Evaluation of spray deposition parameters on blueberry leaves and fruit as influenced by spray water volume

P Rebel, JG van Zyl & JB Wessels

BERRIES ZA
SUPPORTING SOUTH AFRICAN GROWERS

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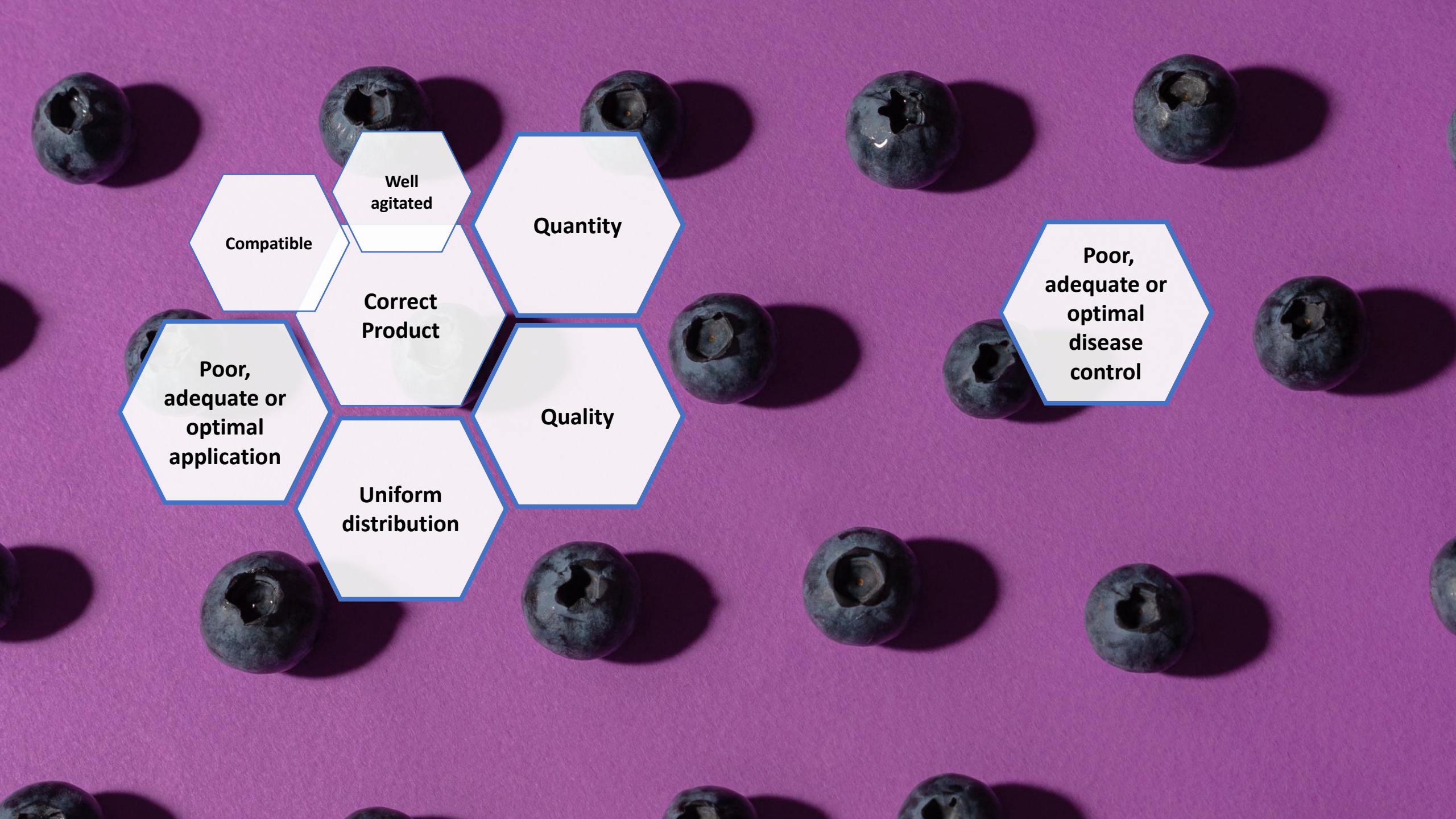
Well agitated
Compatible
Quantity
Correct Product
Poor, adequate or optimal application
Quality
Uniform distribution
Poor, adequate or optimal disease control


Run-off
Drift
Well agitated
Compatible
Quantity
Minimal losses
Poor, adequate or optimal disease control
Correct Product
Efficiency
Application timing
Poor, adequate or optimal application
Quality
Orchard
Climatic conditions
Uniform distribution
Correct Applicator
Canopy management
Wind
Calibration and Setup
Humidity
Tractor speed
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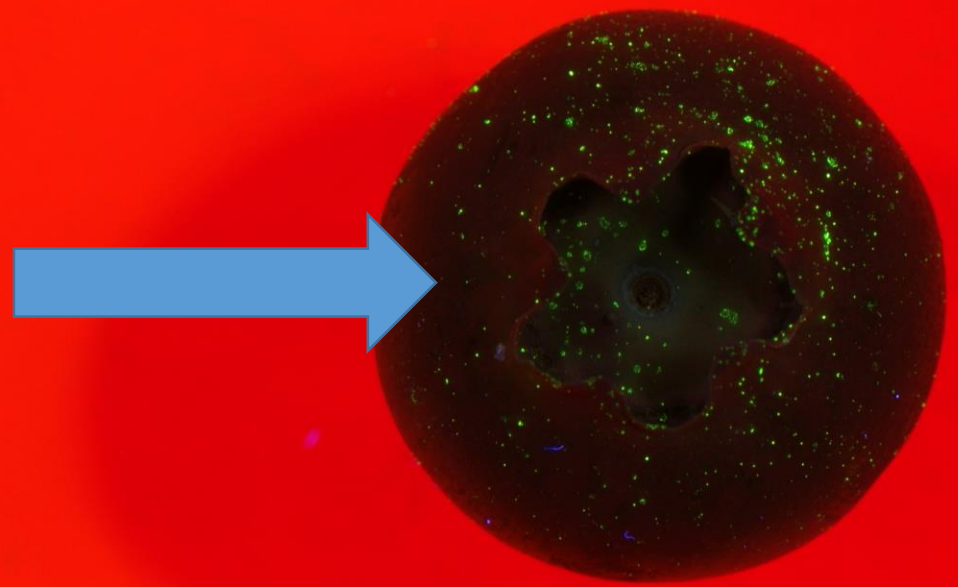
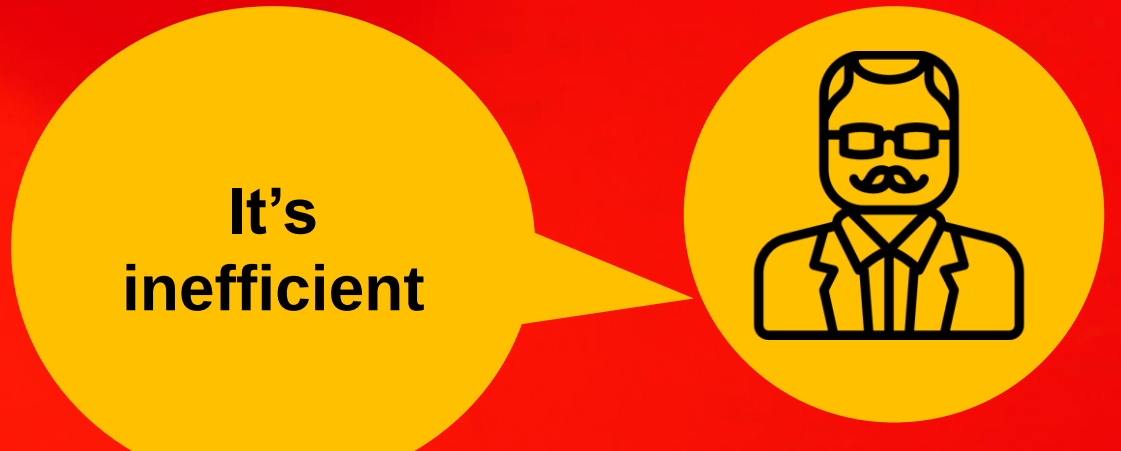
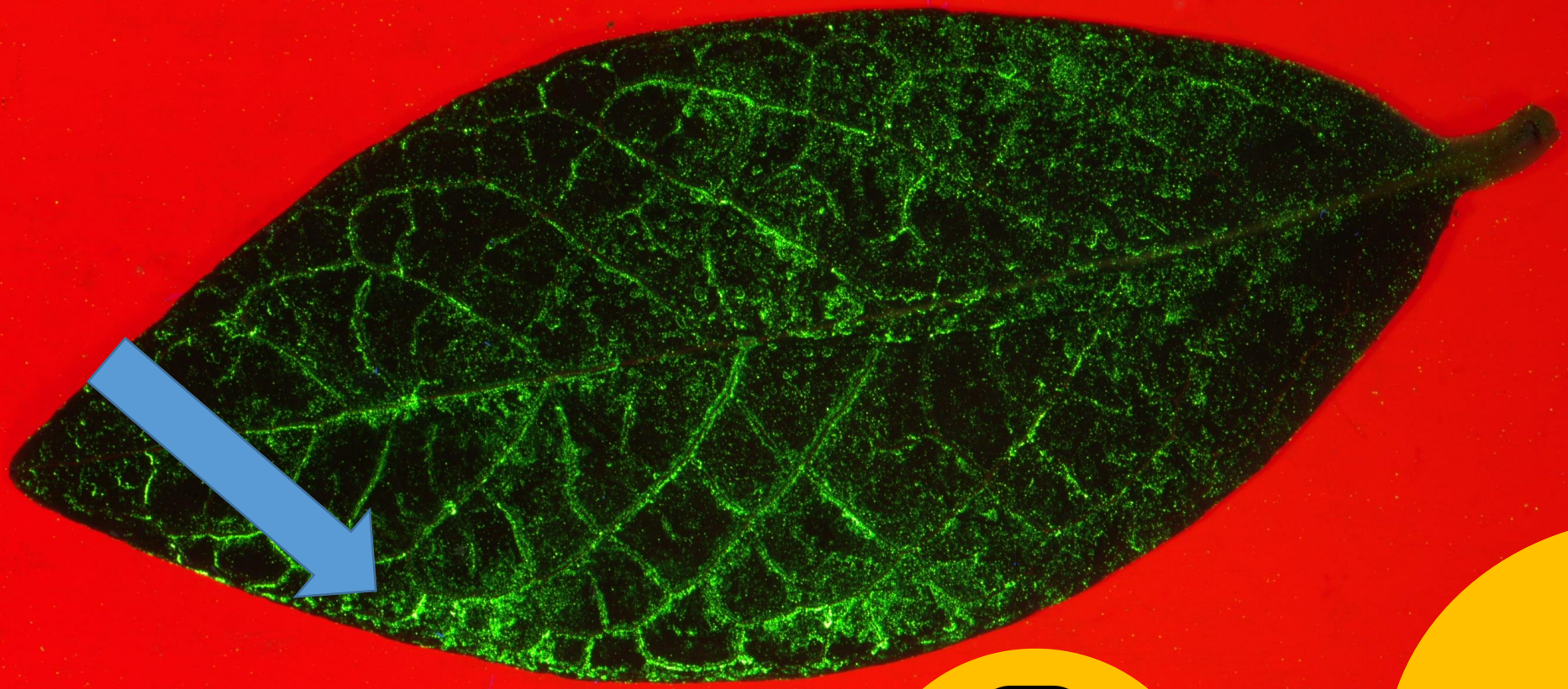
Don’t fix what’s not broken…
It’s inefficient
It’s not broken…

Inadequate deposition due to poor spray methodology, use of too low water volumes





Large losses due to run-off and drift



It’s inefficient

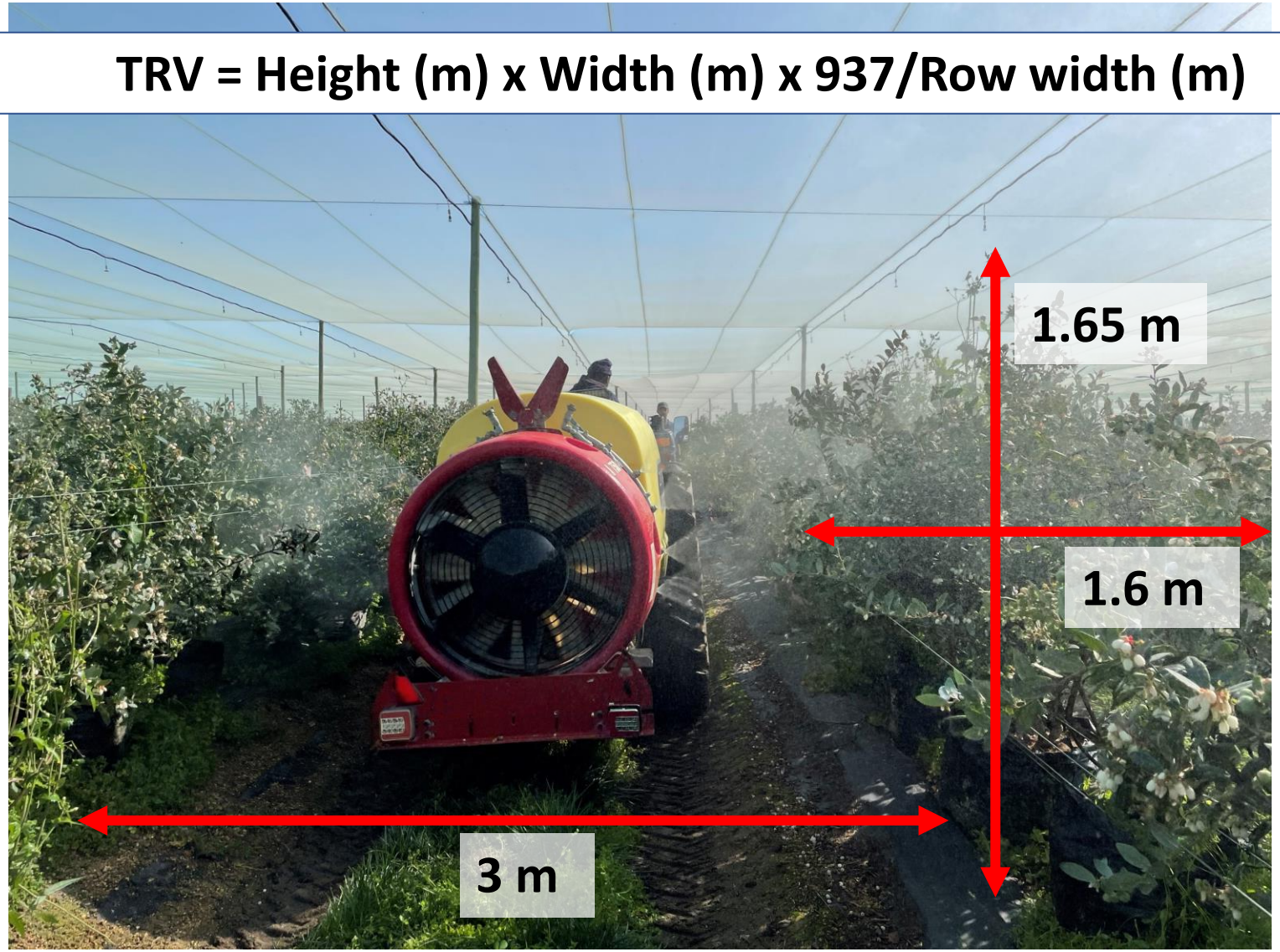
Other inefficiencies
High fuel, time and labour cost
Contamination of operator, equipment, soil and water


Can we be more efficient using correctly determined spray volumes?
More importantly,…Will it work?
Let’s find out!


Preliminary spray deposition evaluation
Spray volume and dosing

Spray water volume baseline selection

TRV = Height (m) x Width (m) x 937/Row width (m)



Tree Row volume (TRV)

- **TRV = 824.5 L/ha calculated point of run-off**

Four volumes selected

- **200 L/ha**
- **400 L/ha**
- **600 L/ha**
- **800 L/ha**

To keep influencing factors to a minimum

- **Sprayer speed kept constant**
- **Water volume manipulated through nozzle selection**
- **Droplet spectrum kept constant**

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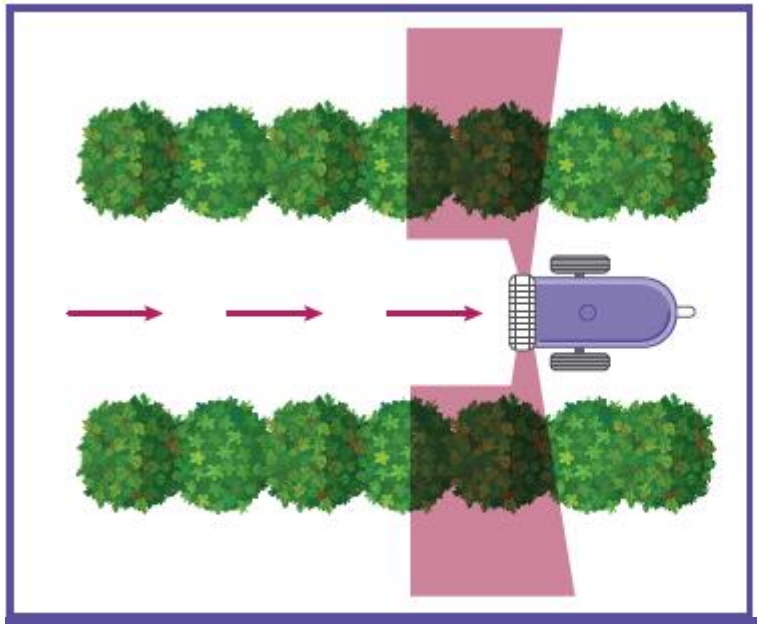
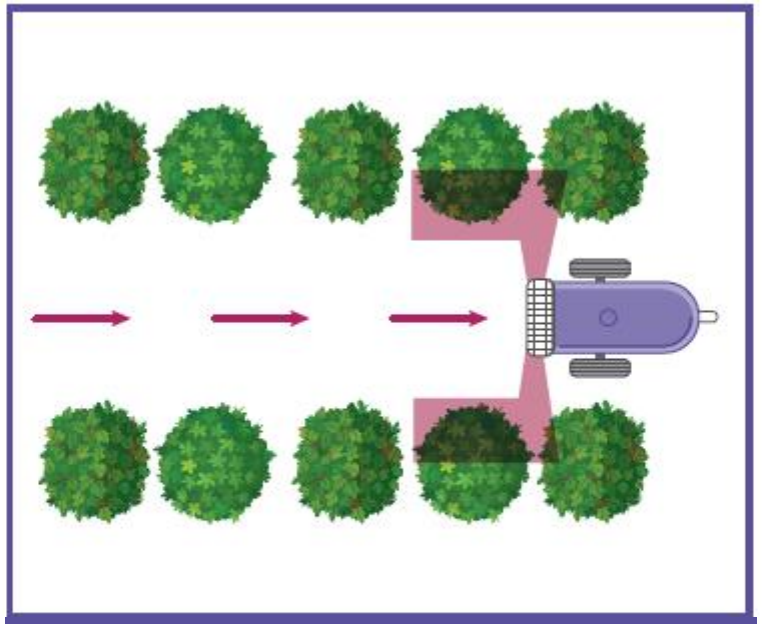
Canopy adapted spraying (CAS)

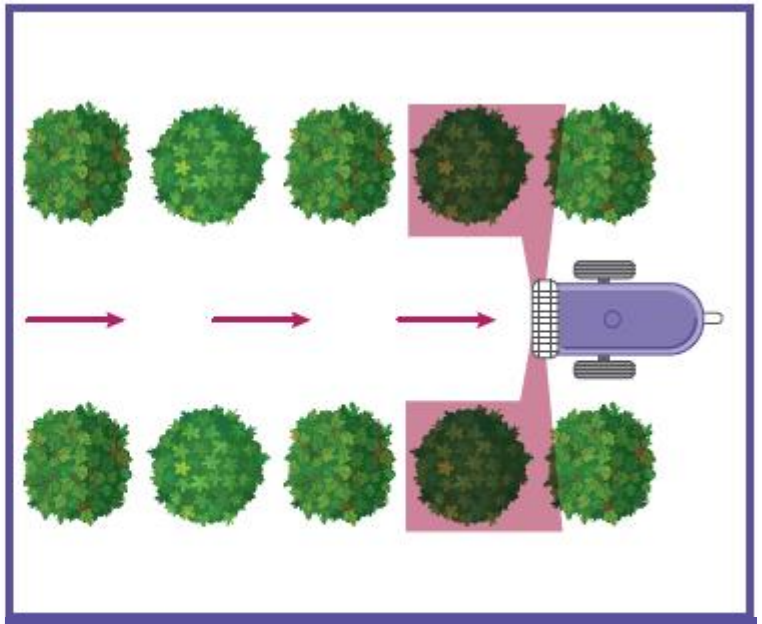
Matching sprayer speed + air output to the canopy
Purpose: Maximise the ratio of deposited droplets versus the amount released. Minimise the amount lost to blow through, blow off and drift



