GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

# GRDC Spray Days – presentations

## Emerald - November 2022

ICAN
Independent Consultants Australia Network

**Contents**

# SOCIAL LICENSE, MRL's &HERBICIDE RESIDUES

BY PAUL McINTOSH- WEEDSMART & PULSE AUSTRALIA

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1

## SOCIAL LICENCE and its DEFINITION

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Is the level of acceptance or approval that stakeholders and communities extend to a project , site , company or industry.

Gaining social license means gaining support for the project from concerned groups or stakeholders over and above any legal requirements

Granting of social license is rooted in the beliefs, reputation and opinions held by the local population and other stakeholders in society.

2

# What about E S G

## Environmental, Social, & Governance

The three pillars of sustainable business



## Environmental factors involve the protection of natural resources or Impact on the planet

- Air and Water quality
- Biodiversity
- Deforestation
- Energy Performance
- Carbon Footprint
- Natural Resource Depletion
- Waste mgt and Pollution

# Social

Involves anticipating every possible customer reaction to your brand and to determine who is best suited to respond , creating a map of how the interaction should unfold , deciding who is authorized to continue the relationship etc .

When executed correctly . The outcome of social governance is simple;

Customers enjoy a positive seamless brand experience



# GOVERNANCE– Internally with ;

Compliance

Security

Control

How an organisation is governed- and transparency ?

All these key elements are inter-twined and will impact our Agricultural industry

eg in Banking

7

**Toxic nation: Australia's pesticide problem**
Pesticides

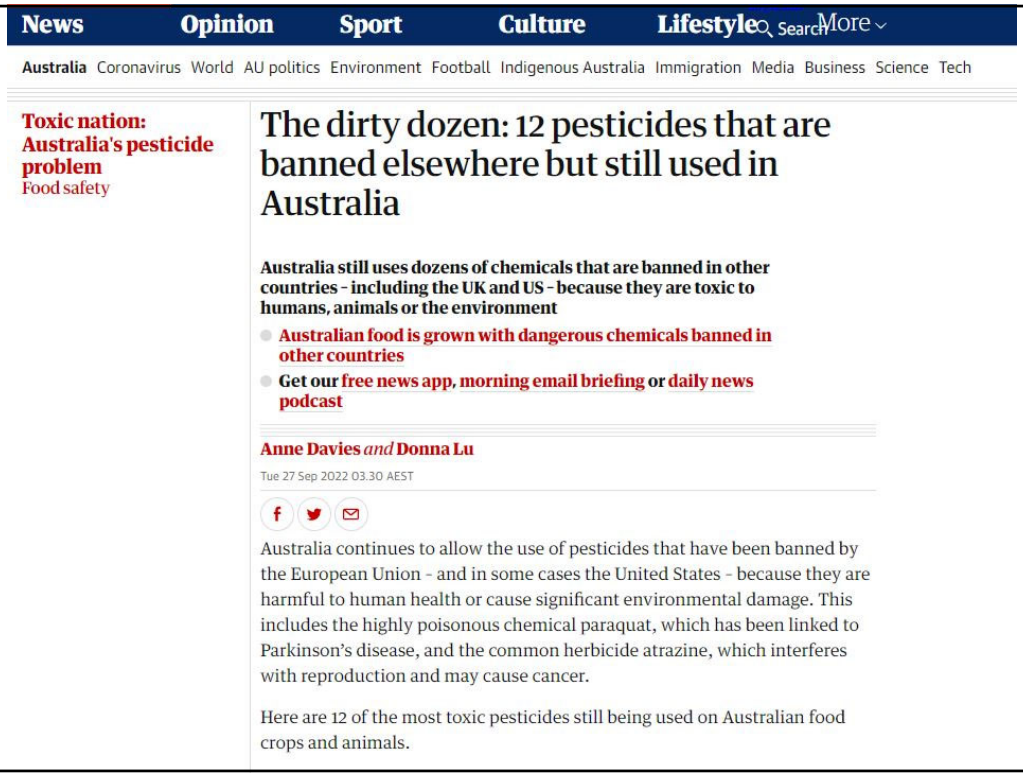
# How big pesticide reaches into every element of rural life in Australia

**Multinational chemical firms subsidise agronomists, provide scholarships, sponsor farm safety programs and even fund the pesticide regulator**

- There are real alternatives to widespread pesticide use
- Who tests your food for pesticides in Australia?
- 12 pesticides banned elsewhere but still used in Australia
- Get our free news app, morning email briefing or daily news podcast

**Anne Davies**
@annefdavies
Fri 7 Oct 2022 03.30 AEDT

8



News Opinion Sport Culture Lifestyle Search More

Australia Coronavirus World AU politics Environment Football Indigenous Australia Immigration Media Business Science Tech

Toxic nation: Australia's pesticide problem
Food safety

# The dirty dozen: 12 pesticides that are banned elsewhere but still used in Australia

**Australia still uses dozens of chemicals that are banned in other countries - including the UK and US - because they are toxic to humans, animals or the environment**

- Australian food is grown with dangerous chemicals banned in other countries
- Get our free news app, morning email briefing or daily news podcast

Anne Davies *and* Donna Lu

Tue 27 Sep 2022 03.30 AEST

Australia continues to allow the use of pesticides that have been banned by the European Union - and in some cases the United States - because they are harmful to human health or cause significant environmental damage. This includes the highly poisonous chemical paraquat, which has been linked to Parkinson's disease, and the common herbicide atrazine, which interferes with reproduction and may cause cancer.

Here are 12 of the most toxic pesticides still being used on Australian food crops and animals.

9

# HERBICIDE RESIDUES IN GRAIN

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## APVMA Reviews

All old actives over time are being re-evaluated by APVMA

- Glyphosate has been reviewed
- 2,4-D has been reviewed
- Fipronil is current on review
- Imidacloprid is current on review
- Paraquat/Diquat is current on review

11

## Bee deaths spark investigation after traces of chemical Fipronil found in hives

ABC Southern Qld / By Lucy Robinson and Belinda Sanders

Posted Thu 18 Feb 2021 at 11:10am, updated Thu 18 Feb 2021 at 4:34pm

12

# HERBICIDE RESIDUES IN GRAIN

## Maximum Residue Limits – (MRLs)

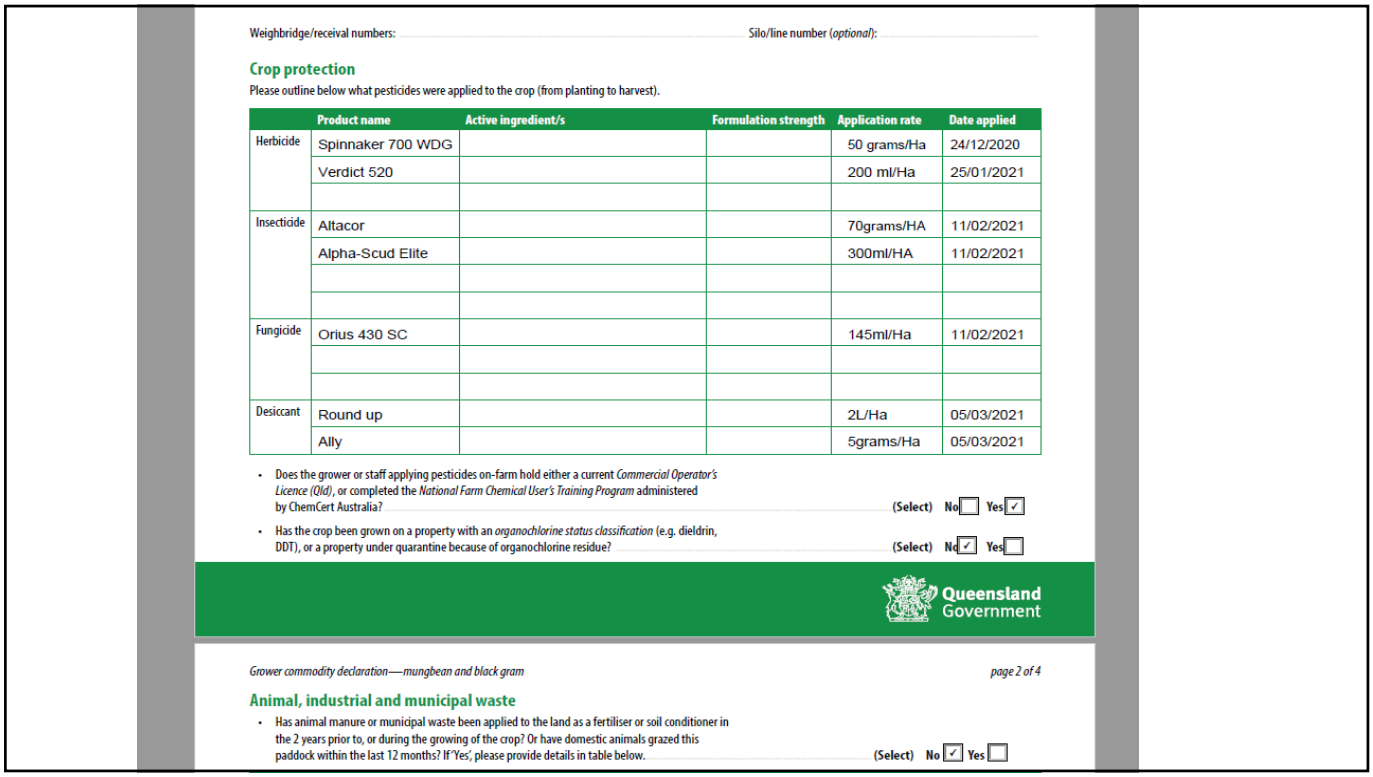
- Defined as the Maximum concentration of residue which is legally permitted as acceptable to be present in agricultural commodity
- Importing countries may have lower or nil MRL compared to Australian MRLs
- National Residue Surveys (NRS)

  2020-21 – 5445 samples collected

  Compliance rate % - 99.3 %

Wheat crop 2020 @ Bathurst

13



Weighbridge/receival numbers: ..... Silo/line number (*optional*): .....

## Crop protection

Please outline below what pesticides were applied to the crop (from planting to harvest).

| | Product name | Active ingredient/s | Formulation strength | Application rate | Date applied |
|---|---|---|---|---|---|
| Herbicide | Spinnaker 700 WDG | | | 50 grams/Ha | 24/12/2020 |
| | Verdict 520 | | | 200 ml/Ha | 25/01/2021 |
| | | | | | |
| Insecticide | Altacor | | | 70grams/HA | 11/02/2021 |
| | Alpha-Scud Elite | | | 300ml/HA | 11/02/2021 |
| | | | | | |
| | | | | | |
| Fungicide | Orius 430 SC | | | 145ml/Ha | 11/02/2021 |
| | | | | | |
| | | | | | |
| Desiccant | Round up | | | 2L/Ha | 05/03/2021 |
| | Ally | | | 5grams/Ha | 05/03/2021 |

- Does the grower or staff applying pesticides on-farm hold either a current *Commercial Operator's Licence (Qld)*, or completed the *National Farm Chemical User's Training Program* administered by ChemCert Australia? ..... (Select) No ☐ Yes ☑
- Has the crop been grown on a property with an *organochlorine status classification* (e.g. dieldrin, DDT), or a property under quarantine because of organochlorine residue? ..... (Select) No ☑ Yes ☐

Queensland Government

*Grower commodity declaration—mungbean and black gram* *page 2 of 4*

## Animal, industrial and municipal waste

- Has animal manure or municipal waste been applied to the land as a fertiliser or soil conditioner in the 2 years prior to, or during the growing of the crop? Or have domestic animals grazed this paddock within the last 12 months? If 'Yes', please provide details in table below. ..... (Select) No ☑ Yes ☐

14

**Collector:** [redacted]

[redacted]

**DALBY QLD 4405**

**Sample Date:** **22 Mar 2021**

**Lab Receipt Date:** **12 Apr 2021**

**Report Date:** **05 May 2021**

**Ship** **DEACON**

| Sample No | Product | Customer Reference No | Destination Country | Marketer | Chemicals/ Contaminants | Residue mg/kg | Aust MRL mg/kg |
|---|---|---|---|---|---|---|---|
| 0320400B | Mung bean | M4510 | Viet Nam | [redacted] | fluazifop-p-butyl | 0.096 | 0.5 |
| | | | | | glyphosate | 0.41 | 10 |
| | | | | | haloxyfop | 0.90 | 0.1* |
| | | | | | Remaining analytes (overleaf) | <LOR | |

* Note: The residue of haloxyfop detected at 0.90mg/kg exceeds the Australian MRL of 0.1mg/kg

15

# ADAMS AUSTRALIA

GRAIN SORGHUM to CHINA and GLYPHOSATE residues

Food (Alcohol) mkt – Proceeding with caution for NIL tolerance red flags warnings

Feed mkt - continuing to export to China.

Haloxyfop free Chickpeas to USA & Canada customers

Heightened awareness in weed seeds in various overseas markets.

