

Deposit variability and prediction in fruit crops:

What use are label rates anyway?

David Manktelow
Alison MacGregor
Sarah Gurnsey



What chemical and spray volume application rates are required and how do growers make these decisions?

How are variations between canopies addressed?
How much variation is introduced by application method?
How much variation is acceptable?

Do we know how much is deposited?
Do we understand deposit requirements with respect to dose and acceptable within-canopy variability?

AND HOW ARE THESE REFLECTED IN CHEMICAL LABEL RATES?

Deposit examples drawn from three tree crops

#1 Citrus

A canopy size versus application volume example

#2 Apples

A Tree-Row-Volume spraying example

#3 Winegrapes

Deposit variations with application method in two distinct canopies

Reference is made in each case to deposit levels, deposit variability and application rate recommendations

Deposit prediction

Why bother?

A useful, albeit crude, indicator of expected deposit levels in fruit trees is Dr Pat Holland's Standard Deposit Theory

This was used in the development of residue predictions on fruit at harvest for NZ apples, kiwifruit and persimmons

Average deposit levels of $2 \mu\text{g cm}^{-2}$ are predicted following application of 1kg ai ha^{-1} to a canopy with a leaf area index of around 3

In practice leaf deposits (two sides) usually range between 1 and $3 \mu\text{g cm}^{-2}$ and deposits on ovoid fruit are usually between 1 and $2 \mu\text{g cm}^{-2}$

Example #1

Spray application in citrus in NZ and Australia



Citrus canopies

Generally forms a dense outer layer of leaves and fruit with an open but shaded interior

Some species (eg lemons) or pruning management can produce open canopies similar to apples in form and density




Citrus canopies

Large ranges in tree sizes

- from small mandarins
- to large orange or grapefruit canopies

Top and side hedging common


Row spacings typically 5-7m



Citrus sprayers

Oscillating boom

- Proven effective in 1970's for red scale control with mineral oil
- Designed to wet inner canopy to runoff
- 8,000-15,000 l/ha in Australia



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Simple boom + guns

- Widely used
- Proven effective
- Inexpensive to build and run
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Low profile airblast

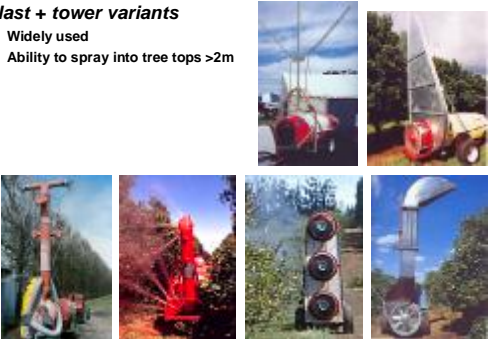
- How widely used?
- Limited ability to spray tree tops >2m



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Airblast + tower variants

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Directed axial fan

- Not widely used.....yet
- Spinning cage vs. hydraulic nozzles



Application volumes to citrus in NZ

Spray application volumes recorded

No volume identified	14%
Under 1000 l/ha	6%
1000 to 1900 l/ha	17%
2000 l/ha	50%
2100-3000 l/ha	11%
Over 3000 l/ha	3%

2002 Grower spray diary data from ca. 150 blocks

What spray volumes are required on different sized trees?

Volume and rate recommendations

Australian applications made at medium (2,000-7,000 l/ha) or high (>7,000 l/ha) volumes

Chemical rates based on label dilute rates per 100 litres of spray mix (not a legal requirement in NZ)

Tree-Row-Volume recommendations for citrus in NZ use coverage factors of 3-5 m²/litre and state:

"because of their very dense foliage citrus trees require roughly double the spray volume per unit TRV as deciduous trees"

The 3 times the deciduous tree recommendations of 7, 10 and 17 ml for dense, open or dormant trees respectively

NZ application volumes trial

Examining application volume + tree size interactions
Using a simple boom sprayer (9 guns) at 4.2 km/hr
Application volumes of ca. 1000, 2000 and 3000 l/ha



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11,000 m²/ha
2,000-3,300 l/ha

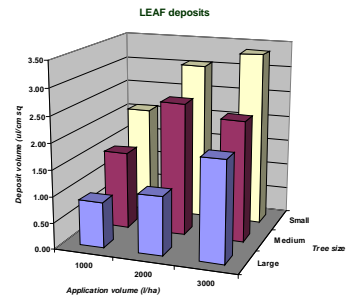
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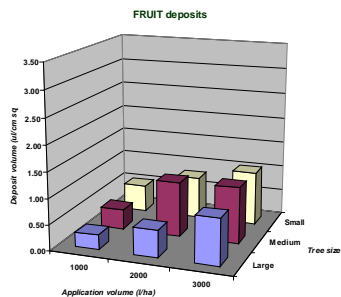
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Spray volumes deposited to leaves



