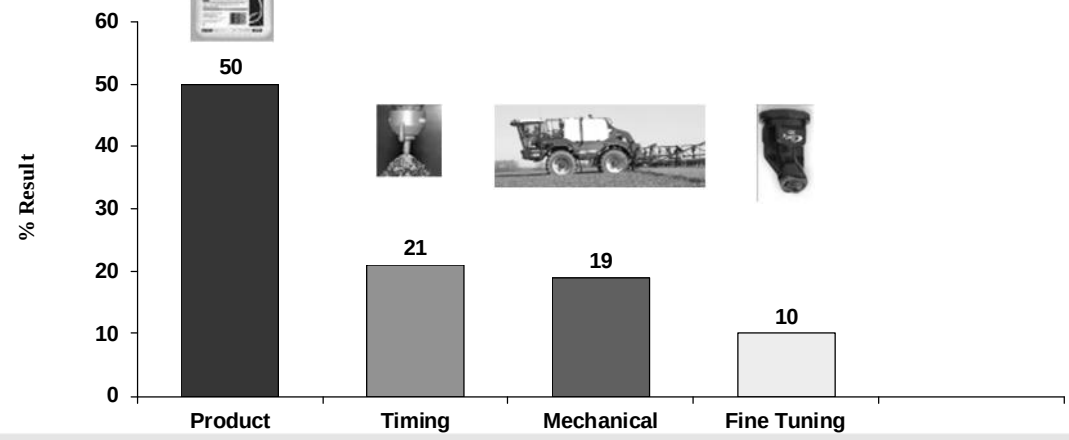
Spraying Technology

- Targets
- Movement of Sprays
- The Law, Wind and LERAPS
- Formulation and Adjuvants
- Water Volumes – Retention, Coverage, and Distribution
- How to make a nozzle, and spray physics.
- More Effective Nozzles
- Recommendations
- Pulse Width Modulation
- Sprayer Set Up

1

Components of 100% Control

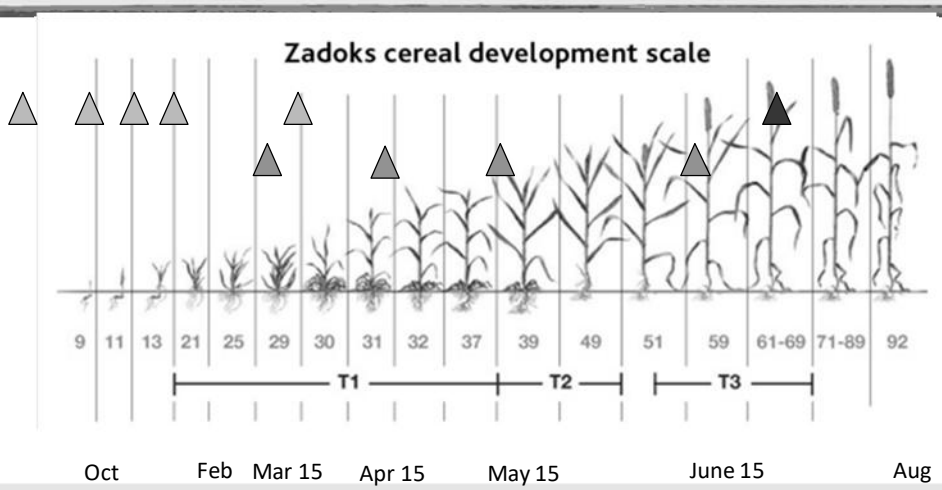


2

Winter Wheat GS 30

3

Sprays in a Crop of Wheat



Herbicide foliar

Herbicide Soil

Fungicide

Insecticide

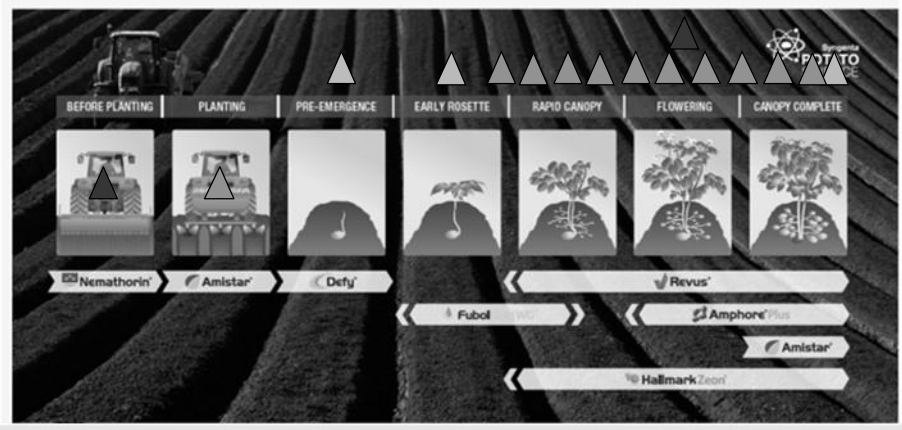
6-8 sprays + Fertiliser

4

Potatoes Meeting Along The Row

5

Sprays in A Potato Crop



- Herbicide foliar
- Herbicide Soil
- Fungicide
- Insecticide

15+ sprays + Fertiliser

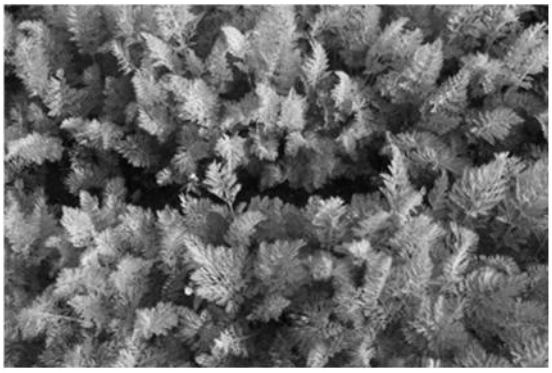
Blight sprays every 7 days

6

Potatoes Full Canopy

7

Carrots



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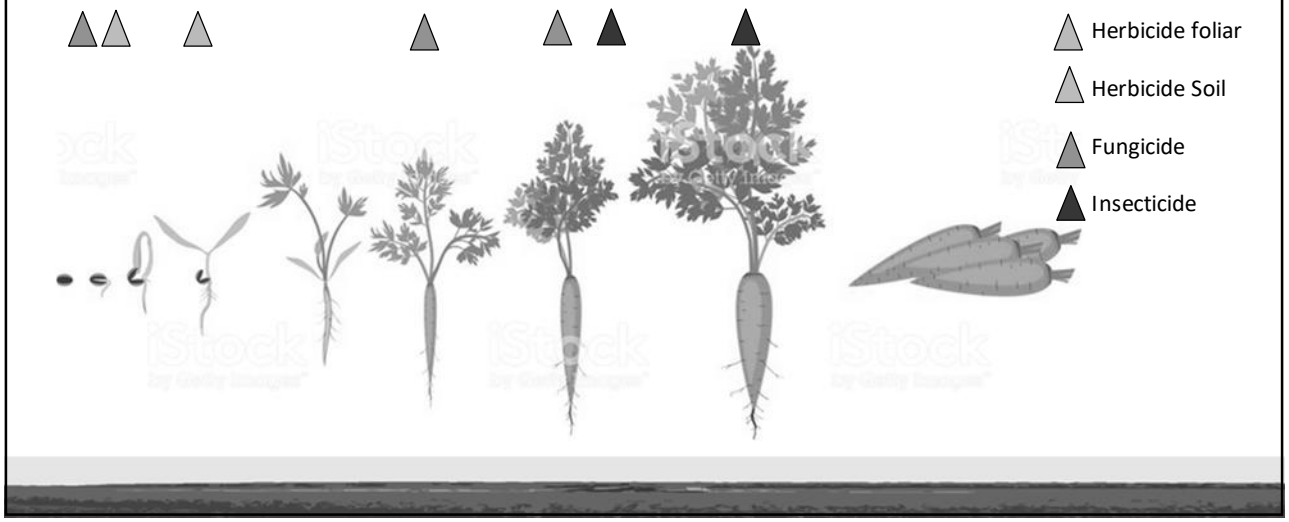
Sprays in a Carrot Crop



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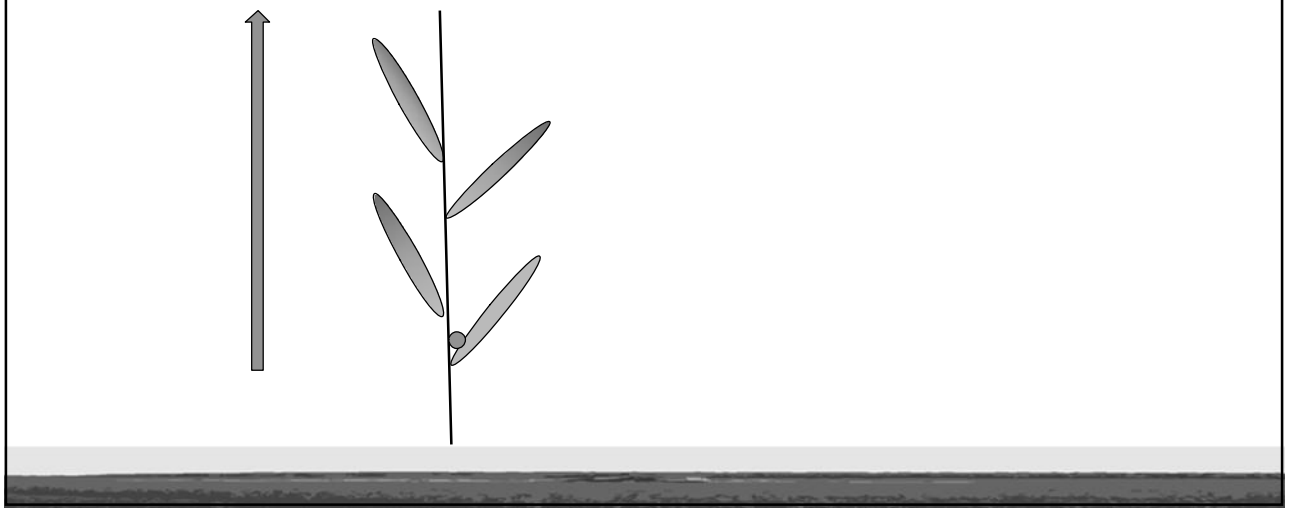
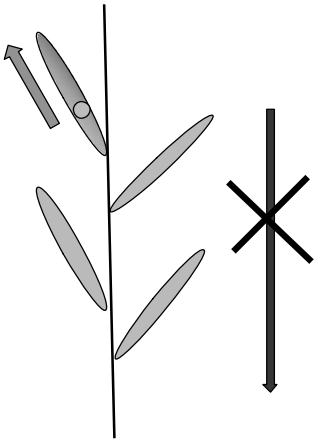
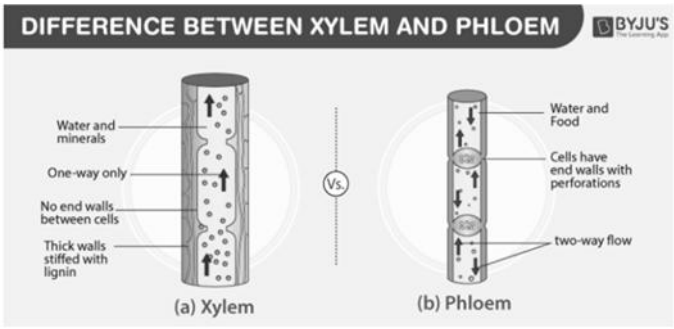
Systemic products



10

Systemic products



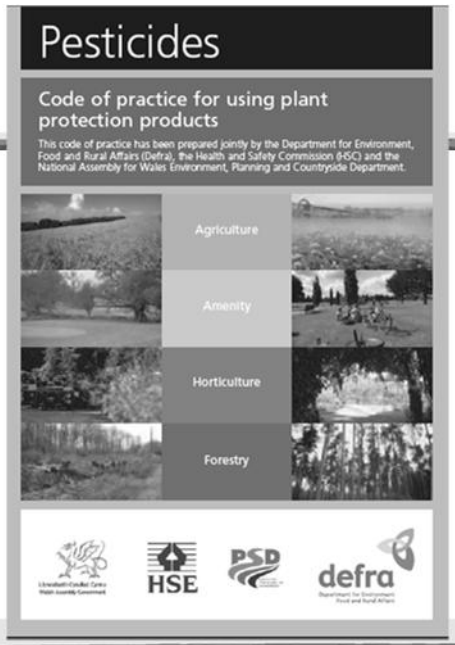


11

Development of new products

- 200 l/ha
- 3.6 km/h
- 015 FanJet
- Fine spray
- Good coverage
- Low boom

12



EU Regulation 1107/2009
Products must be applied with negligible exposure

- Closed transfer
- Drift reducing technologies
- 01/01/2018 default 75% DRT in Holland

13

Beaufort Scale – Windspeed – halve it

Code of Practice

Table 6: A guide to wind speed and using field-crop sprayers with conventional nozzles

Beaufort scale (measured 10 metres above the ground)	Description	Visible signs	Guide for using a standard crop sprayer	Approximate wind speed at the height of the spray nozzle
Force 0	Calm	Smoke rises vertically	Use only 'medium' or 'coarse' spray quality	Less than 2 kilometres an hour (less than 1.2 miles an hour)
Force 1	Light air	Smoke drifts, showing the wind direction	Acceptable spraying conditions	2 to 3.2 kilometres an hour (1.2 to 2 miles an hour)
Force 2	Light breeze	Leaves rustle and you can feel the wind on your face	Ideal spraying conditions	3.2 to 6.5 kilometres an hour (2 to 4 miles an hour)
Force 3	Gentle breeze	Leaves and twigs are constantly moving	Increased risk of spray drift. Avoid spraying herbicides and take special care with other pesticides	6.5 to 9.6 kilometres an hour (4 to 6 miles an hour)
Force 4	Moderate breeze	Small branches are moved and dust and loose paper are raised	Do not spray	9.6 to 14.5 kilometres an hour (6 to 9 miles an hour)

Met Office

Beaufort Scale for Land Areas

Below is a table showing the Beaufort Scale with speeds in knots, miles per hour and kilometers per hour.