16

| Market | Active Ingredient | Commodity (for chickpeas) | MRL (ppm) |
|---|---|---|---|
| Egypt | Acetamiprid | Peas (with pods) | 0.6 |
| Egypt | Acetamiprid | Peas (without pods) | 0.3 |
| Egypt | Acetamiprid | Pulses; Peas | 0.15 |
| India | Acetamiprid | | 0.01 |
| Turkey | Acetamiprid | Peas (with pods) | 0.4 |
| Turkey | Acetamiprid | Peas (without pods) | 0.3 |
| Turkey | Acetamiprid | Pulses; Peas | 0.07 |
| United Arab Emirates | Acetamiprid | Peas (with pods) | 0.6 |
| United Arab Emirates | Acetamiprid | Peas (without pods) | 0.3 |
| United Arab Emirates | Acetamiprid | Pulses; Peas | 0.15 |
| Egypt | Emamectin | Peas (with pods) | 0.03 |
| Egypt | Emamectin | Peas (without pods) | 0.01 |
| Egypt | Emamectin | Pulses; Peas | 0.01 |
| India | Emamectin | | 0.01 |
| Turkey | Emamectin | Peas (with pods) | 0.01 |
| Turkey | Emamectin | Peas (without pods) | 0.01 |
| Turkey | Emamectin | Pulses; Peas | 0.01 |
| United Arab Emirates | Emamectin | Peas (with pods) | 0.03 |
| United Arab Emirates | Emamectin | Peas (without pods) | 0.01 |
| United Arab Emirates | Emamectin | Pulses; Peas | 0.01 |

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Intruder/ Skope Insecticide

Affirm Insecticide

17

**Table 3b. Summer crop growth stage application windows**

| Crop | Crop Growth Stage |
|---|---|
| Lucerne | Apply from 2nd trifoliate leaf onwards |
| Cowpea, Mung beans, Navy beans, Soybeans | Apply from 2nd leaf to flowering |
| Peanuts | Apply from 5cm to pegging |
| Cotton | Apply from 2nd leaf to before the onset of flowering |
| Sunflowers | Apply from 2nd leaf to head initiation |

19

**NOT TO BE USED FOR ANY PURPOSE OR IN ANY MANNER CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION.**

**HARVESTING WITHHOLDING PERIODS**

**NOT REQUIRED WHEN USED AS DIRECTED FOR:**

Canola, Chickpeas, Cotton, Cowpea, Faba beans, Field peas, Lentils, Linola, Linseed, Lupins, Mung beans, Navy beans, Peanuts, Soybeans, Sunflowers and Vetch

**DO NOT HARVEST FOR:**

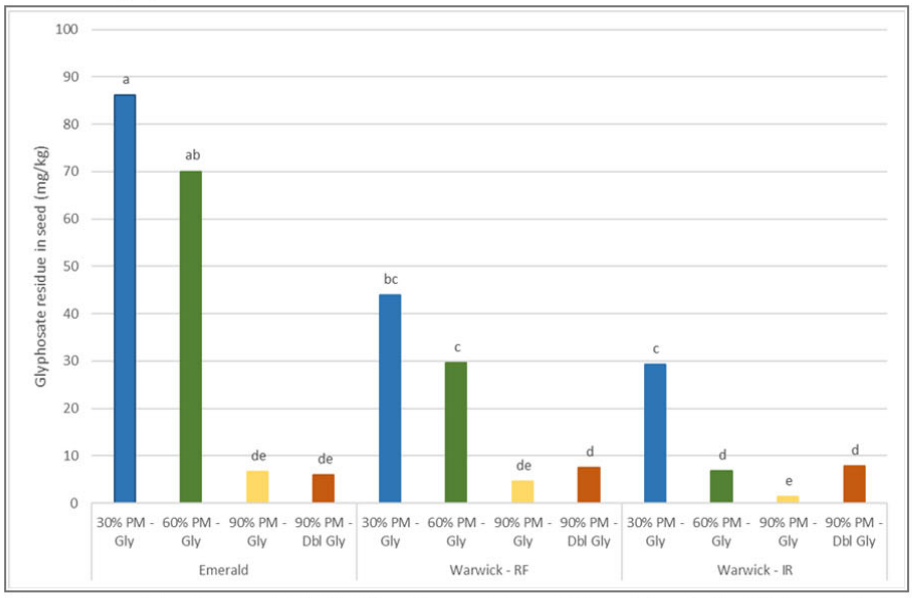
Medic and Clover seed crops **7 DAYS AFTER APPLICATION**

20

# TAIWAN and GLYPHOSATE



# Glyphosate residues from 2021




Glyphosate residue in seed @ 7 DAT at Emerald and Warwick rainfed (RF) and irrigated (IR) trials. *Means with same subscript are not significantly different at the P=0.05 level.*

- Early desiccation will increases residues
- Need to accurately assess physiological maturity
- DANGER spraying green pods

# DRIFT AND PRODUCTION SYSTEM

## What's the problem?

- Movement of chemical outside farm boundaries and off intend target

- Spray Drift is a whole of community issues and everyone has a responsibility to understand their obligations in managing it




# DRIFT AND PRODUCTION SYSTEM

## Impacts of spray drift on cotton crop

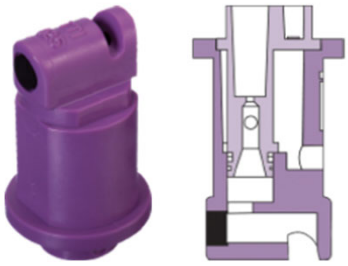
- Grower Surveys for southern NSW

| Years | % of cotton growers affected | Average % of cotton crop area impacted | Average yield cost (in bales / ha) | Average financial cost (in $) |
|---|---|---|---|---|
| 2018 | 19% | 54% | 0.7 | $47,938 |
| 2019 | 23% | 14% | 2 | $16,440 |

# DRIFT AND PRODUCTION SYSTEMS

## 2,4-D label changes 2018

- Minimum mandatory droplet size of Very Coarse (aerial application remains at Very Coarse)
- Advisory – ground boom sprayers minimum of Extremely Coarse between 1st October and 15th April (recommended not legally required)
- Ground boom height restricted to 50cm above the target canopy/crop
- Introduction of – downwind buffer zones
- Addition of – do not apply if there are surface temperature inversions



Turbo TeeJet Induction (TTI)

28

- When we ***Choose to Spray***, will determine where and how far the spray driftable fraction of our application will move
- The ***Sprayer Set-up*** will determine how much product will be left in the air.
- ***Coarser Spray Qualities / Nozzles*** will lower drift risk but can also impact efficacy
- Having a set of ***Spray-Plans*** for different paddock situations will enable efficient, safe and effective spraying.

PLUS - reading all the small print of our labels and even re-check with your marketers

29

# TAKE HOME MESSAGES

- Social licence can't be taken for granted
- Pesticide application beyond the label can leave to a potential residues in the grain that could potentially affect Australia's Market access
- Ineffective application of pesticides may result in significant label changes through government regulation



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@thegrdc

# Advanced Weather Sensors and Information Supporting Spray Decisions

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Goanna Ag

CRDC COTTON RESEARCH AND DEVELOPMENT CORPORATION

1

## TAKE HOME MESSAGE

Stability
Wind
Turbulence
Dispersion

STRONGLY STABLE


Image: Graeme Tepper

2

## NIGHT – COMBINED AND CONCENTRATED


**Hazardous inversions trap pesticides.**

**Laminar winds transport pesticides**

3

## LABEL STATEMENTS

Nufarm Crucial Herbicide & Titan Amine 720 Herbicide

**DO NOT** apply if there are hazardous surface temperature inversion conditions present at the application site during the time of application.

Surface temperature inversion conditions exist most evenings one to two hours before sunset and persist until one to two hours after sunrise.

**Guesswork**
**is the current GoTo method**
**for inversion detection and label compliance**

4

# RESEARCH

**Detailed examination of inversion conditions**


29 towers

WA, SA, NSW, QLD

37 sites

Extensive data set

Over 6 years - every 10 minutes

Research conducted by Graeme Tepper: (MRES) and Dr Warwick Grace (Grace Research Network)

5

# DISCOVERY

**Clear skies and calm are ideal**

**BUT**

**It can be overcast/cloudy**

**Winds can exceed 20kph**

**Calm* is rare**

**Winds are most often 2 to 11kph**

**Ultimately**

**laminar winds**

**cause inversions to be hazardous**

**These discoveries challenge traditional beliefs**

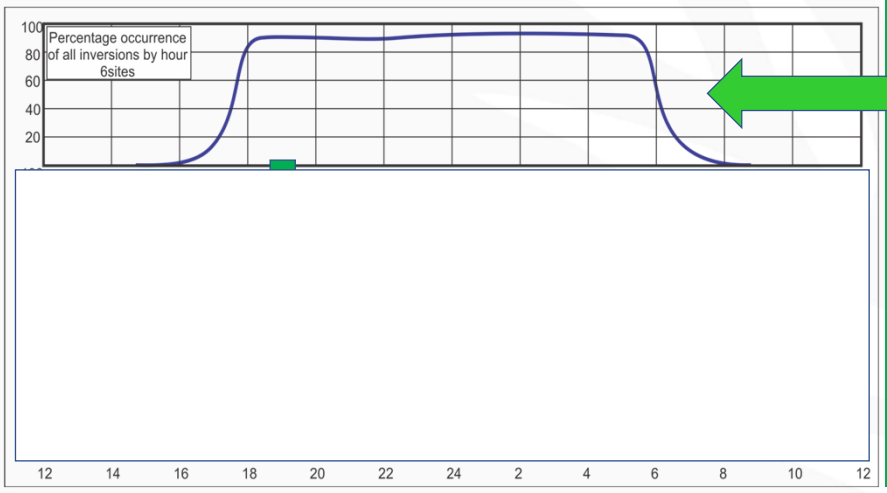
*Cup type wind sensors often record calm even when winds are up to 5 kph.

6

## RECORDING METEOROLOGICAL CONDITIONS

7

## WHEN DO INVERSIONS OCCUR?

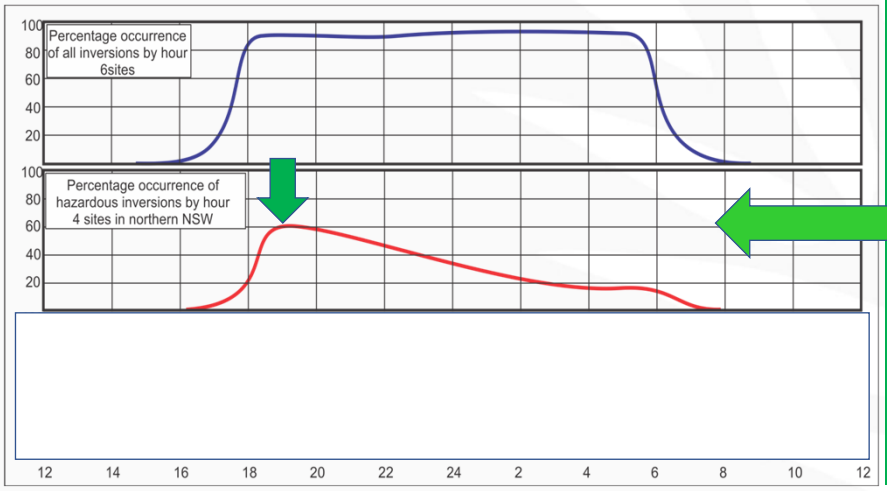



**Inversions form most nights.**

**Some are weak, others are very hazardous**

8

## WHEN ARE INVERSIONS MOST HAZARDOUS

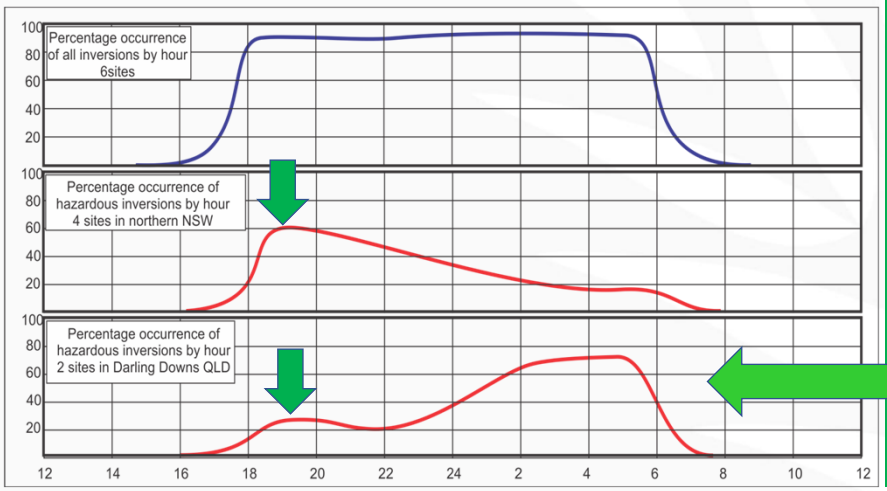



**NSW open plains**

**Early evening**

9

## MOST HAZARDOUS




**Spray guides need to be formulated for regions.**

**Darling Downs**

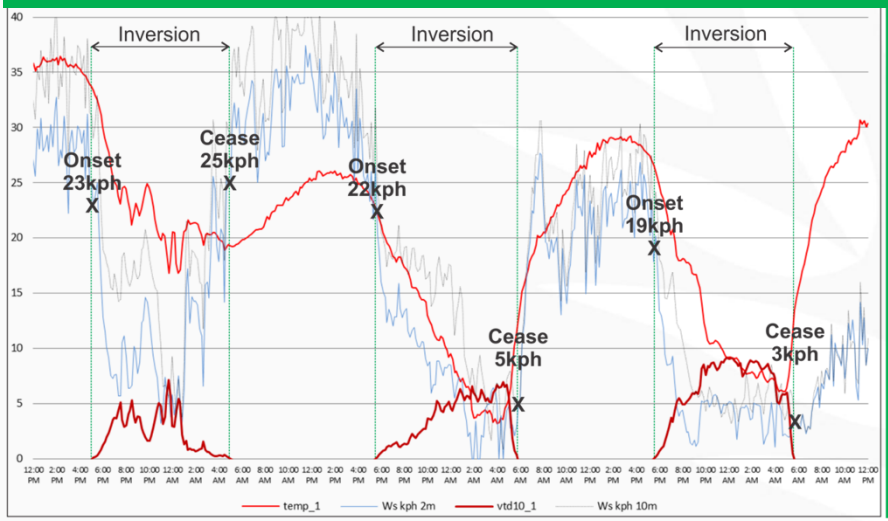
**Two peaks**

**Early evening**

**And 2 to 5am**

10

# EXAMPLE: INVERSION WINDS




**Rarely Calm**

**2m winds average 2 to 12kph**

**10m winds average 2 to 17kph**

11

# INVERSION CLUES
## HELPFUL BUT UNRELIABLE

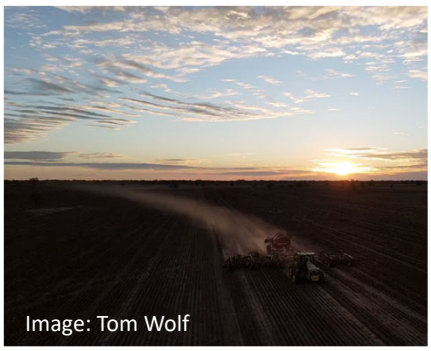


Image: Tom Wolf


Image: Nicola Cottee

**Dust, fog, dew, clarity of noise, high odour, do not necessarily equate to the most hazardous conditions**

**FACT**

**Clues take time to develop or may not occur**



12

# KNOWING IF AN INVERSION EXISTS IS NOT ENOUGH

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## We need to know when laminar winds exist

**Laminar winds transport high concentrations off site**





# VERTICAL TURBULENCE DATA

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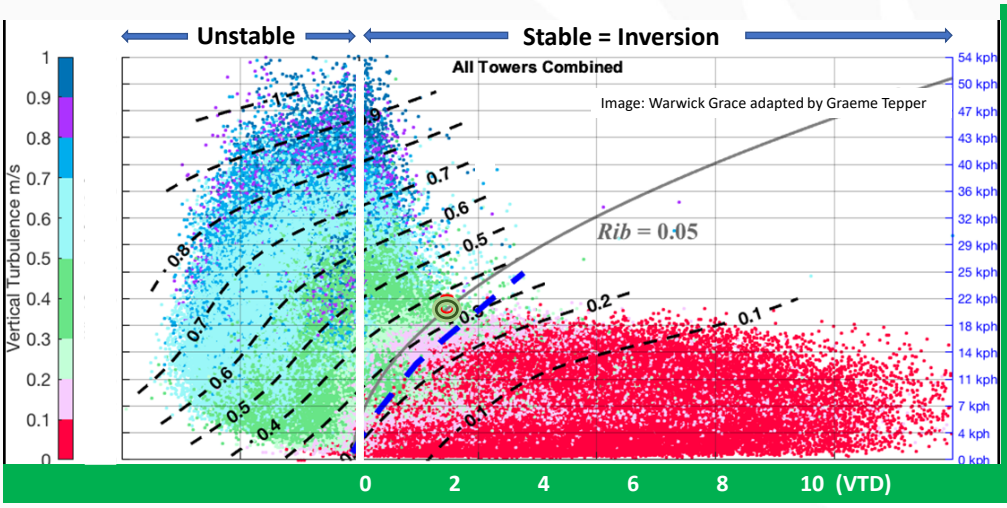