Spray volumes deposited to fruit



Application volume effects on spray volumes deposited

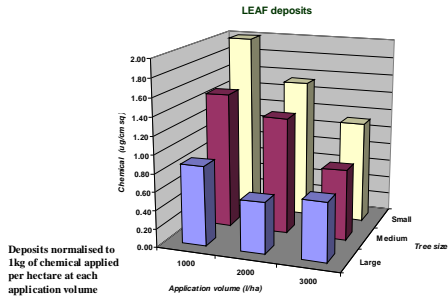
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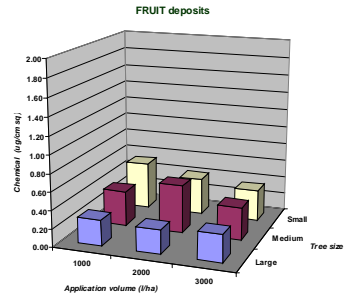
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Chemical deposits on leaves



Chemical deposits on fruit



Application volume effects on chemical deposited

The smaller the tree the greater the chemical deposit per square centimetre of leaf surface area

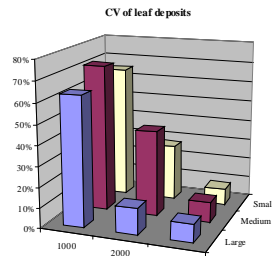
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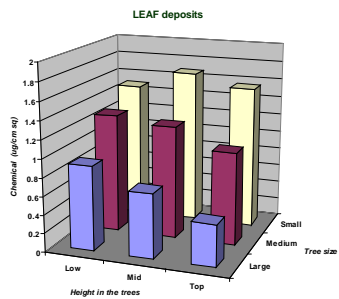
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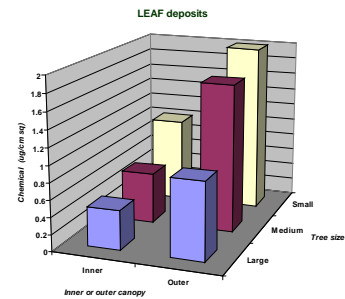
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Variations on leaf deposits with height in the tree



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Two fold deposit variation between the inner and outer canopy



Deposit variability within trees

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Is that sort of variability significant in setting chemical application rates?

Are these observations representative for citrus?

Deposit trends with application volumes were totally consistent with those reported in large Australian canopies

We need to establish some reference dose figures for both leaves and fruit in order to better compare deposit data between canopies and/or application techniques

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May need to develop separate guidelines for dense versus open canopies and for air assisted versus non air assisted sprayers

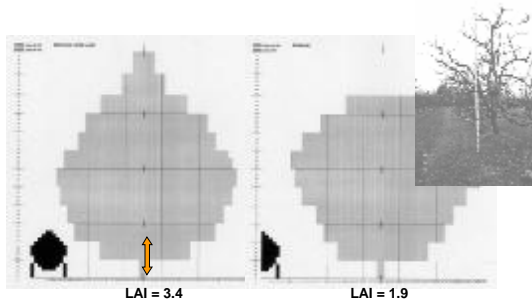
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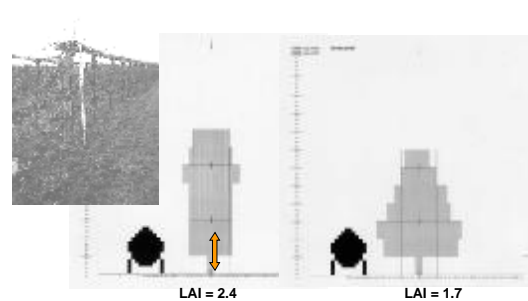
Spray application in NZ apples