Please note that these are these are *mean speeds, usually over 10 min by convention, and not gusts.*
The quoted wind speed is that *measured at 10 m above ground* not at the surface (which, at 2 m, may be only 50-70% of these figures)

Wind Force	Description	Speed km/h	Speed mph	Speed knots	Specifications
0	Calm	<1	<1	<1	Smoke rises vertically
1	Light Air	1-5	1-3	1-3	Direction shown by smoke drift but not by wind vanes
2	Light Breeze	6-11	4-7	4-6	Wind felt on face; leaves rustle; wind vane moved by wind
3	Gentle Breeze	12-19	8-12	7-10	Leaves and small twigs in constant motion; light flags extended
4	Moderate Breeze	20-28	13-18	11-16	Raises dust and loose paper; small branches moved.

Force 3: 6.5 – 9.6 km/h (4 – 6 mph) @ Nozzle Height 0.5m = 12 - 19 km/h (8-12 mph)@ Weather Forecast Height 10m

14

Change in Spraying Practice

15

The Consequences of Faster and Wider

- Raising the Boom
  - Increased Drift
  - Reduced Spray Energy
- Speed (Turbulence)
  - Lose Control of The Spray
  - Trajectory

16

Buffer Zones and Drift Reducing Technologies

- A buffer zone is 'no spray' area alongside a water course, ditch or field boundary
- Buffer zone schemes:
  - Arthropod
  - LERAP A + B
  - Interim Scheme (Aquatic)
  - Drift Reduction Technology Scheme (European Zonal Harmonisation)

17

LERAP Nozzle Constraints

LERAP Low Drift Rating 090012

Operational Settings and Conditions for Hypro Guardian Air Nozzle GA110-035

Atomiser	Size	Hypro Guardian Air Nozzle GA110-035
	Pressure	1.0 to 1.5 bar
	Flowrate	0.808 to 0.990 l/min
Carriage	Nozzle spacing	0.5 m
	Boom height	Up to 0.5 m above target surface, and not more than 2 m above ground surface if crop* continues into buffer zone or not more than 1 m above ground surface if no crop* in buffer zone * or vegetation of at least the same height as the crop being treated
	Forward Speed	6 - 12 km/h
Assistance	Not required	
Conditions	Weather	See UK Code of Practice.
	Crop cover	Not necessary
	LERAP regime	12 m downwind swath

18

90% drift Reduction (4*)

19

Making Products Hit, Stay, and Cover

20

Wetting

Non-ionic wetter

Dose: 0.1% (200 ml in 200l)

21

Herbicide Label Recommendations – UK 2022

Axial Pro

syngenta

Apply AXIAL Pro at 0.55 - 1.1 litres per hectare. The dose rate of AXIAL Pro depends on target grass species and season.

Spray Quality Apply AXIAL Pro using a conventional fan nozzle producing a spray quality at the finer end of the medium range as defined by the British Crop Protection Council.

A spray pressure of 2-3 bars is recommended. Spray Volume Spray AXIAL Pro in 100 - 400 litres of water per hectare.

?

22

Wetting? -Some Products Need More.

Non-ionic wetter

Dose: 0.1% (200 ml in 200l)

☺

Herbicide

Dose: 3 l/ha

☺

herbicide

Dose: (0.4) 0.55 -1.1 l/ha

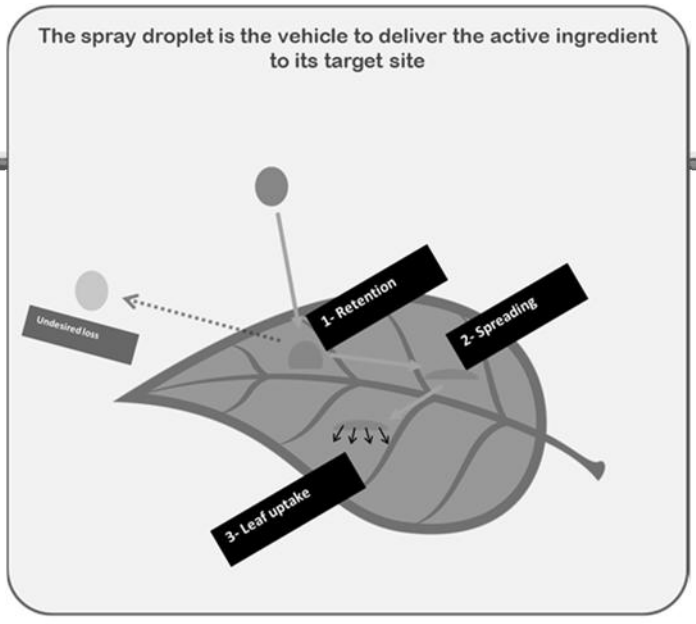
☹ ☺

Insecticide

Dose: 0.05 l/ha (50 ml)

☹

23



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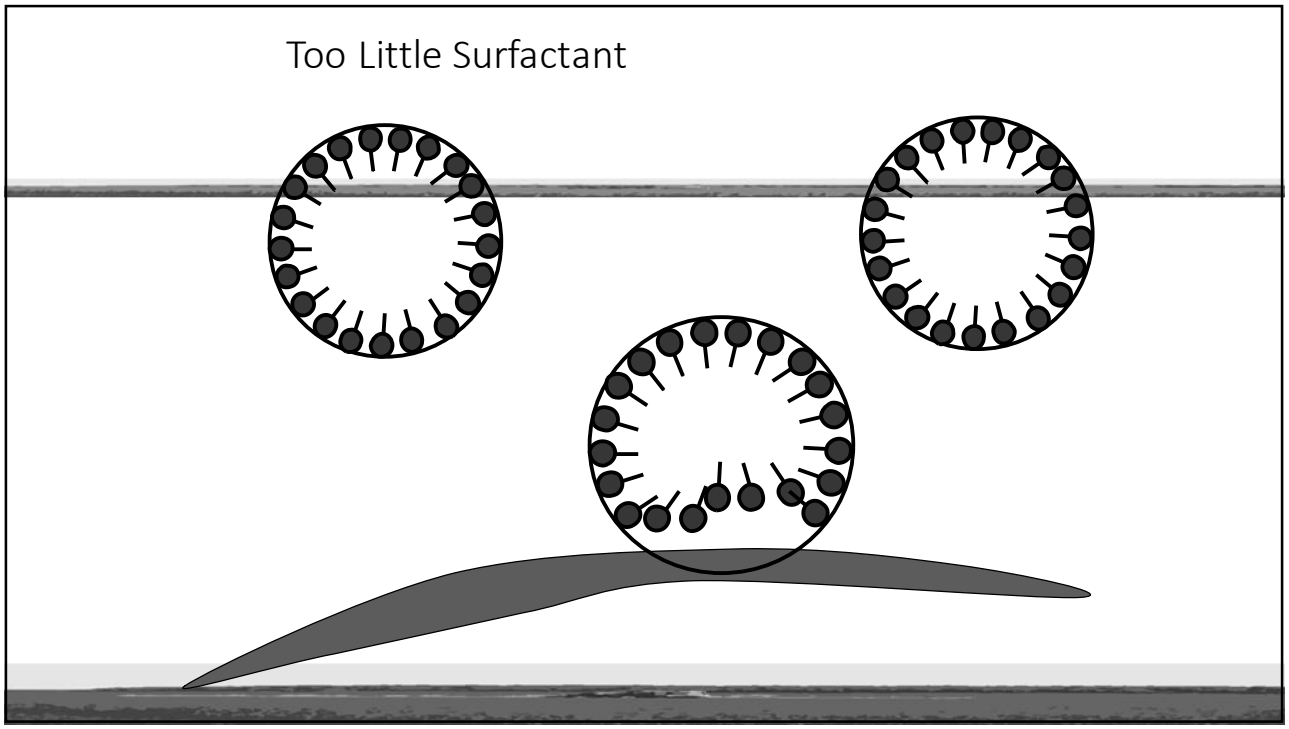

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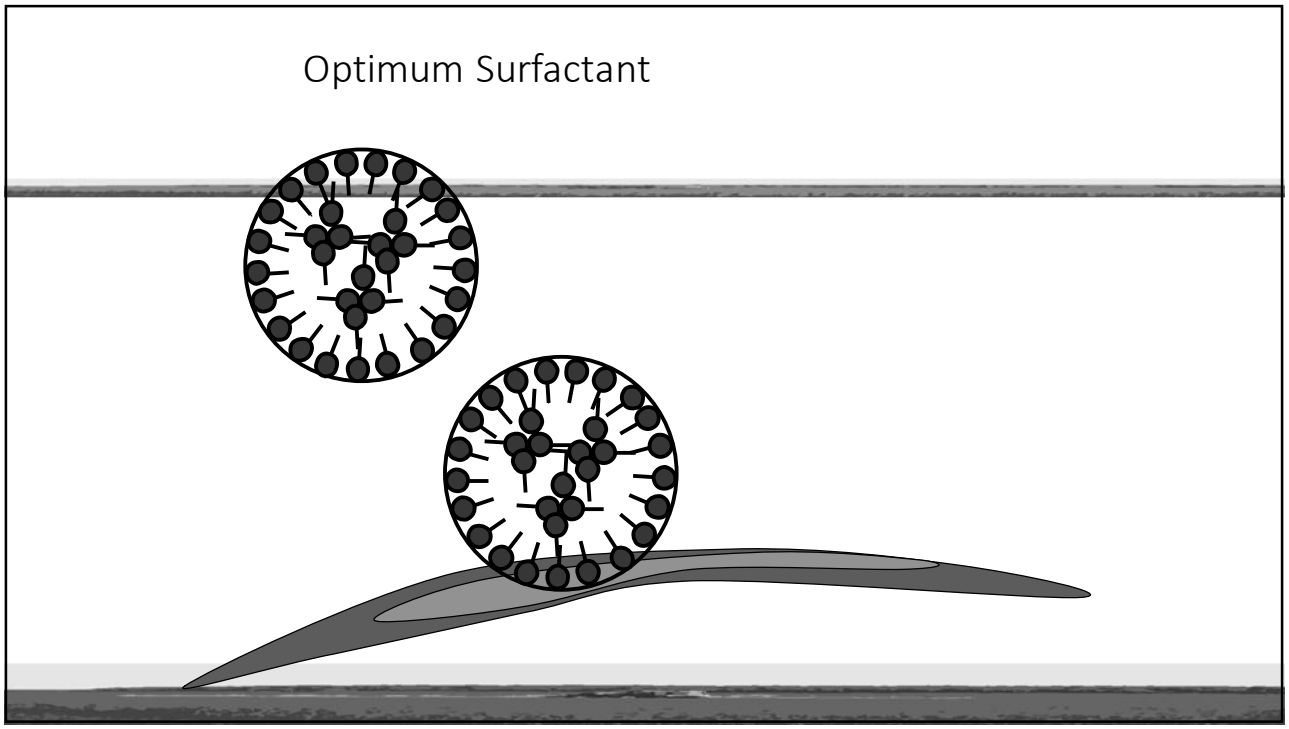