**Red/pink dots indicate when laminar winds can exist.**

# LAMINAR WINDS ARE HAZARDOUS

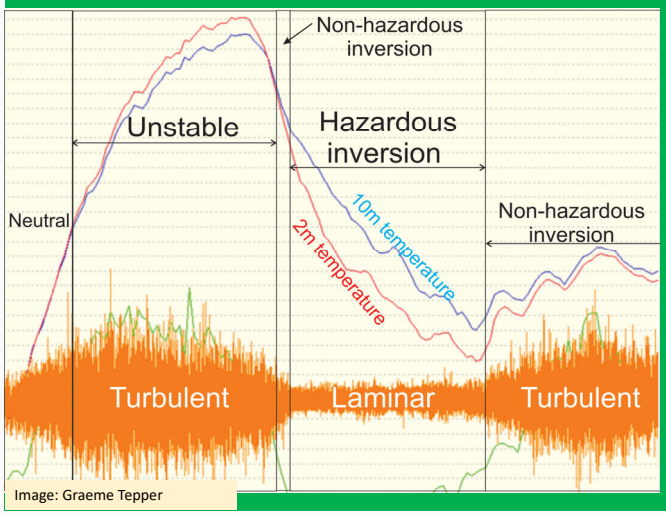



Image: Graeme Tepper

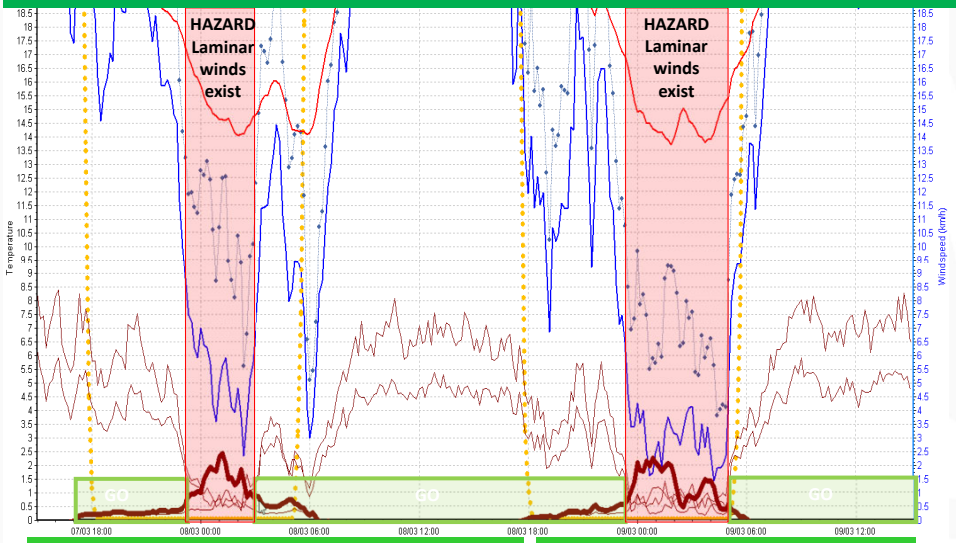
**Laminar winds can carry concentrated drift long distances**

**Note the sharp separation between**

**laminar and turbulent conditions**

15

# HOW MANY SPRAY HOURS GAINED?




**13.5hrs Inversion**
**4hrs Hazardous**

**12hrs Inversion**
**6hrs Hazardous**

In these cases adopting the SDWS increase spray hours by 9.5 & 6 hours

16

# SPRAY DRIFT WARNING SYSTEM

**System**: Goanna Ag is establishing 100 Profiling Automatic Weather Stations (PAWS) across the grain and cotton regions of NSW and southern and central QLD.

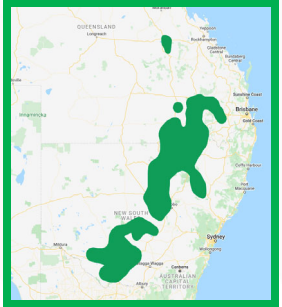


Image: Goanna Ag

**Delivers to Growers**:

1. Accurate and real time data updated every 10 minutes.
2. 2 hour 'Nowcasting'
3. 24-hour forecasts of spray conditions in 2-hour segments updated every 10 minutes.
4. Plus; wind, temperature, delta T and rainfall

The research for the system was made possible by the significant contributions of growers and the support of GRDC, CRDC, AND DPIRD.

17

# WAND
## WEATHER AND NETWORKED DATA

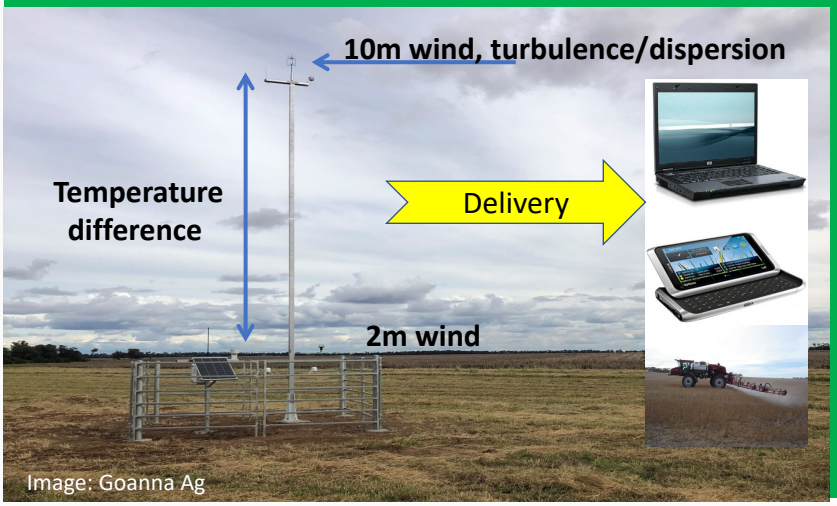



Image: Goanna Ag

**WAND provides information**

**Growers make informed decisions**

18

WAND
WEATHER AND NETWORKED DATA

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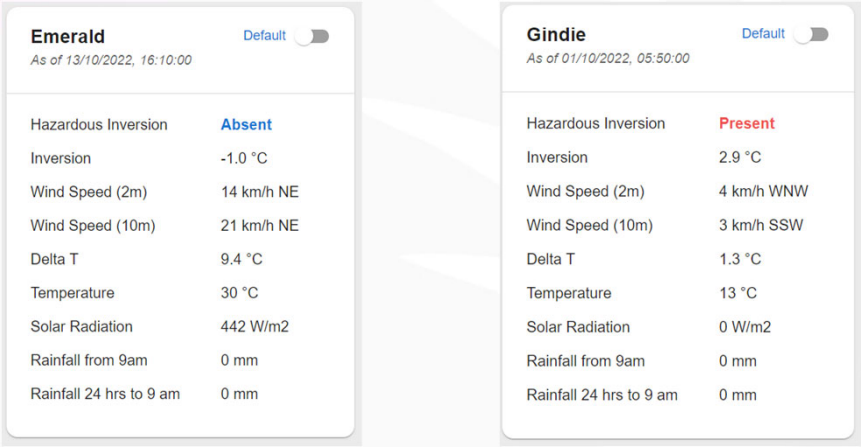


www.wand.com.au

19

# SYSTEM BENEFITS

## SUPPORTS IMPROVED ON-FARM PRACTICES

GRDC
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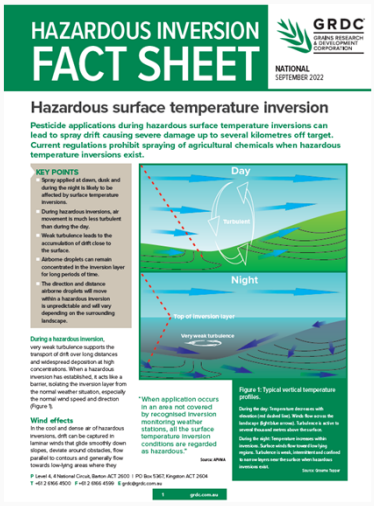
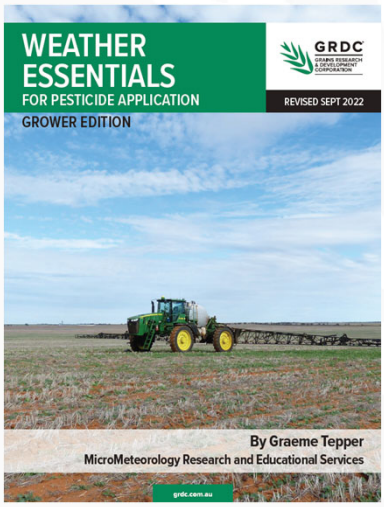
- Identifies the most hazardous spray conditions
- Reveals more hours to spray at night
- Maximizes operator and machine productivity by revealing optimal hours to spray
- Eliminates guesswork
- Reduces the risk of spray drift which is crucial for social, environmental and financial reasons for agriculture and the wider community

**Experienced operators combine wisdom with scientific data to make the best farm decisions**

www.wand.com.au

20

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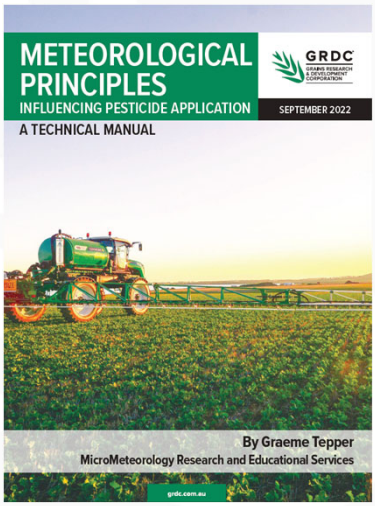


21

Spray drift is a significant issue for agriculture.
This investment represents a vital cross industry collaboration to improve spray outcomes.

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@thegrdc

22

# SENSOR TECHNOLOGIES FOR TARGETED SPRAYING

## CURRENT CAPABILITY AND FUTURE OPPORTUNITIES

Craig Baillie and Derek Long (University of Southern Queensland)

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION



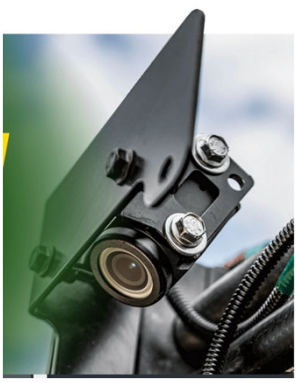
# OVERVIEW

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

**Technologies:** Evolution of weed sensing over the past 20 years.

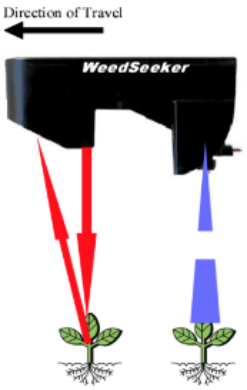
**Developments**: Where are we now and what have we learned?

**Opportunities**: What is in the future for this technology?



# OPTICAL SENSING
# 1990s/2000s

## Reflectance-based sensing




Source: Crop Optics Australia

Research in the 80s and 90s yielded reflectance or fluorescence sensors (WeedSeeker™ and WEED-IT™).

Reflectance-based sensing makes decisions on a single data point – binary decision (plant or not plant).

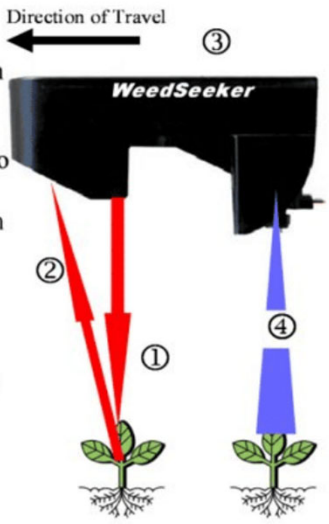
Refinements have improved products over time (self calibrating ?)



## How a *WeedSeeker*® sensor works

1. "Light emitting diodes" (LEDs) produce a combination of invisible infrared and visible red light which is projected onto the target approximately 750 mm below the sensor.

2. The light reflected from the target is captured by a detector at the front of the sensor.




3. Sophisticated electronic circuits inside the sensor analyze the reflected light and determine when it matches the light reflected by green plants.

4. When green plant's reflectance is identified, the sensor waits until the plant is under the spray nozzle and then triggers a fast-fire solenoid valve which sprays the plant.

# CAMERA SYSTEMS MACHINE VISION – 2000s

## **Research** – Cameras with machine vision

Excess green segmentation. Source: Meyer & Neto (2008)

Reflectance-based detection = single data point

Pattern-based detection = multiple data points

The patterns are defined by the developer through hand-crating algorithms.



# CAMERA SYSTEMS MACHINE VISION – 2010s

## **Emerging Products:** Cameras with machine vision (green-on-brown)


IC-Weeder. Source: Sutton Ag

See & Spray Select. Source: John Deere

- Colour-based detection of plant matter is effective against soil backgrounds.
- While adapting the sensing technologies, companies focused on optimal nozzle response to weed detection.

# JOHN DEERE SEE & SPRAY SELECT

- Green from brown site-specific weed control solution
- Engineered for high-speed performance on a free standing boom.
- USQ licensed several novel algorithms contributed to development of See & Spray Select.

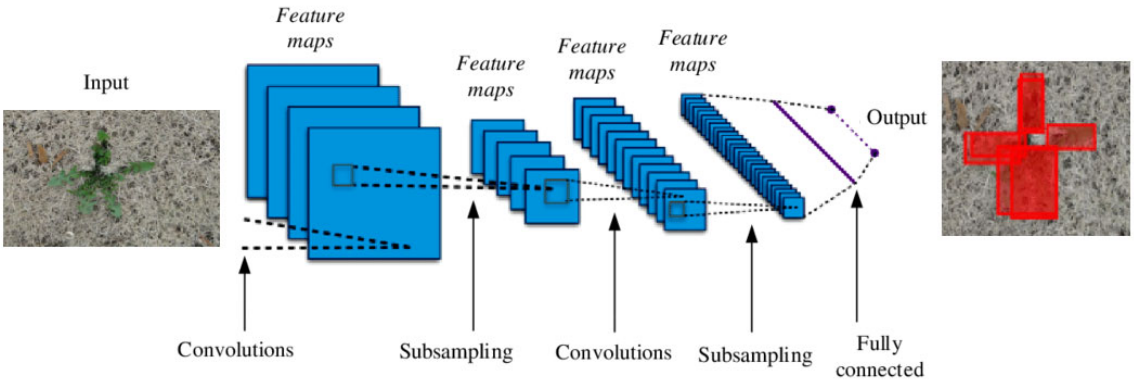

See & Spray Select. Source: John Deere



# CAMERA SYSTEMS
# AI AND DEEP LEARNING – 2010s

**Research** – Cameras with deep learning

In deep learning, the developer no longer specifies the pattern for the target weeds. The computer finds the patterns on its own through iterative learning.