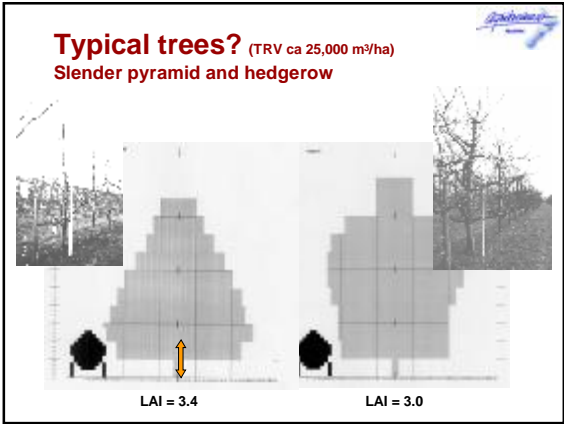
NZ apple canopies

Large trees (TRV >25,000 m³/ha) Old centre leader & multileader



Small trees (TRV ca 10,000 m³/ha) Ebro espalier and slender spindle



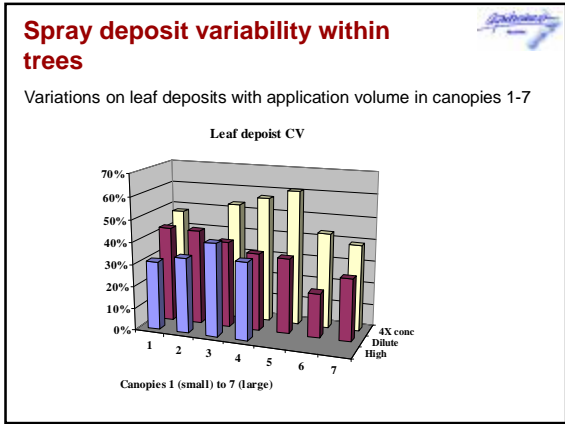
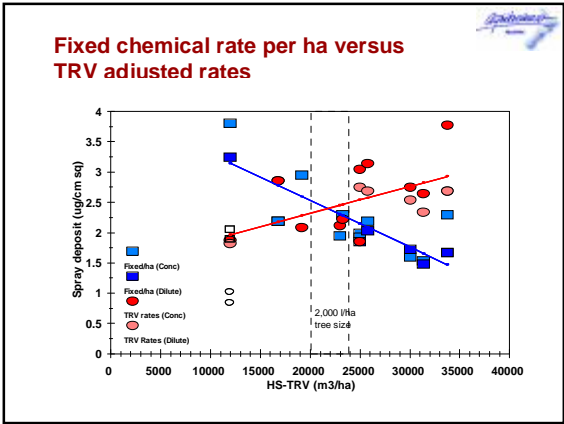
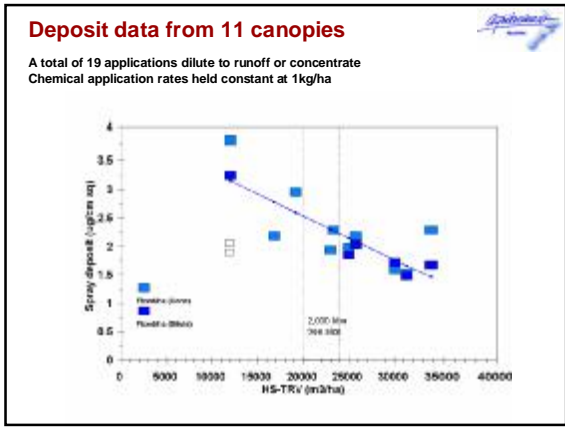
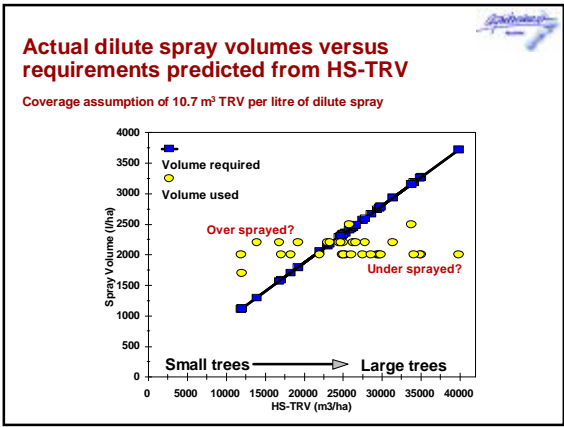
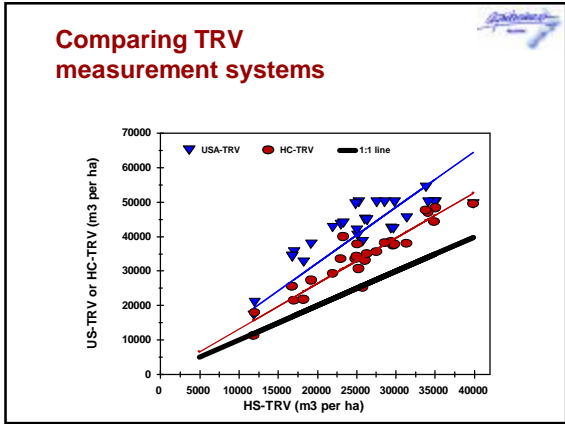
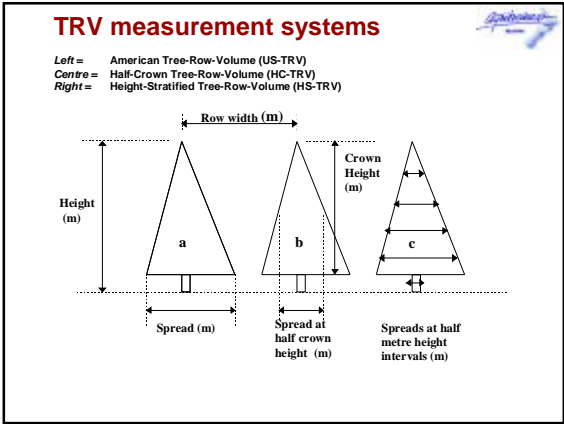