26

Water Volumes, Deposition and Coverage

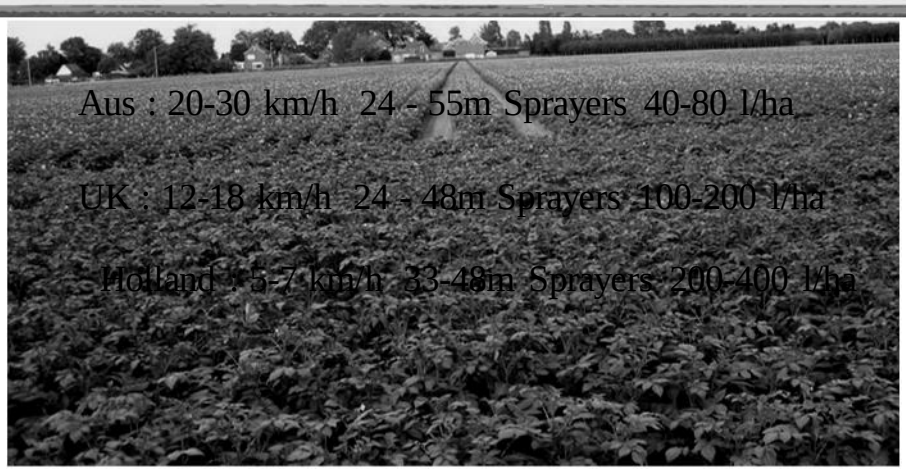
27

Water Volume

- **200 l/ha**
- = 20 ml/m^2
- = 0.02 mm rainfall

28

Field Crop Spraying in Australia, Europe and Japan



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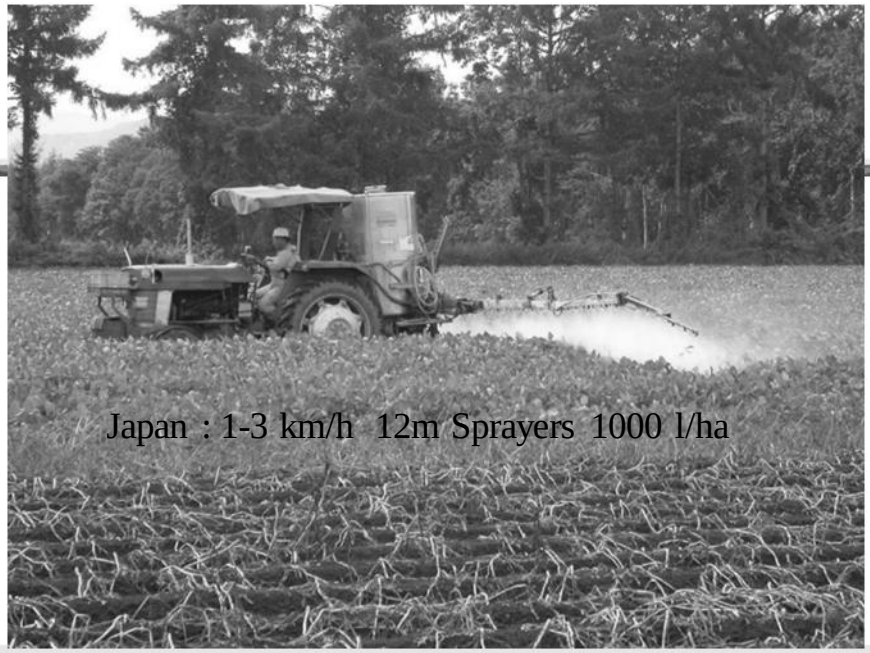


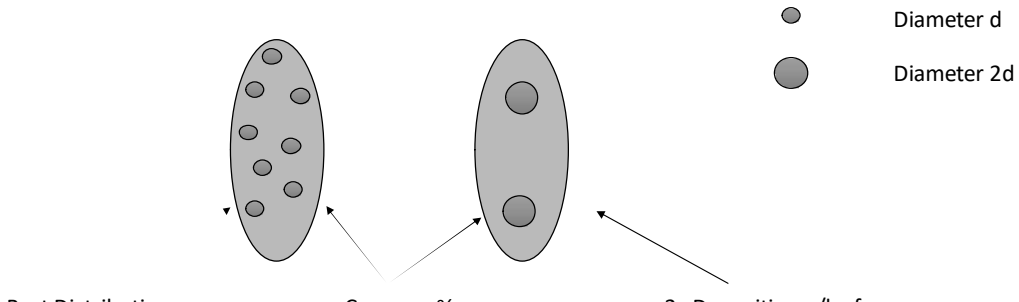
30

Transfer, Coverage, Distribution, Deposition

- Transfer: % Spray reaching the Target
- Deposition: grams a.i. deposited. (g/leaf)
- Coverage: plant area covered by spray (%)
- Distribution; Uniformity of Coverage (Qualitative)

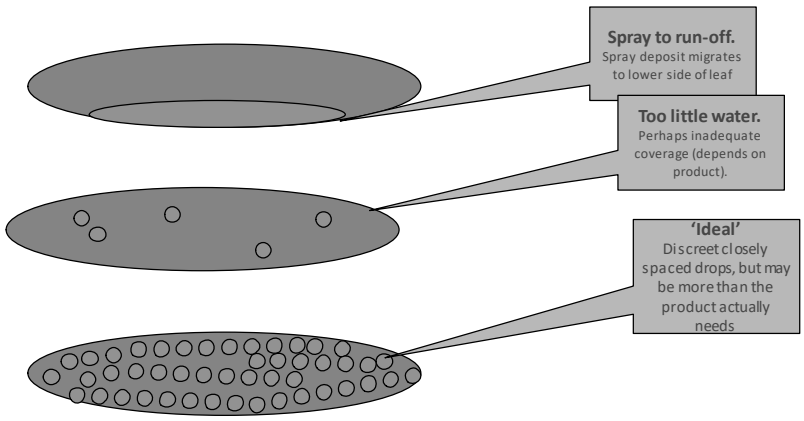
31

Distribution, Coverage, Deposition



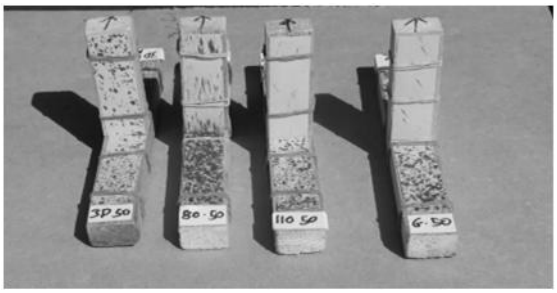
32

Coverage
What are we talking about?



33

Water sensitive paper and 'SnapCard'



34

Sprayer Set Up 1: Water Volume l/ha

Retention on Leaves v. Run- Off

Increasing Volume eg 800 l/ha	
Increases Coverage	+ve
Increases run-off	-ve
Decreases deposition on leaves	-ve
Decreases Concentration of formulation	-ve
Reduces Sprayer Work Rate	-ve

+ve - Soil Applications
+ve - Contact Products
+ve – Crops sensitive to a herbicide

Decreasing Volume eg 200 l/ha	
Decreases Coverage	-ve
Increases deposition of ai	+ve Leaves
Increases Concentration of formulation	+ve
Decreases run-off	+ve Leaves
Increases Sprayer Work rate	+ve

+ve - Foliar Applications
+ve – Sprayer Output ha/day
+ve – Spray Timing

35

Compromise for best result

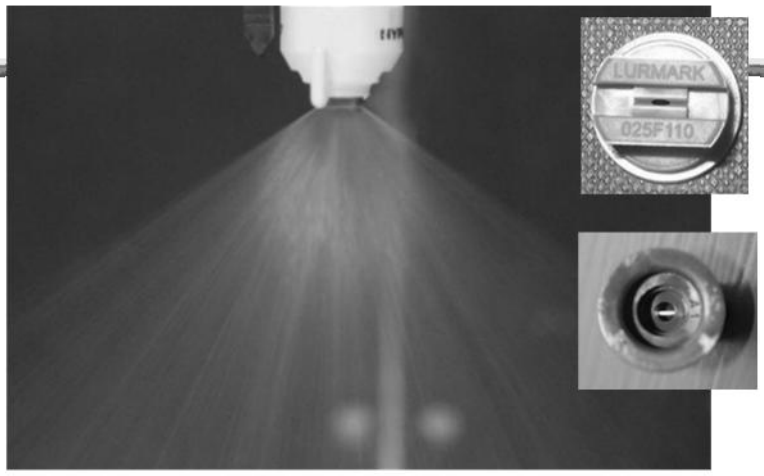
Benefits?

Water Volume + ?
Water Volume - ?
Additional Wetter ?
Additional Oil ?

36

Most Common Nozzle Used in Crop Spraying

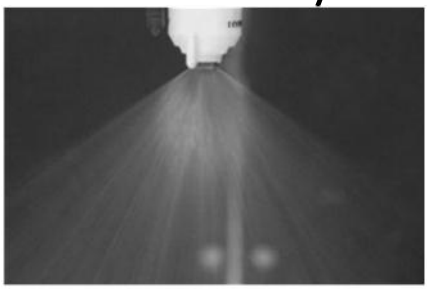
Traditional Fan Jet 110^0



How to make a fan jet, and how it works

37

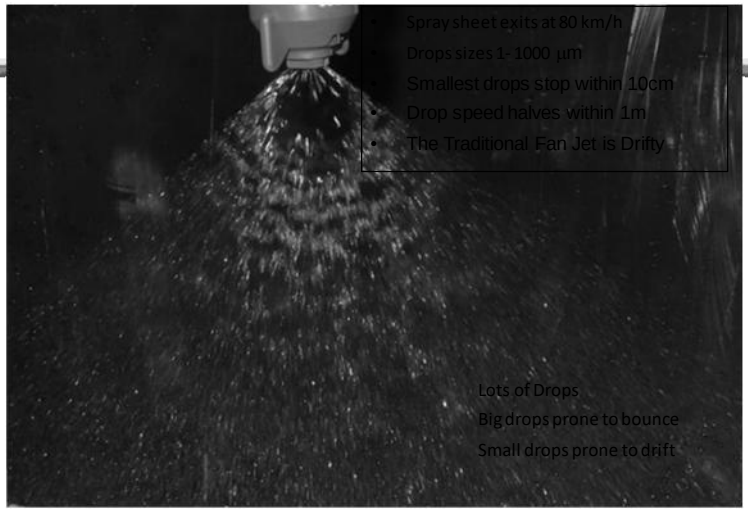
Nozzle Physics



38

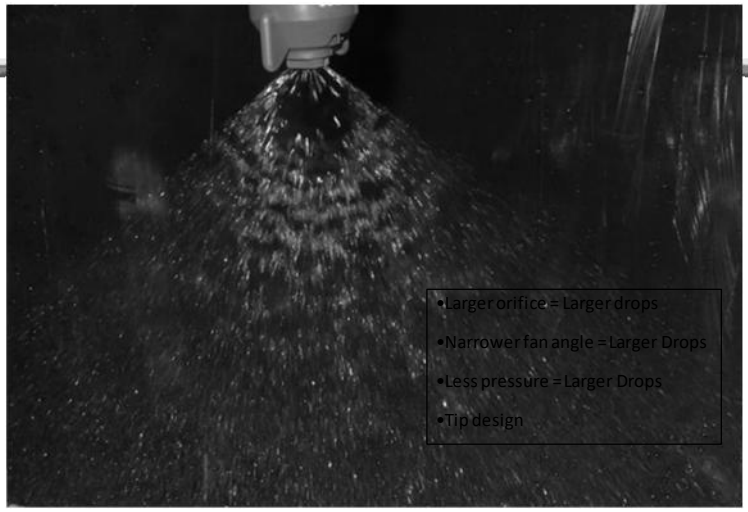
Most Common Nozzle Used in Crop Spraying