Air volume/speed too high, spray speed too slow, blows through bush



Air volume/speed too low, spray speed too fast, poor canopy penetration



Air volume/speed, spray speed in equilibrium, canopy penetration optimal

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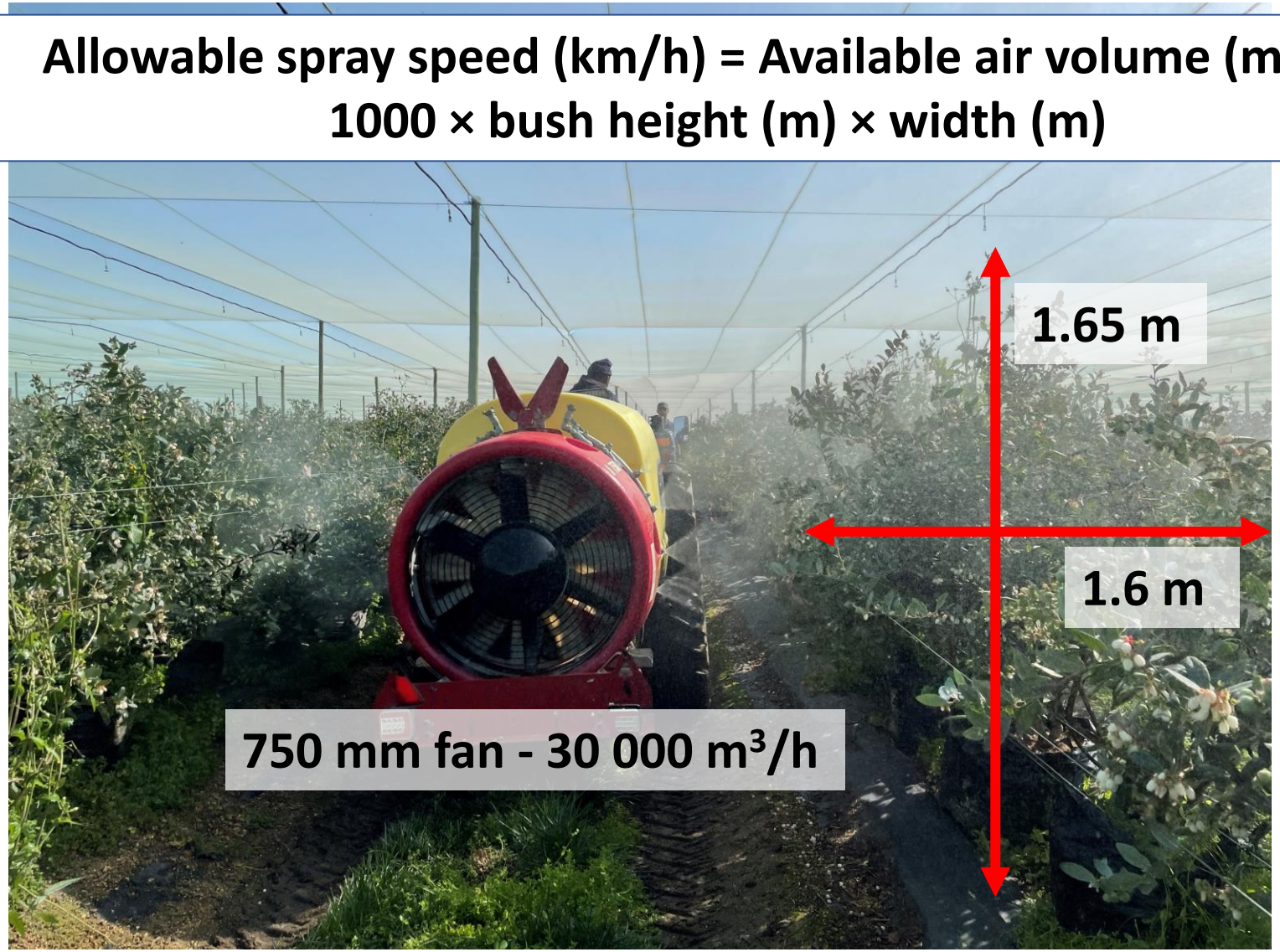
Sprayer speed

Allowable spray speed (km/h) = Available air volume (m^3/h)/ 1000 × bush height (m) × width (m)



Low Profile Hardi Zaturn

- **750 mm diameter axial fan @ 540 PTO RPM**
- **Max air output of 30 000 m^3/h**

- **Selected 5 km/h realistic sprayer speed**
- **2 High 1800 RPM**

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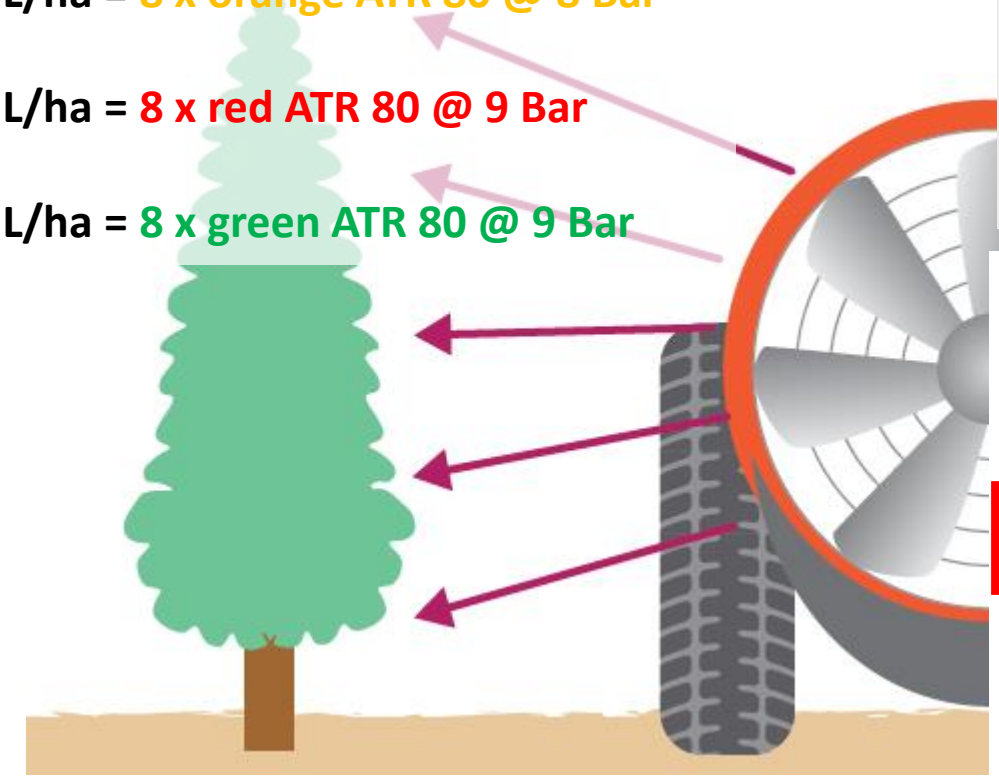
Nozzle selection

VF Very fine (< 159 µm) - F Fine (> 159 / < 231 µm)

Nozzle selection per spray volume (L/ha)

- **200 L/ha = 8 x brown ATR 80 @ 9 Bar**
- **400 L/ha = 8 x orange ATR 80 @ 8 Bar**
- **600 L/ha = 8 x red ATR 80 @ 9 Bar**
- **800 L/ha = 8 x green ATR 80 @ 9 Bar**



bar	ATR 80°									
	WHITE	LILAC	BROWN	YELLOW	ORANGE	RED	GREY	GREEN	BLACK	BLUE
5	VF	VF	VF	VF	VF	F	F	F	F	F
7	VF	VF	VF	VF	VF	F	F	F	F	F
10	VF	VF	VF	VF	VF	F	F	F	F	F
15	VF	VF	VF	VF	VF	VF	F	F	F	F
20	VF	VF	VF	VF	VF	VF	VF	VF	VF	VF

ASABE S572.1 Droplet Size Classification

The American Society of Agricultural and Biological Engineers (ASABE) developed the ASABE S572.1 standard to measure and interpret spray quality from tips.

Spray Quality*	Size of Droplets	VMD Range (Microns**)	Color Code	Retention on Difficult to Wet Leaves	Used for	Drift Potential
Extremely Fine	Small	<60	Purple	Excellent	Exceptions	High
Very Fine		61-105	Red	Excellent	Exceptions	
Fine		106-235	Orange	Very Good	Good Cover	
Medium		236-340	Yellow	Good	Most Products	
Coarse		341-403	Blue	Moderate	Systemic Herbicides	
Very Coarse		404-502	Green	Poor	Soil Herbicides	
Extremely Coarse		503-665	White	Very Poor	Liquid Fertilizer	
Ultra Coarse	Large	>665	Black	Very Poor	Liquid Fertilizer	Low

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Yellow fluorescent pigment dosing

SARDI Yellow Fluorescent Pigment 1 ml/1 L

Water volume (L/ha)	Trial 1 (July 2022)	Trial 2 (November 2022)
	Yellow Fluorescent pigment	
Based on TRV 824.5L/ha	Droplet density	Dosing
200	200 ml/100 ℓ (2x)	400 ml/100 ℓ (4x)
400		200 ml/100 ℓ (2x)
600		133 ml/100 ℓ (1.33x)
800		100 ml/100 ℓ (1x)

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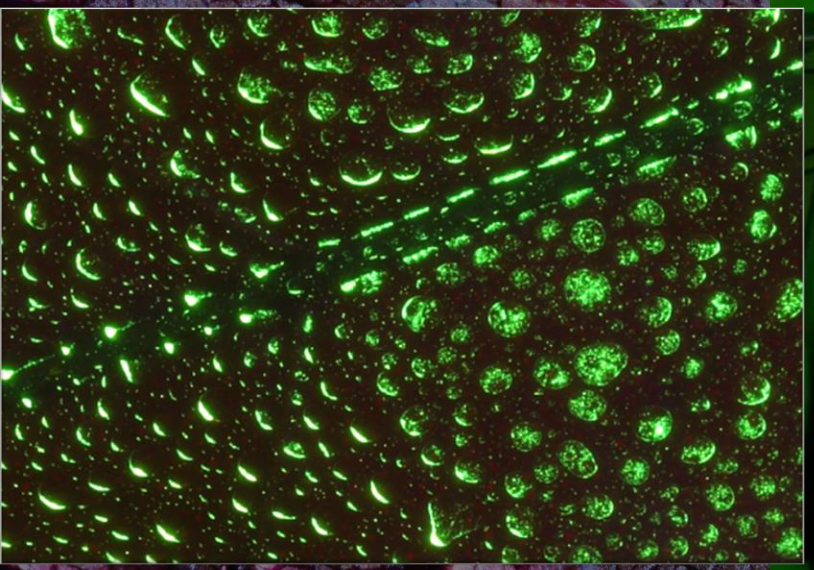
Leaves
Sampling
10 x
3 reps
Berries

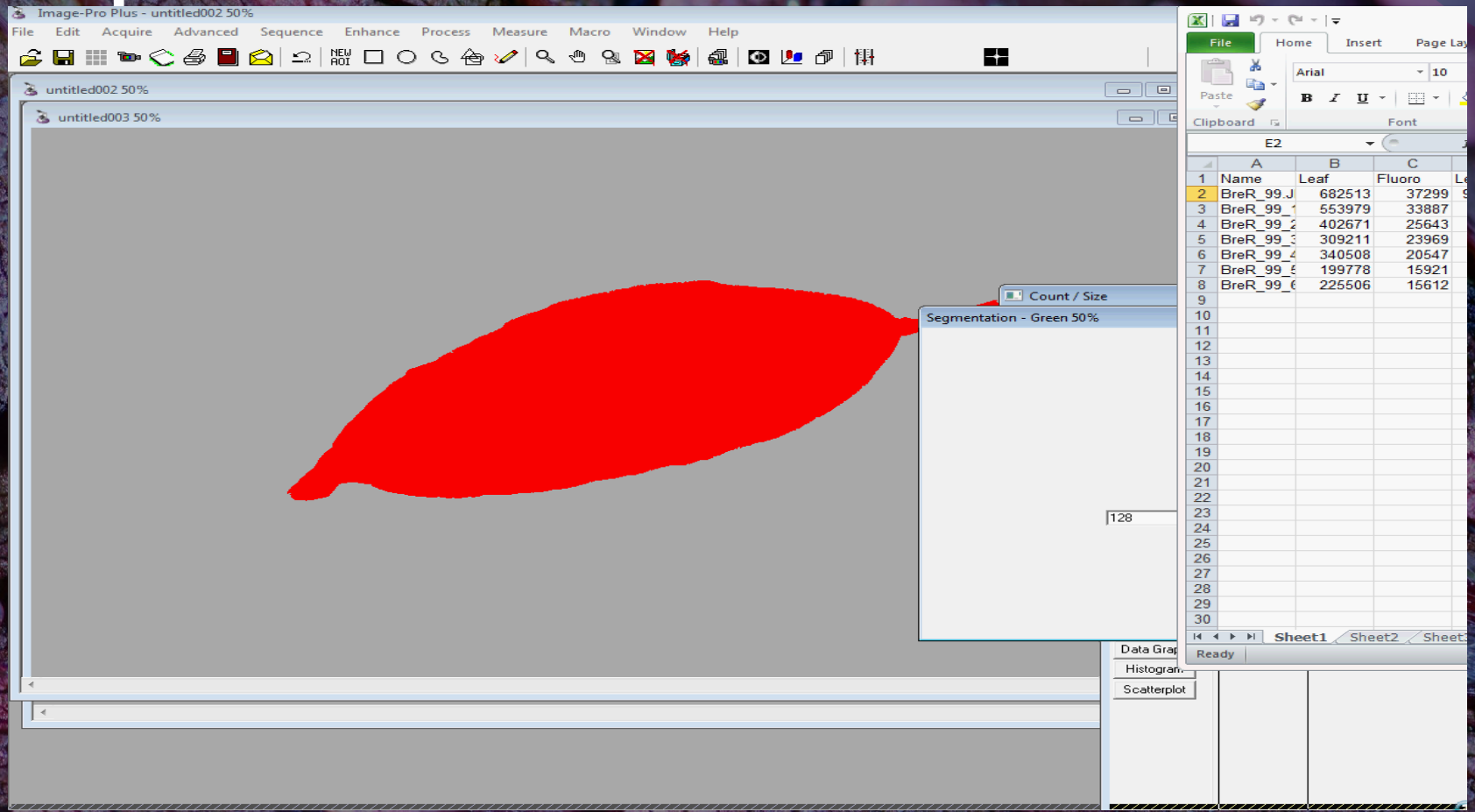
- Digital photography
  - Labino black light (365 nm) illumination
  - Upper/lower surface of leaves is photographed
  - Canon EOS 5DSR with 100 mm macro lens - 28 mb *.raw image

Methodology

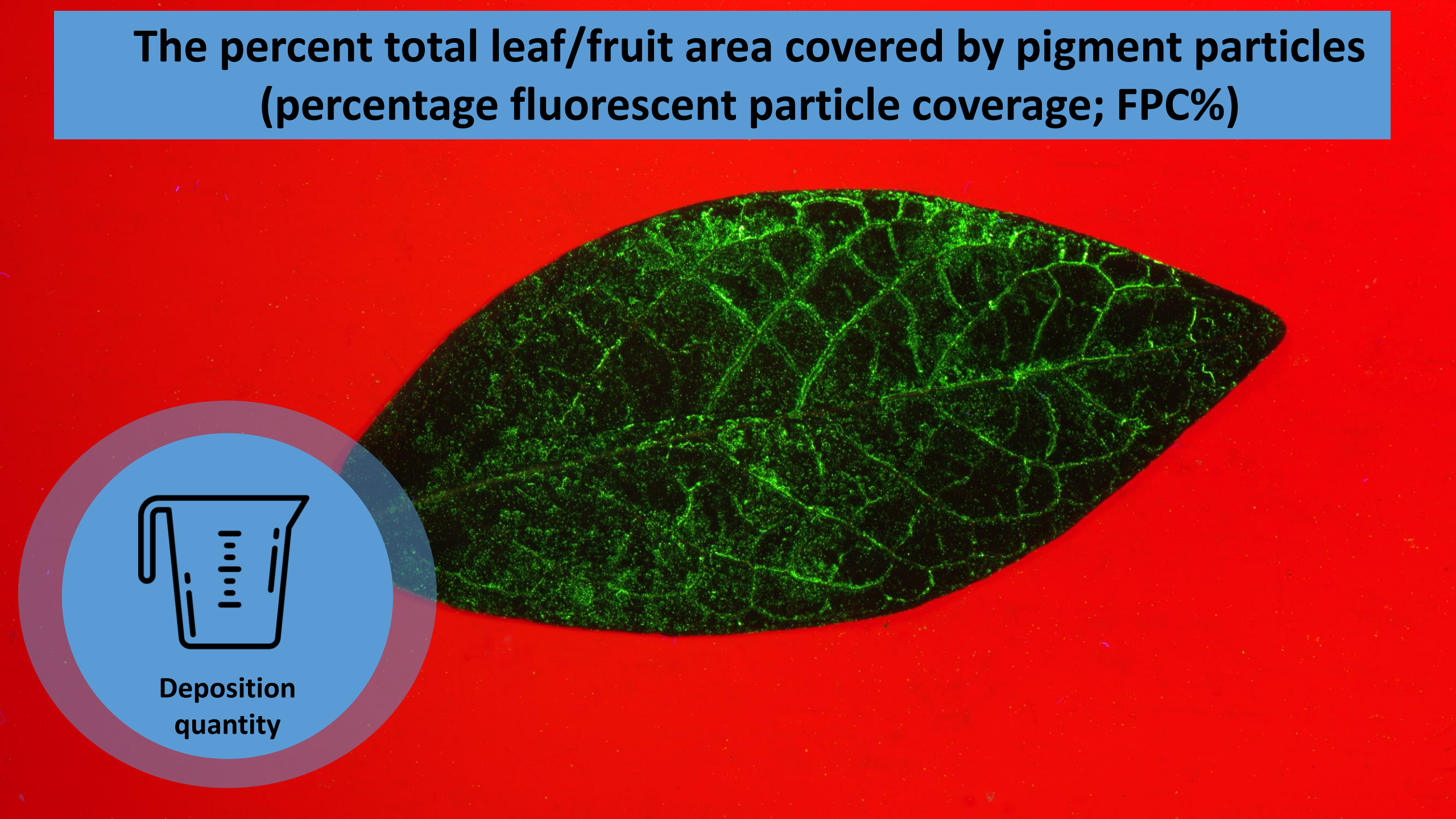


- Digital image analysis
  - *.raw images converted to *.tiff files (35 mb)
  - *.tiff files used in image analysis using Image Pro-plus software
- Deposition parameters determined

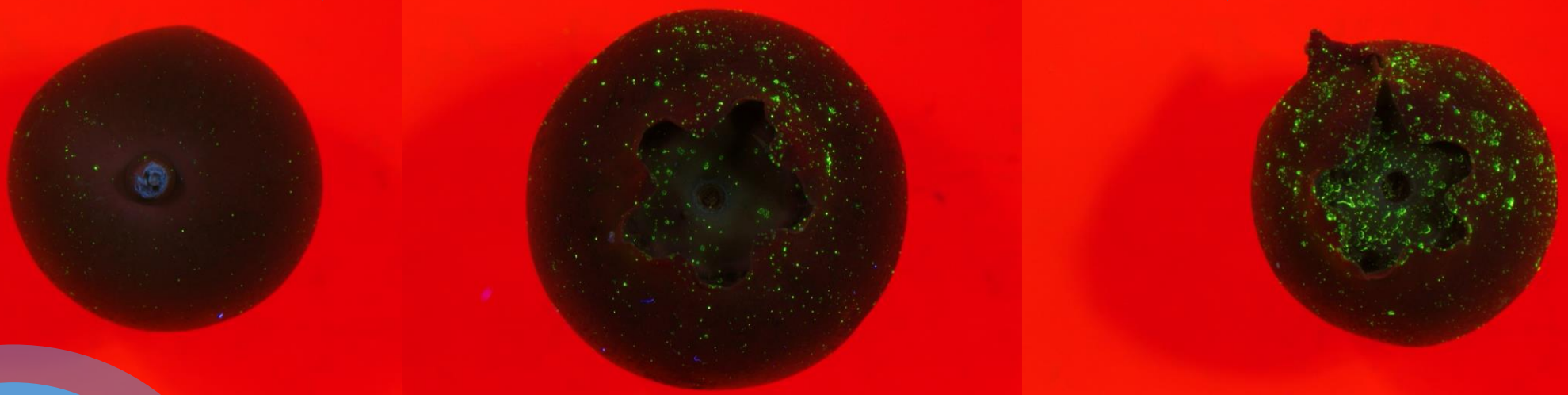
Methodology



The percent total leaf/fruit area covered by pigment particles (percentage fluorescent particle coverage; FPC%)

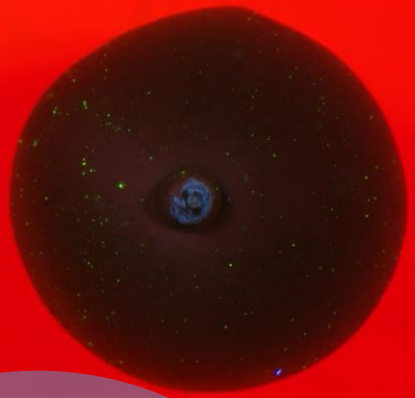


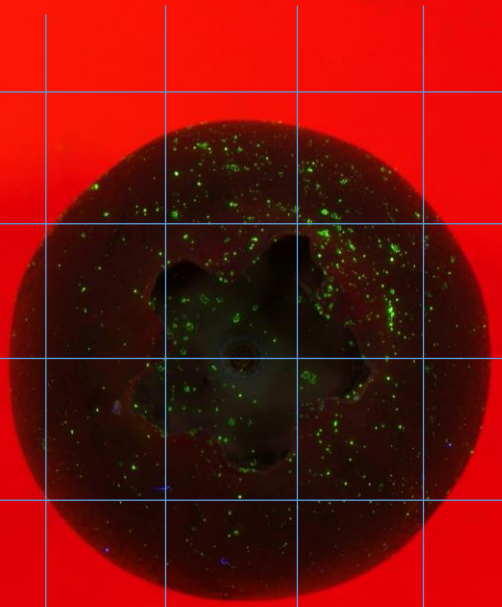
Variation in pigment deposition in a 12-leaf / 3-fruit batch (CV%)

