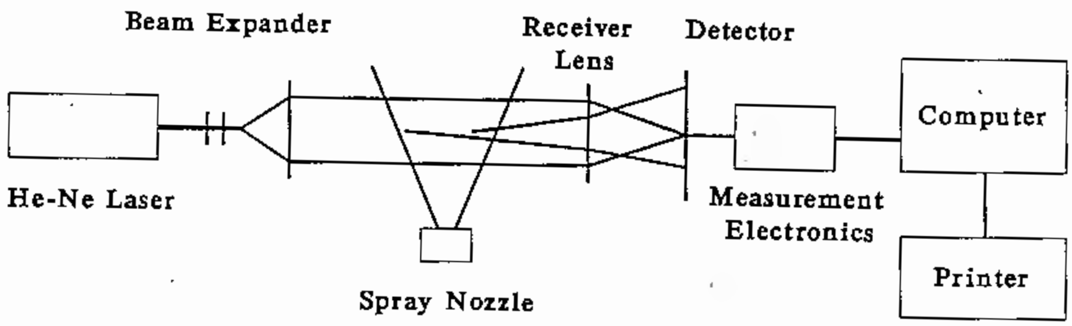
The Malvern 2600 particle sizer provides a quick, simple to use method for determining droplet and particle size.

The sample is illuminated by a low power visible wavelength laser. The particles scatter some of the light at angles which are characteristic of their size forming a series of diffraction patterns. A small particles will scatter light at a greater angle than a large particle.

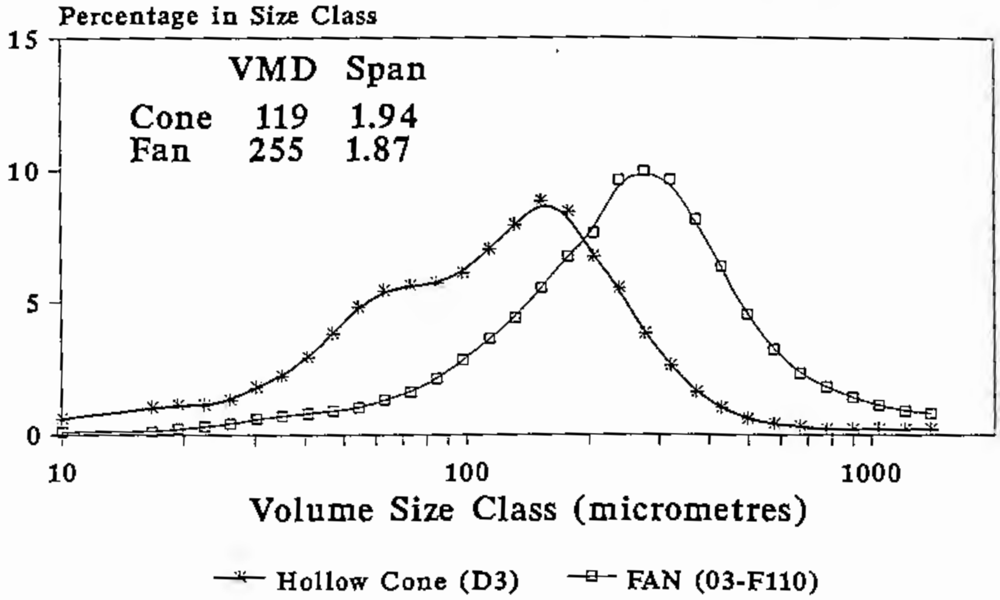
The scattered light is collected by the Fourier optical system and, regardless of the precise position of the particles or their movement, it is brought to focus on a radial diode array detector. The signal from each detector element is proportional to the intensity of the light falling on it. The signal is amplified and digitized and the complete light energy pattern is then analysed by the computer. From this a complete and detailed particle size distribution is derived. This can be presented in a variety of graphical and tabular formats.

Advantages of the Malvern 2600 include the following.

- **It is fast**, typically requiring less than a minute to make a measurement and analyse.
- **It is simple to use.**
- **It has a wide range**, being able to measure particles between 0.5 and 1880 micrometres.
- **It is non intrusive.**
- **It is precise.**
- **It is versatile**, allowing the user flexibility in the choice of operations and output.
- **A variety of materials can be used**, provided that the medium is transparent to the laser wavelength and each phase is distinct optically. Examples include liquid droplets in air, powders in air, bubbles in liquid, powders in liquid and emulsions in liquid.