Traditional Fan Jet 110^0



39

Tuning The Fan Jet



Hand Sprayer

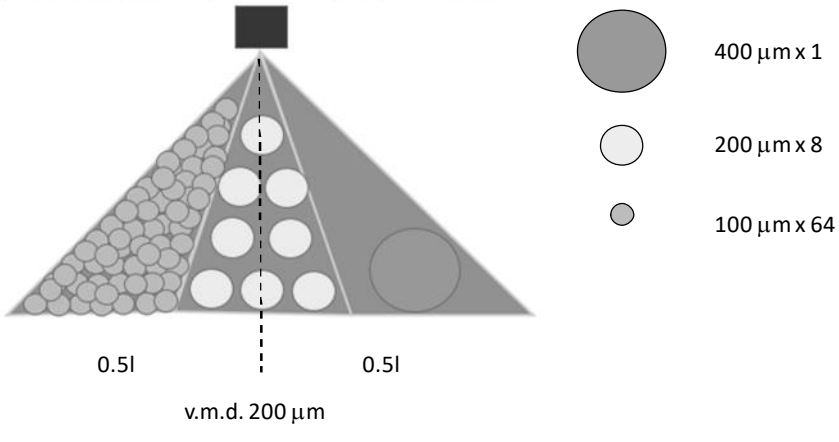
40

Drop Size Measuring Equipment

- All drop size measurements are different
- Measuring makes of equipment use different systems.
- Readings vary depending on atmospheric conditions on the day
- LERAP measurements are always done against a standard nozzle
- Drop size measurements have to be comparative

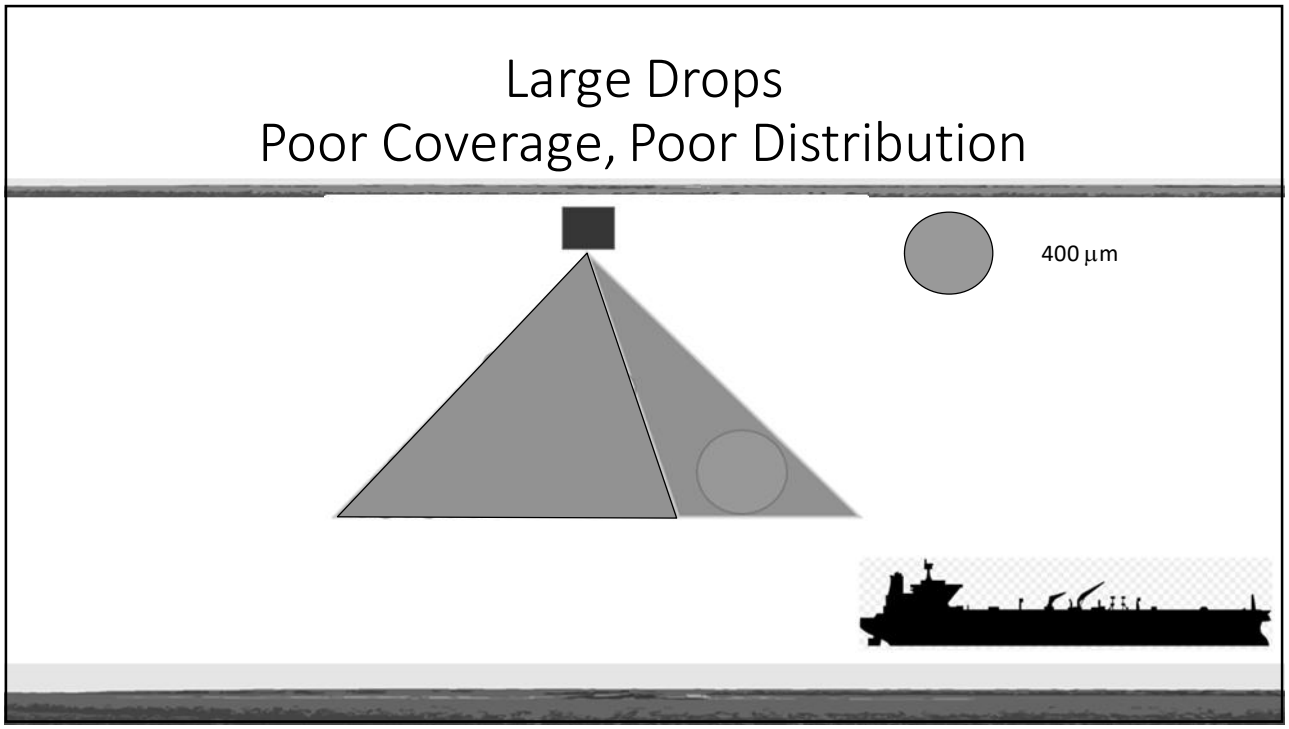
41

Volume Median Diameter (v.m.d.) Drop Size v. Number



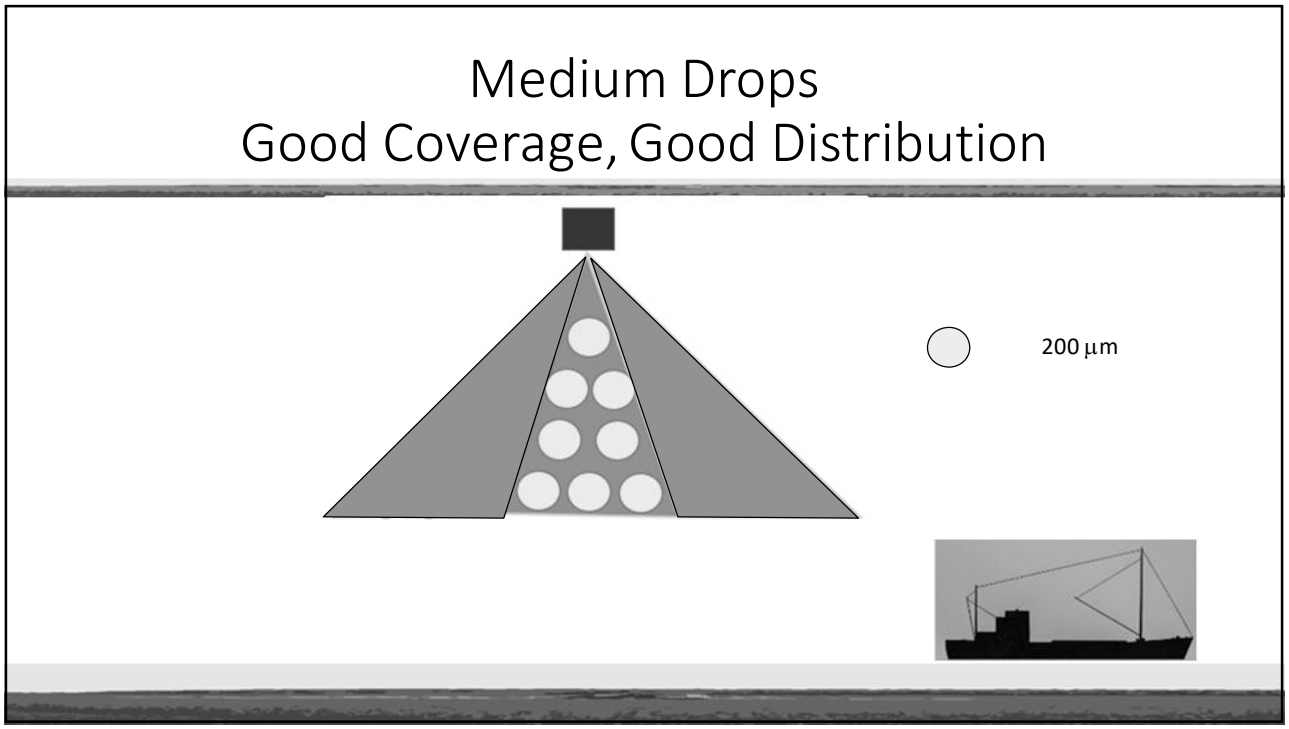
42

Large Drops
Poor Coverage, Poor Distribution



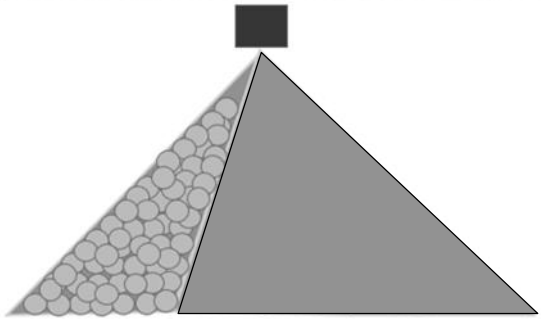
43

Medium Drops
Good Coverage, Good Distribution



44

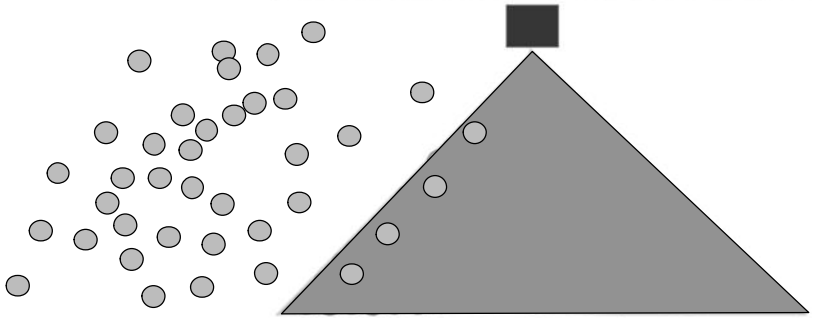
Small Drops (In Principle)
V.Good Coverage V. Good Distribution



100 µm

45

Small Drops (In Practice)
Too Light To Control



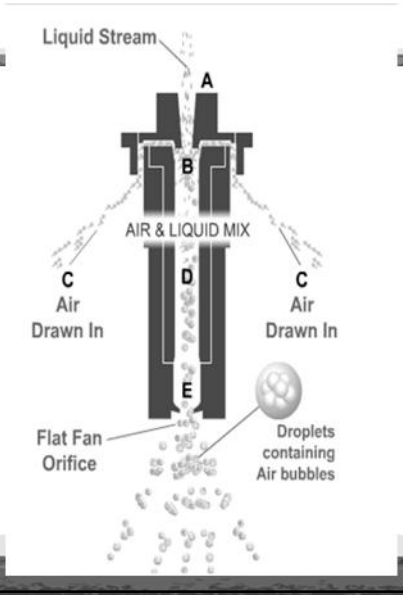
100 µm

46

Spray Quality – Hand Sprayer

47

Air Induction Nozzles - BUBBLE JETS



- Spray sheet exits at 40 km/h
- Drops contain air
- Shock absorber

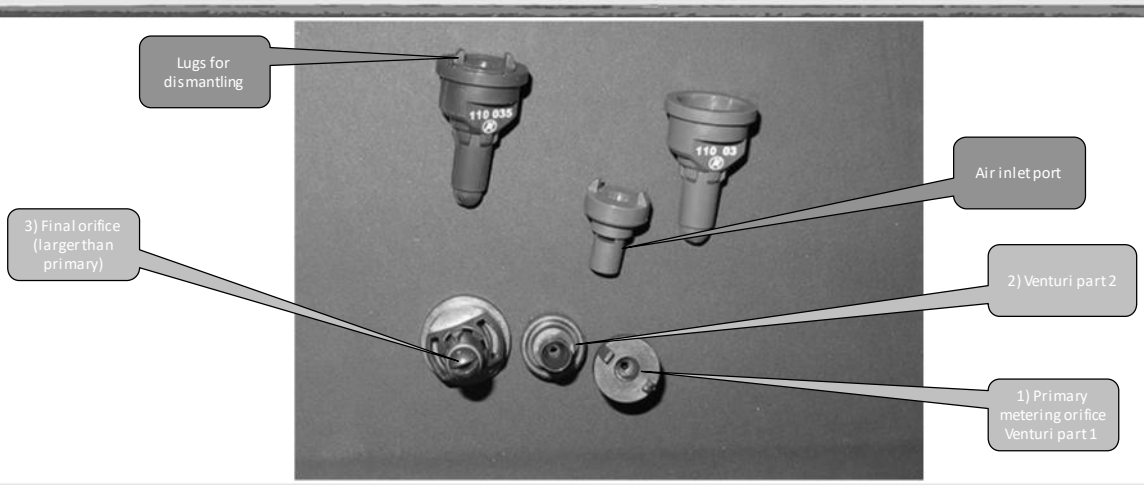
Mixer Tap

48

Air Inclusion - How it Works

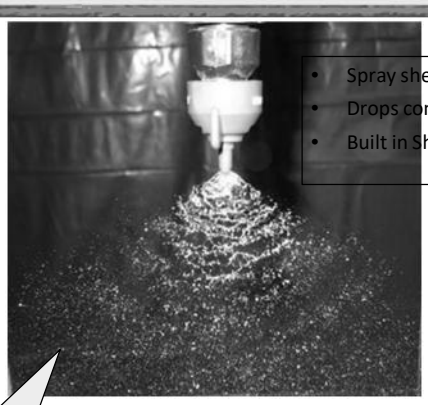
49

Tuning an air Induction Nozzle (Amistar)