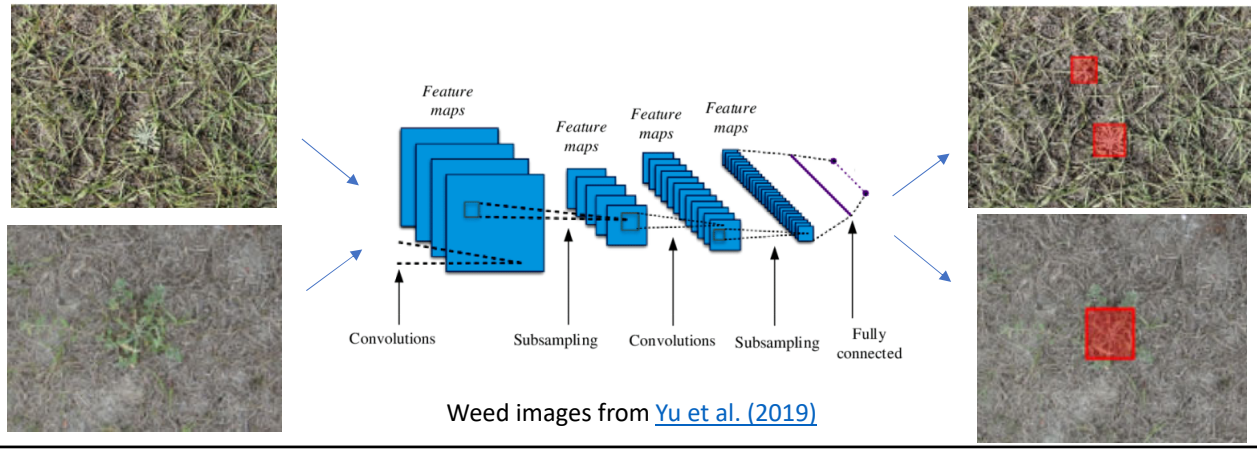



Adapted from Kaymak & Uçar (2018)

# CAMERA SYSTEMS
# AI AND DEEP LEARNING – 2010s

**Research** – Cameras with deep learning

**Input** → **Trained model** → **Output**




Weed images from Yu et al. (2019)

9

# DEVELOPMENTS – NEW KNOWLEDGE

| Machine vision | vs | Deep learning |
|---|---|---|
| + Useful for prototyping | | + Required for high complexity tasks |
| + Appropriate in simple environments | | + No extra processing for detecting multiple classes of object |
| + Can be used to augment DL | | |
| - Solutions are often vastly different per application | | - Can only recognise what it has previously seen |
| - Not suitable for high complexity tasks | | - Limited scope of operations (object detection, classification) |

10

# CAMERA SYSTEMS
# AI / DEEP LEARNING – 2020s

**Emerging Products:**

Cameras with deep learning (green-on-green)

Companies and universities are building datasets for Australian crops/weeds.

Sensor configuration will be similar to green-on-brown camera products.

Early products are available with technology to mature over the 2020s.

Source: John Deere & Blue River Technology



# GROUND VS AIR

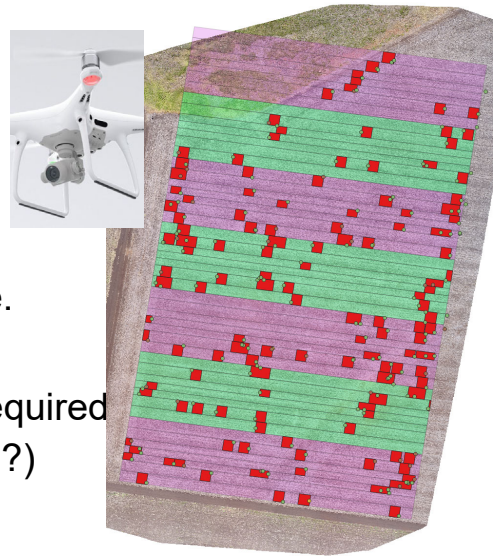
See and …. Spray later.

- Emergence of camera systems for drones (vs boom).
- Fields surveyed via a drone 200 Ha / hr
- Images and GPS data is post processed to geo locate and map weeds.
- Weeds detected 4cm in dia. (within 5cm).
- Shape files uploaded to GPS spray controller
- Spot applications by section or nozzle control.

# GROUND VS AIR

## See and …. Spray later.

- Techniques include:
  - green from brown and
  - green from green (inter row)
- Forward planning to:
  - establish savings
  - prepare the right amount of herbicide.
  - consider high cost formulations
- Greater preparedness and lead time is required
  - cost is prohibitive as a service / DIY (?)



13

# SPRAY APPLICATION SYSTEMS

## Dual Lines and Systems – informed by camera based systems

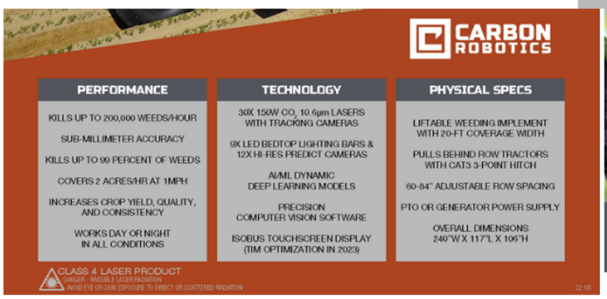
- Elimination of tanks mixes
  - different chemistry depending on weeds.
- Apply a blanket spray and then a higher spot spray rate for larger weeds.
- Blanket spray of fungicides or liquid fertiliser and spot spray weeds
- Higher cost herbicide options at reduced cost due to reduced area

14

# ALTERNATIVE WEED CONTROLS

## Laser systems based on camera systems

- Emergence of alternative weed control techniques
- High energy and slow - aligned with field based robotics.
  - 2 acres/hr @ 1 MPH
- Still largely pre commercial (?)







# DEVELOPMENTS – VISION SYSTEM AIDS

Vision systems are made more reliable by adding constraints to reduce variability.

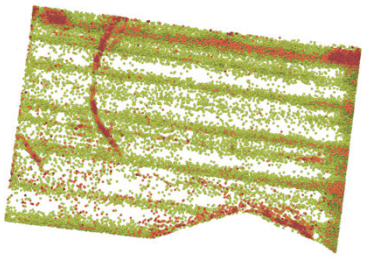
**Hoods (controlled lighting)**

Deep learning spot sprayer systems. Source: Bilberry GRDC Update

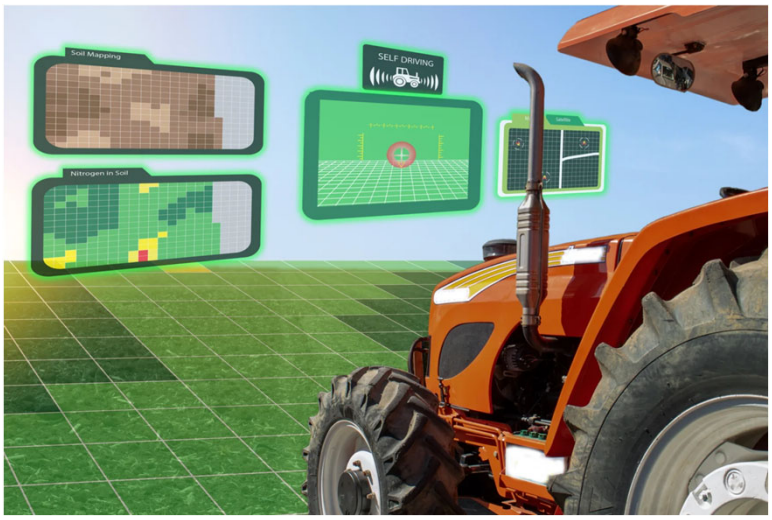
As the technologies mature, the constraints can sometimes be removed.

# DEVELOPMENTS – OTHER APPLICATIONS

Harvester fill optimisation. Source: CLAAS



High resolution drone mapping.




Tractor automation. Source: Here360



# OPPORTUNITIES

Machine vision and deep learning models are simultaneously being adapted for a range of applications throughout the farming system,

Including:

- Pest management
- Crop scanning
- Disease detection
- Yield Prediction
- Nitrogen management
- Phenotyping

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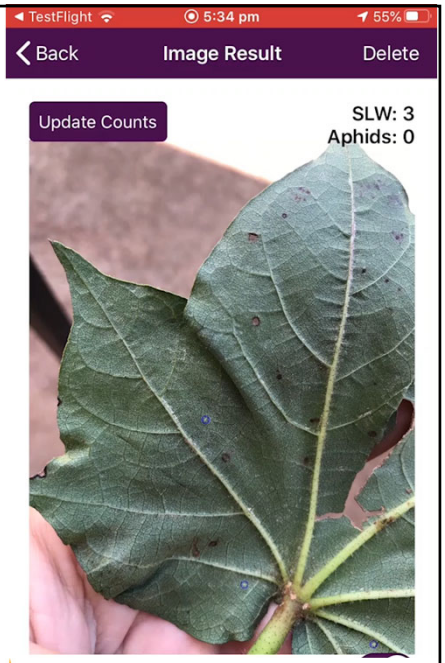


UNIVERSITY OF SOUTHERN QUEENSLAND
Centre for Agricultural Engineering

QUEENSLAND GOVERNMENT
Department of Agriculture and Fisheries

19

# OPPORTUNITIES

UNIVERSITY OF SOUTHERN QUEENSLAND
Centre for Agricultural Engineering

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

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20

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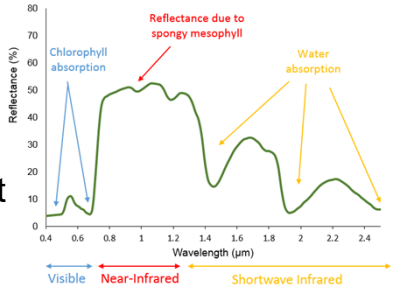
- Yield Prediction
- Nitrogen management
- Phenotyping

**Spectral analysis for crown rot**




**Infected wheat**

**Nil**



# OPPORTUNITIES

Machine vision and deep learning models are simultaneously being adapted for a range of applications throughout the farming system,

Including:

- Pest management
- Crop scanning
- Disease detection
- Yield Prediction
- Nitrogen management
- Phenotyping

**Image collection**

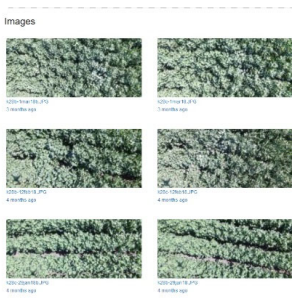



**Image and model analysis**

# OPPORTUNITIES

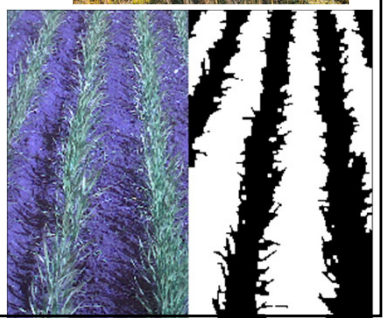
Machine vision and deep learning models are simultaneously being adapted for a range of applications throughout the farming system,

Including:

- Pest management
- Crop scanning
- Disease detection
- Yield Prediction
- Nitrogen management →
- Phenotyping

Machine vision with low-cost cameras has been developed to relate optimal nitrogen rate to N-sensitive colour indices in paddock.

- Calibrated with in-field R-rich strip
- Preliminary results for optimal N-rate measured at $R^2$=0.81, RMSE=10.8 kg N/ha



23

# OPPORTUNITIES

Machine vision and deep learning models are simultaneously being adapted for a range of applications throughout the farming system,

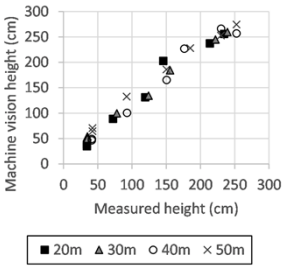
Including:

- Pest management
- Crop scanning
- Disease detection
- Yield Prediction
- Nitrogen management
- Phenotyping →

Image analysis for flower detection

Camera towers (5m and 1m)

Plant height detection by machine vision




24

# REFLECTIONS

1. Expect to see green-on-green for all major crop types and weeds as the technology matures over the decade.

2. Software and hardware are developing rapidly, and the scope of possibilities will change in years, not decades.

3. Much of the next generation of products will be demand driven.
   - This means that you have the power to shape future technologies.