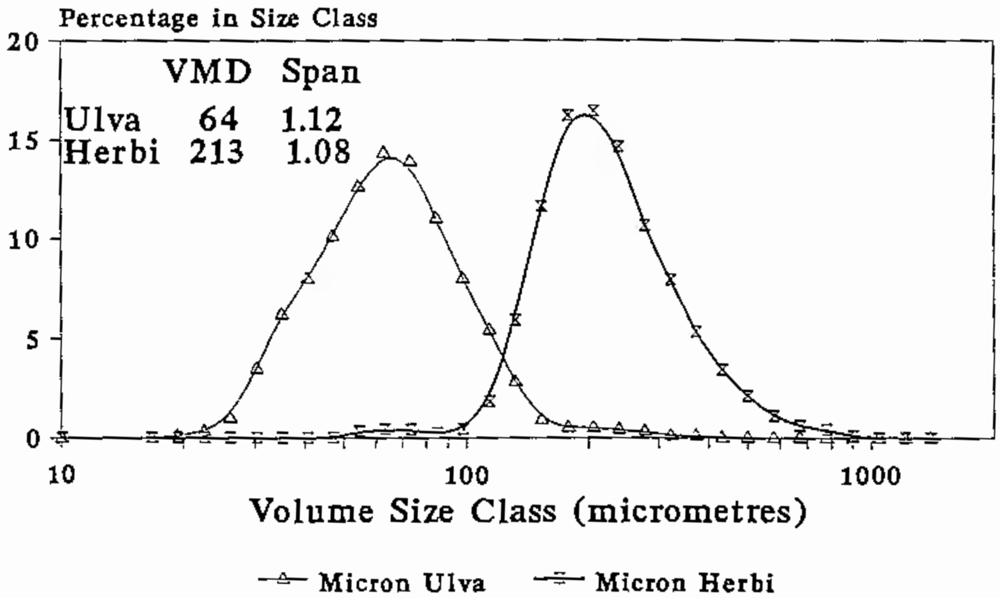


Malvern 2600 - Droplet Spectra
Hollow Cone vs Fan Nozzle



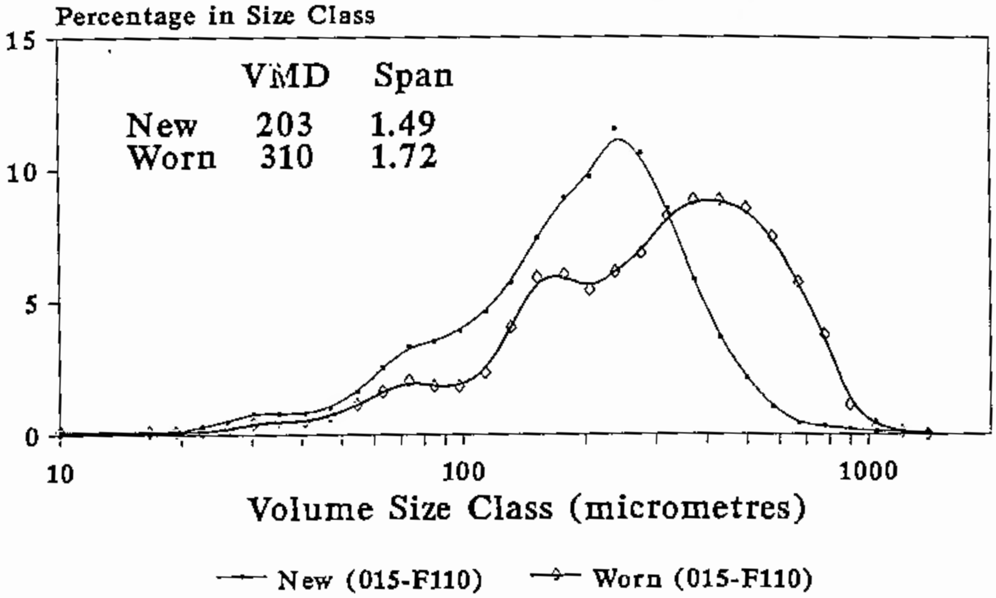
Demonstration only : Water

Malvern 2600 - Droplet Spectra
Micron Ulva vs Micron Herbi