50

Differences Between Air induction Nozzles - 3* LERAP



- Spray sheet exits at 40 km/h
- Drops contain up to 20% air
- Built in Shock absorber

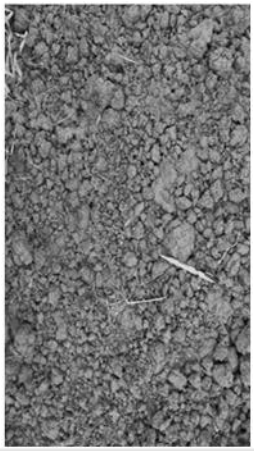
Many More Drops /Litre

51

Label v. Syngenta Best Recommendation

52

Blackgrass as a target - Trajectory

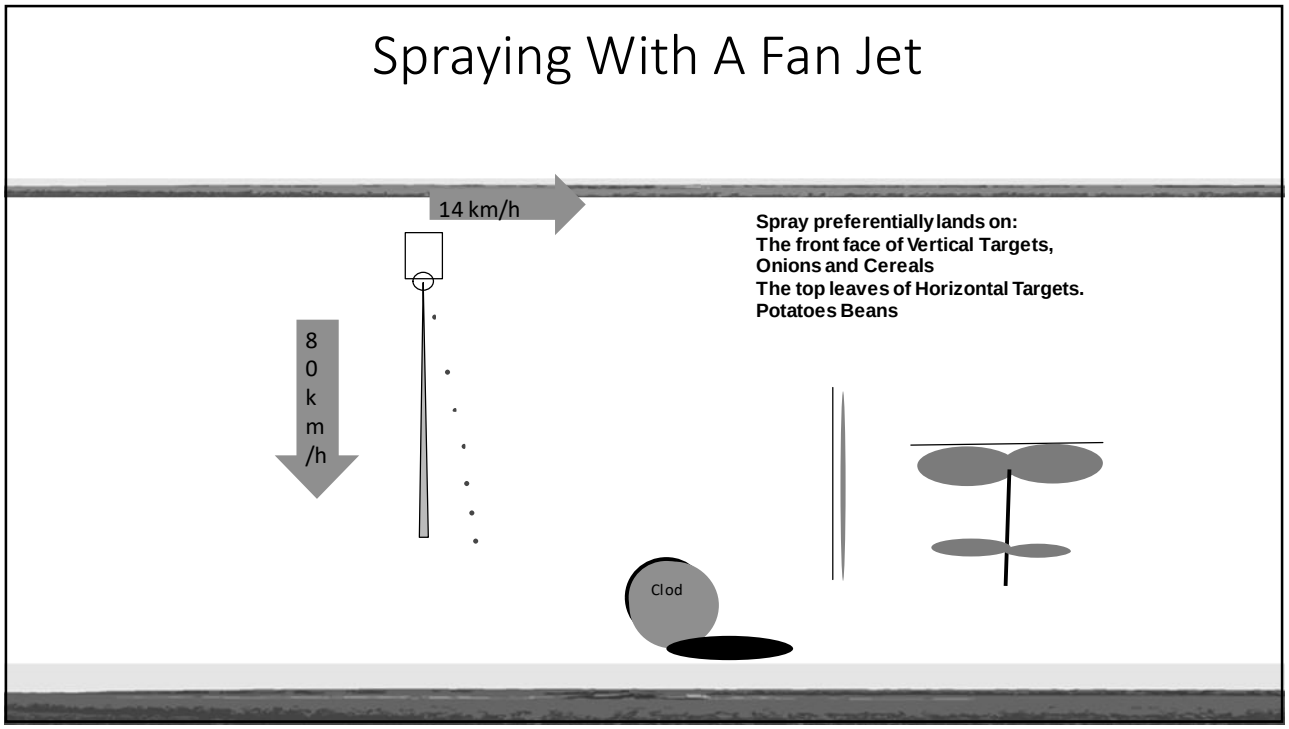


53

Trajectories - Spraying with a Fan Jet

54

Spraying With A Fan Jet



55

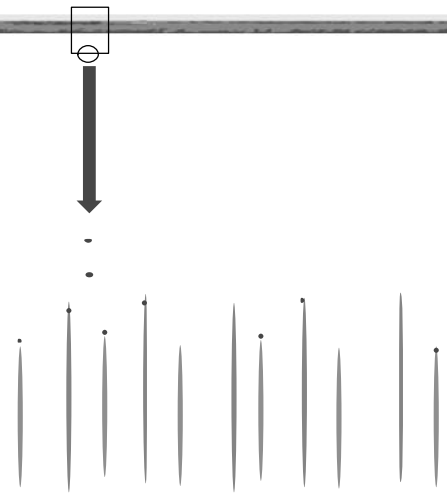
Shading – Snow and Spray drops.

56

Shading – Snow and Spray drops.

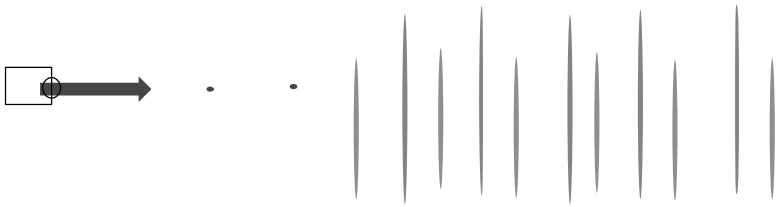
57

Grasses Difficult To Hit From Above



58

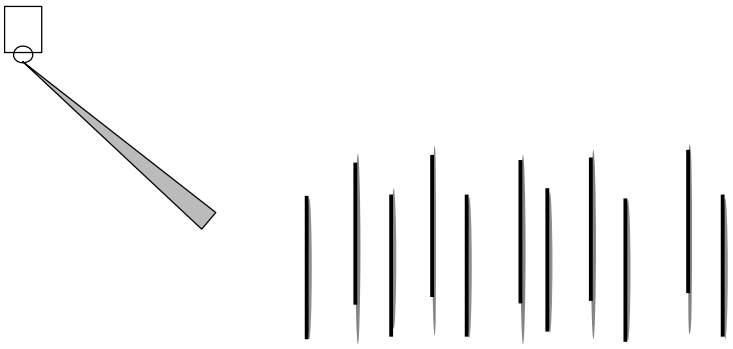
Easier to hit from the side



59

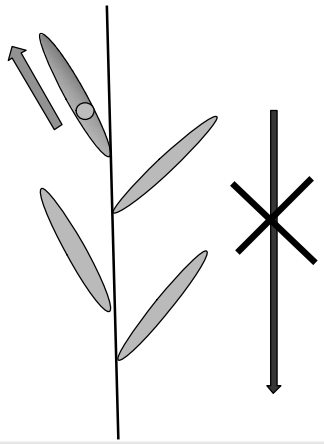
Early Season

Angled Spray = 2x Deposition on Small Grass Weeds (and crop)



60

Systemic product



61

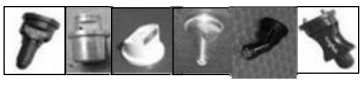
Septoria at GS 37

62

Angled Spray for Potatoes and OSR

63

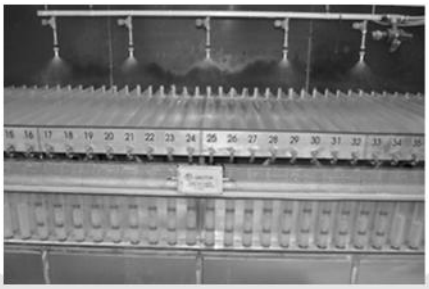
Nozzles and Better Nozzles



64

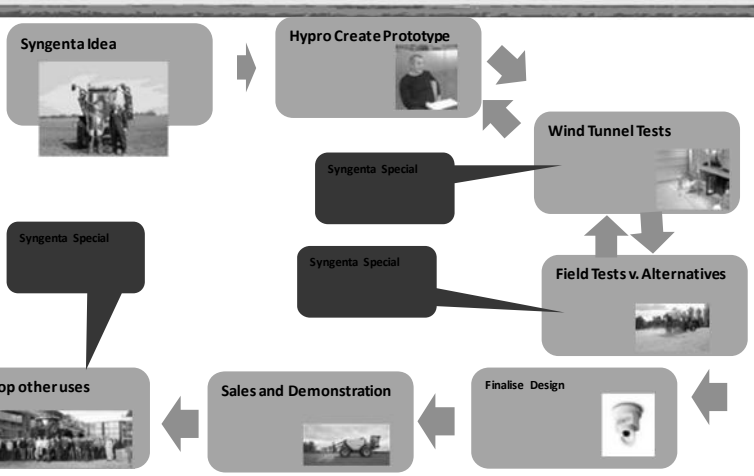
Nozzle Co. Nozzle Development

- Pass JKI Patternator Tests.
- Pass drift tests



65

Syngenta Nozzle Development



66

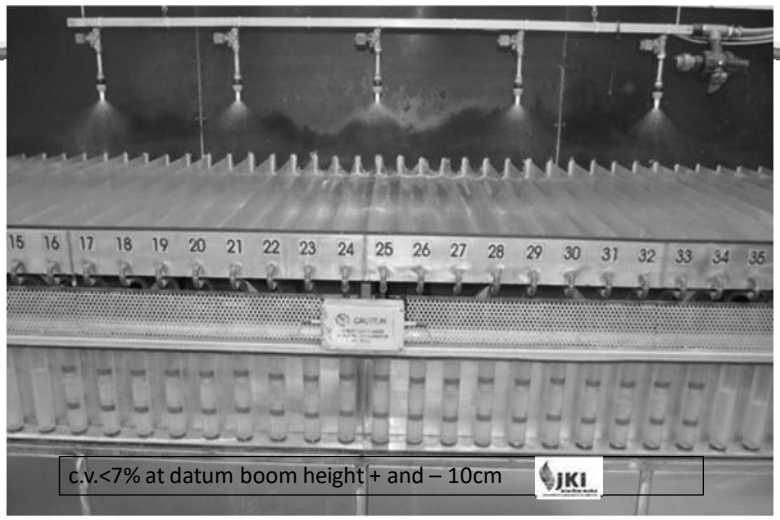
Development of Syngenta Nozzles

67

Spray Physics

68

Patternator



c.v.<7% at datum boom height + and – 10cm

Patternators are designed for vertical trajectory nozzle

69

Angled Nozzles
Single v. Twin

70

Development of Amistar Nozzle Guardian Air

71

The AMISTAR Nozzle

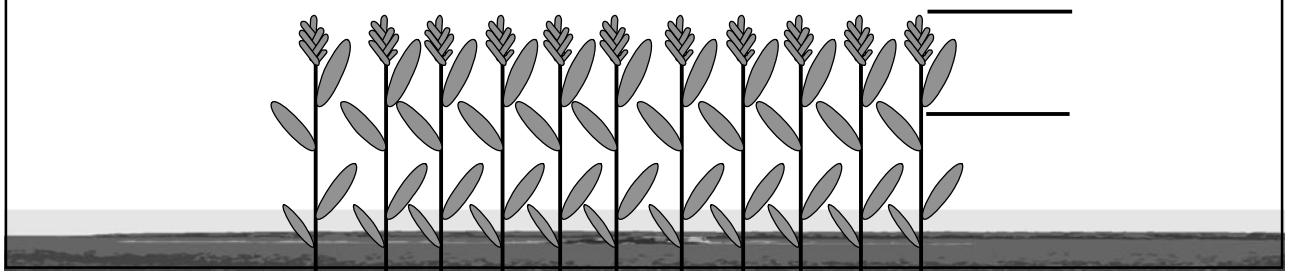
- Originally designed as an ear spray nozzle
- Places more AMISTAR where it's needed – at T1, T2 and T3
- 100 l/ha - improves work rates
- More spraying days
- Better disease control and more yield