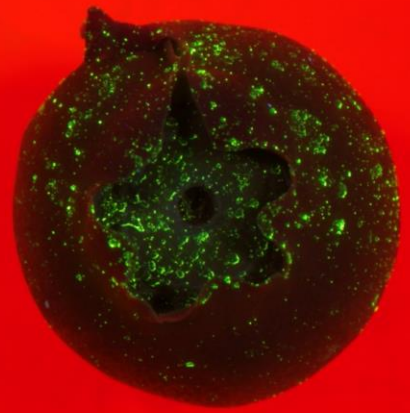


Deposition Uniformity

Variation in deposition on a target leaf/fruit
Interquartile range of distribution (ICD%)

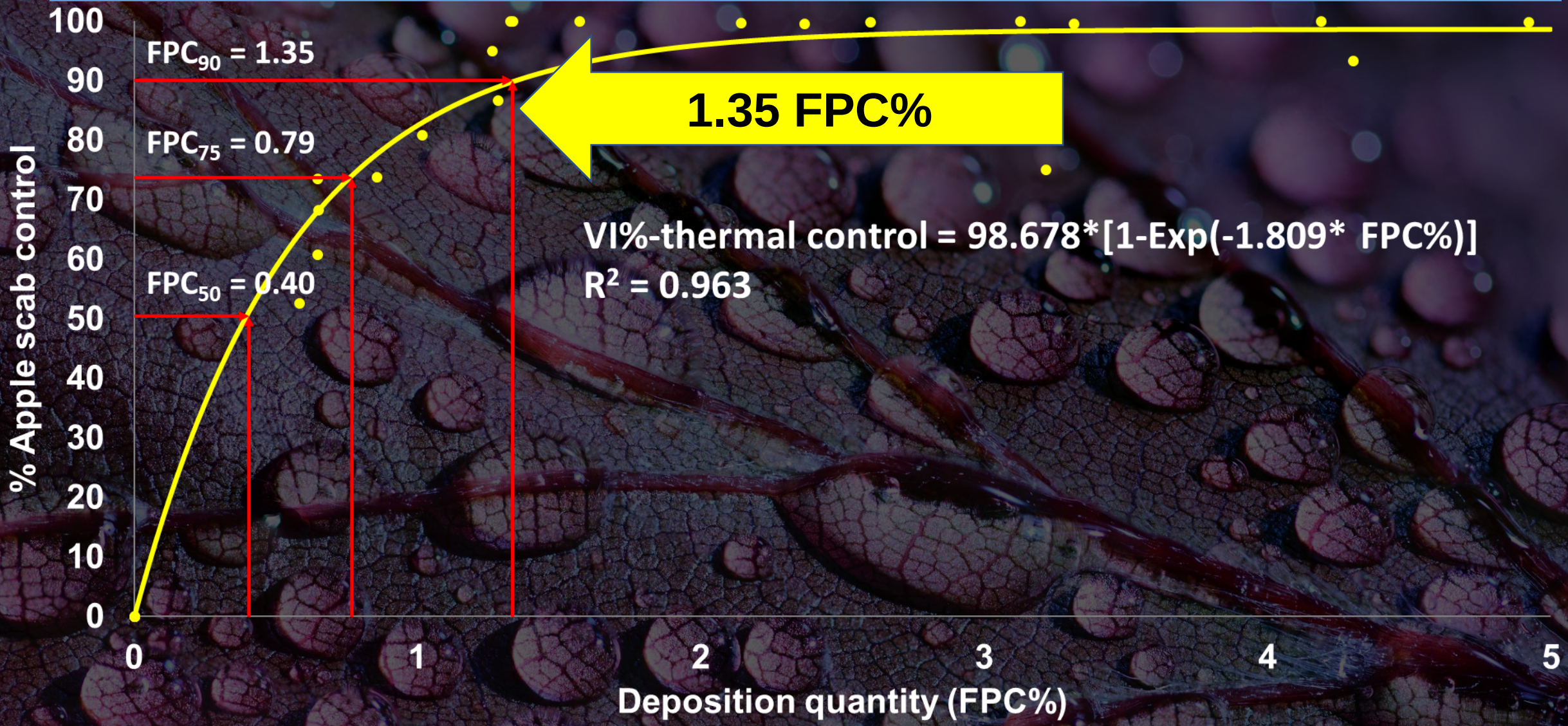




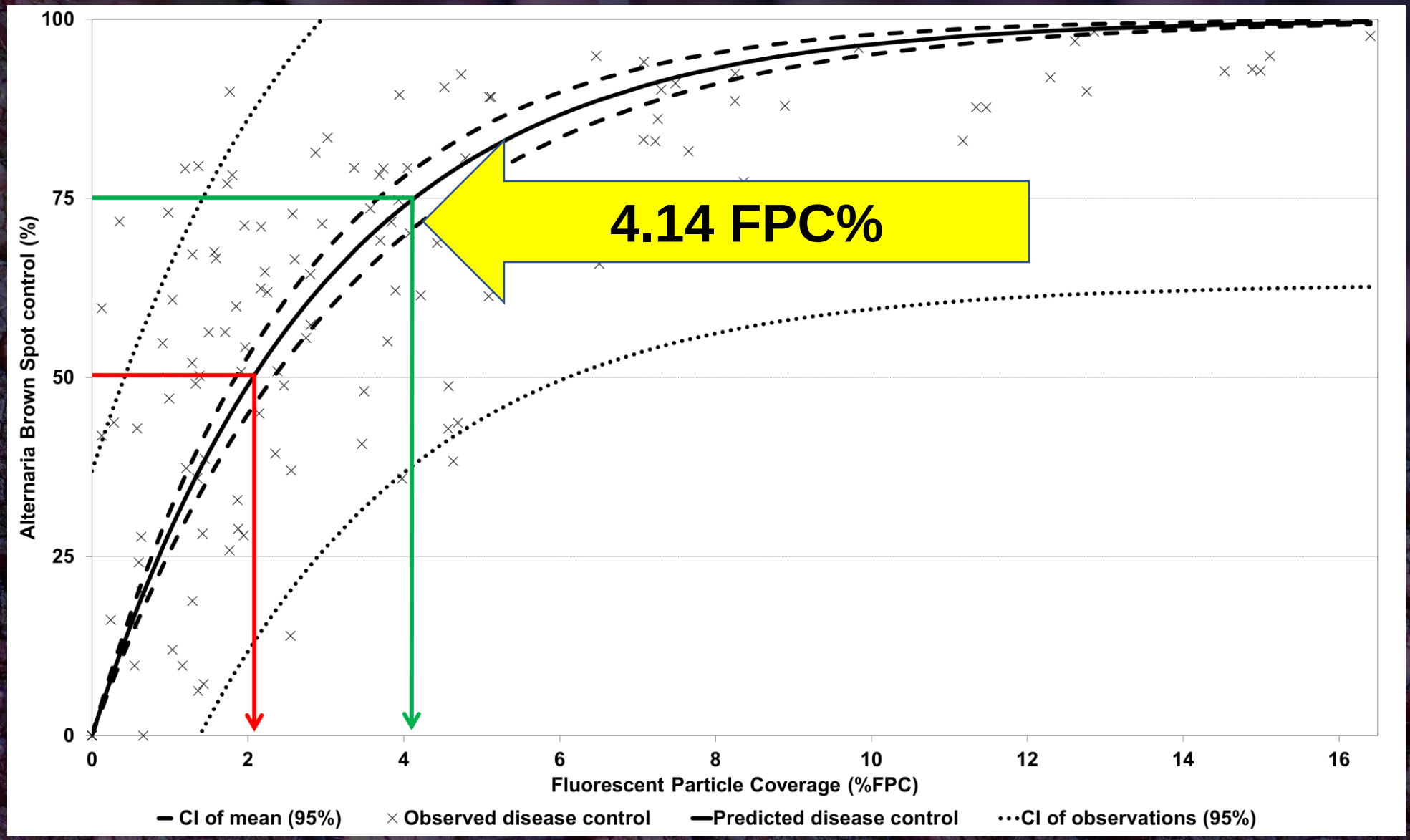


Deposition quality

Deposition benchmarks indicative of biological control - Mancozeb



Deposition benchmarks indicative of biological control – Copper oxychloride



July 2022 Study - Constant spray tank mix

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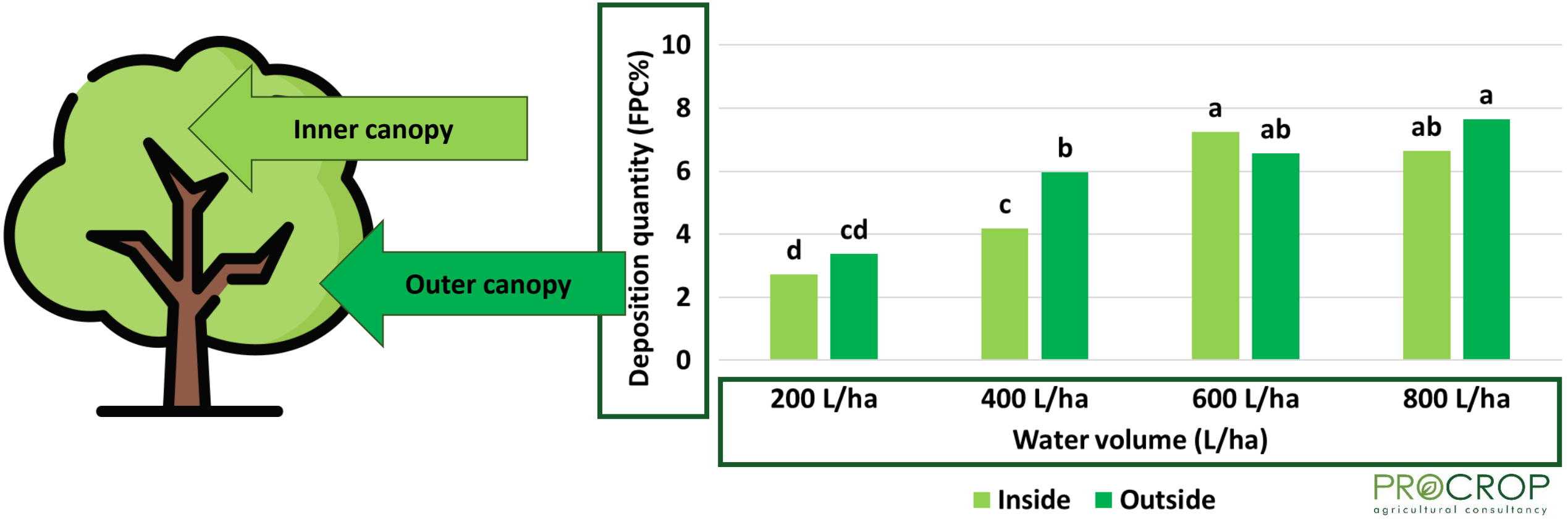
July 2022 Study – Leaves



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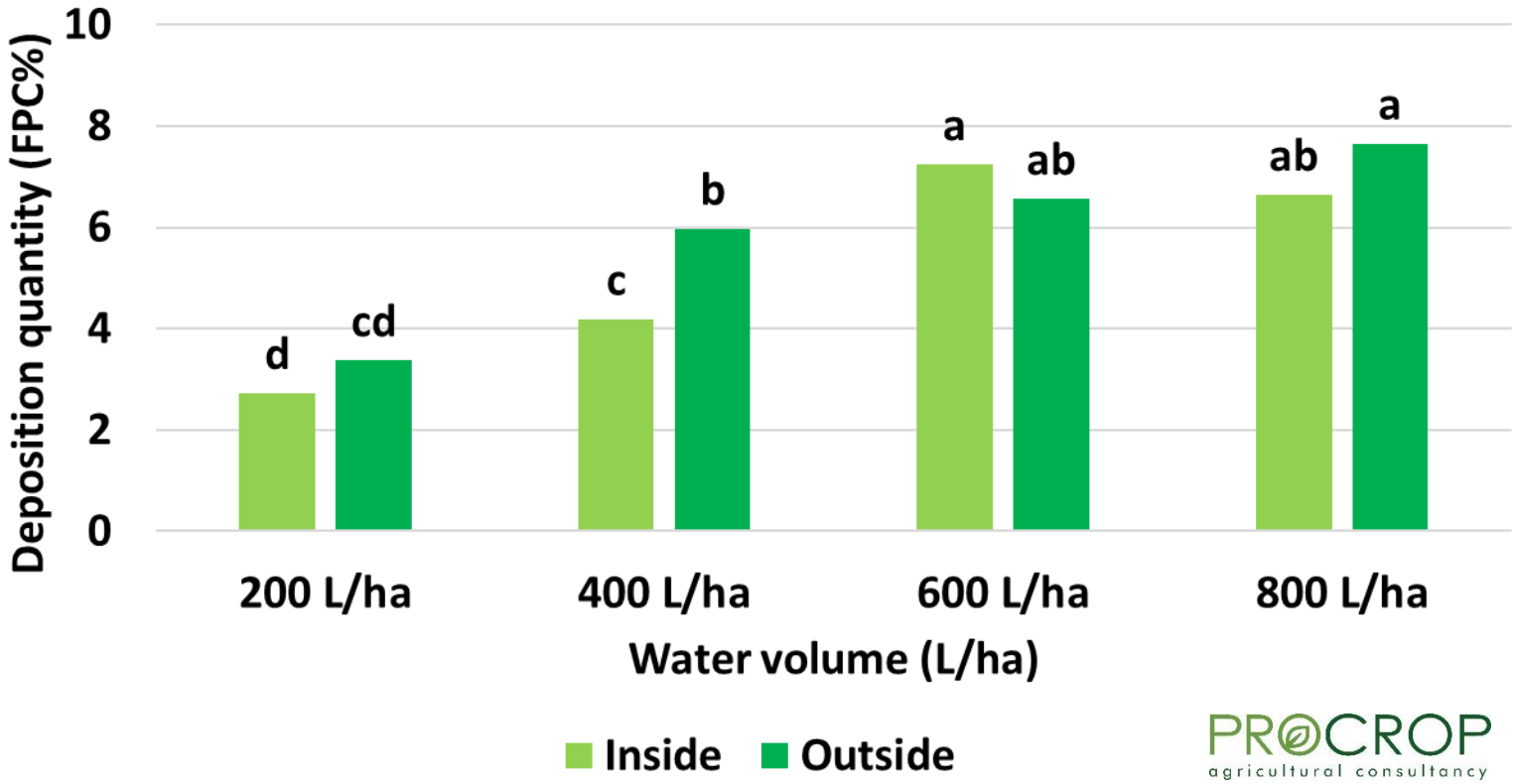
July 2022 Study – Leaves

- **Fluorescent pigment 200 ml/100 L used for all water volumes (2x)**



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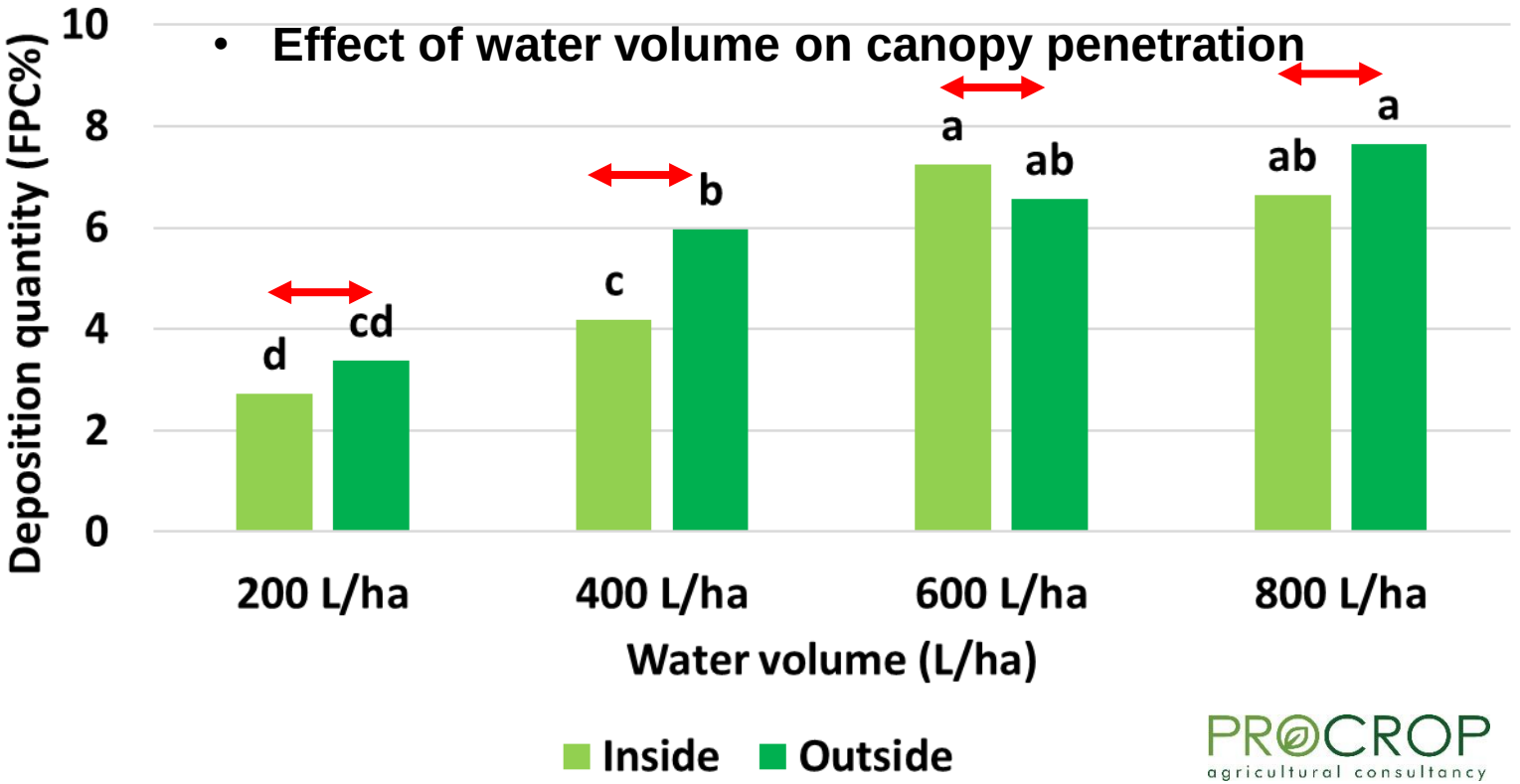
July 2022 Study – Leaves

- Canopy penetration was good for all water volumes sprayed
  - Statistically similar deposition inside vs outside canopy
    - Indicative of spray friendly canopies
    - Effect of water volume on canopy penetration



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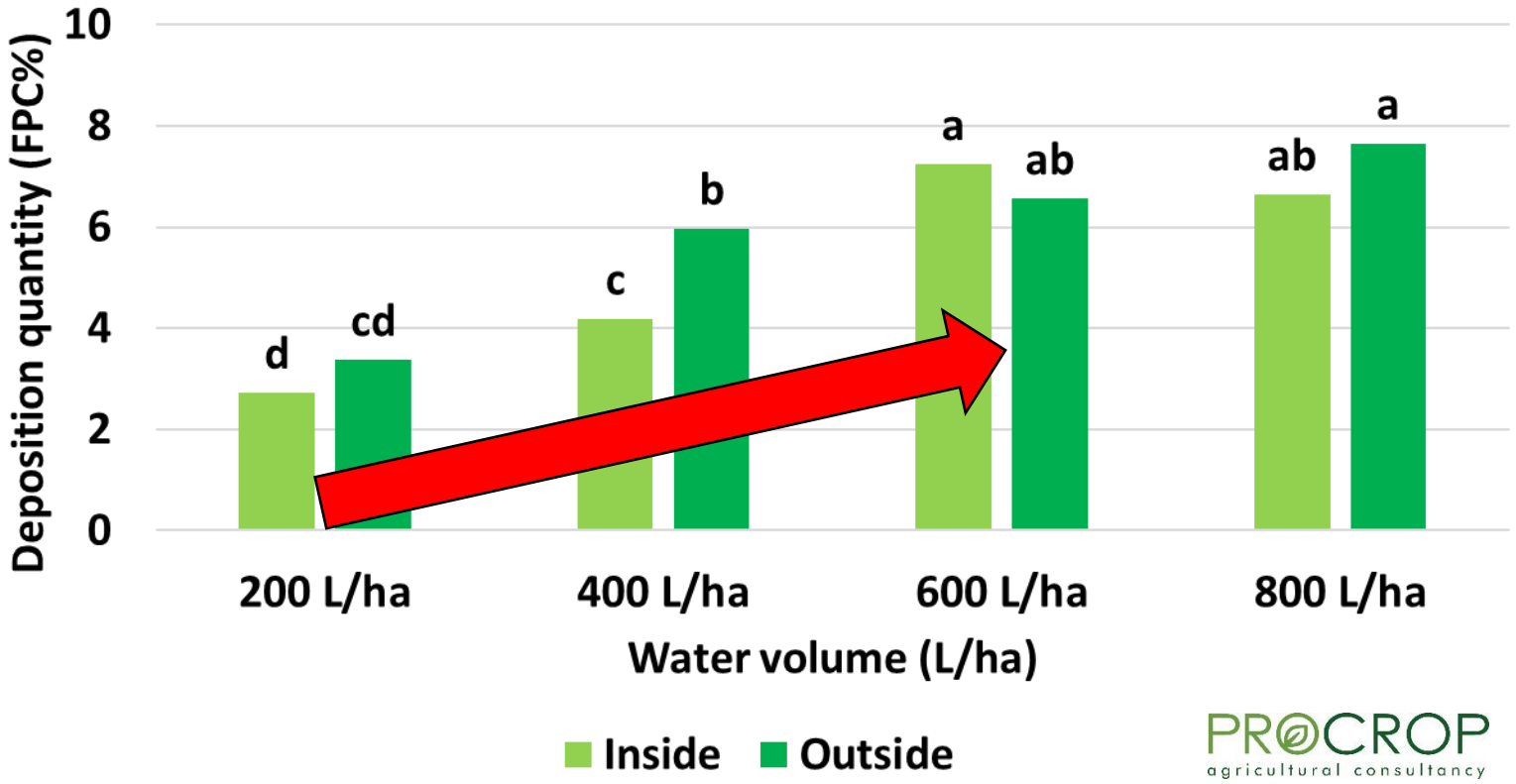
July 2022 Study – Leaves

