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Kiwifruit Spraying Factsheet 2: Interpreting Chemical Labels

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Key Points

This factsheet describes how chemical label rates are determined.

- For a crop like kiwifruit, the chemical label rate per 100 litres is the most reliable guide for the user. This rate is intended for dilute spray application to the point of runoff (outer canopy beginning to drip, inner canopy well covered) and can be expected to result in reliable pest or disease control, provided good target coverage is achieved.

Agrichemical testing and rate setting

Agrichemical testing starts with laboratory screening for potential efficacy. Potential new chemicals are then used in small plot field trials (usually using single tree replicates) based on protocols that have been long established and accepted by the agrichemical industry.

Traditionally small plot spray applications are made as high volume ("dilute") sprays using high-pressure, hand held spray guns, or backpack mist blowers. All target surfaces are thoroughly wetted to a point where some excess spray liquid just begins to drip to the ground ("the point of runoff"). By following this protocol, it is expected that all parts of the plant receive an even chemical dose. It is also assumed that all plant targets in these types of field tests can be treated equally regardless of differences in size, shape or growth stage. This approach ensures a high level of plant surface coverage and means that the level of control achieved in any treatment is directly related to the concentration of chemical applied. This type of testing provides the basis for the dilute chemical mixing rates (chemical rate per 100 litres of dilute spray mix) that appear on chemical labels for fruit and vine crops in New Zealand.

Spraying to the point of runoff aims to eliminate dosage variations between treatments or experiments. However, in practice there will always be some variations in the chemical doses achieved in small plot field trials. For example, there are variations between spray applicators in their perception of the wetting required to reach the point of runoff. There are also variations in how much chemical can be loaded onto plant surfaces when different droplet sizes or wetting agents are used. It is generally accepted that the application of chemicals in volumes below the point of runoff will result in deposits that are 10-20% higher, but more variable, than those from application of equivalent amounts of chemical (per row length or per hectare) in volumes at the point of runoff losses.

In practice actual spray deposits (and hence potential variations in deposits between treatments and tests) from chemical registration tests are seldom quantified. The focus of chemical testing work is quite appropriately on pest or disease control outcomes and chemical residues at harvest. The chemical testing protocols used to develop label rates have served well to identify potentially useful agrichemicals and to define application rates that can be expected to work in commercial practice. The key assumption behind the resulting chemical label rate recommendations is that the

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grower will use high volume sprays that wet most of the outer parts of the target canopy to the point of runoff and provide good wetting and coverage in the inner canopy. It is left to the sprayer operator to work out the application volumes required to treat different canopies and how to most efficiently deliver the spray to the target (Figure 1).

Figure 1. *Application to the point of spray runoff for chemical efficacy trial work.*
(Top) Handgun application to replicate bays in a kiwifruit orchard.
(Bottom) Mistblower application in single vine plots.

Interpreting chemical label rates and application volume requirements

All fruit industries need to define optimal spray application volumes (and hence chemical application rates) for different training systems and seasonal growth stages. The basic application volume requirement assumptions in the NZ kiwifruit industry for different vine growth stages are:

- **Dormant canes** ca. 800 l/ha, more volume will be required to wet large and complex leader wood and trunks to runoff. A row length based application volume recommendation has been developed for leader spraying which expresses required application volumes in terms of litres/100 m of row for different sized leader wood (see KiwiTech Bulletin No N56 Leader Spraying).

- **Early spring** canopies are expected to require approximately 800-1000 l/ha in the early spring period from bud break to approximately four weeks post budbreak.

- **Late spring canopies** (pre bloom) continue to experience rapid emergence and expansion of new leaf tissue. NZ kiwifruit canopies typically require between 1200 to 1500 l/ha to achieve runoff at this stage.

- **Summer canopies** from fruit set to harvest are expected to require ca. 1500 increasing to up to 2500 l/ha to wet to runoff – with the required volume depending on canopy density.

Open canopies, with more space between leaves and lower total leaf area will require lower application volumes than the larger and/or denser canopies.

Very dense canopies, and two layer training systems (e.g. strung gold canopies) will have a greater canopy surface area than most, and will require higher application volumes to reach the point of spray runoff. Also note that canopies with touching fruit will require greater application volumes than canopies where fruit hang free.