- **Nozzle manufactured by Hypro**
- **Testing by Silsoe Research institute**

Amistar MODDUS AXIAL

72

T3: is a unique target



73

Development

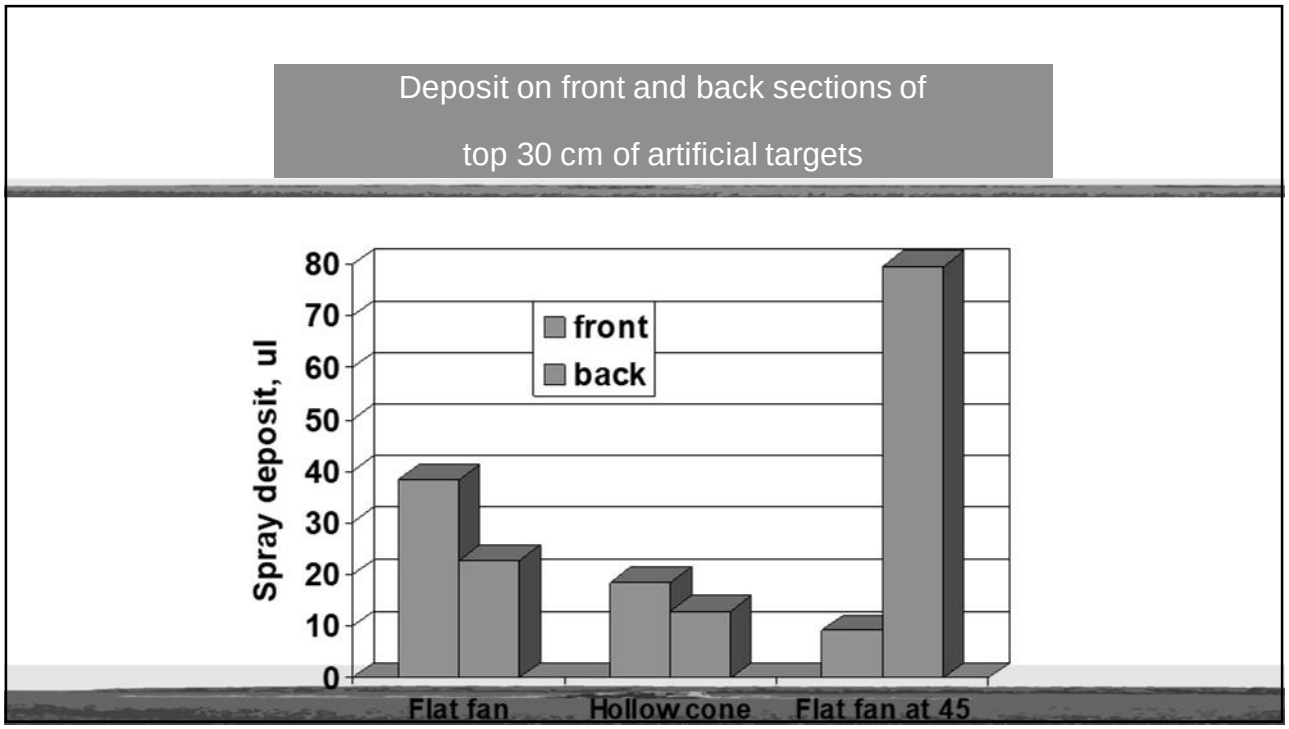
- Tested a wide range of nozzle types and sizes
- Look at the effects of;
  - Nozzle type
  - Drop size
  - Drop type
  - Spray angle

74

75

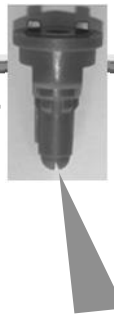
Deposit on front and back sections of

top 30 cm of artificial targets



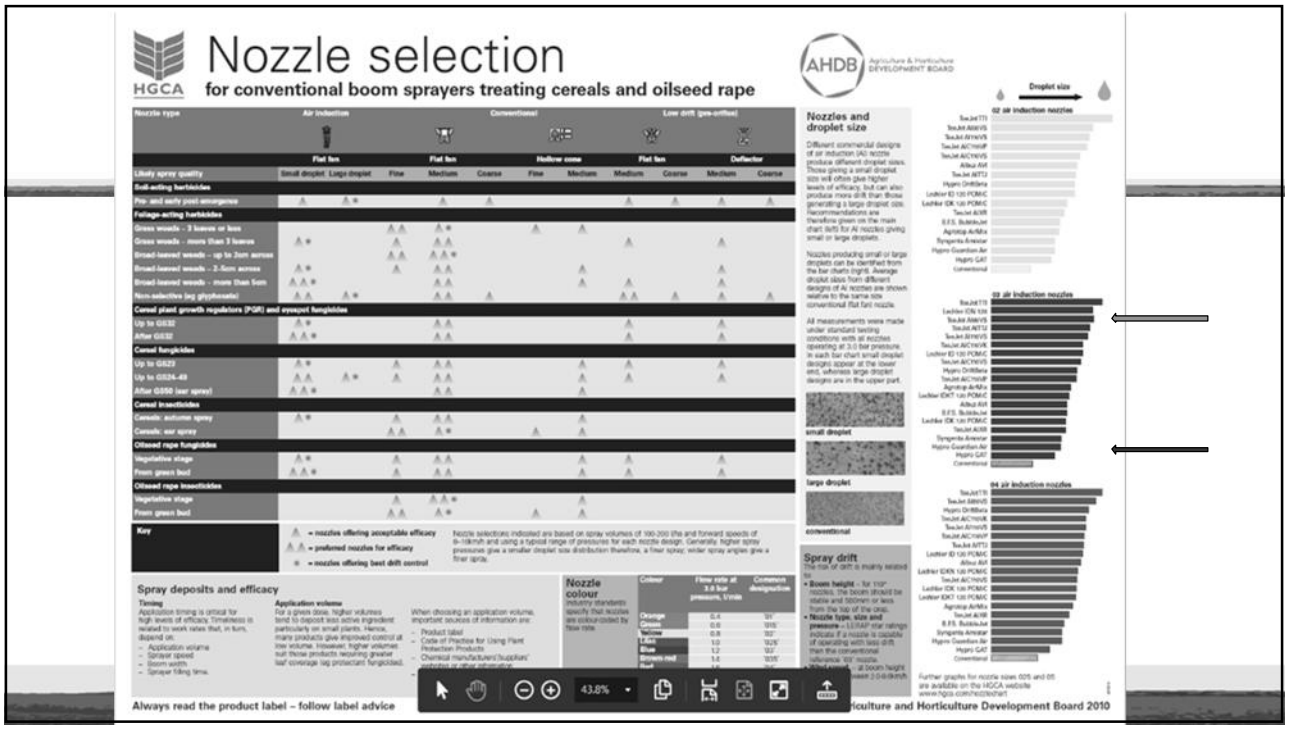
76

10 degree backward angle evens up the spray front and back at 12 km/h



035 and bigger. Angle increases to 13°

77



Nozzle selection

for conventional boom sprayers treating cereals and oilseed rape

HGCA

AHDB Agriculture & Horticulture DEVELOPMENT BOARD

Nozzles and droplet size

Spray drift

Spray deposits and efficacy

Always read the product label – follow label advice

78

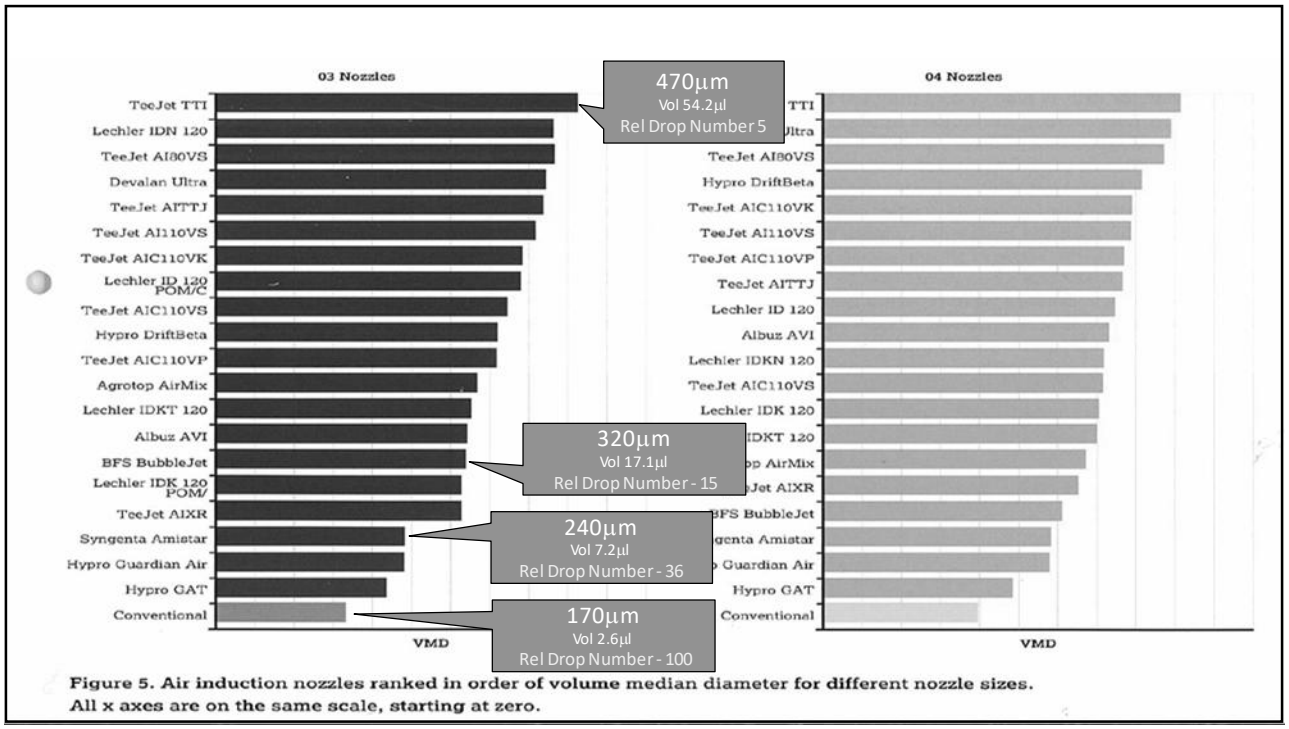


Figure 5. Air induction nozzles ranked in order of volume median diameter for different nozzle sizes. All x axes are on the same scale, starting at zero.

79

Nozzle Choice and Effect

Medium Quality Spray

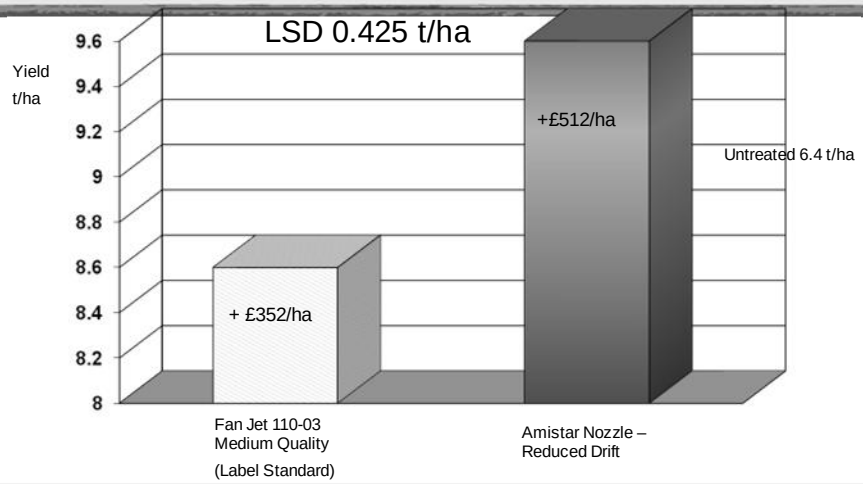
Reduced Drift – Guardian Air

80

T3 Application Trial

- HGCA - 2003

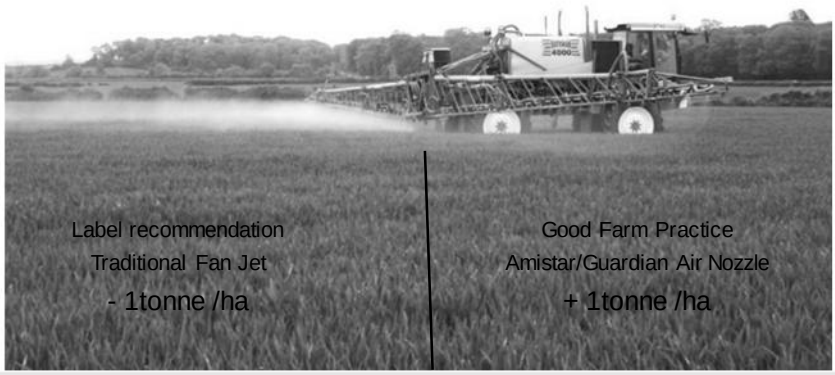
Azoxystrobin + Tebuconazole



E.S. Powell et al – International Advances in Pesticide Application 2004

81

Traditional Fan Jet v. Amistar Nozzle



82

Technology and Characteristics - Traditional Fan Jet

Variable Energy: Very sensitive to boom height and wind conditions

Coverage OK, when/if spray lands.