- **Linear increase in deposition quantity (FPC%) 200 to 600 L/ha**



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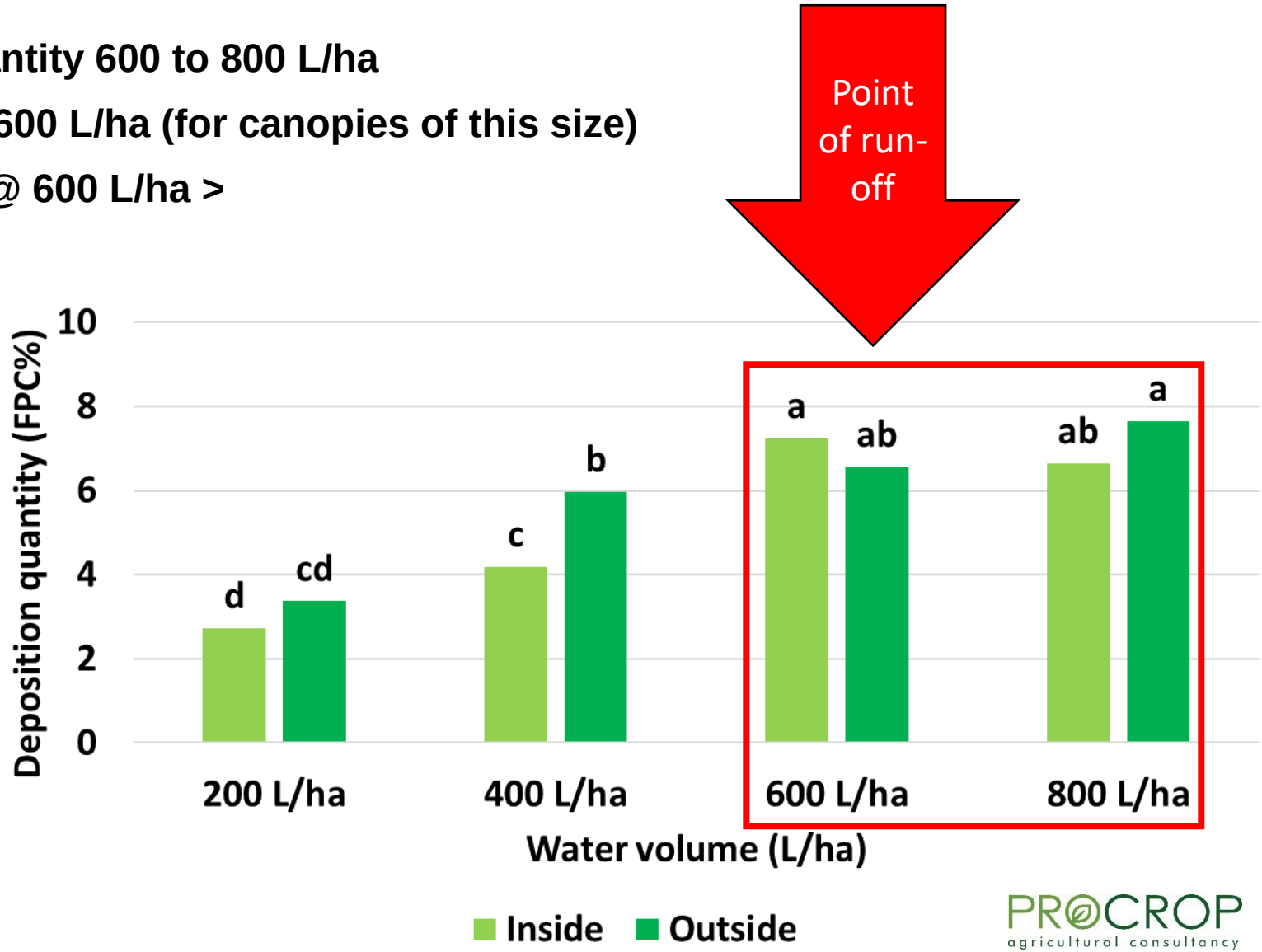
July 2022 Study – Leaves

- **Statistically similar deposition quantity 600 to 800 L/ha**
- **Indicative of spray run-off around 600 L/ha (for canopies of this size)**
- **Run-off visually visible on leaves @ 600 L/ha >**



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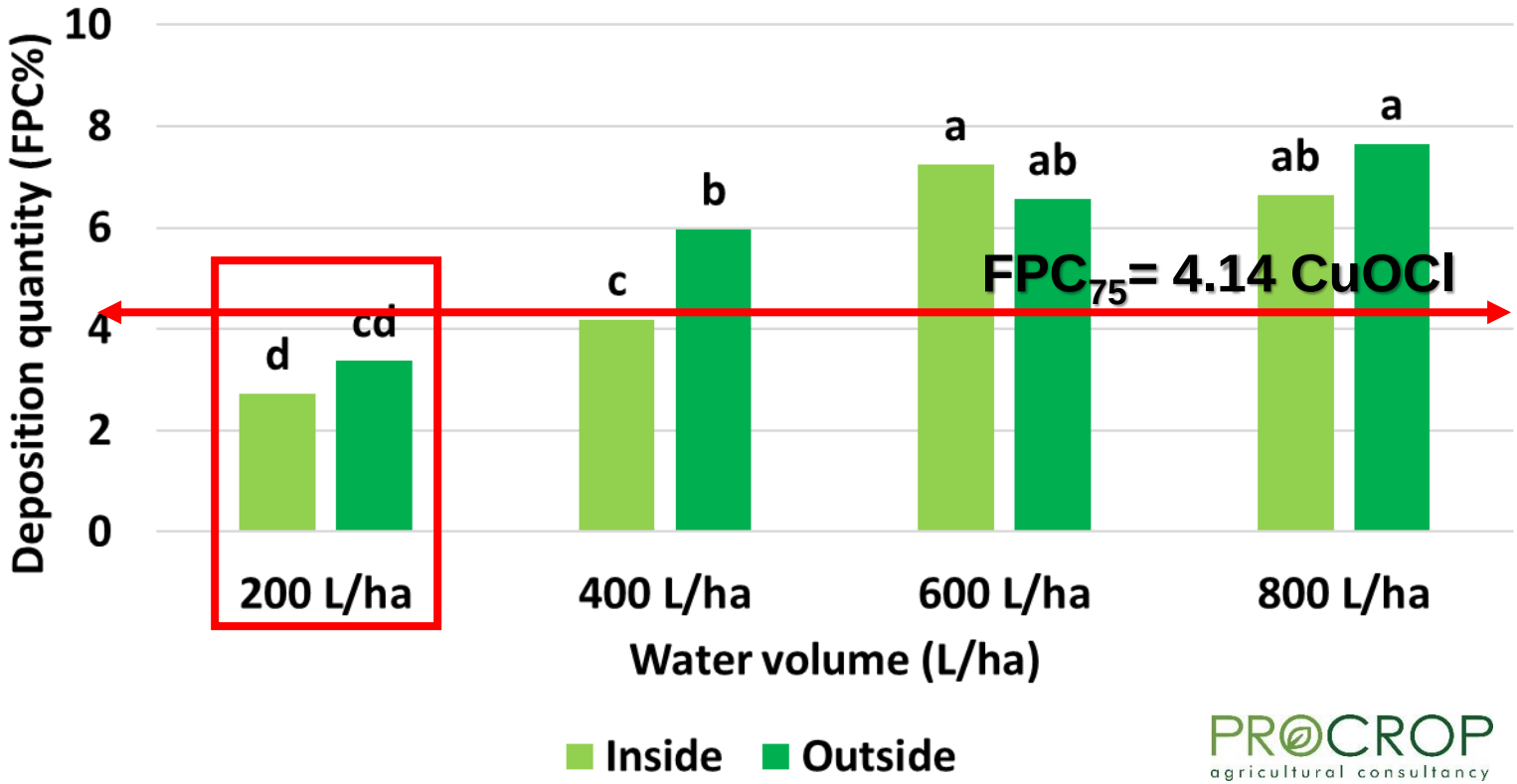
July 2022 Study – Leaves

- **200 L/ha realised deposition quantity below FPC_{75} benchmark (4.14 FPC%)**



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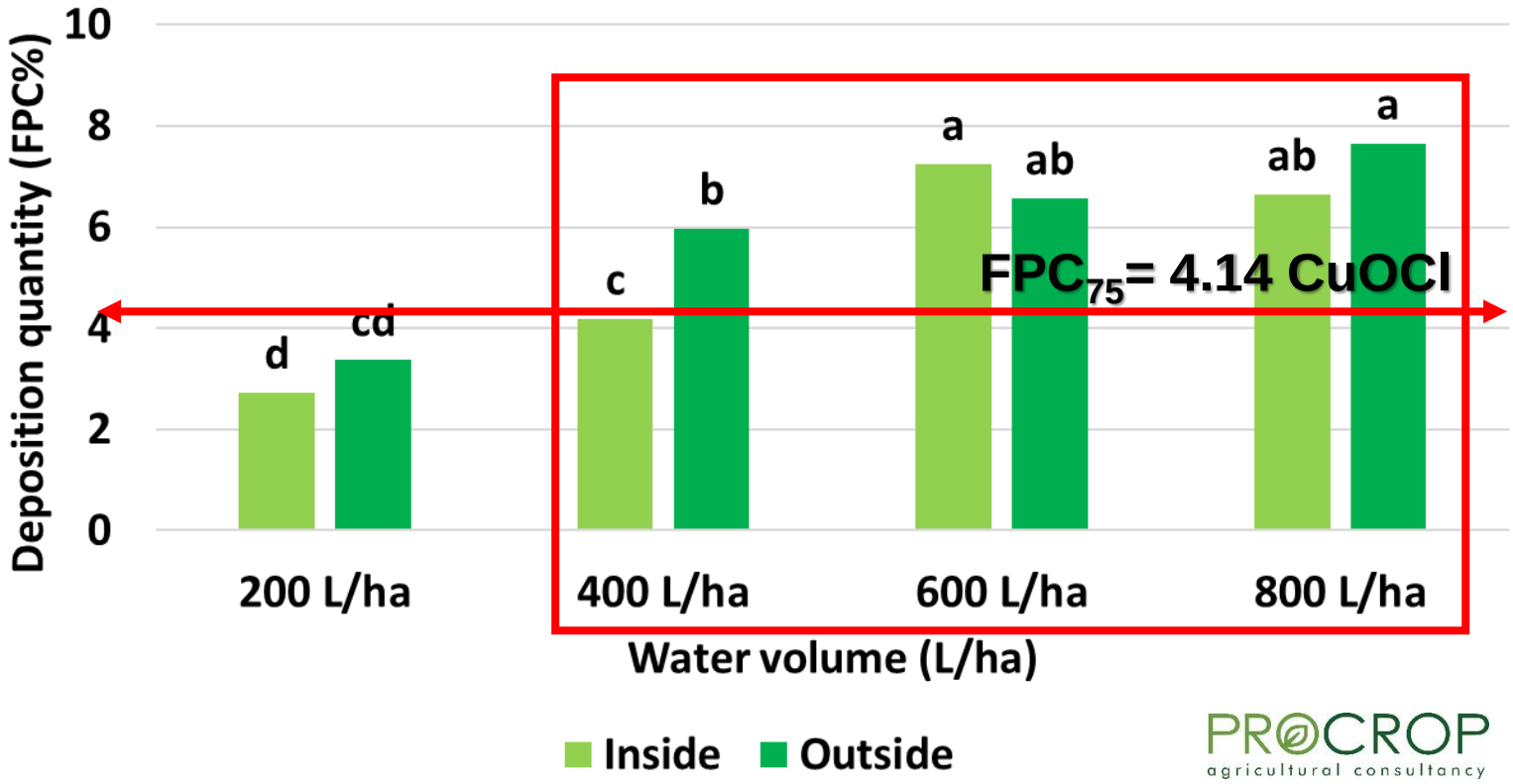
July 2022 Study – Leaves

- **400 L/ha > deposition quantity above FPC_{75} benchmark**



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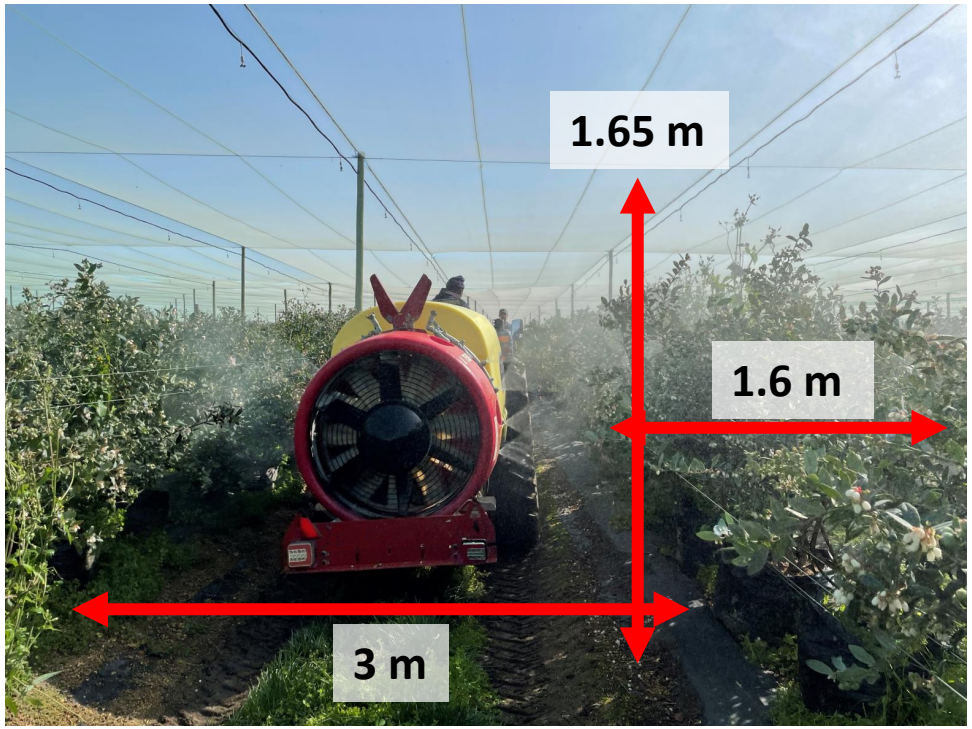
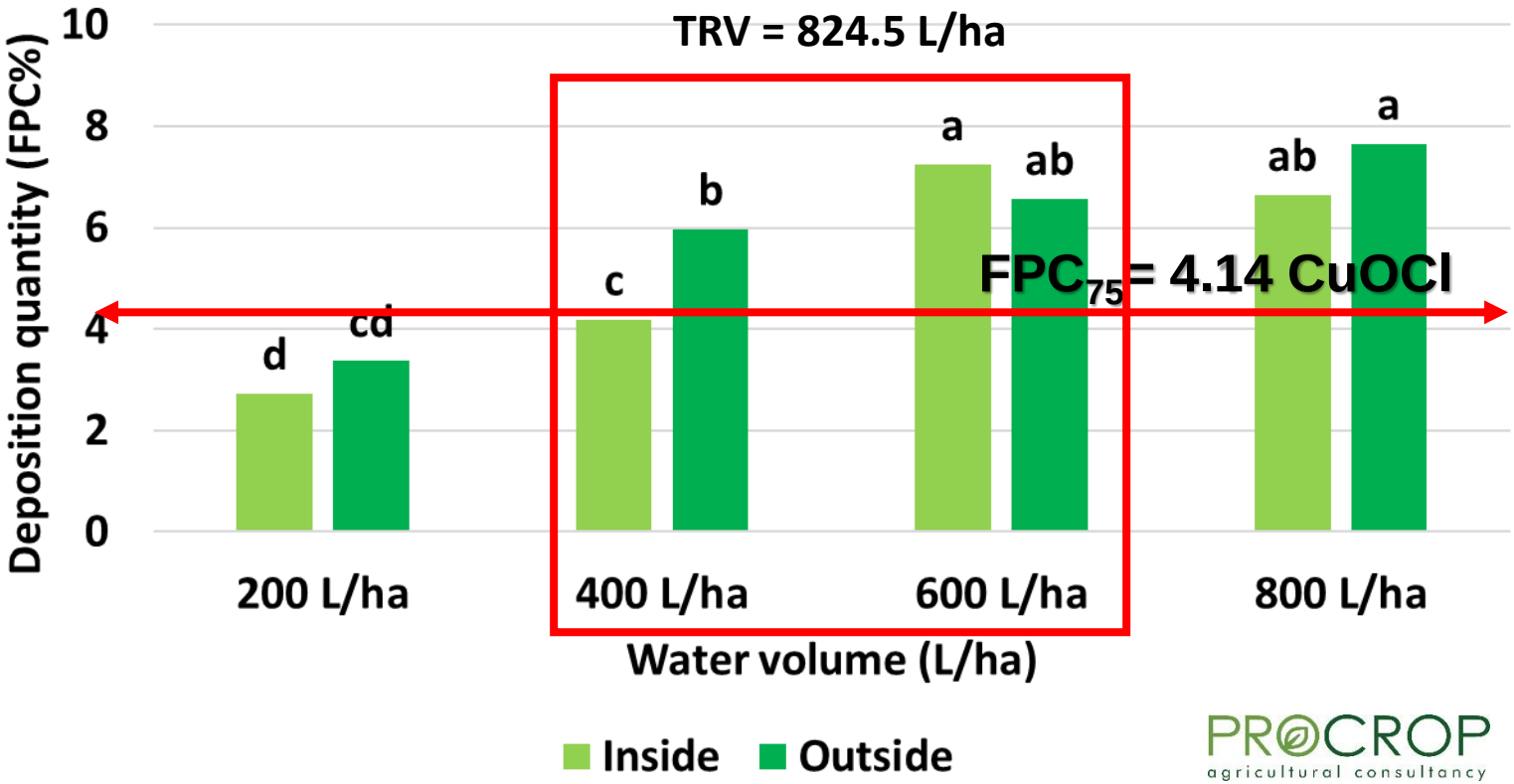
July 2022 Study – Leaves

- For a canopy of 824.5 L/ha TRV a spray volume of 400 L/ha to 600 L/ha looks promising
- Sufficient number of droplets 400 L/ha >
- 800 L/ha = run-off
- Influence of spray concentration?