NZ apple sprayers



Describing and managing deposit variability between apple canopies

- Canopy descriptors**
- Tree height
 - Row spacing
 - Row length
 - Canopy wall surface area
 - Canopy continuity
 - Tree volume
 - Tree-Row-Volume (TRV) ←
 - Leaf area index
 - Leaf area density
 - Light interception



Conclusions from the apple example

- The TRV approach only provides a partial indication of required application rates
- Canopy volume does not appear to be a valid predictor of application rate for highly structured canopies
- Integration of TRV with an independent measure of canopy density should improve predictions
- Any canopy descriptor(s) for use by growers needs to be easy to measure and non subjective
- TRV coverage factors are too arbitrary and need to be set in relation to "runoff volumes" and reference chemical doses



Example #3

Spray application in NZ and Australian winegrapes



Grape canopies



VSP vs. sprawl vs. minimal pruned



↑ NZ canopy
Used in reported in deposit work
LAI = 1.3
TRV = 1,800 m³/ha

↑ Au canopy
LAI = 1.6
TRV = 18,000 m³/ha



Grape sprayers



STANDARD AIRBLAST



- ducted airblast



ADJUSTABLE MULTI-OUTLET






HYDRAULIC
- no air assistance





↑
Sprayer used in NZ deposit work

SMALL DIRECTED AXIAL FAN
- spinning cage
- hydraulic nozzles

↑
Sprayer used in Au deposit work




AIRSHEAR





↑
Sprayers used in Au deposit work →


AIR ASSISTED VERTICAL BOOMS:
- tangential fan
- ducted centrifugal fan


↑
Sprayers used in NZ and Au →

HANDGUN APPLICATION

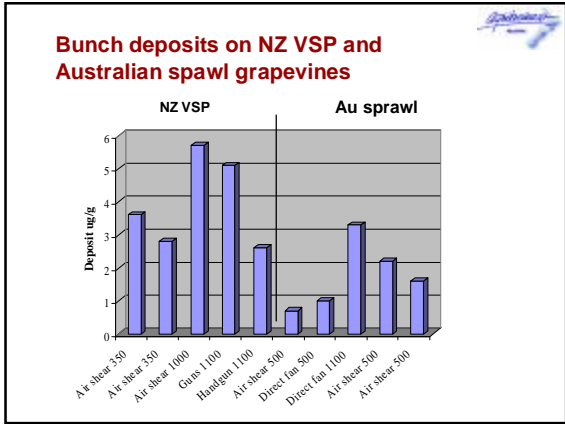
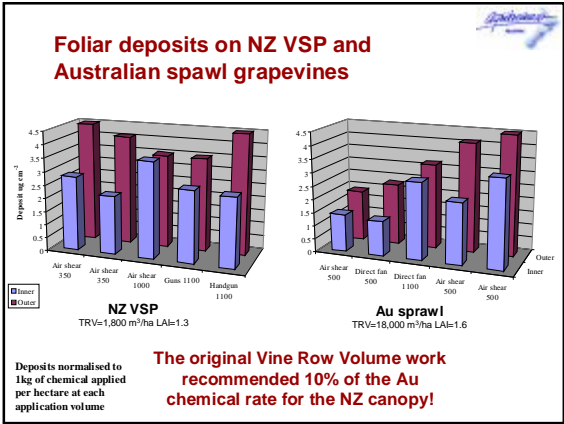
As used in a majority of product registration trials



↑
Sprayer used in NZ deposit work

Winegrape deposit comparisons

NZ VSP and Australian sprawl canopies
Examining deposit variations from different sprayers/volumes
Five treatments reported for each canopy



So how does a grower decide what chemical rate and water volumes are required?

Standards on agrichemical labels

For 24 NZ grape fungicide labels:

- all gave recommended rates per 100 litres dilute
- 6 gave a minimum chemical rate per hectare
- 3 gave minimum water volumes per hectare

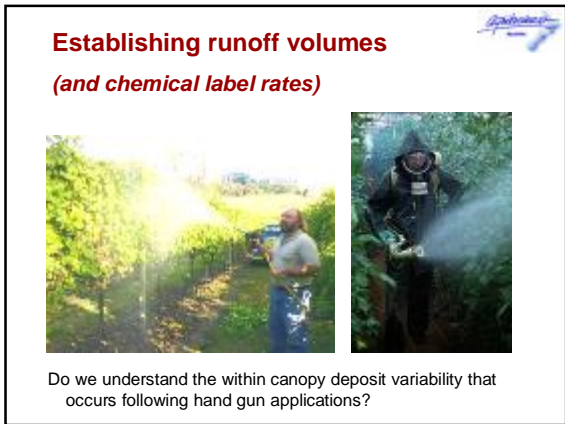
Recommended water volumes per hectare for the 9 products above were calculated to be:

1,000 l/ha (5 products) 1,100 l/ha (1 product)
1,330 l/ha (1 product) 1,500 l/ha (2 products)

The Australians have removed all reference to hectare rates from their grape labels with growers left to work out application volume requirements from runoff at 100 litre chemical rates

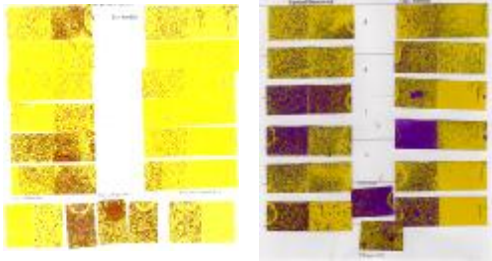
The Australian indicative water volumes guide

INDICATIVE WATER VOLUMES FOR DRIFT SPRAYING GRAPEVINES				
	10% canopy cover	20% canopy cover	30% canopy cover	40% canopy cover
SPRAWL ENERGY				
Minimum volume (L/ha)	100 to 150	200 to 300	300 to 400	400 to 500
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VSP CANOPY				
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WSP coverage from handgun application to runoff

Two examples of inner canopy deposits on water sensitive papers following handgun applications at ca. 1,000 l/ha



Identification of effective dose

The Australian "dose kit" project undertook bioassay studies to identify effective field doses for particular chemicals
e.g. Grapevine powdery mildew disease control was found to require sulphur deposits of $2.3 \mu\text{g cm}^{-2}$ (double for both leaf surfaces)

While the kit for rapid grower measurement of dose was unsuccessful, the reference doses established provide sound deposit benchmarks from which to assess dosage achieved in different situations

In the grape example given, the worst NZ and Au treatments received 2.2 and $1.3 \mu\text{g}$ respectively on inner canopy leaf samples for 1kg ai applied per ha – which suggests that sulphur rates of **at least 2 and 3.5 kg ha⁻¹** would be required to achieve field control

In conclusion

There are large, and often unacceptable, variations between industry spraying practices and recommendations

Agrochemical use reduction efforts should first focus on identifying application rate requirements for different situations

Then on establishing methods by which growers can apply the required quantity of agrochemical in appropriate and efficient application volumes

A step towards achieving this would be for researchers to make greater reference to effective and expected deposited dose ranges from spray application treatments

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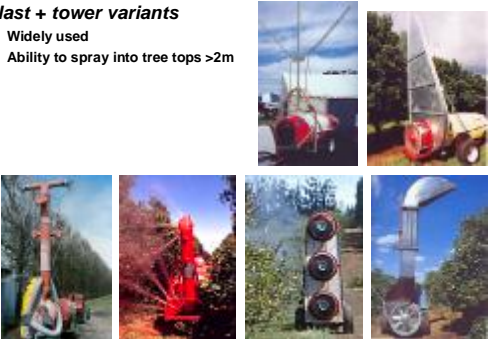
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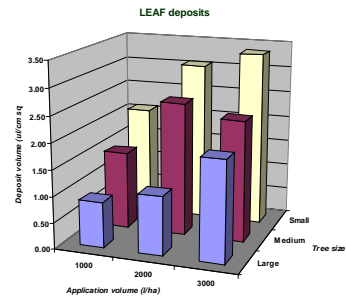
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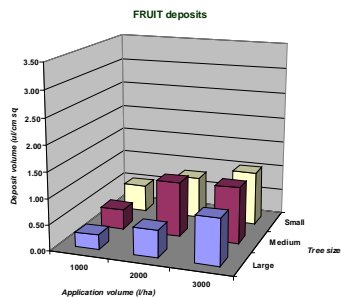
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Spray volumes deposited to leaves