Places most spray on front of plants.

A menace in marginal conditions.

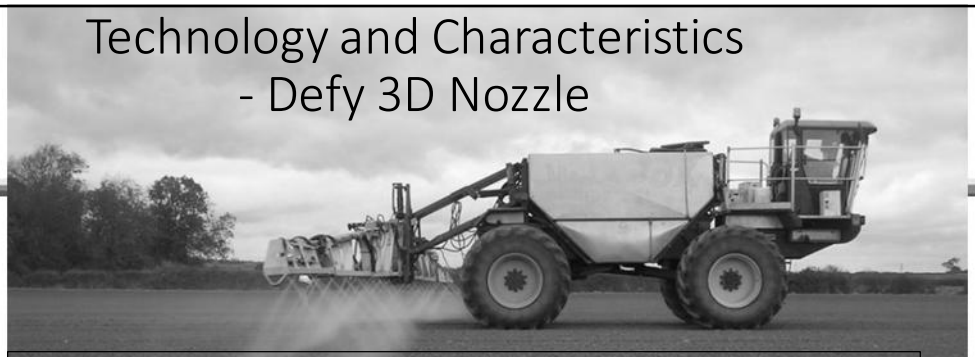
83

Technology and Characteristics – Amistar Nozzle

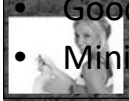
- Medium energy
- Medium Coverage – superior to other air induction nozzles
- Shock absorber in the drops
- Uniform deposition in a wide variety of conditions.

84

Technology and Characteristics - Defy 3D Nozzle

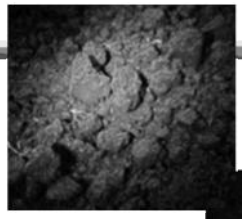


- High Energy –Optimum height 50 cm. Also effective even at higher boom heights 75 cm
- Optimised trajectory – Maximise deposition.
- Good coverage
- Minimise drift

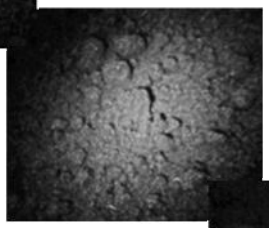


85

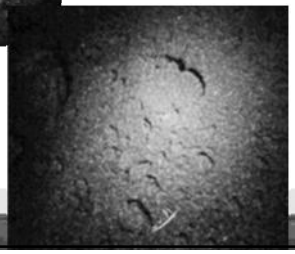
Pre- em Deposits on Soil



Fan Jet



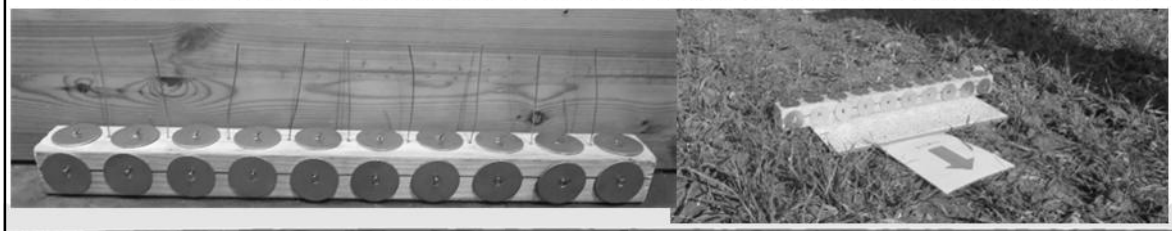
Amistar Nozzle



Defy Nozzle

86

BASF Application Trial 2021

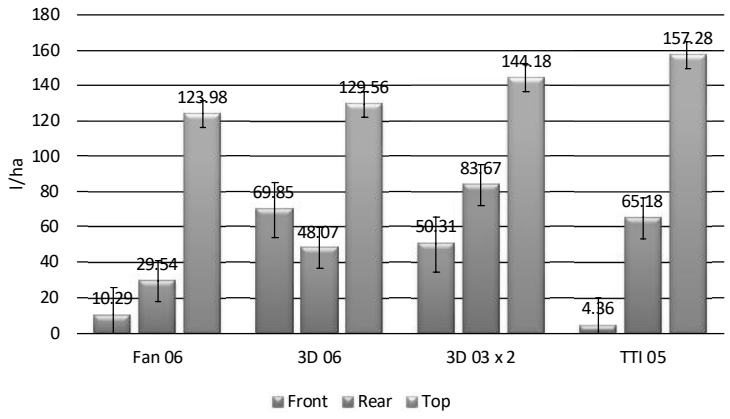


87

- 200 l/ha
- 12 km/h
- Fan Jet 110-06
- 3D – 06
- 3D – 03 x2
- TTI – 05

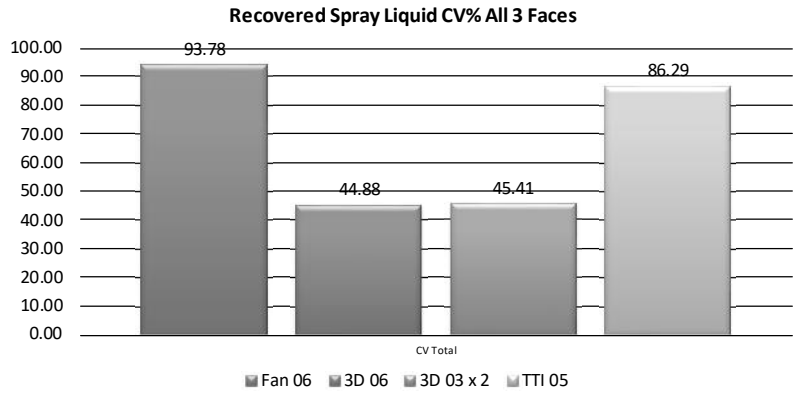
88

Deposition l/ha Front, Rear and Top



89

Spray Liquid CV% Front, Rear, Top



90

Recommendation

- 3D-03 x 2 in good spraying conditions ★★★★★
- 3D – 06 is close behind, and should be used if more marginal ★★★★
- TTI I would use alternately in windy conditions ★★
- Don't use a fan jet!! ★

91

- Nozzle Bath

92

Hitting The Targets






93

Stubble Cleaning with Glyphosate 100 l/ha

94

94

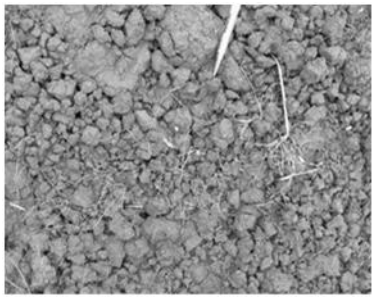
Pre and Peri- Emergence Soil Applications
100 – 200 l/ha

95

Volunteers in Oilseed Rape
100 l/ha

96

Grass weeds post-emergence foliar 100 l/ha



Flat: Forward

Shading: Fwd and Back

97

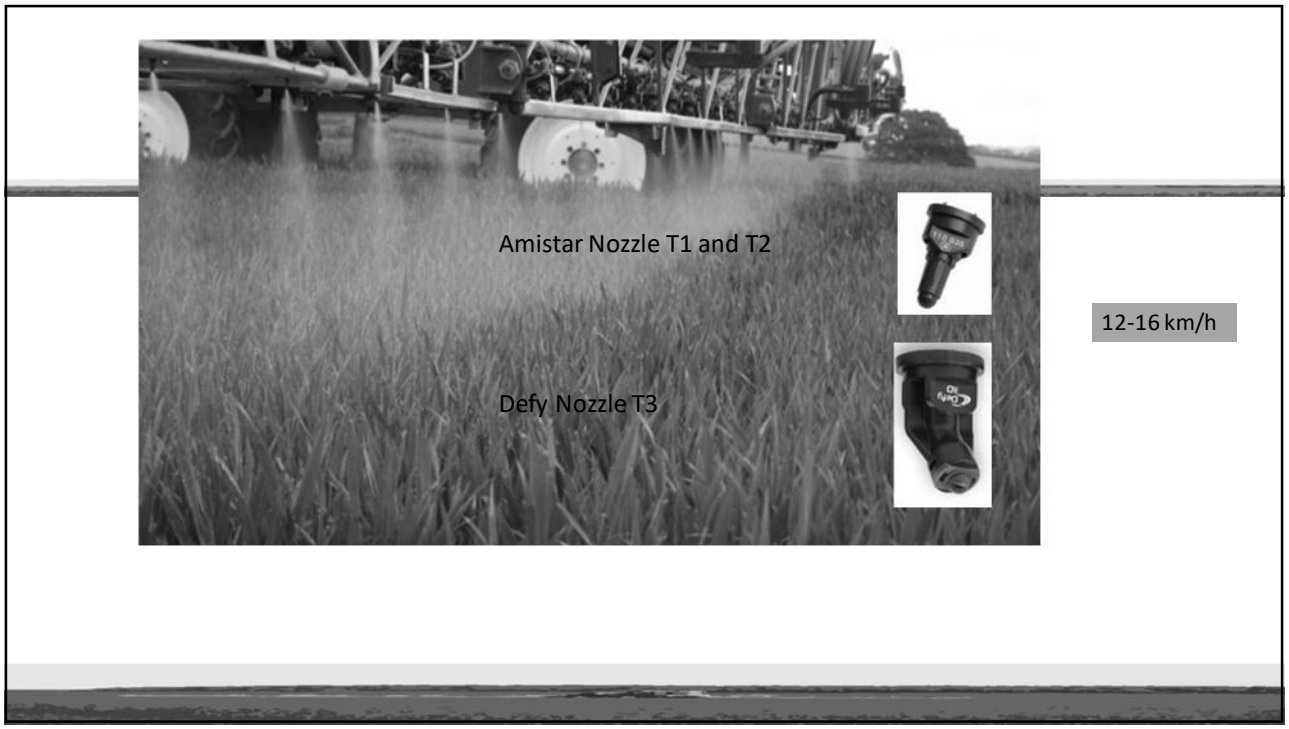
97

Pre- emergence to T0

12 - 16 km/h

98

98



99

Nozzle Summary

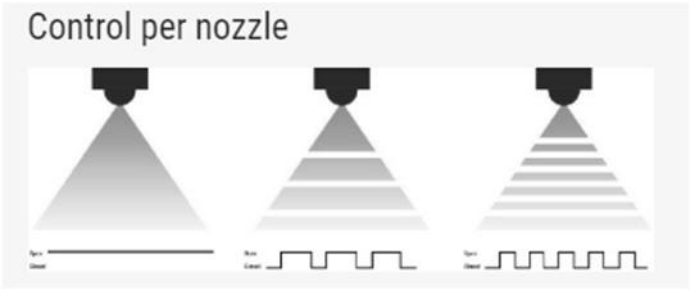
100

Pulsewidth Modulation.

1. Single Nozzle Sections : to minimise overlap, and overdosing
2. Turn Compensation: 100% coverage uniformly across the boom when turning
3. Pressure Independent Rate Control: No change in drop size when speeding up or slowing down
4. Variable Rate Application
5. Agrifac. Capstan. John Deere. Raven. TeeJet

101

What is Pulse Width Modulation (PWM)?



- Frequency: 10-100 Hz (Cycles/sec)
- Duty Cycle: 'On' Time %

PWM has been available commercially in the US since the late 90s: It has been used principally for varying speed without changing spray quality (drop size).

102

Current Practice in US and Canada

- PWM is deployed principally for speed variation while maintaining a constant pressure and drop size.
- PWM is used with Traditional Fan Jets and bespoke PWM Nozzles. Ai nozzles are not suited to PWM.
- Nozzle size is selected for a target water volume (l/ha) and target forward speed (km/h) at a duty cycle of 70-80%.