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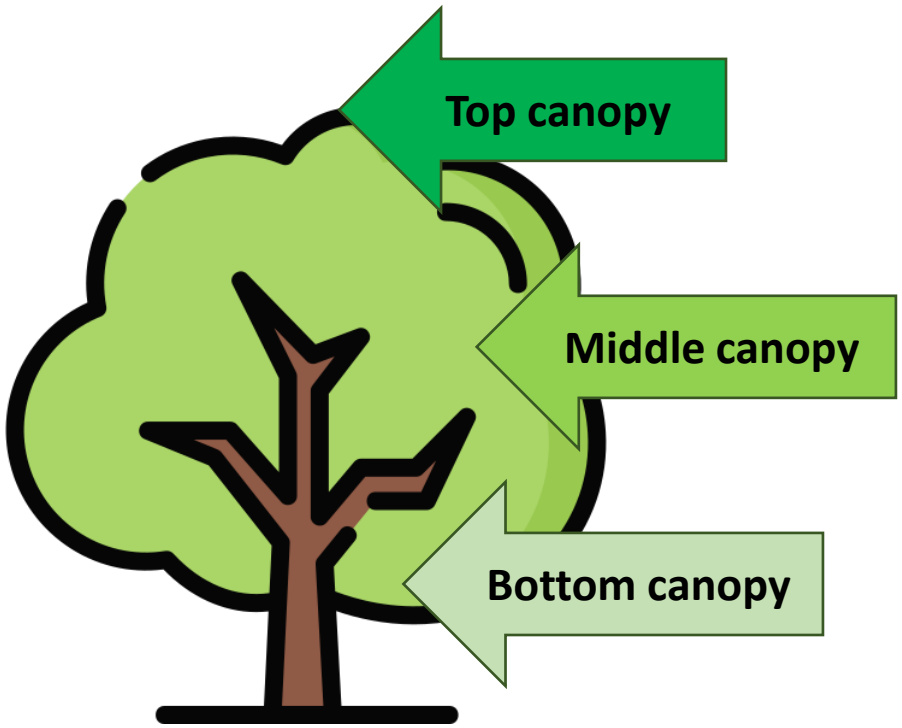
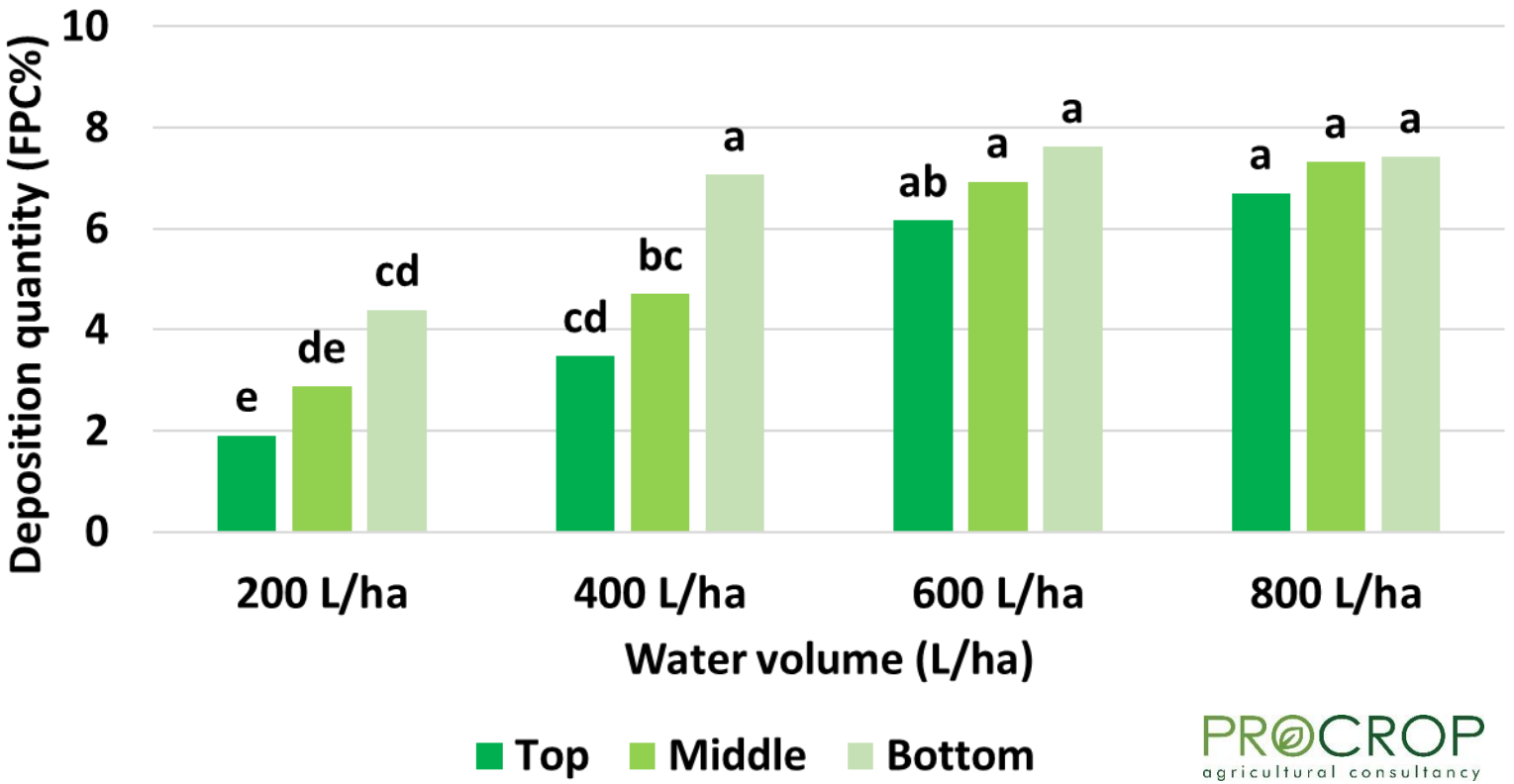
July 2022 Study – Leaves





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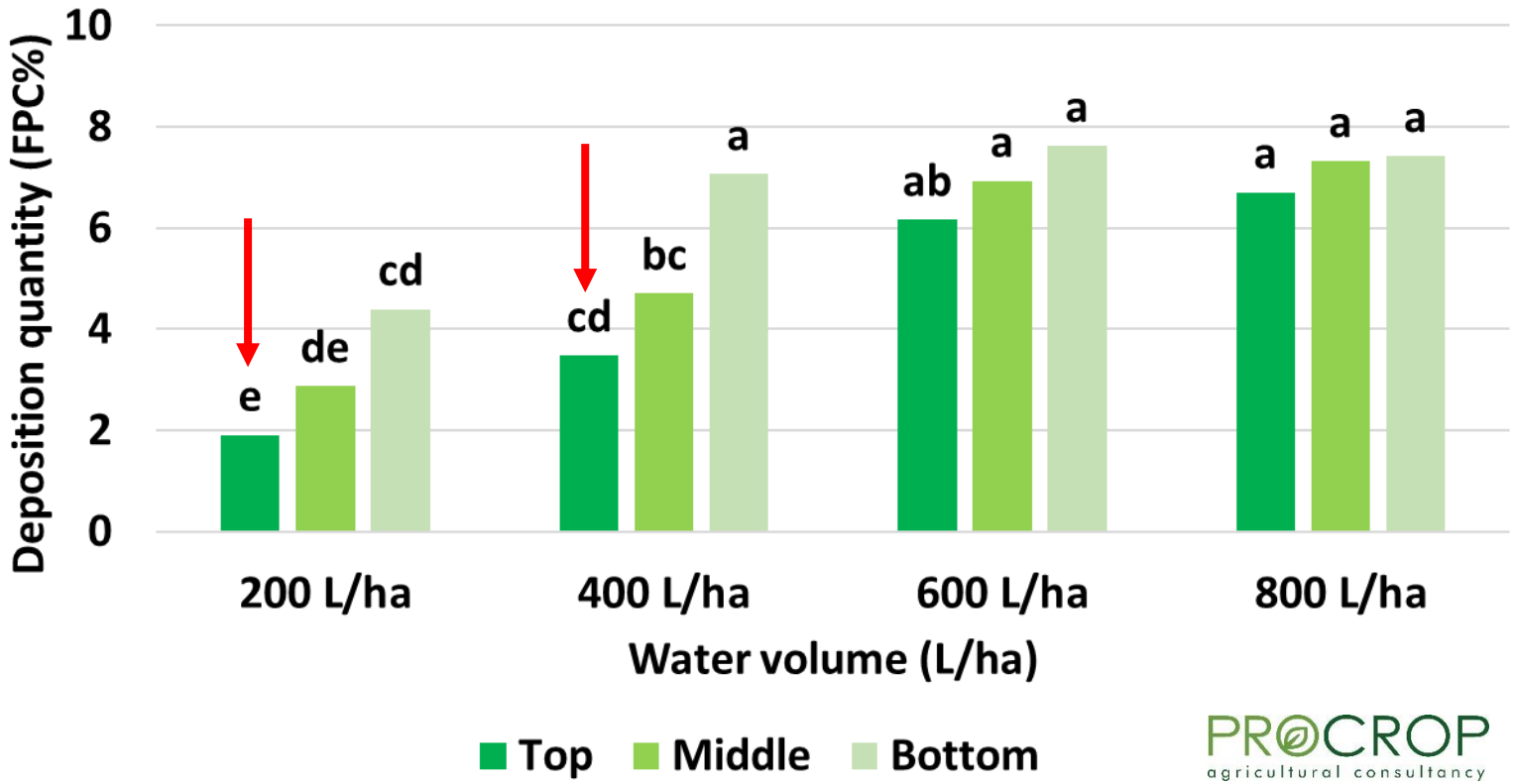
July 2022 Study – Leaves

- **Lower deposition quantity observed on top canopy leaves at 200 and 400 L/ha**
  - **Can possibly be mitigated through nozzle selection**
  - **More droplets projected to top of canopy**



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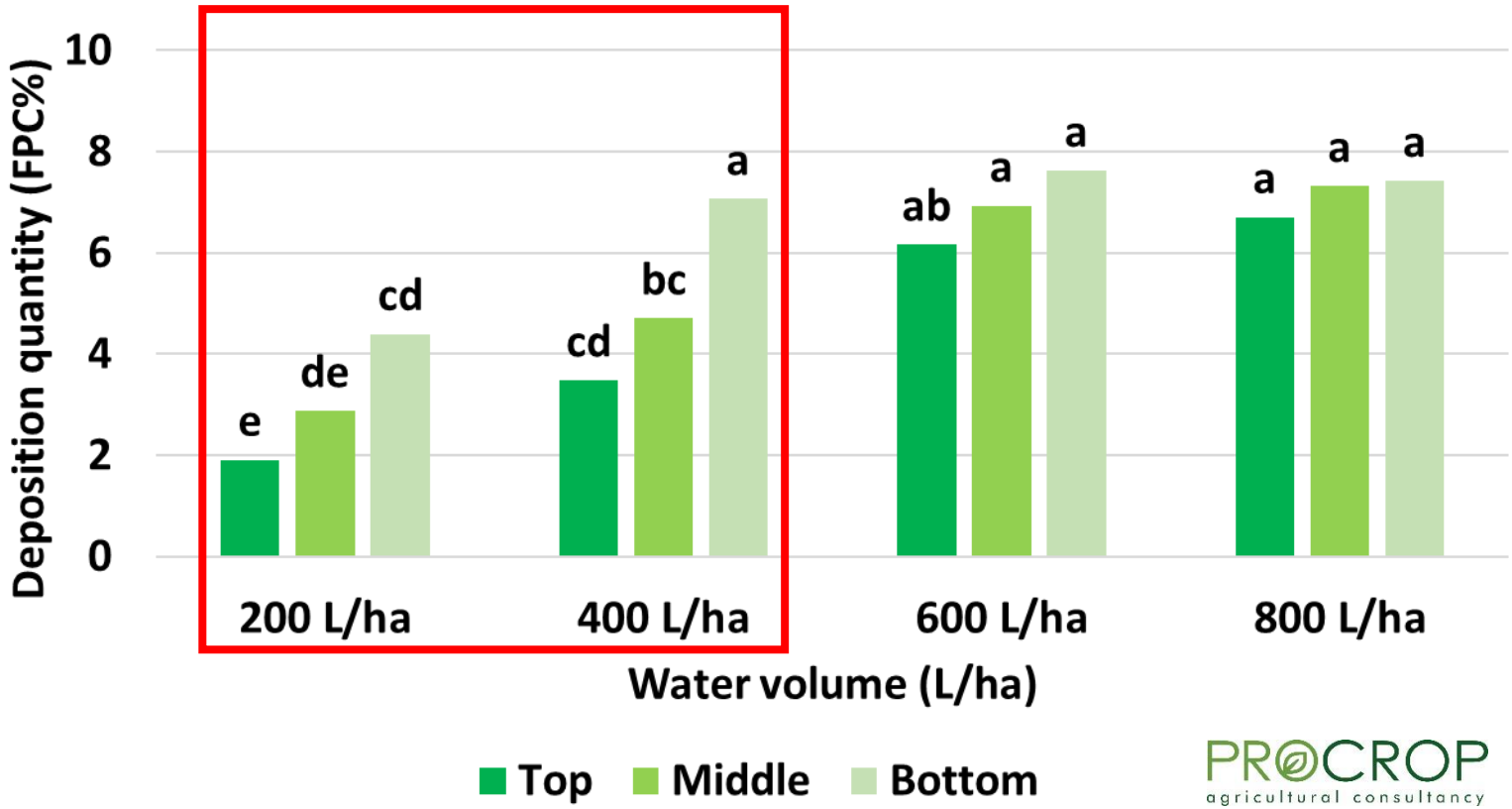
July 2022 Study – Leaves

- **Not enough droplets**



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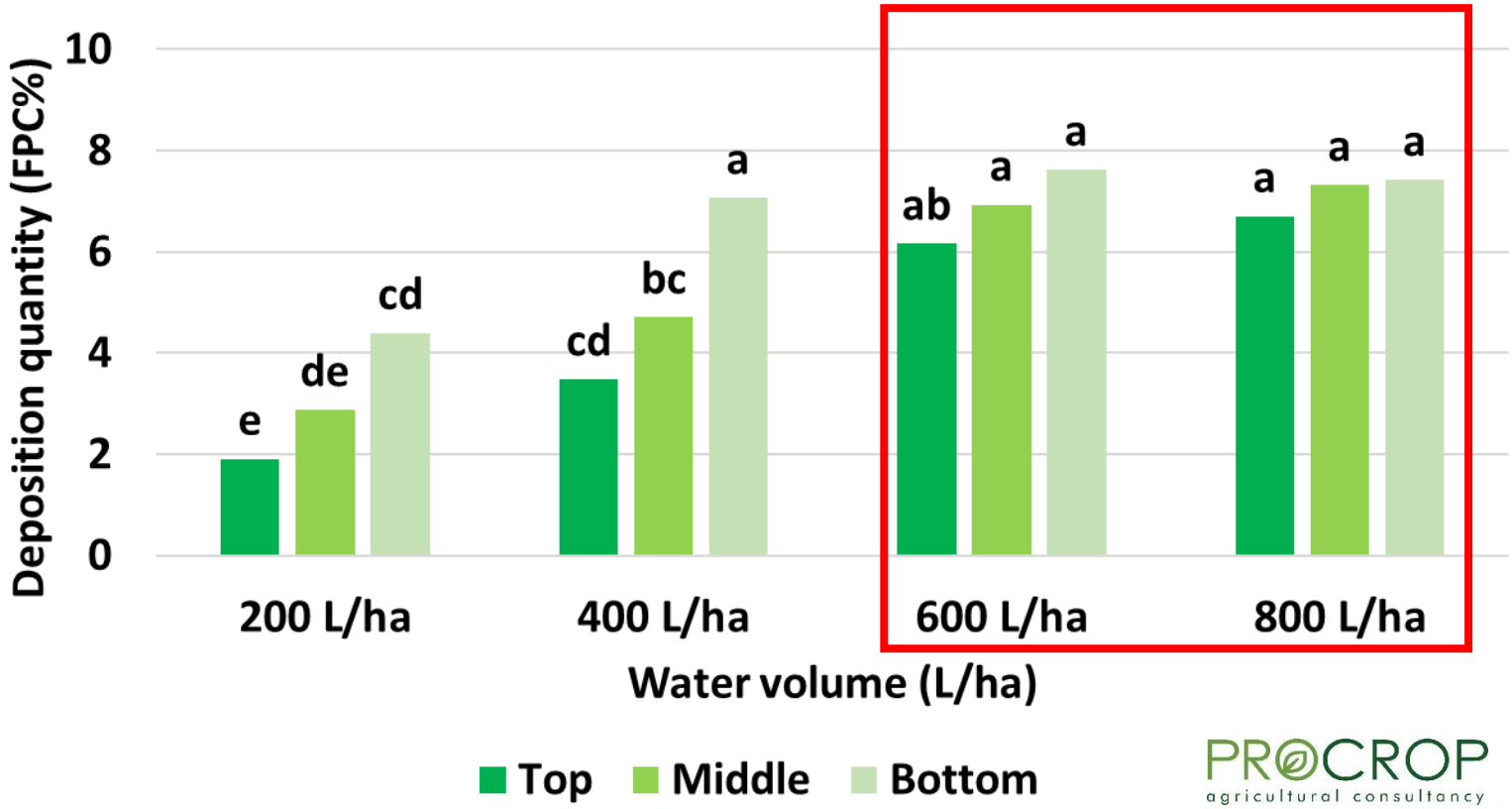
July 2022 Study – Leaves

- **Run-off**



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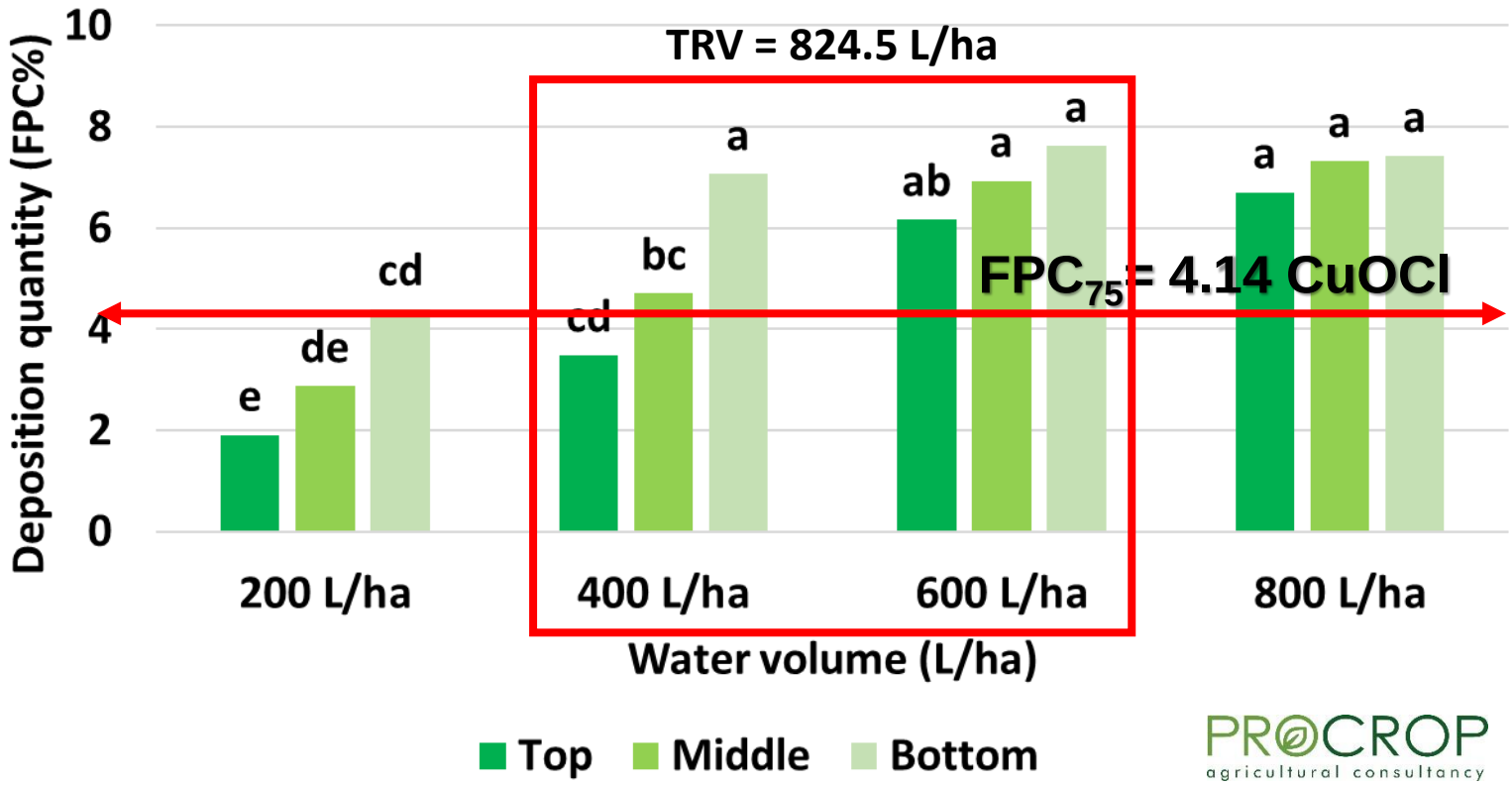
July 2022 Study – Leaves