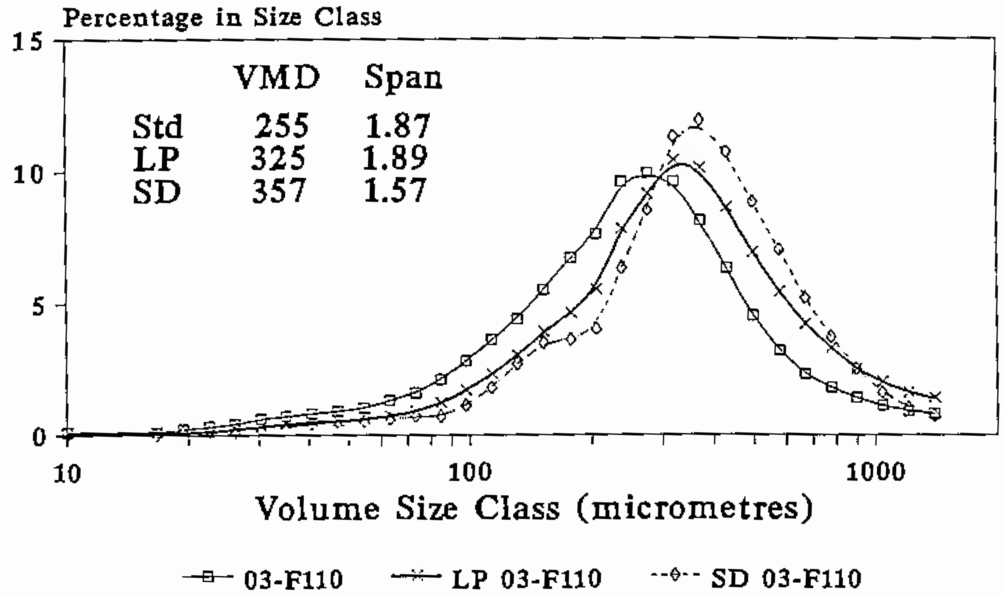
Demonstration only : Water

Malvern 2600 - Droplet Spectra
Worn vs New Fan Nozzle



Demonstration only : Water

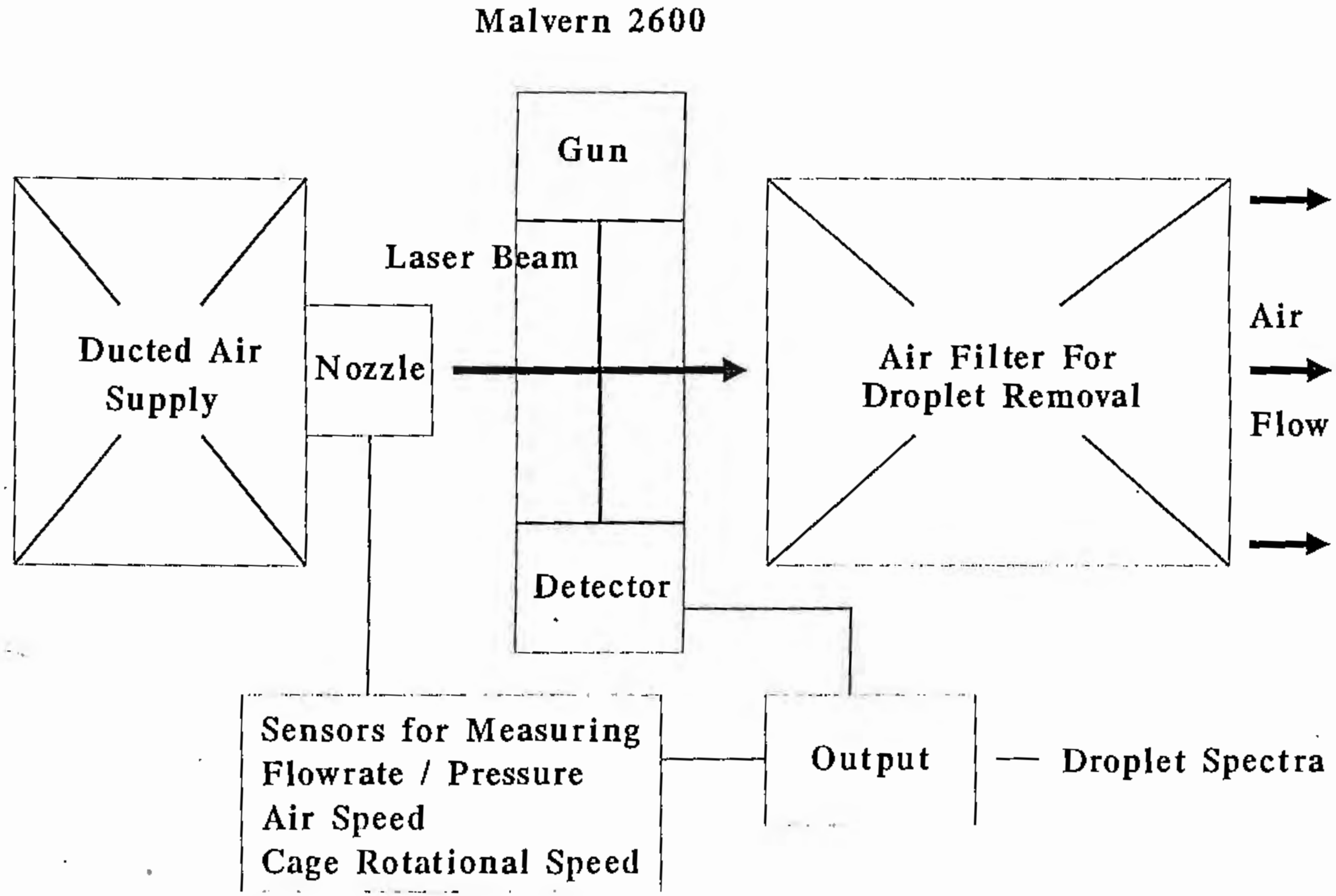
Malvern 2600 - Droplet Spectra
Standard, Low Pressure, Low Drift Nozzle