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@thegrdc

# OPTIMISING GLYPHOSATE EFFICACY

MARK CONGREVE (ICAN)

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION



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# Glyphosate resistance

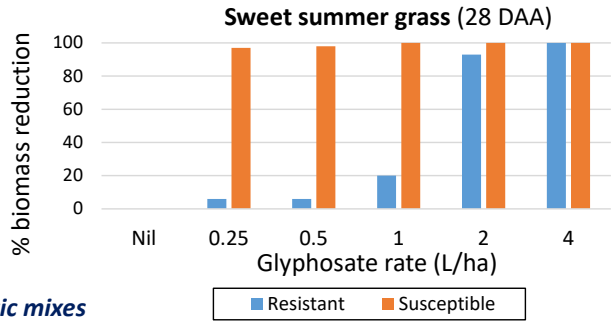
# Herbicide resistance

2021/2022 resistance survey – Central Queensland populations (QDAF unpublished)

| | No. populations screened | % Glyphosate resistance |
|---|---|---|
| Feathertop Rhodes grass | 35 | 100 |
| Sweet summer grass | 26 | 81 |
| Barnyard grass | 2 | 100 |

Initially glyphosate target site resistance is often 'weak'

***May still give control if rate is high and no mitigating factors or allow for a successful double knock***




Cook et. al. (NSW DPI) (2014)

***Dealing with 'weak' resistance***

***Robust rate + Optimise application + Avoid antagonistic mixes***

***Double knock every application***

3

# FTR – many populations now past 'weak' resistance?

10 southern Qld feathertop Rhodes grass populations collected March / April 2017

570 g/L glyphosate applied to 4-5 leaf FTR under glasshouse conditions

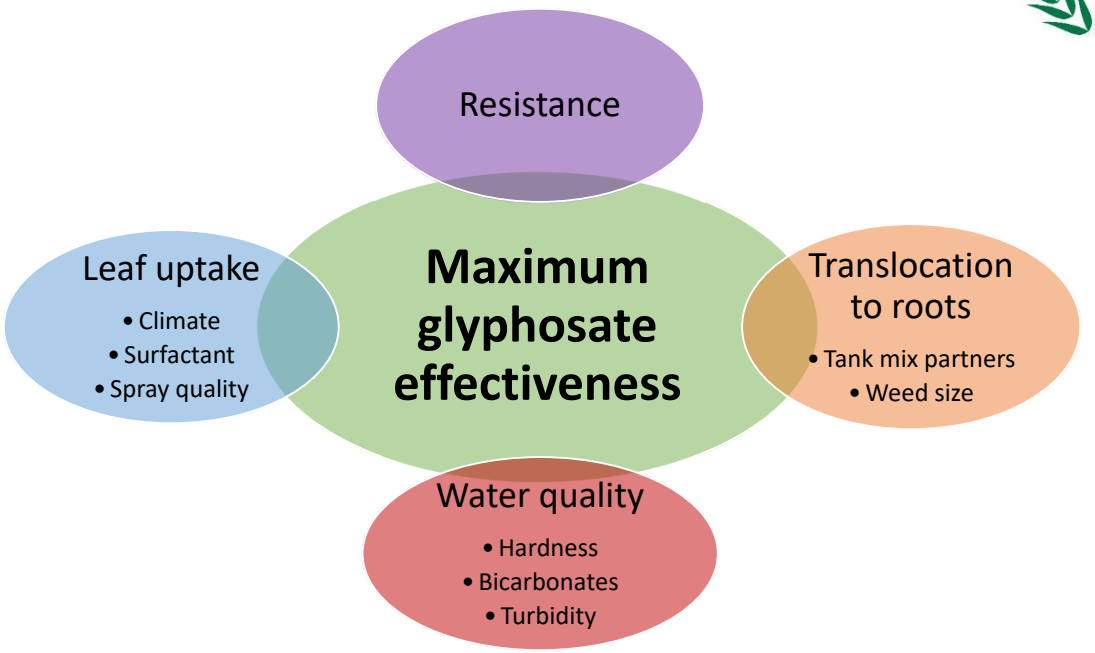
- All had > 80% biomass reduction at rates above 2 L/ha of 570 g/L glyphosate

- Rate to achieve 100% control
  - < 1L/ha 1 'susceptible' (Chinchilla)
  - 4L/ha 1 (St. George)
  - 8 L/ha 1 (Dalby)
  - 16 L/ha 7 (St. George x 3, Cecil Plains x 3, Dalby, Gatton)

'Might' get control at optical sprayer rates

Desai, Thompson & Chauhan (2020) Target-Site Resistance to glyphosate in *Chloris Virgata* biotypes and alternative herbicide options for its control. 570g/L glyphosate applied under optimal conditions.

4

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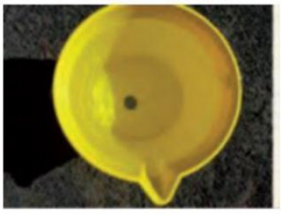
# Getting more glyphosate into the weed

6

# Glyphosate binds tightly to dirt / OM

- Spray water needs to be clean



- Clay based partner herbicides
  - Especially those applied at high rates
- Excessive dust



# Water quality

pH

- 5 to 8.5 ok for most spraying
- If pH is > 8.5 then water will have other problems. Address these.

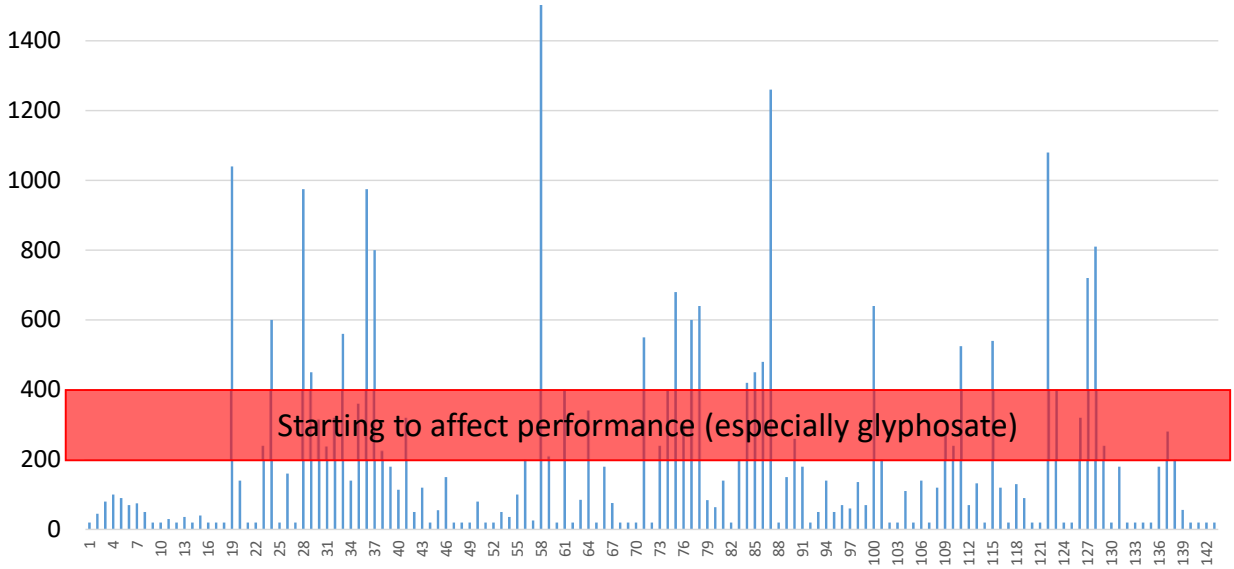
# Water quality

## Total hardness (esp calcium for glyphosate)

| Soft | Intermediate | Hard |
|---|---|---|
| < 200 ppm (mg/L) | 200 – 400 ppm | > 400 ppm |

9

Hardness (ppm) nth NSW/ sth QLD cropping areas 2018-2019 (Data courtesy of Nufarm)




10

# Water quality

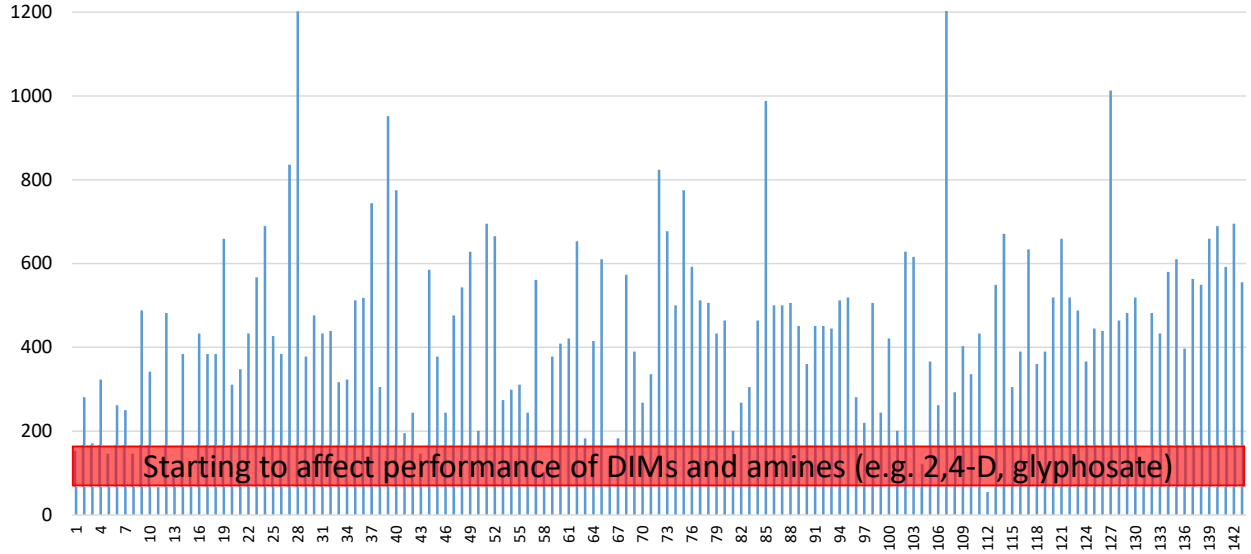
## Total alkalinity (bicarbonates)

- Dims (clethodim) & amine formulations (2,4-D, glyphosate)

| Good | Intermediate | Poor |
|---|---|---|
| < 75 ppm (mg/L) | 75 – 150 ppm | > 150 ppm |

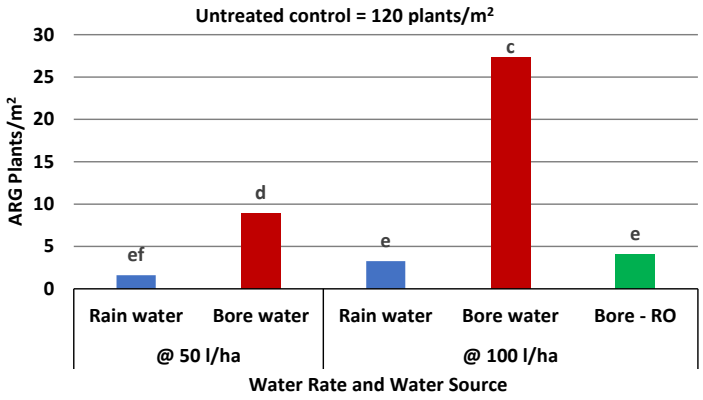
11

Bicarbonates (ppm) nth NSW/ sth QLD cropping areas 2018-2019 (Data courtesy of Nufarm)




12

# Water quality / Spray Volume




Sprayed Mid-April

12°C, 62% RH, Wind 3-6 kph, AIXR015 @ 3 bar (C)

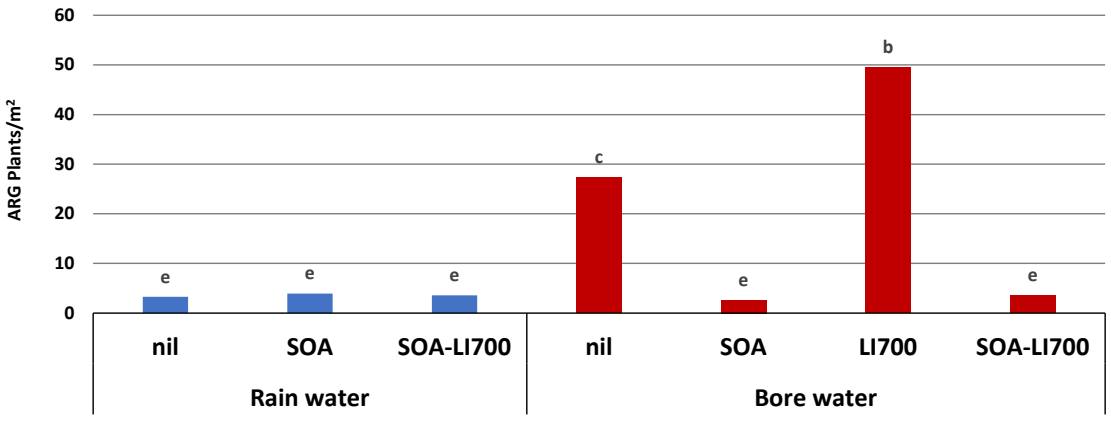
| Roundup Ultramax | Resistance | |
|---|---|---|
| 0.5 L/ha | 80% | RR |
| 0.95 L/ha | 10% | R |
| 1.5 L/ha | 0% | S |

| Water quality | Test | Optimum |
|---|---|---|
| pH | 8.0 | 5.0-8.6 |
| Chloride | 910 | < 350 |
| Sodium | 410 | < 70 |
| Total alkalinity | 480 | < 75 |
| Total hardness | 1000 | < 200 |

Grain Orana Alliance Narromine, NSW

13

# Water conditioning




Grain Orana Alliance Narromine, NSW

14

# Ammonium sulphate (AMS)

Glyphosate's favourite 'wing man'

- 'Fixes' hard water
- Partially fixes high bicarbonates
- Helps with tank mix compatibility
- Assists cell membrane transfer

But needs time

- Fully dissolve in spray tank
  - If impatient – use a liquid formation
- Further 5-10 minutes under agitation

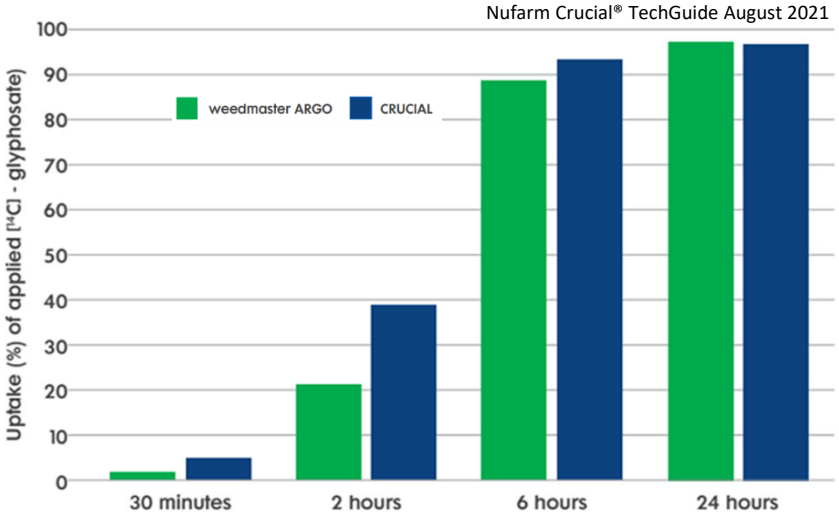
**Kg ammonium sulphate /100 L = (0.001 x Ca (ppm)) + (0.0006 x Na) + (0.0002 x K) + (0.0017 x Mg)**



# Leaf uptake

# Glyphosate is slow to enter the leaf

Nufarm Crucial® TechGuide August 2021




Glyphosate (hydrophilic = water loving) is very slow to penetrate waxy cuticle

Ryegrass under lab conditions **= good conditions for leaf uptake**

17

# Summer applications

Weeds adapted for hot / low humidity conditions (control transpiration losses)

- Leaf hairs (trichomes)
- More cuticle waxes
  - Harder for droplet deposition
  - Reduced penetration (for water-loving herbicides)

18

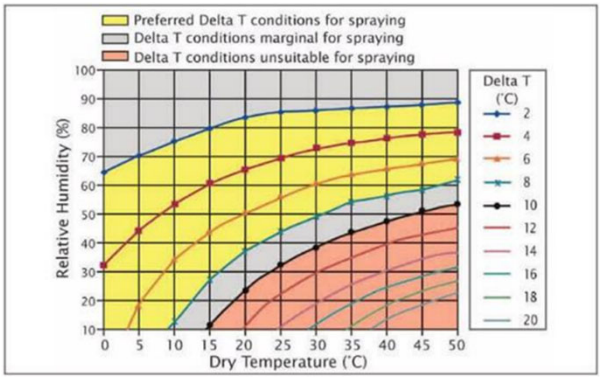
# Droplet survival in summer

## Delta T at & post application

- Evaporation from nozzle to leaf surface (keep boom height low)
- Leaf cuticle receptiveness for uptake
- Time on leaf surface before glyphosate crystallisation