- **Spray volume “sweet spot” indicated to be between 400 – 600 L/ha**



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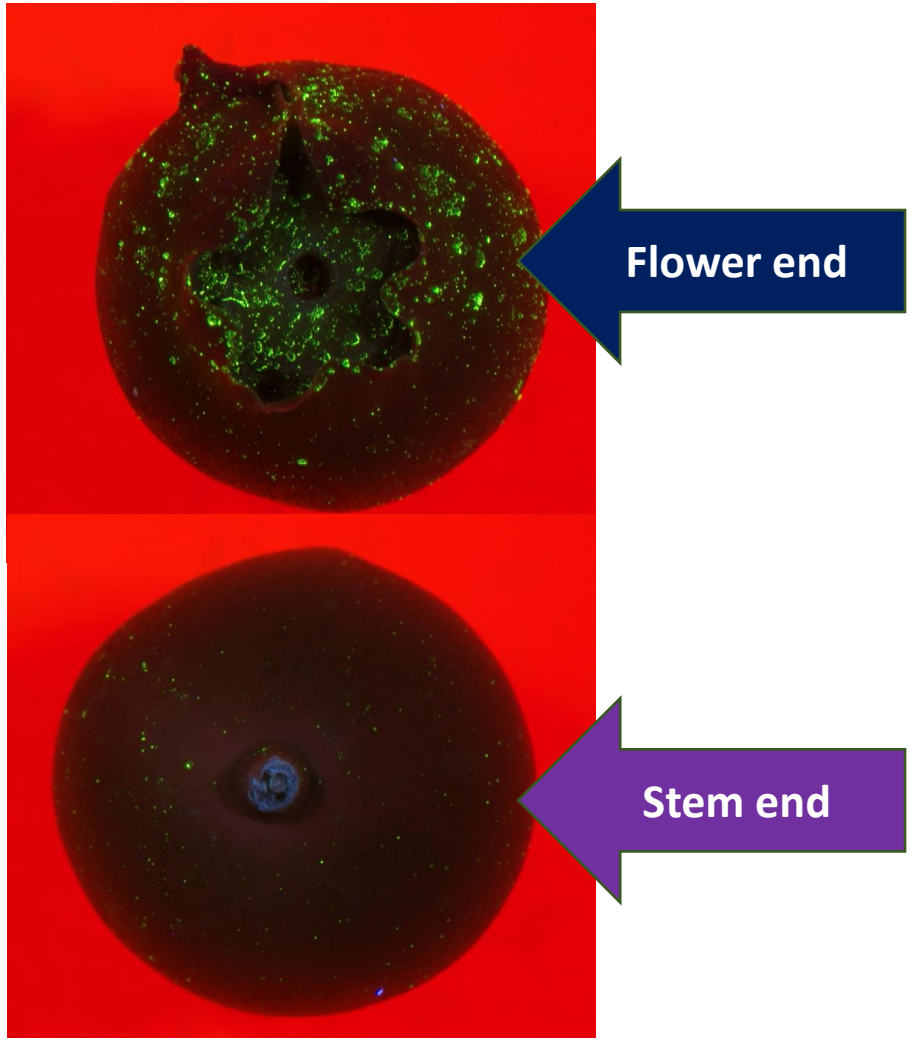
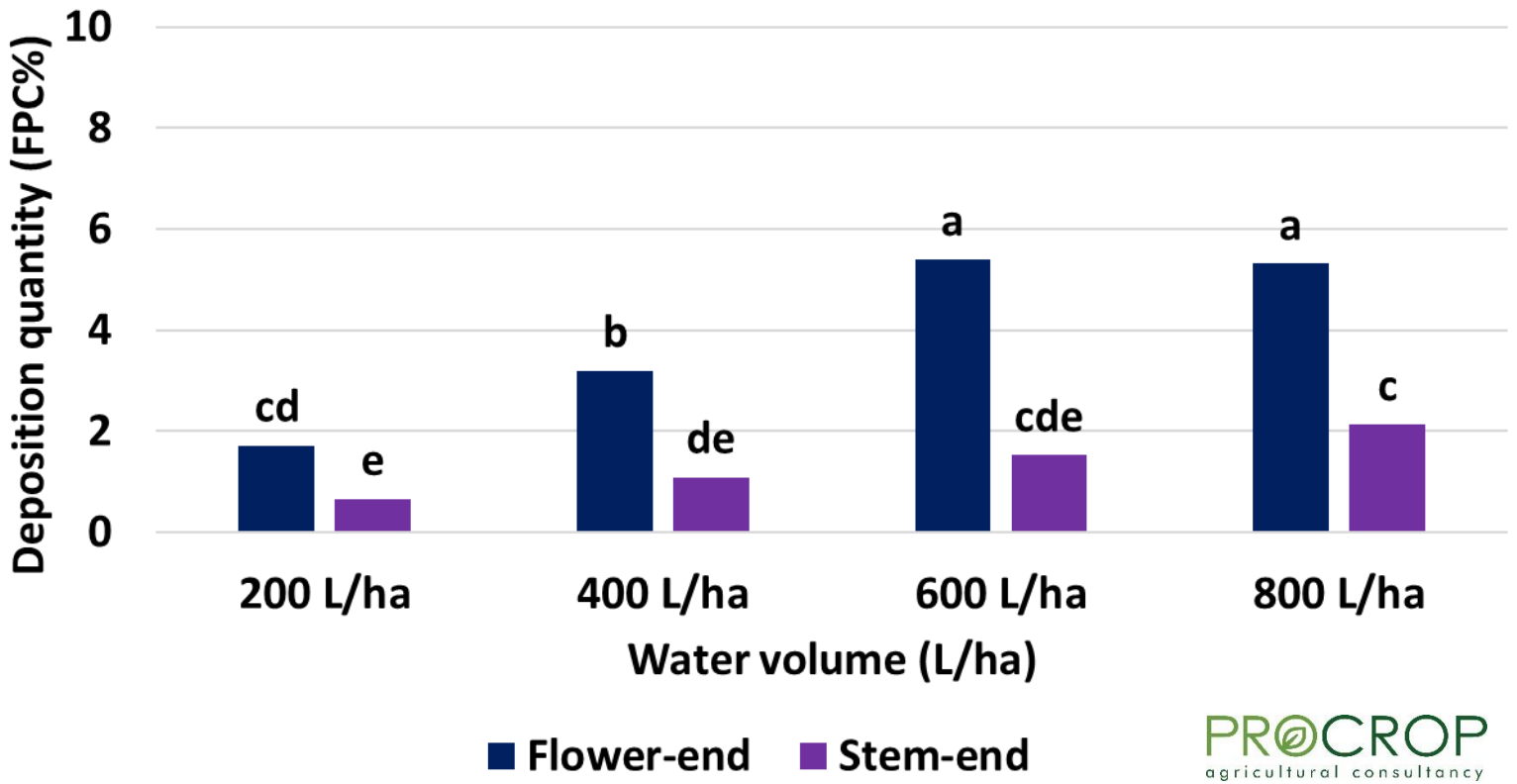
July 2022 Study – Berries





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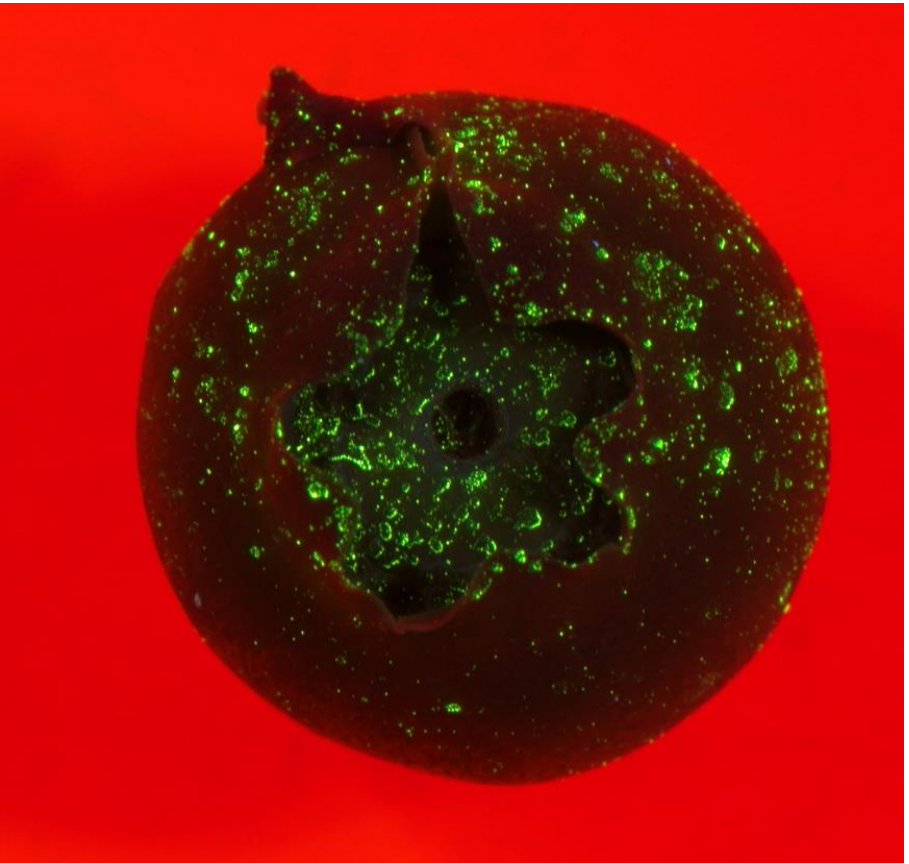
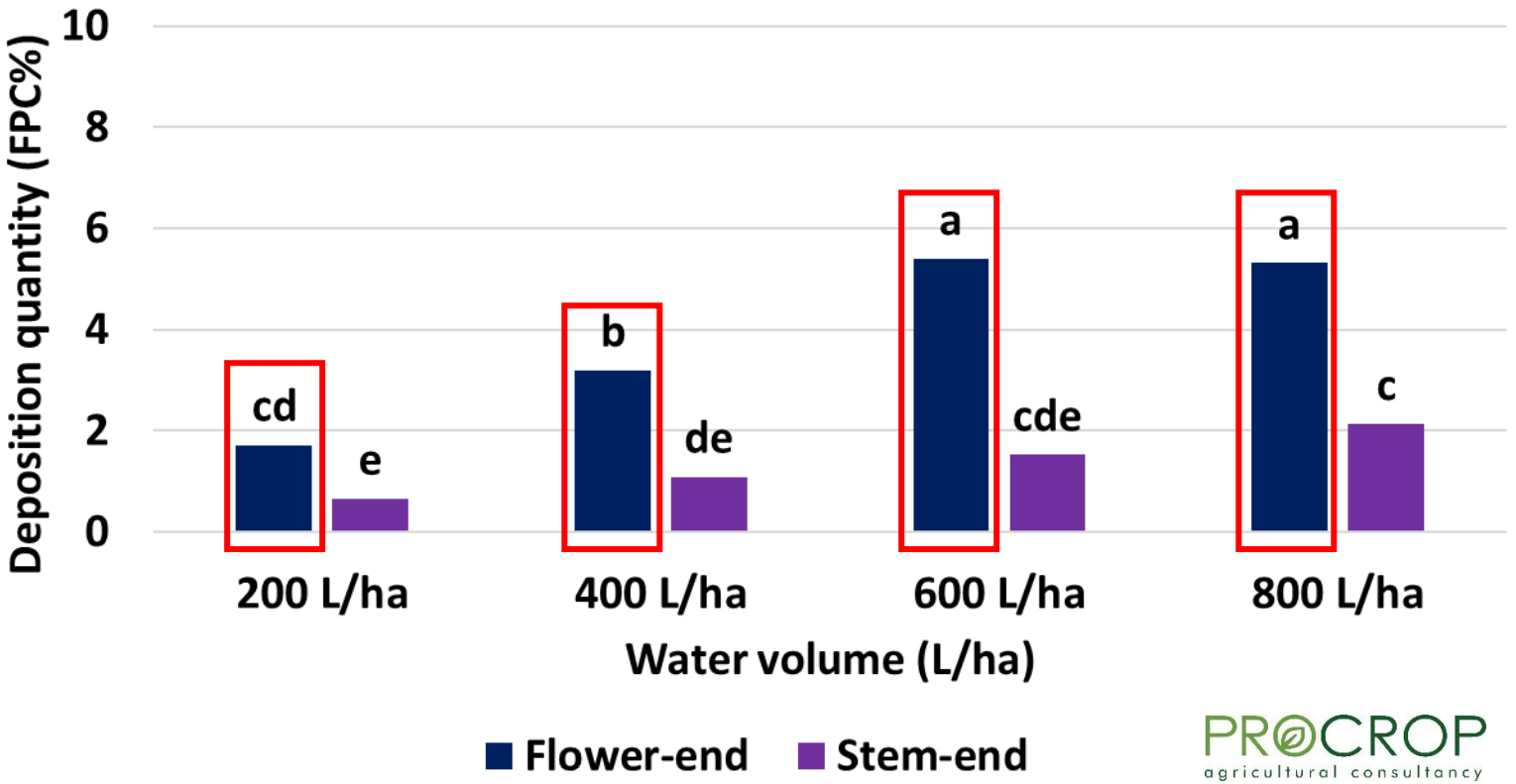
July 2022 Study – Berries

- **Deposition quantity significantly higher on flower end than on stem end**
  - **Flower ends more direct flight path of carried droplets**





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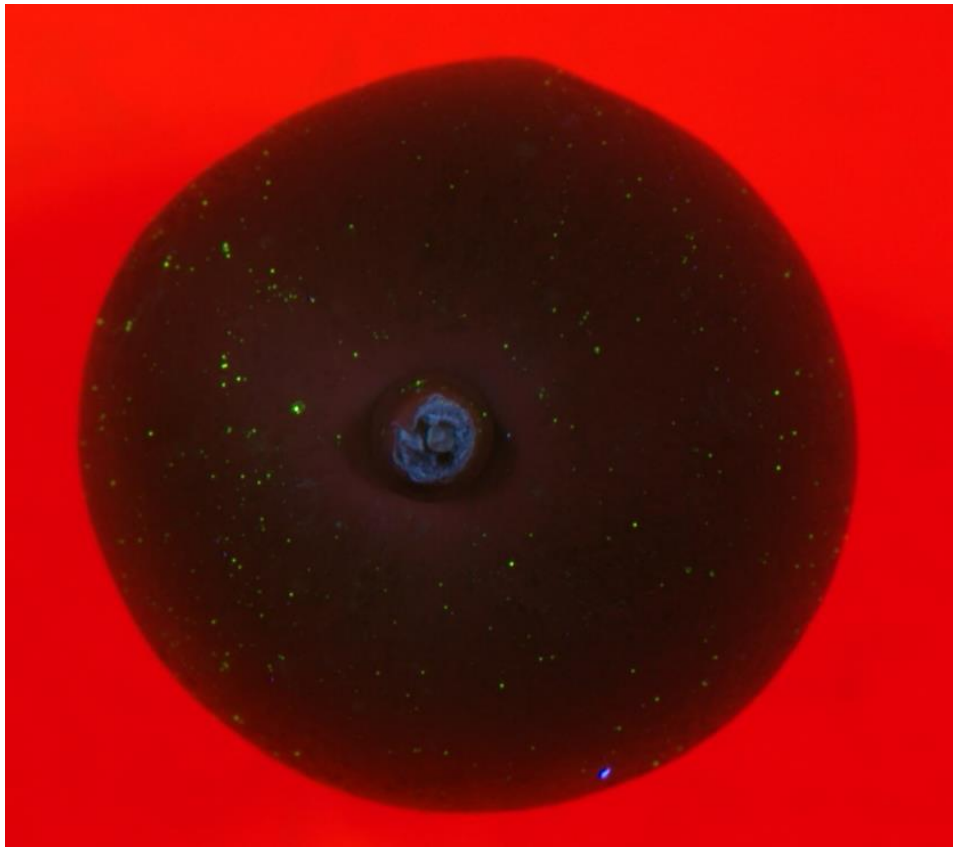
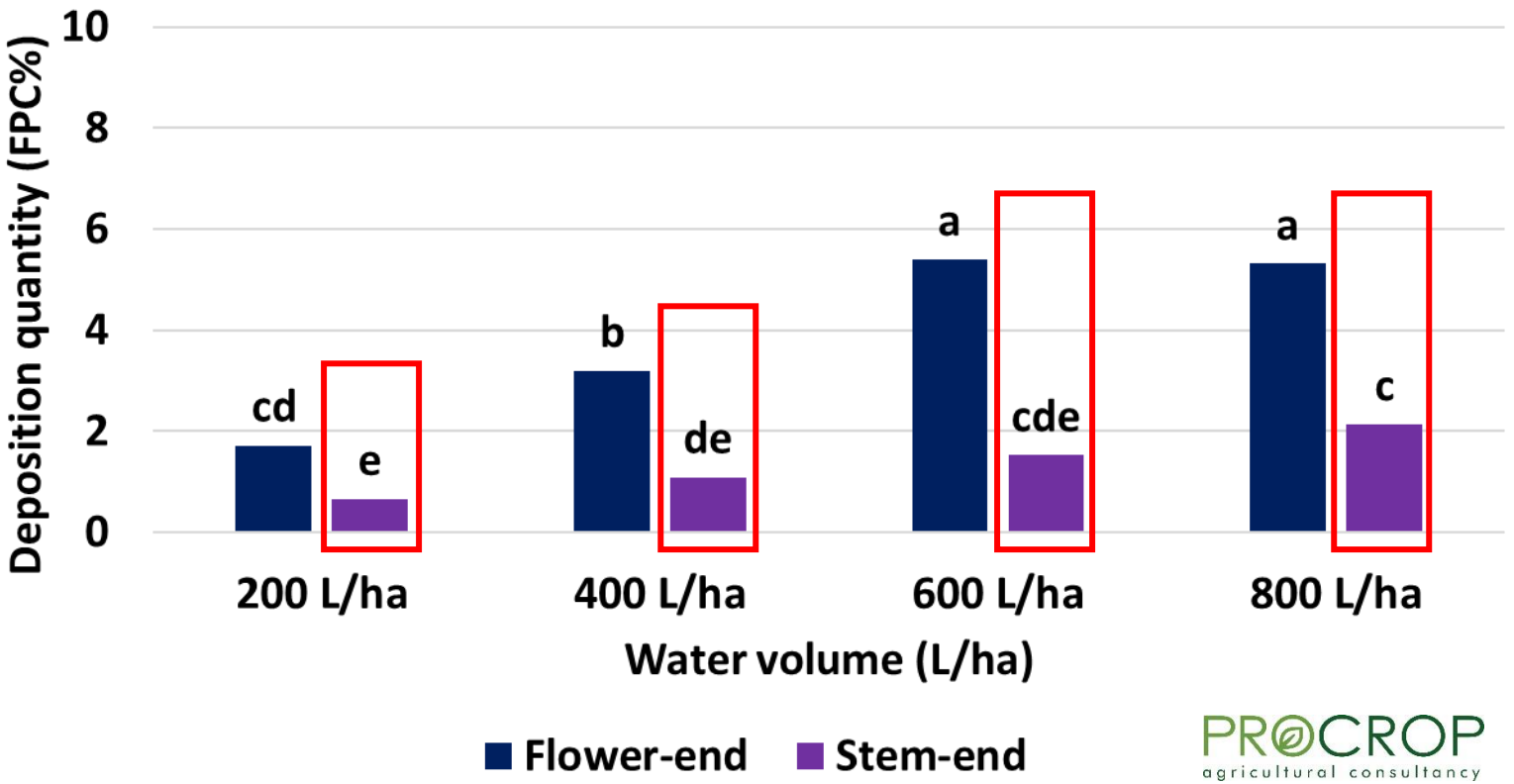
July 2022 Study – Berries

- Stem end obscure targets
  - Droplets not readily reaching the target
  - Higher water volume did not improve deposition quantity at stem end





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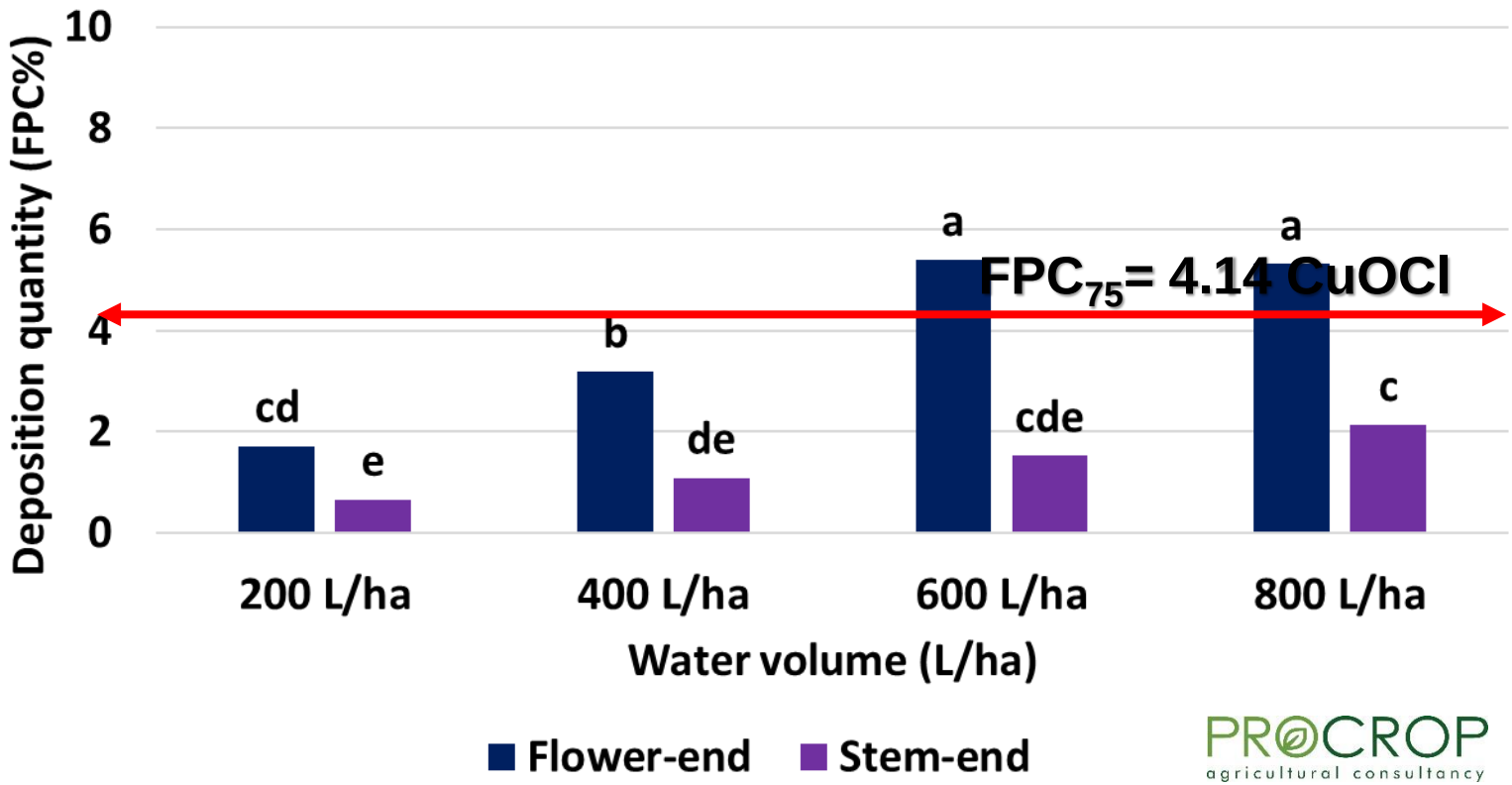
July 2022 Study – Berries