Demonstration only : Water

Nozzle Test Bed for Droplet Spectra Determination

System used for testing ground and aircraft spray nozzles



MALVERN Instruments SB.0B

Nozzle : micro ulva
Pressure : 3 BAR
3/7/92 1:48

000000006036

The Centre for Pesticide Application and Safety
The University of Queensland
Gatton College

ENQUIRIES : PLEASE CONTACT - N. WOODS (074) 601 293

Demonstration for International Pesticide Application Short Course

2752 lds 1a00370

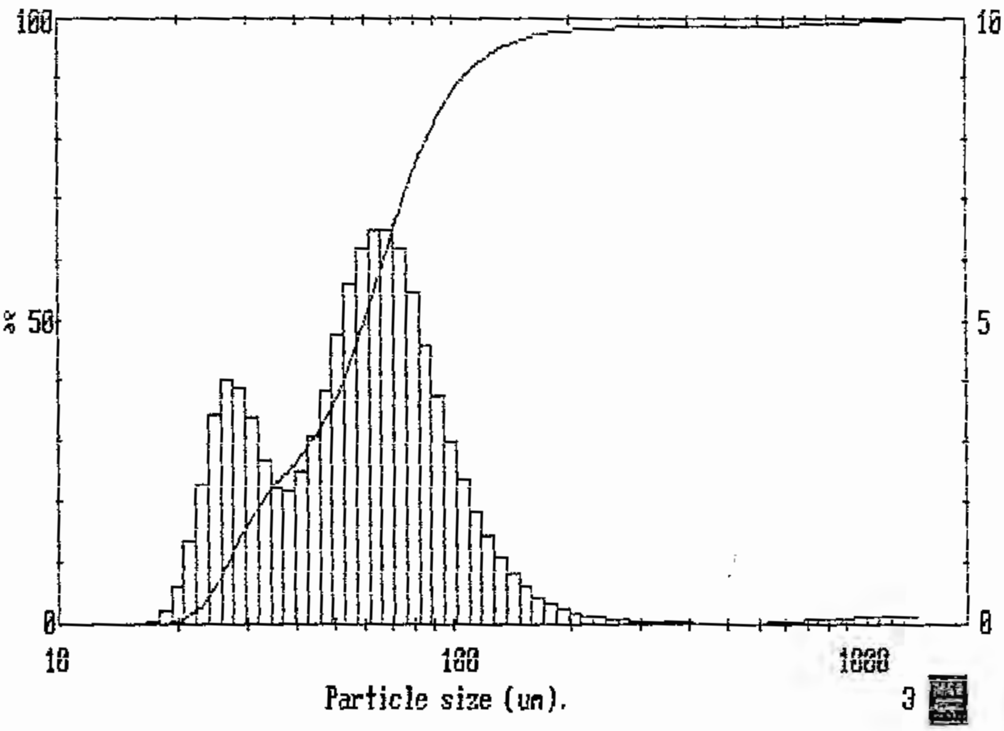
Upper	in	Lower	Under	Upper	in	Lower	Under	Upper	in	Lower	Under
				461	0.0	399	98.8	78.5	12.7	67.7	61.3
				399	0.1	344	98.8	67.7	13.1	58.4	48.1
				344	0.1	296	98.7	58.4	11.0	50.4	37.1
				296	0.1	256	98.5	50.4	7.5	43.5	29.7
1504	0.3	1297	99.7	256	0.2	220	98.3	43.5	5.0	37.5	24.7
1297	0.3	1120	99.5	220	0.4	191	97.9	37.5	4.8	32.4	19.9
1120	0.2	965	99.2	191	0.7	164	97.2	32.4	7.4	27.9	12.4
965	0.2	833	99.1	164	1.3	141	95.9	27.9	7.5	24.1	4.9
833	0.1	719	98.9	141	2.3	122	93.7	24.1	4.0	20.8	1.0
719	0.1	620	98.9	122	3.9	105	89.8	20.8	0.9	17.9	0.0
620	0.0	535	98.9	105	6.3	90.9	83.4	17.9	0.0	15.5	0.0
535	0.0	461	98.9	90.9	9.5	78.5	73.9	15.5	0.0	4.00	0.0