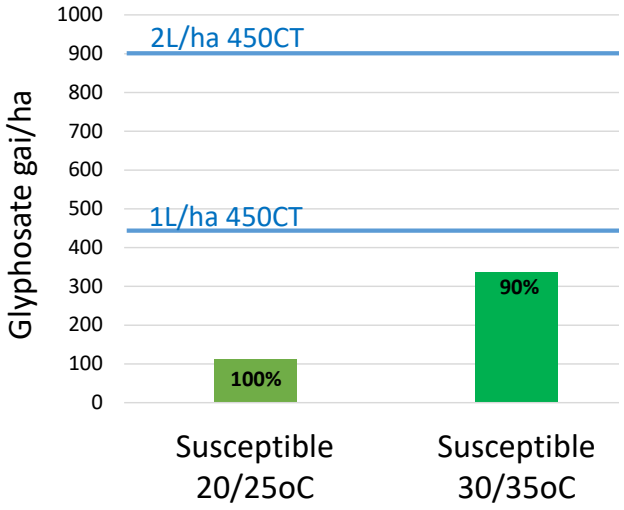
Rule of thumb for maximum glyphosate uptake
*Delta T of 4 to 6 for 4 to 6 hours after application*

If air temp is > 30°C, require RH > 60%
Glufosinate (Basta) is even more sensitive to this




19

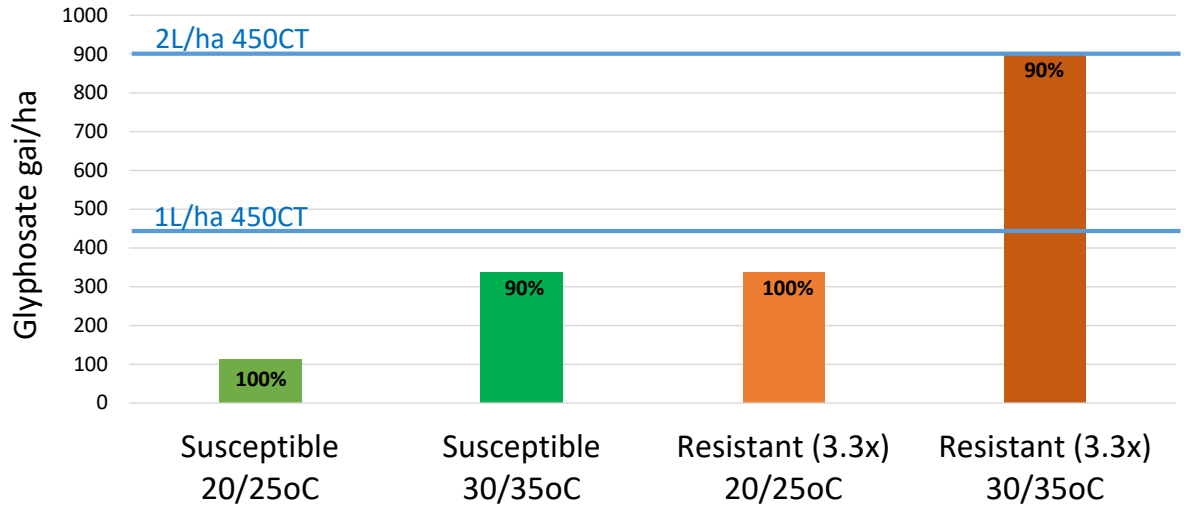
# Barnyard grass (3-4 leaf)




Adapted from Target-site EPSPS Pro-106 mutations: sufficient to endow glyphosate resistance in polyploid *Echinochloa colona*? (Han, Yu, Widderick, & Powles. 2015)

20

# Barnyard grass (3-4 leaf)




Adapted from Target-site EPSPS Pro-106 mutations: sufficient to endow glyphosate resistance in polyploid *Echinochloa colona*? (Han, Yu, Widderick, & Powles. 2015)

21

# Spray quality & concentration

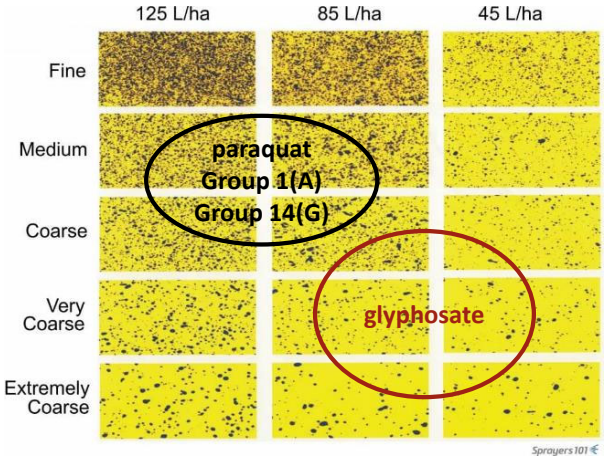
Large droplet (VC+)

- Increases droplet survival
- Reduces off-target losses (drift)

High concentration gradient (robust rate + low carrier volume)

- Assists cuticle uptake

BUT




22

# Small, upright grass weeds

Difficult to contact

- Very large droplets may miss or bounce off

*Increase number of droplets (water rate) if using large droplets on small weeds*


23

## VC or larger

- **ALL 2,4-D mixes**
- Drift reduction
- Required by some labels
- Summer applications
- 'Easy' surfaces for droplet to stick
- High stubble environment

Increase water rate (80-100L/ha) for v. small upright targets

## Medium - Coarse

- Group 14(G) mixes
- Group 1(A) mixes
- Hard to wet surfaces
  - Hairy
  - Small, upright grasses

Don't use

- In summer / high DT situations
- High stubble loads
- Drift sensitive situations

24

# Adjuvants for glyphosate

- **Follow label advice**
  - **When to add additional adjuvant**
  - **What type to use**
- Non-ionic surfactants are not all the same
- 'Oil' can antagonise glyphosate on summer grasses

In-built surfactant varies with different salts, loading and brands

Not just selected for efficacy

- Cost
- Loading
- Aquatic uses
- Eye / skin irritation
- Smell
- Evaporation rate
- Dilution (e.g. broadacre v home garden)
- Viscosity (summer or winter use?)
- Patent

25

# In-built surfactant load

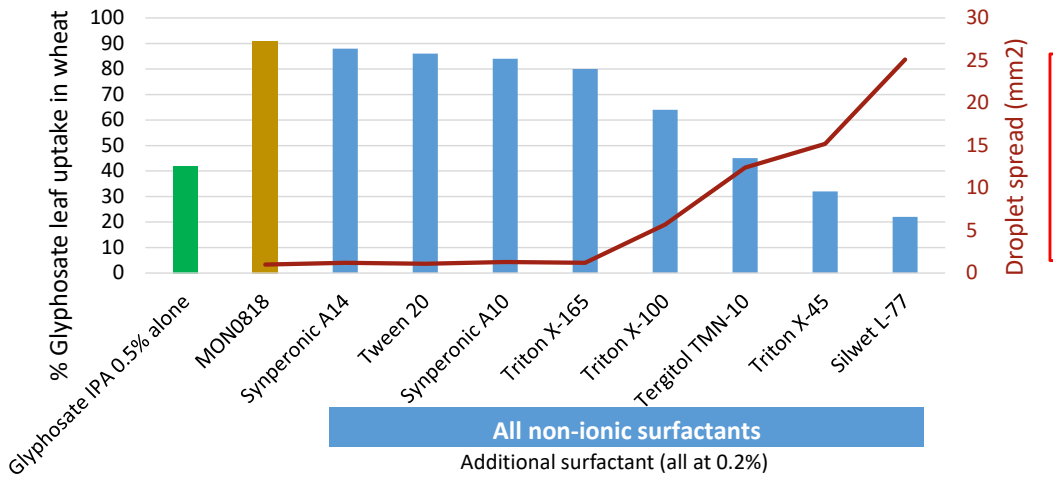
Target active load of around 150-200 gai/100L (**0.15 to 0.2 %**) for surfactants

| **Glyphosate 450 CT containing** | | **Spray volume** | | | | |
|---|---|---|---|---|---|---|
| | | **50 L/ha** | **75 L/ha** | **100 L/ha** | **150 L/ha** | **200 L/ha** |
| 144g/L polyethanoxy (15) tallow amine surfactant | 0.5L/ha | 0.14 | 0.10 | 0.07 | 0.05 | 0.04 |
| | 1 L/ha | 0.29 | 0.19 | 0.14 | 0.10 | 0.07 |
| | 2L/ha | 0.58 | 0.38 | 0.29 | 0.19 | 0.14 |

| Inadequate | Marginal | Optimal | Excess |
|---|---|---|---|

26

# Surfactant type

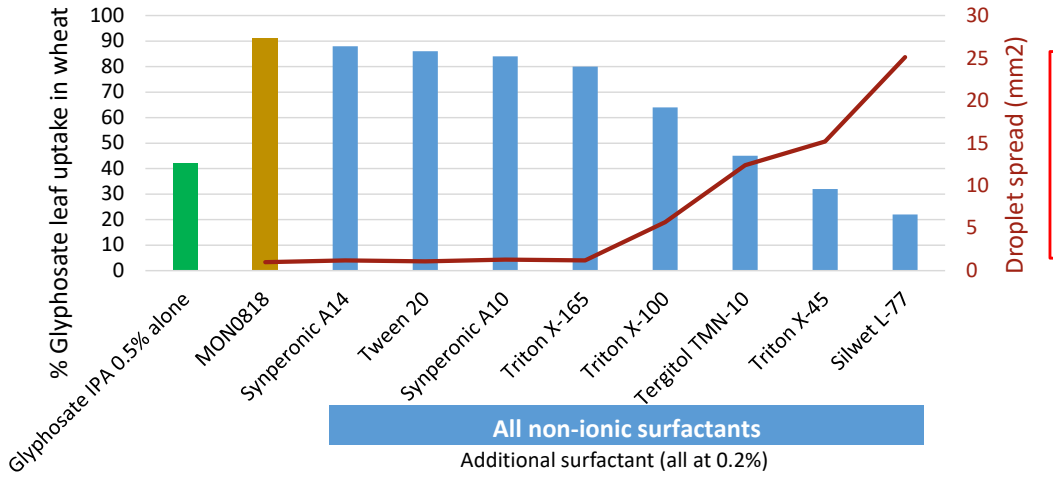



Increased droplet spread (reduced surface tension) will also increase 'fines' / drift potential

Plants grown at 20/25ºC & 70% RH
Adapted from Liu. Z.Q. (2003) Characterization of glyphosate uptake into grass species.



tallowamine e.g. Glysowet | Wetter TX type | Li700 Type | BS1000 type | silicon type e.g. Pulse

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Plants grown at 20/25ºC & 70% RH
Adapted from Liu. Z.Q. (2003) Characterization of glyphosate uptake into grass species.

# Translocation within the plant



## Translocation

Glyphosate requires 2-3 days to fully translocate

Reduced glyphosate translocation

- Weeds are stressed (e.g. very dry, waterlogged)
- Tank mix partners
  - Affecting plant hormones e.g. Group 4(I)
  - Fast acting mix partners that destroy vascular bundle e.g. paraquat, glufosinate, Group 14(G)
    - Faster they work (higher rates, higher light intensity) the more glyphosate translocation is reduced

**'Fast brownout' is NOT a desired feature for glyphosate mixes**

Antagonism is more noticeable:

- Glyphosate resistance
- Higher rates of tank mix partner
- Summer conditions
- Resistant populations

# Glyphosate antagonism

- Most broadleaf partners antagonise grass control
  - More complex the tank mix = more glyphosate needed to counter antagonism
- Glyphosate susceptible grasses
  - If mixing glyphosate + 2,4-D keep ratio at least 3:1

Roundup® UltraMax 1.3L/ha

Roundup® UltraMax 1.3L/ha plus 2,4-D 1L/ha

B. Chauhan. QAAFI, Gatton 2021



# Summary

## Best chance of achieving control for summer applications

- ✓Mild / warm (not hot & dry) – Delta T in range 3-6 following application
- ✓Large (VC) droplets
- ✓Minimum water rate (that still achieves coverage)
- ✓Small weeds
- ✓No rain for >6 hours
- ✓Robust application rates
- ✓AMS
- ✓Good water quality
- ✓Quality formulation (adjuvant package)
- ✓No antagonistic adjuvants or partners
- ✓Slow down / boom lower
- ✓Susceptible population

# OPTIONS TO REDUCE SPRAY DRIFT RISK

Presented by David Johnson (FMC)
Slides by Harry Pickering (Adama) and David Johnson (FMC)

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GRAINS RESEARCH & DEVELOPMENT CORPORATION

1

## TAKE HOME MESSAGES

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- When we ***Choose to Spray***, will determine where and how far the spray driftable fraction of our application will move
- The ***Sprayer Set-up*** will determine how much product will be left in the air.
- ***Coarser Spray Qualities / Nozzles*** will lower drift risk but can also impact efficacy
- Having a set of ***Spray-Plans*** for different paddock situations will enable efficient, safe and effective spraying.