- **Only at water volumes 600 L/ha > deposition sufficient (above FPC_{75} benchmark)**
  - **Only on flower end**
  - **Deposition on stem ends below FPC75 benchmark**
  - **Stem-ends prone to wounding**
  - **Opportunistic infection sites**



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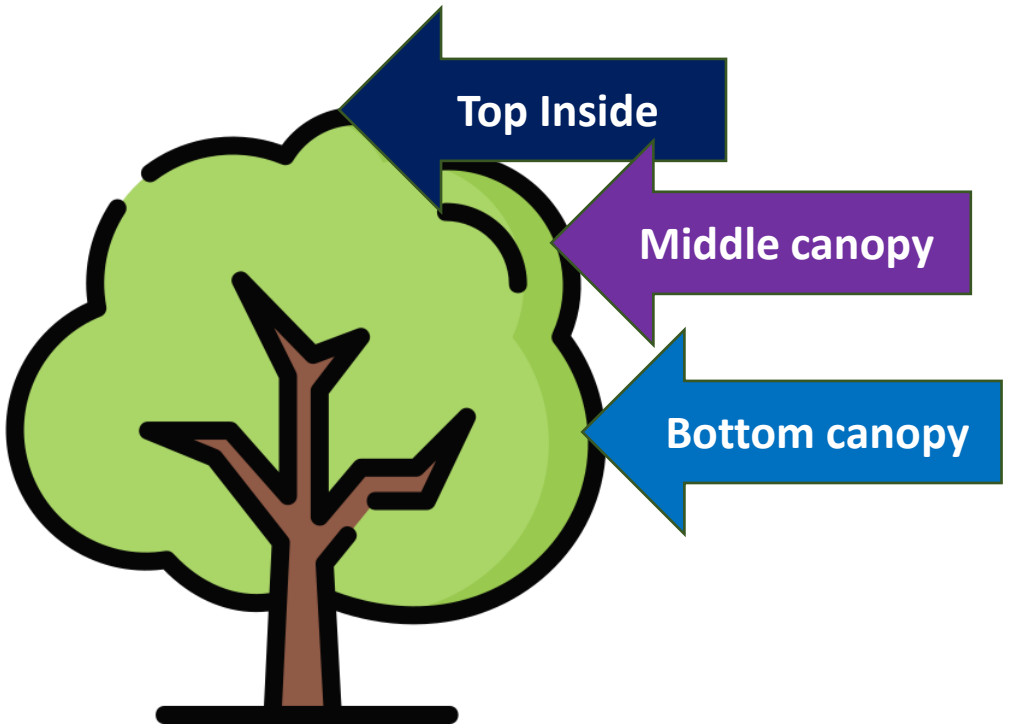
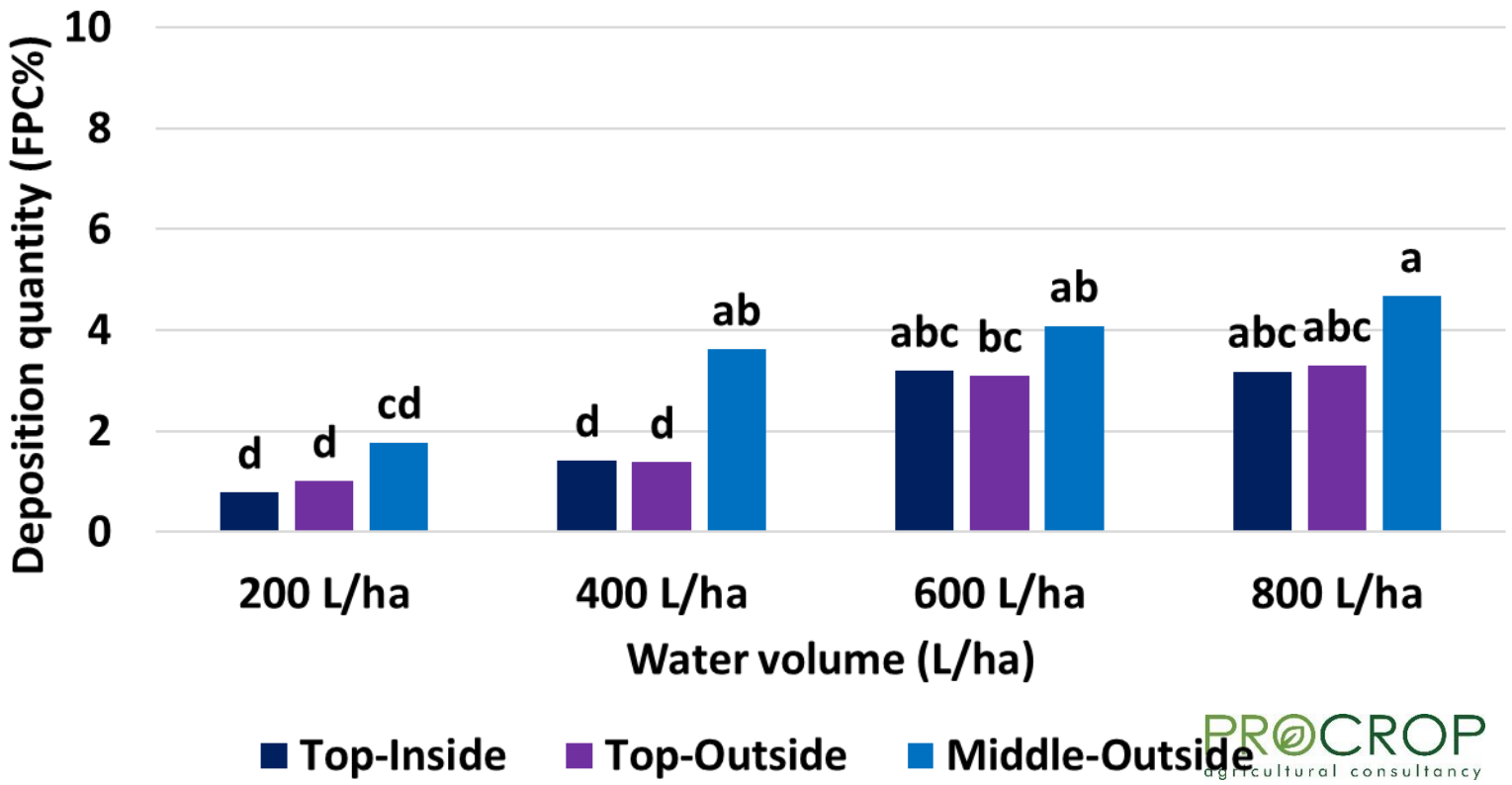
July 2022 Study – Berries





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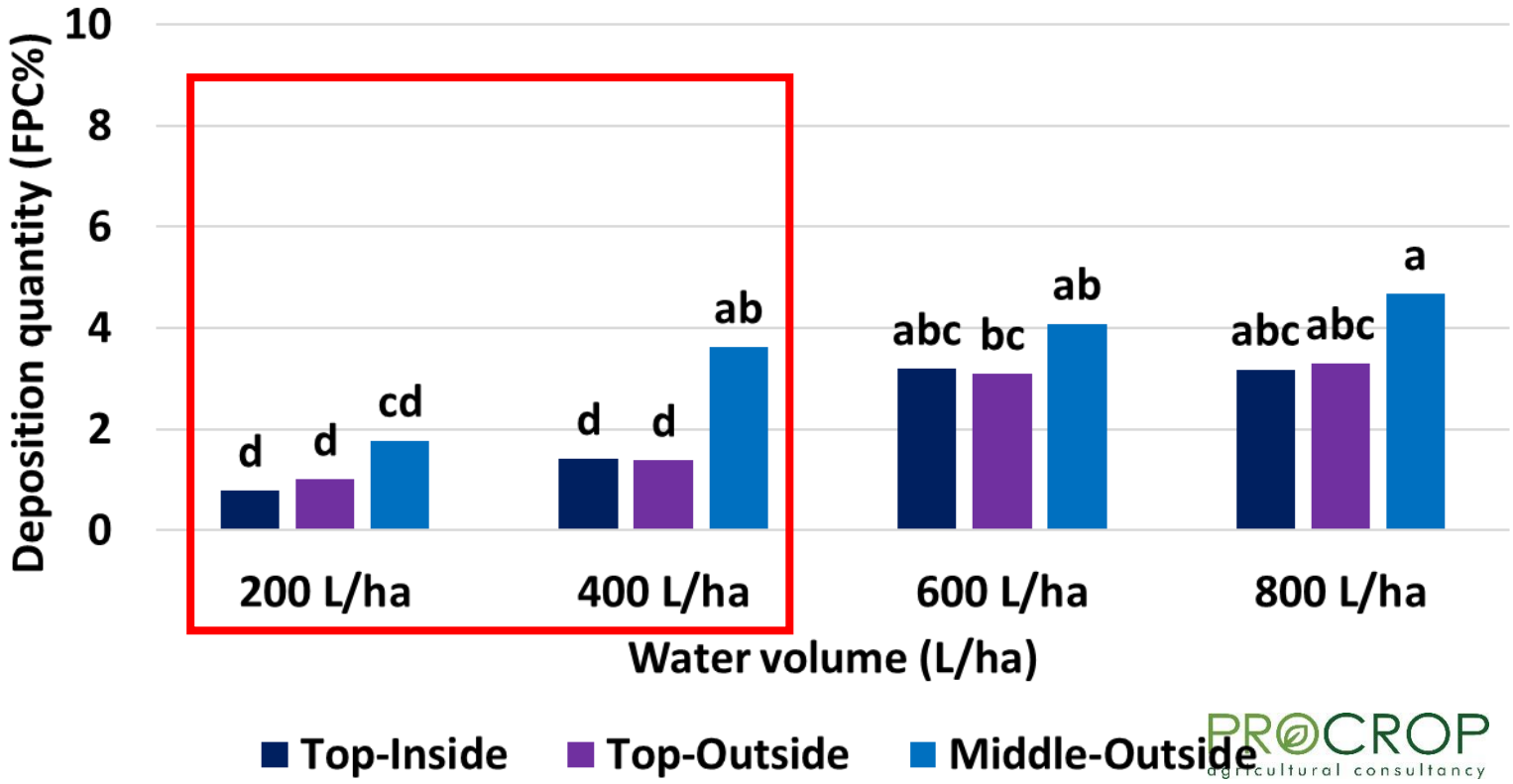
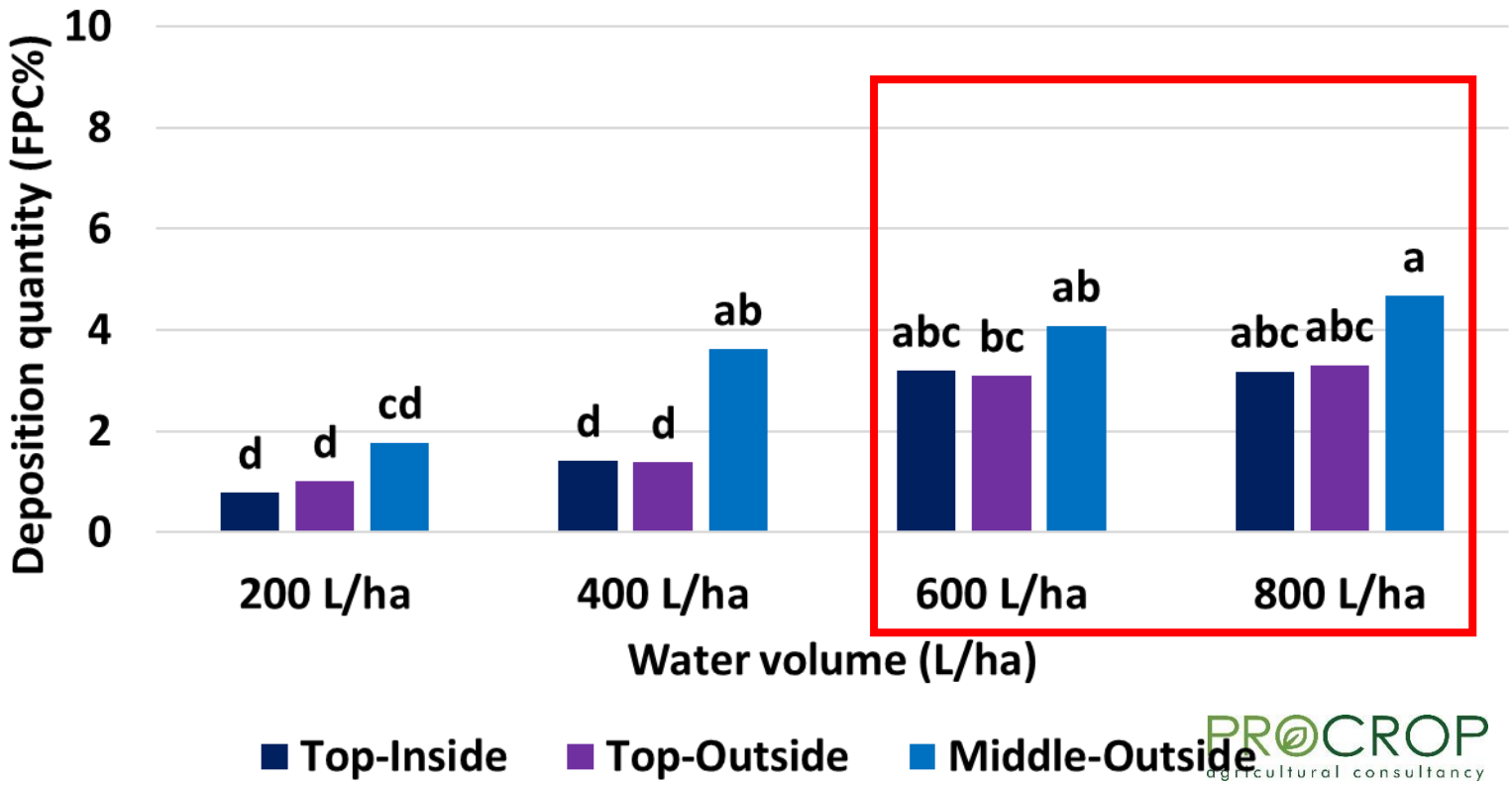
July 2022 Study – Berries

- 200 to 400 L/ha indicating similar trend as was found on leaves
  - Significantly lower deposition on top and inside canopy positions



July 2022 Study – Berries

- 600 to 800 L/ha better droplet distribution over canopy positions (more droplets available)
  - Statistically similar deposition realised
  - Run-off higher volumes 800 L/ha



November 2022 Study – Concentrated tank mix

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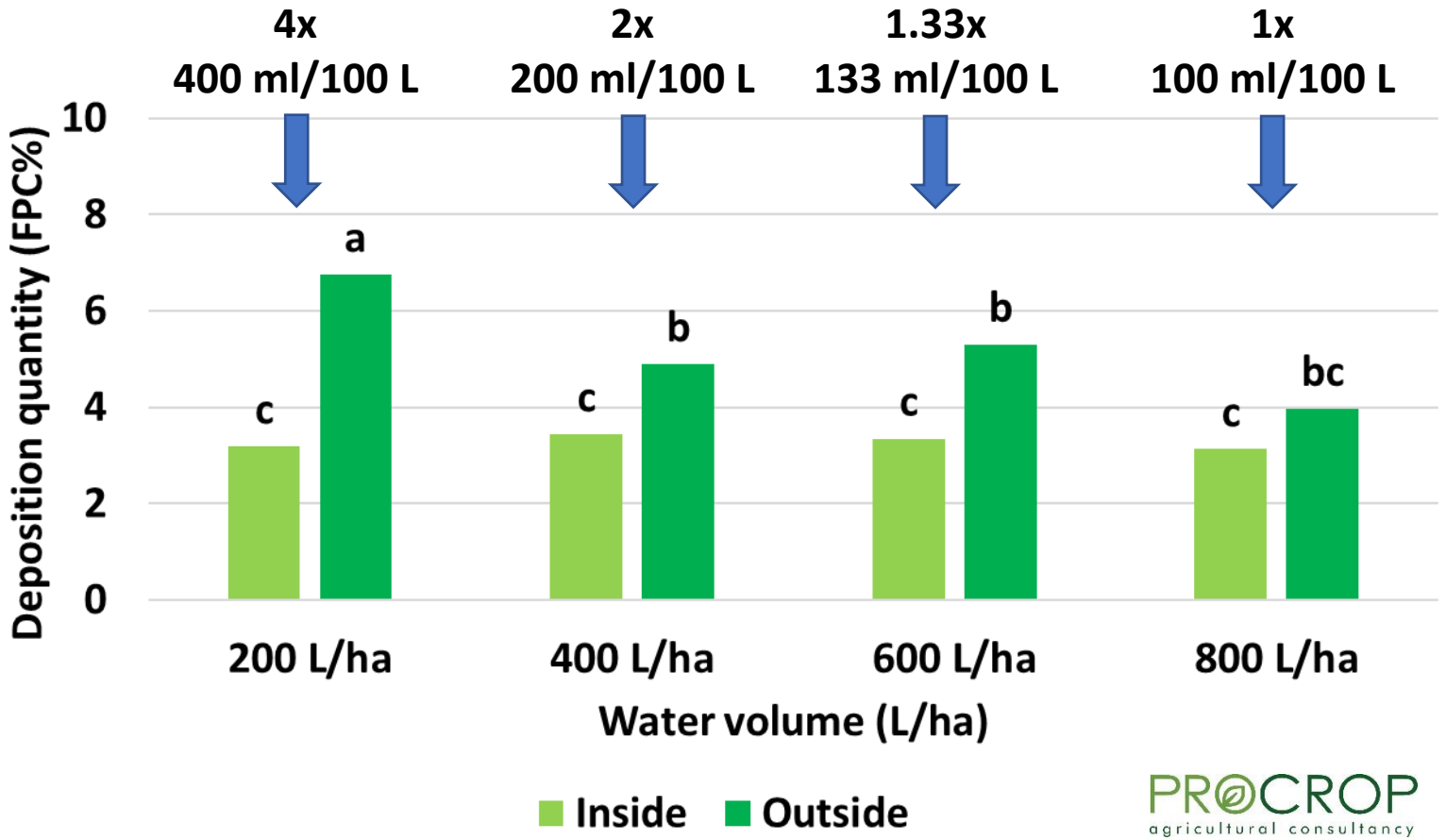
November 2022 Study – Leaves

- **Same dose per ha used (100 ml/100 L) based on TRV of 824.5 L/ha**
- **Similar deposition quantity (FPC%) realised**



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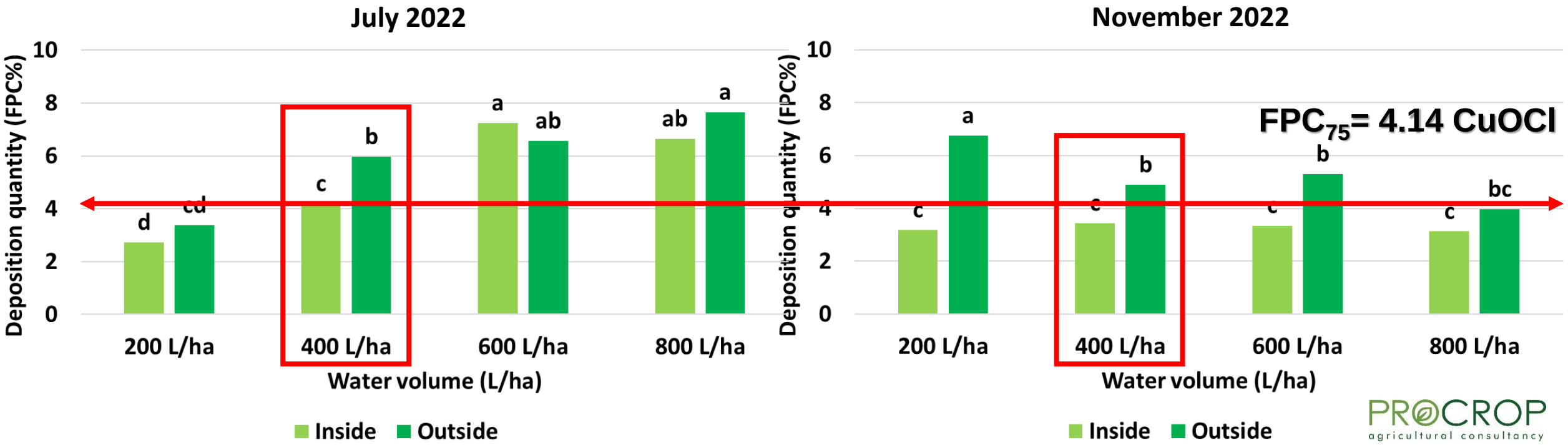
November 2022 Study – Leaves