It is important to realise that these accepted dilute application volumes ***do not guarantee 100% fruit, leaf or wood coverage***. Structures and large wood, leaves or fruit can create "shadow" areas that spray may not reach. It is not uncommon to see 30% or more of fruit surface area completely unwetted (Figure 2). This problem increases with increasing fruit size and is worst when the fruit have leaves in close proximity.

Figure 2. *Partial fruitlet coverage.*

Poor coverage is most commonly seen on the sides of leaves, fruit or wood that were facing away from the sprayer. These gaps are caused largely by the sprayer output air and droplets separating around the obstruction and leaving a "shadow area" in behind.

Simply increasing spray application volumes is not a solution to this type of problem. ***To achieve 100% wetting in kiwifruit spray application using spray volume alone, application volumes would need to be increased to double or even triple the currently accepted dilute application volumes.*** This is not economically or logistically practical and should not be necessary. In most cases some redistribution of spray deposits occurs in dew or rainfall after application and some chemicals are moved systemically within plant tissues.

In the past virtually the only chemistry that has required full coverage of fruit or wood targets to achieve efficacy have been contact oil sprays (that smother target pests). Unfortunately the chemicals currently available to protect kiwifruit vines from infection by Psa are currently all contact in action and best results are expected if spraying achieves full surface coverage. It is considered that intelligent use of spray adjuvants will play an important part in maximizing the coverage and potential efficacy of protectant chemicals for PSA control.

When sprays are applied in multiple application spray programmes repeated underdosing of canopy shadow areas can be minimized if the sprayer travels in the opposite direction down the row on each application pass.

Attention needs to be given to sprayer setup to maximise spray retention and coverage potential. Guidelines for setting up sprayers and assessing coverage are discussed in separate notes. The potential gains from optimising sprayer setup to maximise retention and coverage can be an increase in deposits of 15-30%.

A note on chemical application rates and deposited dose

It is important that growers, researchers and the chemical industry are aware of the expected chemical dose levels (quantity of chemical per square centimetre of cane surface area) that should be achieved from different application rates and spray volumes.

There will always be some variation in chemical dose achieved across a canopy - generally the most distant parts of the canopy will receive as little as half of the dose achieved on areas closer to the sprayer (note that excessive air assistance speeds [greater than approximately 12 m/s at the target] will result in lower deposits on canes closest to high velocity air). This is exactly the trend seen in the open leaf canopy deposit studies that support these recommendations. The good news was that the spray coverage potential on top and bottom surfaces of spring kiwifruit canopies was surprisingly good and it should be possible to achieve effective chemical doses across all target surfaces – at least through to flowering.

Capture and retention of applied sprays increases quickly as the crop canopy develops. Retention does not exceed 10% on dormant vines, but should rapidly increase to ca. 50% or more by flowering, and can reach nearly 90% in fully developed even canopies.

The potential range of deposits expected as a canopy develops are shown in Figure 3.

- In this example a constant chemical application rate of 1kg per hectare has been assumed and deposits have been expressed in micrograms per square centimetre of projected canopy surface area[1].
- The potential maximum deposit (100% retention of all applied spray) is shown in **top line on the graph** below. It can be seen that when a constant application rate per hectare is used, the average deposit per square centimetre of canopy surface area will decrease as total surface area increases.
- The **mid line on the graph** is the realistic potential maximum deposit that could be achieved from a well setup sprayer delivering fine droplets at below runoff volumes with a spray and surfactant mix that achieves maximum droplet retention.
- The **bottom line on the graph** shows the realistic potential lower deposit levels that can be expected from high volume spraying with relatively poor spray retention on hard to wet surfaces.
- Note that Figure 1 shows the range of potential average deposits across the canopy target. Localised deposits can show significant variability, with some areas receiving no deposits and others being over-sprayed.
- Once spray runoff occurs at a particular point in the canopy, a maximum deposit level is usually reached and the addition of more spray volume will not greatly increase deposit levels at that point.
- When applying concentrate sprays, maximum localised deposits can be higher than those seen with high volume sprays.

[1]Projected surface area means that deposits apply to the whole leaf (both surfaces) – average true deposits on top or bottom leaf surfaces would be half this number.