Span	1.33
D[4,3]	75.44µm
D[3,2]	49.59µm
D[v,0.9]	106.25µm
D[v,0.1]	26.68µm
D[v,0.5]	53.70µm

Source = :Sample
Focal length = 800 mm
Presentation = lds

Beam length = 100.0 mm
Log. Diff. = 4.482
Obscuration = 0.0346
Volume distribution

Model indp
Volume Conc. = 0.0006%
Sp.S.A 0.1210 m²/cc.



APPENDIX 4

Ref: image:NW:

IMAGE ANALYSIS

THE OPTOMAX V SYSTEM

The Optomax V image analysis system is capable of analysing images from any standard source of close circuit monochrome signal, selecting objects to be measured by virtue of their grey levels. It offers a high spatial resolution of 704 x 560 pixels and a 256 grey level detection ranging from 0 = black to 255 = white.

Digital image analysis provides a practical and viable means of automating deposit analysis on both artificial and natural surfaces. Images can be obtained from almost any source which provides a good contrast between the image and the background. For example, drop sizes can be analysed from water and oil sensitive cards, photographs, droplets suspended in viscous mediums, and also on natural surfaces with the acid of fluorescent tracers. The Optomax can also be interface to CCD cameras, video cassette recorders, frame stores, optical discs, scanning and transmission electron microscopes.

MEASUREMENT FEATURES

Upon analysis of a sample, both field and feature measurements are taken. Field measurements provide useful information on percentage cover of the sample, while feature measurements provide data relating to each individual feature within the sample. Some of the measurements carried out include: area, perimeter, horizontal and vertical intercepts, longest dimensions along the x and y axis, longest overall dimension, form factor (round indicator), breadth and orientation.

SPECIAL FEATURES

Many facilities are offered in order to achieve the best possible detection under adverse conditions. These include:

1) **True/inverted video modes:** allowing detection of features lighter than the background image, useful for analysing photograph negatives and fluorescent particles.

2) **Shade correction:** can correct uneven illumination in the dynamic state by setting the detection level relative to the background level. It is also possible to store shading patterns where a constant and even illumination source is available.

3) **Holefill:** some features may have light particles within them which are not detected. Using this function the whole feature may be detected.

4) **Averaging:** average measurements can be made in order to negate measurement variations due to light fluctuations, vibrations etc.

5) **Various grey level detector modes:** it is possible to preselect the grey level ranges which are to be detected.

6) **Feature/end count:** gives an indication of the amount of overlapping.

7) **Editing functions:** allows modification of the image before a measurement is taken.

8) **Frame types:** a choice of square, rectangular or circular frames of any size or position is available.

OPTOMAX V
Field Specific Measurement 3.04

Title : Optomax V Demonstration
Sample : Droplet counting - WSP

Calibration : 6.969E-03 CM/pixel

Field	Area	Feat. count	End count	Field area	Area frac %	Count / Area
1	0.0888	67.000	74.000	1.073	8.271	62.426
2	0.0669	62.000	63.000	1.073	6.235	57.767
3	0.0529	54.000	54.000	1.073	4.932	50.314
4	0.0667	58.000	58.000	1.073	6.217	54.041
5	0.0596	60.000	60.000	1.073	5.556	55.904
Total	0.3350	301.00	309.00	5.366		
Mean	0.0670	60.200	61.800	1.073	6.242	56.090
St. Dev.	0.0135	4.817	7.563	1.706E-06	1.255	4.488