Spray volumes deposited to fruit



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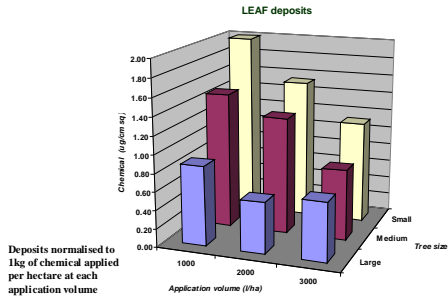
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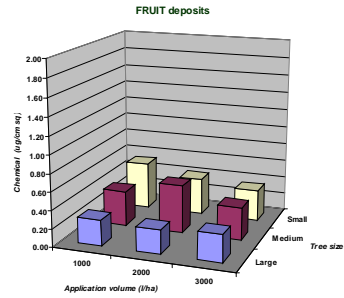
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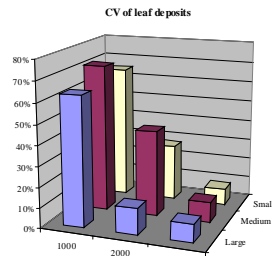
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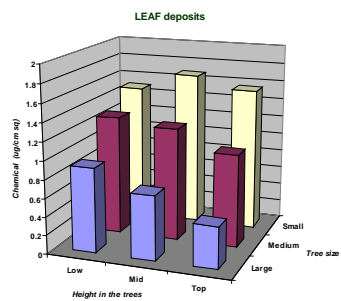
Spray deposit variability within trees

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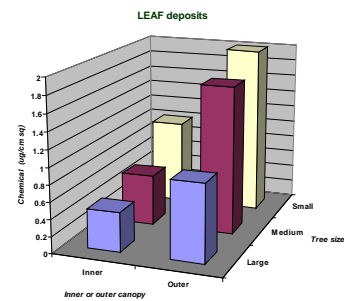
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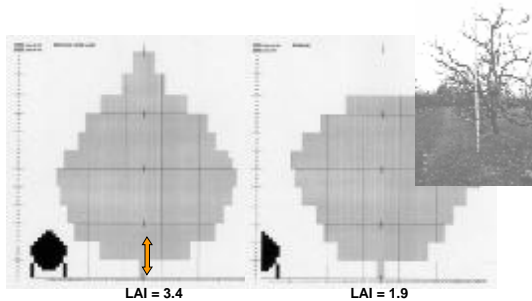
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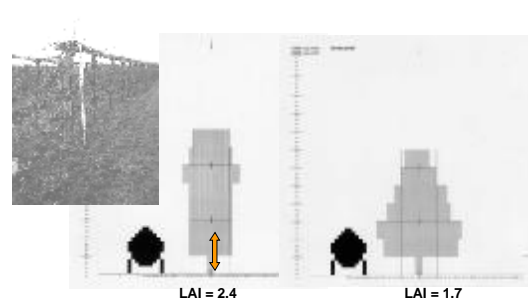
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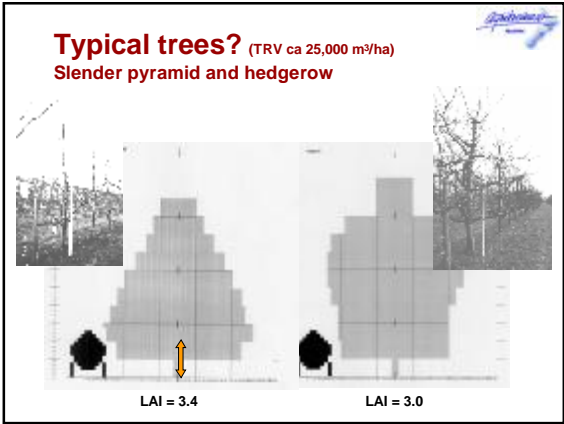
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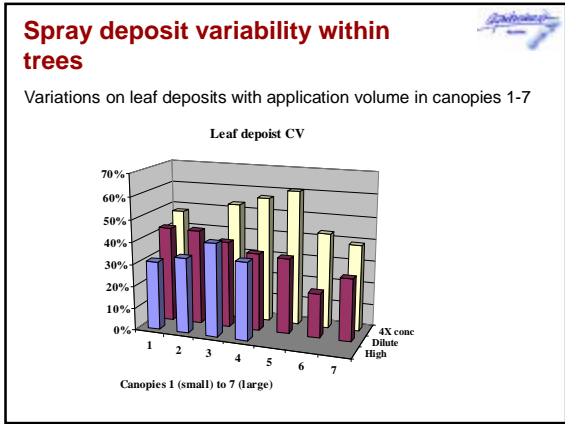
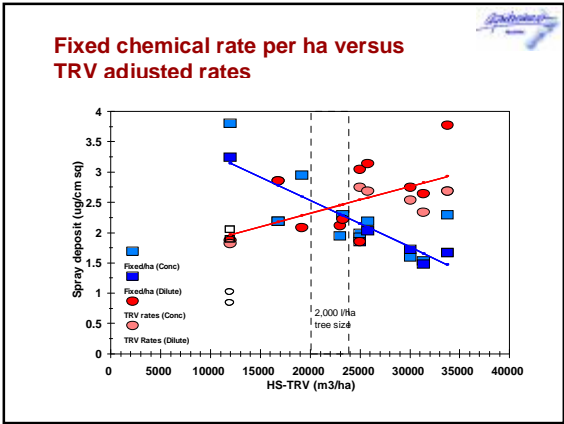
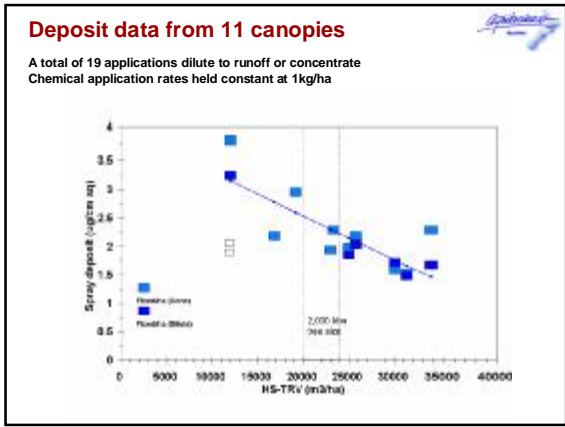
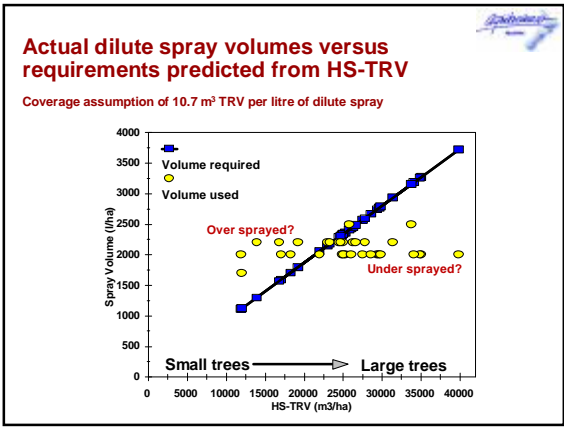
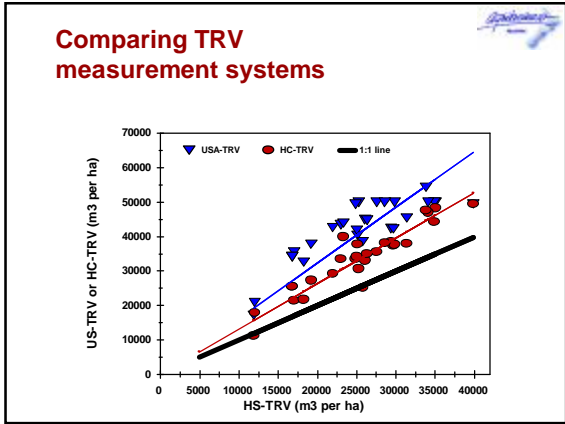
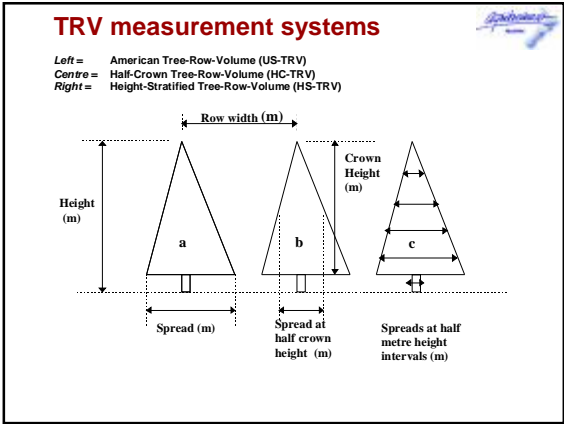