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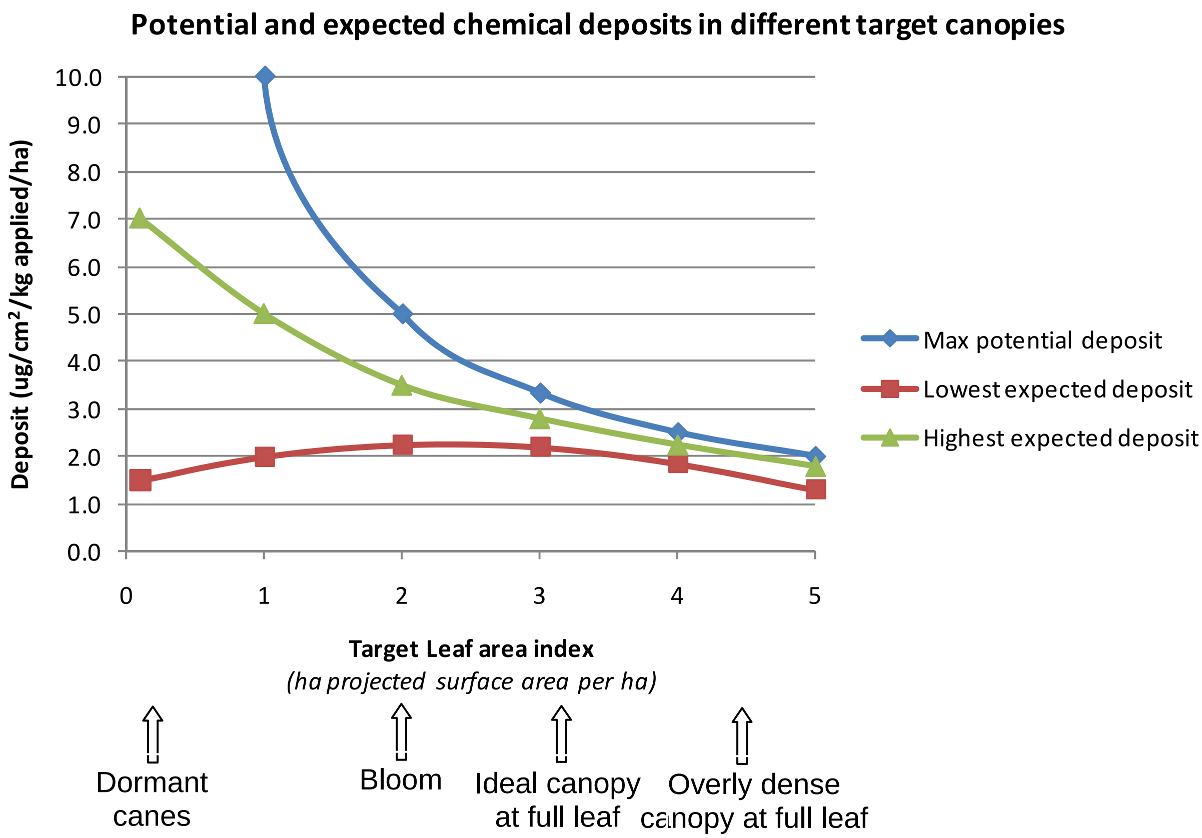

Figure 3. *Maximum potential and expected range of deposits (micrograms per square centimetre of tissue surface) following application of one kilogram of chemical per hectare to canopies with different surface areas.*

- *The top line shows the maximum potential deposit if 100% of the chemical is deposited on the target.*
- *The area between the mid and lower lines represents the range of potential deposits expected with high (mid line) to low (bottom line) spray retention efficiency.*
- *Spray retention efficiency is driven by many factors including; sprayer setup and targeting, spray application volume, spray droplet sizes, target tissue wetablity, target tissue micro-scale surface area (with hairs etc,) and spray solution surface tension and spreading capability.*

The data used to produce Figure 3 are shown below – note that these data are estimates derived from deposit data collected across many experiments and crops where deposits have been measured and some estimate of canopy surface area was available.

Target description	Target canopy LAI (ha/ha)	Max potential deposit ($\mu g/cm^2/kg/ha$)	Expected deposits ($\mu g/cm^2/kg/ha$)		Retention efficiency	
			Lowest	Highest	Lowest	Highest
Bare wood	0.1	100.0	1.5	7.0	2%	7%
Gappy leaf canopy	1	10.0	2.0	5.0	20%	50%
Optimal leaf canopy (early season)	2	5.0	2.3	3.5	45%	70%
Optimal leaf canopy (mid season)	3	3.3	2.2	2.8	66%	84%
Dense leaf canopy	4	2.5	1.9	2.3	74%	90%
Very dense leaf canopy	5	2.0	1.3	1.8	65%	90%