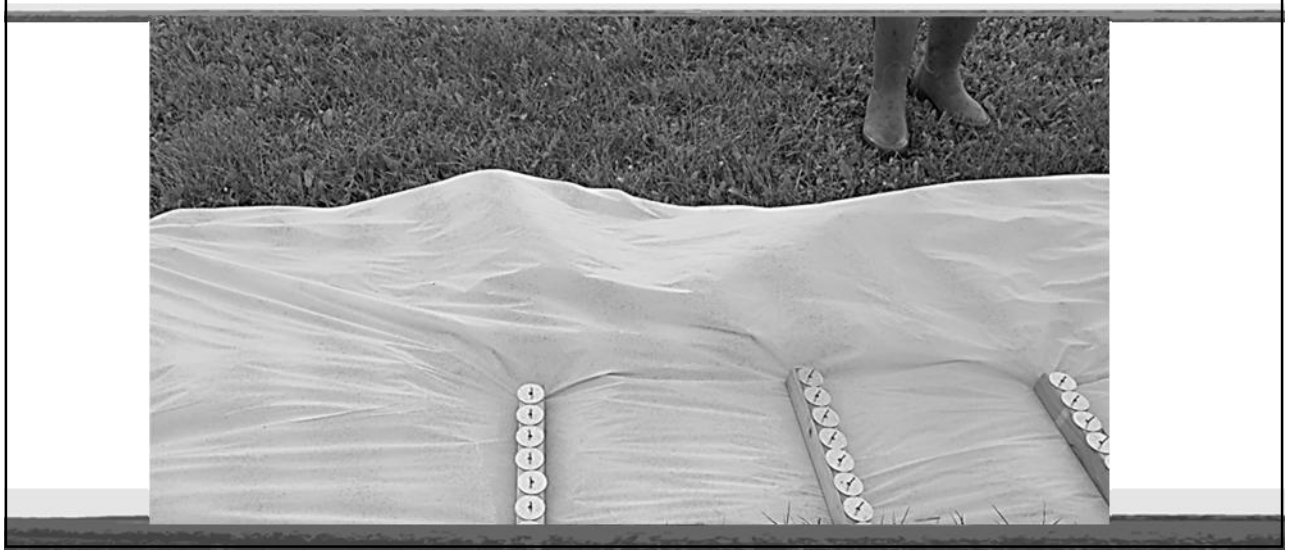
103

Current Practice in US and Canada

- Nozzles fire alternately: blended Pulse Width Modulation (bPWM)
- Concern of gaps in pattern at Duty Cycles <50%
  - 12 km/h = 3.33 m/sec : 33.3 cm/ 0.1 sec
- No accessible field work addressing UK concerns

104

PWM – Incorrect Setup



105

Potential Issues with varying Speeds

- Gaps in the spray in the direction of travel
- Uneven Patternation across the boom
- Dose varies with speed

- 12 km/h = 3.33 m/sec : 33.3 cm/ 0.1 sec

106

Potential Issues with Turn Compensation

- Uneven Dosing
- Unrealistic expectation
- Sensitive to turn radius

107

Potential Issues with Variable Rate Application

Doses 25%, 50%, 75%, 100%

- Gaps in deposition
- Inaccurate dosing
  - 25% dose = 25% Duty Cycle
  - = No spray for 50% of application time!

108

Tight turn 22.5m at 6 km/h

Traditional

With Turn Compensation

109

intelligent farming
it pays to know

Improving efficiency
through boom stability

syngenta

110

Key Set Up Factors

1. Boom Straight and Horizontal
2. Boom Suspension well maintained
3. Correct type and size of Nozzle
4. Nozzle Outputs +/- 2%
5. Nozzles Vertical in check valves
6. Nozzles Vertical down the boom
7. Nozzle height 50 cm above crop
8. Correct Nozzle Height (Zip Tie)
9. Correct Tyres
10. Minimum Tyre Pressures

111

Sprayer Cleaning

1

Programme

- Background
- Fundamentals
- Sprayer Plumbing
- Residual Volume
- Single v. Multiple Rinses
- Tank Cleaners
- Video
- Maintenance

2

Cleaning Sprayers

3

The Problems

- All spray mixes are bad for sprayers.
  - Liquid formulations such as ECs contain solvents
  - Powders and SC formulations contain particles that separate out
    - Powders c. 20-30μm
    - SCs c. 1-3μm

4

Benefits of Cleaning

- Long life of a high performance machine.
- Ready to go, and perform well, when needed.

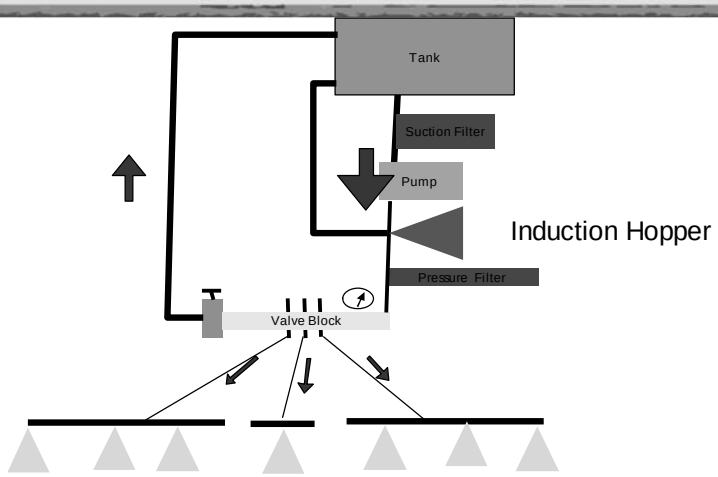
- Avoid contamination of non-target crops
  - E.g. Residual herbicide damaging the target crop (Ally and oilseed rape)
  - Crop rejection due to traces of non – approved product.

5

Sprayers Can Never Be Fully Emptied

6

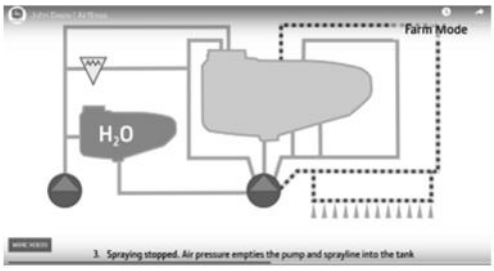
Sprayer Plumbing



7

Sprayer Cleaning

- Residual Volume = 1% - 40l : 4000l
- 3 x 1/3 Rinses: 8 x Cleaner than 1 x 1

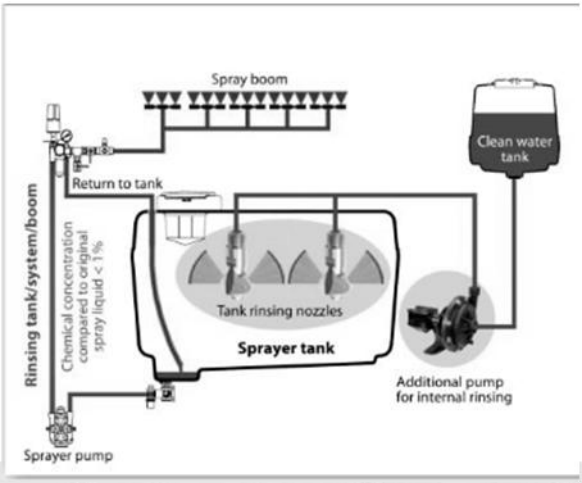


John Deere Air Rinse and Powr-Spray
Residual Volume 0.6%

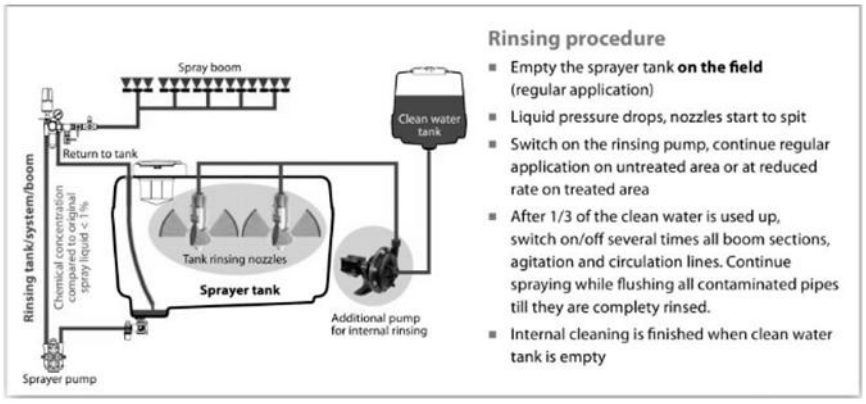
Agrifac claim 0.3%

8

Agrotop Continuous Rinsing



9



Rinsing procedure

- Empty the sprayer tank **on the field** (regular application)
- Liquid pressure drops, nozzles start to spit
- Switch on the rinsing pump, continue regular application on untreated area or at reduced rate on treated area
- After 1/3 of the clean water is used up, switch on/off several times all boom sections, agitation and circulation lines. Continue spraying while flushing all contaminated pipes till they are complety rinsed.
- Internal cleaning is finished when clean water tank is empty

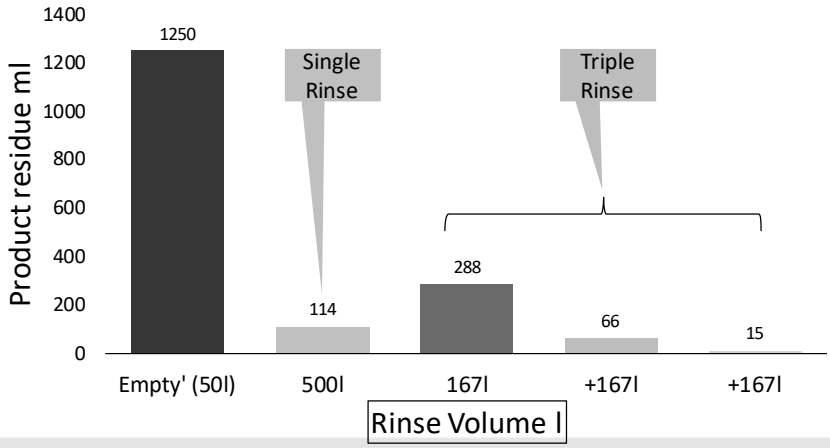
10

Single Rinse 500l v. Triple Rinse 3 x 167l

11

Rinsing a 5000l Sprayer

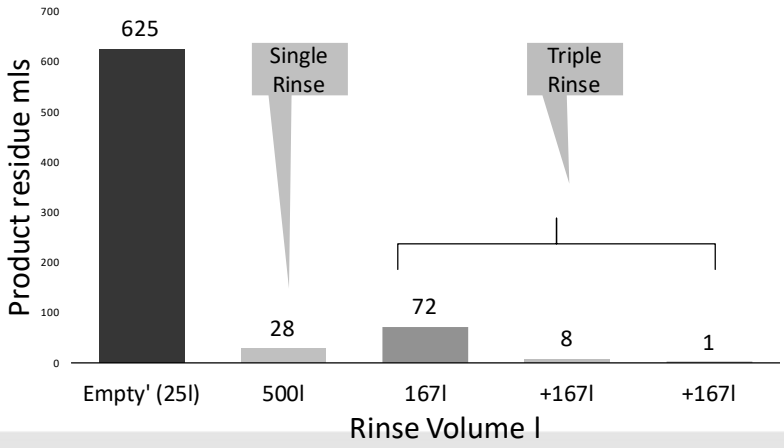
Has Applied 2.5 l/ha in 100l/ha : Residual Volume 1% = 50l



12

Rinsing a 5000l Sprayer

Has Applied 2.5 l/ha in 100l/ha : Residual Volume 0.5% = 25l



13

Tank Cleaners

14

Key Points

- Cleaning starts with a completely 'empty' sprayer. Air coming out of the nozzles.
- All sprayers contain a residual volume of liquid of ½ - 1% when 'empty'
- Clean the sprayer as soon as possible

15

Key Points

- Run the rinse water through all parts of the sprayer.
- A sprayer with multi nozzle bodies; eg Hypro Duo-React, Altek Multi-Spray:
- The final rinse should be run through all the nozzles.

16

Key Points

- 3 x 1/3. is 8-28 x cleaner than a single rinse of a full clean water tank.
- Add tank cleaner to the 2nd rinse. Circulate for 15 minutes
- Some sprayers have an auto rinse cycle. These are effective.

17

Maintenance – 'Richard Riley' Altek

- Without servicing, Altek spray pumps may fail between 350 hours and 1300 hours.

- Difference in time to failure is due to:
  - Poor sprayer hygiene
  - Overloading the pump when filling:
  - – Running the pump at full chat with an empty feed pipe
- Wearing sprayer components should be on a maintenance and replacement programme.

18

Video

Video

19