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↑
Sprayers used in Au deposit work →

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↑
Sprayers used in NZ and Au → deposit work

HANDGUN APPLICATION

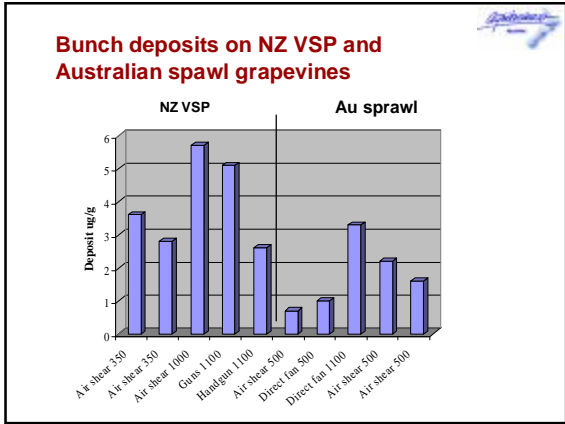
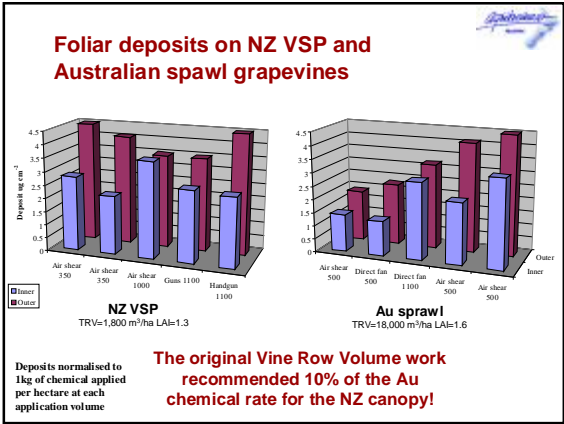
As used in a majority of product registration trials