2

# ALL PESTICIDES DRIFT

## Glyphosate Drift Simulation - Barley

Untreated

5% Drift Simulation
of Wipeout Pro - 1L/ha

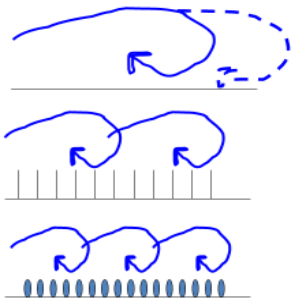
15 DAT
Crop Growth Stage at App - Z22



# "WHEN WE CHOOSE TO SPRAY"

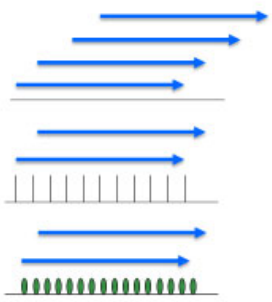
## Air Movement is Key for Spray Drift Management

Air Movement During the Day is
Turbulent
"Fine droplet management"



Daytime Spraying > 7km/h Wind

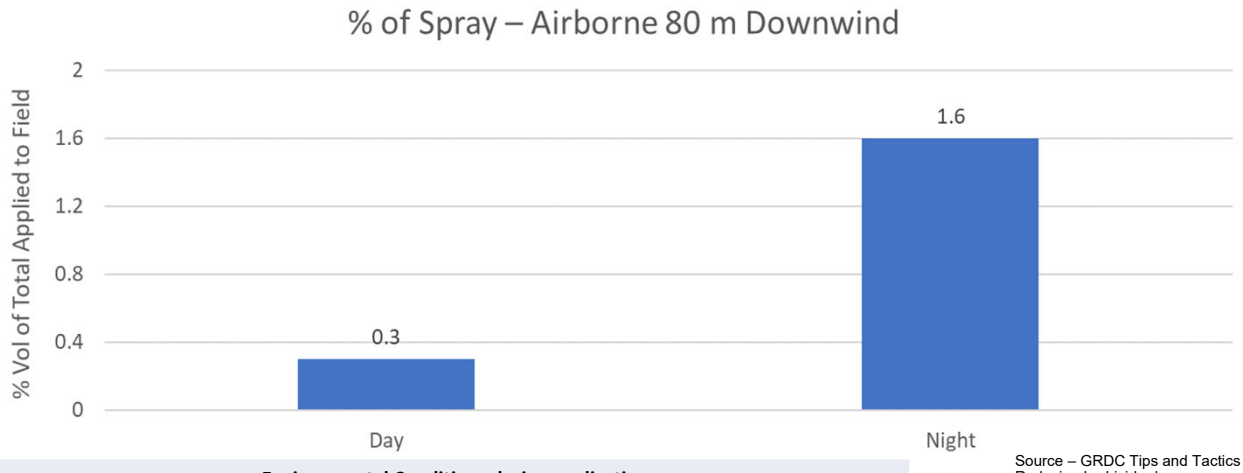

Air Movement During a
Hazardous Surface Temperature Inversion
"Fine droplet mayhem"



Night-time Spraying

# ‘WHEN WE CHOOSE TO SPRAY”

## Air Movement is Key for Spray Drift Management




| Environmental Conditions during application | | | |
|---|---|---|---|
| | Wind Speed (km/hr) | Temperature | Relative Humidity (%) |
| Night | 11.6 | 25.5 | 64 |
| Day | 18.3 | 28.7 | 61 |

Source – GRDC Tips and Tactics Reducing herbicide damage

AIXR 11002 – Medium

4 Bar

22 km/ha travel speed

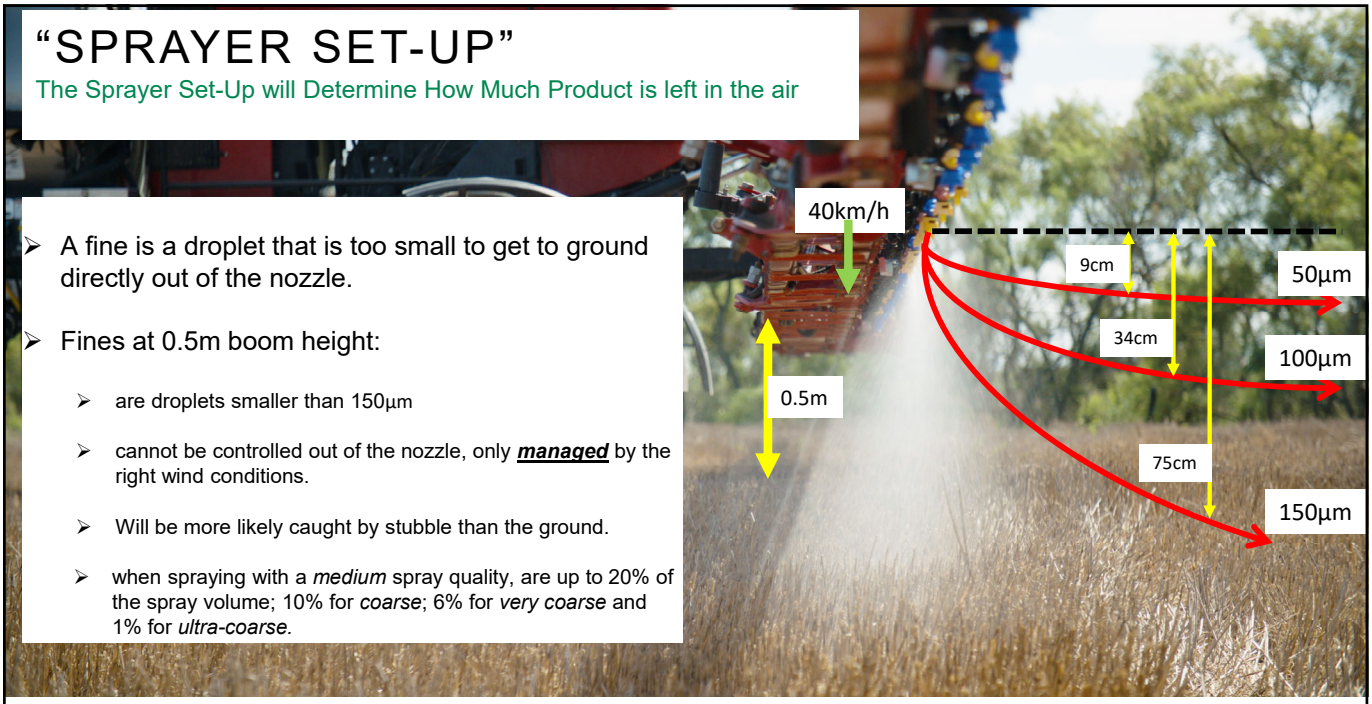
50 L/ha Water Volume

5

# “SPRAYER SET-UP”

## The Sprayer Set-Up will Determine How Much Product is left in the air

- A fine is a droplet that is too small to get to ground directly out of the nozzle.
- Fines at 0.5m boom height:
  - are droplets smaller than 150µm
  - cannot be controlled out of the nozzle, only ***managed*** by the right wind conditions.
  - Will be more likely caught by stubble than the ground.
  - when spraying with a *medium* spray quality, are up to 20% of the spray volume; 10% for *coarse*; 6% for *very coarse* and 1% for *ultra-coarse*.




6

# “SPRAYER SET-UP”

The Sprayer Set-Up will Determine How Much Product is left in the air

- A fine is a droplet that is too small to get to ground directly out of the nozzle.
- Fines at 1m boom height:
  - are double the volume of 0.5m boom height
  - are droplets smaller than 200µm.
  - when spraying with a *medium* spray quality, are up to 40% of the spray volume; 20% for *coarse*; 12% for *very coarse* and 2% for *ultra-coarse.*
  - Can access wind streams, turbulence or wake effects not felt closer to ground.


7

# “SPRAYER SET-UP”

The Sprayer Set-Up will influence downwind buffer zones.

Spraying with a higher boom:

- Is a greater drift risk factor than wind speed
- Increases downwind drift risk zones
- Can be counteracted by using coarser spray qualities

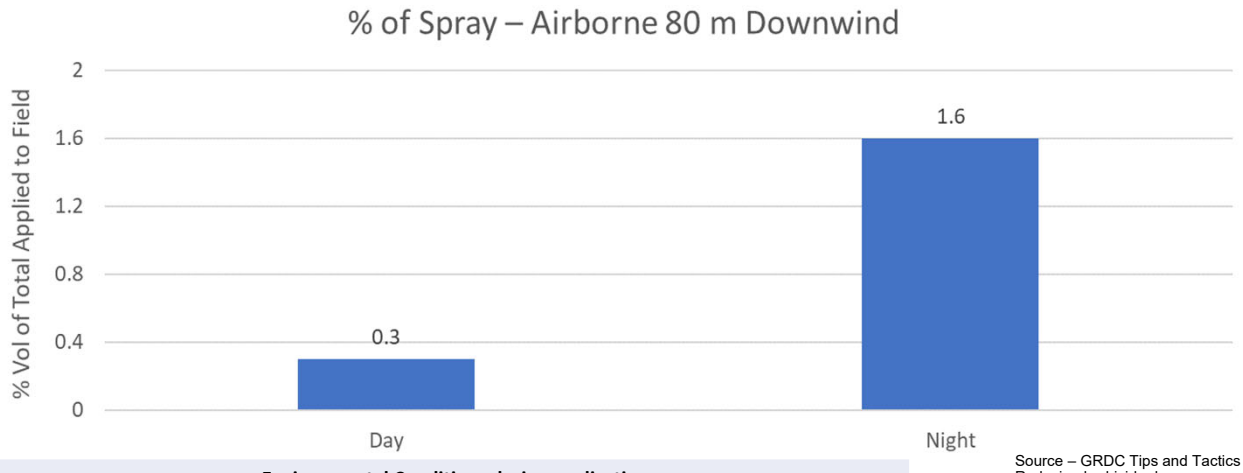
Example: Boom height of 0.5 m, Terrestrial vegetation RAL 1.9 g ai/ha
Wind speed 7 to 20 km/hr

| Wind = 7km/h Spray Quality | Boom Height (m) | | | | |
|---|---|---|---|---|---|
| | 0.5 | 0.6 | 0.8 | 1.0 | 1.2 |
| Fine | 236 | 278 | 324 | 342 | >400 |
| Medium | 44 | 66 | 116 | 158 | 198 |
| Coarse | 30 | 36 | 60 | 88 | 120 |
| Very Coarse | 24 | 30 | 38 | 56 | 78 |
| Ultra-coarse | 0 | 4 | 24 | 30 | 32 |

| Wind = 20km/h Spray Quality | Boom Height (m) | | | | |
|---|---|---|---|---|---|
| | 0.5 | 0.6 | 0.8 | 1.0 | 1.2 |
| Fine | 228 | 234 | 238 | 258 | 280 |
| Medium | 56 | 78 | 124 | 166 | 206 |
| Coarse | 34 | 48 | 76 | 102 | 130 |
| Very Coarse | 30 | 36 | 56 | 72 | 86 |
| Ultra-coarse | 14 | 24 | 32 | 40 | 46 |

8

## Air Movement and Nozzle Selection

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Source – GRDC Tips and Tactics Reducing herbicide damage

AIXR 11002 – Medium

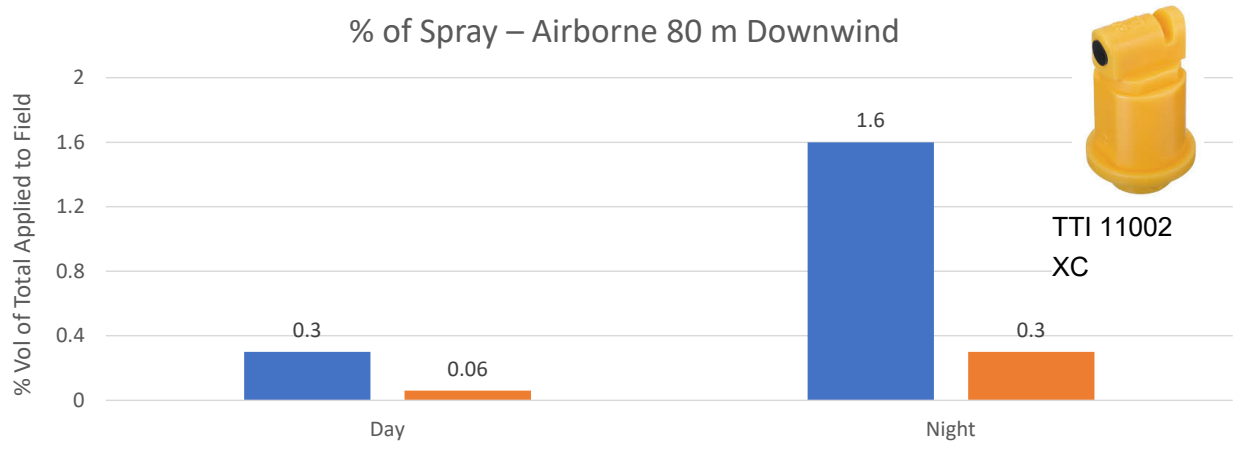
4 Bar

22 km/ha travel speed

50 L/ha Water Volume

9

## Air Movement and Nozzle Selection






TTI 11002

XC

| Environmental Conditions during application | | | |
|---|---|---|---|
| | Wind Speed (km/hr) | Temperature | Relative Humidity (%) |
| Night | 11.6 | 25.5 | 64 |
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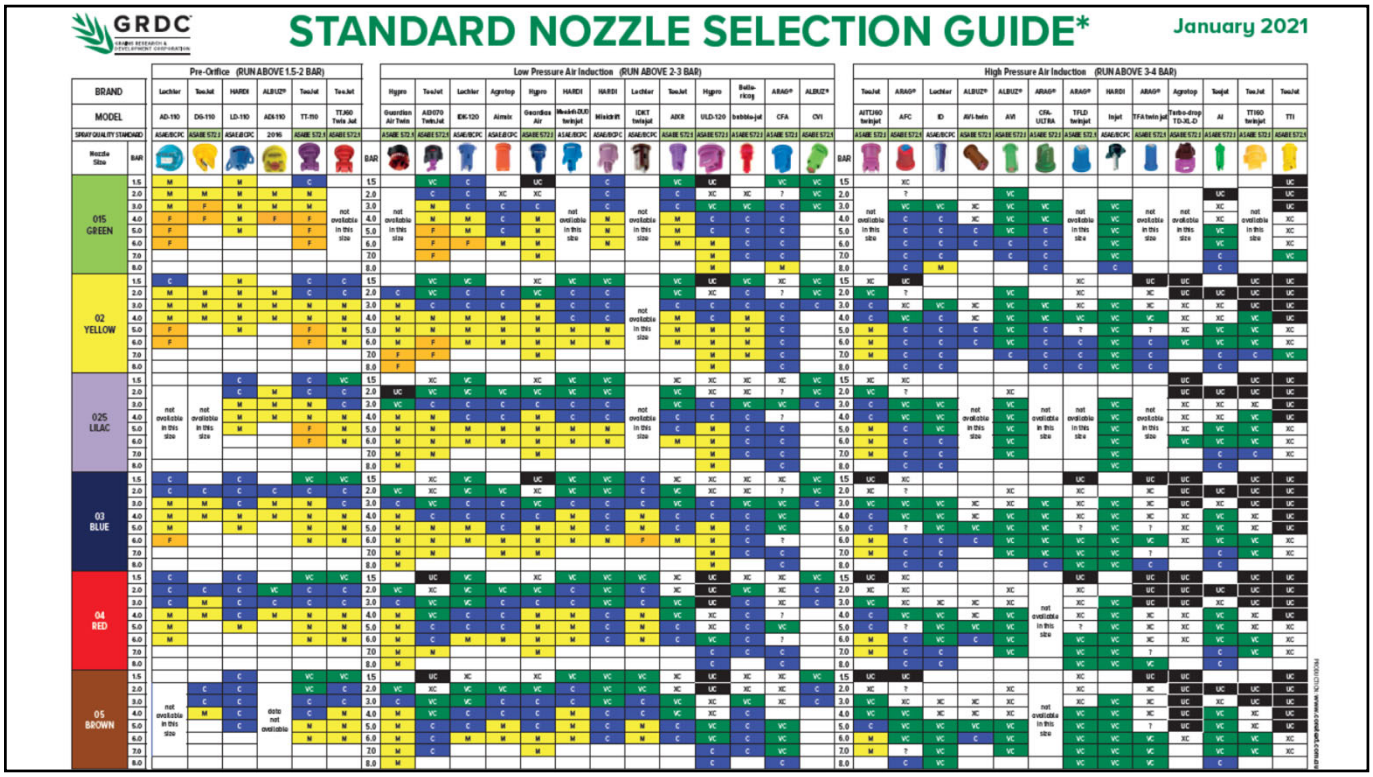
22 km/ha travel speed

50 L/ha Water Volume

10





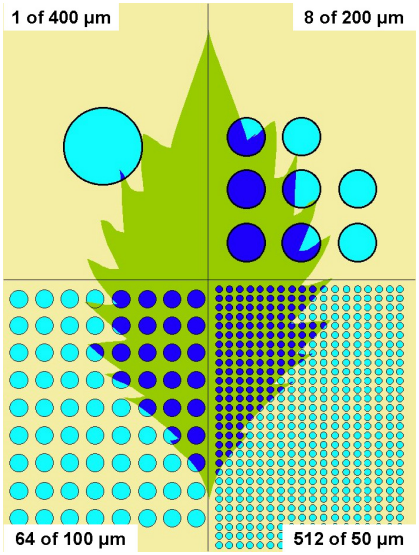

GRDC
STANDARD NOZZLE SELECTION GUIDE*
January 2021

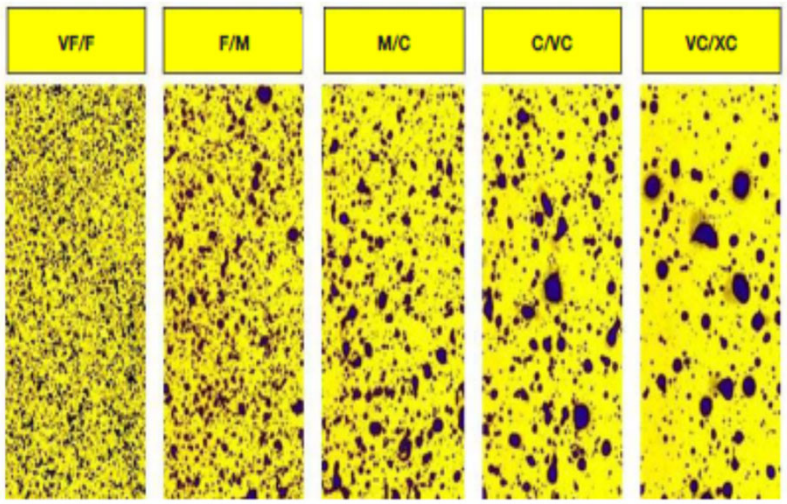
All nozzle spray qualities in the manufacturer charts are measured with water only.