- July vs November 2022 trials
  - 400 L/ha sprays similar deposition (200 ml/100 L)



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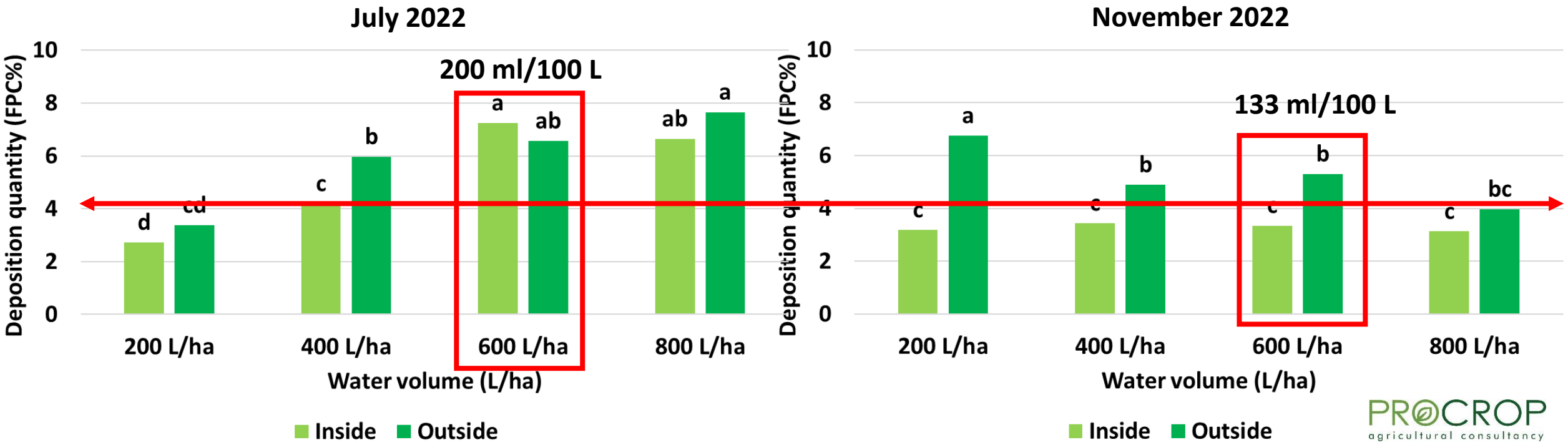
November 2022 Study – Leaves

- **July vs November 2022 trials**
  - **600 L/ha higher deposition quantity July vs November**
  - **July 200 ml/100 L vs 133 ml/100 L**
  - ***Going below 2x concentration – drop of in deposition quantity***



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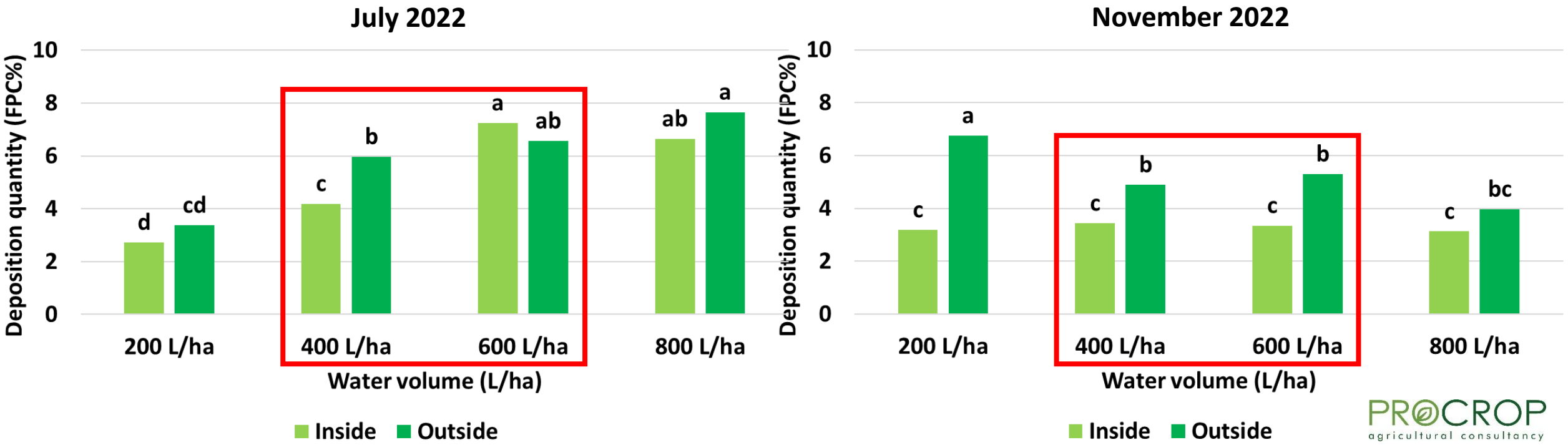
November 2022 Study – Leaves

- Number of droplets (droplet density) vs concentration (amount of active per droplet)
- “Sweet spot” 400 – 600 L/ha for this volume of canopy (824 L/ha)
- Fungicide or pesticide residue realised on target surface needs to be evaluated (droplet density vs active ingredient concentration per droplet)



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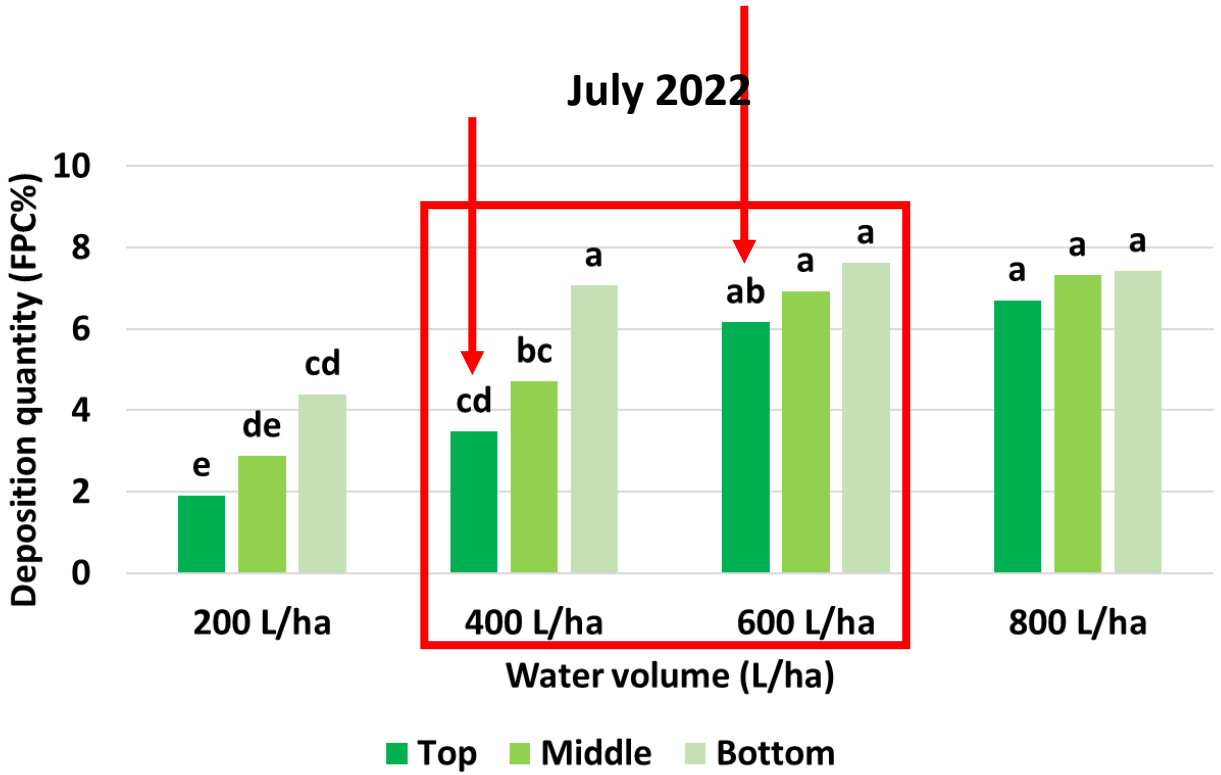
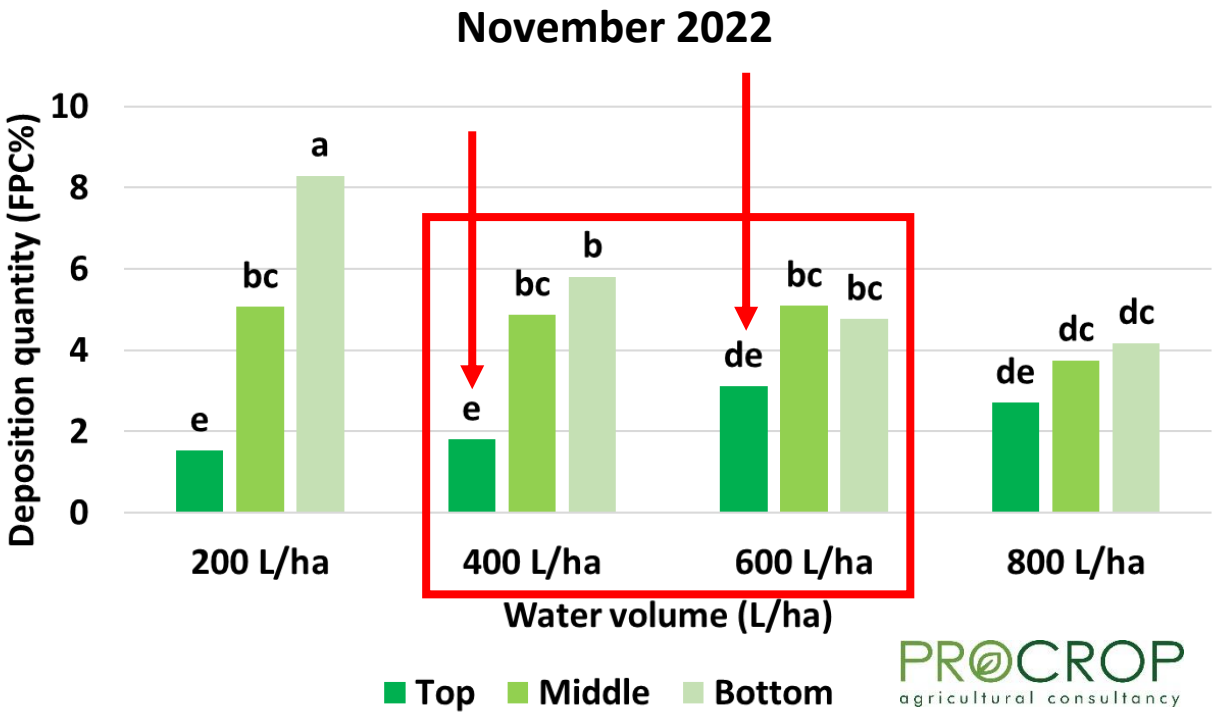
November 2022 Study – Leaves

- Number of droplets (droplet density) vs concentration (active per droplet)
- “Sweet spot” 400 – 600 L/ha for this volume of canopy (824 L/ha)
- Also indicated by deposition quantity realised on top canopy leaves





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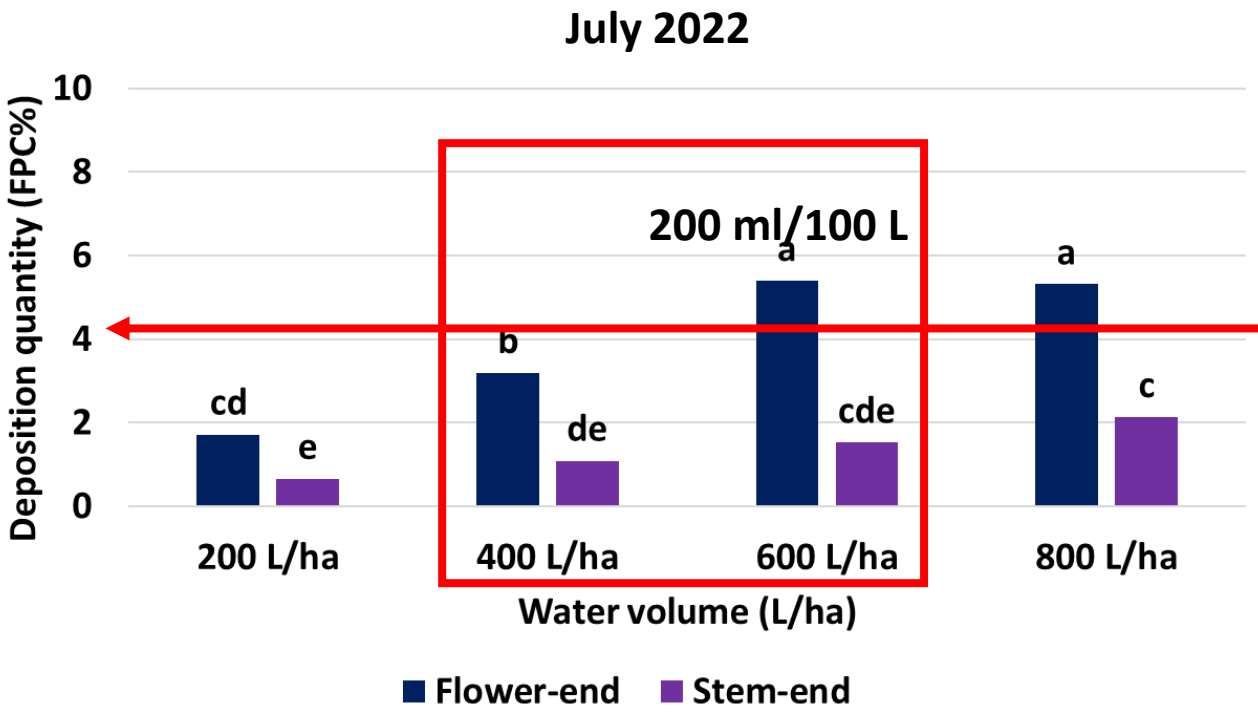
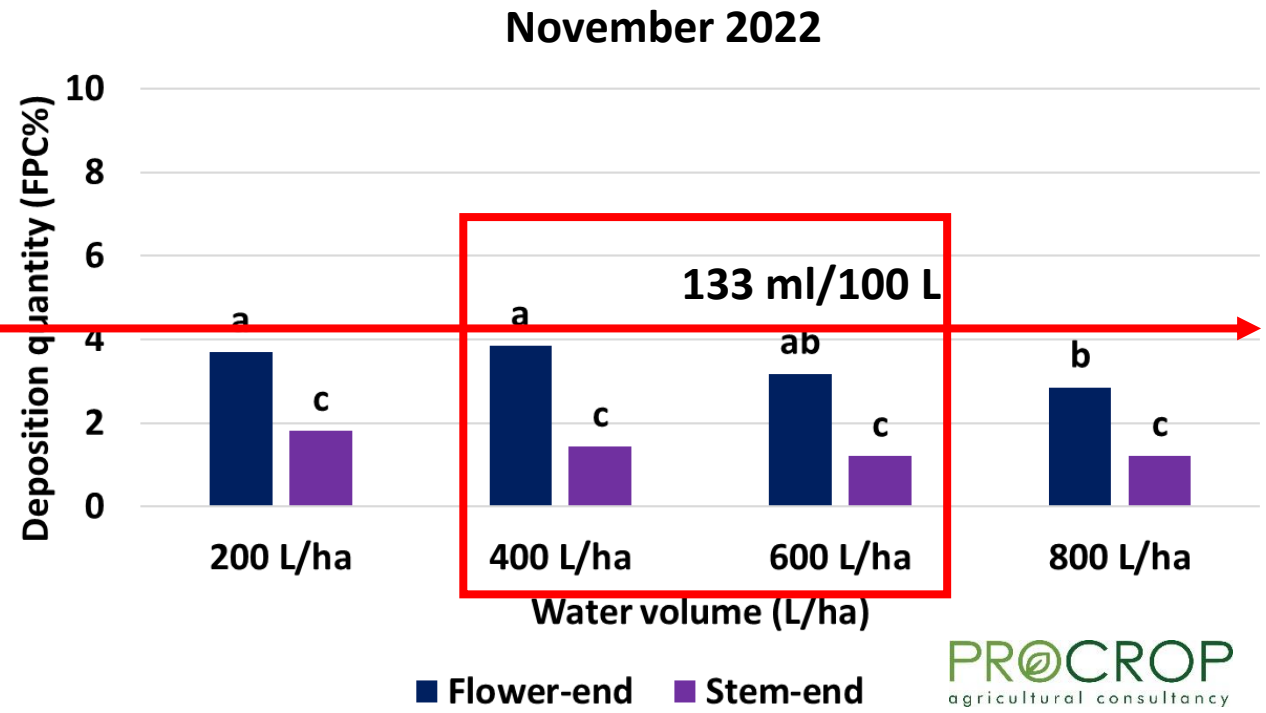
November 2022 Study – Berries

- Similar trend on fruit
- “Sweet spot” for number of droplets needed for sufficient deposition 400 to 600 L/ha
- Again Dosing? Merits residue study to ensure correct dosing





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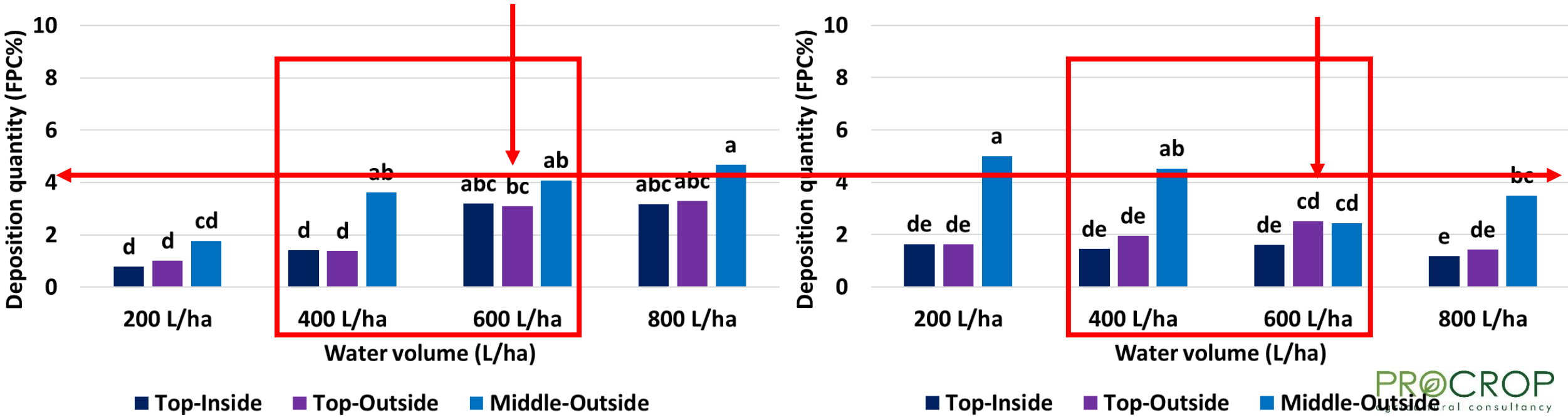
November 2022 Study – Berries

- Canopy position again concurs 400 to 600 L/ha sweet spot
- Higher number of droplets, better distribution through canopy indicated by top canopy positions
- Correct nozzle selection and positioning on sprayer is critical
- Merits residue study to ensure correct dosing



Discussion and conclusion

- Optimal spray application is critical to achieve sufficient or optimal deposition
- On canopies evaluated (TRV of 824.5 L/ha), deposition quantity was acceptable on leaves…
  - Between 400 to 600 L/ha to achieve sufficient…
  - Droplet density (number of droplets needed for sufficient deposition)
  - Product concertation…Work is needed…indicates relevance of residue study
- Deposition on fruit…
  - Lower than on leaves
  - Harder targets to reach, especially stem ends – not in flight path of droplets
  - Higher spray volumes (800 L/ha) did not improve deposition on fruit (flower or stem end)
  - Droplet density was sufficient at 600 L/ha
  - Product concentration…

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Discussion and conclusion

- **Product concentration…**
  - **Spraying similar canopies (TRV of 824 L/ha) at volumes higher than 600 L/ha is inefficient due to run-off**
  - **Spraying at volumes lower than 600-400 L/ha at rates lower than 2x is inefficient… not enough active carried per droplet to target.**

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Discussion and conclusion

- **Data indicates current TRV model using 937 constant not optimal for use on blueberries to calculate point of run-off volume**
  - **Run-off already observed on outer canopy leaves at 400 L/ha**
  - **Full canopy run-off at 600 L/ha**
- **If we assume 600 L/ha to be the ultimate point of run-off for this SPESIFIC canopy sprayed…**
  - **Derive theoretic adjusted TRV model for blueberries**

$$\text{Spray volume/ha} = \frac{Bush\ height\ (m) \times Bush\ depth\ (m) \times 682}{Inter\ row\ width\ (m)}$$

  - **Model needs to be evaluated first!**
    - **When using this model, 2x concentrations is recommended.**
    - **Residue study to improve dosing and residue loading on blueberries is critical**
    - **Plants with heights and depth of less than 1 m still recommended not to use spray volumes less than 300 L/ha at 2x concentrations.**

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Thank you

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