↑
Sprayer used in NZ deposit work

Winegrape deposit comparisons

NZ VSP and Australian sprawl canopies
Examining deposit variations from different sprayers/volumes
Five treatments reported for each canopy



So how does a grower decide what chemical rate and water volumes are required?

Standards on agrichemical labels

For 24 NZ grape fungicide labels:

- all gave recommended rates per 100 litres dilute
- 6 gave a minimum chemical rate per hectare
- 3 gave minimum water volumes per hectare

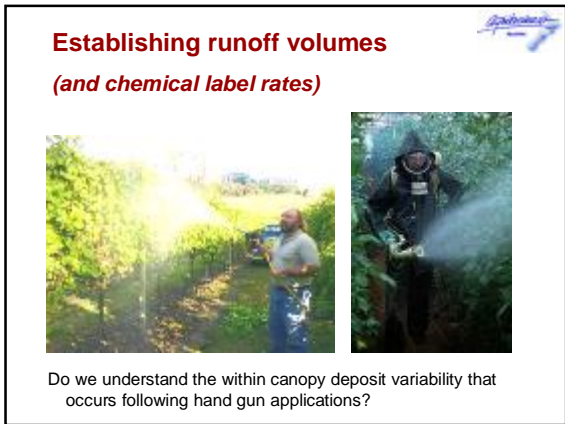
Recommended water volumes per hectare for the 9 products above were calculated to be:

1,000 l/ha (5 products) 1,100 l/ha (1 product)
1,330 l/ha (1 product) 1,500 l/ha (2 products)

The Australians have removed all reference to hectare rates from their grape labels with growers left to work out application volume requirements from runoff at 100 litre chemical rates

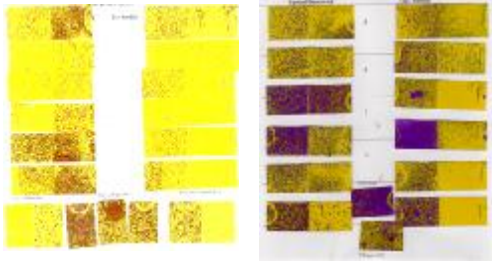
The Australian indicative water volumes guide

INDICATIVE WATER VOLUMES FOR BUNCH SPRAYING GRAPEVINES				
	1000 L/ha	1500 L/ha	2000 L/ha	3000 L/ha
SPRAWL				
Recommended volume	1000 L/ha	1500 L/ha	2000 L/ha	3000 L/ha
Minimum volume	200 L/ha	300 L/ha	400 L/ha	600 L/ha
Maximum volume	2000 L/ha	3000 L/ha	4000 L/ha	6000 L/ha
Water volume	1000 L/ha	1500 L/ha	2000 L/ha	3000 L/ha
Water volume	200 L/ha	300 L/ha	400 L/ha	600 L/ha
Water volume	2000 L/ha	3000 L/ha	4000 L/ha	6000 L/ha



WSP coverage from handgun application to runoff

Two examples of inner canopy deposits on water sensitive papers following handgun applications at ca. 1,000 l/ha



Identification of effective dose

The Australian "dose kit" project undertook bioassay studies to identify effective field doses for particular chemicals
e.g. Grapevine powdery mildew disease control was found to require sulphur deposits of $2.3 \mu\text{g cm}^{-2}$ (double for both leaf surfaces)

While the kit for rapid grower measurement of dose was unsuccessful, the reference doses established provide sound deposit benchmarks from which to assess dosage achieved in different situations

In the grape example given, the worst NZ and Au treatments received 2.2 and $1.3 \mu\text{g}$ respectively on inner canopy leaf samples for 1kg ai applied per ha – which suggests that sulphur rates of **at least 2 and 3.5 kg ha⁻¹** would be required to achieve field control

In conclusion

There are large, and often unacceptable, variations between industry spraying practices and recommendations

Agrochemical use reduction efforts should first focus on identifying application rate requirements for different situations

Then on establishing methods by which growers can apply the required quantity of agrochemical in appropriate and efficient application volumes

A step towards achieving this would be for researchers to make greater reference to effective and expected deposited dose ranges from spray application treatments