- Citing ASABE 572.1 or 2 or 3 does not mean the nozzle's spray quality was measured with a non-ionic surfactant in the mix
- Tank mix can dramatically alter the nozzle's spray quality – up to 2 full categories finer e.g. VC on the chart could be M with a tank mix
- Formulation types have different fining-up effects e.g. NIS > SL > EC > WDG > SC
- Choose adjuvant very carefully
- Spray with as coarse a spray quality that still gives acceptable efficacy
- If in doubt, use the lowest pressure of a nozzle within its optimum operating range (2-4 bar for low pressure AI, 4-6 bar for high pressure AI)
- Slow down – consider farm's capacity to get over the crop at a responsible speed (<22km/h) within the limited ideal spraying window and conditions [Spray Plans].

# DRIFT REDUCTION AND EFFICACY

## Efficacy Needs to be Maintained – Plan Ahead with a Spray Plan




Assess % Coverage with Snapcard app

13

# TAKE HOME MESSAGES

- When we ***Choose to Spray***, will determine where and how far the spray driftable fraction of our application will move
- The ***Sprayer Set-up*** will determine how much product will be left in the air.
- ***Coarser Spray Qualities / Nozzles*** will lower drift risk but can also impact efficacy
- Having a set of ***Spray-Plans*** for different paddock situations will enable efficient, safe and effective spraying.

14

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# Update on Spray Drift Reduction Technologies for Grain Crops

**Andrew Hewitt**

**THE CENTRE FOR PESTICIDE APPLICATION and SAFETY**
**THE UNIVERSITY OF QUEENSLAND, GATTON**

The University Of Queensland
**C-PAS**

1

# Background

- Spray drift management is complex and involves optimising the:
  Equipment setup and nozzle choice
  Application speed (which can affect the wake, stability, coverage uniformity and choice of nozzle/ pressure)
  Boom height
  Tank mix

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# Continued

- Meteorological conditions
- Atmospheric stability
- Buffers and barriers

- Using drift reduction technologies should be a key part of any drift management approach but not all of these support spraying in adverse conditions or too close to non-target sensitive areas

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# Labels

- Always read and follow the label and all applicable local and federal regulations

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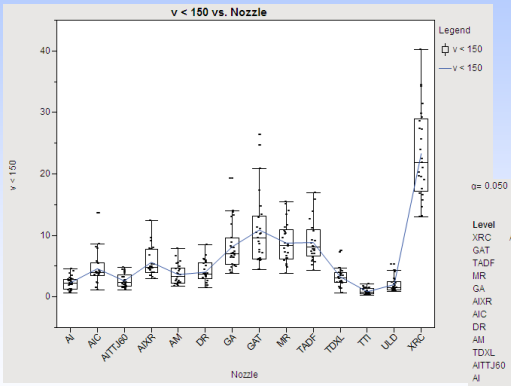
# How Critical Is the Tank Mix for Different Nozzles?




In our early studies with Monsanto and other companies, we found that nozzles that produced more fines were more variable

α= 0.050 t= 1.97361

| Level | | Least Sq Mean |
|---|---|---|
| XRC | A | 23.5 |
| GAT | B | 10.3 |
| TADF | C | 8.8 |
| MR | C D | 8.5 |
| GA | D | 8.1 |
| AIXR | E | 5.4 |
| AIC | F | 4.5 |
| DR | G | 3.8 |
| AM | G H | 3.6 |
| TDXL | H | 3.1 |
| AITTJ60 | I | 2.5 |
| AI | I J | 2.1 |
| ULD | J | 1.9 |
| TTI | K | 0.7 |

Levels not connected by same letter are significantly different.

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# Nozzles for lowest drift potential

- CPAS has tested a wide range of nozzles, pressures and tank mixes for herbicide drift management with and without adjuvants in recent months
- Here are some examples of leading options for maximum drift potential reduction

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# TTI and TTI60 Nozzles

- These single and twin exit orifice nozzles are well suited for drift management with a wide range of tank mixes
- Generally <1% Fines and smaller orifices not always finer
- In US, some companies give away TTI nozzles with herbicides that are high drift concern


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# Magnojet Nozzles

- Tested various Magnojet nozzles in wind tunnel. Example – MUG04 and 05 at 3 to 5.5 bar - percent fines (<100µm) was zero for tank mixes with herbicides, surfactant and DRAs, and <150µm was <1% for all tank mixes.



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# Greenleaf AVI-UC Nozzles

- Minimal Fines across pressures 3 to 5.5 bar
- Single and twin fan options

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# Pentair Hypro 3D Nozzles

- Coarsest sprays with this nozzle are at pressures up to 3.5 bar


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# Hypro PSLDMQ and PSULDMQ Nozzles

- Generally good at pressures up to 3.5 bar


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# Agrotop TDXLD Nozzles

- Good for pressures up to at least 3.5 bar

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# Pentair/ Hypro ULD and ULDM Nozzles

- Coarsest sprays at pressures up to at least 3.5 bar and even higher for M (Max) design


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# Wilger UR Nozzles

- Optimised for Pulsed Width Modulation (PWM) spraying systems (also valuable with conventional non-pulsed systems)


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# Tank Mixing

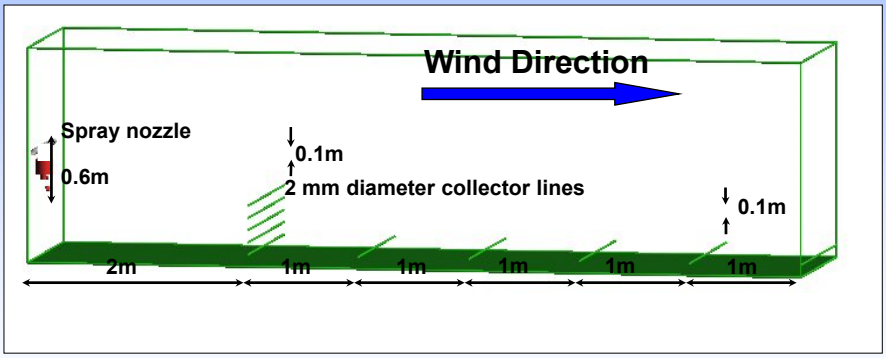
- Some low pH tank mix partners can increase the volatility of some herbicides so take care with AMS and some glyphosates when using low volatile Dicamba products for example
- Most tank mix partners will change the droplet size, particularly where the surface tension decreases with high surfactant loading products




# Drift Reduction Adjuvants (DRAs)

- APVMA has a standard test approach for proving DRA performance where nozzles appropriate to the application are selected and the effect of the DRA on droplet size and drift potential are measured in a wind tunnel

## Wind Tunnel Measurement of Spray Drift Potential

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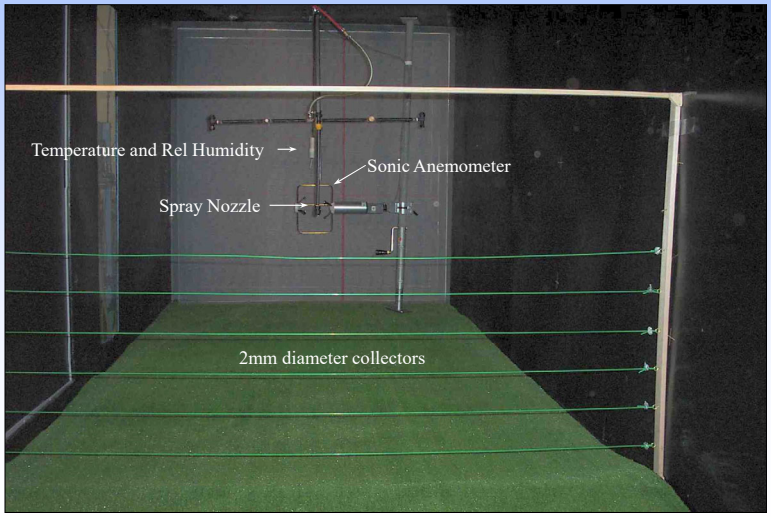
17

## Wind Tunnel Drift Potential Measurement at UQ

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18

# Examples of DRAs

- Encapsulators of active ingredients to prevent smaller (driftable) droplets containing as much a.i. – but are there solid data to back such claims in all cases?
- Guar gums to increase the extensional viscosity which can reduce Fines with suitable nozzles. Some polymers can help as well, but some broaden the droplet size spectrum and narrow the spray angle



# Examples to help control droplet size for narrower size spectra

- Some emulsion chemistries rather than solutions when choosing how to reduce surface tension for optimal spray sticking/ wetting/ rainfastness/ uptake/ spreading on leaves – but performance isn't always as good with some tank mixes as with water tests

# Summary

- Newer nozzles and adjuvants can reduce or eliminate Fines, but be aware that hitting narrow (e.g. grass) weeds and reducing application volume rates can be problematic with sprays that are too coarse
- One size doesn't fit all – some situations may require other technologies such as hoods, shields, barriers, air-assistance etc.

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# Future

- Sensors, robotics, and some drones may help with targeting sprays better at up to 90% lower use rates – we are working on weed control in a 2-year project using sensors
- Tools for applicators to assess the spraying conditions before and during application
- Low volatile products and guidance on tank mixing as well as nozzle interactions

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# How has the drift message changed over the last few years?

- Wind direction: avoiding exposure to non-target areas is the most important factor, and therefore no-spray buffers are directional
- Coarser is better but needs to be in context of avoiding all Fines (e.g. you can use a spray that is Medium but with 0% fines…..its better than a Coarse spray with 10% fines)




# The Drift Message

- Exposure risk varies with a.i. types and adjuvants can play a positive or negative role – choose wisely
- Higher pressure can be better with some AI nozzles and with narrow angle nozzles (e.g. aerial solid streams)
- Slow down because wake effects and air shear are important

# The Drift Message

- Calm conditions are risky, with or without a local surface temperature inversion – the solution to pollution is dilution
- The weather and atmospheric stability can vary in short distances and times – it is very dynamic so be attentive when it is calm (little or no wind)
- Be careful with UAVs – claims are often big, but performance data are scarce

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# Drift

- Delta T is most applicable when sprays are finer, volatile products are higher, release heights greater and application volume rates low

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26

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## Trade display exhibitors

| | | |
|---|---|---|
| SINGLE AG REVOLUTIONARY WEED CONTROL | Know what's there before you spray.<br>Want to spot spray with your existing sprayer? Want to blanket spray and spot spray simultaneously? Want to know the area to spot spray before you spray? Want to scout for herbicide resistant weeds? Find out how, with weed mapping at 200ha per hour at Single Agriculture. | www.singleagriculture.com.au |
| CORTEVA™ agriscience | Colex-D Herbicide contains a novel 2,4-D salt and formulation technology that reduces drift potential, volatility and 2,4-D odour. The proposed label will contain specific criteria and compatibility statements to support these claims. With efficacy equal to 2,4-D amine, this is a 2,4-D that can be applied with confidence. | https://www.corteva.com.au/ |
| HARDI | GeoSelect, a new spraying solution designed to save farmers money, time and create greater efficiency while working the harsh Australian landscape. | https://www.hardi.com.au/ |
| CROPLANDS | Croplands Equipment is a leading manufacturer and supplier of agriculture spraying equipment. We have been partnering with growers around the world to bring out the very best in their operations for over 50 years. | https://croplands.com/au/ |
| McINTOSH DISTRIBUTION<br>Miller Since 1899 SPRAY-AIR<br>WeedSeeker 2<br>bilberry | McIntosh Distribution is leading Australian machinery distributor for national brands including Miller Sprayers and WeedSeeker 2. With a commitment to excellent customer service, McIntosh Distribution aims to provide growers with industry-leading equipment, service and after-sales support. | http://www.mcintoshdistribution.com.au/ |
| FMC An Agricultural Sciences Company | Nobody likes to get a fine.<br>FMC developed On Coarse® DRA (Drift Reducing Adjuvant) to provide applicators with the confidence and knowledge to apply 2,4-D/glyphosate mixtures with a wide range of nozzles to produce genuine Very Coarse (VC), Extremely Coarse (XC) or Ultra Coarse (UC) spray qualities. Make less fines with On Coarse® DRA | www.fmccrop.com.au |
| MILNE BROS TRUCK AND TRACTORS | Detailed discussion on updated Agtronics equipment built to suit the Central Queensland environment, customisation to suit specific needs of farmers. | https://milnebros.com.au/ |
| RDO EQUIPMENT | Using See & Spray Select, farmers and contractors can apply complex tank mixes more efficiently and easily switch from targeted to broadcast spraying without leaving the tractor cab. See & Spray Select has an integrated camera technology that rapidly detects green plants within fallow ground and automatically triggers an application to those plants. In doing so, it achieves a similar hit rate to traditional broadcast spraying but uses, on average, 77% less herbicide. | https://www.rdoequipment.com.au/application-equipment/ |