OPTOMAX V
Feature Specific Measurement 3.07

Feat.	Area	Perimeter	Long Dims.	Breadth	Sphere Dia.	Sphere Vol.
1	4.371E-04	0.0889	0.0355	0.0209	0.0236	6.873E-06
2	3.399E-04	0.0801	0.0287	0.0279	0.0208	4.715E-06
3	4.371E-04	0.0906	0.0312	0.0279	0.0236	6.873E-06
4	2.914E-04	0.0749	0.0287	0.0209	0.0193	3.741E-06
5	6.313E-04	0.1080	0.0424	0.0209	0.0284	1.193E-05
6	6.313E-04	0.1063	0.0424	0.0279	0.0284	1.193E-05
7	3.399E-04	0.0854	0.0312	0.0279	0.0208	4.715E-06
8	3.399E-04	0.0801	0.0287	0.0209	0.0208	4.715E-06
9	5.827E-04	0.1028	0.0375	0.0348	0.0272	1.058E-05
10	3.885E-04	0.0889	0.0355	0.0209	0.0222	5.760E-06
11	5.342E-04	0.1028	0.0375	0.0348	0.0261	9.287E-06
12	1.214E-03	0.1376	0.0493	0.0418	0.0393	3.182E-05
13	2.914E-04	0.0767	0.0287	0.0209	0.0193	3.741E-06
14	3.059E-03	0.2561	0.0998	0.0557	0.0624	1.273E-04
Total	9.518E-03	1.479	0.5572	0.4042	0.3821	2.440E-04
Mean	6.799E-04	0.1056	0.0398	0.0289	0.0273	1.743E-05
St. Dev.	7.251E-04	0.0464	0.0184	0.0102	0.0114	3.243E-05

OPTOMAX V

Field Specific Measurement 3.04

Title : Optomax V Demonstration
Sample : Droplet counting - WSP

Calibration : 6.969E-03 CM/pixel

Field	Area	Feat. count	End count	Field area	Area frac %	Count / Area
1	0.2695	69.000	70.000	4.359	6.183	15.830
2	0.2528	67.000	68.000	4.359	5.799	15.371
3	0.2453	67.000	69.000	4.359	5.627	15.371
4	0.2504	72.000	76.000	4.359	5.744	16.518
5	0.2070	62.000	63.000	4.359	4.748	14.224
Total	1.225	337.00	346.00	21.795		
Mean	0.2450	67.400	69.200	4.359	5.620	15.463
St. Dev.	0.0231	3.647	4.658	8.358E-06	0.5302	0.8367

OPTOMAX V

Feature Specific Measurement 3.07

Feat.	Area	Perimeter	Long Dims.	Breadth	Sphere Dia.	Sphere Vol.
1	1.068E-03	0.1289	0.0493	0.0279	0.0369	2.627E-05
2	1.360E-03	0.1481	0.0575	0.0279	0.0416	3.772E-05
3	2.331E-03	0.1951	0.0754	0.0557	0.0545	8.466E-05
4	7.818E-03	0.3467	0.1383	0.0767	0.0998	5.201E-04
5	4.953E-03	0.2735	0.1005	0.0767	0.0794	2.622E-04
6	5.876E-03	0.2822	0.0998	0.0906	0.0865	3.388E-04
7	1.845E-03	0.1742	0.0657	0.0348	0.0485	5.963E-05
8	2.574E-03	0.2021	0.0754	0.0488	0.0572	9.822E-05
9	2.719E-03	0.2021	0.0754	0.0488	0.0588	1.067E-04
10	9.712E-04	0.1307	0.0446	0.0348	0.0352	2.277E-05
11	2.428E-04	0.0697	0.0279	0.0209	0.0176	2.846E-06
12	8.256E-04	0.1202	0.0441	0.0348	0.0324	1.784E-05
13	1.360E-03	0.1481	0.0531	0.0418	0.0416	3.772E-05
14	4.322E-03	0.2526	0.0938	0.0627	0.0742	2.137E-04
15	6.313E-04	0.1028	0.0375	0.0279	0.0284	1.193E-05
16	1.214E-03	0.1429	0.0507	0.0418	0.0393	3.182E-05
17	2.914E-03	0.2108	0.0711	0.0627	0.0609	1.183E-04
Total	0.0430	3.131	1.160	0.8153	0.8928	1.991E-03
Mean	2.531E-03	0.1842	0.0682	0.0480	0.0525	1.171E-04
St. Dev.	2.087E-03	0.0726	0.0279	0.0201	0.0222	1.409E-04